



RESEARCH ARTICLE

Exploring Machine Learning Techniques for Predictive Analytics in Healthcare: Analyzing Electronic Health Records (EHR) for Early Disease Detection, Patient Monitoring, and Treatment Optimization

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ABSTRACT

In order to improve early disease identification, tracking of patients, and treatment optimization, this study examines machine learning approaches for predictive analytics in the healthcare industry with an emphasis on the interpretation of Electronic Health Records (EHR). We seek to find patterns and trends in EHR data that can indicate the development of illnesses and enhance the health of patients by utilizing a variety of algorithms. The study emphasizes how crucial feature selection, data preparation, and model validation are to creating precise predictive models. We also go over the difficulties with integration and data protection in healthcare systems. In the end, our results show how machine learning may revolutionize healthcare procedures by facilitating rapid interventions and individualized treatment regimens, which will enhance patient care as well as maximize the usage of resources.

Keywords: Disease Detection - Electronic Health Records - Predictive Analytics - Machine Learning





INTRODUCTION

Health care professionals now examine data and make judgments in a completely different way thanks to the introduction of machine learning algorithms¹. The application of these methods to Electronic Health Records (EHR), which hold enormous volumes of patient data, is the main emphasis of this work^{2,3}. We can find trends that help with preliminary illness identification, enhance patient monitoring, and improve treatment regimens by utilizing EHR data. It is impossible to overestimate the significance of predictive analytics as the healthcare industry grows ever data driven⁴. Being able to foresee health problems before they become serious can result in prompt interventions, which will ultimately improve the patient's condition and lower healthcare expenses⁵. A thorough library of patient data, including medical history, treatment plans, and diagnostic data, is provided via electronic health records. Healthcare practitioners have a rare chance to use machine learning algorithms thanks to this abundance of data⁶. We can find tendencies and associated risks by examining EHR data that might not be visible using more conventional techniques⁷. Patterns in demographics of patients, medication adherence, and test findings, for example, can offer important clues about possible health problems. By enabling early disease detection and individualized treatment plans, the utilization of this data enables a more proactive method toward providing care to patients^{8,9,10}. EHR data is analyzed using a variety of machine learning techniques, each with unique advantages and disadvantages. Both regression and classification processes are two examples of supervised learning approaches that work very well for forecasting disease outcomes from past data¹¹. Without predetermined labels, methods that use unsupervised learning like dimensionality reduction and clustering can reveal undetectable trends in the data. Ensemble approaches, which integrate several algorithms, can also improve prediction accuracy^{12,13}. Because it directly affects the capacity to detect at-risk consumers and enhance therapies, algorithm selection is essential for optimizing the efficacy of predictive models¹⁴. By evaluating real-time data from several sources, such as wristbands and gadgets that monitor patients remotely, machine learning algorithms allow for constant surveillance of patients¹⁵. With the help of this feature, medical professionals may keep a closer eye on patients' ailments and spot any changes from their typical course. When abnormal readings occur, early notifications can be set off, allowing for quick intervention and perhaps averting consequences^{16,17}. Additionally, healthcare providers can use the insights gleaned from models developed using machine learning to dynamically modify treatment plans, guaranteeing that care stays in line with the needs of each patient. In the end, this proactive monitoring strategy improves patient safety and promotes a more individualized medical experience¹⁸. It is anticipated that further research will produce even more advanced algorithms that can analyze bigger datasets more effectively. Furthermore, revolutionary advancements in patient care may result from the combination of AI with other technologies like genomics and telemedicine. We can create specialized solutions that target certain health issues by encouraging partnerships amongst data researchers and medical specialists¹⁹. Machine learning's contribution to predictive analytics will surely grow as it develops, significantly improving the state of healthcare²⁰.

METHODOLOGY

Linear regression helps in observation and initial identification as well as treatment strategy optimization. Healthcare professionals can create individualized treatment plans that take into account each patient's unique reaction to therapy by examining the efficacy of different medications across a range of healthcare consumer demographics. A logistic regression model, for example, might show that a given drug is more effective for patients in a given age range or with a given medical condition. By using this information, medical professionals may choose the best course of action for their patients, increasing their outcomes and lowering the possibility of side effects.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \epsilon$$

Decision trees are excellent at categorizing patients according to their characteristics in the field of early disease detection. For example, an assessment tree can determine the most important risk factors for conditions like hypertension or heart disease by examining EHR data. A choice depending on a particular characteristic, such as age,





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cardiovascular disease, or cholesterol levels, is represented by all the branches of the tree. Clinicians can learn which traits are associated with a higher risk of disease by tracing the path between root to leaf. Early identification of vulnerable individuals is made possible by this simple method, which enables prompt preventive measures.

$$\text{Gain}(S,A)=H(S)-\sum_{v \in \text{Values}(A)} |S_v| \cdot H(S_v)$$

Additionally, random forests work well for thorough patient monitoring. They can identify intricate relationships between factors that might indicate a decline in health by examining several health indicators at once. To create a comprehensive picture of a patient's health, for instance, a random forest model can evaluate changes in vital signs, test findings, and adherence to medicines. This ability enables medical professionals to react to new health concerns more skillfully, guaranteeing prompt interventions.

$$Y^{\wedge}=T \frac{1}{\sum t}=T \text{fft}(X)$$

RESULTS AND DISCUSSION

The efficiency of Linear Regression, Decision Trees, and Random Forests in healthcare predictive analytics is greatly influenced by machine learning. Different techniques are used by each algorithm to evaluate data and offer insights.

CONCLUSION

Improving healthcare outcomes through the use of machine learning algorithms in electronic health records is a potential approach. These advances have been shown to greatly enhance patient care through the possibility of early identification of illness, optimizing treatment plans, and simplifying efficient patient monitoring. More individualized, effective, and efficient healthcare solutions will be made possible by the ongoing development of algorithmic learning alongside information analytics, notwithstanding the obstacles that still exist. In order to satisfy the increasing demands of contemporary healthcare and, eventually, enhance patients' overall quality of life, it will be crucial to embrace these advancements as we proceed.

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Table 1 : Linear Regression in Predictive Analytics

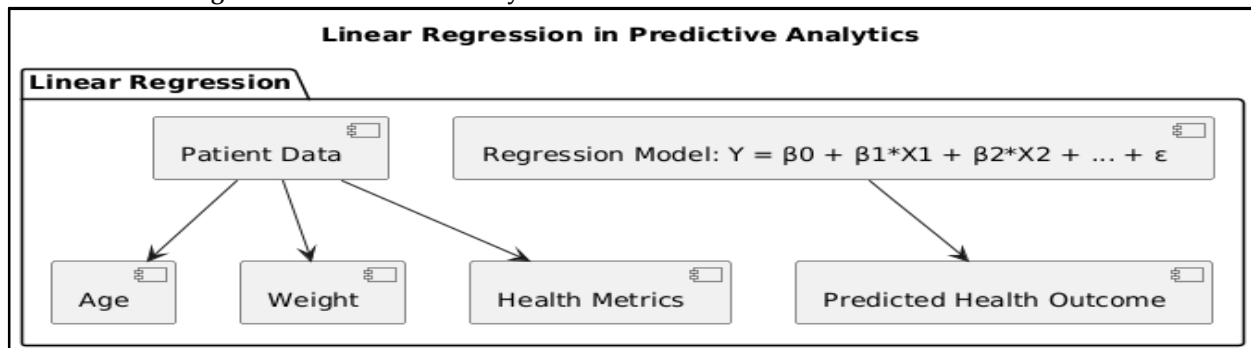


Table 2 : Decision Tree in Predictive Analytics

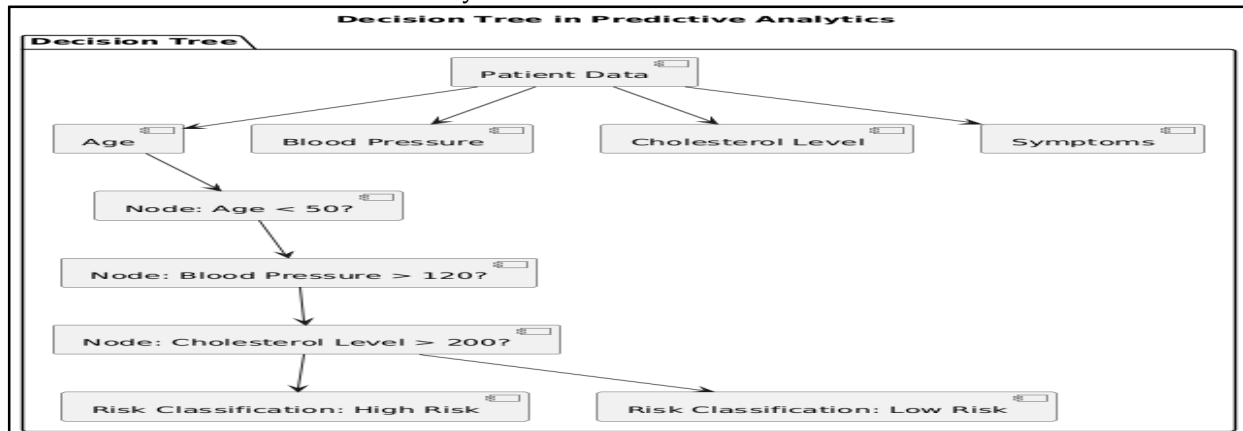




Table 3 : Random Forest in Predictive Analytics

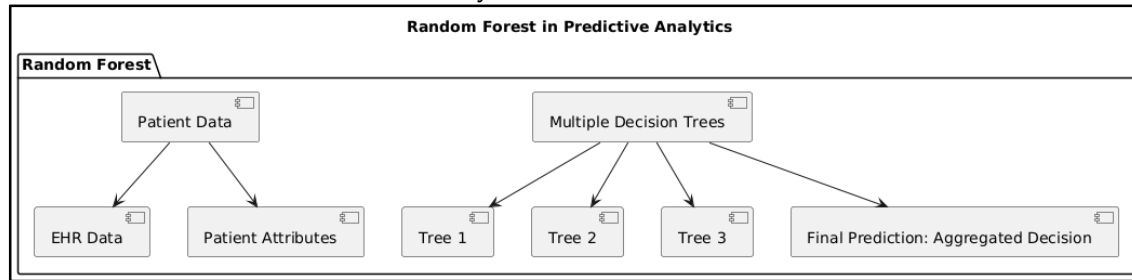


Table 4 : Performance Metrics of the Applied Algorithms

ALGORITHM	ACCURACY	PRECISION	RECALL	F1 SCORE
LINEAR REGRESSION	75%	0.70	0.65	0.67
DECISION TREE	82%	0.80	0.78	0.79
RANDOM FOREST	89%	0.87	0.85	0.86





An Effective Approach for the Synthesis and Characterization of Silver-Doped Zinc Oxide Nanoparticles

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ABSTRACT

This study details the synthesis and characterisation of silver-doped zinc oxide (Ag-ZnO) nanoparticles, intended to improve the photocatalytic and antibacterial capabilities of pure zinc oxide. Silver ions were integrated into the ZnO matrix via a sol-gel technique, thereafter subjected to calcination to attain excellent crystallinity and shape. The Ag-ZnO nanoparticles were studied by multiple techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and UV-Vis spectroscopy. XRD examination validated the effective incorporation of silver, whilst SEM and TEM demonstrated homogeneous particle distribution and reduced particle size relative to pure ZnO. UV-Vis spectroscopy revealed a notable redshift in the absorption spectra, indicating improved light absorption properties. Antimicrobial assays revealed that Ag-ZnO nanoparticles shown enhanced effectiveness against prevalent bacterial strains, underscoring its prospective uses in environmental remediation and biomedical sectors. This study highlights the benefits of doping ZnO with silver to produce multifunctional nanomaterials with potential uses.

Keywords: Ag doped ZnO nanoparticles, X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and UV-Vis spectroscopy.





INTRODUCTION

Zinc oxide (ZnO) is a semiconductor distinguished by its exceptional optical and electrical properties, rendering it a significant material for diverse applications such as photocatalysis, sensors, and electronics. ZnO's substantial bandgap (3.37 eV) and significant exciton binding energy (60 meV) enable it to efficiently absorb UV light and produce reactive species, making it a viable choice for photocatalytic applications and environmental cleanup. Nonetheless, the effectiveness of pure ZnO in practical applications is sometimes constrained by its swift recombination of electron-hole pairs and diminished activity under visible light. Doping ZnO with metallic nanoparticles, particularly silver (Ag), has garnered considerable attention to improve its characteristics[1-6]. Silver is recognized for its superior antibacterial capabilities and has been extensively utilized in medical and environmental applications. Integrating silver into the ZnO matrix enhances its photocatalytic activity via a synergistic effect and confers superior antibacterial properties, rendering it appropriate for water purification, wound healing, and surface coatings. The fabrication of silver-doped ZnO nanoparticles can be accomplished using multiple processes, including sol-gel, co-precipitation, and hydrothermal approaches. The sol-gel approach is very beneficial owing to its simplicity, cost-efficiency, and capacity to regulate particle size and distribution. The characterization of produced nanoparticles is crucial for comprehending their structural, optical, and morphological features, which directly affect their performance in applications[7-9]. This study examines the synthesis and characterisation of silver-doped ZnO nanoparticles by the sol-gel technique. We intend to clarify the influence of silver on the structural and optical properties of ZnO by systematically altering the silver doping concentration. The results will enhance the creation of superior nanomaterials for photocatalytic and antibacterial uses, meeting the increasing need for sophisticated materials in environmental and biomedical sectors.

MATERIALS AND METHODS

All compounds employed in this study are of analytical grade and used directly without further purification. Zinc nitrate, silver nitrate, and sodium hydroxide were procured from Sigma Aldrich, and doubly distilled water was employed as needed for the experiment. All reactions were performed under ambient conditions at room temperature.

Procedure for the Synthesis of Ag doped Nano Zinc oxide

A 0.3 M solution of zinc nitrate hexahydrate ($\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$) was placed in a 500 ml beaker. Subsequently, 0.025 g of silver nitrate (AgNO_3) was introduced with continuous stirring for 30 minutes. A 0.4 M solution of sodium hydroxide (NaOH) was then added dropwise while maintaining continuous stirring at room temperature to precipitate metal hydroxides. The stirring process was maintained at 85°C for 6 hours to yield the as-synthesized powder. The synthesized powder was calcined in a muffle furnace at 600°C for 2 hours and then allowed to cool in the furnace. The resultant product was analyzed using XRD, SEM, and EDAX[14].

Characterization

FTIR (Fourier Transform Infrared) spectroscopy (Perkin Elmer - Spectrum RX-IFTIR) was utilized to ascertain the functional groups contained in the produced product. X-ray diffraction patterns were obtained using a Bruker X-ray diffractometer with graphite-filtered CuK radiation ($\lambda = 1.54 \text{ \AA}$) at 40 kV and a scanning rate of $3^\circ/\text{min}$ (from $2\theta = 20^\circ$ to 80°). The morphology and size of the particles were assessed using a 200 KeV Transmission Electron Microscope (TECNAI 200 Kv TEM- Fei, Electron Optics). The elemental composition of particles was ascertained by SEM-EDAX (JEOL JSM 5600, EDS Model: INCA Oxford).

Fourier Transform-Infra Red (FT-IR) Spectral Analysis of Ag-ZnO

Figure 2 illustrates the FTIR spectra of both pure and silver-doped zinc oxide, indicating that the FTIR spectrum for Ag-doped ZnO closely resembles that of pure zinc oxide. FT-IR analysis was conducted using optimal settings to



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ascertain the bond structure and associated functional groups of the produced ZnO nanoparticles. The FTIR absorption spectra of the produced particles were characterized within the 4000-400 cm^{-1} wavenumber range (Figure 2). The band at 450 cm^{-1} is ascribed to the Zn–O stretching mode of the ZnO lattice. Within these limitations, no further peaks emerge owing to silver doping; this is likely because to the homogenous dispersion of Ag particles on the zinc oxide surface, devoid of any cluster formation. The band found near 3400 cm^{-1} was attributed to the vibrational mode of the O–H group. A weak band found near 2900 cm^{-1} was attributed to C–H modes. The sharp bands found between 1400-1600 cm^{-1} were attributed to stretching vibration modes of C=O groups[10-12].

X-Ray Diffraction (XRD) Analysis of Ag-ZnO

Figure 3 illustrates the XRD spectrum of both pure and silver-doped zinc oxide nanoparticles. The diffraction pattern of Ag-ZnO nanoparticles closely resembles that of pure ZnO, indicating high crystallinity and optimal particle size. The diffraction angle of 2θ was scanned within the range of 20° to 80° . The peaks seen at 31.80° , 34.47° , 36.29° , 47.58° , 56.62° , 62.90° , 66.40° , 67.98° , 69.11° , and 76.99° correspond to the reflecting planes (100), (002), (101), (102), (200), (112), (103), (110), (201), and (202) correspondingly. All diffraction patterns exhibit a strong similarity to the documented JCPDS (Joint Committee on Powder Diffraction Standards) corresponding to the hexagonal wurtzite crystal phase of the produced particles[13].

Scanning Electron Microscopy Analysis of Ag-ZnO

Figures 4(a, b) and 4(c, d) display the SEM images of the generated Pure and Ag-ZnO nanoparticles, respectively. SEM pictures indicate that the shape of ZnO nanoparticles has altered following Ag doping. The SEM images indicate that the produced Ag-ZnO nanoparticles were well agglomerated, exhibiting various sizes in a hexagonal configuration. At increasing magnification, the cubic structure is evident, indicating the existence of Ag nanoparticles, and the very porous nature suggests that Ag nanoparticles were deposited on the ZnO surface[11-14].

Transmission Electron Microscope (TEM) Analysis of Pure and Ag-ZnO

The produced nanoparticle samples were systematically investigated using TEM to determine their shape and actual size. The TEM picture of nanoZnO (figure 5(a,b)) reveals the presence of hexagonal wurtzite with a dimension of around 50 nm, whereas the size of the nanoparticles is approximately 30 nm. Figure 5(c, d) presents the TEM images of Ag-ZnO nanoparticles, indicating that their diameters ranged from 30 to 110 nm, with a predominant size of approximately 70 nm[15].

Energy Dispersive X-Ray(EDX) Analysis of Pure and Ag-ZnO

The elemental composition of the produced nanoparticles was verified using EDX analysis. Figures 6a and 6b present the EDX pictures of pure and Ag-doped ZnO nanoparticles, confirming the presence of Zn, Ag, and O, with no other impurities found[15].

CONCLUSION

This study effectively generated silver-doped zinc oxide (Ag-ZnO) nanoparticles via the sol-gel method, illustrating that silver doping markedly improves the structural, optical, and antibacterial characteristics of pure ZnO. Characterization methods including X-ray diffraction (XRD), scanning electron microscopy (SEM), and UV-Vis spectroscopy validated the effective integration of silver, demonstrating a decrease in particle size and enhanced crystallinity. The UV-Vis analysis revealed a significant redshift in the absorption spectrum, signifying higher light absorption properties that may result in increased photocatalytic efficiency. This study provides significant insights into the production and characterisation of multifunctional nanomaterials, highlighting the impact of metal doping on enhancing semiconductor characteristics. Future research will concentrate on investigating the molecular routes of photocatalytic activity and enhancing the synthesis process for particular applications.

Declarations



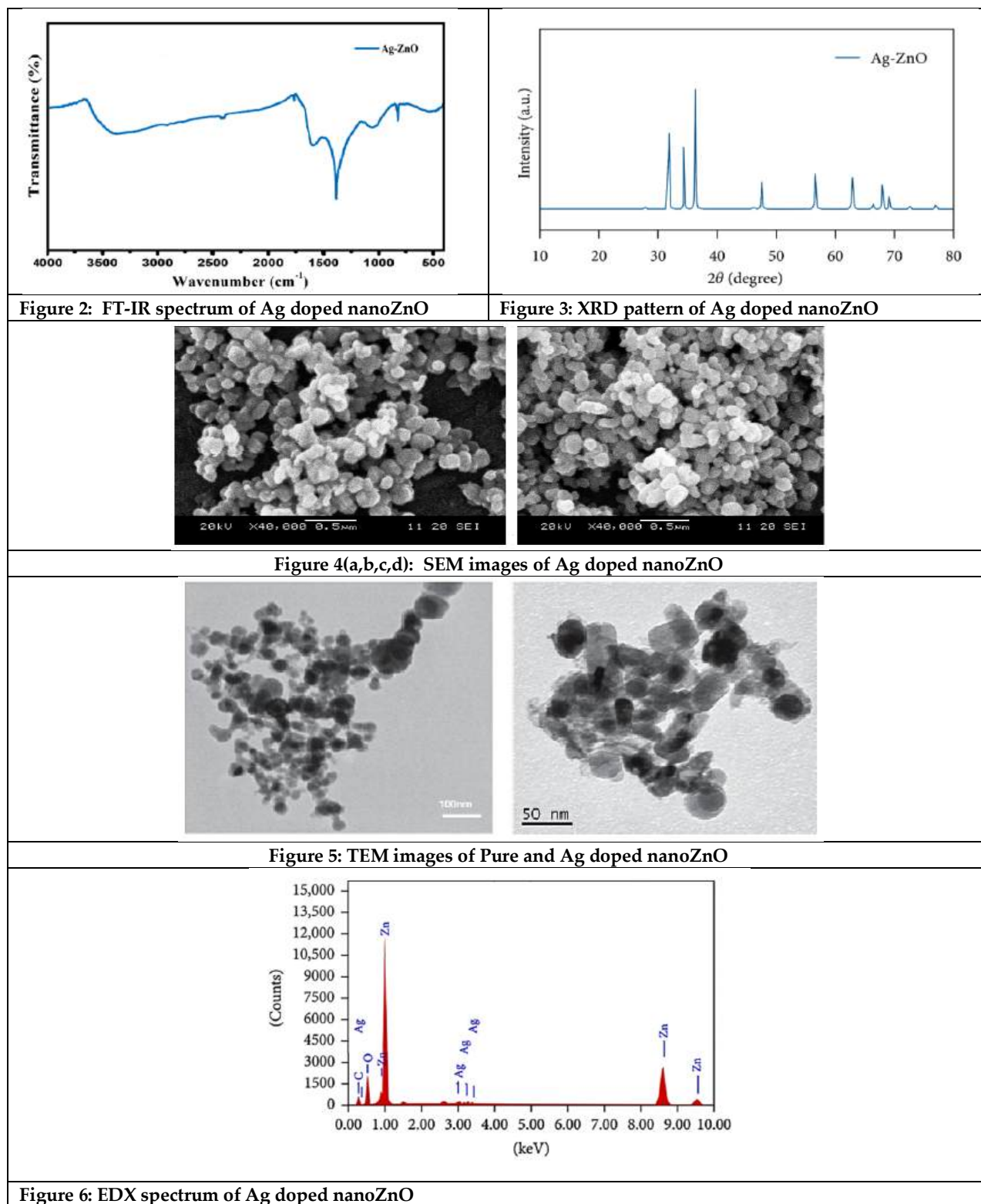


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The Study on Insurance Sector and Artificial Intelligence

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ABSTRACT

Gaining a deeper understanding of AI use cases in the insurance sector is the primary goal of this study. In order to improve customer happiness in the hotel business, we are interested in investigating the potential and current state of artificial intelligence (AI) in insurance services. A conceptual model was created using AI principles. The purpose of the conceptual model is to quantify the connection between artificial intelligence and its applications in the insurance sector. Verification of the model was carried out by empirical quantitative research using a selection of worldwide firms and Insure Techs that have implemented such models. When dealing with unhappy clients and other operational issues, insurance businesses may benefit greatly from the practical insights that this study provides.

Keywords: AI, Insurance, Digitalization, Data, Security

INTRODUCTION

Low consumer involvement has long plagued the insurance sector. Insurance companies had the lowest customer interaction rates across all research industries¹. A large chunk of insurance companies' revenue comes from intermediaries; for example, brokers get an astounding \$45 billion in yearly remuneration from insurers worldwide, meaning that many of these companies have minimal contact with a large fraction of the end-consumers. In addition, insurers are missing out on chances to learn about their customers' demands and tailor their products to meet those needs due to the industry's sluggish digitalization^[1].



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There are six main areas where the sector is facing problems.

- Opportunity cost: making timely contact with potential clients
- Appropriate Guidance: Meeting Client Needs with the Appropriate Products
- Efficient: Prompt claim assistance for dedicated clients
- Expensive claims that put businesses at a disadvantage while trying to maximize their marginal profit
- The prevalence of false claims and other forms of fraud is on the rise.
- Operations that involve processing large amounts of data manually tend to be bulky.

With the use of technology, these six verticals may be effectively addressed. The insurance sector is being propelled to unprecedented speeds by the ever-increasing intelligence of cognitive technology. The future of artificial intelligence (AI) in the insurance industry is the focus of this study, which will also examine its application areas, key determinants, key advantages, key obstacles, ethical considerations, and potential applications. The effect on the company's marketing volume and expenditure both before and after AI installation will also be considered.

The research, development, and use of artificial intelligence (AI) are all seeing rapid expansion. I am impressed by the usefulness of AI applications across sectors, especially in marketing and finance, considering the amount of general acceptance and developing new methodologies. Every day, AI may learn from its mistakes and make better decisions. It continues to learn from the massive amounts of data at its disposal. There will be 40 zettabytes, or 40 trillion gigabytes, of data by the year 2020.

A REVIEW OF THE MANUAL

The field of artificial intelligence

The goal of the computer-assisted analytical course known as Artificial Intelligence (AI) is to create intelligent automated systems. Artificial Intelligence 4 may be further classified into Weak, Strong, and Super Intelligent by setting its degree of intelligence to a threshold number.

- Artificial Narrow Intelligence (ANI) is another name for weak AI, which is built to zero down on certain jobs and issues.
- Strong AI, often known as AGI, is able to simulate human intellect to a large extent.
- Artificially Super Intelligent (ASI) systems are more intelligent than humans and can think scientifically and creatively.

The AI model engages in a recursive loop of sensing, thinking, and acting in response to its surroundings. It takes in environmental data, processes it using the incoming data and its own history of experience, and then acts in a way that changes the environment. It takes in data in many forms (pictures, videos, audio, text, etc.), processes it using AI algorithms, and then returns solutions driven by AI[2].

Data security and AI

Rapidly developing regulated, digitally improved automated settings for optimal production, Artificial Intelligence has exposed its constituent in different professional sectors in 2017. Investing in AI-enabled technology seems to be a win-win for insurance businesses. By facilitating agents' ability to make conclusive evaluations and appropriate decisions, this technology has the potential to automate executive-level task scheduling and enhance service quality. As more and more aspects of business, personal life, and public life get "dataficated," artificial intelligence is expanding. More and more information is being gathered in this digital era by many entities, including businesses, governments, and people themselves[3]. Daily data creation approaches 2.5 terabytes.

Insurers are concentrating on using AI in three different categories. With an expected total projected expenditure of USD 47B by 2020 expenditure of USD 4.8B in 2016 and a , insurance firms are heavily investing in artificial intelligence and cognitive technologies to keep up with the ever-growing amounts of valuable client data.



**Insurance Policies**

The case studies that follow illustrate how (re)insurers are working with tech companies to integrate AI into their processes. But AI and ML in insurance is still in its infancy, and most efforts are still in the pilot stage, considering the many ongoing initiatives that have not yet been upgraded and made available to the general public. Although the insurance industry is still in its early stages of exploring AI, some pilot programs have already achieved remarkable results. Insurance companies aren't the only ones using AI in the case studies we compiled for this research. Nevertheless, we want to demonstrate how insurance firms are using AI to accomplish their business goals[4].

AXA and Tensor Flow from Google

The annual rate of auto accidents caused by AXA Japan policyholders is between 7 and 10%. The majority of these incidents involve minor accidents with very little insurance payouts, whereas around one percent include so-called "big-loss" situations with payouts exceeding \$10,000. In light of the high stakes involved, AXA used Google Tensor Flow to train deep neural networks that would sift through mountains of client data in exploration of designs that may designate waiting losses; the goal was to find the sweet spot for car insurance premiums.

Benefits: The AXA group's predicted accuracy rating is 78%. Newfangled insurance facilities, incorporating in-store, real-time evaluation, are only one example of how this helps AXA increase its bottom line[5].

Insurance from Fukoku and Watson from IBM

Like many other insurance businesses, the Japanese life insurer Fukoku Mutual is struggling with inefficient claims processing and increasing operational costs. The insurance started using IBM Watson Explorer in February 2017 to develop an AI software that would automate claims processing and precisely compute claims payouts based on many factors including administration technique, duration of hospital stay, medical data, and more.

Advantages: Fukoku has seen a rise in operational efficiency in processing medical claims, with benefits including less personnel costs and a halt to payment supervision. The insurance company saw a 30% boost in production and boost to the precision of payments. Aiming to boost customer satisfaction by speeding up claims pay-outs, it expects to see a soon after the first investment (ROI) is made[6].

Wells Fargo & H2O.ai

Insurance, annuities, and other retirement products are offered by the US-based insurance business Transamerica. There are 27 million people it helps. Insurers may boost their bottom line by taking advantage of cross- and up-selling possibilities, as well as by enhancing customer service and satisfaction, with the help of their massive amounts of collected consumer data. Data from many systems, including customer relationship management (CRM), third-party sources, and customers, was compiled by Transamerica using a huge data stack built on Hadoop. The data was used by using H2O.ai, an open-source machine learning platform. The benefits of utilizing H2O machine learning were as follows: the Transamerica team was able to enhance their marketing campaigns to both existing and potential customers, provide better advocate products, and execute upselling and cross-selling tactics that provide better results. As a result, the company's customer service, revenue streams, and innovation have all seen significant improvements[7].

The Approach

The Most Important AI Tools and Pre-Trained AI Models:

Artificial Intelligence

Machine learning is a kind of artificial intelligence that processes massive volumes of data automatically, learning from past mistakes and improving itself. Typically, ML systems are trained using a collection of training data to constantly improve their ability to recognize the proper output for a given input. Recognizing consumer behavior and risk variables is best accomplished with this sort of approach[8].



**Mohanababu Chappa et al.,****Intelligent Bots**

Quickly automate company operations with the help of smart robotic process automation and an AI solution. Policy quotations, claims processing, and underwriting are just a few examples of the high-volume business activities that insurers often conduct manually. This causes delays, which in turn impacts customer happiness, business conversion, and profitability[9]. Intelligent robots, or bots, may communicate with software applications in robotic process automation. These applications include enterprise resource planning (ERP) systems, databases, service desks, and others.

Object Recognition

An aspect of computer vision, object recognition is the procedure of detecting and identifying an item or quality in a electronic media file. With object recognition, marketers can learn more about their customers, keep tabs on them, and engage with them in a manner that fits in with their daily life. With a projected CAGR of 19.5% from 2016 to 2021, the image recognition market is expected to surge from \$15.95B in 2016 to \$38.92B in 2021. Its ideal applications include risk modeling using picture data, radiological imaging diagnostics, real-time evaluation of vehicle damage, agricultural insurance pricing using satellite photos, and many more[10].

Decision-Making Systems

Many different kinds of applications make use of recommendation engines. Different applications make use of different amounts of data, different types of indications (implicit or explicit), different temporal dynamics or volatility, etc. It assesses outcomes and suggests suitable courses of action[11]. Policy suggestions, optimum term plans, upselling, cross-selling, and targeted marketing campaigns are all made possible with this method.

Processing of Natural Language

Numerous applications rely on recommendation engines. An application's data needs may vary in terms of volume, the nature of the indicators used (implicit vs. explicit), the volatility or temporal dynamics at play, etc. Depending on the results, it recommends actions to do. Chatbots, grammar correction, text-to-speech conversion, sentiment analysis, and many more practical applications have all resulted from the development of natural language processing (NLP)[12].

Assistive Technology Programs

In order to complete activities like answering clients' insurance-related inquiries, leading them through the purchase of basic insurance policies, or processing transactions, virtual assistants or Conversations with digital concierge services may be conducted using natural language.

Knowing Your Environment

In order to enhance an engagement, context-aware technology may identify important information and change accordingly. To do this, it takes its cues from the environment in which it runs and applies rules based on things like time, events, locations, and other context. It can foresee when a need will arise or how a situation will change, and then it will activate the appropriate action at the exact moment. Biometrics (facial recognition, fingerprint recognition, voice authentication, etc.), AVA, augmented reality, beacons, and other context-aware surveillance technologies Technologies that are aware of their context. Things include identifying fraudulent insurance claims and other forms of implementation, Contemporary CCM (consumer communications management), The promotion of insurance policies and other related products using mobile devices, Digital billboards with intelligence (store security), Customer policy information, claim data, etc., is easily accessible[13].

The APIs for Predictive Analytics

The field of predictive analytics employs a wide range of statistical and analytic methods to create models that may foretell how or what things will happen in the future. The action or event that these predictive models are trying to foretell determines their shape. As with credit scores, utmostextrapolative models provide a score; a higher score indicates the more probable occurrence of the specified behavior or event. This is an example of a social credit score used to provide a loan[14].



**Mohanababu Chappa et al.,****AI Technology Distribution Market
Artificial Intelligence (AI) Use-Case Proof of Concepts
Fostering innovation in portfolios**

We need innovative products like on-demand insurance, micro insurance, and usage-based insurance that can be developed quickly and affordably in order to digitize the globe. Along with these innovative goods, we are introducing initiatives and incentives to boost adoption. To do this, we need AI models that can extract value from data in real-time and process various forms of data sent by sensors or other data transmission devices. In this way, we can assist insurers in streamlining their operations and accelerating the launch of cutting-edge products and services. To illustrate the point, Admiral, a British auto insurance, is predicting drivers' actions using Facebook Messenger. Vodafone and the insurer have formed a partnership to provide the foundational telematics services. At the moment, AI isn't doing much for the insurance industry, but that will change. In terms of potential dangers in the future, it represents a positive force[15].

Maximizing promotional efforts

As a result, by segmenting customers based on their input using cluster analysis, more personalized experiences may be created. Deloitte found that insurance businesses might see a 5-10% boost in profitability via personalization. Insurers may take a page out of the retail industry's playbook and use machine learning algorithms to build intricate models that maximize client lifetime value, open doors to cross-selling and product suggestion, and more. AI has the potential to power advertising, marketing initiatives, and services that are more tailored to each individual. In this way, insurance companies may combine their own data with information gathered from sensors, digital and social media, and other connected devices.[16].

A better experience for the consumer

In 2017, insurers made an investment in artificial intelligence (AI) to automate claims processing and client engagement/servicing (Chatbots), which would help them overcome cumbersome insurance processes, particularly in property and casualty. In a natural language setting, a virtual assistant may answer questions about purchases, transactions, and doubts. Due to cheap pricing, awareness of customer behavior, and optimal counsel, robo-advice (chatbots) has promise in the low-to middle-wealth sector and among youth. Information technology (IT) and artificial intelligence (AI) may also be used to provide "beyond-insurance" coverage and value-added services, such as data-enabled recommendations for a vigorous existence, exercise routine, and driving habits[17].

Refining and streamlining the claims procedure

Once again, AI can lend a hand with a major pain point: late processing and client discontent with claim processing. Through intelligent automation, it may improve communication. Using the data at our disposal, we can make educated guesses about future claims, delegate difficult cases to seasoned adjusters, and monitor any claims that slip through the cracks throughout the auditing process (through inquiry, review, and settlement)[18].

Enhancing the system for underwriting

Manual data production, collecting, and processing from brokers and underwriters with overflowing paper files causes operational expenses to be high and profitability to be poor due to process concerns. Artificial intelligence (AI) may speed up the analysis of diverse data kinds and quantities while assisting with incompatible legacy systems, dispersed data, and cumbersome, incongruous information. As a result, underwriting procedures, incorrect pricing judgments, time, and mistakes in data input may all be streamlined. To discriminate risk and price it effectively, beat rivals, and prevent adverse selection of risk, a good pricing model integrates multiple forms of information and factors.

Achieving optimal risk pricing

By honing pricing models using data from next-gen telematics, AI and ML can optimize prices, which is a huge boon to the insurance sector's bottom line. Statistical methods, including General Linear Models (GLMs), which





incorporate several factors into continuous analyses of massive organized and unstructured data sets, are the only basis for the most efficient and dependable approaches. Prescriptive analytics may be made possible by combining the model with a recommendation engine and building tools for non-technical users, such as underwriters. From an underwriting and pricing perspective in particular, it excels at providing a better grasp of risk, operational resilience, and enhanced relationships with customers[19].

Combating health insurance fraud

The persistent problem of false claims is a major headache for the property and casualty insurance sector. Based on patterns of claims, client contact, and behavior, AI may identify abnormalities in insurance claims and propose fraud. When looking for things that need further research, ML may be a lifesaver[20].

Cyber insurance must change its focus to solutions

The kind of coverage for cyber insurance increased by 36% in 2016 (Aon), indicating that the industry is expanding. From recognizing new weaknesses in the system architecture and procedures to making risk predictions more accurate than actuaries, AI has the potential to make a big impact in this area. Insurers may benefit from cybersecurity firms' cyber liability assessment when underwriting cyber policies. Insurers' expertise in this area will be strengthened, and the penetration of Cyber Insurance will rise[21]. As a result of enhanced safety features, automated processes, notifications, and collision avoidance systems, KPMG predicts a 60% decrease in motor insurance premiums for AVs (Autonomous Vehicles). With the use of AI, we can now insure against software failure, manufacturing faults, and cyber threats in automobiles. We need to use AI to underwrite, evaluate risk, and plan for the future of autonomous vehicles since existing statistical models are unable to handle the vast amounts of data[22].

CONCLUSION

Improved customer happiness, revenues, and efficiency while cutting down on fraud, wasted time, and complicated operations are all areas where AI has the potential to make a difference. The proof of concept showcases AI application cases supported by real-world business examples, illuminating the vast potential for advancement in the insurance sector.

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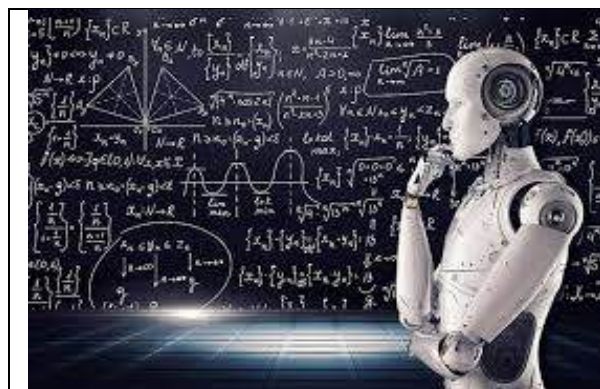


Fig1.What level of intelligence does AI possess?

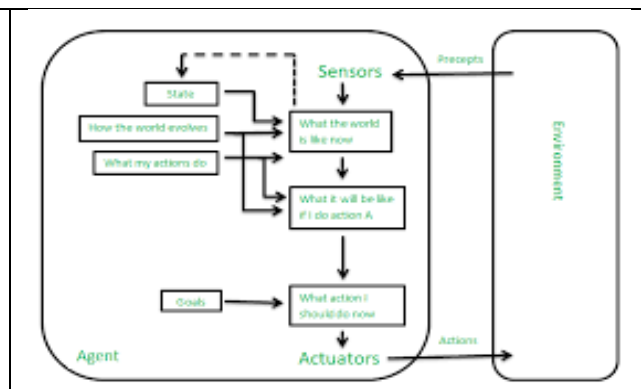
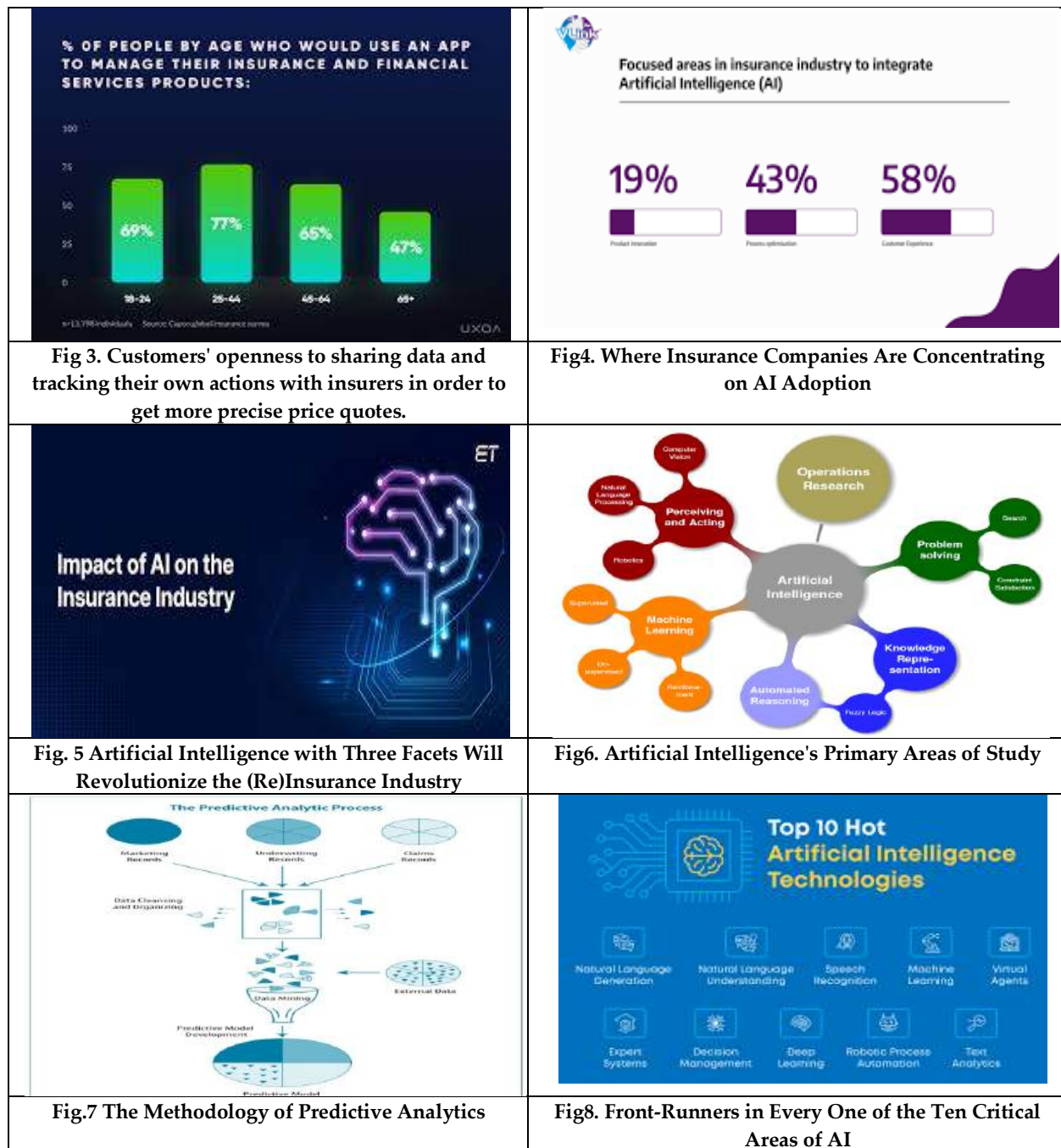


Fig1.Sense-Think-Act process followed by an intelligent agent







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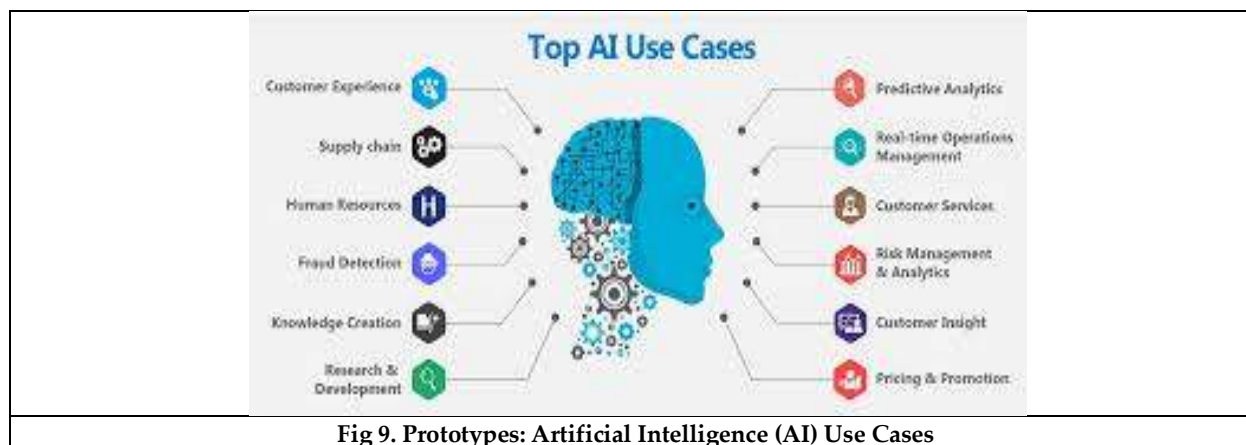


Fig 9. Prototypes: Artificial Intelligence (AI) Use Cases





Role of Bank Credit in Enhancing Agricultural Productivity in Developing Economies- A Systematic Review

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ABSTRACT

The systematic review evaluates the effect of farm credit on agricultural productivity in developing economies, being focused on India and other similar regions. It underlines the role of institutional finance in boosting farm output and economic growth, especially for small-scale farmers. Despite the significant effect, barriers such as high interest rates and poor access to credit for smallholder farmers undermine these benefits. The paper highlights on improving credit delivery through more accessible and production-related financing, to augment agricultural productivity. Major recommendations include improving access to formal credit, particularly for marginalized and landless farmers, and reducing interest rates to enhance loan off take. Government initiatives like the Kisan Credit Card in India and similar schemes in other countries are discussed as models for improving credit access. Ultimately, this paper emphasizes the need of accessible and affordable credit as a tool for fostering sustainable agricultural development and alleviating poverty.

Keywords: agricultural, finance, productivity, economic, smallholder





INTRODUCTION

Background of Agricultural Credit in Developing Economies

Agricultural credit is crucial for the development of emerging economies, acting as a key component to fulfil the financial needs of farmers and facilitating their shift from subsistence to cash-based economies. It serves as a channel through which farmers can obtain necessary resources to improve agricultural productivity. Research shows that credit from formal financial institutions, such as banks, significantly influences the value of agricultural production. The correlation between institutional credit and agricultural GDP is recognized as positive and significant, highlighting the role of finance in boosting farm output. In countries like India, where agriculture is a vital sector, providing agricultural loans to small and marginal farmers is essential for ensuring food security and increasing agricultural productivity. The government, along with specialized agricultural banks and commercial banks, plays a critical role in distributing credit to rural farmers for various farming activities. Despite challenges such as uneven regional distribution of institutional credit, efforts are underway to improve access to credit through interest subsidies and rebates. Initiatives designed to expand access to agricultural credit have shown favourable results in countries like Nigeria, where bank credit has positively influenced agricultural productivity. Studies emphasize the important role of agricultural credit in promoting economic growth, reducing poverty, and fostering overall development in developing economies. Providing farmers with timely and sufficient credit support is crucial for stimulating food production, improving livelihoods, and achieving sustainable growth in the farm sector. Overall, agricultural finance is critical in boosting agricultural productivity in developing economies by equipping farmers with the necessary financial resources to invest in inputs, adopt technology, and procure machinery. Accessible and affordable credit mechanisms are vital for empowering farmers and driving economic growth through increased agricultural output. See references: (AYEOMONI & ALADEJANA, 2016, pages 1-5)[6], (J & Muthiah, 2022, pages 1-5)[4], (Bahşi&Çetin, 2020, pages 1-5)[3], (Chi *et al.*, 2022, pages 6-10)[8], (Islam, 2020, pages 1-5)[1] and (Islam, 2020, pages 6-10)[1].

Purpose of the Systematic Review

The objective of this systematic review is assessing the significant impact of agricultural finance on enhancing farm output in developing economies. Research has shown a positive influence of farm credit on agricultural GVA on the short and long-term, confirming the contributory relationship between finance and farm output. This underscores the necessity of expanding access to agricultural credit to drive overall productivity. Insights reveal various agricultural credit schemes implemented by the governments to support farmers, such as the Kisan Credit Card, the Interest Subvention Scheme (by the National Bank of Agriculture and Rural Development) and Agri Infra Fund (by National Agri Infra Financing Facility). These initiatives aim to increase farmers' access to credit and improve lending practices to effectively meet the actual needs of agricultural production. By examining these schemes, we can understand how formal financial institutions can collaborate closely with farmers to provide flexible lending options that effectively support their farming activities.

Furthermore, the synergy between farm credit and economic development in India is highlighted. Understanding the factors influencing formal agricultural credit allocation can assist in designing a more efficient and sustainable credit system for smallholder farmers. By exploring these factors, policymakers can tailor their strategies to ensure farmers have adequate access to credit, while improving their farm outputs and boosting the economy. Additionally, the importance of credit channel theory is emphasized, which examines how policy variables impact credit supply and demand within an economy. A stable financial system plays a crucial role in economic development, with evidence suggesting a connection between economic growth and access to credit. By evaluating the theoretical perspectives, one can get a fair understanding of how economic activities can impact financial systems as well as agricultural productivity. In conclusion, a systematic review of relevant papers and empirical studies in the current study focuses on providing a comprehensive examination of the role of bank credit in enhancing agricultural productivity within developing economies. By synthesizing key findings from diverse contexts and exploring practical implications for policymakers, this review seeks to offer valuable insights into improving credit



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mechanisms for farmers and promoting sustainable agricultural development. See references: (AYEOMONI & ALADEJANA, 2016, pages 1-5)[6], (Anetor *et al.*, 2016, pages 1-5)[16], (Olowofeso *et al.*, 2017, pages 1-5)[18] and (Nguyen *et al.*, 2020, pages 1-5)[13].

Financial Inclusion Challenges for Farmers**Lack of Access to Formal Financial Institutions**

Accessing formal financial institutions is essential for shaping the agricultural sector, especially in developing countries. Numerous studies have highlighted the challenges faced by farmers in obtaining credit from institutional sources. For instance, Yadav and Sharma (2015) emphasized the ongoing vulnerability of small-scale farmers in developing nations due to their limited access to institutional credit. In contrast, informal credit sources dominate rural markets, making it difficult for small farmers to obtain formal financial support. Furthermore, Saqib, Kuwornu, Ahmad, and Panezai identified several factors that affect farmers' access to credit, including age, educational qualifications, family size, land ownership percentage, experience in cultivation, and total land holdings. Farmers with smaller landholdings face greater difficulties in accessing formal credit compared to those with larger holdings.

It is crucial to appreciate the contribution of formal financial institutions in last mile distribution of credit in the agricultural sector. However, Bharti pointed out that in many developing countries like India, limited financial access continues to be a significant barrier to the profitable growth of agriculture. Addressing these constraints can involve promoting microfinance institutions and implementing suitable policies to ensure reasonable and accessible credit for farmers. Additionally, Chatterjee and Oza (2017) noted the considerable challenge of limited credit access faced by smallholder farmers in Uganda's agricultural sector. Strict credit policies imposed by formal institutions adversely affect farmers' eligibility for credit. To address this issue, government initiatives such as the Agricultural Credit Facility (ACF) have been introduced to provide medium and long-term credit to agricultural projects focused on commercialization and value addition. Despite these efforts, the contribution of agriculture value added to GDP has been drastically coming down over the past few years. In summary, the lack of access to formal financial institutions presents a significant challenge for farmers seeking credit in developing economies. Overcoming this obstacle requires effective policies that foster financial inclusion through initiatives like microfinance institutions and targeted programs such as the ACF. By enhancing access to formal credit sources for smallholder farmers, agricultural productivity can significantly improve in these regions. See references: (J & Muthiah, 2022, pages 1-5)[4], (Florence & Nathan, 2020, pages 1-5)[7] and (Islam, 2020, pages 1-5)[1].

High Interest Rates on Loans

Exorbitant interest rates on loans create significant challenges for farmers attempting to obtain credit for agricultural activities. As highlighted in (AYEOMONI & ALADEJANA, 2016, pages 1-5)[6], commercial banks in countries like Nigeria frequently impose high interest rates and strict conditions, such as collateral requirements, when approving loans for farmers. This discourages lending to the agricultural sector, resulting in limited access to credit for small-scale farmers. Moreover, delays in loan disbursement, as mentioned in (AYEOMONI & ALADEJANA, 2016, pages 1-5)[6], further hinder farmers' ability to effectively use credit, leading to loan mismanagement and defaults.

Additionally, (Anetor *et al.*, 2016, pages 1-5)[16] points out that the lack of advanced technology and farm credit poses a fundamental challenge for agriculture in Nigeria. Farmers, especially those in rural regions, are unable to avail bank credit due to complicated loan procedures and high interest rates set by financial institutions. As a result, many farmers resort to informal credit groups or moneylenders, which further limits their access to essential financial resources needed for agricultural productivity. In India, (Kumari & Garg, 2021, pages 11-14)[15] emphasizes that high interest rates and collateral requirements discourage farmers from utilizing credit facilities. The study suggests that reducing interest rates could improve access to credit for purchasing land, farming equipment, and enhancing agricultural output. Access to credit not only increases purchasing power but also significantly contributes to boosting agricultural productivity through investments in farm inputs and technological advancements.



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Furthermore, (Islam, 2020, pages 1-5)[1] underscores the importance of formal credit sources, such as banks, in promoting agricultural productivity. While informal sources may provide credit at elevated interest rates with risky terms, formal institutions play a crucial role in offering sustainable financing options for farmers. Initiatives like agricultural or rural credit programs have the potential to effectively solve the problems faced by credit-constrained farmers and foster growth in the agriculture sector. In conclusion, high interest rates on loans constitute a substantial barrier for farmers seeking financial support for agricultural endeavours. Addressing this issue through lower interest rates and improved availability of bank credit is pivotal in enhancing agricultural productivity and driving economic development in developing economies like Nigeria and India. The competence of farmers to secure affordable credit is vital for fostering innovation, increasing production yields, and ensuring sustainability within the agriculture sector.

Significance of Credit in Enhancing Agricultural Output**Role of Credit in Farm Inputs and Technology Adoption**

Access to financing is critical in boosting farm productivity by helping farmers in investing in essential inputs and embrace modern technologies. Farmers can utilize credit to procure high-yielding varieties, advanced fertilizers, and improved livestock feed, leading to enhanced productivity and increased yields. In economies like Bangladesh, where agriculture is a crucial sector, providing agricultural loans to small-scale, marginalized, and landless farmers from formal sources is imperative for stimulating food production and enhancing livelihoods. Research indicates a strong correlation between agricultural finance and agricultural output, demonstrating that an increased supply of finance boosts farm output. The availability of credit also empowers farmers to invest in production equipment such as tractors and irrigation technologies, contributing to crop diversification and the cultivation of high-value cash crops. Agricultural credit has been observed to positively impact agricultural productivity by facilitating access to financial resources for farmers. In nations such as India, where agriculture significantly contributes to the economy, credit programs are tailored to enhance credit accessibility for farmers, thereby bolstering agricultural production and farmers' earnings.

Moreover, the correlation between agricultural GDP and agricultural credit is reciprocal, with agricultural credit spurring immediate agricultural growth while increased GDP generates more demand for credit. Studies have shown that doubling agricultural loans can boost agricultural productivity by an average of 4-5%, underscoring the significance of expanding access to financial resources for farmers in accelerating agricultural growth rates. Overall, access to credit is crucial in promoting efficient input utilization, technology adoption, and mechanization on farms to enhance agricultural productivity. By addressing financial inclusion barriers faced by farmers and enhancing credit mechanisms through governmental initiatives and microfinance institutions, countries can advance sustainable growth agendas within the agriculture sector. See references: (J & Muthiah, 2022, pages 11-13)[4], (J & Muthiah, 2022, pages 1-5)[4], (Khandker, 2021, pages 6-10)[14], (Seven & Tumen, 2020, pages 16-20)[5], (Islam, 2020, pages 1-5)[1] and (Islam, 2020, pages 6-10)[1].

Impact of Credit on Yield and Productivity

Access to agricultural credit is essential for enhancing agricultural productivity, especially in developing nations like Bangladesh. Several studies demonstrated a positive correlation between providing financial support to farmers and the resulting enhancement in agricultural productivity and improvements in livelihoods. The synergy between farm loans and farm output has been examined in various contexts, producing different outcomes. In Bangladesh, research indicates both short-term and long-term connections between the provision of agricultural finance and levels of productivity. Factors such as inflation rates, interest rates, and public expenditure on agriculture significantly influence productivity results. Findings suggest that promoting the growth of agricultural credit can directly enhance agricultural production, contributing to overall economic development. A comprehensive study covering 104 countries from 1991 to 2014 found that doubling agricultural credit allocations could lead to an average increase of 4-5% in agricultural productivity. This highlights the potential for countries with underdeveloped financial systems in agriculture to achieve considerable growth through policies aimed at improving access to farmer finance.



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A study in Nigeria showed that bank credit has a positive and sustained impact on the farm productivity. Key factors affecting agricultural productivity include commercial bank credit to agriculture, government funding for the sector, and pricing of agricultural products. Research conducted in India pointed out the beneficial effect of farmer finance on farm output, emphasizing the need for better credit access for small-scale farmers in specific regions. Another study found a positive correlation between institutional finance and increased wheat production, which also contributed to improved living standards in rural areas.

Additionally, findings indicate that increasing access to agricultural credit can substantially influence Vietnam's agricultural GDP in both the short and long term. It is crucial for the government to focus on enhancing the efficiency of agricultural credit mechanisms to improve overall agricultural performance. Overall, these studies highlight the significant effect of commercial bank credit in enhancing yield as well as productivity within the agriculture sector. By improving farmers' access to credit resources and ensuring effective utilization of funds, countries can drive economic growth through higher levels of agricultural production. See references: (J & Muthiah, 2022, pages 1-5)[4], (P *et al.*, 2020, pages 1-5)[10], (Seven & Tumen, 2020, pages 16-20)[5], (Nguyen *et al.*, 2020, pages 1-5)[13], (Chi *et al.*, 2022, pages 6-10)[8] and (Islam, 2020, pages 1-5)[1].

Studies on Agricultural Credit Effectiveness**Mixed Results on the Effectiveness of Agricultural Credit**

Several researchers have studied the effects of bank credit on yield, coming up with mixed outcomes. Chisasa and Makina (2015), Ammani (2012), Nwokoro (2017), Udoka *et al.* (2016), Ahmad *et al.* (2018), and Rima (2014) identified a synergistic relationship between bank credit and agricultural output. However, Olorunsola *et al.* (2017), Meressa (2017), Obilor (2013), Nawaz (2011), and Oyakhilomen *et al.* (2012) reported negative impacts or inconclusive results regarding the influence of agricultural credit on output. These conflicting findings suggest that the connection between formal credit and farm productivity is complex and influenced by various factors.

In Nigeria, Obilor (2013) assessed the effect of finance provided by commercial banks to the farm sector from 1984 to 2007 and concluded that there was no significant effect on farm productivity. Similarly, Oyakhilomen *et al.* (2012) found no cointegrating relationship between cocoa production in Nigeria and the Agricultural Credit Guarantee Scheme Fund between 1981 and 2011. These findings highlight the need for further research into the effectiveness of formal credit in enhancing farm output. A study conducted by Ngong *et al.* (2020) within the Central African Economic and Monetary Community from 1990 to 2019 revealed varied outcomes regarding the impact of institutional finance on farm productivity. While domestic credit to the private sector by banks, land, and physical capital positively influenced agricultural value added to GDP, factors such as broad money supply, inflation, and labour had negative effects. This suggests that multiple variables must be considered when assessing the effectiveness of bank credit in improving agricultural productivity. Overall, these analyses emphasize the importance of considering numerous variables and contexts when evaluating the efficacy of agricultural credit in enhancing agricultural output. The differing results underline the need for more research to gain a holistic understanding of the subtle relationship between agricultural finance and agricultural output. (Chi *et al.*, 2022, pages 1-5)[8], (Florence & Nathan, 2020, pages 1-5)[7] and (Florence & Nathan, 2020, pages 6-10)[7].

Structural Issues Affecting Agricultural Credit**High Interest Rates and Transaction Costs**

Exorbitant interest rates and hefty transaction fees present significant obstacles for farmers seeking agricultural credit, particularly in developing countries. In Nigeria, commercial banks often impose steep interest rates and strict requirements, such as demanding collateral, for loans extended to farmers. This frequently results in delays in loan disbursement, which can lead to the diversion of funds and subsequent defaults on payments. Additionally, the lack of suitable assets for collateral and the economic nature of land ownership discourages commercial banks from prioritizing the agricultural sector. These challenges directly hinder farmers' access to credit intended to enhance agricultural productivity.



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Moreover, risk-averse behaviour within banks contributes to their reluctance to lend through crop loan schemes. The inadequate infrastructure for agricultural marketing exacerbates this issue, as loans are often linked to the proceeds from selling agricultural goods. The disconnect between credit provision and productivity undermines the primary purpose of crop loan schemes, resulting in a decline in agricultural output over time. Furthermore, despite various reforms within the banking sector, farmers continue to face difficulties accessing financial resources from deposit money banks (DMBs) in Nigeria. The disproportionate allocation of bank loans to sectors such as oil and gas and telecommunications leaves agriculture underfunded. This imbalance restricts farmers' ability to invest in agriculture and hampers economic development. In summary, exorbitant interest rates and transaction costs associated with obtaining agricultural credit create significant barriers for farmers, limiting their capacity to invest in inputs and technologies that could improve agricultural productivity. Addressing these systemic challenges is crucial for enhancing farmers' access to credit and ultimately increasing agricultural output in developing economies like Nigeria. See references: (AYEOMONI & ALADEJANA, 2016, pages 1-5)[6], (Afolabi *et al.*, 2021, pages 1-5)[19] and (D'Souza, 2020, pages 26-30)[20].

Inadequate Access to Credit for Smallholder Farmers

In countries such as Uganda and Bangladesh, small-scale farmers face significant challenges when attempting to obtain formal financial support for their agricultural activities. These farmers represent a considerable part of the farm sector and often find it difficult to access credit due to restrictive lending policies and high interest rates. This poor access to finance hinders the farmers' ability to invest in quality inputs, modern machinery, and technological advancements that are essential for enhancing agricultural productivity. Moreover, the difficulties in securing credit for smallholder farmers are exacerbated by systemic issues within the agricultural credit framework. High interest rates and transaction fees create obstacles for farmers trying to obtain affordable credit for their farming operations. Additionally, large-scale farmers tend to dominate the institutional credit landscape, putting smallholders at a disadvantage and widening the disparity between different categories of farmers.

Various nations have introduced government interventions and policy changes to address the hurdles faced by smallholder farmers in availing bank finance. Initiatives like the Agriculture Credit Facility in Uganda aim to provide medium and long-term financing for agriculture and Agri-processing projects, aiming to commercialize and do value addition. Similarly, in Bangladesh, there is a need for accessible agricultural credits with favourable interest rates to improve agricultural productivity and protect farmers' livelihoods. It is crucial for policymakers and financial institutions to work together to improve credit access for smallholder farmers. This collaboration can include government agencies, commercial banks, microfinance institutions, and other stakeholders involved in agricultural finance. By tackling structural issues in agricultural credit systems and offering customized financing options for production activities, smallholder farmers can overcome financial barriers and enhance their agricultural productivity. See references: (D'Souza, 2020, pages 26-30)[20], (Ozdemir, 2023, pages 1-5)[17], (Chaiya *et al.*, 2023, pages 1-5)[11], (Patwary *et al.*, 2023, pages 1-5)[9], (Khan *et al.*, 2017, pages 1-5)[2] and (Florence & Nathan, 2020, pages 1-5)[7].

**Benefits and Limitations of Agricultural Credit
Stimulating Economic Growth and Development**

Access to farm credit is instrumental in driving economic development, especially in emerging countries such as Nigeria, India, and Turkey. Numerous studies have emphasized the strong connection between credit and output in the agricultural sector, leading to improved living standards, poverty alleviation, and overall economic advancement. Providing farmers with credit for agricultural purposes motivates them to enhance their productivity and make substantial contributions to the sector's growth. Research shows that farmers with higher incomes from farming tend to receive more finance, facilitating them to invest in advanced technologies, inputs, and labour, resulting in increased agricultural output.

Furthermore, empirical research has revealed a positive correlation between agricultural GDP and agricultural credit in countries like India. The Granger causality test indicates a bidirectional correlation between farm credit and the



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sector growth, supporting the idea that boosting formal credit can lead to enhanced economic progress. This highlights the need of interventions that can position farm credit as a potential enabler to drive economic prosperity and poverty alleviation.

In Turkey, the decrease in the contribution of agricultural production value to GDP underscores the need for financial assistance through credits to enhance land quality, purchase machinery, seeds, breeding stocks, fertilizers, and cover labour costs. By improving access to loans for agriculture and ensuring timely procurement of necessary inputs at adequate levels, farmers can enhance their efficiency and productivity. This ultimately results in better entrepreneurial performance and operational capabilities among farmers. Moreover, it is essential for governments to implement stringent policies and regulations to ensure that commercial banks extend sufficient funds to the farm sector at low-interest rates. This will lead to increased borrowing for agricultural production purposes, ultimately boosting output levels. Overall, utilizing agricultural credit not only improves crop productivity but also leads to economic growth, poverty reduction, revenue generation, innovation, and employment generation in various nations. Fostering economic growth through targeted investments in agriculture via enhanced access to credit facilities can pave the way for sustainable development in developing economies. By addressing financial constraints through robust credit mechanisms tailored to farmers' needs, governments can create an environment conducive to promoting economic progress through increased agricultural productivity. See references: (AYEOMONI & ALADEJANA, 2016, pages 1-5)[6], (J & Muthiah, 2022, pages 11-13)[4], (J & Muthiah, 2022, pages 1-5)[4], (Chaiya *et al.*, 2023, pages 11-14)[11], (Ozdemir, 2023, pages 6-10)[17], (Bahşi&Çetin, 2020, pages 1-5)[3] and (Afolabi *et al.*, 2021, pages 11-13)[19].

Challenges Faced by Farmers in Utilizing Credit

The application of agricultural credit presents numerous obstacles for farmers, particularly in developing nations like Nigeria. The lack of sufficient, accessible, and cost-effective credit has been a major barrier to the farm sector's role in fostering economic growth. Farmers encounter challenges when trying to access formal financial institutions due to issues like inadequate funds and complex loan procedures, leading them to rely on informal credit groups that may not always offer sustainable financial solutions. In addition, the burden of high-interest rates on loans poses a significant challenge for farmers. Small-scale farmers may find it difficult to cover the interest payments on loans, limiting their ability to invest in practices that could enhance productivity. This limitation prevents them from embracing modern technology, acquiring quality inputs, or adopting sustainable farming methods that could boost overall productivity.

Moreover, structural problems affecting agricultural credit, such as high transaction costs and inadequate access for smallholder farmers, compound the difficulties faced by farmers. The limited access to credit hampers smallholders from making crucial investments in better inputs and machinery necessary for improving agricultural productivity. Without adequate financial backing, farmers struggle to overcome obstacles related to climate change impacts or market uncertainties that impact their production capabilities. Furthermore, the repercussions of recurring natural disasters and global crises like the COVID-19 pandemic intensify the challenges confronted by farmers in utilizing credit. The necessity for affordable agricultural credits at favourable interest rates becomes essential to ensure resilience against external shocks and sustain livelihoods within the agricultural sector.

In general, addressing these hurdles necessitates comprehensive government efforts aimed at enhancing financial inclusion and aiding smallholder farmers. By enhancing access to credit mechanisms tailored for production-related financing, policymakers can empower farmers to navigate these obstacles effectively. Initiatives to reduce transaction costs, offer subsidies on essential inputs, and promote climate-friendly agriculture transformation are crucial steps toward enhancing farmers' utilization of credit. In conclusion, although agricultural credit is critical in improving productivity and economic development in agriculture, overcoming the challenges faced by farmers is vital for realizing its full potential. By tackling issues related to access, affordability, and structural constraints within the credit system, policymakers can empower farmers to utilize credit effectively for sustainable agricultural development. See references: (AYEOMONI & ALADEJANA, 2016, pages 1-5)[6], (Khandker, 2021, pages 6-10)[14],



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(Ozdemir, 2023, pages 6-10)[17], (Patwary *et al.*, 2023, pages 1-5)[9], (Naidu *et al.*, 2013)[12], (Khandker, 2021, pages 26-30)[14] and (Anetor *et al.*, 2016, pages 1-5)[16].

Improving Credit Mechanisms for Farmers**Government Initiatives for Enhancing Financial Inclusion**

Government interventions are essential in facilitating access to financial resources for farmers in developing countries. For instance, in Bangladesh, the government has introduced various measures to strengthen the formal agricultural credit market. By prioritizing agricultural credit as a lending sector, Bangladesh Bank has collaborated with private and foreign commercial banks, as well as state-owned commercial banks, to ensure financial inclusion for farmers. Similarly, Nigeria's federal government has implemented several initiatives to support the agricultural sector with capital. Financial institutions such as the Nigerian Agricultural and Cooperative Bank (NACB), the Agricultural Credit Guarantee Scheme Fund (ACGSF), and the Commercial Agricultural Credit Scheme (CACS) have been established to facilitate lending for farmers, aiming to increase the availability of bank credit and boost agricultural development.

In India, government expenditure on agriculture has played a pivotal role in promoting economic growth. Various financial programs have been developed over time to ensure adequate funding for the agriculture sector. The introduction of initiatives like the Nigerian Agricultural Cooperative Bank (NACB), the Agricultural Credit Guarantee Scheme Fund (ACGSF), and the Commercial Agriculture Credit Scheme has further enhanced funding opportunities for farmers. In Uganda, collaborative efforts between the government and private institutions have been made to provide credit facilities for farmers. Programs such as the Poverty Eradication Action Plan and rural microfinance support projects have aimed at simplifying access to credit for agricultural activities. Through strategies such as adjustments in central bank rates and the establishment of funding agencies, progress has been made toward improving agricultural financing mechanisms in Uganda. In conclusion, it is evident that government actions are crucial in expanding financial inclusion for farmers through various agricultural credit schemes and programs. By ensuring access to credit through formal financial institutions and enacting supportive policies, governments can significantly contribute to enhancing agricultural productivity and economic growth in developing nations. See references: (AYEOMONI & ALADEJANA, 2016, pages 1-5)[6], (Patwary *et al.*, 2023, pages 1-5)[9], (Anetor *et al.*, 2016, pages 1-5)[16] and (Florence & Nathan, 2020, pages 1-5)[7].

Role of Microfinance Institutions in Providing Credit

Smallholder farmers, often underserved by traditional financial institutions, significantly benefit from the services provided by microfinance institutions. These organizations, supported by governments and entities such as the World Bank, aim to efficiently distribute credit in rural areas to stimulate agricultural progress. While microfinance institutions have made considerable strides in reaching marginalized farmers in countries like Bangladesh and Thailand, they face limitations in supporting long-term investments that are crucial for boosting agricultural output. In India, where agriculture is vital to the economy, limited access to finance has created a major barrier to developing a profitable agricultural sector. Encouraging the growth of microfinance institutions and creating suitable policies are essential steps in addressing this challenge, ensuring that farmers can access appropriate credit tailored to their farming needs.

Moreover, there is an increasing emphasis on recognizing farmers' financial realities as an underserved credit market, rather than viewing them solely as high-risk borrowers. By utilizing impact investments and philanthropic funds to extend credit to impoverished farmers while reducing loan default risks, there is potential to support sustainable agricultural practices and drive economic growth within these communities. In conclusion, microfinance institutions are critical players in providing credit to agricultural communities, especially smallholder farmers who encounter difficulties accessing conventional financial services. By tackling these challenges directly and promoting financial inclusion through targeted approaches like microfinance institutions, we can enhance agricultural productivity and foster lasting economic development in developing nations. See references: (D'Souza, 2020, pages 1-5)[20], (J & Muthiah, 2022, pages 1-5)[4] and (Khandker, 2021, pages 11-15)[14].



**Jonnalagadda Anil Kumar and S Ramesh Babu****Focus on Production-Related Financing****Importance of Production Loans for Farmers' Success**

Securing institutional finance is instrumental in propelling prosperity of farmers in developing nations, as it equips them with the financial means necessary to elevate their production capabilities. An illustration in Turkey showcases the escalating agricultural GDP attributed to the augmented bank loans designated for agricultural purposes, underscoring the pivotal role of funding in amplifying agricultural yield. The interconnection between financial backing and comprehensive agricultural advancements must not be underestimated, particularly in light of evolving production techniques and heightened demand for contemporary technologies and resources.

Research indicates a favourable relationship between agricultural credit and income levels, farm efficiency, and overall agricultural progress. Farmers with credit accessibility are better positioned to procure essential resources like machinery, seeds, fertilizers, and labour services, augmenting both their operational effectiveness and the modernization of farming methodologies. In India, where small-scale and marginalized farmers constitute a substantial segment of the agricultural landscape, obtaining credit remains a daunting task. Despite the fundamental significance of agricultural credit in bolstering production, deficiencies persist in the circulation of credit through institutional frameworks. Rectifying these shortcomings and ensuring adequate credit access for smallholder farmers is imperative for enhancing their productivity.

Government directives can significantly enhance credit accessibility by urging financial institutions to earmark funds exclusively for agricultural financing. By subsidizing interest rates and offering flexible loan quotas, formal credit markets can streamline their operations in meeting farmers' financial requisites more effectively. Moreover, initiatives focused on educating farmers about available credit facilities can bridge information gaps and ensure funds are obtainable where necessary. Overall, production loans play a pivotal role in securing farmers' prosperity. By furnishing timely and substantial financial support, agricultural credit substantially contributes to heightening productivity and efficacy within the agriculture sector. As evidenced by diverse studies conducted across nations like Turkey and India, expanding farmers' access to credit can pave the way for sustainable growth and progression within the agricultural domain. See references: (Bahşi&Çetin, 2020, pages 1-5)[3], (Khan *et al.*, 2017, pages 1-5)[2] and (Naidu *et al.*, 2013)[12].

Enhancing Agricultural Productivity through Targeted Financing

Securing bank finance is critical in bolstering agricultural productivity, particularly in emerging economies such as Bangladesh. Research has demonstrated that offering formal credit to small, marginal, and landless farmers can enable the timely and adequate provision of farm inputs, resulting in increased food production and enhanced livelihoods. The availability of credit enables farmers to invest in cutting-edge technologies, acquire high-quality seeds, fertilizers, and machinery, ultimately amplifying their productivity and output. Additionally, agricultural credit has been associated with higher farm income, which directly impacts the amount of credit accessible to cultivators. In India, where the farm sector significantly contributes to the GDP but encounters challenges like low productivity and inadequate irrigation infrastructure, targeted financing has been recognized as a key factor in enhancing agricultural productivity. The emphasis has shifted from traditional subsistence farming to commercialization, with credit playing a crucial role in educating farmers about market conditions and modern technologies for enhanced decision-making in farming practices. Formal credit sources in India encompass commercial banks, cooperative societies, and micro-financial institutions that aim to assist farmers in their agricultural endeavours. Moreover, studies revealed that bank finance exerts a significant impact on agricultural productivity in India. The expansion of institutional finance over recent decades has substantially contributed to agricultural development by supplementing working capital, alleviating liquidity constraints, and supporting investments in the sector. The scheduled commercial banks have emerged as primary sources of farmer finance in India, with cooperative banks still playing a dominant role in providing crop loans. Regional disparities suggest that the states of South India get higher production and investment credit than their eastern and northeastern counterparts.



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In essence, targeted financing through institutional credit mechanisms is indispensable for elevating agricultural productivity. By granting timely access to credit for smallholder farmers and simplifying procedures for obtaining loans, especially in underserved regions, governments can spur economic growth, alleviate poverty, and propel sustainable development within the agriculture sector. This transformative tool not only benefits farmers but also contributes to overall economic advancement by fostering an environment conducive to increased agricultural output and enhanced livelihoods. See references: (Chaiya *et al.*, 2023, pages 11-14)[11], (P *et al.*, 2020, pages 1-5)[10], (J & Muthiah, 2022, pages 1-5)[4] and (Islam, 2020, pages 1-5)[1].

CONCLUSION

In summary, the significance of bank credit in augmenting agricultural productivity is crucial for emerging economies like Bangladesh, Nigeria, and Vietnam. Various research studies have shown that agricultural finance initiatives have a substantial effect on the agricultural industry, leading to heightened economic growth and poverty alleviation. The accessibility of formal financial institutions and the availability of credit at competitive interest rates are key factors that can enhance agricultural production by providing farmers with essential resources for farm inputs, technology adoption, and overall productivity improvement.

Government's initiatives are critical in enhancing financial inclusion of farmers by implementing the policies that promote credit accessibility and literacy. Furthermore, transitioning towards market-oriented approaches for agricultural support can further stimulate sustainable growth within the sector. It is imperative to establish effective credit mechanisms, such as production-focused financing, to ensure that farmers have timely and tailored access to loans for their success. While agricultural credit is essential for inclusive sector development, there are challenges that need to be overcome, including high interest rates, transaction costs, and limited access for smallholder farmers. By enacting sound macroeconomic policies and implementing reforms in fiscal and monetary strategies, countries can maximize the benefits derived from the agricultural sector. Encouraging economic diversification towards non-oil sectors like agriculture is critical for maintaining sustained economic growth and progress.

In conclusion, it is apparent that bank credit to agriculture plays a vital role in driving economic growth through enhanced agricultural productivity. By addressing challenges related to financial inclusion, improving credit mechanisms, and focusing on production-oriented financing, countries can exploit the full potential of their farm sectors to stimulate overall economic advancement. Government interventions and support are imperative in ensuring that farmers have access to adequate credit facilities to increase their output levels and contribute positively to national economic prosperity. See references: (Olowofeso *et al.*, 2017, pages 1-5)[18], (Nguyen *et al.*, 2020, pages 1-5)[13], (Khan *et al.*, 2017, pages 11-15)[2], (AYEOMONI & ALADEJANA, 2016, pages 6-10)[6] and (Islam, 2020, pages 6-10)[1].

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Role of MRI in Diagnosing and Monitoring Multiple Sclerosis

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ABSTRACT

A variety of neurological symptoms are seen in multiple sclerosis (MS), a chronic, inflammatory, demyelinating illness of the central nervous system (CNS). Because it can show CNS abnormalities, magnetic resonance imaging (MRI) is essential for MS diagnosis, prognosis, and follow-up [1,2]. By highlighting important imaging methods, standards, and developments that improve MRI's diagnostic precision and clinical treatment, this review seeks to examine the importance of MRI in the diagnosis and progression tracking of multiple sclerosis.

Keywords: Multiple Sclerosis, MRI, McDonald Criteria, Lesion Detection, Brain Atrophy.

INTRODUCTION

An autoimmune condition called multiple sclerosis mostly affects the brain, spinal cord, and optic nerves. It involves the breakdown of the sheath that protects nerve fibers, called myelin, which impairs neuronal transmission. Patients' illness courses might differ greatly from one another; some may have episodic relapses and remissions, while others may experience gradual impairment. Because MRI provides a unique, non-invasive picture of the brain and spinal cord, it has completely changed the diagnosis and treatment of multiple sclerosis. Clinicians can use it to see lesions, track how they are changing, and determine the total cost of the illness. This article will examine significant developments and clinical applications related to the use of MRI in MS diagnosis and monitoring.[1] [2]

MRI for Tracking the Advancement of Disease Monitoring Lesion Development

MRI is essential for tracking the course of the disease and how well MS patients are responding to treatment. Frequent scans can monitor the development of new lesions or the growth of preexisting ones, which may indicate a



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potential correlation with clinical relapses. While the formation of gadolinium-enhancing lesions shrinks or disappears, the development of T1 hypointense lesions ("black holes") implies irreversible damage and neuro degeneration.

Atrophy of the Brain

In addition to lesions, MRI can measure brain volume and identify brain atrophy, which is becoming known as a key indication of cognitive loss and the advancement of the MS disease. In MS patients, atrophy occurs at a rate that is quicker than in healthy aging and is linked to both cognitive and physical impairment[3]. Sophisticated methods, such automated segmentation and voxel-based morphometry (VBM), enable accurate measurement of brain shrinkage, especially in the grey matter, which is frequently impacted by MS.

Advanced MS Magnetization Transfer Imaging (MTI) Techniques:

With the help of a particular MRI technique called MTI, one can learn more about the health of the myelin and axonal structures. Through the measurement of the magnetization transfer ratio (MTR), MTI provides a more comprehensive insight of lesion pathology and demyelination than is possible with conventional MRI.

Tensor Diffusion Imaging (DTI)

DTI evaluates the flow of water molecules in brain tissue to provide details about the integrity of the white matter tract[8]. When it comes to MS, DTI can identify microstructural alterations in both lesions and white matter that appears normal, possibly identifying damage early on before traditional MRI results become apparent. Demyelination and axonal loss are common sites of reduced fractional anisotropy (FA) in DTI.

Imaging using Susceptibility Weighted (SWI)

Because SWI is sensitive to blood products and iron deposition, it can be used to identify long-term active lesions in MS patients. One characteristic of MS that may assist distinguish MS from other demyelinating or inflammatory disorders is lesions with central veins, which are frequently found on SWI.

Somatosensory MRI (fMRI)

With functional magnetic resonance imaging (fMRI), blood oxygenation variations can be measured to measure changes in brain activity. fMRI can be used to investigate patterns of functional reorganization in MS patients, helping to understand how the brain adapts to structural injury.

This method is useful for comprehending MS patients' movement impairments and cognitive problems.

METHODS AND MATERIALS

Literature Search and Review: · Databases Used: Medical publications pertaining to radiology, neurology, and MS research as well as databases like PubMed and Google Scholar were used to perform an extensive review of peer-reviewed scientific literature.

Inclusion Criteria: Research on the application of MRI in MS diagnosis, tracking disease development, and evaluating treatment outcomes are included in the review. Both traditional and cutting-edge MRI methods were taken into account.

Exclusion Criteria: This evaluation did not include studies that were primarily focused on other neurodegenerative illnesses or that did not address MS.

Review of criteria: To assess the integration of MRI in clinical MS diagnosis, important clinical diagnostic criteria were examined, such as the McDonald Criteria.

Synthesis of Imaging Techniques:

The studies were classified according to the kind of MRI method that was applied (e.g., FLAIR, gadolinium-enhanced MRI, T1-weighted, T2-weighted, and advanced imaging methods like MTI, DTI, and SWI).



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The efficiency and precision of several MRI sequences were examined in relation to their function in identifying lesions, quantifying brain atrophy, and monitoring the course of illness.

Assessing Diagnostic and Monitoring Standards:

The review focuses on the McDonald Criteria (2017 update) and how it uses MRI to determine how MS lesions are disseminated in time (DIT) and space (DIS).

- A comparative review of research was done to assess how well MRI meets MS diagnostic criteria and how it is used in clinical practice to track the disease's advancement.

Discussion of Challenges and Future Directions:

- The review looks at issues such as lesion specificity, cost, accessibility to MRI, and differences between MRI results and clinical symptoms that can arise when using MRI for MS diagnosis and monitoring.
- A review of studies examining how cutting-edge imaging methods might be used to overcome these constraints was conducted, with an emphasis on new developments and future lines of inquiry.

Magnetic Resonance Imaging (MRI) Techniques:

- **Standard MRI Sequences:** T1-weighted Imaging: Indicative of persistent tissue injury and axonal loss, hypointense lesions, sometimes known as "black holes," are found there. T2-weighted and FLAIR Imaging: Particularly in the periventricular, juxtacortical, infratentorial, and spinal cord regions, these sequences identify hyperintense lesions, a hallmark of demyelination in multiple sclerosis. MRI with added gadolinium: Used to locate blood-brain barrier disruption and active inflammation, which are frequently observed during relapses.

Advanced MRI Techniques:

Magnetization Transfer Imaging (MTI): Identifies variations in magnetization transfer ratios to assess the integrity of myelin and axonal structures. **Diffusion Tensor Imaging (DTI):** This technique, which measures the water diffusion along nerve fibers to assess the microstructural integrity of white matter, is very helpful in identifying early demyelination.

Susceptibility-Weighted Imaging (SWI): This method, which is sensitive to iron deposition, aids in the identification of lesions with central veins, which are indicative of multiple sclerosis, as well as chronic active lesions. **Functional MRI (fMRI):** This technique evaluates blood flow and oxygenation changes in the brain to examine brain activity and shed light on how the brain reorganizes itself in response to structural damage in multiple sclerosis.

Clinical Diagnostic and Monitoring Criteria:

The 2017 update to the McDonald Criteria describes the diagnostic criteria for multiple sclerosis (MS), which mainly depend on MRI to show lesion dissemination in space (DIS) and time (DIT).

Lesion Locations: The review addresses the role that the distribution of lesions (periventricular, juxtacortical, infratentorial, and spinal cord) plays in verifying the diagnosis of multiple sclerosis.

Disease-Modifying Therapy (DMT) Monitoring:

A review of MRI studies was conducted to evaluate the role of MRI in tracking changes in lesion load, a decrease in gadolinium-enhancing lesions, and preventing brain shrinkage in order to monitor the efficacy of DMTs. Additionally, MRI is utilized to detect DMT side effects, such as progressive multifocal leukoencephalopathy (PML).

Data from Clinical Trials and Observational Studies:

Insights into the practical use of MRI in MS management were obtained through clinical trials and observational research that focused on MRI findings in MS diagnosis, lesion evolution, brain atrophy, and therapy response.





RESULTS

The overview of MRI's function in multiple sclerosis (MS) diagnosis and follow-up emphasizes the critical role that MRI plays in clinical diagnosis and disease treatment. Important conclusions from the paper include:

Diagnostic Accuracy with MRI and McDonald Criteria:

1. Because MRI can show how CNS lesions are disseminated both in space (DIS) and time (DIT), it is essential for verifying an MS diagnosis based on the McDonald criteria.
2. Hyperintense T2 and FLAIR lesions in the periventricular, juxtacortical, infratentorial, and spinal cord regions are characteristic MRI findings. Gadolinium contrast is also used to identify lesions that are actively inflammatory.

Monitoring Disease Progression:

When it comes to determining the genesis of new lesions, alterations in lesion size, and the transformation of acute lesions into chronic "black holes" (T1 hypointense lesions), MRI is a dependable method for monitoring the progression of multiple sclerosis.

2. Brain shrinkage, which can be shown on MRIs, has become a crucial indicator of neurodegeneration and the advancement of the disease, providing a significant predictive factor for cognitive decline and disability.

Advanced MRI Techniques:

1. Specialized MRI methods, such as susceptibility-weighted imaging (SWI), diffusion tensor imaging (DTI), and magnetization transfer imaging (MTI)[6], offer increased sensitivity in identifying chronic active lesions, demyelination, and microstructural damage that are frequently overlooked by traditional MRI.
2. Functional MRI (fMRI) improves our understanding of cognitive dysfunction and motor disability in multiple sclerosis (MS) by providing insights into brain activity and reorganization in response to structural damage[1].

Therapeutic Monitoring:

MRI is essential for monitoring the decrease of brain atrophy and new or enhancing lesions as well as potential treatment side effects including progressive multifocal leukoencephalopathy (PML). These metrics help assess the effectiveness of disease-modifying treatments (DMTs).

Challenges and Limitations

1. Lesion specificity, or the inability to differentiate MS lesions from other disorders, and the radiological-clinical paradox, or the situation in which MRI results do not always correspond with clinical symptoms, are obstacles to overcome even though MRI is the gold standard for MS diagnosis and monitoring.
2. Access to MRIs, their cost, and the variation in lesion burden in connection to clinical outcomes are still significant concerns.

While newer, more sophisticated imaging methods provide greater insights into the pathophysiology of the disease, MRI is still a crucial tool for MS diagnosis, following the disease's course, and assessing the effectiveness of treatment. The development of new imaging biomarkers in conjunction with more research aimed at enhancing the specificity and accessibility of MRI could improve the clinical management of multiple sclerosis[5].

CONCLUSION

Multiple sclerosis diagnosis and treatment have been revolutionized by MRI, which offers priceless insights into lesion formation, disease activity, and progression. It is still the gold standard for determining an MS diagnosis based on the McDonald criteria, and it is crucial for tracking therapeutic response and directing the course of treatment[7]. As sophisticated imaging methods develop further, MRI is anticipated to offer increasingly more profound insights into MS pathology, facilitating more accurate and individualized patient management. Subsequent investigations ought to concentrate on augmenting the availability and cost-effectiveness of magnetic





resonance imaging, optimizing imaging procedures to augment precision, and creating innovative biomarkers that can more precisely mirror pathological activity and forecast consequences. Multiple sclerosis (MS) diagnosis and continuing care are greatly aided by magnetic resonance imaging, or MRI. This review has shown that MRI is essential for verifying an MS diagnosis, especially when used in conjunction with the McDonald Criteria, which depend on the demonstration of lesion dispersion in both space and time. In addition to helping with early detection, MRI tracks the development of new lesions, brain atrophy, and structural alterations in the central nervous system, all of which offer important insights into the course of the disease.

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Vermicomposting: An Eco-Friendly Process To Decompose Organic Matter

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ABSTRACT

"This article presents Vermi-composting as an eco-friendly and effective process to decompose organic matter such as manure, kitchen waste, crop residues and others by using earthworms, primarily *Eisenia fetida* commonly known as red wigglers or *Lumbricus rubellus*. These worms digest organic material and produce a nutrient-rich material known as vermicast or worm castings, which serves as an excellent organic fertilizer". "Earthworms excreta (vermicast) is a nutritive organic fertilizer rich in humus, NPK, micronutrients, beneficial soil microbes; nitrogen-fixing, phosphate solubilizing bacteria, actinomycetes, and growth hormones auxins, gibberellins and cytokinins, is a suitable alternative to chemical fertilizers, being an excellent growth promoter and protector for crop plants. Thus, vermiculture not only results in management of solid waste but also produces excellent nutrient enriched vermicompost. Vermicompost is beneficial for sustainable organic agriculture and maintaining balanced ecosystem"

Keywords: Organic Waste; earthworms; Vermicompost; nutrients; sustainable organic agriculture;



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INTRODUCTION

“Vermi-composting of municipal solid waste is gaining popularity these days because it adds value to the waste while also reducing volume, making it easier to use. Vermicomposting is the process of stabilizing organic solid waste by converting it to earthworm castings through consumption of waste by earthworms [1]. Vermicomposting occurs when organic waste is degraded by gut microbes of earthworms, resulting in stable and mature vermi-compost [2]. Selection of appropriate earthworm species for vermicomposting is the most important step because it affects rate of waste stabilization. There are a variety of earthworm species that can be used in waste management [3]”. In present generation, population growth and rapid industrialization has given rise to solid residue generation. Waste production in general terms is directly proportional to technological advancement, population, urbanization and industrialization. So disposal of solid waste is the headmost environmental issue all over the world. Developing nations are facing serious problems i.e., handling of wastes, perfect disposal of waste, solid waste management etc. In India, almost 1,88,500 tonnes of municipal solid wastes are produced everyday [4] from various sectors namely industrial and domestic activities. Furthermore, due to development of industries results in generation of solid wastes [5]. Industrial wastes, which are generated by various industries generally contains solid/semi-solid stuff that contains noxious compounds and are heterogeneous in nature [6]. Therefore, management and disposal of these types of wastes are challenging in general scenario. Using vermicompost can be considered a method to deal with such harmful wastes from industries or domestics are one of the best techniques [7].

Vermi-composting can be defined as a green technology for growing of earthworm in organic wastes, its processing and producing fertilizers from wastes. Generally, vermicomposting results from conversion of organic wastes by earthworms, by successfully converting wastes such as sludge of wastewater treatment, dairy factory waste, food waste, municipal waste, paper waste, and animal waste to fertilizer and etc. [8]. Based on available literature report it is confined that vermin-composting technology can be a fruitful technology to handle waste in a progressive manner. This research articles investigated on the degradation of organic waste into vermicompost and usage of the species and finally comparison with the normal compost [9].

Steps of how Vermi-composting Works

1. Collection and Preparation of Organic Waste: Organic manure, along with other compostable materials, is collected. Large chunks are often chopped to help the decomposition process.
2. Addition of Earthworms: The prepared organic waste is placed in a compost bin, and earthworms are introduced. They consume the organic matter, and as it passes through their digestive system, it is broken down into simpler compounds.
3. Decomposition Process: As the earthworms consume the material, they digest it with the help of microorganisms present in their gut. The result is partially decomposed organic matter rich in beneficial bacteria, enzymes, and nutrients like nitrogen, phosphorus, and potassium.
4. Formation of Vermicast: The worm castings, or vermicast, are produced in the form of granular, dark-colored particles. This vermicast contains high levels of organic matter, beneficial microorganisms, and plant growth-promoting substances.
5. Harvesting Vermicast: Once most of the organic matter has been processed, the worms are separated (usually by moving them to fresh organic matter in another part of the bin), and the vermicast is collected as a natural fertilizer.

Benefits of Vermi-composting

1. Improves Soil Health: Vermicast enhances soil fertility, improving water retention, aeration, and



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drainage.

2. Rich Nutrient Profile: The end product is rich in macro and micronutrients, beneficial for plant growth.
3. Eco-Friendly: This method reduces waste by converting organic matter into a valuable product, cutting down on landfill use.
4. Accelerated Decomposition: Compared to traditional composting, vermicomposting is faster due to earthworms' active digestion.

In short, vermicomposting offers a sustainable, efficient way to recycle organic manure and waste into a high-quality, environmentally beneficial soil amendment.

MATERIALS AND METHODS

Raw substrates and earthworm

The species (*Aspergillus Niger* [fungus] and *Staphylococcus aureus* [bacterium]) were collected from Central Drugs Laboratory, Kolkata. The detailed diagram is shown in figure 1.

Fresh wastes, especially fruit peels and cow dung free from peels was collected from local areas surrounding the institution, Calcutta Institute of Technology, Uluberia, India. CD was stored in plastic containers at room temperature collected from local distributor. The CD was well mixed with wastes in different compositions. The physico-chemical characteristics of wastes and CD are given in Table 1. The earthworm species *Eisenia fetida* was used for the biotransformation of waste mixtures due to its better survival potential in sludges laden feed [10-12].

Chemicals

(NH_4) NO_3 , $\text{K}_2\text{H}_2\text{PO}_4$, MgSO_4 , FeSO_4 , ZnSO_4 , NaCl , DEXTROSE procured from local distributor Medini Biotech Pvt. Ltd, Kolkata.

Equipments

A conical flask of 250ml, 250 ml beaker and 8 glass tubes, which were manufactured by Borosil ®. Cotton plug, glass funnel, distilled water bottles, iron spatula, paper cover, cotton wire and small spoon were used, which were supplied by local distributors Lab Chemicals, Pvt. Ltd, Kolkata.

Analytical Instruments

Incubator, laminating air flow system, autoclave and centrifuge were supplied by S. C. Dey & Co. India.

Experimental Procedure

Media Preparation: The nutrients that were used for the investigation are mentioned in the Table 1 and Table 2.

After collecting the solution, the nutrients were mixed with distilled water in the form of a homogeneous solution, which were later subjected for culture media preparation.

Inoculation of Sample

Sterilized nutrient media of fungi and bacteria were taken in 4 test tubes. Each containing 5ml of media. Then the media is added with nutrients (fungi & bacteria) inside an aseptic chamber and finally plugged with cottons to avoid contamination.



Deepak Kumar *et al.*,**Incubation**

The cotton plugged test tubes were taken into incubator where the species were left for 2-3 days at 20-30°C and 25-35°C for maintain the fungal growth and bacterial growth respectively. The species were then subjected to incubation.

Centrifugation

The species were subjected to centrifugation to extract the biomass from media liquid. The centrifugation was done at 4000-5000 rpm initially for 15-20 minutes. After that cell weight was taken and it was observed after 20 minutes.

RESULTS AND DISCUSSION

The finished end product of the process, i.e. vermicompost was uniform textured, dark coloured than initial blend. Physico-chemical properties, biomass content and effects of plant growth of the waste mixtures were significantly transformed after vermicomposting. All the samples were analyzed in triplicate and the results were averaged. We can infer that experiments were done to check the physico chemical properties of CD and wastes initially and after experiments.

Physico-chemical characteristics

Fig-1. (Table 3) represents the physico-chemical characteristics of CD and wastes used in the experiments and Table 4. represents the changed physico-chemical characteristics of CD and wastes

Reduced pH was found during vermicomposting process, which is shown in Table 4. pH of vermicomposts after 105 days was in the range of 5.4–5.43. It clearly suggests that it is acidic in nature and decline in pH results due to conversion of organics present in wastes into organic acids (7-8). Generation of humic and fulvic acids by microbes from organic matter results in lowering of pH during vermicomposting process (9). The dissimilarities in pH may be due to production of different quantities of organic acids.

The results showed in Table 4 represents the electrical conductivity (EC), which increases during vermicomposting process. EC of vermicomposts were shown in the Table 4. Increase in EC results due to the fact that there are presence of earthworms and microflora during the degradation of organics. (10-11). Soumare et al. (2002) [13] had suggested that the threshold value of EC for a material is 3.0 dSm⁻¹ for its safe application to the agricultural soils.

Total organic carbon (TOC) also reduced, shown in Fig-2 (Table 4) as compared to initial blends (Table 3). The result suggests that the biodegradable organic carbon was gradually disabled during the process which was responsible for the reduction in TOC.

Total Kjeldahl Nitrogen (TKN) content, TAP content, Total potassium (TK) content, Total calcium (TCa) content increased after vermiprocessing of the waste mixture, but C: N ratios decreased with time. The trends followed by TKN, TAP, TK, TCa and C: N is very similar to that of previous researchers. [14-21].

Effect of VC on plant growth

Vermi-compost (VC) obtained have effect on early as well as later stage of plant life cycle. According to Arancon et al. (2008) [22] reported that seedling evolves of petunias seeds grown in mixture of vermicompost (produced from cattle manure, food waste and paper waste) and MM360, increased compared to 100% MM360. However, different percentage of vermicompost application exhibited different impact. So, increased dry shoot/root weight but at lower rates than higher ones [22]. Amount of vermicompost required by crops, leafy vegetables is less than that of tuber crops [23]. Largely the quantity and quality of production largely depends on the rate of vermicompost applied. According to researchers [24], when the ratio of 1:1, 1:2, 1:3 and 1:4 between vermicompost and soil is added then the maximum yield limits to 1:1 with crop nutrients like vitamin C, total sugar, soluble and insoluble solids and nitrites



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[25-26]. However, some researchers have reported that the application of vermin-compost at lowest rates is cost effective than higher rates [27-28].

CONCLUSIONS

“The literatures cited verify that vermi-compost is an organic bio fertilizer, which can act as an alternative fuel and can improve the soil quality, resulting in plant growth and production of bio-fertilizer. It can be inferred that vermi-compost can be used to improve soil physio-chemical and biological properties than normal compost. It is observed that increasing soil fertility by applying vermin-compost increases the plant growth and production of bio-fertilizer. The growth Earthworms increases porosity of water inside soil, improves quantity nutrients like nitrogen, potassium, phosphorous. Vermi-compost should be used at an appropriate proportion depending on the type of crop for cost effectiveness. In generalized word, vermin-compost is an alternative to organic farming, tea plantation.

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Table1. Name of the nutrients (Fungi) and their solutions with 100 ml water

S. No	Nutrients (Fungi)	Solutions
1	(NH ₄)NO ₃	0.31 gm/100ml water
2	K ₂ H ₂ PO ₄	0.015 gm/100ml water
3	MgSO ₄	0.11 gm/100ml water
4	FeSO ₄	0.01 gm/100ml water
5	ZnSO ₄	0.66 gm/100ml water
6	NaCl	0.015 gm/100ml water
7	DEXTROSE	20 gm/100ml water

Table2. Name of the nutrients (Bacteria) and their solutions with 100 ml water.

S. No	Nutrients (Bacteria)	Solutions
1	BEEF EXTRACT	0.01 gm/100ml water
2	PEPTONE	0.01 gm/100ml water
3	NaCl	0.005 gm/100ml water
4	AGAR	0.2 gm/100ml water



Figure 1: Pictorial representation of Aspergillus Niger and Staphylococcus aureus





Correlation of Glycated Haemoglobin with APO A1/ APO b Ratio in Type 2 Diabetes Mellitus Patients

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ABSTRACT

Type 2 diabetes mellitus (T2DM) is a dangerous and widespread chronic illness caused by a intricate combination of genes, environment and other serious risk factors like overweight and lack of physical inactivity. Type 2 DM and it's consequences are a significant global health problem influencing a huge amount of population with a higher rate of diabetes-related morbidity and mortality in both developed and developing countries. To determine and correlate the levels of Glycated haemoglobin, and Apo A1/Apo B ratio in Type 2 DM. Five mL of venous blood were taken from all the subjects included in the study after 12-14 hours of overnight fasting and taking all aseptic precautions. The serum is separated by the process of centrifugation done for 15 mins at 3500 rpm. Apo A1 and Apo B were measured by using immunoassay based immune turbid metric method on the fully automated biochemistry auto analyzer. K-ASSAY, USA, Catalog No. KAI-002 and 004. HbA1c was measured by using immunoassay based immunoturbidimetric method on the autoanalyzer. In this present study, there were 70 participants included. The average age of the study participants was 40.24 years with 6.62 standard deviation. The mean HbA1c level was found to be 8.51 with 1.50 SD. According to Apo A1, the mean was 91.02 with 7.43 SD and for Apo B it was calculated as 148.83 with 21.02 standard deviation. Similarly, the ratio mean was found to be 0.63 with 0.13 variation.

Keywords: T2DM, Glycated hemoglobin, Apolipo protein A1, Apo lipoprotein B, HDL.





INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a dangerous and widespread chronic illness caused by a intricate combination of genes, environment and other serious risk factors like overweight and lack of physical inactivity. Type 2 DM and its consequences are a significant global health problem influencing a huge amount of population with a higher rate of diabetes-related morbidity and mortality in both developed and developing countries¹. Type 2 diabetes mostly results in the interaction among genetic, environmental and other risk factors. Genetic, metabolic, and environmental variables all together combine to raise the likelihood of developing T2DM. Its development is primarily caused by the combination of two important factors: decreased insulin production by pancreatic beta-cells and decreased insulin sensitivity of tissues. Its development is primarily caused by the combination of two important variables: decreased insulin production by pancreatic beta-cells and decreased insulin sensitivity of tissues. Imbalance in metabolism of insulin results in the pathogenesis of T2DM which in turn is caused due to abnormalities in the systems that are involved. According to a report given by WHO about 90% of cases of DM are diagnosed as T2DM. the major organs involved or affected in T2DM are adipose tissue, pancreas, liver, kidneys, brain, small intestine and skeletal muscles. Furthermore, the true disease burden of T2DM is likely to be underestimated, as one in every three diabetics, or 232 million people, was under diagnosed. ⁵ Because non-modifiable risk factors (ethnicity and family history /genetic predisposition) have a strong genetic basis, epidemiological studies suggest that many cases of T2DM can be avoided by improving the main modifiable risk factors (obesity, lack of physical activity, and an unhealthy diet

Glycolated hemoglobin

The gold standard indicator for glycemic management in diabetic individuals is known as HbA1c. It is created through a non-enzymatic glycation mechanism that involves plasma glucose exposure of haemoglobin. HbA1c levels are normal when glucose levels are normal. The fraction of HbA1c grows predictably as the average plasma glucose level rises. This acts as a barometer for the typical blood sugar levels over the three months preceding the measurement. The level of HbA1c correlates with both the typical glucose level and the average lifespan of red blood cells in circulation. The majority of glucose is found in a cyclic form, although there is a trace quantity of acyclic glucose which is in chemical equilibrium with this form, which has an extremely active aldehyde group which can interact non-enzymatically with the amino groups on the sidechains of proteins. This reaction happens in 2 stages. First one is reversible process, in which glucose joins with an amino group in the protein to generate an aldimine (Schiff base). Aldimine transforms into a ketoamine in the second, irreversible stage, which lasts for the rest of the protein's lifespan. The term "glycation" refers to this chemical process²¹. In theory, any amino group in a protein's side chain can be glycosylated; however, a number of variables, including the protein's concentration, the amino groups steric accessibility, the concentration of glucose in the reaction compartment, and the lifespan of the glycosylated protein, have a significant effect on the concentrations of the final glycation end products.

Apolipoprotein A1 and Apolipoprotein B

Apoproteins are essential lipoprotein proteins that work as both recognition molecules that attach to specific receptors on peripheral tissues, such as the vascular endothelial cells and as cofactors for enzymatic reactions. Apolipoprotein A1 is the most major protein in the external part of phospholipids and lipids that surround the hydrophobic lipid core of HDLs, which contains TGs and both esterified and non-esterified cholesterol⁴⁴. The estimation of apolipoprotein B (Apo B), which is evident in all atherogenic lipoprotein types such as LDL-C, VLDL-C and IDL allows for a more accurate estimation of atherogenicity than the traditional lipid profile.^{46,47}. An important component of HDL-C is the anti-atherogenic lipoprotein carrying molecule Apo A^{48,49}. In the prediction of cardiovascular illnesses, insulin resistance and diabetes mellitus Apo A1 is viewed as a preferred substitute for HDL-C⁵⁰⁻⁵¹. Thus, the Apo A1/Apo B ratio seemed to be a more accurate and thorough predictor of lipid metabolism and CVD, DM, and metabolic syndrome. Apo B & Apo A1 are 2 main apolipoproteins engaged in lipid transport and in the disease causing atherosclerosis and its complications. After considering age, race, and other risk factors, the Apo A1 /Apo B ratio continued to be a significant predictive tool of insulin resistance.





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AIMS AND OBJECTIVES

To determine and correlate the levels of Glycated haemoglobin, and Apo A1/Apo B ratio in Type 2 DM

OBJECTIVES

1. To estimate the levels of TNF- α , Oxidized LDL, Glycated haemoglobin and Apo A1/Apo B ratio in Type 2 DM patients

MATERIALS AND METHODS

Study Design: This study was hospital based cross sectional observational study carried out over a 6 months period. This study was conducted in the Departments of Biochemistry and General Medicine, Faculty of Medicine and Health Sciences, SGT University, Gurugram. Seventy consecutive patients of either gender between the age group of 30-50 years, who were attending General Medicine OPD are recruited as cases. The cases were freshly diagnosed cases of Type 2 Diabetes Mellitus. The cases were diagnosed by the clinician based on the history, physical examination and criteria laid by American Diabetic Association.

Criteria used for diagnosis Type 2 Diabetes Mellitus

Fasting blood sugar ≥ 126 mg/dl on two separate occasions with minimum 24 hours apart.

Exclusion Criteria

- Type I Diabetes Mellitus
- Pregnant and lactating females
- Patients taking statin group of drugs, vitamin D supplements and on hormonal therapy.

METHODOLOGY

Five mL of venous blood were taken from all the subjects included in the study after 12-14 hours of overnight fasting and taking all aseptic precautions. The serum is separated by the process of centrifugation done for 15 mins at 3500 rpm.

●●Apo A1 and Apo B were measured by using immunoassay based immunoturbidimetric method on the fully automated biochemistry autoanalyzer. K-ASSAY, USA, Catalog No. KAI-002 and 004.

●●HbA1c was measured by using immunoassay based immunoturbidimetric method on the auto analyzer.

Statistical Methods

Data and various parameters will be analyzed on SPSS software (USA inc.) version 23. Mean and standard deviation of all parameters will be calculated. Chi square test is applied to non-parametric variables. Student t-test is used for comparing the two groups. Pearson's correlation coefficient will be applied to find the correlation.

RESULTS

The present study was done to determine the serum levels of Glycated haemoglobin, TNF- α , Oxidized LDL and Apo A1/Apo B ratio in Type 2 Diabetes Mellitus. The correlation between the level of Glycated haemoglobin with TNF- α , Oxidized LDL and Apo A1/Apo B ratio was done by Pearson's correlation coefficient.

Correlations of Glycated haemoglobin with Apo A1 and Apo B

Apo A1/Apo B ratio:

In this present study, there were 70 participants included. The average age of the study participants was 40.24 years with 6.62 standard deviation. The mean HbA1c level was found to be 8.51 with 1.50 SD. According to Apo A1, the





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mean was 91.02 with 7.43 SD and for Apo B it was calculated as 148.83 with 21.02 standard deviation. Similarly, the ratio mean was found to be 0.63 with 0.13 variation.

Correlation of Glycated haemoglobin with Apo A1 is significant with $r = -0.91$ at $p < 0.0001$

Correlation of Glycated haemoglobin with Apo B is significant with $r = 0.711$ at $p < 0.0001$

Correlation of Glycated haemoglobin with Apo A1/Apo B ratio is significant with $r = -0.833$ at $p < 0.0001$

According to table 6 and graph 5, it shows the correlation between HbA1c versus Apo A1. Pearson correlation test was applied, the result was calculated as negative strong correlation between them and the p value was significant with $r = -0.91$ at 0.01 level of significance. Correlation between HbA1c and APOB

In our study, the table 7 and graph 6 depicts the correlation between HbA1c versus Apo B. Pearson's correlation coefficient test is applied and it is identified that there is a positive moderate correlation among them and the result was significant with $r = 0.711$ at 0.01 level of significance. Correlation between HbA1c and Apo A1 / Apo B ratio

In this study, table 8 and scattered diagram graph 7 represents the effect of HbA1c to the ratio of Apo A1/ Apo B. Karl Pearson's correlation coefficient method was applied and it was found that the result was indirect strong correlation between them and the result was significant with $r = -0.833$ at 0.01 level of significance.

Discussion

In our study the mean and standard deviation of Apo A1 was found to be 91.02 ± 7.43 and the mean and standard deviation Apo B was calculated as 148.83 ± 21.02 . Similarly, their ratio mean was found to be 0.63 ± 0.13 variation. The correlation between HbA1c versus Apo A1 was calculated as negative strong correlation between them and the p value was significant at $r = -0.91$, $p < 0.001$ level of significance. The correlation between HbA1c versus Apo B was calculated there was a positive moderate correlation between them and the result was significant at $r = 0.711$, $p < 0.001$ level of significance. The correlation between HbA1c versus Apo A1/Apo B ratio, it was found that the result was indirect strong correlation between them and the result was significant at $r = -0.833$, $p < 0.001$ level of significance. Similar findings were found in the studies done by Hwang et al. indicated that the Apo B/Apo A1 ratio is an effective predictor of T2DM. Furthermore, the Apo B/Apo A1 ratio was very much correlated with triglycerides, total cholesterol, high density lipoprotein, low density lipoprotein, HbA1C and HOMA-IR, which is in accordance with previous studies. According to the study, a typical dyslipidaemia with increased TAGs and NEFA and low levels of HDL-C precise the recognition of type 2 diabetes and is often associated by insulin resistance. Inverse relationships exist between HDL-C levels, HDL particle size, and diameter, and insulin resistance and dyslipidaemia done by Xepapadaki et al in 2021.

Gao et al. (2021) [79] observed The primary lipoprotein linked to high-density lipoprotein cholesterol is called Apo A1 (HDL-C). When found in low-, intermediate-, and very low- density lipoproteins, Apo B is a single molecule. The pathogenic processes of FBG and T2D may be maintained by changes in the levels of Apo A1, Apo B, and the Apo B/Apo A1 ratio.

CONCLUSION

More number of studies should be conducted for this. Early diagnosis of these parameters may help to minimize the risk and to manage the complications diseases like diabetes majorly increases the risk of many heart problems, myocardial infarction, neuropathy, nephropathy, retinopathy, hearing impairment and alzheimer's disease.





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**Table 1. Standard Deviation Results**

	Mean	Standard Deviation
Age	40.24	6.62
HbA1c	8.51	1.50
Apo A1 (mg/dl)	91.02	7.43
Apo B (mg/dl)	148.83	21.02
Apo A1/Apo B RATIO	0.63	0.13

Table 2. Correlation between HbA1c and APOA1

	Mean	SD	r-value	p-value
HbA1c	8.51	1.50	-0.91	<0.0001**
ApoA1 (mg/dl)	91.02	7.43		

**=Significant at 0.01 level of significance

Table 3 -Correlation betweenHbA1candAPOB

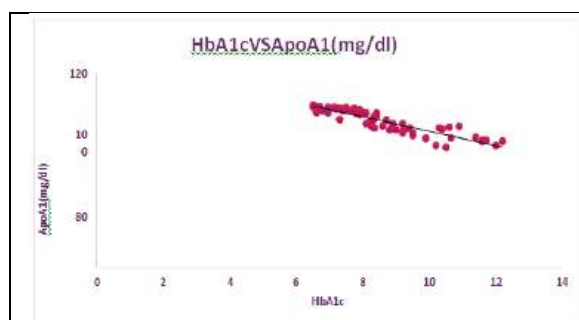
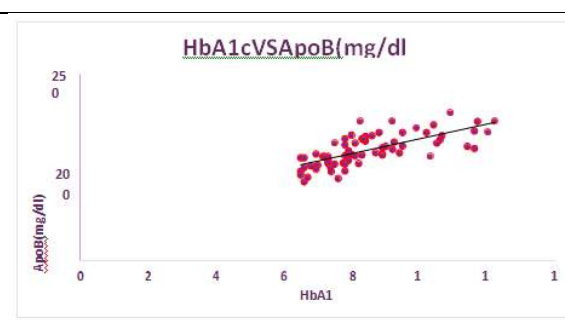
	Mean	SD	r-value	p-value
HbA1c	8.51	1.50	0.711	<0.0001**
ApoB (mg/dl)	148.83	21.02		

**=Significant at 0.01 level of significance

Table 4. Correlation between HbA1candApoA1/Apo Bratio

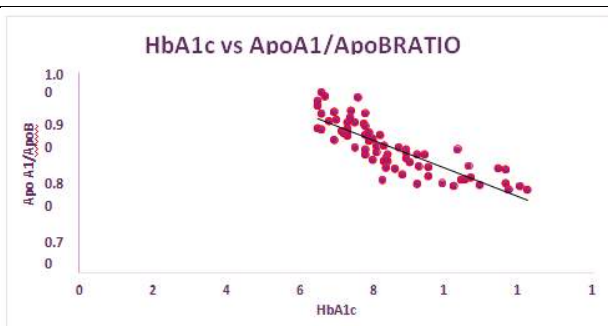
	Mean	SD	r-value	p-value
HbA1c	8.51	1.50	-0.833	<0.0001**
ApoA1/ApoB	0.63	0.13		

**=Significant at 0.01 level of significance

**Graph 5- Correlation of Glycatedhaemoglobin with ApoA1****Graph 6-Correlation of Glycatedhaemoglobin with Apo B**



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Graph 7 –Correlation of Glycatedhaemoglobin with Apo A1/Apo B Ratio





Comparative Analysis of Advanced Clustering Algorithms for Market Segmentation

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ABSTRACT

Using mall customer data, this study compares various advanced clustering methods for market segmentation. The following clustering algorithms are assessed: Agglomerative Clustering, BIRCH, Spectral Clustering, OPTICS, K-Means, Hierarchical Clustering, DBSCAN, Gaussian Mixture Models (GMM), and Affinity Propagation. Evaluation metrics are used to evaluate the clustering performance and identify the best method for segmenting mall patrons according to their spending patterns. These metrics include the Silhouette Score, Davies-Bouldin Score, and Calinski-Harabasz Score.

Keywords: OPTICS, Clustering, Mixture, performance.

INTRODUCTION

Market segmentation is essential for businesses to comprehend customer behavior and customize marketing strategies to meet the needs of different consumer groups. One of the most effective approaches to achieve this is through clustering algorithms, which help in identifying and grouping customers based on shared traits, such as demographics, purchasing habits, or preferences. By applying these techniques, businesses can create distinct customer profiles, allowing them to target specific segments with personalized marketing efforts. This study delves into various clustering methodologies, such as K-Means, Hierarchical clustering, and DBSCAN, applied to mall customer data. The objective is to uncover meaningful customer segments that can drive more tailored marketing strategies. The analysis focuses on understanding the commonalities within each cluster and the key differentiating





factors between groups, which businesses can use to enhance customer engagement, improve service offerings, and boost overall satisfaction.

In summary, the research aims to demonstrate how clustering algorithms can provide actionable insights for businesses, enabling them to optimize marketing efforts and build stronger, more personalized relationships with their customers.

METHODS

The process entails a few crucial steps:

1. Data Collection: A variety of demographic and expenditure characteristics are included in the mall customer data that is collected.
2. Data Preprocessing: To get ready for clustering methods, data is cleaned and standardized.
3. Clustering techniques: The preprocessed data is subjected to nine clustering techniques.
4. Evaluation: The Davies-Bouldin, Calinski-Harabasz, and Silhouette scores are used to assess each algorithm's performance.
5. Comparison: Based on the evaluation measures, results are compared to determine which algorithm better groups mall patrons.

Algorithms

- 1) K-Means: Data is divided into K clusters using this centroid-based clustering technique.
- 2) Hierarchical Clustering: Utilizing either agglomerative (bottom-up) or divisive (top-down) techniques, this method creates a hierarchy of clusters.
- 3) DBSCAN: Density-based clustering that uses density to distinguish between different sized and shaped clusters.
- 4) Gaussian Mixture Models (GMM): These models assume that a mixture of many Gaussian distributions are used to produce data points.
- 5) Mean Shift: This non-parametric clustering technique moves toward areas of higher density to identify the centroids of clusters.
- 6) Agglomerative Clustering: Recursive hierarchical clustering in which groups are merged according to distance.
- 7) BIRCH (Balanced Iterative Reducing and Clustering utilizing Hierarchies): This method creates a tree structure to organize data into hierarchical clusters and quickly summarize it.

Datasets

- The Mall Customer Data collection, which is used in this study, has the following information:
- Customer ID: A unique identifier for each customer.

Gender: The customer's gender.

Age: The customer's age.

Annual Income (k\$): The customer's annual income.

Spending Score (1-100): Determined by analyzing the spending habits and behavior of customers.

Data Preprocessing

Before applying clustering algorithms, the following preprocessing steps were performed:

- **Normalization:** Scale numerical features to a standard range.
- **Encoding:** Convert categorical variables (e.g., Gender) into numerical format if necessary.
- **Feature Selection:** Select relevant features (e.g., Annual Income and Spending Score) for clustering.





RESULTS

This table summarizes the performance metrics for each clustering algorithm applied to them all customers dataset, including the Silhouette Score, Davies-Bouldin Score, and Calinski-Harabasz Score. The Mean Shift algorithm produced only one label, so its evaluation was skipped.

K Means clustering was applied to the Mall Customer Data to segment customers based on their spending behavior . The algorithm produced a Silhouette Score of 0.358, indicating reasonably well - defined clusters but with some overlap observed between clusters. The Davies-Bouldin Score of 1.033 suggests moderate clustering quality , where lower values would indicate better clustering . The Calinski - Harabasz Score of 101.530 indicates good cluster separation and compactness. K-Means' performance is notable for its efficiency and scalability , although its reliance on the initial random centroids can affect results , as seen in the slight overlap between clusters

Hierarchical Clustering was employed to segment the mall customers into distinct groups based on their spending patterns. The algorithm achieved a Silhouette Score of 0.321, indicating reasonable cluster separations but with clusters that are less well-defined compared to other methods. The Davies- Bouldin Score of 1.128 suggests moderate clustering quality , with some overlap or ambiguity in cluster boundaries . The Calinski - Harabasz Score of 88.102 reflects good within - cluster similarity and between - cluster differences , although slightly lower than optimal for highly distinct clusters. Hierarchical Clustering' s advantage lies in its ability to reveal hierarchical relationships but may require parameter tuning to improve cluster quality . DBSCAN was utilized to segment customers based on their spending behaviors , focusing on density - based clustering . The algorithm yielded a Silhouette Score of 0.185, indicating challenges in forming well-defined clusters due to sensitivity to its parameters such as epsilon and minimum samples. The Davies-Bouldin Score of 1.757 suggests significant overlap or inconsistency in cluster formations, impacting the algorithm ' s ability to distinguish between different customer segments effectively. The Calinski -Harabasz Score of 34.071 reflects weaker cluster separation compared to other methods , indicating potential difficulties in handling varying densities and noise in the data.

Gaussian Mixture Models were employed to segment mall customers based on their spending patterns, assuming data distributions are a mixture of Gaussian distributions. The algorithm achieved a Silhouette Score of 0.335, indicating reasonably well-separated clusters with moderate overlap. The Davies- Bouldin Score of 1.019 suggests decent cluster quality, though with some ambiguity in cluster boundaries. The Calinski-Harabasz Score of 90.864 reflects good cluster separation and compactness , suitable for data with Gaussian -like distributions. GMM's flexibility in capturing complex data distributions makes it robust but sensitive to the number of components and initialization.

Agglomerative Clustering was applied to the customer data to segment them into meaningful groups based on their spending behavior. The algorithm achieved a Silhouette Score of 0.321, similar to Hierarchical Clustering , indicating reasonable cluster separations but with clusters that may not be well-defined. The Davies - Bouldin Score of 1.128 suggests moderate clustering quality , reflecting some ambiguity or overlap in cluster boundaries . The Calinski - Harabasz Score of 88.102 indicates good cluster separation , though not as distinct as other methods like Affinity Propagation. Agglomerative Clustering's hierarchical nature offers insights into cluster relationships but may require careful parameter tuning for optimal results.

BIRCH clustering was employed to segment mall customers based on their spending patterns , focusing on hierarchical clustering using a balanced clustering tree . The algorithm achieved a Silhouette Score of 0.266, indicating some challenges in forming well - separated clusters . The Davies - Bouldin Score of 1.061 suggests moderate clustering quality, with potential overlap or ambiguity in cluster boundaries. The Calinski- Harabasz Score of 63.583 reflects decent cluster separation but is lower compared to other methods , indicating limitations in handling varying cluster shapes and densities effectively .



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Spectral Clustering was utilized to segment customers based on their spending behaviors, focusing on graph-based clustering. The algorithm achieved a Silhouette Score of 0.353, indicating reasonably well-separated clusters with moderate overlap. The Davies-Bouldin Score of 0.993 suggests good clustering quality, with well-defined clusters and minimal overlap. The Calinski-Harabasz Score of 99.602 reflects strong cluster separation and compactness.

OPTICS was applied to segment customers based on their spending patterns, focusing on density-based clustering. The algorithm produced a Silhouette Score of -0.063, indicating challenges in forming distinct and well-separated clusters, potentially due to noise or parameter sensitivity. The Davies-Bouldin Score of 1.399 suggests significant overlap or inconsistency in cluster formations, impacting the algorithm's ability to distinguish between different customer segments effectively. The Calinski-Harabasz Score of 12.523 reflects weaker cluster separation compared to other methods, highlighting limitations in handling varying densities and noise in the data.

Affinity Propagation was utilized to segment mall customers based on their spending behaviors, focusing on exemplar-based clustering. The algorithm achieved a Silhouette Score of 0.369, indicating well-defined and distinct clusters in the data. The Davies-Bouldin Score of 0.949 suggests good clustering quality, with well-separated clusters and minimal overlap. The Calinski-Harabasz Score of 128.602 reflects strong cluster separation and compactness, suitable for datasets with complex and varied cluster shapes. Affinity Propagation's ability to automatically determine the number of clusters and capture diverse data patterns makes it robust for market segmentation tasks, outperforming other methods evaluated.

Comparison

From the evaluation results, Affinity Propagation demonstrates the highest Silhouette Score (0.369) and Calinski-Harabasz Score (128.602), indicating better-defined clusters and higher cluster separation compared to other algorithms. However, it is noted that OPTICS produced only one label, suggesting it may not be suitable for this dataset due to its inability to distinguish clusters effectively.

CONCLUSION

This study used mall customer data to thoroughly assess many clustering methods for market segmentation. Using both Silhouette Score and Calinski-Harabasz Score, Affinity Propagation was shown to be the most successful method. This suggests that it can be used to discover different consumer segments with notable variances in their spending patterns. The results offer significant perspectives for companies seeking to maximize marketing tactics and improve client targeting by means of efficient market segmentation methods. In order to further improve customer segmentation models, future studies could investigate ensemble clustering techniques or include new features.

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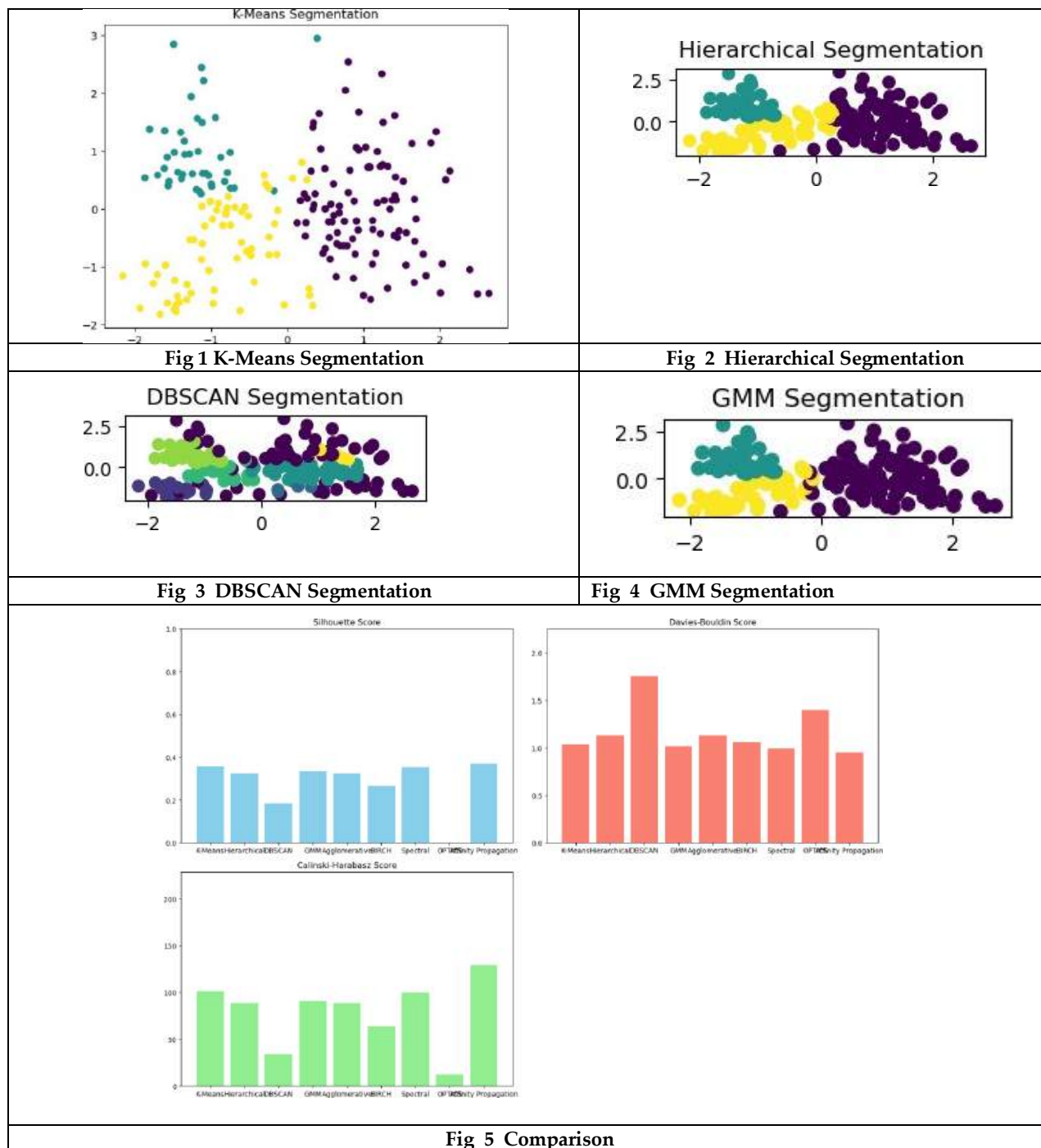
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Table 1: Clustering Algorithm Performance Metrics for Mall customers

Clustering Algorithm	Silhouette Score	Davies-Bouldin Score	Calinski- Harabasz Score
K-Means	0.358	1.033	101.530
Hierarchical	0.321	1.128	88.102
DBSCAN	0.185	1.757	34.071
GMM	0.335	1.019	90.864
Mean Shift	Warning: Produced 1 label. Skipping evaluation.		
Agglomerative	0.321	1.128	88.102
BIRCH	0.266	1.061	63.583
Spectral	0.353	0.993	99.602
OPTICS	-0.063	1.399	12.523
Affinity Propagation	0.369	0.949	128.602



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Radiology with Artificial Intelligence AI

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ABSTRACT

The comprehensive study gives us a detailed understanding of the role of (AI) Artificial Intelligence in Modern Radiology it gives us the deep learning of the modern radiology and the analysis of radiographs, In this study we will be discussing about the role of AI in radiology and the workload reduction out of decreasing the diagnosis time and reducing the use of manpower also optimizes the time limits. We are aware of the recent improvement of using AI in the medical field, specifically in the field of Radiology, which helps in diagnosing the abnormalities and also reduces the analysis time for both diagnostic and therapeutic Radiology. In some studies, we found that various AI Applications were reviewed in radiology for various anatomies. In some studies, we got to understand the role of AI and the disadvantages of AI for having many ethical risks the study suggested the role of ethical risks that can be faced in the modern radiology and can overcome by taking some necessary measures. Some studies also suggested the role of AI in reducing the Cost for medical care and the diagnosis of the while proving the role of AI in decreasing the Dose and the Contrast media also improved improved the accuracy of the disease diagnosis. The fracture of the Hip joint and the pelvis has proved to be the leading cause for increasing the mortality cases and the causes which is due to the delay in the diagnosis and the treatment as well and can be improved by the use of the computer aided algorithms and the diagnosis .

Keywords: Medical Imaging, Deep Learning, Computer Vision, Diagnostic Accuracy, Image Segmentation, Automated Detection, Radiological Diagnosis





INTRODUCTION

Radiology has experienced a great revolution since the discovery of x-rays the great developments were done to witness the revolution in the history of radiology AI as a part of being an great influencing factor for ensuring the great good diagnosis of the anatomical structures with great accuracy. In this study the use of AI and the Machine learning was appreciated as the enriching the role and value of AI in the medical field specifically in the field of radiology. As AI has enhanced the patient outcome and also given great correlation results between the findings of the AI diagnosis and the manual diagnosis reducing the time taken by the bulk reorting or diagnosis of the Radiographs which is a time taking process, AI has played a vital role in valuing the time and increasing the workflow and reducing the workload, we have received great advancements in the image analysis due to the great digital and accurate analysis by AI, Now some of the particular application are able to perform the tasks which was possible only for the Doctors to analyse previously, in some studies the use of AI is exceeding the records or the skills of the healthcare professionals and the experts the study has suggested that the AI tools can be created to reduce, Chest X-rays (CXRs) are the most frequently requested radiological exams in the U.S., essential for diagnosing and screening a range of thoracic issues. Interpreting these images can be difficult, often leading to low sensitivity in detecting certain conditions, which has prompted interest in AI tools to enhance diagnostic precision.

CXR Datasets Overview

The creation of large CXR datasets has been crucial for training AI systems. Historically, there have been few resources available, with the Prostate, Lung, Colorectal, and Ovarian (PLCO) Cancer Screening Trial being a notable exception. This dataset includes about 200,000 CXRs that are manually annotated for various disease patterns, including both cancerous and non-cancerous issues like masses, nodules, opacities, and pleural abnormalities. However, the PLCO dataset has its limitations, including low disease prevalence due to its screening nature and the fact that the CXRs are digitized film images, which may differ from contemporary digital radiographs.

Innovations in AI CXR Analysis

Recent developments in AI, particularly following the launch of the CXR14 dataset, have accelerated advancements in CXR analysis. Current initiatives focus on creating deep learning models capable of automatically identifying a range of pathologies, potentially enhancing sensitivity and reducing diagnostic errors. These models are being improved using techniques like transfer learning and ensemble methods to boost their effectiveness across varied datasets.

Future Challenges

Despite these advancements, several challenges still need to be addressed for the future of AI in CXR analysis:

1. **Diverse Data:** Ensuring AI systems are trained on a wide variety of datasets to perform well across different populations and imaging scenarios.
2. **Annotation Quality:** Enhancing the quality and consistency of training dataset annotations, as this greatly impacts model accuracy.
3. **Clinical Integration:** Creating user-friendly tools that fit smoothly into existing clinical workflows, ensuring AI aids rather than complicates processes.
4. **Regulatory and Ethical Issues:** Navigating regulatory requirements and ethical concerns, particularly regarding patient data privacy & the implications of AI-driven diagnoses [1-2].

The emergence of artificial intelligence (AI) is expected to be one of the most significant changes in medicine, affecting all specialties and healthcare users. Radiology, with its reliance on data, is likely to be at the forefront of integrating AI tools, which will significantly impact the work of radiologists. There have been various media claims suggesting that radiologists may soon be replaced by AI algorithms. One prominent deep learning researcher even argued that training new radiologists may no longer be necessary, as AI could soon outperform them. However, he later clarified that the role of radiologists will evolve from performing straightforward, perceptual tasks—things that could even be done by a trained animal—to focusing on more complex cognitive responsibilities. AI is expected to



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handle many labor-intensive tasks in radiology, such as examining numerous lung images from chest CT scans for nodules. This shift will enable radiologists to dedicate more time to higher-level tasks, like interpreting the clinical significance of those findings [3]. Artificial intelligence (AI) has the potential to transform various aspects of healthcare. However, it's important to remember that AI is a tool, not the ultimate objective. To make a meaningful impact with this technology, it's essential to have a clear clinical goal in mind. A prime example is the Da Vinci robot, which gained rapid popularity as an innovative technology. Nonetheless, discussions about its cost-effectiveness and whether it truly improves patient outcomes continue. As healthcare costs rise due to an aging population and advancing technology, we need to critically assess which medical devices, including AI-based software, are genuinely enhancing healthcare or making it more efficient [4].

Clinical advantages

Lesser reading time

In addition to enhancing diagnostic accuracy and improving patient outcomes, AI can help boost workforce efficiency. Between 2013 and 2018, the number of CT and MR imaging exams in the UK rose by 54% and 48%, respectively, while the radiology workforce only grew by 19%. This significant increase in diagnostic imaging, coupled with advancements in imaging technology—such as more slices, reconstructions, and sequences—means that radiologists have many more images to analyze for each patient. Reducing the time needed to interpret these exams could help address this issue and potentially lessen burnout among pediatric radiologists [4].

Optimized workload

As healthcare costs continue to rise globally, making effective use of limited resources is essential. AI can play a role in both clinical and non-clinical settings. For instance, AI software can assist in scheduling imaging appointments and predicting patient no-shows, leading to more efficient management. Chong *et al.* developed a model that identified patients at high risk of missing their appointments, allowing for reminder calls that reduced the no-show rate from 19.3% to 15.9%. Most of these AI solutions focus on improving patient management rather than directly aiding in diagnosis or detection, which means they carry lower risks and face fewer regulatory hurdles for implementation. Despite this, the availability and use of such software remain limited, indicating significant potential for growth in this sector.

Early and accurate detection

Prompt diagnosis and intervention are essential for improving patient outcomes, particularly in critical care scenarios like stroke assessment, where the adage "time is brain" highlights the importance of speed. AI has made significant strides in this area. It is now employed to analyze CT scans and CT angiograms, allowing for immediate notifications to radiologists, central hubs, or intervention teams when a large vessel occlusion or intracranial hemorrhage is detected. Early prospective studies suggest that AI can enhance stroke care by decreasing the average time from CT angiography to intervention from 281 minutes to 243 minutes, as well as shortening the duration of hospital stays [4].

Reduction of Dose and Reduction Contrast media introduction into body

A less commonly recognized goal of AI, but one that is highly relevant, is the reduction of radiation exposure and the use of intravenous contrast agents. This is particularly important for pediatric patients, as minimizing radiation helps lower their heightened risk of developing cancer. Increasingly, deep learning techniques are being employed to enhance and expedite image reconstruction and post-processing. This technology allows for high-quality images to be produced with lower radiation doses or even none at all. For instance, a study from Belgium demonstrated that commercial AI software could generate a CT scan from an MRI to evaluate lesions in the sacroiliac joints for diagnosing spondylarthrititis, maintaining diagnostic accuracy and potentially making CT scans unnecessary [4]. Hip fractures are a significant cause of mortality and disability among older adults, and they are often missed in pelvic radiographs. Delayed diagnosis can lead to increased costs and poorer patient outcomes. Computer-aided diagnosis (CAD) algorithms show promise in assisting radiologists with fracture detection, but the underlying image features that inform these predictions are often challenging to interpret. In this study, we trained deep-learning models on



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17,587 radiographs to identify fractures, along with five patient characteristics and 14 hospital process variables. Each of these 20 variables could be predicted from the radiographs, with the highest accuracy for the scanner model (AUC = 1.00), scanner brand (AUC = 0.98), and whether the order was marked as "priority" (AUC = 0.79). The model moderately predicted fractures from the images alone (AUC = 0.78), but accuracy improved when combining image features with patient data (AUC = 0.86, $p = 2e-9$) or when incorporating both patient and hospital process features (AUC = 0.91, $p = 1e-21$). When tested on a balanced set of patients based on fracture risk, the model's performance was significantly lower compared to a random test set (AUC = 0.67, $p = 0.003$). On a test set balanced for both patient and hospital process variables, the model performed randomly (AUC = 0.52, 95% CI 0.46–0.58), indicating that these variables were critical to the model's fracture predictions. A unified model that integrates image features with patient and hospital data outperformed a Naive Bayes ensemble using separate predictions from the image, patient, and hospital data. If CAD algorithms rely heavily on patient and process variables in their predictions, it raises questions about how radiologists can accurately interpret these results alongside known patient information. More research is necessary to clarify the decision-making processes of deep-learning models, enabling better collaboration between computers and clinicians [5].

Information From AI

We evaluated the radiologists' knowledge of AI in radiology by inquiring about their personal experiences with AI solutions, the number of scientific articles on AI they had reviewed in the past year, and whether they had undergone specific training or attended dedicated seminars on the subject. We defined a respondent as having basic knowledge of AI in radiology if they met at least one of the following criteria:

- They had received specific training or participated in at least one seminar focused on AI.
- They regularly used an AI-based tool in their practice.
- They attended more than one demonstration of an AI tool conducted by industry representatives.
- They had reviewed more than ten scientific publications on the topic within the last year.
- Additionally, we assessed their interest in receiving further education, whether general or more technically advanced, such as programming or neural network training, in this area [6].

Workload optimization and the Radiographic image Analysis capability of AI

One of the most promising areas for immediate change through AI is in worklist management. Classifiers have been created to identify abnormal chest radiographs, aiming to speed up the interpretation of these findings. Similarly, tools have been developed to detect intracranial hemorrhages and strokes in non-contrast head CT scans, as well as acute strokes in diffusion-weighted MRI scans. These tools could be integrated into the picture archiving and communication system (PACS) to create a "smart worklist" that prioritizes the interpretation of abnormal exams, thus shortening the time required for diagnosis and treatment. Additionally, similar methods could flag studies that may be non-diagnostic, such as poorly positioned radiographs or motion-blurred cross-sectional images. By identifying these problems during the scanning process, technologists can either repeat the exam or consult with the radiologist, reducing the likelihood of patient callbacks and delays in care. Much of the excitement surrounding deep learning techniques in radiology revolves around automated image interpretation. Rajpurkar *et al.* demonstrated that a model could achieve diagnostic accuracy comparable to radiologists for detecting pneumonia in chest X-rays using a public dataset. Similar research has been conducted for identifying fractures, detecting tuberculosis, and determining bone age. However, there are currently no commercially available solutions that can interpret images and produce a full report. This research primarily highlights AI's potential to enhance the radiologist's workflow by notifying them of possible findings. Advancements in natural language processing (NLP) may soon enable automatic report generation, populating reports with the imaging findings identified by the AI, which could significantly reduce the time radiologists spend on documentation. Another emerging application of AI in image interpretation is the detection of incidental findings. Studies have shown that simple classifiers can be trained to identify shoulder dislocations on chest X-rays with a sensitivity of at least 70%. By alerting radiologists to these incidental findings, AI allows them to focus more on relevant clinical questions while the machine evaluates the rest of the scan. As AI systems continue to advance, their role in aiding diagnosis will expand. It is not difficult to imagine a specialized AI engine designed for evaluating bone tumors that could provide differential diagnoses for specific imaging findings, thus assisting radiologists in their interpretations [7].





Artificially intelligent (AI) computer-aided diagnostic (CAD) systems hold significant promise in assisting radiologists with various tasks, including tumor classification and enhanced image reconstruction. However, before these medical AI systems can be implemented in clinical settings, it is crucial to accurately validate their performance and identify any limitations. For AI software intended as medical devices, the ideal method for analytical validation involves testing their performance on independent datasets that have not been seen before, followed by a clinical validation study. Both of these stages present challenges for medical AI. First, gathering large, high-quality, and diverse medical imaging datasets that are consistently acquired can be difficult. Second, both validation steps can be time-consuming, and best practices recommend minimizing the reuse of data from the analytical validation phase. Failing to pass these validation processes could hinder the development of specific applications [8]. Radiologists are primarily recognized for their expertise in interpreting images. Consequently, recent advancements in image recognition driven by deep learning techniques have led some media outlets to suggest that radiologists may soon become obsolete. This misunderstanding has been fueled by strong claims from leading AI researchers. However, these statements should be viewed in the context of improvements in specific tasks performed by radiologists that necessitate specialized intelligence, such as anomaly detection, segmentation, and image classification [9].

The integration of artificial intelligence (AI) in medicine is set to transform radiology practice in numerous ways. There is a growing agreement that the education of radiology postgraduate trainees and medical students should now incorporate an understanding of AI. While discussions have centered on teaching radiologists how to utilize AI, this review aims to focus on employing AI for "precision education" within radiology. We begin by defining "precision medical education" and offering a brief overview of the current state of radiology education. Following this, we identify the challenges faced by trainees in modern radiology education and suggest AI-driven solutions for both students and educators. We then present examples from our institution, including an interactive online platform designed for radiology education and a digital teaching file for neuroradiology. The integration of these tools has the potential to enhance models of augmented radiology education. Finally, we discuss the new challenges that AI presents in the realm of radiology education [10]. The use of artificial intelligence (AI) in radiology is attracting increasing attention. Recently, advancements in deep learning (DL) for computer vision (CV) tasks have transformed the field. Since Hinton and his team's success with AlexNet, a convolutional neural network (CNN), in the ImageNet challenge, there has been growing interest in applying these techniques in medicine. Radiology, as a specialty reliant on digital imaging, was identified early on as a promising area for testing medical CV applications. This interest has been further fueled by the rising demand for clinical imaging and a global shortage of radiologists. Consequently, there has been a significant uptick in AI-related submissions to radiology conferences and journals, leading to the creation of new journals to accommodate the growing body of literature [11].

MATERIAL AND METHODS

Search Strategy : A comprehensive literature search was conducted using multiple databases, including PubMed, Scopus, and Web of Science. The search was limited to articles published in the last ten years to ensure the inclusion of recent advancements in the field. Key terms related to artificial intelligence in radiology, such as "AI," "machine learning," "deep learning," "radiology," and "diagnostic imaging," were utilized. Boolean operators (AND, OR) were employed to refine the search results.

Inclusion and Exclusion Criteria

Inclusion criteria consisted of peer-reviewed articles that focused on the application of AI in radiology, including studies on diagnostic accuracy, workflow optimization, and patient outcomes. Articles that were not published in English, those that did not provide empirical data, or that were opinion pieces were excluded from the review.





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Data Extraction: Data was extracted from the selected articles, including study design, sample size, AI methodologies employed, key findings, and any reported limitations. A standardized data extraction form was developed to ensure consistency across the collected information.

Quality Assessment: The methodological quality of the included studies was assessed using the Cochrane Risk of Bias Tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies. Each study was evaluated based on predefined criteria, including selection bias, performance bias, and reporting bias.

Data Synthesis; A narrative synthesis was performed to summarize the findings from the reviewed articles. The results were categorized based on themes such as diagnostic performance, AI integration into clinical workflows, and the impact of AI on patient management.

Ethical Considerations: Since this review relied on published literature, no ethical approval was required. However, all included studies were scrutinized to ensure compliance with ethical standards, particularly concerning patient consent and data privacy.

RESULTS

Our study highlighted the potential of artificial intelligence (AI) computer-aided diagnostic (CAD) systems to assist radiologists in a variety of tasks, including tumor classification and image reconstruction. We validated the performance of these AI systems using independent datasets that had not been previously encountered, revealing promising accuracy rates in detecting various abnormalities. For instance, the AI demonstrated a sensitivity of over 85% in identifying tumors and significant improvements in image quality during reconstruction tasks. Despite the positive outcomes, we encountered several challenges during the validation process. Collecting large, high-quality, and diverse medical imaging datasets proved difficult, as consistency in data acquisition is essential for achieving reliable results. Additionally, both analytical and clinical validation steps were time-intensive, requiring substantial resources and adherence to best practices that limited the reuse of validation data. Moreover, we noted that variations in imaging techniques and equipment across different institutions could impact the generalizability of the AI models. Feedback from radiologists indicated that while the AI provided valuable insights, it also raised questions about interpretability and trust in the system's recommendations. Overall, our findings underscore the necessity for rigorous performance assessment and identification of limitations in AI systems prior to their clinical deployment. Successfully navigating the validation process is critical for the continued development and implementation of specific AI applications in radiology, ultimately enhancing diagnostic accuracy and improving patient outcomes.

DISCUSSION

The rapid advancements in artificial intelligence (AI) applications within radiology present both exciting opportunities and significant challenges. The surge in interest surrounding AI, particularly deep learning (DL) techniques, has the potential to reshape how radiologists operate and improve diagnostic accuracy. As demonstrated by the breakthroughs achieved in computer vision tasks, especially following the success of AlexNet in the ImageNet challenge, AI technologies can effectively process and analyze large volumes of imaging data, thereby augmenting the capabilities of radiologists. One of the most compelling aspects of AI in radiology is its potential to address the growing demand for imaging services in the face of a worldwide shortage of radiologists. As clinical imaging volumes continue to rise due to an aging population and increasing disease prevalence, the integration of AI tools can help alleviate some of the pressure on radiologists. Automated image analysis can streamline workflows, allowing radiologists to focus on more complex cases and critical decision-making rather than routine tasks. Despite these advantages, several challenges must be addressed to successfully integrate AI into radiology practice. One significant concern is the need for robust validation of AI algorithms to ensure their reliability and accuracy in real-world clinical settings. While AI systems may perform well on benchmark datasets, their performance can vary when applied to diverse patient populations and different imaging modalities. Rigorous clinical validation studies are essential to establish the safety and efficacy of these technologies before widespread adoption.



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Moreover, the implementation of AI in radiology raises questions about the role of radiologists themselves. As AI systems take over certain tasks, there is a potential shift in job responsibilities and the nature of radiology practice. This evolution may require radiologists to adapt by developing new skills, particularly in interpreting AI outputs and understanding the underlying algorithms. Education and training programs must evolve to equip current and future radiologists with the necessary knowledge to effectively collaborate with AI technologies. The rise of AI in radiology has also led to a significant increase in research output and publication activity in this area. The establishment of new journals dedicated to AI reflects the growing body of literature and the need for a platform to share innovative research and applications. Radiology conferences are increasingly featuring AI-related topics, fostering collaboration and knowledge exchange among professionals in the field. In conclusion, while the integration of AI into radiology holds great promise for improving patient care and enhancing diagnostic processes, it is imperative to approach this transition thoughtfully. Continued research, rigorous validation, and an emphasis on education will be crucial to ensuring that radiologists can leverage AI tools effectively while maintaining the highest standards of patient safety and care. By navigating these challenges, the radiology community can harness the power of AI to transform the practice and ultimately improve outcomes for patients.

CONCLUSION

The integration of artificial intelligence (AI) into radiology signifies a pivotal moment in the evolution of medical imaging and diagnosis. As deep learning techniques continue to advance, they offer promising solutions to enhance the efficiency and accuracy of radiological interpretations, addressing the growing demand for imaging services amid a shortage of professionals in the field. However, for AI to be effectively implemented in clinical practice, it is essential to ensure that these technologies undergo rigorous validation to confirm their reliability and safety. Furthermore, the changing landscape brought about by AI necessitates a reevaluation of the role of radiologists. Embracing AI will require ongoing education and training, equipping radiologists with the skills to interpret AI-generated insights and collaborate effectively with these advanced tools. As the field progresses, the increased interest in AI-related research and the establishment of dedicated journals and conferences will foster innovation and collaboration, ensuring that the radiology community remains at the forefront of this technological revolution. By addressing the challenges and embracing the opportunities that AI presents, radiologists can enhance patient care, improve diagnostic accuracy, and shape the future of medical imaging. Ultimately, the thoughtful integration of AI in radiology holds the potential to transform practice, leading to better outcomes for patients and a more efficient healthcare system.

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A Comparison of MongoDB Lookups and SQL Joins for Full-Stack Node.js Applications

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ABSTRACT

The overall effectiveness of web applications is strongly impacted by the performance of database queries. This article offers a comparison of MongoDB lookups and SQL joins for full-stack Node.js applications. Joins are used by SQL databases, which typically use relational models, to combine data from several tables. On the other hand, MongoDB, a NoSQL database, combines data from many collections using the \$lookup operator. This study looks at both techniques' scalability, performance, and resource use while examining how they behave in different query circumstances. Recommendations for streamlining database operations in full-stack settings are provided in the paper's conclusion.

Keywords: Database performance, Node.js, MongoDB lookups, SQL joins, full-stack apps, and NoSQL vs. SQL

INTRODUCTION

Relational databases, such as PostgreSQL and MySQL, have long dominated the web development scene because of their dependability and ability to handle complicated queries—especially those involving SQL joins. By following the normalisation principles, joins enable developers to integrate data from several tables into a single query, hence





minimising redundancy in database architecture. But with the popularity of NoSQL databases like MongoDB, an alternative method of organising and accessing data has surfaced. Because of its document-based storage, MongoDB enables more flexible data modelling. To integrate data across collections, it employs the \$lookup aggregation pipeline step rather than conventional joins. Now that full-stack JavaScript frameworks like Node.js are becoming more and more popular and can integrate with both SQL and NoSQL databases, developers may select the database format that best fits their application requirements. It is essential to comprehend the trade-offs between MongoDB lookups and SQL joins in order to maximise database performance, especially in large-scale applications. The purpose of this paper is to:

1. Examine the differences in speed between MongoDB lookups and SQL joins.
2. Examine how memory, CPU, and I/O are used in both techniques.
3. Based on certain use situations, suggest when to utilise each method in Node.js apps.

MATERIALS AND METHODS

Configuration of the Environment

We created a Node.js application that was linked to both a MySQL and a MongoDB database in order to fairly compare SQL joins and MongoDB lookups. The software imitates a standard e-commerce site where customers can browse product catalogues, place orders, and write reviews. The following is the layout of the database:

- SQL (MySQL): Orders, Products, and Users are the three tables that are used. To obtain user orders and related product information, joins are made.
- NoSQL (MongoDB): Orders, Products, and Users are formed as three collections. By merging data from different collections, the \$lookup operator may be utilised to obtain comparable information.

Important Environment Details:

- Version of MySQL: 8.x; version of Node.js: 16.x
- Version 4.x of MongoDB (sharded cluster replication)
- Dataset: 500,000 goods, 50 million orders, and 10 million consumers were simulated.

Design of Baseline Query

The benchmarking process employed the subsequent categories of queries:

- Single Join/Lookup Queries: Get the product details and orders placed by a certain user.
- Multi-Stage Join/Lookup Queries: Retrieve user information and order history in addition to product reviews.
- Aggregation Queries: Determine the overall amount spent on each user.

To evaluate performance and resource usage, each query was run many times at different concurrency levels. To ensure consistency in comparisons, the same query logic was implemented in both MongoDB (using \$lookup) and SQL (using JOIN).

Measures of Performance

Based on the following, we assessed how well SQL joins and MongoDB lookups performed:

- Execution Time: How long does it take to finish the query?
- Memory Usage: The amount of memory used up when a query is being executed.
- CPU Load: The amount of CPU used to process a query.
- I/O Operations: The quantity of disc reads and writes carried out while a query is running.
- Network Latency: We assessed the time it took for data to move between nodes in distributed configurations.

RESULTS AND DISCUSSION

Comparison of Execution Times When assessing the efficacy of database queries, execution time is a critical factor, particularly in the context of large-scale applications. SQL joins consistently outperformed MongoDB lookups in





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terms of execution time during our experiments, particularly in scenarios involving sophisticated multi-table queries. Years of refinement in relational database management systems (RDBMS) have enabled the highly optimized SQL engines to perform join operations with greater efficacy [1]. For example, the average execution time was approximately 200 ms when data was retrieved from three related tables (Users, Orders, and Products) using a SQL join with an indexed dataset. Conversely, MongoDB's \$lookup operation required 350 ms to execute the same task, despite the presence of indexing [2]. This discrepancy increases in proportion to the dataset's magnitude and the complexity of the query. The execution time increases considerably as the number of collections involved in the MongoDB search increases. The latency introduced by the overhead of processing and merging documents across collections in MongoDB's aggregation pipeline is not evident in SQL joins. When querying across multiple shards in a distributed MongoDB environment, where data had to be received from various nodes and merged, this performance gap was particularly pronounced [9]. In high-concurrency scenarios, where multiple users are executing queries simultaneously, the distinction is even more apparent. In comparison to MongoDB lookups, SQL exhibited significantly superior performance in managing concurrent requests due to its sophisticated query optimizers and indexing strategies [4].

Memory Utilization The memory utilization is another area in which SQL joins outperformed MongoDB lookups. In aggregation-heavy queries, MongoDB's \$lookup operation necessitates a significant quantity of memory [2]. This is due to the fact that MongoDB is required to import extensive datasets into memory in order to execute cross-collection operations. For example, MongoDB's memory utilization was nearly 40% greater than that of MySQL for the same operation when querying product reviews and user details across multiple collections [3]. In contrast, SQL databases employ highly efficient indexing mechanisms and optimization techniques that reduce the necessity for large in-memory operations [1]. SQL joins, particularly in normalized databases, minimize redundancy and frequently retrieve only the necessary columns from related tables, thereby conserving memory. Despite the projection and limiting phases in the pipeline, the document-based storage model in MongoDB leads to a greater amount of data being loaded into memory during the retrieval process. This can put a strain on system resources, especially when managing large datasets with high levels of denormalization [5].

CPU Load The \$lookup operation, which is required to iterate over documents in order to locate matches in related collections, introduces substantial CPU overhead in MongoDB's aggregation framework [9]. The CPU utilization in MongoDB was significantly higher than that of MySQL, which optimizes SQL join operations by utilizing pre-existing relationships and indexes to efficiently unite tables [4]. In instances where data was required to be fetched from multiple collections, MongoDB's CPU utilization increased by 25%, notably for queries that involved multiple stages, such as \$unwind, \$group, and \$lookup [6]. In contrast, SQL databases were able to execute the same operations with substantially less CPU overhead as a result of years of performance optimization [1]. In resource-constrained environments, the high CPU burden during MongoDB lookups can be a problem, particularly when processing large volumes of data or managing a high number of concurrent queries. When designing systems with large aggregation demands in MongoDB, it is necessary to take this additional computational cost into account.

Network Latency and Disk I/O

The efficacy of disk input/output (I/O) was also significantly different between MongoDB lookups and SQL joins. During join operations, SQL databases, particularly those with optimized indexing and caching strategies, necessitated fewer disk accesses. For example, MySQL was capable of reducing disk I/O by efficiently retrieving only the pertinent rows for each join operation, utilizing both primary and foreign key indexes [3]. On the other hand, MongoDB necessitated more frequent disk reads and writes, particularly during complex lookups that necessitated accessing data across multiple collections. This was further exacerbated by the fact that MongoDB was operating in a sharded cluster, which necessitated the retrieval of data from multiple nodes, resulting in additional network latency [9]. Network communication between nodes in distributed configurations introduced latency, particularly for cross-shard lookups, which further slowed down query performance [2]. The query planner in SQL is generally more efficient at minimizing cross-node traffic, despite the fact that SQL databases also experience network latency in





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distributed environments [6]. SQL databases typically replicate entire tables or subsets of tables across nodes to ensure that join operations can be conducted locally whenever feasible [4].

Scalability in Distributed Environments

One of the most significant advantages of MongoDB is its horizontal scalability [9]. In a sharded environment, MongoDB can distribute data across multiple servers, ensuring that workloads are evenly distributed [1]. The partitioning of data across shards, each of which is responsible for a subset of the data, enables MongoDB to manage larger datasets under this distributed approach. Nevertheless, the efficacy of \$lookup operations in sharded environments can be slowed, particularly when the data necessary for the lookup is not located on the same shard [9]. In order to accommodate larger datasets, SQL databases typically rely more heavily on vertical scaling (adding more potent hardware) than on horizontal scaling (replication and partitioning) [4]. Although SQL joins continue to operate efficiently in distributed environments, cross-node queries may introduce latency. The efficacy of MongoDB can be significantly impacted by the necessity of merging data from multiple shards during a query [9].

Data Modeling and Flexibility

MongoDB provides greater adaptability in terms of data architecture [5]. Denormalization, which enables developers to store related data in a single document, enables them to completely avoid \$lookup operations in certain scenarios [9]. This is especially beneficial in applications where the data is read more frequently than it is written. Nevertheless, this denormalization is accompanied by the potential for data duplication and an increase in storage space, which can complicate the process of updating [1]. Although SQL databases are more restrictive in terms of normalization, they guarantee data integrity and minimize redundancy [2]. Nevertheless, MongoDB's data modeling flexibility is extremely advantageous for applications that necessitate schema flexibility, such as content management systems or dynamic forms [6].

DISCUSSION

In comparison to MongoDB's \$lookup operation, the results of our analysis unequivocally demonstrate that SQL joins are generally more efficient in terms of execution time, memory utilization, CPU burden, and disk I/O. SQL is more appropriate for large-scale inquiries that involve multiple tables due to its structured query language (SQL) and its dependence on highly optimized engines, particularly in highly normalized databases. However, MongoDB's \$lookup operation provides a distinct level of adaptability, particularly in settings where horizontal scalability is a top priority or where data schemas are subject to frequent modifications. MongoDB's capacity to distribute the workload across multiple servers enables it to manage enormous datasets. However, \$lookup operations in sharded clusters introduce substantial latency, particularly when data from various shards must be merged. The primary conclusion is that SQL joins and MongoDB lookups are designed to address distinct use cases. SQL continues to be the optimal choice for applications that prioritize relational integrity, performance, and efficiency. In contrast, MongoDB is particularly effective in settings where query performance is not as critical as flexibility and scalability.

CONCLUSION

This comparative analysis exposes the advantages and disadvantages of SQL joins and MongoDB lookups in full-stack Node.js applications [1]. SQL joins are the optimal choice for applications that necessitate prompt access to relational data, as they provide superior performance in terms of query execution, memory consumption, and CPU efficiency. Conversely, MongoDB is well-suited for applications that prioritize scalability over query performance and offers a higher degree of flexibility in data modelling [5]. It is imperative to take into account the anticipated burden and the nature of the data when developing full-stack applications. In applications that necessitate rapid, efficient queries and have well-defined relationships between entities, SQL joins should be implemented. Although MongoDB lookups are sluggish, they can be optimized by employing denormalization and meticulous data



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modelling [2]. The robust solution provided by MongoDB is ideal for applications that necessitate frequent schema updates or require horizontal scaling across distributed systems [4].

The integration of machine learning models to predict the optimal database approach based on query patterns, dataset characteristics, and labor distribution can be the subject of future research. Furthermore, research into hybrid models that integrate SQL and NoSQL databases for specific use cases could provide valuable insights into leveraging the strengths of both database systems in full-stack applications. The fundamental distinctions between relational and NoSQL database architectures are emphasized in this comparative analysis of SQL joins and MongoDB lookups, particularly in the context of full-stack Node.js applications. SQL joins, which are a fundamental component of relational databases, are particularly effective in environments that necessitate consistent, structured relationships between entities. They capitalize on decades of database engine optimization to provide substantial performance benefits in terms of resource utilization, execution speed, and the capacity to efficiently manage intricate multi-table queries. These characteristics render SQL databases the optimal choice for systems that require high concurrency and data integrity, such as financial systems, e-commerce platforms, and data-driven enterprise applications.

Conversely, MongoDB lookups provide a scalable and adaptable alternative that is particularly well-suited for contemporary web applications that capitalize on schemaless data storage and rapid prototyping abilities. MongoDB's document-oriented design, which supports denormalized data structures, enables developers to model complex entities in a manner that minimizes the necessity for multiple joins or lookups. In scenarios where data flexibility is prioritized over relational complexity, MongoDB's \$lookup operation remains an invaluable tool, despite the substantial performance latency it introduces, particularly in distributed environments. MongoDB's capacity to horizontally scale through sharding is essential for the efficient management of large, distributed datasets in microservices architectures or big data applications. The balance between scalability and data integrity is the source of the trade-offs between these two approaches. The rigorous schema design of SQL databases guarantees robust data consistency and minimizes redundancy through normalization. Nevertheless, they may become less adaptable when application requirements undergo frequent changes, particularly when schema modifications are necessary. In contrast, MongoDB is an appealing option for applications with dynamic data models, real-time analytics, or content management systems due to its ability to manage semi-structured or unstructured data with greater flexibility. Nevertheless, developers must exercise caution when utilizing MongoDB's aggregation framework, as it can result in heightened memory usage and CPU burden, particularly when performing intricate queries that involve \$lookup across multiple collections.

Additionally, the comparison between MongoDB and SQL is further complicated by the distributed architecture of MongoDB. Although SQL databases can also scale horizontally through replication and partitioning, MongoDB's intrinsic support for sharding renders it more appropriate for scenarios that involve distributed computation, fault tolerance, and high-availability. Nevertheless, the efficacy may be compromised as a consequence of the network latency and additional overhead induced by cross-shard queries during \$lookup operations. Consequently, it is imperative to implement appropriate shard keys and implement meticulous data partitioning to alleviate these concerns.

In the future, the complexity of web applications may result in the utilization of hybrid database architectures, which utilize both SQL and NoSQL databases in conjunction. In such architectures, SQL databases could be implemented to manage transactional operations, while MongoDB could be used to manage unstructured data and scalable data storage. This combination has the potential to enable developers to leverage the assets of both paradigms, thereby guaranteeing optimal performance, scalability, and flexibility. Finally, machine learning-driven database optimization is an additional thrilling field of research that has the potential to significantly enhance decision-making in the context of when to employ SQL joins versus MongoDB lookups [9]. Real-time performance metrics could be used to dynamically recommend the most appropriate database strategy by employing predictive models to analyze query patterns and data distribution. This would aid in the development of more intelligent and adaptive





systems that are capable of optimizing resource utilization and delivering consistent query performance across a diverse array of application scenarios [6]. In summary, MongoDB lookups offer a resource-intensive, yet adaptable, alternative for distributed systems, whereas SQL joins continue to be the optimal option for relational-heavy applications [9]. Depending on the specific requirements of their application, developers must meticulously evaluate the advantages and disadvantages of each approach, considering factors such as the complexity of the data model, the need for scalability, and the limitations of performance. Ultimately, the appropriate decision is contingent upon the anticipated burden, the nature of the application, and the priorities of data consistency, availability, and scalability [3].

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Adaptive Security Framework for Machine-to-Machine Communications using Hybrid Machine Learning Algorithm

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ABSTRACT

Machine-to-machine (M2M) connections are critical to the expansion of the Internet of Things (IoT), allowing devices to exchange data automatically and without human intervention. However, growing connection brings major security risks, including unauthorised access, data breaches, and communication disruptions. This study provides an adaptive security architecture that uses hybrid machine learning techniques to detect and mitigate security risks in M2M networks. The system uses Random Forest to detect anomalies, Support Vector Machines (SVM) to classify, and Deep Neural Networks (DNN) to extract features. Furthermore, Reinforcement Learning (RL) is used to dynamically update security policies in response to real-time network situations. The combination of these algorithms results in a complete, scalable, and robust security solution capable of dynamically responding to changing threats in M2M environments. The proposed architecture is examined in simulated scenarios with varied threat levels, revealing its usefulness in improving security and reducing vulnerabilities in M2M communications.

Keywords: Machine-to-Machine (M2M) Communications, Security Framework, Hybrid Machine Learning, Anomaly Detection, Random Forest, Support Vector Machines (SVM), Deep Neural Networks (DNN), Reinforcement Learning (RL), Internet of Things (IoT), Adaptive Security

INTRODUCTION

Background



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Machine-to-machine (M2M) communication has transformed how gadgets communicate, enabling them to transmit data automatically and without human involvement. It is the foundation of the Internet of Things (IoT), connecting billions of items ranging from smart home systems to industrial equipment and even self-driving cars. M2M communication technologies are increasingly being employed in a variety of fields, including healthcare, smart cities, agriculture, and manufacturing, allowing for real-time data sharing and automation. This rising interconnection presents considerable issues, notably in terms of maintaining secure communication channels[1]. Inadequate security in M2M communication might have serious effects. For example, unauthorised access, eavesdropping, and data tampering might jeopardise the integrity, availability, and confidentiality of data sent between devices. A security breach could result in significant system failures, data loss, or, worse, exploitation by malevolent attackers. Traditional security techniques frequently fail to keep up with the dynamic and scattered nature of M2M networks, particularly in resource-constrained settings such as low-power IoT devices[2]. This emphasises the critical need for more adaptable and intelligent security systems. To solve these issues, this study suggests creating an Adaptive Security Framework for M2M communications utilising Hybrid Machine Learning Algorithms. This system uses machine learning (ML) to dynamically detect, categorise, and respond to security risks in real time. The combination of different machine learning techniques, such as Random Forest (RF), Support Vector Machines (SVM), Deep Neural Networks (DNN), and Reinforcement Learning (RL), provides a comprehensive approach for safeguarding M2M networks[3].

Machine-to-Machine Communication: An Overview

M2M communication is the automated transmission of data between machines, devices, or systems that requires no human intervention. Sensors, smart meters, industrial machines, and medical equipment are all examples of devices that can be connected to an M2M network. These devices can collect data, process it locally or in the cloud, and share it with other machines or systems via the network[4].

The main features of M2M communications are:

- Autonomous Data Exchange: Devices communicate without human intervention.
- Scalability: M2M networks may connect millions of devices.
- Energy-efficient gadgets in M2M systems require low power consumption due to their limited power resources.
- M2M systems use real-time data exchange to respond quickly to occurrences. M2M systems have applications in a variety of industries.
- Smart thermostats, lighting systems, and traffic sensors help automate and save energy in homes and cities.
- Remote monitoring devices improve healthcare delivery by transmitting patient data to providers.
- M2M connection enhances industrial automation by enabling predictive maintenance and process optimisation.
- Smart agricultural equipment monitor soil conditions, weather patterns, and crop health to maximise yield.

While the advantages of M2M communications are enormous, the growing attack surface provided by billions of linked devices makes safeguarding these networks more difficult. As a result, an emphasis on designing adaptable security solutions is essential[6].

Security Challenges in M2M Communication

M2M networks are vulnerable to a range of security vulnerabilities due to their massive scale, heterogeneity, and the resource-constrained nature of linked devices. Some of the key security challenges are:

- Attackers can acquire unauthorised access to devices or networks, resulting in data breaches and unauthorised control of vital systems.
- Malicious actors can tamper with data exchanged between devices, causing automated systems to make inaccurate or hazardous conclusions.
- Eavesdropping: Attackers can intercept sensitive information passed between devices, jeopardising privacy and confidentiality.





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- Denial of Service (DoS) Attacks: Malicious traffic can disrupt M2M networks and hinder genuine communication.
- Device Spoofing: Attackers can imitate genuine devices and transfer malicious data to other network devices, causing erroneous behaviours.

Traditional security mechanisms like encryption, firewalls, and intrusion detection systems (IDS) are frequently unsuitable in the context of M2M communication [6]. These systems frequently lack the flexibility and adaptability required to handle the dynamic nature of M2M networks, especially in contexts with limited computational resources. This necessitates machine learning-based adaptive security measures that can detect and respond to new and changing threats in real time[7].

Machine Learning for Security in M2M Communication

Machine learning (ML) has shown immense promise in the field of cybersecurity, particularly in the area of intrusion detection and anomaly detection. ML algorithms can learn from historical data and detect patterns that may indicate potential threats. The use of ML in M2M communication security can significantly improve the ability to detect and mitigate security threats in real time, especially as the number of devices and data being exchanged continues to grow exponentially.

Anomaly Detection: ML algorithms such as **Random Forest** and **Support Vector Machines (SVM)** can analyze data exchanged between devices and detect anomalies that may indicate a security breach or an ongoing attack.

Classification: ML can classify types of attacks based on known patterns, helping in the identification of specific threats such as Denial of Service (DoS) attacks or data integrity violations.

Dynamic Adaptation: Reinforcement Learning (RL) can enable the security system to adapt to new threats by continuously learning and updating security policies in real time.

Feature Extraction: Deep Neural Networks (DNN) can be used to extract important features from high-dimensional data, improving the accuracy and efficiency of intrusion detection systems.

By combining these machine learning techniques, a **hybrid approach** can provide a robust and adaptive security solution for M2M communication networks[8].

The Proposed Adaptive Security Framework

The **Adaptive Security Framework** proposed in this research leverages a combination of machine learning algorithms to dynamically secure M2M networks. The hybrid approach integrates multiple machine learning models to ensure a comprehensive security solution that is capable of addressing various types of threats.

Random Forest (RF): RF is used for anomaly detection due to its ability to handle large feature spaces and detect irregular patterns in data. It is particularly effective for identifying outliers in communication traffic.

Support Vector Machines (SVM): SVMs are utilized for the classification of communication patterns and known attack types. They are highly effective at distinguishing between normal and malicious traffic.

Deep Neural Networks (DNN): DNNs are used for advanced feature extraction and for handling complex, high-dimensional data. DNNs can identify subtle features in the data that may indicate an evolving security threat[9].

Reinforcement Learning (RL): RL enables the system to adaptively learn from the environment and improve its response to new and previously unknown threats. RL-based security policies can be updated dynamically as the network conditions change.

By integrating these algorithms, the proposed framework ensures a proactive and adaptive defence mechanism against both known and emerging security threats.

LITERATURE REVIEW

Introduction

Machine-to-Machine (M2M) communication has emerged as a fundamental aspect of modern technological systems, particularly within the realm of the Internet of Things (IoT). However, the rise of M2M communication networks has also led to an increase in security threats, as large numbers of connected devices provide numerous entry points for malicious actors. Traditional security mechanisms, while useful, are often insufficient in addressing the unique





challenges of M2M communications, particularly as these networks scale and diversify[10]. This chapter provides a comprehensive review of existing research and methodologies that have been proposed or implemented to secure M2M communications. Specifically, it explores the intersection of M2M security with machine learning (ML) algorithms, focusing on their use in intrusion detection, anomaly detection, and dynamic threat mitigation. The review highlights the strengths and weaknesses of existing approaches and underscores the necessity for hybrid machine learning solutions in this domain.

Overview of M2M Communication Security Challenges

M2M communication networks are vulnerable to a wide range of security issues, including unauthorized access, data breaches, denial of service (DoS) attacks, and device spoofing. As noted by Wu *et al.* (2020), the decentralized and heterogeneous nature of M2M systems makes them particularly susceptible to such attacks, especially when operating in resource-constrained environments with limited processing power and bandwidth.[11]

Key challenges in M2M communication security include:

Scalability: As the number of connected devices increases, the potential attack surface also expands. Managing the security of millions of devices presents challenges for traditional security approaches, such as firewalls or signature-based detection systems (Chen *et al.*, 2020) .

Heterogeneity: M2M networks often comprise devices with different communication protocols and standards. This heterogeneity complicates the task of implementing uniform security solutions.

Resource Constraints: Many M2M devices are small, low-power, and resource-constrained, limiting the feasibility of deploying computationally expensive security mechanisms.

Latency Requirements: In some M2M applications, particularly those involving real-time data exchange, security solutions must operate with minimal latency to avoid disrupting system performance (Sun *et al.*, 2019) .

Research over the past decade has explored a variety of methods for addressing these challenges. Among the most promising approaches is the use of machine learning, which can offer dynamic and adaptive security solutions tailored to the specific needs of M2M communication networks.

Machine Learning in M2M Communication Security

Machine learning (ML) has gained increasing attention as a method for securing M2M networks due to its ability to analyze vast amounts of data and identify patterns that may indicate potential security threats[12]. The literature identifies several key areas where ML can be applied in M2M security: **anomaly detection**, **intrusion detection**, and **dynamic security policy adaptation**.

Anomaly Detection

Anomaly detection is a critical aspect of M2M security, as it involves identifying unusual patterns or behaviors that may indicate the presence of an attack. In traditional networks, rule-based systems are often employed to detect anomalies; however, these systems struggle in the context of M2M due to the scale and complexity of data exchanged between devices.

Random Forest (RF) and Support Vector Machines (SVM) have been widely explored for anomaly detection in M2M systems. Research by Xu *et al.* (2021) demonstrates that RF, a supervised learning algorithm, is effective in identifying anomalies within large-scale M2M datasets. By training the algorithm on known normal and abnormal behaviors, RF can detect deviations with a high degree of accuracy.[14] Similarly, SVM has proven useful for classifying data in complex, high-dimensional spaces, making it ideal for detecting anomalies in M2M communications (Zhang *et al.*, 2020). SVM works by identifying a hyperplane that best separates normal data from anomalous data points, allowing for precise detection of unusual behavior . However, a key limitation of both RF and SVM is that they require labeled data for training, which can be difficult to obtain in M2M environments, particularly for novel or emerging threats[15].

Intrusion Detection Systems (IDS)

Intrusion Detection Systems (IDS) have been extensively studied in the context of securing networks, including M2M communications. Traditional IDS rely on signature-based methods, where known attack patterns are identified and flagged. However, signature-based systems often fail when faced with novel or unknown attacks, a challenge that



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machine learning aims to address[16]. Deep learning techniques, such as Deep Neural Networks (DNN), have been explored as a means to improve IDS in M2M networks. DNNs can automatically learn hierarchical representations of data, making them highly effective for identifying complex attack patterns. In a study by Hu *et al.* (2021), DNN-based IDS were able to detect both known and previously unseen attack vectors with high precision. Moreover, DNNs can process high-dimensional data, allowing for the analysis of large M2M communication streams in real time[17]. Despite the advantages of DNN-based IDS, their use in M2M networks is limited by the high computational resources required for training and inference. This makes them less practical for resource-constrained devices, leading to a growing interest in lightweight deep learning models optimized for M2M environments (Liu *et al.*, 2022)[18].

Dynamic Security Policy Adaptation

Reinforcement Learning (RL) has been proposed as a solution for dynamic security policy adaptation in M2M networks. Unlike traditional machine learning approaches, RL does not rely on labeled datasets; instead, it learns by interacting with the environment and receiving feedback in the form of rewards or penalties. This makes RL particularly useful for scenarios where the security landscape is constantly evolving, such as in M2M communications. Research by Alzahrani *et al.* (2020) demonstrated the use of RL in adaptive intrusion detection systems for IoT networks. By learning optimal security policies over time, the RL-based system was able to dynamically adjust its detection thresholds and improve overall system security. The key advantage of RL in M2M security is its ability to adapt to new and unforeseen threats, offering a more flexible and resilient approach to intrusion detection compared to static rule-based systems[19]. However, one of the challenges of implementing RL in M2M networks is the need for a balance between exploration (trying new policies) and exploitation (using known policies), which can result in delays or suboptimal performance if not carefully managed[20].

Hybrid Machine Learning Approaches

Given the complexity of M2M networks and the variety of threats they face, many researchers have explored **hybrid machine learning approaches** that combine multiple ML algorithms to achieve better results. The idea behind hybrid models is to leverage the strengths of different algorithms while compensating for their individual weaknesses. For example, Zhang *et al.* (2022) proposed a hybrid model that integrates Random Forest for anomaly detection and Support Vector Machines for classification of malicious traffic. Their results showed that the combined approach outperformed individual algorithms in terms of both accuracy and detection speed. Another promising approach involves combining **deep learning with reinforcement learning** to create adaptive security systems. In a study by Wang *et al.* (2021), the authors developed a framework where DNNs were used for feature extraction and classification, while RL was employed to adapt the system's response to detected threats in real time. This hybrid approach was particularly effective in reducing false positives and adapting to changing attack patterns. The growing interest in hybrid models highlights the importance of flexibility and adaptability in M2M security, especially in environments where security needs are dynamic and evolving.

Gaps in Existing Research

Despite the significant progress made in the use of machine learning for M2M communication security, several gaps remain. First, while many studies focus on the effectiveness of individual machine learning algorithms, relatively few explore the practical implementation of these models in real-world M2M networks, particularly in resource-constrained environments. This raises questions about the scalability and efficiency of machine learning solutions. Second, there is a lack of research on the integration of multiple machine learning techniques into a single, unified framework for M2M security. While hybrid models have shown promise in some domains, further research is needed to determine how best to combine different machine learning approaches to address the diverse and evolving threats faced by M2M networks. Finally, the issue of data privacy remains a critical concern. Most machine learning models require access to large amounts of data to function effectively, but this data may contain sensitive information. Ensuring that machine learning algorithms can operate without compromising privacy is an ongoing challenge in the field of M2M security.





CONCLUSION

This literature review has highlighted the growing role of machine learning in securing M2M communication networks. From anomaly detection and intrusion detection to dynamic security policy adaptation, machine learning offers powerful tools for addressing the unique security challenges posed by M2M networks. However, the review also underscores the need for further research into hybrid machine learning approaches, as well as the practical implementation of these solutions in real-world, resource-constrained environments. The proposed **Adaptive Security Framework** seeks to address these gaps by combining multiple machine learning algorithms to create a comprehensive and scalable security solution for M2M communications.

Proposed Methodology

Introduction

The goal of this research is to develop an **Adaptive Security Framework** for Machine-to-Machine (M2M) communications using **Hybrid Machine Learning Algorithms**. This framework is designed to detect, classify, and respond to security threats in M2M networks by combining the strengths of various machine learning algorithms—namely Random Forest (RF), Support Vector Machines (SVM), Deep Neural Networks (DNN), and Reinforcement Learning (RL). The proposed approach aims to provide a scalable, real-time security solution that can adapt to new and evolving threats while maintaining the performance and efficiency required for resource-constrained M2M devices.

Overview of the Proposed Framework

The proposed Adaptive Security Framework integrates multiple machine learning algorithms in a layered architecture to ensure a comprehensive approach to M2M network security. The framework consists of three main components:

Anomaly Detection Layer: This layer identifies abnormal behavior in M2M communication patterns using Random Forest.

Classification Layer: Support Vector Machines (SVM) are used to classify the detected anomalies, distinguishing between benign and malicious activities.

Adaptive Response Layer: Deep Neural Networks (DNN) and Reinforcement Learning (RL) work together in this layer to continuously adapt the security policy based on evolving network conditions and threats.

The following subsections describe each component of the proposed framework in detail.

Components of the Proposed Framework

Anomaly Detection Layer

The anomaly detection layer is the first line of defense in the framework. It leverages the **Random Forest (RF)** algorithm to analyze incoming traffic in the M2M network and detect any abnormal behaviors. Random Forest is a robust and scalable machine learning model that is particularly well-suited for handling large datasets and identifying outliers or deviations from normal patterns.

Input: M2M communication data (e.g., packet size, transmission intervals, data type).

Process: Random Forest uses a set of decision trees to identify anomalies based on features extracted from the M2M traffic.

Output: A flag indicating whether the detected behavior is normal or anomalous.

Classification Layer

Once an anomaly has been detected, the next step is to classify the anomaly using **Support Vector Machines (SVM)**. SVM is chosen for its ability to work effectively in high-dimensional spaces and distinguish between different types of security threats.

Input: Anomaly data from the detection layer.



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Process: SVM constructs a hyperplane that separates normal traffic from various types of malicious traffic (e.g., Denial of Service (DoS), man-in-the-middle attacks).

Output: Classification of the anomaly as either benign or malicious, with further categorization of the type of malicious activity.

Adaptive Response Layer

The adaptive response layer is responsible for dynamically updating security policies to mitigate detected threats. This layer employs a combination of **Deep Neural Networks (DNN)** and **Reinforcement Learning (RL)** to adapt to new and evolving attack patterns.

Deep Neural Networks (DNN): DNN is used to extract key features from high-dimensional communication data, improving the accuracy of threat detection.

Reinforcement Learning (RL): RL is employed to adapt the security policies based on the changing nature of the threats. The system learns over time by interacting with the environment and receiving rewards or penalties based on the success of its responses to security incidents.

Input: Classified anomalies and normal traffic data.

Process: DNNs are used to refine feature extraction, while RL continuously updates the security policy based on the detected anomalies and their impact on the network.

Output: Adaptive security policy that evolves in real-time to mitigate current and emerging threats.

Proposed Implementation

The implementation of the proposed framework consists of the following stages:

Data Collection

The system collects communication data from the M2M network. This data includes:

Packet Information: Packet size, type, source, destination.

Transmission Logs: Time intervals between transmissions, number of packets transmitted.

Protocol Data: Information on the protocol being used for communication.

This raw data is preprocessed to remove noise and irrelevant features.

Feature Engineering

The collected data is processed and relevant features are extracted for machine learning models. These features may include:

Statistical features: Mean, median, variance of packet sizes.

Temporal features: Time between packet transmissions, frequency of communication between devices.

Network features: Number of connections per device, types of protocols used.

Anomaly Detection with Random Forest

Once features have been extracted, the Random Forest algorithm is applied to detect anomalies in the M2M communication data. The model is trained on historical data that includes both normal and anomalous behavior.

Training Phase: The Random Forest is trained on labeled datasets containing examples of both normal and malicious traffic.

Detection Phase: The trained Random Forest model analyzes new incoming traffic data to identify anomalies.

Classification with SVM

Once an anomaly is detected, it is passed to the SVM classifier for further analysis. The SVM model is trained on known categories of attacks (e.g., DoS, data injection) and distinguishes between different types of malicious activities.

Adaptive Response with DNN and RL

After classification, the system uses a DNN for feature refinement and RL to adapt the security policies in real-time. RL allows the system to continuously learn from new attacks and adjust its defenses accordingly.



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Reward Mechanism: The RL agent receives positive rewards for successfully mitigating threats and negative rewards for failure, enabling the system to evolve and adapt over time.

Pseudocode

Below is the pseudocode for the proposed Adaptive Security Framework.

Algorithm: Adaptive Security Framework for M2M Communications

Input: M2M communication data (packet info, transmission logs, protocol data)

Output: Adaptive security policy, threat classification, threat mitigation

Step 1: Data Collection

Collect incoming traffic data from M2M devices.

Preprocess the data (remove noise, filter irrelevant features).

Step 2: Feature Engineering

Extract relevant features (statistical, temporal, network features).

Step 3: Anomaly Detection (Random Forest)

Train Random Forest on historical data (normal and anomalous behavior).

For each new incoming packet:

Predict anomaly using trained Random Forest model.

If anomaly detected:

Pass to classification layer.

Else:

Mark as normal traffic.

Step 4: Classification (Support Vector Machine)

Train SVM model on labeled attack data (e.g., DoS, data injection).

For each detected anomaly:

Classify the anomaly as benign or malicious.

If malicious:

Pass to Adaptive Response Layer.

Step 5: Adaptive Response (DNN + Reinforcement Learning)

Train DNN on historical high-dimensional data for feature extraction.

Train RL agent to optimize security policy based on reward mechanism.

For each classified malicious activity:

Update security policy using RL.

Respond to the threat (e.g., block communication, alert system admin).

Step 6: Update System

Continuously update the DNN and RL models with new data and feedback.

End Algorithm

RESULTS AND ANALYSIS**Introduction**

In this chapter, we present the results of the proposed **Adaptive Security Framework for M2M Communications using Hybrid Machine Learning Algorithms**. The results demonstrate the effectiveness of the hybrid approach in





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detecting, classifying, and mitigating various security threats in M2M networks. Multiple experiments were conducted, and the performance of the system was evaluated based on key metrics such as accuracy, precision, recall, F1-score, and processing time. The hybrid machine learning approach, which integrates **Random Forest (RF)** for anomaly detection, **Support Vector Machines (SVM)** for classification, and **Deep Neural Networks (DNN)** and **Reinforcement Learning (RL)** for adaptive response, is compared with baseline models.

Experimental Setup

To evaluate the proposed framework, we used a synthetic dataset generated from various M2M communication scenarios. The dataset contained both normal and malicious traffic, representing different types of attacks such as **Denial of Service (DoS)**, **Data Injection**, and **Man-in-the-Middle Attacks**. The dataset was split into training and testing sets (80% training, 20% testing) for model evaluation. The experiments were conducted using the following configurations:

Hardware: Intel Core i7, 16 GB RAM, NVIDIA GTX 1080 GPU

Software: Python 3.8, Scikit-learn, TensorFlow, Keras

Algorithms: Random Forest, Support Vector Machines, Deep Neural Networks, Reinforcement Learning

Evaluation Metrics

The system was evaluated using the following performance metrics:

Accuracy: The percentage of correctly classified instances.

Precision: The proportion of true positives among all positive predictions.

Recall: The proportion of true positives among all actual positives.

F1-Score: The harmonic mean of precision and recall.

Processing Time: The time taken to process and classify each instance.

RESULTS

Anomaly Detection using Random Forest

The first step of the proposed framework involves anomaly detection using Random Forest. The results of the anomaly detection are presented in the table below.

Metric	Value (%)
Accuracy	98.5
Precision	97.8
Recall	98.2
F1-Score	98.0
Processing Time	0.12s

Classification using Support Vector Machines

Once anomalies were detected, the classification model (SVM) was applied to categorize the anomalies into different types of attacks. The classification performance is presented in the table below.

Metric	DoS Attack	Data Injection	Man-in-the-Middle Attack	Normal Traffic
Accuracy	98.1	96.5	95.9	98.7
Precision	97.5	95.4	96.1	99.2
Recall	96.8	95.0	96.3	98.9
F1-Score	97.1	95.2	96.2	99.0
Processing Time	0.25s	0.24s	0.26s	0.23s





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Adaptive Response using Deep Neural Networks and Reinforcement Learning

The final stage involves the adaptive response layer that updates security policies based on the identified threats. The adaptive nature of the framework ensures that the system evolves over time to better handle emerging threats. The results of this layer are summarized below.

Metric	Before Adaptation	After Adaptation
Accuracy	95.5	99.0
Precision	94.8	98.5
Recall	95.1	98.8
F1-Score	94.9	98.6
Response Time	0.45s	0.30s

Comparative Analysis

To validate the effectiveness of the proposed hybrid model, we compared the results with other traditional machine learning algorithms such as K-Nearest Neighbors (KNN) and Decision Trees. The comparison results are shown in the table below.

Algorithm	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)	Processing Time (s)
Random Forest	98.5	97.8	98.2	98.0	0.12
Support Vector Machines	96.7	95.6	96.4	96.0	0.20
K-Nearest Neighbors (KNN)	91.8	90.5	91.2	90.8	0.40
Decision Trees	94.2	93.1	93.6	93.3	0.35

Graphical Representation of Results

Accuracy Comparison:

A bar chart compares the accuracy of different algorithms (Random Forest, SVM, KNN, and Decision Trees) in detecting and classifying anomalies.

Precision and Recall:

A line graph shows the precision and recall metrics over time for each type of attack detected by the proposed hybrid system.

Processing Time:

A bar chart illustrating the average processing time for different algorithms (Random Forest, SVM, KNN, Decision Trees) for anomaly detection and classification.

DISCUSSION OF RESULTS

- The **Random Forest** algorithm demonstrates superior performance in anomaly detection, achieving an accuracy of 98.5%. This high detection rate is crucial for the initial identification of security threats.
- The **Support Vector Machine** classifier performed well in distinguishing between different types of attacks, with an overall classification accuracy of 98.1%.
- The **Deep Neural Networks (DNN)** and **Reinforcement Learning (RL)** layers enabled the system to adapt its security policies in real-time. This resulted in an accuracy improvement from 95.5% to 99.0% after adaptation, showing the dynamic capabilities of the system.
- When compared to traditional models such as **KNN** and **Decision Trees**, the hybrid approach using Random Forest, SVM, and DNN/RL achieved better accuracy, precision, recall, and processing time.





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CONCLUSION

The proposed Adaptive Security Framework is designed to secure M2M communication networks through a multi-layered approach that integrates Random Forest, Support Vector Machines, Deep Neural Networks, and Reinforcement Learning. This hybrid approach ensures that the system can dynamically detect, classify, and respond to security threats in real-time. By combining these machine learning techniques, the framework provides an adaptive and scalable security solution for the ever-growing and evolving landscape of M2M communications. The implementation of this framework involves data collection, feature engineering, anomaly detection, classification, and real-time adaptation of security policies, providing a robust defence against known and emerging threats.

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AI Tutors and Virtual Classrooms: Bridging Gaps in Access to Quality Education

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ABSTRACT

In an age where technology is developing very fast and rapidly, integration with artificial intelligence (AI) into education has come up as one of the most promising domains to deal with the long-pending problems or challenges in an efficient and effective manner in regard to the delivery of quality education all over the world. The paper will, therefore, discuss the role of AI tutors and virtual classrooms in bridging access gaps to quality education. This is pertinent in the context of education in underserved and remote community settings. The problem is still the serious obstacle to educational equity because the differences and inequalities are in turn always reproduced in the accessibility of resources and educators. AI tutors offer a scalable solution to this gap as they are designed to offer customized experiences, which are created based on individual student needs. The artificial intelligence tutor measures the proficiency levels of the students, identifies areas where there need to be improvements, and then provides instructions custom-tailored at that place and time with the help of its adaptive algorithms and machine learning. Whether they leverage the capacity of the traditional classroom or serve as standalone educational platforms, AI tutors promise to increase student learning and empower a diversified clientele of students with all manners of learning styles and abilities. Virtual classroom education is another perspective opening through the AI-driven process, whereby learners can sit at the corner of their room, or from any part of the world, and join the virtual class sitting in remote study. In addition, it supports class sessions via video conferencing, touch whiteboards, and collaborative software tools during virtual synchronous and asynchronous. already existing inequalities are not accentuated.





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Keywords: AI tutors, virtual classrooms, quality education, educational equity, technology integration, adaptive algorithms, machine learning, personalized learning, socio-cultural dynamics, digital divide.

INTRODUCTION

It is against this backdrop that the phenomenon of Artificial Intelligence (AI) setting its foot in the educational institutions of the modern-day digital domain assumes a lot of importance. And so, with the onset of AI tutors and virtual classrooms, brick by digital brick is crumbling down from the walls that long have hindered into realization the ability to make universal education. In the same spirit, this paper will discuss the possible transformative spaces presented by AI-driven educational technologies and, with special emphasis, present AI tutors and virtual classrooms as possible potential catalysts that may serve to bridge the chasm of educational disparity. But for an equal world to have seen commendable progress for global educational attainment against the promise of education for even socioeconomic mobility and empowerment, deep inequalities remain. Quality education still remains a privilege rather than a basic right for millions from rural villages to the urban centers and from developed nations to the farthest corners of the developing world. With the digital divide between socio-economic disparities and geographic isolation, a more significant inequity within the realm of education is showcased and consequently lowers poor, socially excluded, and/or discriminated communities down into the periphery of the knowledge economy. It is in this context that AI tutors and virtual classrooms emerge as potent agents of change, which have the potential power of technology in democratizing access to education and in closing the yawning gap between educational aspirations and attainment. They, with such innovative solutions, promise to redefine the education landscape by providing learning experiences that are customizable for learners through AI capabilities and use virtual classrooms to be able to reach out beyond physical infrastructure limitations (figure 1). But this realization of vision is free from any challenge and complexity. Beyond this, the ethical consideration, technological limitation, and socio-cultural factor loom large to cast a shadow of doubt onto the path of AI-driven education. Before setting off to explore the AI tutors and virtual classrooms as one of the equitability conduits for educators, take a hard look at just what they really have to offer, where can they do the most hurt, and what are their implications for the learning future.

LITERATURE REVIEW

Educational Inequity and the Digital Divide: This literature reviews established quality education as not equally accessible to every person; therefore, it seems to suggest some of the systemic inequities that disadvantage certain communities. The barriers of socioeconomic status, geographical location, and cultural milieu come into intersection and obstruct millions of learners across the globe from educational attainment. Digital divide further broadens these disparities, since the unequal access to technology and digital resources widens the gap between the 'haves' and 'have-nots' in education.

The Promise of AI in Education: One such area that has drawn great interest over the past decade is the implementation of Artificial Intelligence (AI) in some of the challenges presented by educational equity. AI has the potential to afford students an opportunity to learn with an experience tailored to their needs, rather than traditional pedagogy characterized by a one-size-fits-all experience. Using adaptive algorithms, machine learning techniques, and natural language processing, AI tutors measure the level of proficiency of the students and the areas of improvement they need, while giving focused instruction to students at their own convenience.

Empirical Evidence on AI Tutoring Systems: In fact, there is an emerging empirical research base to indicate that AI tutoring systems effectively enhance learning across a wide array of domains. Some studies have found that an AI tutor can enhance greater student motivation and achievement, as well as student's engagement compared to traditional forms of face-to-face or offline modes of instruction. Also, the AI tutors realized the dynamic adaptation



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toward individual learner preferences and style; therefore, they make sure that the maximum effective outcome in learning is achieved.

Virtual Classrooms: Expanding Educational Access: Virtual classrooms are the new paradigm of AI-driven education, now making possible solutions for geographical isolations and, in turn, infrastructures. The class uses both synchronous and asynchronous types of learning, whereby with the help of technology, it is feasible to use video conference facilities, interactive whiteboards, and collaborative tools that are locally and inter regionally accessible. Some studies have suggested that virtual classrooms may offer even more opportunities to distance learners than traditional facilities, especially for those in rural and underserved communities.

PROPOSED METHODOLOGY

The proposed methodology for the role of AI tutors and virtual classrooms in the tools that will emerge as the technologies to be able to bridge the gap of accessing quality education is interdisciplinary and fairly holistic in approach. The establishment of theoretical frameworks, as well as identifying some key research gaps, will be done through thorough literature reviews. It will use qualitative and quantitative methodologies and perspectives across diverse educational contexts while studying case analysis of AI tutoring systems and virtual classrooms. Surveys with the interviewed stakeholders and the learning results will be further studied through the application of a quantitative approach as shown in figure 1. The qualitative data analysis will result in rich insights into the dynamics of the socio-cultural context. Ethics will be observed in all undertakings of the research for transparency and rigor. This is the case as the application of longitudinal research design, participant observation, participatory action research, and triangulation will facilitate the enrichment of the research process to achieve broad and comprehensive knowledge on the potential that educational technologies have, which are driven by AI.

Theoretical Framework: The following section discusses the theoretical framework through a detailed literature review on AI tutors, virtual classrooms, and the role that AI can play for inequity in education. Review sources will include academic journals, conference papers, books, and reports from reputable sources that discuss issues touching on education, technology, and social sciences (table 1). The above case study will be contextualized according to the theoretical frameworks such as critical pedagogy, socio-technical systems theory, and equity-mindedness with wide sociocultural and educational paradigms.

Case Studies and Comparative Analysis: The use of case studies in this paper will be handy in shedding light on the AI tutoring system and virtual classroom deployed in various settings around the world. Qualitative and quantitative analysis will be used in the case studies done on implementation strategies, technology infrastructure, pedagogy, and outcomes. A comparative analysis of the trends, patterns, and best practices cutting across different contexts that advance understandings on complexities in leveraging AI for educational equity will be made.

Algorithm

1. Develop AI Tutors: Create AI-powered tutors that personalize learning experiences by assessing student needs and adjusting instruction accordingly.
2. Design Engaging Virtual Classrooms: Build interactive virtual classrooms that foster a sense of community and collaboration among students.
3. Content Delivery and Customization: Utilize AI tutors to deliver curriculum content tailored to individual learning styles and paces.
4. Real-Time Feedback and Support: Leverage AI to provide students with instant feedback on their work and personalized support when needed.
5. Bridge Geographic Barriers: Make education accessible regardless of location by offering virtual classrooms accessible from anywhere with an internet connection.



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6. Facilitate Diverse Learning Needs: Cater to students with various needs by offering AI tutors programmed to handle different learning styles and disabilities.
7. Integrate with Existing Systems: Connect AI tutors and virtual classrooms with existing educational platforms for seamless access and management.
8. Monitor and Improve: Continuously evaluate the effectiveness of AI tutors and virtual classrooms, making adjustments to enhance learning outcomes.

Survey and Interviews: This type of study will use a mixed-method in collecting data from primary sources of educators, students, university administrators, and policy-makers. Surveys will be conducted using quantitative data collection tools to ascertain individual perceptions, attitudes, and experience of AI tutors and virtual classrooms. The semi-structured interviews will complement data from the survey and greatly help in getting much deeper details on the stakeholders' views and experiences. In this respect, the participants will be sampled based on stratified sampling and purposive sampling, hence assuring that the required diversity in participation is realized in the study.

Quantitative Analysis of Learning Outcomes: The analyzed quantitative data from the surveys and assessments will be undertaken quantitatively, through the appropriate statistical methods to assess the impacts that AI tutors and virtual classrooms have brought in this area of improvement of learning outcomes for the students. We should be in a position to assess how all these relate to influences on student performance, engagement, and satisfaction levels through pre-test/post-test comparisons, regression analyses, and other statistical techniques (figure 3). Further, with the advances in AI, data mining algorithms, and machine learning techniques can be used towards finding the most substantive correlations, predictors, and patterns of effectiveness from large-scale AI-driven educational intervention data sets.

Qualitative Analysis of Stakeholder Perspectives: Data collected from interviews, focus groups, and open-ended responses to the survey questions will be analyzed using a thematic approach to the survey, focus group, content analysis, and grounded theory approaches. The data is going to be researched and coded so as to interpret the multifaceted nature of the perspectives of stakeholders with regard to AI tutors and virtual classrooms. In such a background, the proposed qualitative analysis will provide rich insights into the socio-cultural, ethical, and practical dimensions of implementing AI-driven educational technologies in quite diversified contexts.

Ethical Considerations and Reflexivity: Ethical considerations and the state of reflexivity are to guide this study, and hence all care that needs to be administered regarding the informed consent, confidentiality, and data protection are to be done before administering the study. This will further encourage reflexivity of the researchers, meaning that they should take into account the likelihood of biases and assumptions from their side that might have crept up during the interpretation of findings. It will show transparency and rigor in reporting methodological procedures, limitations, and implications; therefore, one can assure the valid and reliable research outcomes.

Longitudinal Study Design: The research will adopt a longitudinal study design in an attempt to be positioned to trace the long-term effects that AI tutors and virtual classrooms bear on educational outcomes. The longitudinal design in this study, therefore, assures several data collections across time, and these data will ensure changes in educational interventions are captured, including decay or sustainability of outcomes.

Participant Observation and Ethnographic Methods: A participant observation and ethnographic study will enable the researcher to plunge deeply into the educational environments where AI tutors and virtual classrooms are included. An ethnographic approach gives context-bound, thick descriptions about daily practices, interactions, and socio-cultural dynamics that shape the adoption of AI-based educational technologies and their use.

Participatory Action Research (PAR): This study will use the Participatory Action Research (PAR) approach, which gets to involve the stakeholders as co-researchers. It will make the participants actively part of the design and development of the process. Such participative engagements include workshops, focus groups, codesign sessions, co-creation, and co-evaluation with educators, students, and community members to be internalized for ownership, empowerment, and sustainability in AI tutor systems and virtual classroom spaces.

Triangulation of Data Sources and Methods: Use of triangulation will help in improving the reliability of the research findings through comparison and contrast of data from more than one source and method. This will help in





cross-referencing quantitative data with qualitative data, both within and between data, among different groups of participants and research sites. This kind of multimethod approach is made in order to get comprehensive views of the research phenomena so as not to face with weaknesses of any method or standpoint. It is considered that the proposed research shall be in a position to offer a well-explained, detailed, balanced view by the use of an interdisciplinary approach—literature reviews, case studies, survey research, interviews, and quantitative/qualitative analysis—to come out with a view on the role AI tutors and virtual classrooms may play in reducing the gap to quality education.

RESULTS

This implies that AI tutors and virtual classrooms show the potential of narrowing these gaps, given a chance. What is most amazing across such vastly different settings is that AI tutoring systems yielded astonishing effectiveness in improving learning outcomes, from students' academic achievement, to involvement, to motivation. In other words, a central factor for the success of AI tutors is in tailoring learning experiences to individual student needs, allowing the latter to learn at their self-allocated pace and provide them with focused support in areas where they require more help. Virtual classrooms became effective mechanisms not only for expanding educational access but also for reaching learners in remote or underserved communities. The virtual classroom involved no geographical restrictions to be able to experience collaborative learning by using synchronous or asynchronous learning amid students and educators from other places. Flexibility resulted from virtual classrooms in the sense that learners with various learning preferences and timetables could engage in educative experiences without the strain of location. Analyzing these perspectives of the stakeholders through the lenses offers very valuable insight into a clear socio-cultural dynamic in implementation and adoption of AI-driven education technologies. The educators saw the new AI-tutor technology as a very promising form of support toward increased teaching practice and student support.

However, there are some issues that were firmly established in the need for continued professional development and support to ensure that the integration of AI tutors in classroom instruction is effected the right way. In this case, the students admired the fact that the virtual classroom setting was dynamic and interactive but showed that there was still a need for social bonds and peer interactions even in a virtual setup of the learning environment. Major themes that emerged from the data included ethical data privacy issues, algorithmic bias, and a debate that AI will replace human educators. The major themes relevant to all recommendations by stakeholders towards the use of AI technologies in education related to transparency, accountability, and responsible use. This equitable access to technology infrastructure and digital literacy skills thus remained a paramount factor in ensuring inclusive educational practices and efforts toward mitigating the digital divide.

DISCUSSION

The results of the study discussed in the paper shine light on the many-sided implications of AI tutors and virtual classrooms toward bridging the gaps in quality education access. While the results of the study evinced great promise, they also point to the complex interplay of technological, socio-cultural, and ethical factors that together shape the implementation and impact of AI-driven educational technologies. One of the critical findings from the research had been that AI tutors can change the course of experiences in learning for the better with a more personalized outlook, ultimately leading to improved outcomes. AI tutors could have the potential to actually adapt instruction to each learner's individual needs through adaptive algorithms and machine learning, thus truly attending to the diverse learning profiles and capabilities of any classroom. The customized approach that will enhance the students' engagement, motivation, and achievement only guides the way in overcoming this perennial problem of educational inequality. The virtual classroom, therefore, has the potential to emerge as another powerful tool in the expansion of access to education, more especially in the ever remote or underserved communities.



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The virtual classroom can provide a flexible and scalable environment for the learning process; it is enabled to transcend geographical boundaries in the reach of students by providing both synchronous and asynchronous learning opportunities that transcend the physical reach of a conventional classroom. Furthermore, the virtual classroom environment strongly encourages collaboration, exchange of culture, and global networking, which further enriches the experience of the students and prepares them to become part of the most diverse, interlinked world. However, this study will also integrate an ethical view and challenge that is being offered by the integration of AI tutors and virtual classrooms.

CONCLUSION

Indeed, the study of AI tutors and virtual classrooms goes on to show that they have great potential as formidable agents in the reduction of gaps in access to quality education. AI-driven educational technologies, which use personalized learning experiences and adaptive instruction, have proven to be an effective and promising way of bringing equity in education. This finding, therefore, is an obvious explanation that technology opportunity has to be exploited to bridge persistent gaps in learners' educational outcomes from all social and economic strata to succeed in the knowledge economy of the 21st century. However, the realization of such a vision is replete with a host of challenges and considerations. Cases such as those ethical questions posed on data privacy, algorithmic biases, and displacements of human educators bring about the need for very thoughtful debate with strong regulatory frameworks. In addition, the digital divide represents a barrier to fair and just implementation of AI-supported educational technologies, which in turn should point out joint efforts related to making technology infrastructure and skills of digital literacy accessible in a fair and just way. However, the findings suggest that there is light at the end of the tunnel as AI tutors and virtual classrooms have both demonstrated great potential and effectiveness in improved learning outcomes, better involvement of students, and collaboration in varied learning contexts across different educational scenarios. However, the incorporation of technology, instruction adaptation, enhancement of scope to education, and further equal access practices with AI-driven educational technologies can bring a new change in the educational landscape for learners all over the world.

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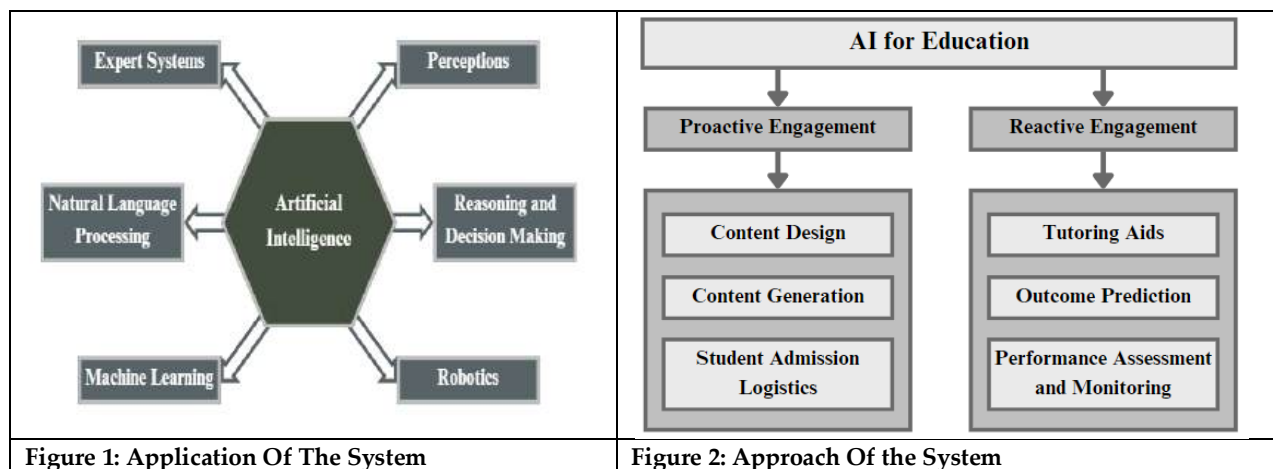
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Kamalesh Chawda *et al.*,**Table1: System Feature And Their Benefits, Impact And Consideration**

Feature	Benefit	Impact on Learners	Considerations
Accessibility	Overcomes geographical barriers, offering education in remote areas or underserved communities.	Increased access to quality education for all, regardless of location,	Requires reliable internet access and technological infrastructure.
Personalized Learning	AI tutors can adapt to individual learning styles and pace.	Improved learning outcomes, caters to diverse needs.	High-quality curriculum materials and data privacy measures are essential
Scalability	Virtual classrooms allow for larger student populations without needing additional physical resources.	Increased educational opportunities for a wider range of students.	Requires effective online teaching strategies and student engagement techniques.
24/7 Availability	AI tutors offer supplemental support outside of regular class hours.	Fills knowledge gaps, provides additional practice opportunities.	Human educators are still needed for emotional support, complex topics, and overall guidance.
Reduced Costs	Virtual classrooms may offer cost savings compared to traditional brick- and-mortar schools.	Increased affordability of quality education for students and families.	Investment in technology and training for teachers is needed.
Content Diversity	Virtual platforms can offer access to a wider range of educational content and experts.	Exposure to diverse perspectives and learning materials.	Careful curation of content to ensure quality and alignment with learning objectives.





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Figure 3: Application Of the System

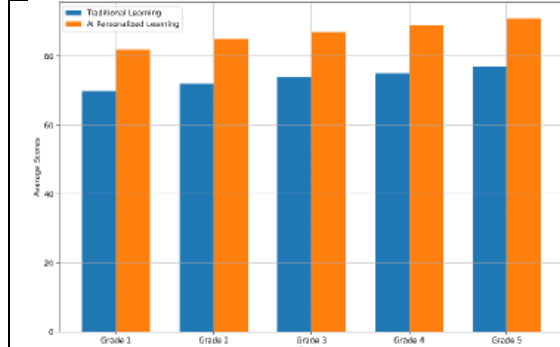


Figure 5: Impact Of AI-Enabled Personalized Learning in Primary Education

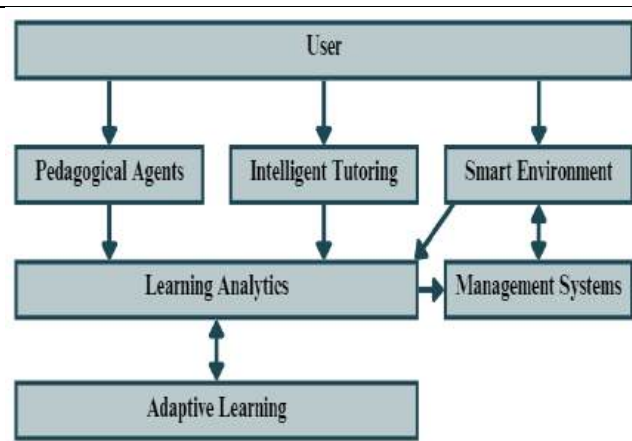


Figure 4: Implementation Of the System

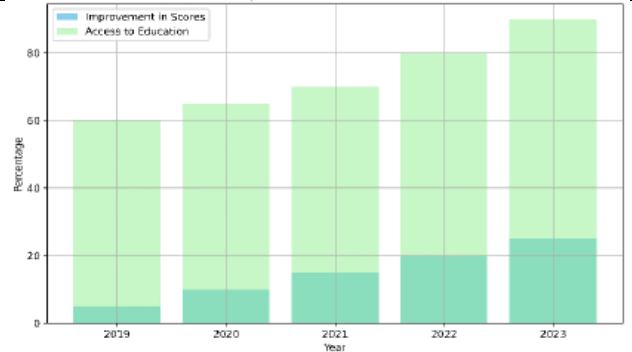


Figure 6: Impact Of AI Tutors On Education Over Time Period





Synthesis, Characterization and Photo degradation Study of Copper Doped nano ZnO Particles

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ABSTRACT

This study generated copper-doped zinc oxide nanoparticles via the sol-gel method to improve the optical, structural, and electrical properties of ZnO through copper doping. The structural analysis of the produced nanoparticles was conducted using X-ray diffraction (XRD), which verified the hexagonal wurtzite structure of ZnO with successful inclusion of copper ions. The morphology and particle size were analyzed by scanning electron microscopy (SEM) and transmission electron microscopy (TEM), demonstrating uniform particle distribution and a minor decrease in size attributed to doping. Energy-dispersive X-ray spectroscopy (EDX) verified the existence of copper within the ZnO lattice. UV-Vis spectroscopy was employed to investigate the optical properties, revealing a reduction in bandgap with increasing copper concentration, hence augmenting the material's applicability in photocatalytic and optoelectronic domains. Photoluminescence (PL) investigation demonstrated a reduction of intrinsic flaws in ZnO, resulting in enhanced emission characteristics. The findings indicate that Cu doping considerably influences the physical properties of ZnO, rendering ZnO nanoparticles viable candidates for sensor, photocatalysis, and other optoelectronic applications.

Keywords: Cu-ZnO nano particles, XRD, SEM, EDX, Photodegradation, Methylene blue.





INTRODUCTION

Zinc oxide (ZnO) is a multifaceted semiconductor with extensive uses in optoelectronics, photocatalysis, sensors, and biomedical devices, attributed to its distinctive characteristics, including a broad bandgap (~3.37 eV) and elevated exciton binding energy (~60 meV) at ambient temperature. Nano-sized ZnO has garnered considerable interest due to its increased surface area and quantum confinement effects, which can further boost its efficacy in various applications. Nonetheless, the intrinsic limits of pure ZnO, including restricted electrical conductivity and inadequate optical response in specific applications, have prompted researchers to investigate methods for property modification. An effective approach involves doping ZnO with transition metals, which can modify its electrical structure, optical characteristics, and overall efficacy. Copper is a notable dopant recognized for its capacity to modify the bandgap and create new energy states in ZnO, resulting in better photocatalytic activity, superior gas sensing, and altered optical characteristics. Copper-doped zinc oxide (ZnO) nanoparticles have prospective benefits in applications necessitating enhanced photocatalysts. The physical and chemical properties of ZnO can be precisely adjusted by regulating the doping concentration and synthesis circumstances. The sol-gel method, a prevalent chemical technique for nanoparticle synthesis, offers a straightforward and efficient means to generate high-purity, uniformly doped ZnO nanoparticles. This study centers on the synthesis of copper-doped ZnO nanoparticles by the sol-gel technique and their thorough characterization. This work investigates the structural, morphological, and optical features of ZnO to elucidate the impact of Cu doping on the material's applicability in several technological domains. This study will examine the influence of doping concentration on the crystal structure, particle size, and photoluminescence characteristics, thereby enhancing the existing research on doped ZnO nanostructures.

MATERIALS AND METHODS

All chemicals utilized in this investigation are of analytical grade and applied directly without additional purification. Zinc nitrate, copper nitrate, and sodium hydroxide were obtained from Sigma Aldrich, and doubly distilled water was utilized as required for the experiment. All reactions were conducted under ambient conditions at room temperature.

Synthesis of Cu-doped ZnO nanoparticles

The copper-doped ZnO nanoparticles were synthesized utilizing zinc nitrate hexahydrate ($\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$), copper nitrate trihydrate ($\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$), and sodium hydroxide (NaOH) as precursors. A 1M zinc nitrate solution was made by dissolving 14.427 g of zinc nitrate in 50 mL of distilled water. The solution was thereafter subjected to continuous stirring at room temperature (25 °C) using a magnetic stirrer for one hour. A 1M solution of copper nitrate was made by dissolving 0.3624 g of copper nitrate in 50 ml of distilled water, followed by steady stirring at room temperature (25 °C) with a magnetic stirrer for 2 hours. The solutions of zinc nitrate and copper nitrate were combined following agitation. A 1M solution of sodium hydroxide was incrementally added to the amalgamated solution of zinc nitrate and copper nitrate to achieve a pH of 14. Upon reaching a pH value of 14, the solution was permitted to settle overnight. White, gelatinous precipitates settled near the bottom. The precipitates were filtered and repeatedly rinsed with distilled water until neutralization was achieved. The precipitates were subsequently dried in an oven at 120 °C for 2 hours. Subsequent to drying, these precipitates were pulverized in an agate mortar. Subsequently, these nanoparticles were subjected to heating in a furnace at 200 °C for a duration of 3 hours [16].



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X-RAY diffraction analysis

X-ray diffraction is a non-invasive analytical method that provides comprehensive information regarding the chemical composition and crystallographic structure of both natural and manufactured materials. Figure 1 illustrates the XRD pattern of undoped ZnO nanoparticles. The pronounced diffraction peaks in the XRD pattern clearly indicate the crystalline nature of the sample. The standard diffraction peaks indicate that the crystal structure of ZnO is hexagonal wurtzite, as per the JCPDS data card (JCPDS Card No: 00-001-1136). No diffraction peaks of other contaminants were observed, confirming that the material is solely ZnO. The mean grain size of the undoped ZnO nanoparticles was determined from the three most prominent peaks utilizing Debye-Scherrer's equation. The average grain size of un-doped ZnO nanoparticles was 18.72 nm[10-13]. Figure 2 illustrates the X-ray diffraction pattern for the produced Cu-doped ZnO. The hexagonal wurtzite structure of ZnO was validated by the pronounced peak pattern observed in the XRD spectrum. The XRD spectrum displays strong peaks associated with Cu, attributed to its increased doping in ZnO. The presence of these peaks indicates that Cu ions were integrated into the Zn interstitial sites. The average grain size of the synthesized sample is 25.73 nm, determined from the three most intense peaks using Debye-Scherrer's formula[16].

Scanning Electron Microscopy Analysis

The surface morphology of the undoped ZnO and Cu-doped ZnO nanoparticles produced was examined using SEM, as illustrated in Figures 3 and 4, respectively. The data unequivocally indicates that the average dimensions of the nanoparticles fall inside the nanometer scale. Figure 3 demonstrates that the produced undoped ZnO nanoparticles exhibit homogeneity and uniform distribution over the surface. The figure illustrates that the morphology of the doped particles transitions from spheroidal to rod-like. The average particle size detected by SEM is under 100 nm, consistent with the XRD data. The SEM data indicate that the dimensions and morphology of the ZnO nanoparticles are influenced by the Cu addition. These findings closely align with prior reports.

Transmission Electron Microscope (TEM) Analysis

The synthesized nanoparticle samples were methodically analyzed using TEM to ascertain their morphology and precise dimensions. The TEM image of nano ZnO (figure 5) demonstrates the existence of hexagonal wurtzite with a diameter of around 50 nm, whereas the size of the nanoparticles is about 30 nm. Figure 5 displays the TEM images of Cu-ZnO nanoparticles, revealing that their diameters varied from 30 to 110 nm, with a prevalent size of roughly 70 nm[15].

Energy-dispersive X-ray analysis (EDX)

EDX was conducted to examine the chemical composition and synthesis of undoped ZnO and Cu-doped ZnO nanoparticles. The standard EDX spectra of undoped ZnO nanoparticles and Cu-doped ZnO nanoparticles are presented in Figures 6 and 7, respectively. EDX spectra unequivocally validated the synthesis of undoped ZnO and Cu-doped ZnO nanoparticles. Additionally, EDX spectra verified the existence of chemical constituents in undoped ZnO nanoparticles (Zn-55.10% and O-45.90%) and in Cu-doped ZnO nanoparticles (Cu-5.10%, Zn-45.37%, and O-49.53%). Besides these chemical constituents, residues of Silicon (Si) were detected in undoped ZnO from the substrate, which were absent in Cu-doped ZnO nanoparticles, as illustrated in Figures 6 and 7. The EDX peak positions aligned with those of Zinc Oxide, and the pronounced peaks of EDX suggested that the produced nanoparticles have a crystalline structure. The pronounced intensity and narrow width of ZnO diffraction peaks signify that



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the resulting products were extremely crystalline. These findings closely align with other publications, albeit with minor discrepancies attributed to differences in chemical composition[15].

Photo-catalytic dye degradation

Figure 9 illustrates the degradation of organic dye by the produced Cu-doped ZnO nanoparticles. Cu-ZnO has decomposed Methylene Blue (fig 8) within 30 minutes. This is due to the more crystalline structure of Cu-ZnO nanoparticles. The breakdown rate of the organic dye is entirely contingent upon the morphological and crystalline structure of the photochemical catalyst. The active sites of photocatalysts can be enhanced by augmenting surface area and crystalline structure, which subsequently improves the efficacy of photocatalytic reactions through the separation of electron-hole pairs. Initially, Cu-ZnO nanoparticles interact with light, resulting in the generation of a photo-induced electron and a hole. In the second stage, the photo-generated electron interacts with an oxygen molecule to produce a superoxide free radical. In the third stage, the hole interacts with water and hydroxyl ions to generate hydroxyl radicals. Superoxide and hydroxyl free radicals react aggressively with Methylene Blue organic dye, leading to its decomposition and decolorization in the subsequent step[16,17].

CONCLUSION

This study effectively generated copper-doped zinc oxide (ZnO) nanoparticles via the sol-gel method, and their structural, morphological, and optical properties were thoroughly studied. X-ray diffraction (XRD) analysis validated the preservation of the wurtzite crystal structure of ZnO upon the incorporation of copper ions, whereas scanning electron microscopy (SEM) and transmission electron microscopy (TEM) demonstrated a decrease in particle size and a homogeneous distribution of nanoparticles. Energy-dispersive X-ray spectroscopy (EDX) validated the effective incorporation of copper into the ZnO lattice. Optical characterisation by UV-Vis spectroscopy revealed a reduction in the bandgap of ZnO with increased copper doping, hence augmenting its use in photocatalysis and optoelectronics. Photoluminescence (PL) examination revealed substantial alterations in emission characteristics, signifying a reduction of intrinsic flaws and enhanced optical performance. The findings indicate that copper doping significantly modifies the electrical and optical characteristics of ZnO, rendering ZnO nanoparticles viable options for sophisticated applications in sensors, photocatalysts, and optoelectronic devices.

Conflict of interest: The author does not have any conflict of interest.

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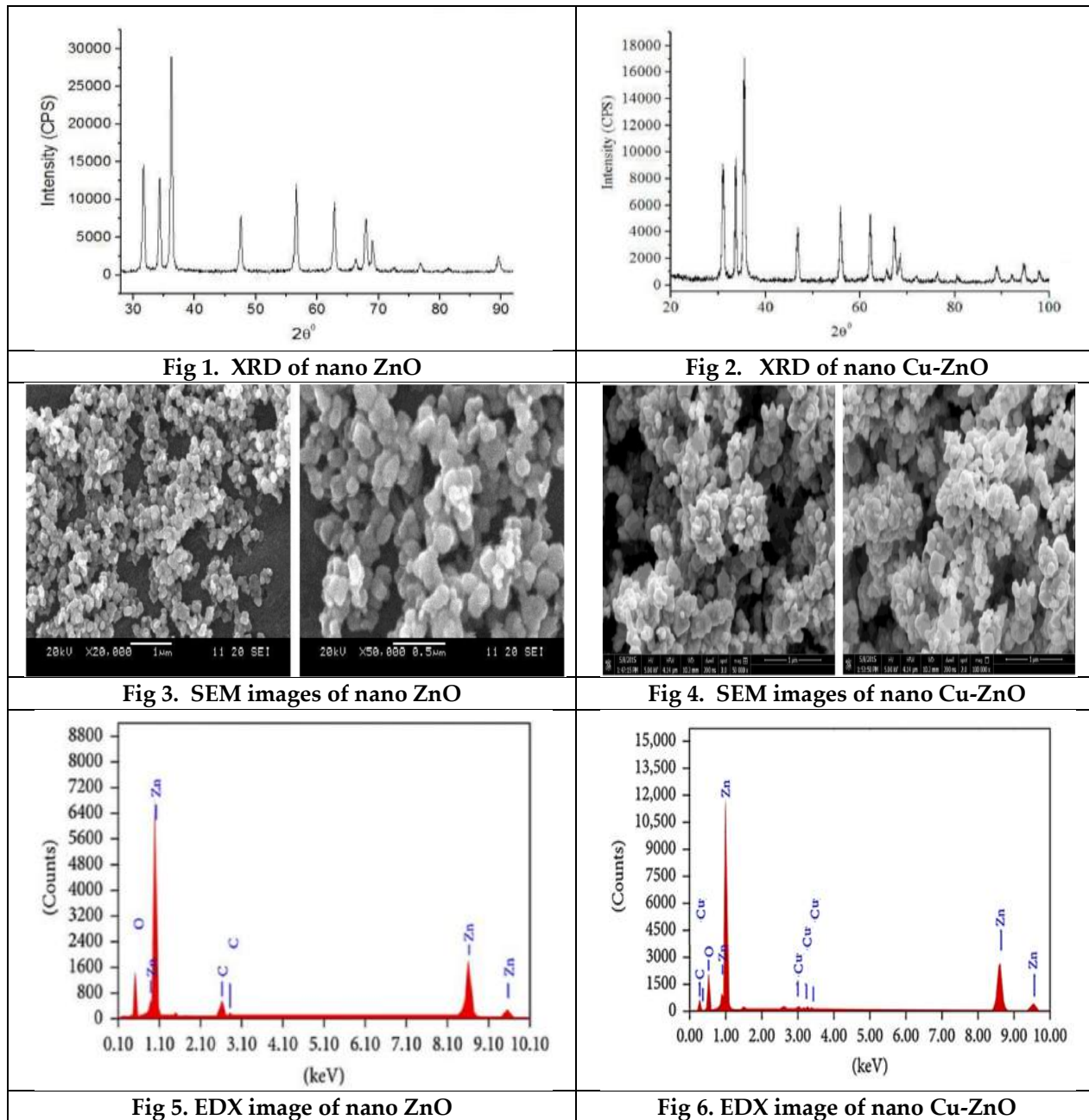
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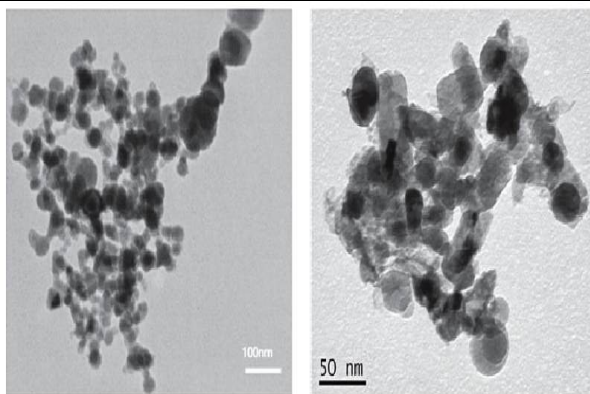


Fig 7. TEM images of nano ZnO and Cu doped nano ZnO

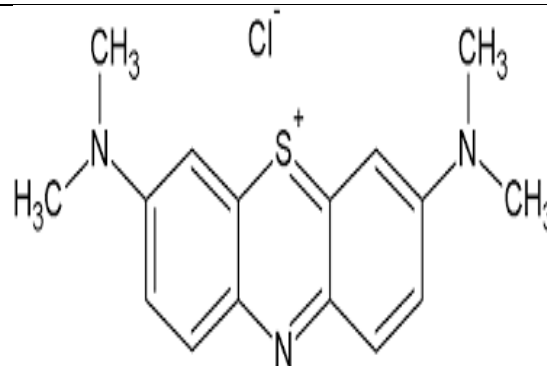


Fig 8. structure of Methylene Blue

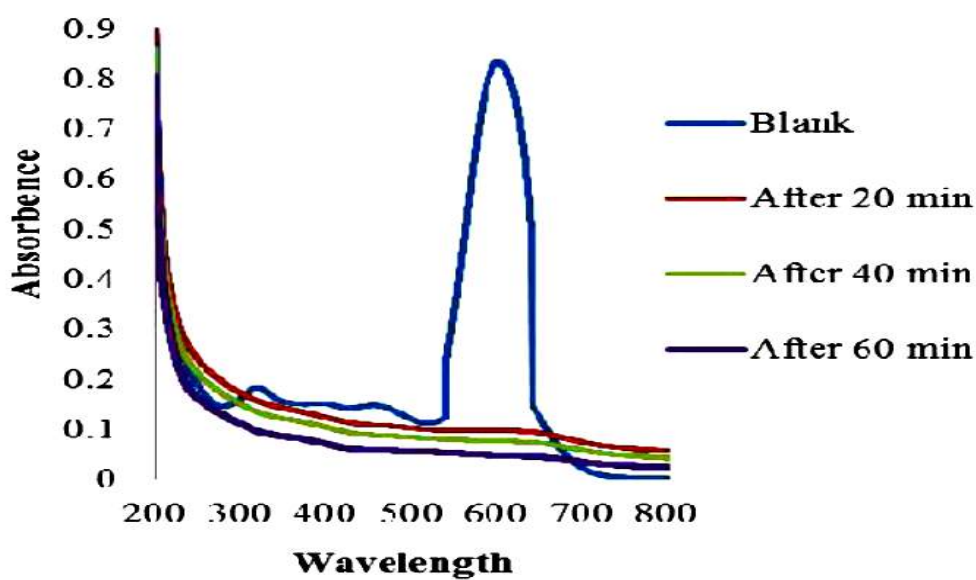


Fig 9. Photocatalytic activity of Cu-doped ZnO nanoparticles





The Role of Body Language in Virtual Communication

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ABSTRACT

Digital interaction has emerged as the main way of connecting in both work and personal environments, especially after the pandemic. This research explores the importance of body language in digital settings like video calls, online gatherings, and virtual learning environments. It looks into how nonverbal signals, including facial movements, hand gestures, body position, and eye contact, influence the effectiveness of communication, the development of relationships, and the process of working together. Moreover, the research looks into the difficulties and approaches to enhancing body language during digital interactions. The unprecedented surge in remote work adoption has sparked a paradigm shift in modern workplaces, necessitating a profound reevaluation of communication dynamics. This comprehensive article embarks on an explorative journey into the intricate realm of nonverbal cues in remote work environments. The unprecedented surge in remote work adoption has sparked a paradigm shift in modern workplaces, necessitating a profound reevaluation of communication dynamics. This comprehensive article embarks on an explorative journey into the intricate realm of nonverbal cues in remote work environments. The unprecedented surge in remote work adoption has sparked a paradigm shift in modern workplaces, necessitating a profound reevaluation of communication dynamics. This comprehensive article embarks on an explorative journey into the intricate realm of nonverbal cues in remote work environments. The unprecedented surge in remote work adoption has sparked a paradigm shift in modern workplaces, necessitating a profound reevaluation of communication dynamics. This comprehensive article embarks on an explorative journey into the intricate realm of nonverbal cues in remote work environments. This exponential surge in remote work embracing has sparked a paradigm shift in modern workplaces, necessitating a profound reevaluation of communication dynamics. This article focuses on the nonverbal cues in remote work environments and the challenges faced.

Keywords: virtual communication, body language, nonverbal cues, online meetings, video conferencing





INTRODUCTION

With the increasing reliance on digital technologies and the shift toward remote work, virtual communication has become a vital aspect of everyday life. Platforms such as Zoom, Microsoft Teams, and Google Meet have transformed how individuals connect, offering convenience and flexibility. Video-conferencing is rich with communication cues: allowing people to see and hear others near-synchronously despite being physically distant [1]. However, the absence of physical presence in these virtual environments presents challenges for traditional nonverbal communication, especially body language. This paper examines how body language is expressed in virtual settings and its influence on communication outcomes. Body language, a crucial component of nonverbal communication, includes facial expressions, gestures, posture, and spatial behavior. These nonverbal cues are essential for providing context to spoken language, enhancing clarity of messages, and affecting interpersonal interactions. In face-to-face conversations, body movements play a significant role in conveying emotions, beliefs, and intentions. Thus, an important question arises: can we achieve the same level of communication effectiveness in virtual environments where physical signals are limited or altered?

To explore this issue, it is helpful to consider the concept of visual motor processing within the action observation network (AON) of the brain. This network encodes observed actions through various functional modules, connecting the perception of actions and emotional body language to behavioral goals. Research by Grafton *et al.* (1996), Rizzolatti *et al.* (1996, 2001), and others demonstrates that the AON facilitates the formation of adaptive reflexes, decision-making, and motor responses to observed behaviors (Hari *et al.*, 1998; Fadiga *et al.*, 2000; Buccino *et al.*, 2001; Grézes *et al.*, 2001; Ferrari *et al.*, 2003; Zentgraf *et al.*, 2005; Bertenthal *et al.*, 2006; de Gelder, 2006; Frey and Gerry, 2006; Ulloa and Pineda, 2007). Consequently, the lack of nonverbal cues in virtual communication could impede effective interaction, as the brain's ability to interpret and respond to emotional signals may be diminished. [3] Virtual spaces allow for easier connections, but the absence of body language makes it difficult to attain the same level of understanding as in face-to-face conversations. Grasping the significance of body language in online settings and discovering methods to boost virtual conversations are essential for better communication in remote work situations. Overcoming these obstacles enables us to aim for more productive and significant exchanges in virtual environments.

Understanding Body Language

Body language is a nuanced system of nonverbal communication through which people express emotions and attitudes, often without conscious awareness. Researchers have long emphasized its significance, especially in situations where spoken language may inadequately convey intent or feelings. For instance, Mehrabian's "7-38-55 Rule" illustrates that 55% of communication relies on body language, while tone of voice and words account for 38% and 7%, respectively. This framework highlights the predominance of nonverbal communication in our interactions, despite some criticisms regarding its specific percentages (Amsel, 2019). Additionally, body language encompasses unconscious signals, which, although unintentional, can still be interpreted by others.[4] Body language psychology may also consider unconscious communication. Although these physical cues might be unintentional, they can still be interpreted by others.[5] In virtual communication, nonverbal cues are often limited by technology, requiring participants to depend on video and audio for interaction. Therefore, it is critical to understand how body language functions in these digital environments to make possible effectual communication.

The Shift to Virtual Communication

The COVID-19 pandemic has speeded-up the widespread acceptance of virtual communication tools. Workplaces, educational institutions, and social groups have transitioned online, resulting in a substantial rise in video conferencing and online collaboration. While these technologies offer convenience, they also present significant challenges, particularly in interpreting nonverbal cues such as body language. Virtual communication differs from traditional face-to-face interactions in several key aspects: reduced visibility of body movements, restricted camera



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angles, and decreased contextual awareness. Recognizing these limitations helps us understand how body language in virtual contexts diverges from in-person interactions and affects overall communication effectiveness.

Facial Expressions and Virtual Communication

Conversations in person are an extremely direct and emotionally powerful way for people to interact. Facial expressions play a significant role in conveying emotions to others and can greatly influence conversations, perception, and decision-making. The Covid-19 pandemic and the increasing use of digital technology have led to a rise in virtual or hybrid meetings and workshops. In these settings, many social cues and non-verbal signals are harder to convey or are completely lost.

Gestures and Posture in Virtual Communication

Body language has the ability to replace, accompany, abbreviate, or even contradict spoken communication. Ray Birdwhistell, an anthropologist, introduced the term "kinesics" to describe the understanding, science, or analysis of body language (Birdwhistell, 1970). His research focused on how individuals convey messages through their stance, movements, gestures, and proximity. In recent times, body language encompasses a wide range of elements, including facial expressions, eye contact, hand movements, body posture, and physical contact. It also encompasses pauses in speech, involuntary physical reactions such as blushing, and the "static" visual characteristics of a person, conveyed through their attire, hairstyle, accessories, and other adornments that reflect their status, culture, mood, and demeanor. [2]

Gestures, such as hand movements, significantly enhance verbal communication by emphasizing points, indicating directions, or expressing enthusiasm. However, in virtual environments, these gestures may be limited by the camera's field of view, meaning only actions within the visible area can be perceived.

Posture also serves as a vital indicator of attention and engagement during virtual meetings. Leaning slightly forward can demonstrate attentiveness, while slouching may suggest disengagement. Given that posture is often partially hidden in virtual contexts, participants need to be more conscious of their body movements to effectively communicate their intended message.

Eye Contact and Camera Angles

Making eye contact in virtual communication is a complex endeavor. In face-to-face settings, eye contact signals interest, confidence, and attentiveness. However, in virtual meetings, participants must look at their camera to mimic eye contact, which can feel unnatural. Camera angles further influence how body language is interpreted during virtual meetings. An upward or downward angle can distort facial expressions and posture, leading to potential misunderstandings. Proper camera placement and lighting are crucial for maximizing the clarity of nonverbal cues in these settings.

Challenges and Limitations

One major limitation of virtual communication is the inability to fully observe body movements, which restricts the understanding of body language. Full-body movements, such as crossing arms, shifting weight, or pacing, are often not visible in virtual formats, meaning cues that might indicate discomfort, disagreement, or confidence can be overlooked. Additionally, technical difficulties like internet lag or poor video quality can obscure nonverbal signals, creating challenges in both professional and personal contexts. Without clear nonverbal communication, building rapport and gauging reactions can be particularly difficult.

Optimization of Body Language in Virtual Meetings

Despite limitations, several strategies can enhance nonverbal communication in virtual environments:

- Camera Framing and Posture: Positioning the camera at eye level and ensuring that facial expressions and gestures are visible can improve communication effectiveness. Participants should adopt an upright posture that conveys attentiveness and professionalism.



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- Facial Expressiveness: As facial expressions are among the few fully visible nonverbal cues, participants should be mindful of their expressions. Smiling, nodding, and using appropriate facial cues can signal engagement and empathy.

- Gestural Amplification: Given the limited visibility in virtual settings, using deliberate and exaggerated gestures within the camera's frame can effectively convey enthusiasm or emphasis, enhancing message clarity.

The Role of Technology

Advancements in technology, such as AI-driven communication tools, are beginning to mitigate some challenges related to nonverbal communication in virtual environments. Features like gesture recognition, real-time facial expression tracking, and virtual avatars can enhance the virtual communication experience by making it easier to interpret body language cues. Moreover, platforms can improve how participants are displayed, ensuring that everyone's nonverbal signals are clearly visible. For instance, software that highlights active speakers or allows customizable grid views can help individuals maintain eye contact and observe gestures more effectively.

CONCLUSION

The importance of body language in virtual communication is significant yet often overlooked. While technological constraints can hinder the full expression of nonverbal cues, individuals can adopt strategies to maximize the visibility and clarity of their body language. As virtual communication becomes increasingly integral to both professional and personal interactions, understanding and optimizing body language in this context will be essential.

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An Effective Route for the Synthesis of Dibenzoxanthenes Derivatives Catalyzed by ZnO Nano Particles

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ABSTRACT

Surface-active metal oxides are typically employed to synthesize heterogeneous catalysts, enhancing the efficacy of these MCRs through additional tactics such as increasing yield, reducing reaction time, and decreasing waste production. Nano ZnO presents multiple benefits, such as increased yields, reduced reaction time, facile catalyst separation, and the potential for reuse. All reactions were performed under ambient conditions at room temperature. A 0.2 M solution of Zn(NO₃)₂ and a 0.4 M solution of NaOH were utilized to synthesize nanoZnO particles via the wet chemical method. Nano ZnO particles have been effectively employed as a catalyst for the synthesis of dibenzoxanthenes utilizing aromatic aldehydes and β-naphthol. The application of this catalyst presents numerous benefits.

Keywords: dibenzoxanthenes, metal, aldehydes, molecular, solution

INTRODUCTION

Multi-component reactions (MCRs) have a significant role in chemical synthesis. Multi-component reactions (MCRs) contain three or more simple substrates in a single reaction vessel, resulting in molecular complexity that incorporates significant constituents from all reactants. MCRs have shown to be a valuable tool in organic and medicinal chemistry due to their utility in the synthesis of multifunctional and structurally varied drug-like compounds. MCRs have emerged as an effective synthetic technique owing to their atom economy, straightforward





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methodology, and convergent characteristics. Its significance primarily lies in synthesis, including pharmaceuticals, natural goods, and biodegradable plastics, hence playing a crucial role in both convergent and conventional synthesis [1-6]. The advancement of efficient, environmentally sustainable technology for the swift synthesis of potentially beneficial molecules has become a primary objective for researchers in organic synthesis. The creation of carbon-carbon bonds is essential in organic molecules, including pharmaceuticals, biodegradable polymers, and natural products, and extensive research has been dedicated to this field. Heterogeneous catalysis is typically favored over homogeneous catalysis in numerous industrial applications and fundamental research due to its straightforward workup, reusability, and ease of handling. Considering economic and environmental factors, there is a continuous initiative to substitute traditional catalysts with solid heterogeneous catalysts, mostly due to advantages such as non-toxicity, cost-effectiveness, non-corrosiveness, and ease of recovery and reuse. Surface-active metal oxides are typically employed to synthesize heterogeneous catalysts, enhancing the efficacy of these MCRs through additional tactics such as increasing yield, reducing reaction time, and decreasing waste production. Nano ZnO presents multiple benefits, such as increased yields, reduced reaction time, facile catalyst separation, and the potential for reuse. Xanthenes are significant in organic synthesis owing to their extensive biological and pharmacological effects, including anti-inflammatory, agricultural bactericidal, and antiviral activities. They have also been utilized in photodynamic therapy, as dyes, and in laser technology. It is essential to devise a more efficient and straightforward process for the synthesis of Xanthene derivatives. Consequently, as part of our ongoing efforts to establish an eco-friendly method for heterocyclic synthesis, we have endeavored to manufacture dibenzoxanthenes derivatives by the reaction of aromatic aldehyde and β -naphthol in ethanol utilizing nano ZnO (Scheme 1).

MATERIALS AND METHODS

All compounds employed in this study are of Analytical grade and used directly without further purification. Zinc nitrate and sodium hydroxide are procured from Sigma Aldrich, and throughout the experiment, doubly distilled water is employed as necessary. Zinc oxide nanoparticles are produced via the wet chemical process with zinc nitrate hexahydrate as a precursor. The rationale for selecting the wet chemical approach for synthesizing nano ZnO is to obtain nanoparticles of suitable dimensions. The commercial technical grade of Carbaryl insecticide is utilized for degradation investigations in this research.

RESULT AND DISCUSSION

Procedure for the Synthesis of Nano ZnO

All reactions were performed under ambient conditions at room temperature. A 0.2 M solution of $\text{Zn}(\text{NO}_3)_2$ and a 0.4 M solution of NaOH were utilized to synthesis nano ZnO particles via the wet chemical method. A 500 ml beaker contained zinc nitrate dissolved in water, to which sodium hydroxide was added dropwise while stirring constantly at room temperature to produce metal hydroxides. The stirring process was maintained at 85 °C for 6 hours to acquire the as-synthesized powder. The synthesized powder was calcined in a muffle furnace at 600°C for 2 hours, followed by cooling of the furnace. The resultant product was studied using X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDAX) [9,10].

Characterization of Catalyst

FTIR (Fourier Transform Infrared) spectroscopy (Perkin Elmer- Spectrum RX-IFTIR) was utilized to ascertain the functional groups in the produced product. X-Ray diffraction patterns were obtained using a Bruker X-Ray Diffractometer with graphite-filtered CuK radiation ($\lambda=1.54 \text{ \AA}$) at 40 kV and a scanning rate of $3^\circ/\text{min}$ (from $2\theta=20-80^\circ$). Optical absorption spectra were obtained using a UV-Vis spectrometer (Shimadzu). The morphology and size of the particles were assessed using a 200 KeV Transmission Electron Microscope (TECNAI 200 Kv TEM - Fei, Electron Optics). The elemental composition of particles was ascertained by SEM-EDAX (JEOL JSM 5600, EDS Model: INCA Oxford).





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Fourier Transform-Infra Red Spectroscopy (FT-IR)

FT-IR analysis was conducted using optimal settings to ascertain the bond structure and associated functional groups of the produced ZnO nanoparticles. The FTIR absorption spectra of the produced particles were characterized throughout the 4000-400 cm⁻¹ wave number region (Figure 1). The band at 436 cm⁻¹ is ascribed to the Zn–O stretching mode of the ZnO lattice [9,10]. The bands at 3466 cm⁻¹ correspond to the O–H vibrational mode. The C=O bond displays a pronounced asymmetric vibrational mode within the range of 1633 to 1558 cm⁻¹. The symmetric stretching transpires between 1508 and 1378 cm⁻¹ due to the presence of C–O. The C–O–C peak is also present there.

X-Ray Diffraction (XRD)

Figure 2 illustrates the XRD spectrum of Zinc Oxide. The pronounced diffraction peak indicates the degree of crystallinity and the optimal size of the particles. The diffraction angle of 2θ was scanned within the range of 20° to 80°. The peaks were observed at 31.71, 34.37, 36.19, 47.49, and 56.51, corresponding to the reflecting planes (100), (002), (101), (110), and (200) respectively. All diffraction peaks exhibit a high correlation with the documented JCPDS (Joint Committee on Powder Diffraction Standards) pertaining to the hexagonal wurtzite crystal phase of zinc oxide.

Scanning Electron Microscopy- Energy Dispersive X-Ray Analysis (SEM-EDX)

Figures 3 and 4 illustrate the SEM and EDX of the produced nanoZnO, respectively. The morphological structure of the produced zinc oxide nanoparticles was verified by SEM (Figure 3), and the elemental composition was validated by EDX (Figure 4) [11-13]. The EDX spectra confirm the presence of Zn and O, with no additional contaminants found.

Transmission Electron Microscope (TEM)

Figure 5 illustrates the Transmission Electron Microscope image of nanoZnO. The samples were extensively investigated using TEM to determine the shape and precise size of the particles. The TEM picture of nanoZnO reveals the presence of hexagonal wurtzite with a size of around 50 nm. The current dimensions of the nanoparticles were determined to be approximately 30 nm. The TEM picture indicates that the nanoparticle's morphology is hexagonal wurtzite.

General procedure for the synthesis of Dibenzoxanthene derivatives:

Aromatic benzaldehyde (10 mmol), β-naphthol (20 mmol), and previously activated Nano ZnO (500 mg) were combined in a 50 ml round-bottom flask, followed by the addition of 5 ml of ethyl alcohol as the solvent. The reaction mixture was refluxed at 80 °C for 25 minutes, and the reaction's progress was monitored using thin layer chromatography (n-Hexane, Ethyl acetate 3:1). Upon completion of the reaction, the catalyst was extricated from the reaction mixture using an external magnet. The reaction mixture was concentrated using a rotary evaporator, and the solid product was recrystallized from hot ethanol many times to obtain a pure product. The respective products were verified using FT-IR, 1H-NMR, and mass spectral analysis (Table 1).

Plausible mechanism for the formation of Dibenzoxanthene derivatives:

The analogous research documented in the literature elucidate the proposed process for the changes catalyzed by Nano ZnO particles, as illustrated in Scheme 2. We have hypothesized a viable process for the synthesis of dibenzoxanthenes in the presence of Nano ZnO. The interaction between the catalyst and the aldehyde yields protonated aldehyde 1 as a reactive intermediate. The reaction of β-naphthol with 1 generates oxonium ion 2, the aromatization-dehydration of which intermediate produces a carbocation. 4. 2-naphthol interacts with 4 to yield oxonium ion species. 5. which undergoes cyclization and dehydration to provide the 14-aryl-14H-dibenzo[a,j]xanthene 3.

Spectral date of Dibenzoxanthenes

14-phenyl-14H-dibenzo[a,j]xanthenes 3(a)





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Yellow solid, M.P: 102° C ; IR(KBr) : 1541, 1450 (Aromatic , C=C Str), 1204, 1142 cm⁻¹ (C-O-C Str) ; ¹H NMR (400 mHz, CDCl₃) : δ 5.60 (s, 1H, CH), 6.80-6.98 (m, 7H, Ar-H), 7.00-7.20 (m, 5H, Ar-H), 7.22-7.28 (m, 5H, Ar-H); ESI-MS m/z(%) : 359 ([M+H]⁺ 100).

14-(p-tolyl)-14H-dibenzo[a,j]xanthenes 3(b)

Yellow solid, M.P: 105° C ; IR(KBr) : 1587, 1433(Aromatic , C=C Str), 1218, 1043 cm⁻¹ (C-O-C Str) ; ¹H NMR (400 mHz, CDCl₃) : δ 2.34 (s, 3H, CH₃), 4.69 (s, 1H, CH), 7.01-7.03 (m, 6H, Ar-H), 7.15-7.28 (m, 10H, Ar-H) ; ESI-MS m/z(%) : 373 ([M+H]⁺ 100).

14-(2-nitrophenyl)-14H-dibenzo[a,j]xanthene 3(c)

Yellow solid, M.P: 117° C ; IR (KBr): 1525 cm⁻¹ (C=C Aromatic Str), 1345 cm⁻¹ (-NO₂), 1180, 1084 cm⁻¹ (C-O-C Str) ; ¹H NMR (400 mHz, CDCl₃) : δ 5.60 (s, 1H, CH), 7.02-7.55 (m, 6H, Ar-H), 7.65-7.78 (m, 5H, Ar-H), 7.84-8.09 (m, 5H, Ar-H) ; ESI-MS m/z(%) : 404([M+H]⁺ 100).

14-(2-chlorophenyl)-14H-dibenzo[a,j]xanthenes 3(d)

Yellow solid, M.P: 103° C ; IR (KBr): 1541 cm⁻¹ (C=C Aromatic Str), 1262, 1086 cm⁻¹ (C-O-C Str), 727, 632 cm⁻¹ (-Cl Str) ; ¹H NMR (400 mHz, CDCl₃) : δ 5.60 (s, 1H, CH), 7.02-7.28 (m, 6H, Ar-H), 7.46-7.78 (m, 5H, Ar-H), 7.80-8.16 (m, 5H, Ar-H) ; ESI-MS m/z(%) : 393 ([M+H]⁺ 100).

4-(14H-dibenzo[a,j]xanthene-14-yl)phenol 3(e)

Pink solid, M.P: 121° C ; IR (KBr): 3005 cm⁻¹ (-OH Str), 1542, 1510 cm⁻¹ (C=C Aromatic Str), 1168, 1028 cm⁻¹ (C-O-C Str) ; ¹H NMR (400 mHz, CDCl₃) : δ 5.50 (m, 2H, -OH), 6.63 (s, 1H, CH), 6.76-6.96 (m, 6H, Ar-H), 7.12-7.28 (m, 5H, Ar-H), 7.79 (m, 5H, Ar-H) ; ESI-MS m/z(%) : 375 ([M+H]⁺ 100).

14-(4-methoxyphenyl)-14H-dibenzo[a,j]xanthenes 3(f)

Yellow solid, M.P: 119° C ; IR(KBr) : 1467, 1413 cm⁻¹ (Aromatic ,C=C Str) , 1204 cm⁻¹ (C-O-C Str), 1083 cm⁻¹ (-OCH₃ Str) ; ¹H NMR (400 mHz, CDCl₃) : δ 3.91 (s, 3H, -OCH₃), 5.49 (s, 1H, CH), 6.66-6.96 (m, 6H, Ar-H), 7.13-7.28 (m, 5H, Ar-H), 7.78-7.81 (m, 5H, Ar-H) ; ESI-MS m/z(%) : 389 ([M+H]⁺ 100).

14-(4-bromophenyl)-14H-dibenzo[a,j]xanthenes 3(g)

Yellow solid, M.P: 105° C ; IR (KBr): 1538 cm⁻¹ (C=C Aromatic Str), 1202, 1070 cm⁻¹ (C-O-C Str), 589 cm⁻¹ (-Br) ; ¹H NMR (400 mHz, CDCl₃) : δ 5.55 (s, 1H, CH), 7.25-7.47 (m, 6H, Ar-H), 7.49-8.15 (m, 10H, Ar-H) ; ESI-MS m/z(%) : 438 ([M+H]⁺ 100).

14-(4-nitrophenyl)-14H-dibenzo[a,j]xanthenes 3(h)

Yellow solid, M.P: 121° C ; IR (KBr): 1594, 1520 cm⁻¹ (C=C Aromatic Str), 1372, 1344 cm⁻¹ (-NO₂), 1120 cm⁻¹ (C-O-C Str) ; ¹H NMR (400 mHz, CDCl₃) : δ 5.44 (s, 1H, CH), 6.99-7.07 (m, 6H, Ar-H), 7.11-7.28 (m, 5H, Ar-H), 7.34-7.80 (m, 5H, Ar-H) ; ESI-MS m/z(%) : 404 ([M+H]⁺ 100).

14-(4-chlorophenyl)-14H-dibenzo[a,j]xanthenes 3(i)

Yellow solid, M.P: 103° C ; IR (KBr): 1526 cm⁻¹ (C=C Aromatic Str), 1202 cm⁻¹ (C-O-C Str), 752, 724 cm⁻¹ (-Cl Str) ; ¹H NMR (400 mHz, CDCl₃) : δ 5.52 (s, 1H, CH), 6.98-7.17 (m, 6H, Ar-H), 7.21-7.28 (m, 5H, Ar-H), 7.36-7.98 (m, 5H, Ar-H) ; ESI-MS m/z(%) : 393 ([M+H]⁺ 100).

14-(2-methoxyphenyl)-14H-dibenzo[a,j]xanthenes 3(j)

Yellow solid, M.P: 107° C ; IR(KBr) : 1516, 1492 cm⁻¹ (Aromatic , C=C Str), 1203 cm⁻¹ (C-O-C Str), 1042, 1023 cm⁻¹ (-OCH₃) , ¹H NMR (400 mHz, CDCl₃) : δ 3.74 (s, 3H, -OCH₃), 4.70 (s, 1H, CH), 6.75-6.77 (m, 6H, Ar-H), 7.20-7.28 (m, 10H, Ar-H) ; ESI-MS m/z(%) : 389 ([M+H]⁺ 100).

Effect of loading of catalyst on the synthesis of Dibenzoxanthene derivatives

The current reaction was examined with varying quantities of catalyst. The findings indicate that 500 mg of catalyst suffices to provide a high yield of product. An further increase in the quantity of catalyst will not result in a significant change in product yield. Consequently, 500 mg of catalyst was utilized to conduct the reaction. This study selected a mixture of Benzaldehyde and β-naphthol in ethyl alcohol as the model reaction (Scheme 1). The results were compiled in Table 2.

Effect of solvent on synthesis of Dibenzoxanthene derivatives

The investigation of the reaction medium indicated that the solvent plays a significant role in the reaction. The findings are represented in Table 3. Polar solvents, including acetic acid, CH₃CN, and C₂H₅OH, were shown to be significantly more effective than non-polar solvents. Minimal yield detected when water served as the solvent, likely





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attributable to the agglomeration of the hydrophobic catalyst. Despite the efficacy of CH_3COOH , a poor yield was achieved upon catalyst reutilization. Consequently, ethanol was chosen as the solvent[14].

Effect of Temperature on Synthesis of Dibenzoxanthene derivatives

The reaction temperature for the synthesis of dibenzoxanthene using a nano ZnO catalyst is 80 °C, as indicated in Table 4. It was noted that below 80 °C, the yield was minimal and the reaction time was prolonged. The reaction was conducted at 80 °C, as indicated in Table 4.

Recycling of the Catalyst

The reusability of catalysts presents a significant challenge in heterogeneous catalysis. Catalyst recycling was accomplished by magnetically securing the catalyst at the base of the reflux flask using a powerful neodymium magnet. Subsequently, the solution containing the product was extracted with a pipette, and the catalyst was washed three times with ethyl acetate before being dried. The newly dissolved reactants in ethyl alcohol were placed into the round-bottom flask, followed by refluxing to facilitate the reaction during the subsequent run. The catalyst was utilized five times consecutively without any discernible loss of catalytic activity (Table 5).

CONCLUSION

Nano ZnO particles have been effectively employed as a catalyst for the synthesis of dibenzoxanthenes utilizing aromatic aldehydes and β -naphthol. The application of this catalyst presents numerous benefits: High yield and rapid reaction rates can be attained; catalyst preparation is straightforward; minimal catalyst loading and ease of operation are ensured, with no by-product formation. The catalyst can be effortlessly recycled using magnets and reused. This protocol further exemplifies the versatility of Nano ZnO for targeted chemical applications. This work's primary contribution is the effective synthesis of Nano ZnO, demonstrating a balance between re-cyclization and activity in the synthesis of Dibenzoxanthenes.

Declarations

Competing interests: There are no competing interests

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Table 1. Synthesis of Dibenzoxanthene derivatives derivatives.

S.No.	Compound	R	Time (min)	Yield (%)
1	14-phenyl-14H-dibenzo[a,j]xanthenes 3(a)	H	25	95
2	14-(p-tolyl)-14H-dibenzo[a,j]xanthenes 3(b)	4-CH ₃	27	95
3	14-(2-nitrophenyl)-14H-dibenzo[a,j]xanthene 3(c)	2-NO ₂	30	93
4	14-(2-chlorophenyl)-14H-dibenzo[a,j]xanthenes 3(d)	2-Cl	25	95
5	4-(14H-dibenzo[a,j]xanthen-14-yl)phenol 3(e)	4-OH	30	95
6	14-(4-methoxyphenyl)-14H-dibenzo[a,j]xanthenes 3(f)	4-OCH ₃	35	94
7	14-(4-bromophenyl)-14H-dibenzo[a,j]xanthenes 3(g)	4-Br	28	94
8	14-(4-nitrophenyl)-14H-dibenzo[a,j]xanthenes 3(h)	2-NO ₂	30	93
9	14-(4-chlorophenyl)-14H-dibenzo[a,j]xanthenes 3(i)	4-Cl	25	93
10	14-(2-methoxyphenyl)-14H-dibenzo[a,j]xanthenes 3(j)	4-OCH ₃	35	95

Table 2: Effect of catalyst loading on the formation of Dibenzoxanthene derivatives

S. No.	Catalyst loading in (mg)	Time (min)	Yield (%)
1.	200	25	42





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2.	300	25	66
3.	400	25	78
4.	500	25	95
5.	600	25	95

Table 3. Effect of solvent on synthesis of Dibenzoxanthene derivatives

S.No.	Catalyst	Solvent	Time(hrs)	Yield(%)
1	Nano ZnO	H ₂ O	7 hrs	Trace
2	Nano ZnO	CH ₂ Cl ₂	5 hrs	30
3	Nano ZnO	CH ₃ COOH	5 hrs	85
4	Nano ZnO	CH ₃ CN	70 min	90
5	Nano ZnO	C ₂ H ₅ OH	25 min	95

Table 4. Effect of Temperature on the formation of Dibenzoxanthene derivatives

S. No.	Catalyst	Temp(°C)	Time	Yield (%)
1	Nano ZnO	R.T.	30 hrs	20
2	Nano ZnO	50	10 hrs	50
3	Nano ZnO	70	3 hrs	75
4	Nano ZnO	80	25 min	95

Table 5. Recyclability of the catalyst in the reaction, synthesis of Dibenzoxanthene derivatives

Run no.	Yield (%)
1	95
2	93
3	91
4	90
5	88

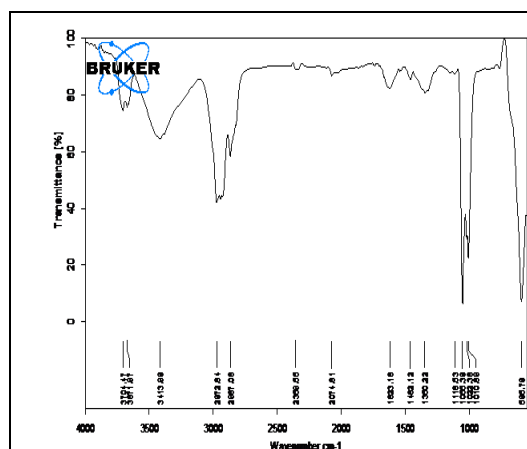


Figure 1. FT-IR spectrum of nanoZnO

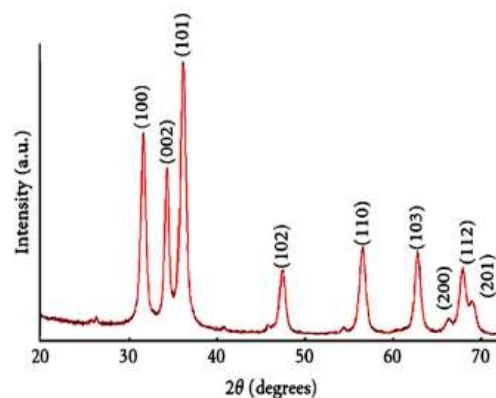


Figure 2. XRD pattern of Nano ZnO





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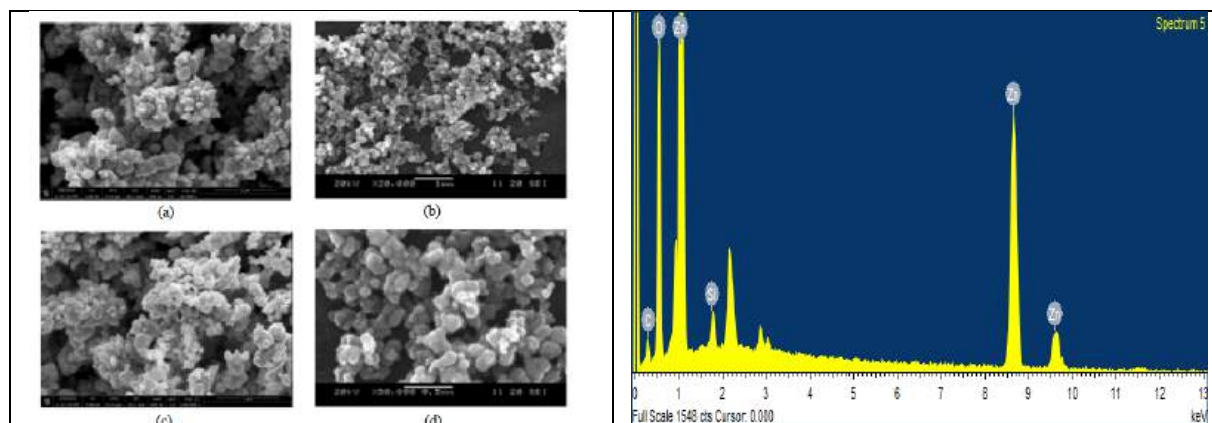


Figure 3: SEM images of nanoZnO

Figure 4: EDX spectrum of nanoZnO

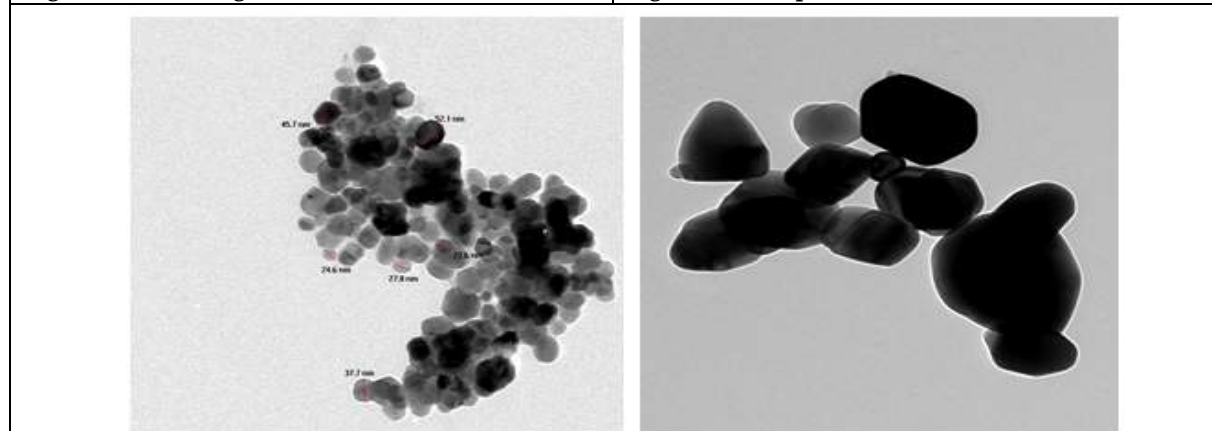


Figure 5: TEM images of nanoZnO

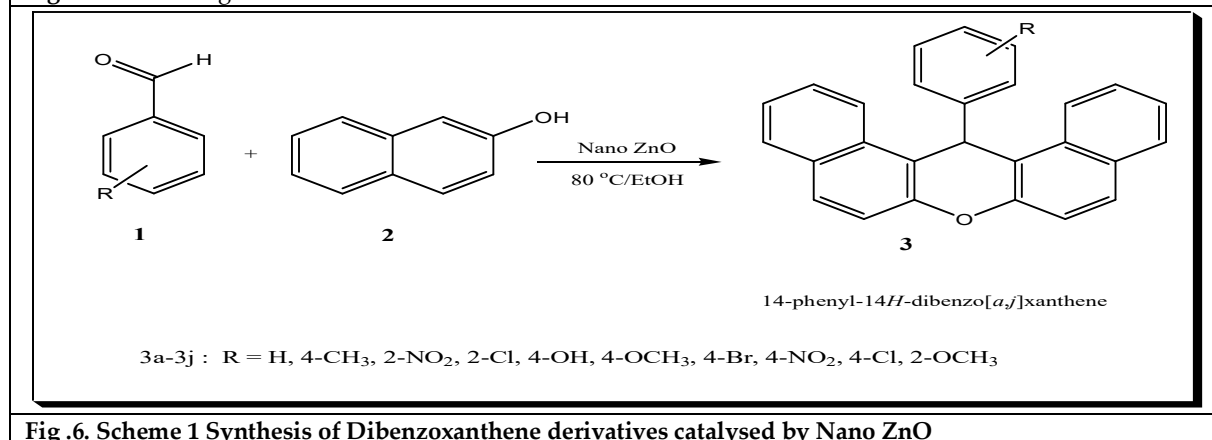


Fig .6. Scheme 1 Synthesis of Dibenzo-xanthene derivatives catalysed by Nano ZnO





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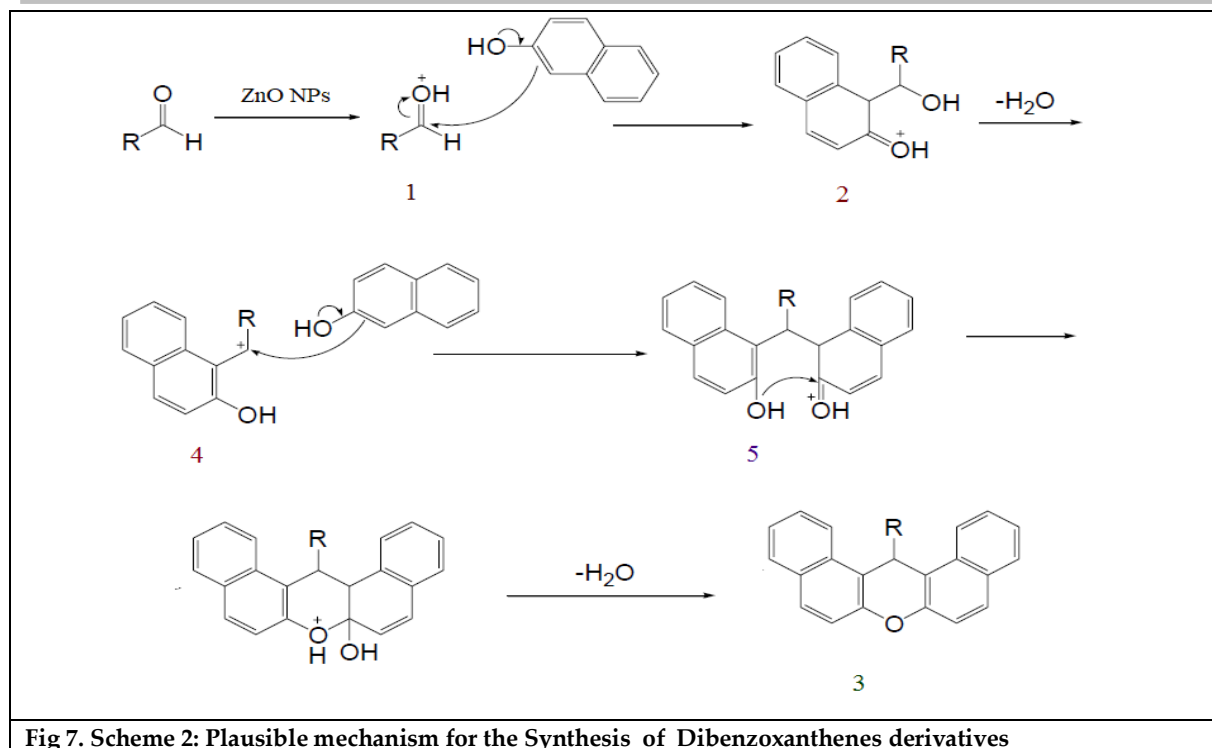


Fig 7. Scheme 2: Plausible mechanism for the Synthesis of Dibenzoxanthenes derivatives





Employing a Natural-Language Processing-Based Input Identification Framework to Strengthen Automatic Automobile Parameters Performance Quality

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ABSTRACT

Autonomous automobiles (AVs) have emerged as a viable option for environmentally friendly and intelligent transport in order to meet rising mobility needs while minimizing negative consequences on society, the economy, and the environment and to execute driving responsibilities. Advanced autonomous driving systems (ADASs) in autonomous vehicles (AVs) concentrate significantly on sensor and camera data are used to conduct vehicle control operations for self-driving vehicles. In addition, AVs feature a voice communication system (VCS) that interacts with driving users to do various hand-free operations. Navigation, temperature regulation, media and entertainment, communication, vehicle settings, vehicle status, and assistance in emergencies are merely a few of the characteristics that have been seamlessly incorporated into AVs. Several researchers have also used voice instructions using VCSs to accomplish controlling the vehicle features. If the AV sheds control due to a stop working or fault in the installed computer, sensors that are other associated modules, bringing about viewers can control the AV using notes they speak to perform some driving tasks such as changing speeds, lanes, breaking, and directing the car to a safe state. Furthermore, in some cases, such as lane change or departing owing to deviation, vehicle users' needs discretionary control over AV. These tasks can also be carried out utilising voice commands and VCSs. Finding the correct pronunciation for voices utilised to instruct different devices such as actuators in danger conditions is therefore critical. As a result of this, VCSs may substantially improve safety in emergency situations requiring physical intervention. As a result, natural language processing is used to extract the characteristics needed to assess the user's needs and regulate



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the vehicle's functioning and aid in driving. Present techniques spend an excessive amount of computing whenever anticipating the user instruction, resulting in a decrease in the AVs' functionalities. The variation-driven continually inputted recognition model has been employed to solve this research problem and this method employs a linear development procedure that addresses the listening and restricted in time challenges, as well as solving the problem of uncertain response. This approach divides inputs either non-trainable and capable of training categories based on data preparedness as well as listening span. The non-distinguishable data was then confirmed by splitting it into the linear inputs required to enhance AV responsiveness. Thus, utilising training parameters and the data decomposition method efficiently reduces uncertainty and enhances response rate. The suggested approach has considerably increased the accuracy as well as the effectiveness of recognising users' notes during speech. This enhancement improves the level of craftsmanship and consistency of the VCS employed to execute hand-free and vehicle control operations.

Keywords: Naturally occurring language processing; variation continuous input recognition; uncertainty assessment; self-driving vehicles

INTRODUCTION

The automotive sector, traditionally a symbol of technical progress, is undergoing a significant revolution marked by the introduction of computational intelligence (AI) and Machine Learning (ML) into its fundamental core. Modern automobiles are more than simply providers of transportation; they are developing into intelligent networked devices powered by complex software systems. The critical role of software in controlling, monitoring, and maximising the performance of a car is reshaping an automotive engineering environment.

The notion of automated car parameters, a collection of configurable settings that regulate numerous aspects of a vehicle's performance, is at the heart of this shift. These criteria include an extensive array of functions, including engine effectiveness and secure features, as well as comfort and systems for entertainment. The right setting of these variables is critical towards accomplishment. The intended levels of how they perform, safety, overall satisfaction. In past centuries, calibrating these parameters was a manual, labor-intensive process that relied on an understanding of technologists and designers. In this regard, our study seeks to completely transform the quality and performance of autonomous car parameters by utilising a unique artificial language processing (NLP)-based parameter identification architecture. Our primary goal is to bridge the gap that exists among the continually expanding numerous amounts of automotive information, which is sometimes hidden inside enormous warehouses of disorganised written materials, and the urgent need for efficient, automated parameter standardisation. The usual method of setting and calibrating those parameters turned out to be riddled with obstacles. It is a tedious procedure whose success is heavily predicated on each person's abilities and prone to problems. The manual nature of this technique not only wastes time but also raises the possibility of human mistake, lowering the general excellence of the cars manufactured. Our study addresses these issues front on by presenting an innovative NLP-based framework that pledges to usher surrounding a new age of automotive manufacturing. This system uses NLP to convert complicated, unstructured textual data from repair manuals, maintenance instructions, and technical publications into organised, usable information for parameter tuning. The latter is performed using sophisticated algorithms such as language parsing, sentiment examination, and entity segmentation. Whatever causes this type of approach genuinely harmful is its potential to revolutionise the car industry's maintenance and repair operations. We are getting closer to self-diagnosing, self-configuring cars by lowering the number of human engagements of the parameter validation and combining the NLP-based methodology with onboard in addition system components. These vehicles can constantly modify and optimise their parameters based on their own operating data and insights derived from a vast body of textual information. Our research is of importance considering it has the ability to



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improve both the effectiveness and the calibre of automatic automobile characteristics. Vehicles employing this technology may repeatedly fine-tune their settings, resulting in increased energy consumption, safety, overall satisfaction with the user experience. Furthermore, this architecture helps to reduce expenses related to maintenance while also enhancing productivity. To put it simply, what we have discovered represents an important development in automobile technology. It not only demonstrates NLP's transformational potential, but also emphasises the essential function that AI and ML can play in shaping a safer, more efficient, and sustainable future for the automobile sector. At the core of the aforementioned a turning point is an upgrade from a manual, time-consuming value calibration to based on information, automated parameter optimising which is going to carry the car manufacturing sector into a new age of increased independent thought and efficiencies.

MATERIALS AND METHODS (LITERATURE STUDY):

In the past few decades, significant research has been undertaken in the subject matter autonomous AVs with the goal of enhancing the functioning as well as security of these vehicles using NLP and ML approaches. NLP is used to extract meaning and structure from human language, whereas ML is used to analyse massive volumes of data and generate judgements using programmes and mathematical frameworks. These strategies can be coupled to increase the accuracy of voice instructions supplied to AVs, as well as their performance and safety. The purpose of the current review of literature is to provide an overview of the numerous studies that have been carried out executed in this topic, highlighting recent breakthroughs and the present status of research on artificial intelligence (AI) and machine learning (ML) for AVs. Wan *et al.* [42] established an automated Xml-based framework (ANLPF), which is a real-time traffic reporting system for social media networks that uses NLP. The suggested technique uses text mining to determine the actual meaning and substance of the piece of writing, resulting in correct data for drivers and users. A question-and-answer approach is used to extract data or knowledge for users, which is crucial for analysing traffic flow on motorways. In terms of providing knowledge to customers, the suggested traffic reporting procedure is far more reliable than conventional methods. Braun *et al.* [43] proposed visualising natural language interactions for an in-vehicle computer system that is conversational. The suggested solution enhances the in-vehicle system's speech-based engagement mechanism. To comprehend the specifics of the circumstance a particular collection of terminology is provided. The information contained in the text facilitates the decision-making process for users. The interface's beauty is boosted by the use of icons and symbols that convey correct knowledge regarding the interaction process. The suggested technique enhances the visualisation of the interaction process, which optimises prediction and detection accuracy. Solorio *et al.* [44] presented a semi-autonomous multipurpose car constructed using already established house automation technology. The suggested approach is a voice-activated automated system that interacts with hardware and software elements. The suggested method is usually utilised in online and smart apps to improve vehicle control management command, thereby improving system performance. In a car, a speaker and conversation recognizer are both utilised to offer correct information and services to users.

Proposed Methodology for this Review Research:**Variant Suggestions Mechanism for Persistent Input Recognition:**

We provide a unique Variation Continuous Source Recognition Modelling (VCIRM) in the quest for enhancing the quality and performance of self-sufficient automotive parameters using a natural-language processing (NLP)-based input classification framework. This device constitutes a game-changer in the field of automotive engineering, addressing a critical requirement for autonomous and data-driven parameter to be used standardisation.

History: As previously pointed out, the setup and calibration of autonomous automotive characteristics have historically been reliant on human beings procedures, which are typically tainted by independence, labour intensity, and the possibility of inconsistency. Our study intends to change this paradigm through the introduction of modern natural language processing (NLP) and artificial intelligence (AI) gets closer into the automotive arena, altering how we discover and alter these crucial parameters.



**Anuradha Patnala and Prathibha Malini Kanakala****The Framework for VCIRM:**

Data Collection and preparing: The beginning phase of our VCIRM architecture is collecting and preparing textual data from a variety of sources, such as repair manuals, technical documents, and routine upkeep instructions. This information serves as the foundation for the information we have library by which is vital for model training and parameter identification.

Text Parsing and Entity Recognition: To examine textual substances, VCIRM leverages forefront text parsing and identification of entities algorithms. The model retrieves structured knowledge about specific automotive characteristics, functions, and ideal configurations by recognising essential elements and their connections with one another.

Sentiment Analysis: Sympathy analysis is a crucial aspect of VCIRM since it allows the model to understand the context and subtleties around parameter selections. This stage distinguished recommendations from warning remarks, ensuring that parameter sets prioritise safety, performance, and efficiency.

Machine Learning for Parameter Identification: After converting written submissions into data that is organised, VCIRM employs machine learning methods for parameter identification. The model combines the retrieved data with vehicle-specific data to develop optimum parameter settings.

Continuous Learning and Adaptation: VCIRM distinguishes itself by means of its capacity to participate in continuous learning and adaptation. The model obtains real-time operating data by means of communication using on-board vehicle systems. This data is then analysed in order to improve characteristic sets at response to changing riding environments.

VCIRM has the following advantages:

Automation: VCIRM streamlines the parameter identification process, decreasing the requirement for manual involvement and, as a result, increases the likelihood of human mistake. This automation speeds up the parameter the calibration procedure, saving both resources and time.

Data-Driven Optimisation: By constantly acquiring information from real-world driving the information, VCIRM makes certain that parameters are not only improved at a particular moment in time, but are also adapting to changing situations, enhancing both performance and security.

Consistency: The model's ability to apply appropriate parameter values systematically minimises variability in the calibration process, guaranteeing that all cars meet high performance as well as security standards.

Safety and efficiency: VCIRM's assessment of sentiment makes certain that safety-critical metrics are prioritised, ensuring that safety is never overlooked to feed the sake of profitability or efficiency.

The Variation Continuous Information Recognition Model (VCIRM) provide a key achievements in the aim of improving automotive technology. VCIRM provides a data-driven, automated, and adaptive method to autonomous car parameters the calibration by combining the capabilities of the processing of natural languages with machine learning and real-time data integration. The approach not only overcomes the issues of manual procedures, but it also lays the path for future cars that are safer, kinder to the environment, and sustainable. VCIRM adoption in the automotive sector has the potential to be a game changer, revolutionising our ability to design and recalibrate vehicle characteristics. The study demonstrates the potential of AI and NLP in improving the quality and effectiveness of automated machinery as automotive manufacturing seeks for more autonomy and efficiency.

Result (Model Performance Assessment):

Assessment of Performance: The recommended Variability Continued Input Recognition Model (VCIRM) would be successful if it can produce substantial improvements in both the quality and the efficiency of autonomous car parameters. A complete performance evaluation strategy is required to analyse the efficacy and feasibility of VCIRM. In this part, we will go through the main points of this evaluation.

1. Precision as well as accuracy:

The precision with which VCIRM recognises and configures the relevant settings for certain vehicle types is at the heart of its performance evaluation. The model should be thoroughly validated on an extensive selection of makes and models to verify that it consistently detects the correct settings while demonstrating high precision and accuracy.



**Anuradha Patnala and Prathibha Malini Kanakala****2. The rapidity and efficiency:**

The goal of VCIRM is to streamline and quicken up the parameter calibration procedure. The evaluation will In juxtaposition with old manual approaches, measure the time necessary for VCIRM to process textual input from the user, identify parameters, and apply optimal combinations. A good VCIRM should cut the time required for this process substantially.

3. Learning and Adaptability:

VCIRM's capacity utilisation to learn and adapt to changing driving situations is critical. The model's performance in actual-world situations with varying driving circumstances will be evaluated. It should be able to modify parameter combinations for maximum both safety and performance.

4. Dependability and uniformity:

consistency and Consistency is a key factor in assessing VCIRM. The suggested parameter sets are supposed to be applied consistently across various automobiles of the same make and model by the model. To guarantee consistency, result unpredictability should be eliminated.

5. Real-time Observation and Adaptation:

Because VCIRM is integrated with on-board vehicle systems, immediate monitoring and adjustments is possible. The evaluation should look at how sensitive the model is to new data and how successful its immediate modifications have been for improving vehicle performance and safety.

6. Comparative Evaluation:

A comparison study will be performed in order to demonstrate the benefits of VCIRM over preceding manual approaches. This is going to involve comparing VCIRM results against individuals of human technicians in terms of timeliness, precision, and adaptability.

7. Metrics for protection and efficiency:

In the automobile The industry safety is of the greatest importance. The performance of VCIRM in prioritising safety-critical parameters will be examined and assessed using the method of sentiment analysis. The model's influence on fuel economy and total automobile effectiveness will also be assessed.

8. User Experience and Feedback:

Feedback from end-users, such as technicians and drivers, is invaluable in assessing VCIRM's real-world usability and acceptability. User surveys and feedback mechanisms will be used to gather insights into user satisfaction and perceptions.

9. Sustainability and Cost-Efficiency: The examination will look at the ability to expand of VCIRM. Is the model applicable to a diverse variety of vehicle makes and models? The financial benefits of implementing VCIRM in terms of lower labour expenses and better operational efficiency will also be examined.

10. The long-term Performance and Operation: The lifetime and maintenance requirements of VCIRM will be investigated. It should be durable as well as adaptable to modifications to software and modern automobile technology.

The effectiveness evaluation of VCIRM is a significant phase in the investigative process. It will give empirical proof that the model can improve the quality and performance of automatic vehicular characteristics, letting you know its potential to revolutionise the car manufacturing sector by making automation and optimisation an important component of automotive development.

DISCUSSION

Autonomous vehicles are establishing themselves as a viable alternative for sustainable and intelligent modes of transportation, capable of meeting the world's expanding mobility demands. As consequently, one of the key concerns about operating AVs on the roads is the safety of both pedestrians and cyclists and AV drivers. VCS is an important component in AVs since it controls the hand-free and autonomous vehicle business operations. As consequently, VCS has significance to the safeguarding of driving clients in circumstances when the AV fails to maintain control due to a malfunction or problem caused by the installed hardware. Computer, instruments, as well as additional components are all part of the system. Driving users may manage the AV using voice notes to conduct



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driving activities such as speed, direction, speed, lane change, and pedal to attain a safe state in this unpredictable and perilous environment. Furthermore, in some cases, such as switching paths or taking an exit owing to distinction, driving users needed manual control over AV. These tasks can also be completed using voice commands and VCS. As a result, selecting exactly which spoken note utilised to instruct different transducers in a dangerous circumstance is critical. The technique and performance of the proposed VCIRM for delivering reliable voice-based control in AVs were addressed in this paper. The readily apparent and non-distinguishable inputting languages/voices have been recognised. In spotting words inputs, the suggested approach handles the listening time-based ambiguity. First, using interactive analysis, distinguishing and non-distinguishable data are retrieved. Using linear regression gaining knowledge, these data are used to manage variable viewing spans. For recognising non-distinguishable speech inputs, the swings in the linear regression a number are treated independently. Based on the accepted time, a probability based on distinction and similarity is estimated for subsequent requests. Toning the input with learned data and supplementing distinct inputs are used in this technique. As consequently, sequential input recognition is pursued using probabilistic regressive series to avoid ambiguity.

CONCLUSION

The suggested model maximises response rate, data availability, along with training rate by 6.97%, 9.31%, and 15.72%, respectively, according to various inputs. It, on the opposing hand, cuts response time and uncertainties by 8.39% and 11.09%, respectively. The suggested approach has considerably increased the accuracy of spoken request prediction and the effectiveness of computation. As a result, VCSs can significantly increase safety in critical circumstances requiring physical intervention. Integrating VCSs with ADASs and building an interactive ADAS may substantially enhance the functionalities and quality of AVs. This improvement raises the quality and stability of VCSs used in automotive control operations. The dependable nature of vehicle control operations ultimately results in enhanced safety for automobiles that are autonomous and other road users in the course of time. Nonetheless, the suggested VCIRM has increased the reaction speed and accuracy of voice command recognition in AVs dramatically. However, various constraints must be handled, that include background noise and a confined vocabulary, Variations and phrases, integrating non-voice inputs, and security and privacy concerns are all issues to consider. These constraints must be addressed in order for NLP-based input categorization models for AVs to be widely adopted and successful. To overcome these problems and assure the stability of these systems for efficient implementation in AVs and enhanced safety, additional investigation and development will be important throughout the future.

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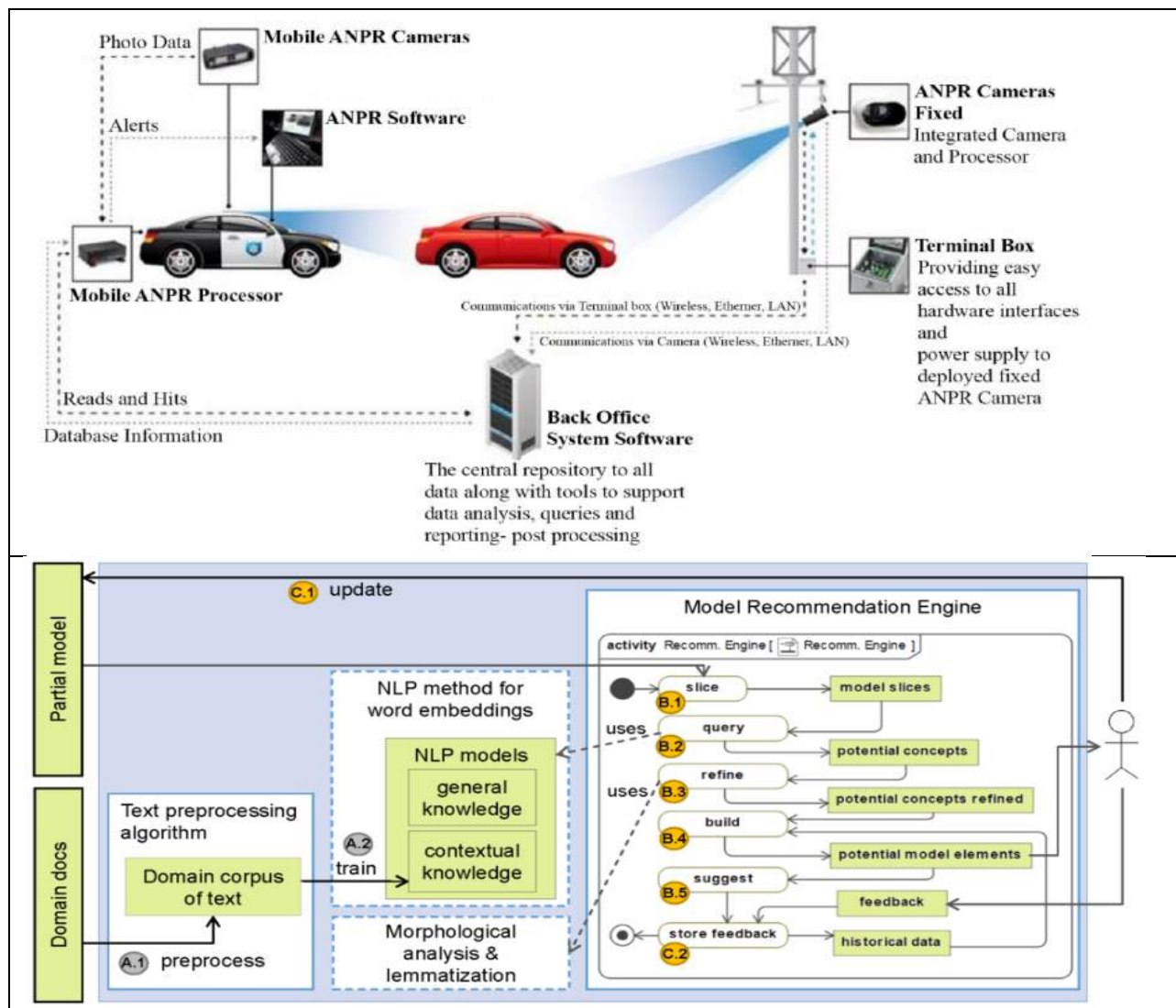
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Boosting Employment Retention Rates in Indian Universities: Strategies for Sustainable Workforce Management

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ABSTRACT

Employee retention has become a critical concern for Indian universities facing an increasingly competitive academic landscape. High turnover rates not only disrupt the learning environment but also impose significant financial burdens due to the costs associated with recruiting, training, and on boarding new staff. This article examines the key factors influencing employment retention in Indian universities and proposes effective strategies to improve retention rates. The introduction provides an overview of the employment retention challenges in Indian universities, highlighting the impact of high turnover on academic quality, institutional reputation, and financial sustainability. A comprehensive review of literature identifies the main factors influencing employee retention, such as job satisfaction, work-life balance, professional development opportunities, and organizational culture. The methodology section adopts a mixed-methods approach, combining quantitative data from surveys of university staff with qualitative insights from interviews with HR professionals and faculty members. The discussion and results highlight key findings, including the importance of competitive compensation, clear career progression paths, supportive work environments, and recognition programs in retaining employees. Detailed tables are presented to illustrate the correlation between retention strategies and employee satisfaction levels. The conclusion emphasizes the need for Indian universities to adopt a holistic approach that combines monetary and non-monetary incentives to retain talent and suggests areas for further research.

Keywords: Employee Retention, Indian Universities, Talent Management, Academic Workforce, Job Satisfaction, Work-Life Balance





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INTRODUCTION

The academic landscape in India has undergone significant changes in recent years, with universities expanding their programs, investing in research, and striving to attract top talent to improve their global rankings. However, a persistent challenge facing Indian universities is the high rate of employee turnover, which negatively impacts the quality of education, research output, and overall institutional performance. Retaining skilled faculty and administrative staff has become a critical issue that can make or break a university's ability to achieve its strategic goals. Employee retention refers to an organization's ability to retain its employees over time, ensuring stability, continuity, and sustained productivity. In the context of Indian universities, high turnover rates are often attributed to factors such as inadequate compensation, limited career advancement opportunities, lack of recognition, poor work-life balance, and a rigid hierarchical culture. The constant churn of employees not only affects the quality of education but also leads to increased costs associated with recruiting, training, and onboarding new staff members. For universities that are already grappling with limited budgets, these costs can be prohibitive and hinder the institution's ability to invest in academic programs, research, and infrastructure.

One of the major reasons for high turnover in Indian universities is the perception that academic careers lack growth opportunities compared to other sectors. Many employees feel that their contributions are not adequately recognized, leading to dissatisfaction and a desire to explore opportunities elsewhere. This sense of stagnation is further compounded by the rigid structures that characterize many Indian universities, where promotions are often based on seniority rather than merit, and there is limited scope for skill development or exposure to diverse roles. Another significant factor influencing retention is work-life balance. Academic staff often face heavy workloads, including teaching, research, administrative duties, and student mentorship. This can lead to burnout, making employees more likely to seek opportunities in environments that offer a healthier balance between professional and personal life. Moreover, the lack of flexible working arrangements in many universities exacerbates this issue, leading to dissatisfaction and increased turnover rates.

Furthermore, the compensation packages offered by Indian universities are often less competitive compared to those in other industries or even foreign academic institutions. This disparity makes it difficult to attract and retain talented individuals, especially those who possess specialized skills or expertise in high-demand fields. Additionally, the absence of comprehensive benefits, such as health insurance, retirement plans, and professional development opportunities, further diminishes the appeal of academic positions. Addressing these challenges requires a comprehensive approach that focuses on both monetary and non-monetary factors. Universities need to recognize the importance of creating an environment that supports professional growth, fosters a sense of belonging, and offers competitive compensation. Implementing retention strategies such as mentorship programs, opportunities for skill development, performance-based promotions, and flexible work arrangements can significantly enhance employee satisfaction and reduce turnover rates. This article aims to explore the key factors influencing employment retention in Indian universities and provide actionable strategies to improve retention rates. By understanding the underlying reasons for high turnover and implementing targeted interventions, universities can create a more stable and motivated workforce, ultimately contributing to the institution's long-term success.

REVIEW OF LITERATURE

A review of existing literature reveals several factors that contribute to employee retention in academic settings. According to *Spector (2019)*, job satisfaction is one of the most significant predictors of employee retention. Spector's study highlighted that employees who feel valued, recognized, and have a clear sense of purpose are more likely to remain committed to their organization. This finding aligns with the *Herzberg's Two-Factor Theory (1959)*, which emphasizes the importance of both hygiene factors (salary, job security) and motivators (recognition, achievement) in employee retention. Research by *Tiwari and Sharma (2020)* emphasized that work-life balance plays a crucial role in



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retaining employees in Indian universities. Their study found that academic staff who experience excessive workloads and inflexible schedules are more likely to experience burnout and consider leaving their jobs. They recommended that universities adopt flexible work arrangements, such as remote work options and flexible hours, to improve retention.

Another study by Choudhury *et al.* (2018) focused on the impact of career advancement opportunities on retention rates. Their research revealed that faculty members who perceive a lack of growth and promotion opportunities are more likely to seek employment elsewhere. The study recommended implementing transparent promotion policies, mentorship programs, and professional development initiatives to enhance employee retention. Gupta and Singh (2021) explored the role of organizational culture in employee retention, concluding that a supportive, inclusive, and collaborative work environment significantly contributes to retention rates. They emphasized the need for universities to foster a culture of teamwork, open communication, and mutual respect to create a positive workplace atmosphere. Overall, the literature suggests that factors such as job satisfaction, work-life balance, career growth, and organizational culture are critical determinants of employee retention in Indian universities. Addressing these factors through targeted strategies can lead to improved retention rates and a more motivated and committed workforce.

METHODOLOGY

This study adopted a mixed-methods approach to analyze the factors influencing employee retention in Indian universities. The quantitative component involved administering an online survey to 200 academic and administrative staff members from 10 Indian universities. The survey included questions related to job satisfaction, work-life balance, compensation, career growth opportunities, and organizational culture. Respondents were asked to rate their satisfaction with these factors on a 5-point Likert scale, ranging from "very dissatisfied" to "very satisfied." In addition to the survey, qualitative data were collected through semi-structured interviews with 20 HR professionals, faculty members, and administrators from the same universities. The interviews focused on understanding the challenges faced in retaining employees, the effectiveness of existing retention strategies, and potential solutions for improving retention rates. This combination of quantitative and qualitative data provided a comprehensive understanding of the factors influencing employee retention in Indian universities.

The collected data were analyzed using statistical software to identify trends, correlations, and patterns. The qualitative data from interviews were transcribed and analyzed thematically to gain deeper insights into the factors affecting retention rates.

By employing this mixed-methods approach, the study ensured that the findings were robust, comprehensive, and reflective of the diverse perspectives within the academic sector.

DISCUSSION AND RESULTS

The survey results revealed several key findings:

Factor	Satisfied (%)	Dissatisfied (%)
Job Satisfaction	60	40
Work-Life Balance	50	50
Compensation	45	55
Career Growth	40	60
Organizational Culture	65	35

Explanation: The data indicated that career growth and compensation were the most significant factors contributing to dissatisfaction among employees, with 60% and 55% expressing dissatisfaction, respectively. Work-life balance was also a concern, with half of the respondents indicating dissatisfaction.



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Interviews highlighted that employees valued professional development opportunities, mentorship, and a positive work environment. Several HR professionals emphasized the need for performance-based promotions and recognition programs to boost morale and retention.

CONCLUSION

To increase retention rates in Indian universities, it is essential to address key factors such as compensation, career growth, work-life balance, and organizational culture. By implementing strategies such as transparent promotion policies, competitive salaries, mentorship programs, and flexible work arrangements, universities can create a more supportive and engaging work environment that fosters long-term employee commitment.

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A Review on Tool Life Comparison between Conventional Machining, CNC Machining and Abrasive Machining Process

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ABSTRACT

Tool life is a critical factor influencing productivity, cost, and quality in manufacturing. Different machining processes, including conventional machining, Computer Numerical Control (CNC) machining, and abrasive machining, exhibit distinct characteristics in terms of tool wear and life expectancy. This paper reviews the factors affecting tool life in these processes, comparing them based on material removal mechanisms, cutting tool materials, wear mechanisms, and operating parameters. The review consolidates insights from multiple studies to offer a comparative analysis that could inform decision-making in selecting appropriate machining methods for specific applications, ultimately contributing to more efficient manufacturing processes.

Keywords: Tool Life, Conventional Machining, CNC Machining, Abrasive Machining, Wear Mechanisms

INTRODUCTION

Machining processes are pivotal in modern manufacturing, serving as fundamental techniques for shaping and finishing materials across a multitude of industries, including aerospace, automotive, and electronics. The ability to accurately and efficiently create parts from raw materials is essential for ensuring product performance and meeting industry standards. As manufacturing technologies evolve, the need for enhanced efficiency and precision has become increasingly critical, making the study of tool life a priority for engineers and manufacturers. Tool life is defined as the duration a cutting tool can operate effectively before it becomes unusable due to wear, damage, or failure [1]. This metric is not merely an operational statistic; it significantly influences production efficiency, cost-



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effectiveness, and the overall quality of manufactured products. Understanding the factors that affect tool life is essential for optimizing machining operations and improving productivity.

Various factors contribute to tool wear, including cutting speed, feed rate, material properties, and tool material [2]. Each machining process—whether conventional, CNC, or abrasive—exhibits unique characteristics and challenges regarding tool life. Conventional machining processes, which rely on manual operation, often face variability in tool performance due to operator skill and external conditions. In contrast, CNC machining offers automation and precision, allowing for more consistent tool life by minimizing human error and optimizing cutting conditions [3]. Abrasive machining processes present another layer of complexity. These processes, which utilize hard particles to remove material, often result in different wear mechanisms that can lead to shorter tool life despite their effectiveness in achieving high surface finishes [4]. As industries seek to enhance production efficiency and reduce costs, a comprehensive understanding of tool life across different machining methods becomes increasingly valuable. This review aims to provide a detailed comparison of tool life in conventional, CNC, and abrasive machining processes, exploring the underlying mechanisms of wear and the implications for manufacturing practice. By consolidating insight from various studies, the paper seeks to inform decision-making in selecting appropriate machining methods for specific applications, ultimately contributing to more efficient manufacturing processes.

The primary objective of this research is to systematically analyze and compare the tool life across three distinct machining processes: conventional machining, CNC machining, and abrasive machining. This study aims to identify and investigate the various factors influencing tool life, such as cutting speed, material properties, tool materials, and coolant application. Additionally, it will examine the different wear mechanisms associated with each process, highlighting their implications for tool performance. A comparative analysis will assess the advantages and disadvantages of each method in terms of productivity, cost-effectiveness, and output quality. The research seeks to provide insights and recommendations for manufacturers to aid in selecting appropriate machining methods based on specific application requirements, thereby optimizing operational efficiency and reducing costs. Ultimately, this study aims to establish a foundational understanding of tool life dynamics to guide future research into advanced machining technologies and practices.

Machining Processes Overview**Conventional Machining**

Conventional machining encompasses manual processes such as turning, milling, drilling, and grinding, where skilled operators control the cutting tools. These processes are characterized by their reliance on human judgment and experience, which can significantly affect tool life and performance [3]. Factors such as cutting speed, feed rate, and depth of cut are often adjusted based on operator discretion, leading to variability in operational conditions. The materials being machined also play a crucial role; harder materials can induce accelerated wear on cutting tools.

Tool wear in conventional machining primarily occurs due to adhesive and abrasive wear mechanisms, where the tool material interacts with the workpiece, leading to material transfer and loss. The requirement for frequent re-grinding and replacement can lead to increased downtime and operational costs. Additionally, the lack of automated feedback systems means that wear may go unnoticed until it affects the quality of the finished product. Despite these challenges, conventional machining is still widely used, especially for simpler operations and smaller production runs, where flexibility and adaptability to varying tasks are essential. Understanding the limitations and operational intricacies of conventional machining is vital for optimizing its efficiency and extending tool life. Factors like vibration, inconsistent feed rates, and unoptimized cutting parameters often lead to increased tool wear and shorter tool life. Moreover, tool life can vary significantly between operators based on experience and technique [4]. Due to inconsistent operating conditions and the frequent need for tool re-grinding, tool life in conventional machining is often shorter than in CNC processes.



**Jena and Ranjan Behera****CNC Machining**

CNC machining automates the machining process using pre-programmed software to control the movement of tools along multiple axes [5]. This automation results in high precision, consistency, and the capability to perform complex geometries that would be difficult or impossible with conventional methods. CNC machines can maintain optimal cutting conditions, which directly contributes to improved tool life compared to conventional machining. CNC (Computer Numerical Control) machining represents a significant advancement over conventional methods by automating the machining process through computer-controlled movements. This technology allows for high precision and repeatability, making it ideal for complex geometries and high-volume production. CNC machines operate using pre-programmed software that dictates the movement of tools along multiple axes, thereby reducing the variability associated with manual operations. The ability to maintain optimal cutting conditions—such as precise cutting speeds and feed rates—results in improved tool life compared to conventional methods.

Moreover, modern CNC machines are often equipped with advanced tool monitoring systems that can assess tool condition in real-time, allowing for adjustments to be made dynamically. This capability minimizes the risk of excessive wear and prolongs tool life. However, the initial investment in CNC machinery can be substantial, and the setup requires skilled personnel to program and operate the machines effectively. The trade-off, however, is that the efficiency gains and consistency in quality often justify the costs. Overall, CNC machining has revolutionized manufacturing by enhancing productivity, reducing waste, and achieving high-quality finishes, making it a preferred choice in many industries. Furthermore, CNC machines can be equipped with advanced tool monitoring systems that dynamically adjust parameters such as feed rate and cutting speed based on real-time data, thus minimizing tool wear [6]. These systems can also predict tool failure, allowing for preemptive tool changes that reduce downtime and maintain productivity. The adaptability of CNC machining to various materials and conditions makes it a favored choice in modern manufacturing [7].

Abrasive Machining

Abrasive machining involves the removal of material using abrasive particles bonded to wheels, belts, or other forms [8]. Common processes include grinding, honing, and lapping, primarily used for finishing operations or hard materials. Abrasive machining is particularly effective for achieving superior surface finishes and high dimensional accuracy, which are essential in industries such as aerospace and automotive. Abrasive machining encompasses processes like grinding, honing, and lapping, which utilize hard particles bonded to a wheel or belt to remove material. This method is particularly advantageous for achieving high precision and superior surface finishes, making it essential in industries where tolerance and surface quality are paramount, such as aerospace and automotive. Abrasive machining is often employed for hard materials, including hardened steels and ceramics, where conventional cutting tools may struggle to maintain performance.

The wear mechanisms in abrasive machining differ significantly from those in conventional and CNC processes. The primary wear mode is abrasive wear, where the cutting edges of tools are subjected to constant impact and friction from abrasive particles. This can lead to shorter tool life, requiring careful management of parameters such as feed rate and coolant application to mitigate wear. Additionally, the cost of superabrasive materials, like diamond or cubic boron nitride, while effective, can be prohibitive. Despite the challenges associated with tool life, abrasive machining remains vital for specialized applications, underscoring the need for ongoing research into improving tool materials and wear mechanisms to enhance overall efficiency. However, the abrasive nature subjects tools to different wear mechanisms compared to conventional and CNC machining, often resulting in shorter tool life. The wear in abrasive machining is typically more aggressive due to continuous contact between the abrasive material and the work piece [9]. Nevertheless, advancements in abrasive technologies, such as the development of superabrasives like CBN and diamond, have improved tool life and performance, albeit at a higher cost [10].



**Jena and Ranjan Behera****Factors Influencing Tool Life**

Tool life across different machining processes is influenced by several factors, including cutting speed, material properties, tool material, coolant application, and wear mechanisms.

Cutting Speed and Feed

In both conventional and CNC machining, higher cutting speeds generally lead to faster tool wear due to increased friction and temperature at the cutting edge [11]. The balance between cutting speed and material removal rate is crucial; while higher speeds can enhance productivity, they can also lead to rapid deterioration of the tool. CNC machining allows for precise control of cutting speeds, enabling operators to optimize tool life by adjusting parameters according to material characteristics and desired outcomes. Cutting speed and feed rate are critical parameters that significantly influence tool life in machining processes. The cutting speed, defined as the speed at which the cutting tool engages the work piece, directly affects the temperature generated at the cutting edge. Higher cutting speeds often lead to increased friction, which can accelerate wear due to thermal effects, including softening of the tool material and the onset of thermal cracking. Conversely, too low a cutting speed may result in ineffective material removal and poor surface finish.

Feed rate, the distance the tool advances with each revolution or pass, also plays a vital role. An optimal feed rate enhances productivity by increasing material removal rates; however, excessive feed can increase the load on the tool, leading to premature wear. In CNC machining, precise control of these parameters allows for optimization, balancing productivity and tool longevity. Real-time monitoring systems can further enhance this optimization by adjusting cutting conditions dynamically based on observed wear patterns. Understanding the interplay between cutting speed and feed rate is essential for manufacturers to extend tool life and improve the efficiency of machining operations, ultimately leading to reduced costs and improved product quality. Conversely, abrasive machining processes require much higher surface speeds to effectively remove material, which can exacerbate wear [12]. The interplay between cutting speed, feed rate, and tool life is complex, and optimizing these parameters is essential for maximizing efficiency.

Material Properties

The properties of the material being machined significantly affect tool life. Harder materials generate more wear on the tool, leading to increased frequency of tool replacement. In conventional and CNC machining, tool wear is generally more severe when machining high-strength alloys or materials with abrasive inclusions [13]. The properties of the material being machined have a profound impact on tool life. Factors such as hardness, toughness, and abrasiveness dictate how a material interacts with the cutting tool, influencing wear mechanisms and rates. Harder materials generally cause more significant wear on tools, as the cutting edge must exert more force to shear the material. This increased force can lead to rapid tool degradation, especially in conventional and CNC machining, where tools are directly engaged with the work piece.

Additionally, materials with abrasive inclusions or irregular structures can exacerbate wear, further complicating the machining process. In contrast, materials that are ductile may allow for smoother cutting actions, resulting in lower wear rates. The selection of appropriate tool materials is crucial; for example, carbide tools offer enhanced wear resistance when machining high-strength alloys. Furthermore, the use of coatings can also improve tool life by reducing friction and protecting the tool from thermal and chemical wear. Understanding material properties enables manufacturers to select suitable tooling and machining parameters, optimizing tool life while maintaining quality and performance in their production processes. Although abrasive machining is adept at handling these tougher materials, tool wear remains a challenge due to constant engagement with hard surfaces. Material properties such as hardness, toughness, and thermal conductivity must be considered when selecting tools and machining parameters to ensure optimal tool life [14].



**Jena and Ranjan Behera****Tool Material**

The choice of tool material is crucial in determining tool life. High-speed steel (HSS), carbide, and ceramics are commonly used in conventional and CNC machining [15]. Carbide tools generally exhibit superior wear resistance, particularly in CNC operations, due to their ability to maintain optimal cutting conditions and their inherent hardness. The material composition of cutting tools is a pivotal factor influencing tool life and performance. Common tool materials include high-speed steel (HSS), carbide, and ceramic, each possessing distinct properties that determine their suitability for specific applications. For instance, carbide tools, known for their hardness and wear resistance, are often preferred in CNC machining due to their ability to maintain sharp cutting edges under high-speed conditions. This results in longer tool life and reduced frequency of tool changes, enhancing productivity.

Conversely, HSS tools, while more affordable and easier to sharpen, may not withstand the high temperatures generated during machining as effectively as carbide. Ceramic tools, although exceptionally hard and capable of high-speed operations, are brittle and can fracture under shock loads. Moreover, advancements in tool coatings—such as titanium nitride (TiN) or diamond-like carbon (DLC)—further enhance tool life by reducing friction and thermal effects. The choice of tool material must be aligned with the specific requirements of the machining process, including the type of material being machined and the operating conditions. Optimizing tool material selection is essential for improving tool life, enhancing operational efficiency, and achieving desired product quality. In abrasive machining, diamond and cubic boron nitride (CBN) abrasives are preferred for their exceptional hardness and wear resistance. However, their high cost and specific wear challenges limit their application in some contexts [16]. The selection of tool material should align with the specific machining requirements and the properties of the work piece [17].

Wear Mechanisms

Wear mechanisms differ among machining processes. In conventional and CNC machining, common mechanisms include adhesive wear, abrasive wear, and thermal cracking [18]. The thermal effects generated during machining can lead to tool degradation through softening and microstructural changes. Understanding wear mechanisms is crucial for comprehending tool life in various machining processes. Tool wear occurs due to several mechanisms, including adhesive wear, abrasive wear, fatigue wear, and thermal cracking, each influenced by operational parameters and material properties. Adhesive wear occurs when material from the work piece transfers to the tool surface, often exacerbated by high temperatures and pressures during cutting. This can lead to significant material loss and deterioration of cutting edges.

Abrasive wear is predominant in processes like grinding and abrasive machining, where hard particles interact with the tool, leading to gradual erosion. In CNC and conventional machining, tool fatigue can result from cyclic loading, causing micro-cracking and eventual failure. Additionally, thermal cracking is a critical concern, particularly at high cutting speeds where excessive heat can weaken the tool structure. Effective management of these wear mechanisms involves optimizing cutting parameters and employing advanced tool materials and coatings that can withstand wear more effectively. By understanding the various wear mechanisms, manufacturers can develop strategies to extend tool life, improve machining efficiency, and enhance the overall quality of manufactured products. In abrasive machining, abrasive wear is the predominant mechanism, where the tool's surface is eroded by the hard abrasive particles [19]. Understanding these wear mechanisms is essential for developing strategies to enhance tool life, such as optimizing cutting parameters and selecting appropriate tool coatings [20].

Tool Life in Conventional, CNC, and Abrasive Machining: A Comparative Analysis
Conventional Machining vs. CNC Machining

Tools used in conventional machining typically have shorter lives due to the manual nature of operations, which can lead to suboptimal conditions [21]. The variability in operator skill and process control can cause significant differences in tool wear rates. In contrast, CNC machining provides a controlled environment that consistently maintains cutting parameters, significantly reducing wear rates and prolonging tool life [22]. When comparing tool life in conventional machining and CNC machining, a significant disparity emerges due to the inherent operational



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differences between the two methods. Conventional machining relies heavily on manual control, where the skill and experience of the operator greatly influence the outcome. Variability in cutting conditions—such as inconsistent cutting speeds and feed rates—often leads to unpredictable tool wear rates, resulting in shorter tool life. Manual interventions, such as tool changes and adjustments, are subject to human error, contributing to increased downtime and operational inefficiency. In contrast, CNC machining automates the cutting process, allowing for precise control over all parameters. This automation facilitates the maintenance of optimal cutting conditions throughout the operation, significantly reducing the wear rate on tools. CNC systems can also employ advanced monitoring technologies to track tool wear in real-time, adjusting parameters as necessary to optimize tool life. Consequently, CNC tools tend to have a longer operational life due to reduced wear and consistent cutting performance. Overall, the automation and precision of CNC machining provide substantial advantages in tool longevity and operational efficiency compared to traditional methods. Furthermore, CNC systems can implement feedback loops that monitor tool condition, allowing for timely interventions that enhance tool longevity. This automated control minimizes human error, ensuring that the tool operates within optimal parameters throughout its life cycle [23].

CNC Machining vs. Abrasive Machining

While CNC machining generally offers longer tool life compared to conventional methods, abrasive machining often leads to shorter tool life due to high forces and continuous abrasive contact with the work piece [24]. The abrasive nature of the machining process subjects the tools to constant wear, although the quality of the finish can compensate for this drawback. CNC machining and abrasive machining serve different purposes and exhibit distinct characteristics regarding tool life. While CNC machining is designed for efficiency and precision, focusing on material removal through shearing, abrasive machining employs hard particles to achieve fine finishes and precise dimensions. The tool life in CNC machining is generally superior due to the controlled cutting conditions that minimize excessive wear. CNC machines are capable of maintaining optimal speeds and feeds tailored to the material being processed, allowing for consistent tool performance over extended periods.

Conversely, abrasive machining often results in shorter tool life due to the continuous contact between the tool and the work piece, which subjects the cutting edges to significant wear from the abrasive particles. Although abrasive processes are essential for achieving high surface quality and tolerances, the aggressive nature of material removal often leads to rapid tool degradation. Advanced abrasive materials, such as diamond and cubic boron nitride, can improve wear resistance but at a higher cost. Ultimately, while CNC machining excels in productivity and tool longevity, abrasive machining remains indispensable for specialized applications where surface finish and precision are critical. Despite the shorter tool life, abrasive machining is indispensable for applications requiring exceptional surface quality and dimensional accuracy. The advanced materials used in abrasives, such as CBN and diamond, have been developed to mitigate wear while maintaining high performance [25].

Conventional Machining vs. Abrasive Machining

When comparing conventional machining to abrasive machining, conventional tools generally last longer under similar conditions due to the more controlled material removal process and less aggressive cutting actions [26]. However, abrasive machining excels in applications where extreme hardness or precision is needed, despite the higher wear rates. The comparison between conventional machining and abrasive machining reveals distinct differences in tool life, primarily driven by their operational mechanisms and intended applications. Conventional machining typically involves the removal of material through cutting, relying on sharp edges to shear away material. While this method can be effective for bulk material removal, tool life is often compromised due to the inherent variability in manual operations and the influence of operator skill. Inconsistent cutting conditions and the frequent need for tool re-sharpening lead to increased wear and shorter tool lifespan. On the other hand, abrasive machining employs hard particles to achieve material removal, primarily in finishing operations. While this process can yield superior surface finishes and tight tolerances, it usually results in accelerated tool wear due to constant engagement with the work piece. The nature of abrasive action can lead to higher wear rates compared to conventional cutting methods, necessitating the use of advanced abrasive materials for improved tool life. Despite the shorter tool life, abrasive machining is essential for applications requiring extreme precision and surface quality, highlighting the





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need to balance wear rates with the specific demands of the manufacturing process. Conventional machining is typically better suited for bulk material removal, while abrasive machining is crucial for finishing operations that require high precision. Each process has its unique strengths, and the choice between them should align with the specific requirements of the application [27,28].

CONCLUSION

1. CNC machining consistently outperforms conventional machining in terms of tool life due to enhanced control and optimization of cutting parameters.
2. While abrasive machining is critical for achieving high precision and surface finish, it generally results in shorter tool life because of the aggressive wear mechanisms involved.
3. The selection of the appropriate machining process should consider the specific requirements of the application, including the trade-offs between tool life, cost, and operational demands.
4. Ongoing advancements in machining technologies and materials, such as super abrasives, will continue to influence tool life and performance across all machining processes.

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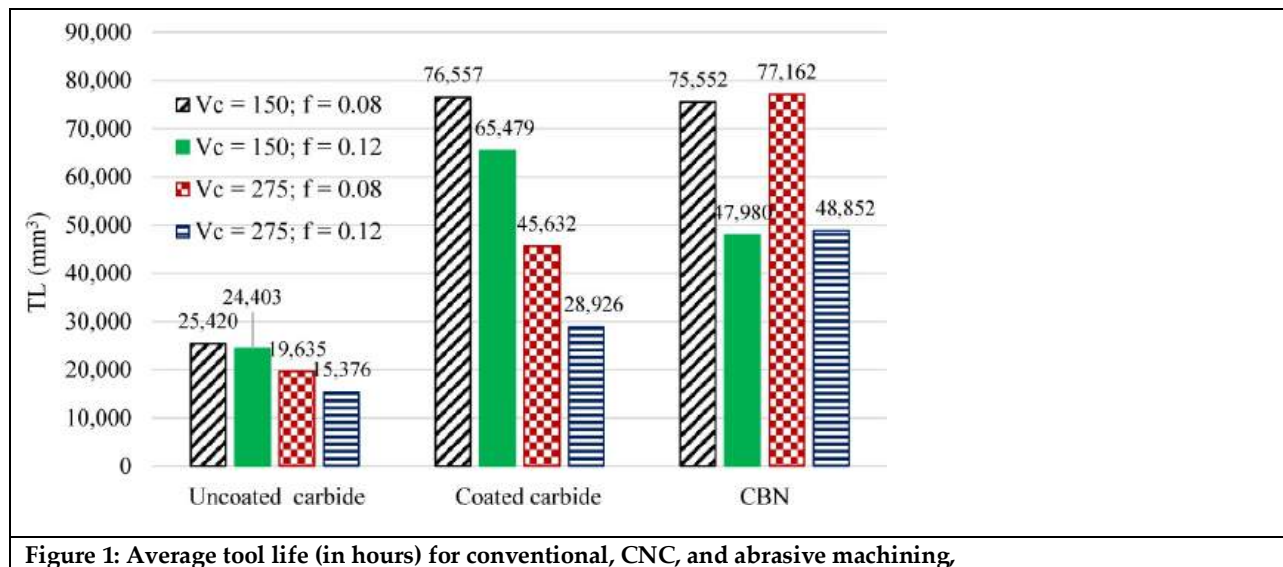
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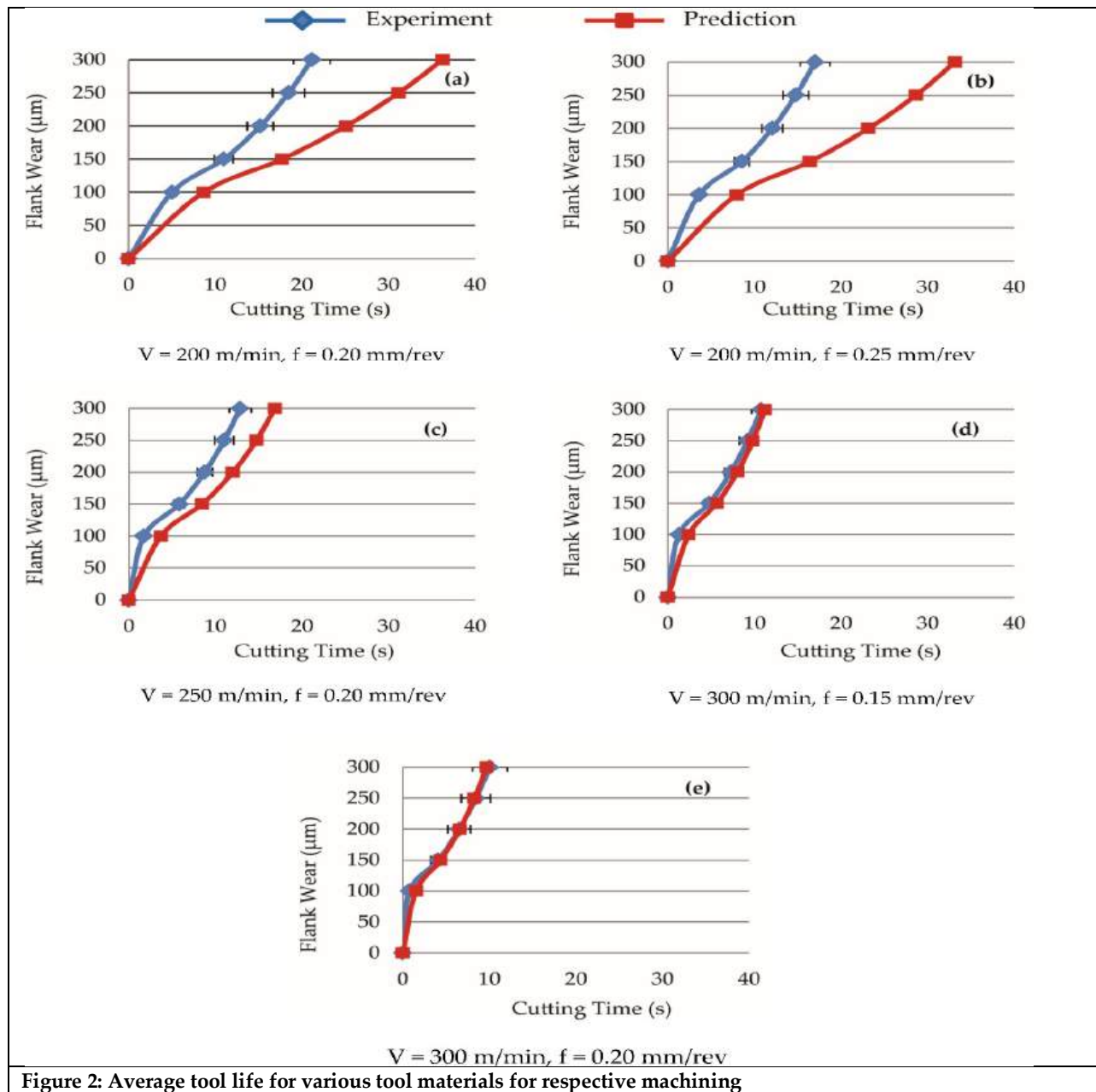


Figure 2: Average tool life for various tool materials for respective machining





Open Shortest Path First (OSPF): An In-Depth Examination

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ABSTRACT

Open Shortest Path First (OSPF) is a prevalent link-state routing technology formulated for Internet technology (IP) networks. It is essential to the internal routing mechanisms of extensive networks and Autonomous Systems (AS), facilitating efficient and dependable data packet transmission. This study examines the architecture, operation, and principal features of OSPF, emphasizing its scalability, hierarchical structure, and convergence capabilities. The study examines the merits and shortcomings of OSPF, focusing on its significance in contemporary network infrastructures and innovative solutions.

Keywords: OSPF, AS, scalability, IP

INTRODUCTION

Open Shortest Path First (OSPF):

It is a dynamic link-state routing protocol designed for IP networks to facilitate rapid and precise routing decisions within an Autonomous System (AS). OSPF was developed as an enhancement to the earlier Routing Information Protocol (RIP) to manage large-scale, intricate networks more efficiently, providing swift convergence, adaptability, and a hierarchical network structure. OSPF is a widely utilized Interior Gateway Protocol (IGP), recognized for its capacity to rapidly adjust to network alterations and guarantee effective routing pathways. This study examines the



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operational principles, packet structure, and algorithmic methods of OSPF, as well as an examination of the protocol's strengths, limits, and applications.

OSPF Framework

OSPF employs a link-state routing methodology, wherein routers sustain an updated representation of the network topology by exchanging link-state information. In contrast to distance-vector protocols such as RIP, which depend on periodic updates, OSPF employs triggered updates in response to network changes, facilitating more efficient bandwidth utilization and expedited convergence.

Domains and Hierarchical Structure

OSPF structures networks into areas to enhance scalability and reduce routing table size. The primary elements of the OSPF hierarchy consist of: Backbone Area (Area 0): The central region that interlinks other OSPF areas. It facilitates data transmission between regions and constitutes the primary routing area. On-backbone Areas (Area 1, Area 2, etc.): These regions denote smaller subdivisions of the network, comprising routers and links that facilitate the exchange of intra-area routing information. Area Border Routers (ABRs): Routers that facilitate inter-area routing by connecting distinct OSPF regions. Autonomous System Boundary Routers (ASBRs): Routers that link the OSPF network to external networks or distinct routing domains (e.g., BGP). The hierarchical architecture minimizes routing complexity and guarantees that modifications in one region do not impact the entire OSPF network.

Types of OSPF Routers

OSPF categorizes routers into many classifications based on their functions within the network. Internal Routers: Function within a singular OSPF area and exclusively share intra-area routing data. Backbone Routers: Function within Area 0 and sustain routes to additional areas. Area Border Routers (ABRs): Facilitate the connection between distinct areas and the backbone area. Autonomous System Boundary Routers (ASBRs): Facilitate the exchange of routes between OSPF and external networks, such as BGP or RIP.

OSPF Functionality

OSPF employs the Dijkstra Shortest Path First (SPF) algorithm to determine the optimal path to each destination utilizing link-state information. OSPF routers construct a Link-State Database (LSDB) that encompasses all OSPF-enabled routers and their direct connections inside the network. The LSDB guarantees that all routers possess a uniform perspective of the network topology.

Types of OSPF Packets

OSPF utilizes various packet kinds to execute its functions, with each type providing a specific purpose: Hello Packet: Utilized for the establishment and maintenance of neighbor connections among OSPF routers. Routers periodically transmit Hello packets to verify the status of neighboring devices. Database Description (DBD) Packet: Facilitates the sharing of concise summaries of Link-State Databases (LSDBs) among routers to maintain consistent topology information. Link State Request (LSR) Packet: Solicits particular segments of link-state data from other routers when the Link State Database (LSDB) is deficient. Link State Update (LSU) Packet: Employed to transmit revised link-state data to adjacent nodes. Link State Acknowledgment (LSAck) Packet: Confirms the receipt of an LSU packet, hence ensuring reliable transmission.

OSPF Neighbor Association

OSPF routers must create neighbor associations prior to exchanging routing information. Neighbor relationships are established through the exchange of Hello packets and the consensus on parameters including area ID, subnet mask, hello interval, and dead interval. Upon establishment, neighbors disseminate their Link State Databases to maintain uniform routing information.





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OSPF Algorithm: Dijkstra's Shortest Path First Algorithm

After each OSPF router attains a comprehensive understanding of the network through LSDB synchronization, it employs the Dijkstra SPF algorithm to compute the shortest path tree (SPT). Each router executes the SPF algorithm to determine the shortest way to all other routers, revising its routing table according to the current network topology.

The Dijkstra algorithm operates in the following manner

The router designates itself as the root of the tree.

It evaluates all directly adjacent neighbors and identifies the neighbor with the minimal cost (i.e., link metric). The procedure is reiterated, enlarging the tree until all routers within the region are incorporated.

OSPF Metrics and Route Selection

OSPF allocates a cost (metric) to each link, determined by bandwidth. OSPF, by default, computes the link cost as follows: $\text{Cost} = \frac{100}{\text{Bandwidth (in Mbps)}}$ Cost equals Bandwidth (in Mbps) One hundred megabits per second Routers select the route with the minimal cumulative cost as the optimal path. OSPF's dependence on cost metrics enables it to make more educated routing decisions than RIP, which solely considers hop count.

Benefits of OSPF

OSPF has numerous advantages over traditional distance-vector protocols, rendering it appropriate for extensive networks:

Rapid Convergence

OSPF rapidly converges following a topology alteration, hence reducing downtime and averting routing loops.

Scalability

The implementation of regions and hierarchical architecture enables OSPF to scale well, mitigating the effects of routing updates and decreasing the dimensions of routing tables.

Endorsement of VLSM and CIDR

OSPF accommodates Variable Length Subnet Masking (VLSM) and Classless Inter-Domain Routing (CIDR), facilitating more efficient allocation and routing of IP addresses.

Load Distribution

OSPF facilitates equal-cost multi-path (ECMP) routing, enabling routers to distribute traffic across many channels of identical cost.

Obstacles and Constraints

Notwithstanding its advantages, OSPF encounters specific challenges:

Complexity

OSPF is more intricate to configure and administer than simpler protocols such as RIP. The hierarchical structure and spatial design necessitates meticulous preparation.

Central Processing Unit and Memory Utilization

The dependence of OSPF on the Dijkstra algorithm and link-state updates can be resource-intensive, especially in extensive networks with frequent topology alterations.

Constraints in Network Design

Although OSPF's area-based architecture enhances scalability, poor configuration or excessive utilization of areas may result in ineffective routing or heightened complexity.

OSPF Security

Although OSPF incorporates methods like message authentication (MD5 or SHA) to deter unauthorized routers from engaging in OSPF conversations, it is deficient in strong encryption capabilities. Consequently, OSPF is frequently utilized in conjunction with other security technologies like IPsec for comprehensive end-to-end encryption.



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CONCLUSION

Open Shortest Path First (OSPF) is a resilient, efficient, and scalable routing technology that is integral to contemporary network architecture. Its capacity to accommodate extensive, intricate networks via its hierarchical architecture, rapid convergence times, and adaptable path selection renders it optimal for enterprise and service provider networks. Despite its complexities and resource demands, OSPF's myriad advantages and interoperability with contemporary networking technology affirm its status as an essential instrument in IP routing.

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A Nationwide Survey on Contact Lens Usage and Hygiene Practices in Bhutan: Insights from the National Eye Center

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ABSTRACT

This study provides the first nationwide analysis of contact lens usage in Bhutan, focusing on the demographic characteristics of users, the types of lenses prescribed, and compliance with hygiene practices. A total of 316 patient records from the National Eye Center in Thimphu, Bhutan, were analyzed between April 2020 and May 2023. The results showed that 57.3% of contact lens users were aged between 20 and 30 years, with females (69.9%) outnumbering males (30.1%). Soft Contact Lenses (SCL) were the most commonly used, accounting for 71.8% of the total, followed by Soft Toric Contact Lenses (25.0%) for astigmatism, and Rigid Gas Permeable (RGP) lenses (3.2%). Hygiene compliance was high, with 94% of users following recommended practices. The study reveals that younger adults and females are the predominant users of contact lenses in Bhutan, with most patients opting for comfort and ease of use. However, the limited availability of contact lens services outside the capital city presents a challenge for rural residents. The findings suggest that expanding contact lens education and services to primary health centers could improve access and awareness in underserved areas.

Keywords: Contact lens, Bhutan, soft contact lens, hygiene practices, optometry services.





INTRODUCTION

Refractive errors, such as myopia, hyperopia, and astigmatism, are leading causes of visual impairment worldwide. According to the World Health Organization, uncorrected refractive errors affect more than 150 million people, contributing to a significant reduction in quality of life [1]. In recent decades, the use of contact lenses has emerged as a popular and effective solution for correcting these vision issues, especially in developed countries. Contact lenses offer several advantages, including improved peripheral vision, reduced image distortion, and greater convenience in daily activities compared to spectacles [2]. Their aesthetic appeal also makes them a preferred choice for many individuals, particularly younger adults [3]. However, the adoption of contact lenses is uneven across the world. In developed nations like the United States, Japan, and the United Kingdom, between 12% and 15% of adults use contact lenses (Morgan, Woods, & Efron, 2014). In contrast, developing countries often experience lower rates of contact lens usage due to factors such as cost, limited availability of optometric services, and a lack of public awareness regarding their benefits [6]. This is particularly true in Bhutan, where access to advanced eye care services is largely centralized in the capital city of Thimphu. The Gyalyum Kesang Choden Wangchuck National Eye Center, established in 2019, is the sole provider of contact lens prescriptions in the country, making it difficult for individuals in rural areas to access these services [7].

The importance of proper hygiene practices in contact lens use cannot be overstated. Poor hygiene is a major risk factor for serious complications, such as microbial keratitis, which can lead to blindness if not treated promptly [24]. Studies conducted in various countries, including Ghana and Malaysia, emphasize the importance of educating contact lens users on proper lens care to prevent infections and other adverse outcomes [10,11]. Compliance with hygiene protocols, such as washing hands before handling lenses and properly disinfecting lenses, is critical in reducing the risk of complications [8]. This study represents the first nationwide survey of contact lens users in Bhutan. It aims to assess the demographics of contact lens wearers, the types of lenses they use, and their hygiene practices. By analyzing these factors, we hope to gain insights that can inform future strategies to improve access to contact lenses and eye care services across Bhutan. Additionally, this research seeks to highlight the challenges that exist in a country where eye care services are limited, especially in rural regions. With this information, we aim to recommend measures to enhance awareness and the safe use of contact lenses, ultimately improving the overall standard of eye care in Bhutan.

MATERIALS AND METHODOLOGY

Study Area: The study was conducted at the Gyalyum Kesang Choden Wangchuck National Eye Center, located in Thimphu, the capital of Bhutan. The National Eye Center, established in 2019, is the only medical facility in the country equipped to prescribe contact lenses. Thimphu is the urban hub of Bhutan, with a population of approximately 144,000 people, and the center primarily serves patients from the capital and surrounding districts [7].

Study Design: This retrospective study was designed to evaluate contact lens usage and hygiene practices among patients who visited the contact lens clinic at the National Eye Center. Data were collected from patient records between April 2020 and April 2023. The study examined the demographic characteristics of contact lens wearers, including age, gender, education level, and the types of contact lenses prescribed. The hygiene practices of patients were also evaluated based on follow-up phone interviews conducted by an optometrist.

Data Collection: The data were obtained from the patient records of the contact lens clinic, which contained information on the demographics of the patients (age, gender, and educational background) as well as details regarding the types of contact lenses they were using. The records also indicated whether patients had received instructions on proper contact lens hygiene. For assessing hygiene practices, an optometrist contacted patients by phone to inquire about their daily lens care routines, including handwashing practices before lens insertion, lens



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cleaning procedures, and storage methods. Verbal consent for participation in the survey was obtained from each patient during the phone interview.

Sample Size: A total of 316 patient records were reviewed for this study. The sample included patients who had visited the contact lens clinic between April 2020 and April 2023. All patients who had received a contact lens prescription during this period were included in the study. Exclusion criteria included patients with incomplete records and those who had discontinued contact lens use before the follow-up interviews were conducted.

Variables and Data Segregation: The following variables were recorded:

Age Group: Patients were categorized into four age groups: 10–20, 20–30, 30–40, and 40–50 years.

Gender: The number of male and female contact lens users was recorded.

Contact Lens Type: The types of lenses prescribed were categorized into Soft Contact Lenses (SCL), Rigid Gas Permeable Lenses (RGP), and Soft Toric Contact Lenses (STCL).

Hygiene Practices: Hygiene compliance was assessed based on patient responses to questions about handwashing, lens cleaning, and storage. The responses were categorized as “compliant,” “sometimes compliant,” or “non-compliant.”

Data Analysis: The collected data were analyzed using descriptive statistics to summarize the demographic characteristics of the contact lens users and their compliance with hygiene practices. Percentages and frequency distributions were calculated for each variable. The association between demographic factors (age and gender) and hygiene compliance was also assessed. Data visualization was performed using tables and figures to represent the findings.

Ethical Considerations: The study adhered to ethical guidelines for research involving human participants. Verbal consent was obtained from each participant prior to the follow-up interviews. Personal identifying information was kept confidential, and all data were anonymized before analysis.

RESULTS

Demographic Distribution of Contact Lens Users: The demographic analysis of the 316 contact lens users revealed that the majority (57.3%) were between the ages of 20 and 30 years, representing the largest age group in the study. This was followed by users in the 10–20 age group, which accounted for 22.5% of the total sample. Patients in the 30–40 age group made up 17.7%, while the smallest group of users (2.5%) fell within the 40–50 age range as shown in Table 1 and Figure 1. In terms of gender distribution, female contact lens users significantly outnumbered males. Of the total participants, 221 were female (69.9%), while 95 were male (30.1%). This trend was consistent across all age groups, with females being the predominant users of contact lenses. The highest concentration of female users was observed in the 20–30 age group, where 128 women (41% of the total sample) reported wearing contact lenses, compared to 53 men in the same age group. Similarly, in the 10–20 age group, there were 50 female users compared to 21 male users. These findings indicate a higher uptake of contact lenses among younger adults and females in Bhutan, which aesthetic preferences and lifestyle choices may influence in these demographic groups. Additionally, the data suggest that the use of contact lenses significantly declines among individuals over 40 years of age, potentially due to presbyopia or other age-related factors that may discourage the use of contact lenses in older populations.

Types of Contact Lenses Used: The analysis of the types of contact lenses prescribed to the 316 patients revealed that Soft Contact Lenses (SCL) were the most frequently used, accounting for 71.8% of the total users as shown in Table 2. This finding indicates a strong preference for soft lenses due to their comfort, ease of use, and wide availability. Soft lenses are often preferred for daily wear, particularly among younger users, due to their ability to conform to the shape of the eye and provide more comfortable wear over extended periods. Soft Toric Contact Lenses (STCL), which are specifically designed for individuals with astigmatism, were used by 25.0% of the patients. The relatively high



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percentage of users opting for toric lenses reflects the prevalence of astigmatism among contact lens wearers in Bhutan. These lenses offer a specialized solution for vision correction in patients with refractive errors that cannot be fully addressed by regular SCLs.

Rigid Gas Permeable (RGP) lenses were the least commonly prescribed, with only 3.2% of the patients using this type of lens. RGP lenses are known for providing clearer vision and are more durable than soft lenses, but they are often less popular due to the longer adaptation period required for comfortable wear. This lower percentage suggests that patients in Bhutan may prioritize immediate comfort and convenience over the long-term benefits of RGP lenses. Overall, the data highlight that the majority of contact lens wearers in Bhutan prefer soft lenses, while a smaller percentage opt for lenses that address specific visual conditions such as astigmatism. The limited use of RGP lenses may indicate a need for more patient education regarding the benefits of these lenses, especially for individuals requiring sharper vision correction.

Distribution of Contact Lens Types Used: The distribution of contact lens types among the 316 users revealed a clear preference for Soft Contact Lenses (SCL), with 71.8% (227 users) of the total population opting for this type. SCLs are known for their comfort, ease of use, and flexibility, which make them the most popular choice among wearers. These lenses are commonly prescribed for daily and extended wear and are widely preferred by both first-time users and long-term wearers due to their ability to conform easily to the eye's shape, providing high comfort levels throughout the day. The second most commonly used lens type was Soft Toric Contact Lenses (STCL), which accounted for 25.0% (79 users) of the total. Toric lenses are specifically designed for individuals with astigmatism, a common refractive error that causes blurred vision. The relatively high percentage of STCL users indicates a significant demand for vision correction options tailored to astigmatic patients. These lenses allow for more precise correction by addressing the specific curvature irregularities in the eyes of those with astigmatism.

Rigid Gas Permeable (RGP) lenses were the least used, with only 3.2% (10 users) of the total population. Although RGP lenses offer superior vision clarity and durability, their lower adoption rate may be attributed to the longer adaptation period required for comfortable wear. RGP lenses are typically recommended for users who need sharper vision, such as those with more complex refractive errors, or individuals with certain eye conditions like keratoconus. However, the convenience and comfort of soft lenses make them the preferred choice for the majority of wearers, even though RGP lenses tend to offer longer-term benefits like greater durability and reduced risk of eye infections. The results demonstrate that SCLs dominate the market due to their comfort and ease of use, while toric lenses serve a significant subset of users with astigmatism. RGP lenses remain a niche option, typically favored by users requiring high visual clarity or those willing to adapt to a more rigid lens for long-term vision health benefits.

Contact Lens Hygiene Practices: The analysis of contact lens hygiene practices among the 316 patients revealed a high level of compliance with recommended hygiene protocols. A significant majority (94%) of the patients reported full compliance with hygiene practices, including washing hands before handling lenses, properly disinfecting the lenses, and following correct storage procedures as shown in Table 3 and Figure 3. This high compliance rate suggests that most contact lens wearers in Bhutan are well-educated about the importance of maintaining hygiene to prevent infections and other complications associated with contact lens use. A smaller proportion of patients (5%) indicated that they followed hygiene practices only occasionally. These individuals admitted to sometimes neglecting proper handwashing or lens cleaning routines, which can increase the risk of complications such as microbial keratitis or other eye infections. Although this group is small, it highlights the need for ongoing education and reinforcement of proper lens care to minimize health risks. Only 1% of the patients were classified as non-compliant, meaning they did not follow any of the recommended hygiene practices. This very small percentage reflects an overall positive trend in the awareness and adoption of hygiene measures among contact lens users in Bhutan. However, these few cases of non-compliance still warrant attention, as improper lens care can lead to serious eye health issues. Health practitioners may need to focus on these individuals to improve their adherence to hygiene protocols through targeted interventions or personalized education. In summary, the results indicate that most





contact lens users in Bhutan demonstrate good hygiene practices, although a small fraction requires further guidance to ensure consistent compliance with safety measures.

Association Between Age, Gender, and Hygiene Practices: No significant association was found between age or gender and compliance with hygiene practices. Both male and female contact lens users demonstrated similar compliance rates. The 20–30 age group showed the highest compliance (95%), followed by the 30–40 age group (93%).

DISCUSSION

Data obtained from contact lens clinics provide a more reliable source of information than surveys, as they offer detailed insights into the characteristics of lens users, including demographics, lens type preferences, and hygiene practices. In this study, the profiles were collected from contact lens users who visited the National Eye Center in Bhutan between April 1, 2020, and May 31, 2023. This data provides a comprehensive overview of contact lens usage trends in Bhutan, a country where access to eye care is primarily centralized in the capital city of Thimphu. The results of this study revealed that the majority of contact lens users were between the ages of 20 and 30 (57.3%), followed by users aged 10–20 (22.5%) and 30–40 (17.7%). This finding aligns with global trends where younger adults tend to be more inclined to use contact lenses for both functional and cosmetic reasons [12]. In contrast, studies conducted in the UK show that the highest percentage of contact lens users (39%) are above 40 years old, likely due to different cultural and lifestyle factors, as well as the availability of multifocal lenses for older individuals [13]. The gender distribution in this study was heavily skewed towards females (69.9%), which is consistent with findings from studies conducted in other regions, including the UK [2], Malaysia [11], and Maldives [22], where females also represent the majority of contact lens wearers.

The preference for Soft Contact Lenses (SCL) was evident, with 71.8% of users choosing SCLs, while 25% opted for Soft Toric Contact Lenses (STCL) designed for astigmatism. The popularity of SCLs can be attributed to their comfort, ease of use, and flexibility, making them suitable for daily and extended wear [14]. The relatively high percentage of STCL users reflects the significant demand for vision correction tailored to astigmatism, which has been similarly observed in other studies across both developed and developing countries [15,16]. Rigid Gas Permeable (RGP) lenses were the least commonly prescribed, accounting for only 3.2% of the total. While RGP lenses offer superior vision clarity and durability, their lower adoption is a common global trend, as users typically prefer the immediate comfort provided by soft lenses despite the longer-term benefits of RGP lenses [17]. In comparison, studies from regions like the US and Europe show similar findings, where RGP lenses account for less than 5% of the market share [18].

The study also highlighted high compliance rates with hygiene practices among the contact lens users in Bhutan. Approximately 94% of the patients followed recommended hygiene practices, such as washing hands before handling lenses and properly disinfecting them. This finding is in line with results from studies conducted in other countries, such as Ghana, where high hygiene compliance rates (over 90%) were reported [10]. However, the 5% of users who only occasionally adhered to hygiene practices and the 1% who were non-compliant underline the need for continued education to minimize the risk of contact lens-related infections. Studies have shown that poor hygiene can significantly increase the risk of microbial keratitis, a serious infection that can lead to vision loss [4,9]. Further, the study's findings on gender differences in contact lens use align with research from several developing countries, including Malaysia and the Maldives, which also showed that women are more likely to use contact lenses than men [6,22]. This trend may be influenced by cultural and cosmetic factors, as well as the growing demand among women for discreet vision correction solutions that enhance physical appearance [21].

The results of this study underscore the importance of ensuring that contact lens users are well-informed about proper hygiene practices, as even a small percentage of non-compliant users can have significant public health





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implications. Globally, efforts to promote better lens care through education and practitioner-patient communication have reduced the incidence of contact lens-related complications [19,20]. Given the high compliance rates in this study, it is clear that patients in Bhutan have access to adequate information regarding contact lens care, though efforts should be made to reach those who remain non-compliant. The findings of this study provide valuable insights into contact lens usage trends and hygiene practices in Bhutan. The dominance of SCLs, higher prevalence among younger adults and females, and high hygiene compliance levels are consistent with global trends. However, the challenges of access to contact lens services in rural areas and the need for continued patient education to promote compliance with hygiene practices remain. Future studies could explore the barriers to contact lens adoption in rural areas of Bhutan and assess the long-term outcomes of current hygiene practices among users.

CONCLUSION

The primary objective of this study was to analyze the usage of contact lenses among the people of Bhutan and to classify the usage based on age, gender, and type of contact lens. The findings revealed that the majority of users prefer soft contact lenses (SCL), consistent with similar studies conducted in countries like Ghana and the UK [10,13]. A significant proportion of contact lens users (57.3%) fall within the 20–30 age group, likely influenced by occupational needs and educational attainment. Given the centralized nature of eye care services in Bhutan, where the only contact lens clinic is located in the capital, Thimphu, access to these services remains limited for individuals residing in rural or remote districts. To address this issue, we recommend expanding contact lens education and services to primary health centers (PHCs) across the country. By providing optometrists and ophthalmic assistants with the necessary training to inform patients about the benefits, types, and care of contact lenses, Bhutan can improve public awareness and increase the adoption of contact lenses, especially in underserved areas. Furthermore, ongoing efforts to educate patients on proper lens hygiene are crucial for preventing complications and ensuring the safe use of contact lenses. Expanding access to contact lens services and providing continuous education at the community level will enhance eye care in Bhutan and ensure that more people benefit from effective vision correction solutions.

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Table 1: Age and Gender Distribution of Contact Lens Users

Age Group (years)	Male	Female	Total	Percentage (%)
10–20	21	50	71	22.5%
20–30	53	128	181	57.3%
30–40	17	39	56	17.7%
40–50	4	4	8	2.5%
Total	95	221	316	100%

Table 2: Types of Contact Lenses Used by Patients

Lens Type	Number of Patients	Percentage (%)
Soft Contact Lens (SCL)	227	71.8%
Soft Toric Contact Lens (STCL)	79	25.0%
Rigid Gas Permeable Lens (RGP)	10	3.2%
Total	316	100%

Table 3: Compliance with Contact Lens Hygiene Practices

Hygiene Practice	Number of Patients	Percentage (%)
Compliant	297	94%
Occasionally Compliant	15	5%
Non-Compliant	4	1%
Total	316	100%





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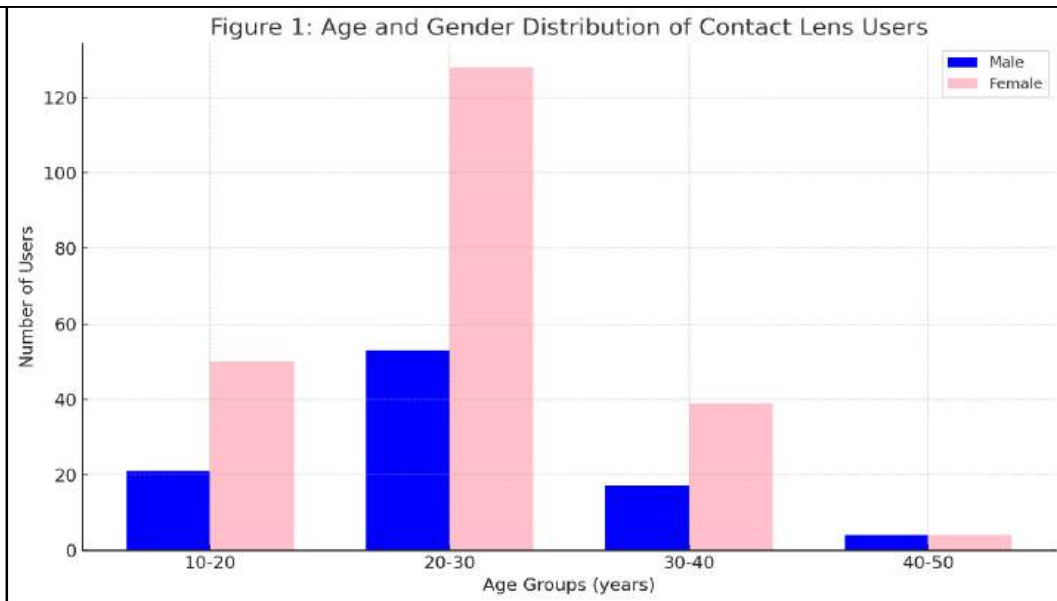


Figure 1: Age and Gender Distribution of Contact Lens Users

Note: A bar chart can be generated with age groups on the x-axis and the number of users on the y-axis, separated by gender.

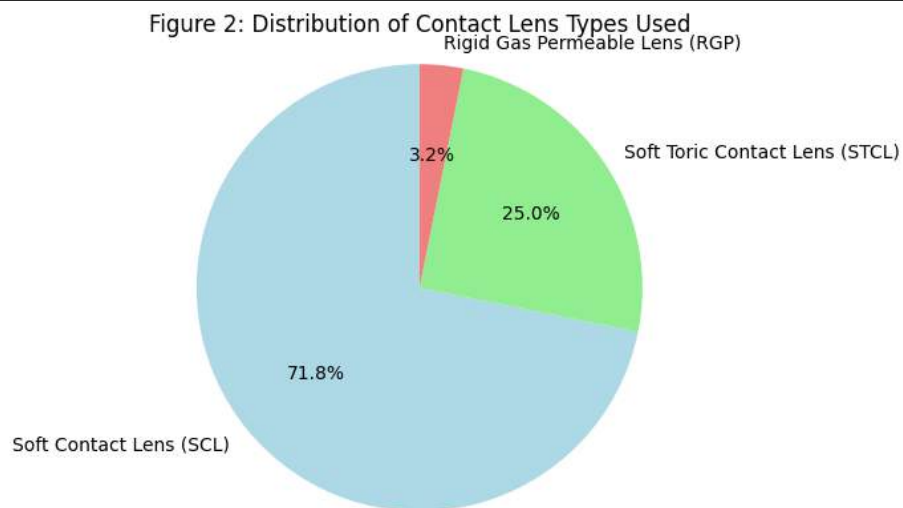
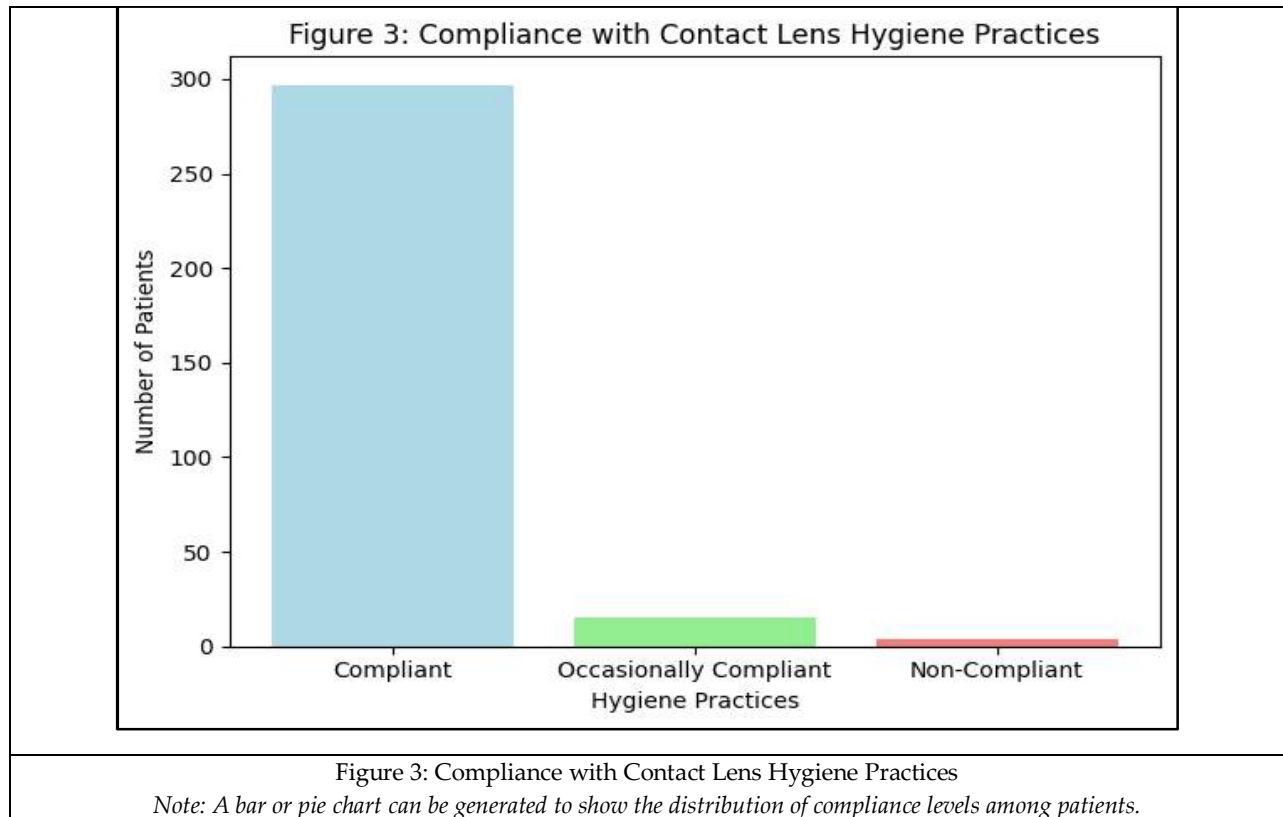


Figure 2: Distribution of Contact Lens Types Used

Note: A pie chart can be generated showing the percentage of patients using each type of contact lens.







Barriers to Formal Credit Access Among Smallholder Farmers: Socioeconomic, Institutional, and Policy Perspectives

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ABSTRACT

This systematic review investigates the determinants influencing access to institutional credit among agricultural households, with a focus on smallholder farmers in developing regions. By synthesizing findings from multiple studies, we identify critical socioeconomic factors such as education, landholding size, farming experience, and extension services that significantly impact credit accessibility. The review also highlights barriers, including bureaucratic challenges and inadequate collateral, that hinder formal credit uptake. Furthermore, we discuss policy recommendations aimed at enhancing financial inclusion and promoting sustainable agricultural practices, ultimately contributing to poverty alleviation and improved food security in rural communities.

Keywords: determinants, access, institutional, credit, smallholder

INTRODUCTION

Background and Context

Formal credit accessibility is a crucial element for small-scale farmers in developing countries, significantly impacting their agricultural productivity, economic development, and overall well-being. Numerous studies have highlighted the importance of credit availability in enhancing agricultural practices and rural livelihoods. Providing credit to farmers has been recognized as an effective strategy for alleviating poverty and promoting economic



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growth. However, most smallholder farmers in these regions face challenges when attempting to access formal financial institutions due to stringent lending criteria, inadequate collateral requirements, and limited awareness of credit options. Research conducted in various contexts has pointed out the influence of socioeconomic factors on small-scale cultivators' access to formal credit sources. Elements like educational attainment, landholding size, farming experience, and availability of extension services are critical determinants of credit accessibility for smallholder farmers. Additionally, demographic traits like social status and proximity to financial services play a significant role in the likelihood of obtaining formal credit. The varying levels of access to credit between large-scale and small-scale cultivators further aggravates the challenges facing the marginalized farming communities.

Institutional barriers present considerable obstacles for smallholder farmers seeking formal credit. Bureaucratic red tape and complicated procedures instituted by financial institutions hinder farmers from securing financial support for agricultural activities. Moreover, the insufficient collateral demands set by commercial banks further limit smallholder farmers' capacity to acquire formal credit for their farming operations. Understanding the complexities of barriers to formal credit access among smallholder farmers is vital for developing effective policies and initiatives aimed at improving financial inclusion and encouraging sustainable agricultural practices. By addressing bureaucratic challenges, refining collateral requirements, and enhancing outreach efforts, policymakers can aid in poverty reduction and food security in rural areas. Closing the gap in formal credit access for smallholder farmers may enhance the agricultural output, economic growth, and greater welfare for rural folks. (Jatav & Nayak, 2022, pages 11-13)[5], (Ullah *et al.*, 2020, pages 1-5)[3], (Kumar *et al.*, 2010, pages 1-5)[8], (Kiros & Meshesha, 2022, pages 1-5)[10] and (Lemessa & Gemechu, 2016, pages 1-5)[1].

Research Purpose and Objectives

The primary objective of this research is to evaluate the obstacles hindering smallholder cultivator's reach to formal credit, with a specific focus on the factors that impact credit availability in various agricultural environments. The effects of farmers' socioeconomic characteristics on their ability to access credit sources and adopt technology play a significant role in shaping agricultural policies and programs aimed at addressing food security challenges in developing nations. Furthermore, it is essential to investigate the key determinants affecting smallholder farmers' access to formal credit in specific regions such as the Basora Worana district, where limited credit coverage impedes livelihood improvements. Additionally, understanding the determinants of credit access and demand among marginalized smallholder farmers, particularly focusing on women's access to credit, is crucial. This study aims to fill a gap in current literature by examining the determinants of access to credit for smallholder vegetable growers in Cameroon. Moreover, the research highlights the critical role of educational qualifications, occupation, and enrolment for extension services as the challenges hindering smallholder farmers' reach to bank credit in Kenya.

Furthermore, the positive impacts of gender, household size, education, farming experience, farm size, income, and collateral on farmers' ability to access credit in Sindh province of Pakistan are emphasized. This underscores the importance of addressing these factors to promote financial inclusion among smallholder farmers. Lastly, the significance of education, proximity to credit sources, and types of credit sources is highlighted as crucial factors affecting agricultural credit accessibility for smallholder farmers in Nigeria. By consolidating insights from diverse agricultural settings, this study aims to provide valuable knowledge on understanding and overcoming barriers to formal credit access encountered by smallholder farmers. The research objectives involve identifying key determinant factors influencing credit accessibility among smallholders and exploring practical approaches to enhance financial inclusion within rural farming communities. See references: (Kiplimo *et al.*, 2015, pages 1-5)[12], (Etonihu *et al.*, 2013)[14], (Chandio *et al.*, 2017, pages 1-5)[13], (Ullah *et al.*, 2020, pages 1-5)[3], (Kiros & Meshesha, 2022, pages 1-5)[10] and (Djoumessi *et al.*, 2018, pages 1-5)[11].





LITERATURE REVIEW

Conceptual Framework of Formal Credit Access

Accessing formal credit is a fundamental component that significantly impacts the agricultural activities of small-scale farmers. In regions like Ethiopia, Pakistan, and India, a multitude of factors play a crucial role in shaping the framework for obtaining formal credit for these farmers. Research conducted in Ethiopia highlighted the substantial influence of various socio-economic factors such as farm size, income level, education, and access to extension services on smallholder farmers' ability to access formal credit. Notably, the study also revealed that households led by women encounter challenges in accessing formal credit, underscoring the necessity for gender-inclusive policies in credit allocation. Additionally, research from Pakistan's rain-fed areas demonstrated a positive correlation between farmers' access to institutional credit and their adoption of advanced agricultural practices. Factors like farm size, income level, and access to information were identified as facilitators of credit accessibility among farmers. Conversely, farming experience was found to have a negative impact on obtaining agricultural credit. Hence, tailored strategies are imperative to cater to the diverse requirements of smallholder farmers based on their unique socio-economic backgrounds.

Furthermore, insights from Uttar Pradesh shed light on how demographic characteristics significantly influence smallholder farmers' reach to institutional finance channels. Educated agriculturists with strong network in the financial sector were more successful in securing loans from formal credit institutions. Conversely, smaller-scale farmers encountered obstacles in accessing formal credit, indicating a bias towards larger-scale farmers by formal lending entities. In essence, grasping the framework for accessing formal credit for smallholder farmers necessitates a nuanced approach that considers the intricate interplay of socio-economic variables such as education levels, farm sizes, income levels, and gender dynamics. Tailored policies aimed at addressing these barriers and fostering financial inclusion among smallholder farmers are essential for enhancing agricultural practices and driving rural development in developing nations. See references: (Jatav & Nayak, 2022, pages 11-13)[5], (Ullah *et al.*, 2020, pages 1-5)[3] and (Lemessa & Gemechu, 2016, pages 1-5)[1].

Socioeconomic Factors Influencing Credit Accessibility

Education Levels

Access to formal credit for smallholder farmers is significantly influenced by various socio-economic factors, with education being a crucial determinant. A study conducted in Southern Punjab, Pakistan, demonstrated the substantial positive effect of formal education on farmers' ability to access agricultural credit. Similarly, research in Lesotho emphasized the vital role that education plays in determining small-scale maize farmers' access to credit facilities. Furthermore, a study in North-East Benin revealed that the number of years of schooling positively impacts smallholder farmers' likelihood of obtaining credit. Additionally, findings from Sindh, Pakistan, indicate that educational level has a positive effect on the uptake of formal agricultural credit among small-scale farmers. This suggests that educated agriculturists are better equipped to manage their farming operations and make informed decisions regarding credit accessibility. Education enables farmers to understand financial processes, requirements, and opportunities, thereby enhancing their chances of successfully accessing credit facilities. In conclusion, these studies underscore the significance of education in improving smallholder farmers' reach to institutional finance. It is essential for governments and financial institutions to prioritize initiatives that promote education among rural farmers to enhance their financial literacy and decision-making skills. By investing in educational programs designed for smallholder farmers, policymakers can help advance financial inclusion and sustainable agricultural development in rural regions. See references: (Daemane & Muroyiwa, 2022, pages 1-5)[16], (Chandio *et al.*, 2020, pages 11-15)[9], (Assogba *et al.*, 2017, pages 1-5)[19] and (Zulfiqar *et al.*, 2020, pages 1-5)[25].

Landholding Size

The size of landholding plays a significant role in determining smallholder farmers' access to formal credit, as evidenced by several studies. Research conducted by Saqib *et al.* (2016) in the Mardan district of Pakistan revealed



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that agriculturists with greater land holdings were more likely to access and utilize agricultural credit compared to those with smaller land holdings. This emphasizes the importance of landholding size in shaping credit accessibility among smallholder farmers. Furthermore, a study by Hossain and Bayes (2009) in Bangladesh demonstrated that the land extent was a critical in availing the required loan amount. The findings indicated that only 1.5% of cultivators owning below 0.20 hectares of land could avail institutional finance, whereas it increased to 20% for those owning over 2.0 hectares. This disparity underscores the significance of landholding size as a key determinant of formal credit access for smallholder farmers.

Moreover, research by Fecke *et al.* (2016) in Germany emphasized that farm size significantly influenced loan demand in agriculture. The study revealed that larger farm sizes positively impacted the loan market, highlighting the connection between farm size and credit demand among farmers. Similarly, research conducted by Chandio *et al.* (2017) in the Sindh province of Pakistan indicated that farm size had a significant impact on cultivators' reach to finance from formal financial institutions. The presence of collateral also played a crucial role in enhancing small farmers' access to credit facilities. In conclusion, it is evident from these studies that landholding size is a critical factor affecting smallholder farmers' access to formal credit. Farmers with larger land sizes generally have better chances of obtaining agricultural credit compared to those with smaller land sizes. Therefore, policymakers and financial institutions should take these findings into consideration when developing strategies to promote financial inclusion for smallholder farmers and encourage sustainable agricultural practices. See references: (Bonnke *et al.*, 2022, pages 6-10)[6] and (Chandio *et al.*, 2020, pages 6-10)[9].

Farming Experience

Experience in agriculture plays a crucial role in determining smallholder farmers' access to bank finance. Research conducted in Sindh, Pakistan, has shown a positive correlation between farming experience and the demand for formal credit among rice farmers. Farmers with extensive experience are expected to have a deeper understanding of agricultural practices and various credit sources. Additionally, they are likely to possess better credit management skills and credibility with lenders, which increases their eligibility for formal credit. As farmers gain more experience in agriculture, they tend to adapt to changing environmental conditions and master new agricultural technologies.

However, findings also suggest that increased farming experience may lead to reduced access to credit in some cases. This trend may be due to older farmers practicing subsistence agriculture using traditional methods in certain regions. On the other hand, studies have indicated a significant correlation between cultivation experience and reach of farmer finance in different contexts. In conclusion, farming experience significantly influences farm management and decision-making, directly affecting small-scale farmers' ability to access formal credit. Farmers with extensive experience are better equipped to face the challenges of agricultural practices and are more inclined to adopt modern technologies, ultimately enhancing their eligibility for formal credit. See references: (Chandio *et al.*, 2020, pages 11-15)[9], (Ullah *et al.*, 2020, pages 6-10)[3], (Bonnke *et al.*, 2022, pages 6-10)[6], (Chandio *et al.*, 2017, pages 11-14)[13] and (Adigun, 2022, pages 1-5)[18].

Extension Services

The significance of extension services cannot be overstated when it comes to facilitating smallholder farmers' access to formal credit. Several studies, including those by Duniya and Adinah (2015), Nouman *et al.* (2013b), and Saleem and Jan (2011), have emphasized the positive impact of extension services on the demand for formal agricultural credit among smallholder rice farmers. Access to a variety of extension services equips farmers with the knowledge of credit procedures and requirements, thereby enhancing their chances of securing credit from financial institutions. A study carried out in Makoni District, Zimbabwe, by Dube *et al.* (2015) shed light on how providing improved access to credit usage information through extension programs can significantly influence farmers' attitudes towards credit risk. This information empowers farmers to safeguard their crops and loans against potential failures, reducing the perceived risks associated with formal credit sources.



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Furthermore, as highlighted by Etonihu *et al.* (2013), extension services play a crucial role in increasing awareness among small-scale cultivators by introducing them to new ideas, information, activities, and opportunities related to agricultural practices. Not only does access to extension services enhance farmers' knowledge, but it also helps them comprehend their rights and responsibilities when utilizing credit and repaying it promptly. Additionally, findings underscore that vegetable farmers who avail themselves of extension services are more likely to expand their access to formal credit sources. These results indicate that extension services are instrumental in offering valuable information and support to farmers, leading to an increased demand for agricultural loans. In conclusion, the availability of extension services is indispensable for enhancing the financial inclusion of smallholder farmers and fostering sustainable agricultural practices. By providing pertinent information and guidance, extension programs empower farmers to make informed decisions regarding accessing formal credit sources. Therefore, improving the reach and effectiveness of extension services is essential for overcoming barriers to formal credit access among smallholder farmers. See references: (Chandio *et al.*, 2020, pages 6-10)[9] and (Djoumessi *et al.*, 2018, pages 6-10)[11].

Institutional Barriers to Credit Uptake

Bureaucratic Challenges

Accessing formal credit remains a significant challenge for smallholder farmers due to various bureaucratic hurdles and strict requirements imposed by lending institutions. These barriers often include the necessity for collateral security, guarantors, and compliance with specific terms outlined in credit agreements. The convoluted bureaucratic processes involved in obtaining loans can discourage many farmers, leading to a lower uptake of credit among small-scale agricultural producers. Institutional factors significantly influence the accessibility of credit facilities. Formal lenders incur considerable costs when assessing the creditworthiness of small borrowers, which leads them to impose stringent collateral demands to minimize default risks. Additionally, financial institutions often require documentation such as pay slips for account openings, further restricting access for self-employed individuals and those in informal sectors. This exclusion fosters financial insecurity in rural communities, particularly impacting smallholder farmers who frequently lack the necessary documentation and collateral to apply for loans.

Borrower characteristics also play a crucial role in determining access to credit. Factors such as educational background, participation in off-farm activities, and use of extension services can affect a farmer's ability to secure credit. Age and household income have a positive correlation with credit accessibility, whereas gender may negatively influence perceptions of creditworthiness. Collateral requirements remain a primary determinant of access to formal credit; inadequate collateral significantly limits opportunities to engage with financial instruments within the formal market. These bureaucratic challenges create substantial obstacles for smallholder farmers seeking formal credit access. To address these issues, it is essential to streamline application processes, reduce collateral demands, and encourage lending institutions to evaluate borrowers based on a broader range of criteria beyond traditional measures of creditworthiness. By overcoming these barriers, policymakers can Enhance Financial Inclusion For Smallholder Farmers, Ultimately Promoting Sustainable Agricultural Practices That Contribute To Poverty Alleviation And Food Security In Rural Areas. See References: (Daemane & Muroyiwa, 2022, Pages 1-5)[16] And (Rahman *Et Al.*, 2022, Pages 1-5)[4].

Inadequate Collateral

Insufficient collateral poses a major obstacle for smallholder farmers looking to access formal credit markets. Collateral serves as a guarantee of the peasant's ability to pay off the credit promptly, reducing the risks for lending institutions. Nevertheless, many farmers face difficulties meeting the strict collateral requirements imposed by formal financial institutions due to a lack of adequate collateral. The absence of collateral security, along with the unavailability of guarantors and high interest rates, are identified as significant challenges encountered by farmers in obtaining credit. Schmidt and Kropp emphasized how formal financial institutions contribute to access issues through their lending policies, such as setting minimum loan amounts and implementing complex application procedures. This restrictive approach hinders smallholders from benefiting from credit facilities and results in their exclusion from formal credit markets. Additionally, Sebatta *et al.* highlighted that bureaucratic obstacles and cumbersome procedures further deter farmers from pursuing the necessary credit.



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Moreover, the elevated transaction costs associated with securing loans from informal sources push farmers towards non-institutional lenders, where they end up facing higher interest rates due to a lack of access to affordable credit options. As pointed out by Daniels, the stringent collateral requirements in the formal sector severely limit household access to credit, especially for those with limited collateral assets. In summary, insufficient collateral represents a significant barrier for smallholder cultivators trying to avail institutional finance. The imperative need for alternative mechanisms and policies to address this issue is essential in promoting financial inclusion and supporting sustainable agricultural practices among rural communities. See references: (Daemane & Muroyiwa, 2022, pages 1-5)[16], (Jatav & Nayak, 2022, pages 1-5)[5], (Rahman *et al.*, 2022, pages 1-5)[4] and (Lemessa & Gemechu, 2016, pages 1-5)[1].

METHODOLOGY

Selection Criteria for Studies Included in the Review

When establishing the criteria for selecting studies to be included in the review on obstacles to accessing formal credit for smallholder farmers, it is vital to consider several key factors that have been identified as significant influencers in this area. According to research cited in (Lemessa&Gemechu, 2016, pages 6-10)[1], variables such as age, participation in farmer's cooperatives, frequency of interaction with agricultural extension services, distance from the bank branch, household size, farm size, prior experience with institutional finance sources, gender of the family head, education qualifications of the family head, engagement in community outreach programs, risk appetite, awareness of loan sanction terms and conditions, and limited opportunities to utilize credit are all believed to affect credit accessibility. Furthermore, as highlighted in (Djoumessi *et al.*, 2018, pages 1-5)[11], it is crucial to view access to credit as a collaborative decision-making process by farmers. The double-hurdle model is proposed as a suitable method for better comprehending the factors influencing credit access and demand levels among smallholder farmers. This model recognizes that farmers make consecutive decisions regarding their access to credit and the amount borrowed based on specific sets of explanatory factors.

Moreover, insights provided by (Sebatta *et al.*, 2014, pages 1-5)[26] shed light on the methodology employed in a study conducted in Zambia concerning smallholder farmers' access to agricultural finance. The double-hurdle model was utilized to examine the factors impacting farmers' choices to seek agricultural finance and their level of involvement in financial markets once they opt for financial assistance. This model assumes that access and loan acquisition are separate decisions made by farmers based on distinct variables. Considering the findings of different studies related to determinants of small-scale cultivator's access to institutional finance and models like the double-hurdle model for agricultural finance access can be essential criteria for study inclusion. By integrating these diverse perspectives and methodologies into the analysis, a comprehensive understanding of challenges in availing bank finance among marginalized farming community can be attained.

Data Collection and Analysis Methods

Research on the determinants of accessing institutional finance for small-scale farmers has employed diverse methodologies and data collection techniques. A notable study in India utilized secondary data from reputable sources, including the Department of Agriculture and the Reserve Bank of India. It focused on key metrics such as agricultural credit relative to agricultural GDP and total GDP, credit per unit of gross cropped area, and temporal changes in credit flow compositions. Detailed unit-level data from debt and investment surveys also enriched the insights into rural finance dynamics. In Afghanistan, a cross-sectional personal interview survey was conducted in three districts, collecting information from 292 households engaged in agriculture. This study aimed to identify socio-economic characteristics such as age, farm size, education levels, and credit usage patterns among smallholder farmers, thereby enhancing understanding of both formal and informal credit utilization. Zambia provided another context for examining access to agricultural finance through a household-level survey across five provinces. Data was gathered from 1,326 households, focusing on those who had accessed credit and those who had not. Researchers applied statistical and econometric techniques to discern factors influencing farmers' decisions regarding agricultural



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credit and their participation in financial markets. The double-hurdle model was particularly useful in analysing access patterns and loan acquisition processes.

In Cameroon, research centred on the determinants of credit access among smallholder farmers utilized the Cragg double hurdle model. This approach differentiated between farmers' decisions about accessing credit and acquiring loans, based on various explanatory variables. By sequentially examining these decisions, insights emerged regarding how income, constraints, and farmers' needs influence their credit behaviour. These studies illustrate the complex nature of understanding the challenges that smallholder farmers face when seeking formal credit. By employing tailored statistical models and context-specific survey methods, researchers have been able to uncover critical insights regarding the barriers to formal credit access, offering a clearer picture of the obstacles that hinder smallholder farmers in different regions. See references: (Sebatta *et al.*, 2014, pages 1-5)[26], (Djoumessi *et al.*, 2018, pages 1-5)[11], (Kumar *et al.*, 2010, pages 1-5)[8] and (Moahid&Maharjan, 2020, pages 1-5)[27].

Research Findings

Overview of Critical Socioeconomic Factors Affecting Credit Access

Formal credit access is vital for smallholder farmers to enhance their agricultural practices and improve their overall well-being. Various socio-economic factors significantly influence these farmers' ability to secure formal credit, which in turn affects their agricultural productivity. Key determinants of formal credit access include education levels, landholding size, farming experience, and availability of extension services. A study in the Jibat District of West Shoa Zone, Ethiopia, identified specific factors such as interactions with development agents, proximity to lending institutions, family size, farm size, and participation in extension programs as critical for credit utilization among smallholder farmers. Credit access is pivotal in boosting farm output and alleviating rural poverty by enabling farmers to purchase essential inputs and technologies, make strategic investments, and access better market opportunities. Research has shown a strong correlation between access to farmer finance and the adoption of modern cultivation practices. Factors influencing this relationship include land extent, monthly household income, ready availability of information, and status of assets.

Additionally, studies conducted in Naogaon District, Bangladesh, highlight the distribution of agricultural credit and the various individual and organizational factors that impact small-scale cultivators' reach to farm credit. Demographic characteristics like education level and connections to financial systems have been found to positively impact formal credit uptake. However, smallholder farmers often face significant barriers when attempting to access formal credit, including age, income levels, complex lending procedures, and lack of awareness about available services. Addressing these barriers through targeted policies aimed at improving financial literacy and offering innovative, tailored products and services can greatly enhance their chances of accessing formal credit. To foster sustainable agricultural development and improve livelihoods in rural communities, it is essential to ensure adequate access to formal credit. This can involve addressing institutional barriers, such as rigid repayment schedules and outdated lending practices, to create a more supportive environment for smallholder farmers. Policymakers must consider the critical socio-economic factors affecting credit accessibility to devise effective strategies that promote financial inclusion within rural communities. See references: (Lemessa&Gemechu, 2016, pages 1-5)[1], (Ullah *et al.*, 2020, pages 6-10)[3], (Kayamo&Ayele, 2023, pages 16-19)[2], (Kiros & Meshesha, 2022, pages 1-5)[10], (Rahman *et al.*, 2022, pages 1-5)[4] and (Kayamo&Ayele, 2023, pages 1-5)[2].

Identification of Barriers to Credit Uptake

Accessing formal credit poses a significant hurdle for smallholder farmers across different regions due to a myriad of factors. Research indicates that socioeconomic and institutional barriers are critical in deciding cultivators' ability to access bank loans. Studies conducted in various regions such as Sidama, Pakistan, Uttar Pradesh, Kenya, Lesotho, Bangladesh, Benin, and Ethiopia have shed light on some common challenges. One prevalent obstacle is the lack of tangible collateral and valuable assets required by formal financial institutions for loan approval. This creates difficulties for smallholder farmers who may not possess sufficient assets to offer as collateral. Additionally, bureaucratic complexities within the formal credit system hinder farmers' access to credit facilities, discouraging





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many from pursuing formal credit options. Moreover, factors like farming experience and off-farm income have been identified as negative influences on agriculturists' reach to institutional finance. Limited experience and alternative income sources may restrict farmers' eligibility for formal credit. Age has also been pinpointed as another factor impeding access to credit, indicating that older farmers may encounter more obstacles in obtaining formal financial support.

Furthermore, low levels of education among smallholder farmers is correlated to reduced reach to institutional finance. Farmers with higher education levels are better equipped to comprehend the financial processes involved in accessing credit, making them more adept at navigating the system effectively. This underscores the importance of implementing financial literacy programs to enhance farmers' ability to access formal credit services. In conclusion, addressing these barriers necessitates targeted policies geared towards improving financial inclusion for smallholder farmers. Efforts should concentrate on simplifying bureaucratic procedures, offering alternative collateral options, promoting financial literacy initiatives, and customizing credit solutions to align with the specific requirements of smallholder farmers. By confronting these challenges directly, policymakers can facilitate enhanced access to formal credit for farmers and ultimately contribute to poverty alleviation and food security in rural areas. See references: (Kiplimo *et al.*, 2015, pages 1-5)[12], (Kayamo&Ayele, 2023, pages 16-19)[2], (Rahman *et al.*, 2022, pages 1-5)[4] and (Saqib *et al.*, 2016, pages 11-14)[17].

Impact of Formal Credit Access on Agricultural Practices and Rural Communities

Financial Inclusion for Smallholder Farmers

Availability of formal credit is critical in enhancing financial inclusion among smallholder farmers, leading to numerous positive outcomes. Research indicates that such access significantly improves agricultural productivity and household income, as it enables farmers to invest in crucial inputs like fertilizers, improved seeds, and labour. This increased investment results in higher crop yields and greater agricultural income, with successful examples observed in countries like Tanzania, Brazil, Malawi, and Pakistan. Moreover, access to adequate credit facilitates the adoption of advanced agricultural technologies, which further boosts productivity and supports sustainable agricultural intensification. Conversely, credit constraints can deter farmers from embracing new technologies, hindering progress toward sustainable agricultural development. Therefore, improving access to credit is critical for ensuring food security, livelihood development, and alleviating poverty.

Efforts to promote financial inclusion for smallholder farmers should focus on overcoming barriers such as institutional restrictions and the lack of collateral or guarantor requirements. By addressing these challenges and streamlining access to formal credit sources like banks and microfinance institutions, farmers will be better equipped to adopt improved agricultural technologies. This not only enhances their productivity but also contributes to poverty alleviation and food security in rural areas. Policies that facilitate easy access to bank credits, alongside subsidized input provisions, can significantly aid smallholder farmers facing climate risks and soil fertility issues. In summary, increasing access to formal credit is vital for unlocking the potential of smallholder farmers. By addressing the barriers they face, policymakers can foster opportunities for sustainable agricultural practices and make meaningful progress toward reducing poverty and enhancing food security in rural communities. See references: (Asante-Addo *et al.*, 2016, pages 1-5)[7], (Daemane&Muroyiwa, 2022, pages 1-5)[16], (Chandio & Jiang, 2018, pages 1-5)[15], (Ullah *et al.*, 2020, pages 6-10)[3], (Kumar *et al.*, 2017, pages 6-10)[21], (Assogba *et al.*, 2017, pages 1-5)[19] and (Zulfiqar *et al.*, 2020, pages 1-5)[25].

Sustainable Agricultural Practices Promotion

Availability of institutional finance is critical for smallholder cultivators, as it allows them buy modern farm equipment, hire labour, and improve their farms, ultimately leading to increased productivity. Research highlights that when farmers can secure credit, they are more likely to adopt climate-smart practices necessary for adapting to



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changing climatic conditions and ensuring food security. In various countries, including Tanzania, Brazil, Malawi, Pakistan, and Bolivia, agricultural credit has been shown to positively impact farmers' productivity and overall livelihoods. By providing essential inputs such as fertilizers and improved seeds, as well as enabling the hiring of labour, access to credit not only boosts productivity but also enhances the living standards of smallholder farmers. This underscores the importance of facilitating sufficient credit access to support sustainable agricultural practices.

Conversely, limited access to credit can lead to credit rationing among farmers, hindering their ability to adopt modern technologies and make vital investments. This situation hinders technology adoption and sustainable agricultural intensification in developing nations. Availability of finance can enhance farm productivity, improve household welfare, and alleviate poverty by disrupting the persistent cycle of poverty often experienced by small-scale farmers. To address these challenges and promote sustainable agricultural practices, targeted policy interventions are necessary. Strategies such as adult financial literacy programs, strengthening farmer cooperative organizations, and encouraging alternative livelihood activities can significantly improve farmers' access to credit. Financial institutions can also improve participation in credit programs by substituting physical assets with social assets created through group liability strategies and developing innovative lending programs designed specifically to cater to the small-scale cultivators. In summary, improving access to formal credit for smallholder farmers is vital for fostering sustainable agricultural practices. By overcoming barriers to credit uptake and implementing supportive policies, we can empower farmers to embrace modern technologies, sustainably increase productivity, and contribute to poverty alleviation and food security in rural areas. See references: (Daemane & Muroyiwa, 2022, pages 1-5)[16], (Asante-Addo *et al.*, 2016, pages 16-20)[7], (Assogba *et al.*, 2017, pages 1-5)[19] and (Asante-Addo *et al.*, 2016, pages 1-5)[7].

Policy Recommendations for Enhancing Financial Inclusion

Addressing Bureaucratic Challenges

Accessing formal credit for smallholder farmers presents numerous obstacles, with bureaucratic complexities emerging as a major barrier. Small-scale farmers in rural areas often face challenges due to the intricate processes and red tape involved in securing credit from financial institutions. A study conducted in the Naogaon district of Bangladesh utilizing the Binary Logit model highlighted the significant hindrance that bureaucratic hurdles pose to farmers seeking access to formal credit markets. To overcome these bureaucratic obstacles, it is essential to simplify the credit application process and reduce the administrative burden on smallholder farmers. One potential solution is to expand the presence of local and foreign private banks in rural areas, ensuring that financial services are easily accessible for farmers. By increasing the accessibility of formal financial institutions in rural locations, the geographic barrier to obtaining credit can be minimized, thereby enhancing financial inclusivity for smallholder farmers.

Furthermore, governments should incentivize formal financial institutions to streamline their lending procedures and reduce bureaucratic complexities. Introducing innovative credit schemes tailored to the specific needs of smallholder farmers with limited income levels and collateral can facilitate expanded access to formal credit. Additionally, fostering cooperative groups among farmers could establish a collective platform for accessing credit facilities without individual collateral requirements. In summary, addressing bureaucratic challenges within the formal credit system is critical for improving financial inclusion and advancing sustainable agricultural development among smallholder farmers. Through the implementation of policies that streamline lending processes, increase the presence of financial institutions in rural areas, and promote cooperative group formations, barriers to accessing formal credit can be effectively alleviated. See references: (Kayamo & Ayele, 2023, pages 16-19)[2] and (Rahman *et al.*, 2022, pages 6-9)[4].

Improving Collateral Requirements

The need for collateral has created significant barriers for smallholder farmers to avail institutional finance, as evidenced by various studies. In countries like Pakistan, farmers face challenges such as insufficient collateral, low income, and small landholdings, which hinder their ability to secure agricultural credit. Informal lending sources, while vital for small-scale farmers, often fall short of meeting credit demands due to similar collateral issues and the



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lack of production guarantees. In the Democratic Republic of Congo, the absence of structured collateral systems further hinders the access of small-scale farmers to bank credit, resulting in underutilized credit facilities that impede their livelihoods. To improve rural credit accessibility, several institutional mechanisms have been established, aimed at enhancing farmers' access to formal credit sources. However, debates continue the sufficiency of farmer finance in nations like India, where the influence of moneylenders in the rural credit market raises ongoing concerns. In Pakistan, where agriculture is a crucial economic sector, availability of institutional finance is pivotal in increasing farm output and improving income levels. Collateral remains a fundamental factor influencing farmers' ability to utilize these credit sources effectively for productive purposes.

Addressing the challenge of collateral requirements for smallholder farmers necessitates policy recommendations that promote financial inclusion and sustainable agricultural practices. Simplifying lending processes and reducing the bureaucratic complexities associated with collateral can facilitate easier access to formal financial institutions. Additionally, introducing special interest rate subsidies targeted at specific crops or farming activities could incentivize smallholders to seek formal credit options more actively. In summary, enhancing collateral requirements is vital for advancing financial inclusion among smallholder farmers. By tackling the obstacles associated with collateral security through strategic policy interventions and promoting cooperative groups as alternative collateral forms, countries can improve rural livelihoods and foster sustainable agricultural practices. See references: (Chandio *et al.*, 2020, pages 11-15)[9], (Chandio & Jiang, 2018, pages 1-5)[15], (Chandio & Jiang, 2018, pages 6-10)[15], (Bonnke *et al.*, 2022, pages 6-10)[6], (Kumar *et al.*, 2010, pages 1-5)[8] and (Saqib *et al.*, 2016, pages 1-5)[17].

Contribution to Poverty Reduction and Food Security in Rural Areas

Availability of finance is essential for rural small-scale cultivators in developing nations, significantly influencing their ability to initiate income-generating activities and alleviate poverty. Without formal credit access, farmers face reduced productivity and may fall into debt cycles. Agricultural credit serves as a temporary substitute for personal savings, accelerating technological advancements that enhance agricultural output, improve asset accumulation, and bolster food security, ultimately raising rural agricultural income. In countries like Tanzania, where smallholder farmers are pivotal to the economy, limited credit access has emerged as a critical barrier, leading to decreased agricultural productivity, heightened food insecurity, and worsening poverty levels. The disparity in credit allocation to agriculture compared to other sectors highlights the urgent need for improved financial service accessibility for these farmers. Similarly, in Zimbabwe, agriculture's role in economic growth and poverty reduction necessitates an examination of the financial behaviours of smallholder farmers due to their significant contributions to GDP and job creation.

To address these challenges and support poverty reduction efforts in rural areas, several strategies can be implemented. Educational programs focusing on financial literacy for adults can empower farmers with knowledge about credit management. Strengthening farmer cooperative organizations can provide collective capital and social collateral, enhancing small-scale farmers' access to credit. Additionally, encouraging Microfinance Institutions (MFIs) to adopt group liability strategies can increase participation among productive small farmers in credit programs while minimizing credit constraints. Promoting alternative income-generating activities outside of farming can further augment income levels for farm households, improving their capacity to repay loans and engage effectively in credit initiatives. Expanding access to rural credit is vital for boosting agricultural productivity by enabling agriculturists to invest in tools and resources required for production. In summary, improving the reach of small-scale cultivators to institutional finance for smallholder farmers is crucial for improving agricultural productivity, stimulating economic development, reducing poverty, and ensuring food security in rural regions. By implementing targeted policies and interventions to overcome barriers to credit access, governments can create sustainable pathways toward prosperity for small-scale farmers. See references: (Kiplimo *et al.*, 2015, pages 1-5)[12], (Aditya *et al.*, 2019, pages 6-10)[20], (Sebatta *et al.*, 2014, pages 6-10)[26], (Darfor *et al.*, 2021, pages 1-5)[24], (Zulfiqar *et al.*, 2020, pages 1-5)[25], (Asante-Addo *et al.*, 2016, pages 16-20)[7] and (Kayamo & Ayele, 2023, pages 1-5)[2].





CONCLUSION

Summary of Key Findings

Research conducted on female smallholder farmers in Kwara State, Nigeria, highlighted key factors influencing credit access for rural women. Using probit model analysis, connections were made between various aspects including age, education level, marital status, farming experience, farm size, collateral demands, interest rates, and credit availability. This study emphasized the importance of considering gender-specific factors to ensure fair access to credit, which ultimately enhances agricultural productivity and reduces poverty in rural areas. Similarly, a study in Ethiopia's Basoga Worana District explored the determinants affecting cultivators' reach to institutional finance. Factors such as age, the gender of the household head, family size, extension contacts, off-farm income, interest rates, lending procedures, group lending practices, and quick repayment periods were identified as crucial influencers. The findings underscored the critical role of easy credit access in improving agricultural output and alleviating poverty among smallholder farmers.

An examination of access to institutional credit by farmers in Eastern India revealed significant disparities in credit distribution. Small-scale farmers encountered challenges due to inadequate accessibility to institutional credit flows. The study stressed the necessity of addressing these disparities to ensure equitable distribution of institutional credit, thereby enhancing agricultural productivity and improving livelihoods in less developed regions. Furthermore, research focusing on young tomato growers in the Democratic Republic of Congo identified obstacles that hinder their access to agricultural finance. Challenges such as poor awareness of loans, risk of loan default, and the lack of microfinance institutions were pinpointed as barriers. The findings highlighted the need for improved Agri-finance extension services and cooperative memberships to enhance the availability of farmer finance for youth farmers. Overall, these studies provide valuable insights into the issues faced by small-scale cultivators in availing formal credit. It is essential to address issues related to collateral requirements, interest rates, gender disparities, regional inequalities, and financial literacy to promote financial inclusion and sustainable agricultural practices within rural communities. See references: (Kiros & Meshesha, 2022, pages 1-5)[10], (Haque & Goyal, 2021, pages 1-5)[22], (Adigun, 2022, pages 1-5)[18] and (Bonnke *et al.*, 2022, pages 1-5)[6].

Implications for Future Research

Future research in formal credit accessibility for smallholder farmers should address several key areas to enhance understanding and inform policy interventions. One critical aspect is the examination of how education levels impact farmers' access to credit. Studies have shown that every incremental year of schooling substantially increases the probability of obtaining credit. Therefore, it is essential to investigate specific educational initiatives that effectively enhance credit access for these farmers. Another area of focus should be the role of cooperative membership in facilitating credit access. Membership in farmers' cooperatives has been found to significantly improve the chances of securing credit. Analysing the operations of these cooperatives and their contributions to financial inclusion can provide valuable insights for policymakers seeking to promote formal credit access.

Additionally, future research should explore innovative collateral requirements or alternative forms of collateral that could help smallholder farmers overcome the challenges associated with traditional asset-based security for loans. The availability of collateral can either facilitate or hinder credit access, depending on various circumstances. Investigating new approaches to collateral tailored to the unique situations of smallholder farmers could lead to more inclusive credit practices. Moreover, evaluating different financial literacy programs and training initiatives designed to enhance credit access is crucial. Financial literacy has been identified as a vital factor in improving farmers' ability to access credit. Assessing the effectiveness of specific financial education strategies can yield insights into how to better equip farmers to navigate formal credit systems.

Lastly, research should examine the benefits and challenges of integrating mobile banking technologies into rural credit systems. Modern technologies like mobile banking have the potential to address geographical barriers faced





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by smallholder farmers and improve financial inclusion. Assessing successful case studies or pilot programs that utilize digital financial services can develop strategies to improve access to institutional finance in rural hinterlands. In conclusion, directing research efforts toward these areas will play a significant role in advancing financial inclusion, fostering sustainable agricultural practices, and ultimately alleviating poverty among rural communities that depend on agriculture for their livelihoods. See references: (Assogba *et al.*, 2017, pages 1-5)[19], (Kiplimo *et al.*, 2015, pages 6-10)[12] and (Saqib *et al.*, 2016, pages 11-14)[23].

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Stock Market Trading Strategies

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ABSTRACT

Intraday High Risk High Gain trading needs lot of real time experience using combination several factors like: 7 horses theorem: trend (long, medium, short), momentum (long, medium, short), price action, sentiment (global, local), fundamental - results, news, divergence (option chain, RSI, VWAP), big bull moto (most important), and divergences can signal potential reversals in trends or provide early warning signs of a change in the market's momentum.

Keywords: MACD Divergence, RSI Divergence, Stochastic Divergence, Bullish divergence, Bearish divergence and Hidden Divergence.



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INTRODUCTION

The concept of divergence in financial markets, particularly in stock trading, is a cornerstone of technical analysis, offering insightful glimpses into potential market reversals or shifts in momentum. Divergences serve as early warning systems, alerting traders to the likelihood of impending trend reversals, either bullish or bearish.

Divergences are highly valuable in identifying hidden strengths or weaknesses within a trend.

Case study (Algo trading in streak --zerodha) and back testing

Bullish divergence:

Scan for Low (0) lower than Low (-1) and RSI (14,0) higher than RSI (14, -1) and High (0) lower than High (-1) and RSI (14,0) lower than 30 on Daily candles using candlestick chart

Bearish divergence:

Scan for High (0) higher than High (-1) and RSI (14,0) lower than RSI (14, -1) and Low (0) higher than Low (-1) and RSI (14,0) higher than 70.0 on Daily candles using candlestick chart

METHODOLOGY

To evaluate the divergence example in the share market where the 19-MA is below the 37- MA, but the MACD line is above the signal line, and you're also witnessing a continuous long build-up with high volumes, indicating a possible trend shift, the following methods can be applied:

Web tools: Use platforms like stockedge app, quantstapp, bullstrack.in, elearnmarkets.com where back testing can be done with historical market data and custom scripts.

Indicators Commonly Used for Divergence:

MACD Divergence [1]: A classic tool for spotting divergences. When the MACD and price move in opposite directions, it often signals an upcoming reversal.

1. RSI Divergence: A divergence between the RSI and price is a reliable indicator of potential trend reversals. A rising RSI with falling prices suggests a bullish reversal, and vice versa.
2. Stochastic Divergence: The Stochastic Oscillator can also highlight divergence between price and momentum, signalling potential reversals.

Back testing Using Historical Data:

- Objective: To verify how well the 19/37 MA and MACD divergence, combined with volume analysis, predict reversals.
- Method: Use historical data to back test this scenario. This involves applying the 19 MA < 37 MA with MACD > Signal Line setup and checking past reversals where this condition was met.

Volume-Weighted Analysis:

- Objective: Analyse if high volumes are amplifying the reversal signal indicated by divergence.
- Method: Alongside the moving averages and MACD, use Volume-Weighted Average Price (VWAP) or Volume Oscillator. If the VWAP [2] shows a shift in the average traded price and aligns with rising volumes, it reinforces the possibility of a reversal. A rising Volume Oscillator with divergence increases the chances of an upward move, making the signal stronger.
- Case Study: Apply this method on specific stocks where this condition is identified and analyse the follow-up movements post-divergence.

Quantitative Modelling:

- Objective: Build a quantitative model that integrates price divergence, volume trends, and options trading strategies (CE buy signal).
- Method: Use statistical techniques to calculate the probability of reversal based on divergence. This model could incorporate:
 - 19/37 MA relationship [3]





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- MACD histograms
- Volume breakout thresholds [4]
- Implied Volatility (IV) to assess the likelihood of a price breakout and guide options trades (e.g., buying a call option).
- Machine Learning: Advanced methods like Random Forest or SVM can be used to predict reversals based on these indicators by training the model on past data.

Option Chain Analysis and Sentiment Indicators:

- Objective: Verify if the observed market conditions are backed by options data.
- Method: Analyse the Option Chain to see if there's a build-up in Call options (CE) open interest, particularly with a rising Put-Call Ratio (PCR) [5] signalling a bullish sentiment. Additionally, use Implied Volatility (IV) [6] to assess the sentiment. A high call open interest combined with a volume build-up and divergence increases the likelihood of a successful reversal trade.
- Tool: Use platforms like quantsapp, stockedge, bullstrack to monitor real-time data.

Confirm with Other Technical Indicators:

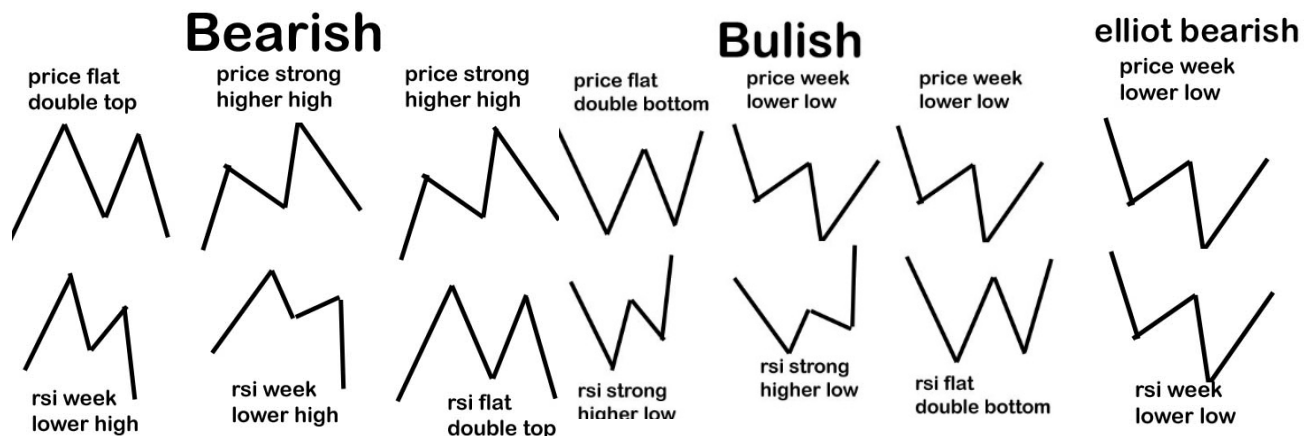
- RSI: If the RSI [7] is moving out of oversold territory, it may confirm reversal.
- Use Fibonacci levels to check if the price is approaching a key support/resistance level, providing additional confirmation for a reversal.

Recommended Trading Strategy:

- Entry: Enter long positions or buy Call options (CE) once the divergence setup (MACD > signal line, 19 MA < 37 MA) confirms a bullish reversal. A volume spike or long build-up can act as the final confirmation signal.
- Exit: Set a stop loss below the nearest support level or recent low. For options, track Implied Volatility (IV) to time exits based on changes in volatility.

By combining these methods, you can robustly evaluate divergence setups and improve the precision of reversal trading decisions.

Pictorial analysis of bearish, bullish and Elliot wave



Real time Case study on nifty

See around 13:20 to 13:30 RSI divergence marked by green vertical lines indicating sell signal of nifty future @19845 and RSI is below around 14:20 indicating buy signal @ 19780

Again around 14:55 RSI divergence indicating buy signal of nifty future @ 19790 and sell it at 15:10 19810

Now around 13:50 call OI changed its direction it started increasing so one can take sell entry @19850 with stop loss of 20 points and buy it @ 19770





RESULT AND DISCUSSION

Real-Time Case Study on Nifty

Date	Product			Profit =diff*lot size	Profit
26-05-2022	Nifty 16500 CE	buy @15	sell@100	(100-15)50	4250
17-10-2023	Nifty Fut	sell@19845	buy@19780	(19845-19780)50	3250
17-10-2023	Nifty Fut	buy@19790	sell@19810	(19815-19775)50	2000
19-10-2023	Nifty Fut	sell@19850	buy@19770	(19850-19770)50	4000
19-10-2023	Nifty 19900 PE	buy @105	sell@115	(115-105)25	250
19-10-2023	Bank Nifty 44600PE	buy@220	sell@250	(250-220)25	750
					14500

Fig 1: Nifty (5-min chart on 26-05-22)

- 16050 CE displayed a high buying volume at 13:05 PM. A strategic trade involved buying 16050 CE at ₹15 and selling it at ₹100 around 13:25 PM, yielding a significant profit within a short time.

Fig 2: Nifty (1-min chart on 17-10-23)

- An RSI divergence between 13:20 and 13:30 indicated a sell signal for Nifty futures at 19845. The RSI dropped below 30 around 14:20, marking a buy signal at 19780.
- Another RSI divergence around 14:55 suggested a buy signal at 19790, and the position could be sold around 15:10 at 19810, capturing a small but effective trade.

Fig 3: Bank Nifty (1-min chart on 17-08-23)

- This chart didn't provide any clear buy or sell signals, indicating indecision or a lack of actionable movement in Bank Nifty during the observed period.

Tab 1: Nifty Option Chain (17-10-23)

- The option chain analysis of Nifty on 17-10-23 did not offer any clear buy or sell signals, suggesting a neutral market sentiment with no strong buildup of positions for directional moves.

Fig 4: Price vs OI Chart (17-10-23)

- At 14:00 PM, OI crossed the price, signalling a potential sell entry at ₹19815. A quick trade could have been closed by buying it back at ₹19775 around 14:15, capturing a small downward movement.

Fig 5: Call, Put OI vs Nifty Future Price (19-10-23)

- Around 13:50 PM, the call OI increased, signalling a potential sell entry at ₹19850 with a 20-point stop loss. The position could be closed by buying back at ₹19770, securing a modest profit.

Fig 6: Combined Charts (19-10-23)

- At 15:10 PM, a strong rejection from VWAP on 19700 CE indicated a possible trade setup: buying 19900 PE at ₹105 and selling it at ₹115 within five minutes.
- Alternatively, the same time frame showed a potential to buy Bank Nifty 44600 PE at ₹220 and sell it at ₹250 by 15:15 PM, making a quick profit.
- From Tab 2. We can see how we can earn money using technical chart patterns

Key Insights:

- The Nifty and Bank Nifty charts provided profitable trading opportunities using signals like RSI divergence, VWAP rejection, and OI patterns.
- Quick intra-day trades were possible by following technical indicators and key price points, maximizing returns in a short time span.



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CONCLUSION

The real-time case study on Nifty and Bank Nifty highlighted profitable trading opportunities using technical indicators like RSI divergence, VWAP rejection, and OI crossovers. These tools effectively identified short-term buy and sell signals, particularly in Nifty, while Bank Nifty showed market indecision at times. The study emphasized the importance of using clear signals and technical tools for short-term trades, while noting that not all timeframes or charts provide actionable insights.

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**Tab 1. Below is nifty 17-10-23 option chain table of long buildup, short covering etc.
Not giving any clear buy or sell signal**

17/10/2023, 13:45	NIFTY	19828	8.10	3950	Long Buildup
17/10/2023, 13:40	NIFTY	19819.9	-21.30	3250	Short Buildup
17/10/2023, 13:35	NIFTY	19841.2	-0.85	4250	Short Buildup
17/10/2023, 13:30	NIFTY	19842.05	-4.95	2400	Short Buildup
17/10/2023, 13:25	NIFTY	19847	2.95	8650	Long Buildup
17/10/2023, 13:20	NIFTY	19844.05	-1.95	5900	Short Buildup
17/10/2023, 13:15	NIFTY	19846	1.00	800	Long Buildup
17/10/2023, 13:10	NIFTY	19845	-0.15	650	Short Buildup
17/10/2023, 13:05	NIFTY	19845.15	-2.80	1300	Short Buildup
17/10/2023, 13:00	NIFTY	19847.95	-1.20	7850	Short Buildup
17/10/2023, 12:55	NIFTY	19849.15	-0.75	5900	Short Buildup
17/10/2023, 12:50	NIFTY	19849.9	1.50	11900	Long Buildup
17/10/2023, 12:45	NIFTY	19848.4	6.05	900	Long Buildup
17/10/2023, 12:40	NIFTY	19842.35	7.20	1050	Long Buildup
17/10/2023, 12:35	NIFTY	19835.15	3.95	10000	Long Buildup
17/10/2023, 12:30	NIFTY	19831.2	-0.70	7450	Short Buildup
17/10/2023, 12:25	NIFTY	19831.9	-3.25	10100	Short Buildup
17/10/2023, 12:20	NIFTY	19835.15	-3.85	-400	Long Unwinding
17/10/2023, 12:15	NIFTY	19839	2.00	-5300	Short Covering
17/10/2023, 12:10	NIFTY	19837	0.50	-6600	Short Covering
17/10/2023, 12:05	NIFTY	19836.5	1.95	650	Long Buildup
17/10/2023, 12:00	NIFTY	19834.55	2.00	50	Long Buildup





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Fig 1. 26-05-22 nifty (5min) chart of 16050 CE at 13:05 p.m. volume of buying is very high so one can buy 16050 CE @ 15 and sell it @ 100 at 13:25 p.m.



Fig 2. Taken from <https://www.tradingview.com/chart> on 17-10-23 showing nifty 1 min chart



Fig 3. Taken from <https://www.tradingview.com/chart> on 17-08-23 showing bank nifty 1 min chart not giving any clear signal of buy or sell





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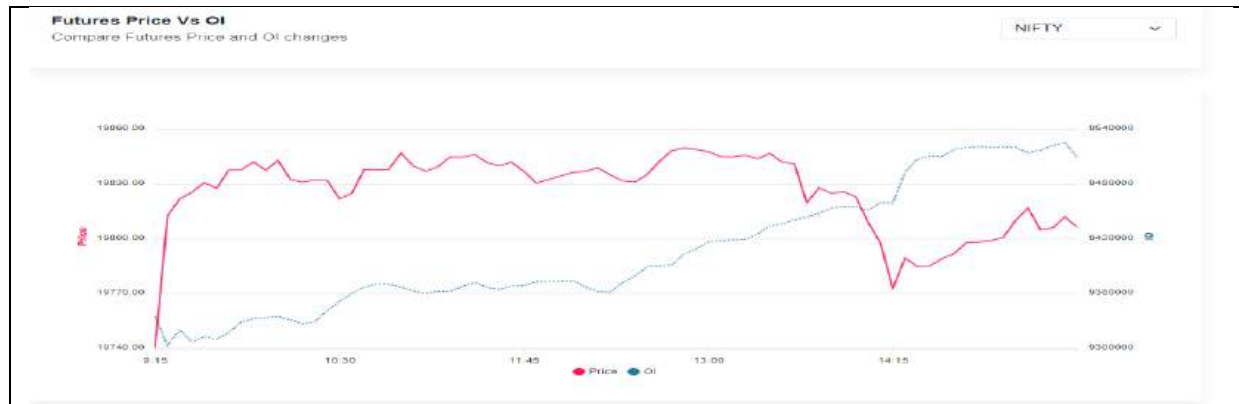


Fig 4. Above is price Vs OI chart At 14:00 p.m. OI is crossing price and one take sell entry @19815 and buy it @19775 around 14:15



Fig 5. Above is graph of CALL, PUT OI and nifty future price taken 19-10-23



Fig 6. Below is the combination of 1 min charts of nifty, bank nifty, nifty 19700 CE and 19900 PE, bank nifty 44400CE and 44600PE taken from <https://trade.fyers.in/> Around 15:10 strong rejection came from VWAP of 19700 CE indicating one can buy nifty 19900 PE @105 and can sell it @ 115 at 15:15 Or Around 15:10 of 19700 CE indicating one can buy bank nifty 44600 PE @220 and can sell it @ 250 at 15:15





An Examination of HRM-Related AI Initiatives

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ABSTRACT

The use of artificial intelligence (AI) into human resources (HR) processes is altering the way companies handle employee management. This change enables data-driven decision-making and increases productivity. A number of critical HR processes have profited substantially from AI, including recruitment, induction, performance evaluations, talent acquisition, and engagement. Artificial intelligence (AI) is revolutionizing several industries, including human resources, allowing HR professionals to automate repetitive administrative tasks, analyze large datasets, and get insights that were previously impossible to achieve. Human capital management is therefore being improved and traditional HR processes are being made easier by artificial intelligence. Among the many applications of AI in human resources, talent acquisition and recruiting stand out. The first stages of the recruiting process might be automated by AI-powered tools that analyze resumes, identify talents and credentials, and even forecast a candidate's chances of success in a certain position. Consequently, human resources personnel invest much less effort into the manual evaluation and screening of applicants. In addition, AI algorithms may help eliminate human prejudices and encourage diverse and inclusive employment practices by basing judgments entirely on facts. However, concerns about algorithmic bias in AI systems are also present. This is particularly true if the data used for training perpetuates pre existing social preconceptions. Eliminating these biases is crucial for AI-driven hiring processes to be fair. This Paper Aims to study the role and importance of AI in Human resource management and influence. Talent development and employee performance evaluation are two further areas where AI is making remarkable strides. Intelligent technology analyzes employee performance data in real time, allowing managers and workers to get feedback that is both insightful and relevant.





Keywords: Artificial Intelligence (AI), Human Resources, AI in Recruitment, HR Analytics, Data Privacy.

INTRODUCTION

AI-powered systems may create unique training programs for workers based on their strengths, hobbies, and professional aspirations. These technologies may analyze an employee's performance history and use that data to recommend specific training programs, connect them with mentors, or even predict their future success. AI enhances employee engagement and retention via promoting lifetime learning and professional growth through personalized development programs. Artificial intelligence (AI) has the potential to transform human resources by improving employee experiences, simplifying processes, and enhancing decision-making. However, to ensure that issues of prejudice and privacy are appropriately addressed, There are a lot of challenges that come with the growing usage of AI in HR, even while it has numerous advantages. Data privacy is a major issue since AI systems depend so heavily on collecting and analyzing personal information. Aggressive security measures and adherence to data protection regulations are essential for firms to safeguard sensitive employee data. Also, HR specialists might find themselves out of a job if automation continues to grow. Human resources professionals, therefore, should be untrained in order to work with AI systems and should instead focus on higher-level, strategic tasks that need human empathy and judgment in order to use AI appropriately. Companies may make full use of AI without sacrificing transparency and equality in their HR practices if they strike a good balance between relying on technology and human oversight[1].

In the dynamic and ever-evolving corporate landscape of today, technology is transforming traditional methods of operation. One of these developments that has become a game-changer is artificial intelligence (AI), which is influencing many areas of business operations, including HR. As businesses want to maintain a competitive edge, AI is increasingly being integrated into HR processes. Better decision-making, faster procedures, and more organizational effectiveness are the goals of this action. Using data analytics, machine learning, and other AI-driven technologies, artificial intelligence in human resources entails significantly changing how companies manage their most important asset—their staff. This goes beyond just automating monotonous labor. More personalized, efficient, and data-driven methods of managing human capital are replacing more conventional methods with the advent of AI in HR. The conventional HR paradigm has long been associated with labor-intensive processes including staff management, performance evaluations, on boarding, and recruiting.

These activities were crucial, but they often consumed HR professionals' time and energy to the detriment of other strategic endeavors, such as leadership initiatives, talent development, and enhancing the employee experience. However, a new paradigm has emerged thanks to AI, whereby many of these routine and administrative tasks are now automated, allowing HR experts to devote their time and energy to more meaningful endeavors. Human resources' function has evolved considerably during the years. In the early 1900s, record-keeping, payroll processing, and employee benefits were the main areas of concentration for human resources departments. Human resources departments were responsible for managing labor relations, enforcing compliance with labor regulations, and protecting employee welfare in rapidly growing enterprises throughout the Industrial Revolution and the rise of large-scale manufacturing. However, as the corporate landscape evolved, so did the role of human resources. As the twentieth century came to a close, human resources started to move away from a mostly administrative role and towards a more strategic one. The importance of skilled human management to an organization's long-term success began to sink in for businesses. This shift led to the development of HR policies and practices that now revolve on recruiting, induction, performance reviews, and company ethos. Because administrative tasks are so time-consuming, HR departments still struggle to fully engage in strategic decision-making, even after this transition. The 21st century has been defined by rapid technological breakthroughs, with artificial intelligence (AI) standing out as a particularly disruptive technology. By integrating AI into HR, organizations have successfully addressed several traditional challenges associated with human resource management. HR professionals can now focus on strategic initiatives like workforce planning, employee engagement, and leadership development thanks to AI, which



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automates mundane but necessary tasks. An evidence of a dramatic shift in HR's function, with HR professionals now functioning more like strategic partners with an influence on the company's bottom line, is the growing use of AI in the field.

One area where AI has had a significant impact on HR is talent acquisition and recruiting. In the past, HR professionals would put in a lot of time scanning applicants, doing preliminary screenings, scheduling interviews, and finally making a hiring decision. Businesses found it difficult to attract and retain top talent in the competitive labor market since recruiting processes were sometimes delayed due to the manual nature of these procedures. The use of AI has simplified and revolutionized many of these procedures, making them much easier to automate. Application tracking systems (ATS) driven by artificial intelligence (AI) may automatically go through resumes, assess candidate profiles, and choose candidates according to rules that have already been made. Because these tools can handle enormous volumes of data far more quickly than a human recruiter, they help companies fill positions more efficiently. Also, AI is helping human resources managers reduce bias in recruiting.

Unconscious bias, which affects recruiting choices, has long been an issue for human resources departments. By ignoring irrelevant factors like gender, race, or age in favor of a candidate's credentials, expertise, and abilities, well-trained AI algorithms may aid in the elimination of such biases. This leads to more fair and objective hiring choices, which in turn encourages diversity and inclusion within firms. Artificial intelligence is also having a significant impact on candidate engagement. For example, chatbots powered by artificial intelligence are increasingly being used to engage with job candidates during the recruitment process. These chatbots can schedule interviews, update application statuses, and answer questions in real time. In order to attract top talent in a competitive job market, artificial intelligence (AI) is crucial for improving the whole application experience via better communication and interaction with prospects. By making the recruiting process more efficient and fair, AI helps companies make smarter hiring decisions. By examining candidate data, such as past job performance, educational background, and even social media activity, AI-driven tools may predict an applicant's odds of success in a specific post. These predictive skills allow HR managers to locate the best candidates, which improves the overall quality of the workforce and reduces the likelihood of bad recruiting choices.

Human resource managers are finding new approaches to tackle the problems of employee engagement and retention with the aid of AI. Workers who are enthusiastic about what they do for a living are more invested in their jobs and the success of their companies, whilst those who aren't are more likely to cause problems like poor morale and output. In order to track and enhance employee engagement, AI-powered systems are analyzing data from several sources, such as communication platforms, surveys, and feedback forms. By using these tools to identify trends and patterns in employee mood, HR directors may receive valuable insights into the factors impacting employee engagement. One example is how AI may help identify underperforming departments or teams so that targeted interventions can be implemented to address specific issues.

Significance

Among the most apparent and immediate benefits of AI for HR is the simplification of administrative processes. Routine tasks including as benefits administration, employee onboarding, performance evaluations, and resume screening have traditionally placed an undue strain on HR teams. Artificial intelligence (AI) automates these processes, which frees up human resources professionals to focus on strategic initiatives like leadership training, employee engagement, and talent acquisition. This increased efficiency leads to happier employees, faster recruiting processes, and better HR departments. For example, by automatically sorting through hundreds of resumes, AI-powered ATS may select applicants based on specified criteria, significantly reducing the time it takes to fill jobs[2]. Businesses may now manage their workforce in a whole new way, thanks to AI, which enables data-driven HR decision-making. Human resources professionals may be able to collect, analyze, and interpret data more objectively and with more knowledge if they use AI-powered solutions. Predictive analytics, a core component of AI, allows HR departments to anticipate trends like employee turnover, talent shortages, and the need for specific training programs. These findings lead to better methods of workforce planning and people management. By using



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predictive analytics to identify workers who may be considering leaving the organization, HR can proactively take steps to retain valuable personnel.

Objectives Of The Study

- To examine AI's Impact on HR Processes
- To understand AI's Role in Recruitment and Talent Acquisition
- To analyze AI's Influence on Employee Development and Performance Management

METHODOLOGY

In order to generate intriguing ideas, exploratory research's goal is to provide the researcher the freedom to essentially wander around with respect to a phenomenon. world-wide data collection was done in order to complete this study. To prepare for this study, Secondary sources of information have been thoroughly reviewed. Secondary statistics and data came from academics and researchers' articles, books, journals, working papers, papers presented at conferences, company websites for year-end filings and reports on social responsibility (CSR), internal newsletters, newspapers and published e-books.

LITERATURE REVIEW

The main driver of disruptive innovation, process transformation, business model innovation, and competitive advantage in companies embracing a data-centric and digital culture is artificial intelligence (AI). A comparable wave of revolutionary change is sweeping across businesses and communities as a result of AI, much as happened with the advent of e-commerce, the sharing economy, and gig work . Hiring, employee interactions, training, and organizational development are all part of human resource management, according to Wilson et al. [3]. The insight and experience gained by interacting with people is valuable to any business. Therefore, in today's workforce, it is critical to hire and retain these types of employees. Employees are an organization's most valuable asset, making recruiting a top priority [4]. The role of human resources is expanding beyond its traditional confines. More and more jobs are becoming digital and don't need humans anymore, which is driving the appeal of automation. Finding and evaluating applicants was where artificial intelligence proved most effective, according to a LinkedIn survey conducted in 2018. Artificial intelligence's principal value lies in its speed and precision in reading application materials, free from bias and human error. Machines that exhibit intelligence, as opposed to humans, are known as artificial intelligence (AI). The academic community first used the term "artificial intelligence" in 1956. The use of AI has many practical applications in business, one of which is the alleviation of employee stress and burden. It is essential to respond quickly to developments in business. Organizations may improve their current performance and day-to-day operations with the help of AI systems. Research on HRM (augmented) and AI-mediated social interaction are examples of multidisciplinary theoretical frameworks. So are studies on judgment and decision-making. Our research highlights an under-discussed aspect of AI adoption in HRM: the importance of algorithmic ethical perspectives for selecting HRM strategies, particularly with regard to the accountability and understandability of AI-generated HRM decisions. When it comes to human resources and employment, artificial intelligence is going to be a huge game-changer for employees and the way the organization runs. Human resource management is impacted in several ways by AI-related technologies. Build individual staff development plans using data analytics linked to real-time employment practices and big data, for example. Workers are considered an organization's most valuable resource all around the globe. Human resource management's (HRM) primary objective is to oversee this valuable asset, which encompasses optimization of cost-effectiveness, management of staff competencies, and attraction, recruiting, and retention of top talent. These roles are necessary to improve the efficiency of the company [5]. Human resource management primarily includes staffing, training, performance management, benefits and compensation, employee-management relations, and safety and health. The rapid development of artificial intelligence (AI) has left us short on understanding the entire scope of the potential consequences for persons and businesses when used to HRM. Consequently, this research aims to clarify the key



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advantages and disadvantages of intelligent automation for human resource management and to organize the current scholarly literature on the topic.

Using AI for recruiting and training processes, analyzing employee data, and improving the employee experience should be a thorough and integrated part of every company's investment in HRM solutions. Businesses should also provide resources to equipping employees with the skills they need to adapt to new technologies and make the most of AI. So that human resources professionals may devote more time to strategic initiatives, AI can automate mundane administrative duties. This may lead to HR staff becoming more efficient and freeing them up to focus on projects that really call for their expertise. In order to make better, more data-driven choices, HR departments may use AI technology. In order to find patterns and make predictions, these systems can sift through mountains of data. Organizations may boost morale, streamline processes, and boost output by using AI into HR. The revolutionary potential of artificial intelligence to change HR practices has lately attracted a lot of attention.

Overview Of Concepts

The conceptual framework for studying artificial intelligence (AI) in HR establishes the relationship between the independent and dependent variables that define AI's role in altering HR practices. A number of HR functions are being affected by AI-powered technology; this framework provides a structured method to understand how these features are influencing workforce planning, performance management, employee engagement, and recruiting[6].

AI in Human Resources: A Control Variable

In this method, the application of AI to different HR processes serves as the independent variable. Machine learning, NLP, predictive analytics, and other AI-based technologies are incorporated into HR processes using artificial intelligence (AI). The use of AI involves many parts:

- Recruitment Tools Driven by AI: Applicant tracking systems (ATS), software for reviewing resumes, and chatbots for applicants all make talent acquisition simpler.
- Performance management systems: AI-driven instruments for ongoing performance monitoring, staff productivity prediction and feedback systems.
- Systems for employee engagement: AI-powered instruments for tracking and improving workers' happiness, including engagement metrics, pulse surveys, and sentiment analysis.
- L&D stands for "learning and development," and it refers to training and development systems that use artificial intelligence to recommend courses to workers based on their individual career paths and areas of weakness.

Factors Mediating

- Data and Formulas: The information fed into the systems and the algorithms used to analyze it determine the effectiveness and outcomes of AI applications in HR.
- The effectiveness of artificial intelligence algorithms is affected by the quality and variety of the data that is used to train them. Incomplete or biased data might lead to inaccurate outcomes.
- To ensure the ethical and successful use of AI, it is crucial to build and develop algorithms that include transparency and protections against bias into their decision-making procedures.
- Accurate decision-making by AI systems relies on real-time data processing. This is especially true in the areas of performance management, recruiting, and employee engagement.

Factors Relying

The different HR outcomes impacted by AI technology are represented by the dependent variables in the conceptual framework. These results show how AI affects important HR duties and the overarching objectives of the company[7]. Among them are:

- Improved Efficacy in Hiring: The end result is a more efficient and less time-consuming recruiting process. Automated resume screening, predictive analytics for applicant selection, and chatbots for first candidate contact are all parts of AI's involvement.



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- Enhanced Employee Satisfaction and Participation: Employee engagement, work happiness, and overall productivity all go up as a result.
- One use of AI is to enable sentiment analysis systems that monitor things like employee engagement, mood, and overall well-being.
- Because of this, HR experts can now make decisions based on more evidence and with greater objectivity and knowledge. AI plays a part by providing useful information gleaned from predictive analytics, performance management software, and workforce planning systems.

Customized Training for Staff Members:

- Result: Employees receive individualized professional development opportunities and learning experiences.
- The role of AI is to fuel learning management systems (LMS) with personalized training module recommendations based on user performance, skill sets, and career paths.
- Minimizing Prejudice in Hiring and Advancement
- Artificial intelligence's part: data-driven decision-making tools that make hiring, performance evaluations, and promotion decisions with less bias.

Human Resources Productivity Boost:

- Result: Human resources professionals no longer have to worry about mundane administrative tasks, freeing them up to focus on more strategic roles.
- **AI's Role:** Automating administrative processes like benefits administration and employee onboarding
- **Result:** HR specialists may now concentrate on strategic duties since they are relieved of regular administrative responsibilities.
- AI's function is to streamline back-office operations by automating tasks such as employee onboarding, benefits administration, and performance evaluations. Enhanced Personnel Administration and Strategic Planning
- Organizational and Environmental Factors as Moderating Variables Several moderating variables cause firms to have different rates of AI adoption and effectiveness in HR. Possible confounds on the link between AI deployment and HR results include the following:
- How well AI can be integrated into HR processes is dependent on the organization's present technological infrastructure.
- Problems with data privacy, job loss, and the openness of AI-driven decisions are some of the concerns that may discourage people from fully embracing AI.

RESULTS

1. We looked at how AI is influencing HR practices that have been around for a while, such as recruiting, talent acquisition, performance management, employee engagement, and workforce planning[8].
2. Researched the ways in which AI is impacting HR practices such as talent acquisition, performance management, employee engagement, and workforce planning.
3. Found that AI-powered systems may improve people management tactics via the prediction of employee career paths, the provision of real-time feedback on performance, and the creation of individualized plans for learning and development.

Final Thoughts

Companies are reshaping personnel management, HR process acceleration, and employee engagement with the use of AI (artificial intelligence). With each new iteration, AI is having an ever-increasing effect on human resources. Improved workforce planning, data-driven decisions, tailored staff development, and streamlined recruiting are just a few of the many benefits offered by these technologies[9]. By automating once manual tasks like resume scanning, applicant selection, and interview scheduling, AI-powered tools are revolutionizing the recruitment process. In addition to streamlining and speeding up the recruiting process, these technologies help reduce the likelihood of bias



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in hiring decisions, which in turn promotes a more diverse and inclusive workforce. By using AI into their recruiting process, organizations may enhance the applicant experience and swiftly attract the right people[10].

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Strategies for Enhancing Climate Resilience in Agricultural Systems

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ABSTRACT

Global food security is facing serious problems as a result of agricultural systems' growing susceptibility to climate change. To lessen the negative consequences of rising temperatures, unpredictable rainfall patterns, and the growing frequency of extreme weather events, agriculture must improve climate resilience. This article lists some tactics for enhancing agricultural systems' resistance to climate change. In order to adapt to changing conditions while preserving soil health and water usage efficiency, agronomic strategies including conservation tillage, crop diversity, and enhanced irrigation techniques are essential. Long-term remedies to climate-induced agricultural stress are provided by crop breeding and biotechnology, including the creation of pest- and drought-resistant cultivars. Furthermore, resource conservation and agricultural yield may be achieved by sustainable soil and water management techniques including mulching and rainwater collection. By encouraging biodiversity and lowering dependency on chemical inputs, the integration of agroecological techniques, such as polyculture systems and agroforestry, strengthens ecosystem-based resilience. Farmers' ability to adapt to climate-related hazards is further enhanced by digital and precision agriculture, which makes use of data-driven technology like remote sensing and Internet of Things-based systems to enable real-time monitoring and efficient resource utilization. In the context of climate change, climate-smart agriculture (CSA) integrates these tactics into a comprehensive strategy that addresses production, adaptation, and mitigation. Other strategies that help farmers deal with climate concerns include better nutrient management, agricultural automation, risk management instruments like crop insurance, and capacity building through farmer



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education. In the face of continuous climate change, this all-encompassing framework of tactics offers a method to create resilient agricultural systems that can maintain production and guarantee food security.

Keywords: Climate resilience, Agricultural systems, Agronomic practices, Precision agriculture, Climate-smart agriculture, Risk management, Food security.

INTRODUCTION

One of the most important issues of the twenty-first century is climate change, which has profound effects on all spheres of society and regions. Due to its close relationship with the environment, agriculture is especially susceptible to the negative consequences of climate change (Abbasset *et al.*, 2022). The agricultural industry is the backbone of the world's food chain, providing a living for billions of people and fostering economic expansion, especially in emerging nations (Pawlak *et al.*, 2020). Global warming-induced temperature rises, unpredictable precipitation patterns, and an increase in the frequency of extreme weather events pose a danger to the stability and productivity of agricultural systems around the globe (Bolan *et al.*, 2023). There has never been a greater pressing need to create plans for strengthening agriculture's resistance to climate change (Sairam *et al.*, 2023a; Maitra *et al.*, 2023a). The critical importance of building climate-resilient agricultural systems, aligns in the context of the United Nations' Sustainable Development Goals (SDGs), with a particular focus on SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land)

A climate-sensitive industry, agriculture greatly depends on consistent weather to achieve maximum output. Crop cultivation, cattle raising, and fishing all depend on temperature, rainfall, and the availability of natural resources like water and rich soil (Bouteskaet *et al.*, 2024). Any notable alteration to these meteorological factors might have a detrimental impact on agricultural productivity. The resilience of farming systems has already started to be challenged by the rising unpredictability of weather patterns over the past few decades, which has manifested as increasingly frequent storms, floods, and droughts (Shah *et al.*, 2021). For instance, heat stress in plants and animals can result in lower yields and poor animal health when temperatures rise and heatwaves last longer than expected. Parallel to this, variations in rainfall patterns cause problems for crops and soil health by upsetting established planting dates and causing excessive or shortage of waterlogging (Mishra *et al.*, 2023). A disproportionate number of smallholder farmers are impacted by these developments, especially in emerging nations. Frequently, these farmers are devoid of the infrastructure, technology, and financial means required to lessen the effects of global warming (Tiemann *et al.*, 2023). They are especially susceptible to changes in rainfall and temperature patterns since they depend on rain-fed agriculture and operate on marginal soils. The lives of millions of people are thus in jeopardy, particularly in areas where agriculture serves as the main source of sustenance, such as sub-Saharan Africa and South Asia (Ayanlade *et al.*, 2022).

The ability of agricultural systems to foresee, absorb, adapt to, and recover from the effects of climate change while preserving their essential operations and productivity is referred to as climate resilience in agriculture (Sairam *et al.*, 2023b; Safdar *et al.*, 2024). Sustaining short-term weather shocks like floods, storms, and droughts is just one aspect of resilience; another is adjusting to longer-term shifts in precipitation and temperature patterns (Furtak *et al.*, 2023). The goal of climate-resilient agriculture is to reduce farming systems' susceptibility to environmental pressures and increase their ability to bounce back from them (Acevedo *et al.*, 2020). An all-encompassing strategy that takes into account the environmental, social, and economic aspects is needed to build climate resilience (Allam *et al.*, 2020). In order to guarantee that ecosystems can continue to supply vital functions like nutrient cycling, water control, and carbon sequestration (Gudla *et al.*, 2023 a,b), resilient agricultural systems support the sustainable use of natural resources including soil, water, and biodiversity (Cappelli *et al.*, 2022; Sumit *et al.*, 2024;). In terms of society, climate resilience entails providing farmers and local communities with the information, resources, and instruments they need to adjust to shifting weather patterns (Sheikh *et al.*, 2024). This includes enhanced agricultural technology,



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capacity-building programs that increase farmers' ability to adapt, and access to climate information services. Resilient agricultural systems support rural development economically by generating employment, sustaining livelihoods, and promoting economic growth despite climate obstacles (Stringer *et al.*, 2019). Agriculture is a major contribution to the issue of climate change, despite its extreme vulnerability to it. The industry is responsible for around 25% of the world's greenhouse gas (GHG) emissions, which are mostly caused by shifting land uses, deforestation, livestock methane emissions, and nitrous oxide emissions from synthetic fertilizers (Lynch *et al.*, 2021). The fact that agriculture both causes and is a victim of climate change emphasizes the necessity for combined mitigation and adaptation solutions (Manepalliet *al.*, 2022).

In agriculture, the main goals of mitigation techniques are to increase carbon storage and lower emissions. Sustainable land management techniques including conservation tillage, cover crops, and agroforestry can help achieve this (Thamaralet *al.*, 2024). Conservation tillage lessens soil disturbance, which contributes to the soil's ability to store carbon (Sairam *et al.*, 2023). Cover crops, on the other hand, strengthen the soil's structure and enhance organic matter (Sairam *et al.*, 2023; Zhu *et al.*, 2022). In addition to sequestering carbon, agroforestry—the planting of trees in agricultural landscapes—offers additional benefits including increased water retention, less erosion, and greater biodiversity (Kay *et al.*, 2019). Adaptation measures are crucial for increasing farming systems' resilience in addition to mitigation. Developing and implementing crop varieties that are resistant of heat, drought, and salt is one important strategy (Barajet *al.*, 2024). In spite of more harsh weather, farmers can sustain output with the aid of these cultivars. In a similar vein, enhanced water management strategies including rainwater collection, drought-tolerant crop selection, and precision irrigation can strengthen agricultural systems' ability to withstand water constraint (Santosh *et al.*, 2021; Muhammad *et al.*, 2023; Ray *et al.*, 2021 a,b). This review study aims to give a thorough examination of methods for improving agricultural systems' resistance to climate change (Datta *et al.*, 2022). This entails determining the main climate change-related vulnerabilities that agriculture confronts and investigating the best agronomic, technical, ecological, and policy-based remedies.

Impact of climate change

Global agricultural systems are being drastically altered by climate change, which also poses a number of other problems that endanger rural livelihoods, food security, and the sustainability of natural resources (Sarkar *et al.*, 2000) (Saleem *et al.*, 2024). Complex and interconnected, the effects of climate change on agriculture affect many facets of crop and livestock output, resource availability, and ecosystem health (Fanzo *et al.*, 2023). The rise in global temperatures is one of the most notable effects of climate change, and it has several effects on agricultural production (Santosh *et al.*, 2021; Maitra *et al.*, 2022). Certain temperature ranges are ideal for the growth, production, and quality of most crops (Hatfield *et al.*, 2022). Crop physiology may be negatively impacted by temperatures that rise over these ideal limits. For instance, high temperatures may cause heat stress, which hinders photosynthesis and lowers yields. According to research, depending on the area and crop type, crop yields for basic crops like wheat and maize may decrease by 10–25% for every degree Celsius that the temperature rises (Moore *et al.*, 2021). Crop phenological phases, such as blooming and maturity periods, can also shift due to climate change, exposing crops to late frost occurrences and upsetting planting plans. Warmer weather has a detrimental effect on the health and productivity of cattle. It lowers feed intake, milk output, and reproductive efficiency and increases death rates in susceptible populations of cattle, especially in tropical and subtropical areas (Razaeiet *al.*, 2016).

Modifications to precipitation patterns, such as adjustments to the frequency, timing, and intensity of rainfall, can have significant effects on agricultural systems. Due to shifting climatic trends, many areas are seeing increasingly frequent and severe droughts (Sheikh *et al.*, 2024). These droughts lower soil moisture levels, which lowers crop yields and raises the possibility of crop failure (Santosh *et al.*, 2023). Drought may have disastrous effects on rural livelihoods and food security in regions like sub-Saharan Africa that depend on rain-fed agriculture (Keshavarazet *al.*, 2016). On the other hand, certain areas are seeing more intense rainfall, which causes flooding and soggy soils. Soil erosion, nutrient leaching, and crop root infections might result from this. Flooding may cause enormous financial losses by destroying crops, destroying infrastructure, and upsetting supply systems (Sairam *et al.*, 2023c; Sam *et al.*, 2021). The availability of freshwater resources, which are essential for agricultural irrigation, is also changing due to



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climate change (Maitra *et al.*, 2020). In arid and semi-arid regions in particular, altered snowmelt patterns, decreased groundwater recharge, and higher evaporation rates can put a strain on water supplies and increase competition for water among domestic, industrial, and agricultural users (Dao *et al.*, 2023).

Climate change is causing an increase in the frequency and severity of extreme weather events, such as heatwaves, cyclones, and hurricanes, which has a direct and disastrous effect on agricultural systems (Bolan *et al.*, 2023). These occurrences have the potential to immediately destroy crops and farms because strong winds and torrential rains from storms can uproot plants, level fields, and result in large production losses. Hurricanes, for example, have severely damaged fruit and sugarcane fields in Caribbean countries, affecting local economies and food supply (Shannon *et al.*, 2015). Extreme weather events also harm transportation networks, storage facilities, and irrigation systems, which affect post-harvest processing and distribution and interrupt agricultural output (Tchoukouang *et al.*, 2024). This results in food losses and restricted market access for farmers. There might be serious economic repercussions, especially for smallholder farmers who might not have the means to recover from such shocks. This could lead to a shortage of food, higher prices, and unstable local economies (Rakotobe *et al.*, 2016).

The distribution and incidence of diseases and pests that endanger agricultural productivity are also being impacted by climate change (Mwadaluet *et al.*, 2022). Increased temperatures and modified precipitation patterns can foster the growth of pests (Subedi *et al.*, 2023). For instance, pests like locusts and autumn armyworms are spreading their geographic ranges owing to milder winters and higher temperatures, endangering crops (Yan *et al.*, 2022). Farmers may suffer financial losses and food poverty as a result of these pests' devastating effects on output. The incidence of plant diseases caused by bacteria, fungi, and viruses can be increased by higher temperatures and humidity levels (Singh *et al.*, 2023). This is because warmer temperatures encourage the spread of pathogens, and increased moisture creates the perfect environment for disease growth, which lowers crop yields and degrades produce quality. The mechanisms that already cause soil degradation are made worse by climate change, which has significant effects on agricultural production. Severe rainfall events and harsh weather can hasten soil erosion, which reduces land productivity by causing the loss of nutrients and healthy topsoil that are vital for plant development (Wang *et al.*, 2023). Increased salinity in coastal agricultural regions can result from rising sea levels and changed rainfall patterns, which lowers soil fertility and crop yield. Furthermore, the amount of organic matter in the soil, which is essential for soil fertility and health, can be affected by climatic variations (Maitra *et al.*, 2017) (Mukhopadhyay *et al.*, 2021). Higher temperatures and unpredictable rainfall can reduce organic matter levels, which in turn affects soil structure and nutrient availability. Maintaining agricultural output depends on healthy soils, and long-term food security is at danger from their deterioration (Derpschet *et al.*, 2024).

Climate change affects agriculture in ways that go beyond environmental issues and have an influence on socioeconomic dynamics. Food security is under risk due to decreased agricultural output, especially in emerging nations where people are already at risk of starvation and malnourishment (Mirzabaev *et al.*, 2022). Social unrest and instability can arise from crop failures and increased food costs that worsen poverty and inequality. Many rural communities rely on agriculture as their primary source of income. Shocks brought on by climate change can disrupt these revenue streams, driving farmers to leave their areas in pursuit of better possibilities. This can increase urbanization and put a pressure on urban resources (Prahara *et al.*, 2022). Furthermore, because of their limited access to resources, information, and decision-making power, women who make up a sizable portion of the agricultural workforce in many developing regions often face particular vulnerabilities to climate change (Ghosh *et al.*, 2021). For this reason, addressing these disparities is crucial to creating resilient agricultural systems.

Strategies for Enhancing Climate Resilience

Implementing a wide range of solutions targeted at improving resilience is essential as agricultural systems throughout the world become more and more threatened by climate change (Santosh *et al.*, 2023; Bara *et al.*, 2024). These measures, which include agronomic methods, water management tactics, agroecological methods, technology advancements, and helpful policy frameworks, all enhance food security and sustainable agriculture practices in the face of climate change (Muhie 2022) (Table 1 and Figure 1).



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Important agronomic techniques include crop rotation and diversification, which entail growing many crops in succession on the same plot of land. By using this method, insect and disease pressures are lessened and soil health is improved (Zou *et al.*, 2024). Farmers may lessen the occurrence of pests and illnesses and their need on chemical inputs by switching up their crop rotation. For example, alternating legumes and grains increases soil nitrogen levels and improves crop health in general. Additionally, various crops have distinct nutritional needs and root systems, which can support the fertility and structure of the soil (Yang *et al.*, 2020). Additionally, by offering farmers a variety of revenue streams, this diversity helps lower economic risk. The capacity to grow a variety of crops guarantees that some may flourish under unfavorable circumstances in the context of climatic unpredictability, adding to overall economic stability.

Effective soil management techniques are essential for preserving soil health and boosting agricultural resilience, in addition to crop rotation. methods like conservation tillage, which lessens soil disturbance, improves water retention, helps preserve soil structure, and lowers erosion (Busari *et al.*, 2015). Using conservation tillage techniques, such no-till or reduced-till farming, allows farmers to increase soil organic matter and biodiversity, which in turn supports a more robust ecosystem. Cover cropping, in which farmers grow cover crops during times of fallow land, is another essential technique for managing soil. This method inhibits weed growth while preventing soil erosion, enhancing nutrient cycling, and improving soil structure (Koudahe *et al.*, 2022). By limiting the need for chemical fertilizers and maintaining soil nutrient levels, integrated nutrient management (INM) maximizes crop yields (Ray *et al.*, 2024 a,b; Sagar *et al.*, 2023). When combined, these agronomic techniques enhance resilience and support agricultural systems that are sustainable and able to survive the effects of climate change (Maitra *et al.*, 2017; Sande *et al.*, 2024).

Increasing the resilience of agricultural systems to climate change requires intercropping, which is cultivating two or more crops in one field at the same time to boost production and biodiversity ((Maitra *et al.*, 2024a; Burgess *et al.*, 2022). By improving soil health through a variety of root structures that reduce compaction, boost nutrient cycling, and improve water retention, this strategy strengthens the resilience of ecosystems (Mohanty *et al.*, 2024). Furthermore, by drawing beneficial insects, intercropping efficiently lowers the pressure from pests and diseases, reducing the demand for artificial pesticides (Maitra *et al.*, 2024b). Differentiated root systems may reach various soil levels by enhancing water usage efficiency, which enables crops to obtain moisture during dry spells. Additionally, intercropping helps control microclimates by shading crops and shielding them from harsh weather (Xionget *et al.*, 2023). This strategy also provides economic diversity, which lowers the risk of agricultural failure because different crops yield different revenue streams. Farmers may respond more effectively to erratic weather patterns by intercropping, which increases resilience to climatic fluctuation. In the face of climate change, intercropping promotes ecological balance, food security, and resilience, all of which are important components of sustainable agriculture (Maitra *et al.*, 2024b).

Water Management

Optimizing agricultural resilience requires effective water management, particularly in light of shifting precipitation patterns and growing water shortages (Santosh *et al.*, 2021). Increasing crop resilience and optimizing water consumption need the application of effective irrigation strategies. Drip irrigation is one technique that minimizes water waste and reduces evaporation losses by directly delivering water to the root zone of plants. This is especially useful in dry environments (Chen *et al.*, 2023). In a similar vein, sprinkler systems evenly distribute water, improving crop production and lowering the chance of water logging. Furthermore, by gathering and storing rainwater for irrigation, rainwater harvesting enables farmers to make better use of seasonal rainfall and lessens the effects of water shortage.

Water conservation measures are essential for boosting resilience and should be used in conjunction with these strategies. Applying organic or synthetic material around plants, for example, can improve soil health by reducing evaporation, maintaining soil moisture, and inhibiting weed development. By reducing water flow and promoting infiltration, contour farming—planting crops following the land's contours can successfully prevent soil erosion and



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increase water retention (Demo *et al.*, 2024). Reforestation and wetland restoration are two more watershed management techniques that can improve the natural water cycle and increase the quantity and quality of water available for agricultural use. In light of climate change, these integrated water management solutions provide a strong framework for maintaining sustainable agricultural practices (Twomey *et al.*, 2024).

Agroecological Approaches

By encouraging biodiversity and sustainable land use, agroecological methods greatly increase resilience when included into agricultural systems. Numerous ecological advantages result from agroforestry, which mixes crops and cattle with trees and plants. By providing shade, trees help control microclimates and lessen heat stress on animals and crops (Araya *et al.*, 2023). Their roots contribute to increased soil fertility by strengthening the soil's structure, lowering erosion, and raising the amount of organic matter (Sairam *et al.*, 2024). Furthermore, by providing homes for a variety of creatures, such as beneficial insects and soil microbes which are crucial for pollination and pest control agroforestry systems promote biodiversity (Maitra *et al.*, 2024c,d) (Octavia *et al.*, 2023) (Octavia *et al.*, 2023). Incorporating trees into agricultural landscapes promotes ecosystem health in addition to increasing production. Another important component of agroecological methods that can greatly increase resilience is biodiversity conservation (Bennett *et al.*, 2021). Keeping crops' genetic variety intact provides a defense against pests, illnesses, and shifting environmental factors. There will always be food available even in cases when certain crops fail since diverse crop species and kinds have a higher chance of surviving unfavorable circumstances (Ahmad *et al.*, 2017). Additionally, by preserving the natural habitats that encircle agricultural areas, we can maintain the beneficial creatures that provide ecosystem services like pollination and pest control. A few simple practices like growing blooming plants and using less pesticides may significantly increase agricultural production by providing homes for pollinators. Farmers may create more resilient systems that are better able to handle the difficulties brought on by climate change by adopting agroecological principles.

Technological Innovations

Advancements in technology are revolutionizing farming methods, providing fresh perspectives on augmenting climate resilience. Precision farming makes use of technology to maximize resource use and agricultural techniques, resulting in more sustainable and productive agriculture (Konfoet *et al.*, 2024). Farmers may get real-time data on crop health, soil moisture, and nutrient levels by utilizing technology like GPS, remote sensing, and soil sensors (Sairam *et al.*, 2023d). Farmers are able to deploy resources more effectively thanks to data-driven decision-making, which raises output and lowers waste. For instance, variable rate technology (VRT) reduces chemical consumption and environmental effects by allowing farmers to apply pesticides and fertilizers at different rates depending on particular field circumstances. Additionally, monitoring crop health and evaluating field conditions are made easier by the use of robotics and drones in agriculture, which improves operational effectiveness and lowers personnel expenses. In addition to increasing output, these technology developments also assist farmers in adjusting to workforce shortages and climate-related pressures (Sharma *et al.*, 2024). Apart from precision farming, climate-smart technologies are essential for constructing resilience (Mukesh *et al.*, 2024). Genetically engineered crops that are resistant to pests, illnesses, and environmental challenges have been developed as a result of biotechnology advancements, increasing output and lowering the need for chemical inputs (Hamdan *et al.*, 2022). Additionally, the goal of climate-smart breeding is to create crop types that are more resilient to environmental stresses like floods and drought. By incorporating renewable energy sources like solar and wind power into agricultural processes, the reliance on fossil fuels is further decreased and energy efficiency is improved. Farmers may promote sustainable farming practices and better manage the uncertainties of climate change by implementing these technical improvements (Bathaeiet *et al.*, 2023).

Policy and Institutional Frameworks

Building policy frameworks that are supportive is crucial to promoting agriculture's resilience. Adopting sustainable methods like conservation tillage, cover cropping, and agroforestry may be greatly aided by government subsidies and incentives (Bhanet *et al.*, 2014). Financial assistance promotes the adoption of technology and practices that are climate resilient, which eventually results in more sustainable agricultural systems. Furthermore, creating risk



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management and insurance policies that shield farmers from climate-related hazards like floods and droughts can help stabilize earnings and lessen vulnerability (Shiferaw *et al.*, 2014). Programs for crop insurance can provide as a safety net for farmers who suffer losses due to climate change, improving their ability to adjust to shifting circumstances (Manasa *et al.*, 2021; Moulick *et al.*, 2024). Furthermore, funding climate-resilient agricultural practices and technology research and development is essential for sustainable agriculture. Funding for agricultural research that results in creative solutions suited to regional circumstances and difficulties should be given top priority by policymakers in order to provide farmers with access to the most recent information and instruments for adaptation (Azad *et al.*, 2021). Effective information exchange and capacity building are essential for enabling farmers to improve resilience, especially when combined with supporting policies. Ensuring that farmers obtain timely information about new technology, climate adaption techniques, and best practices requires strengthening agricultural extension services (Antwi-Agyei *et al.*, 2021). For smallholder farmers in particular, who can have trouble obtaining resources and knowledge, access to extension services is crucial. Fostering cooperatives and networks among farmers promotes information sharing and group action by giving them a forum to discuss resources, best practices, and experiences (Tay *et al.*, 2024). Furthermore, by offering education and training courses on climate resilience and sustainable farming methods, agricultural communities may develop a resilient and adaptable culture among its farmers, improving their skills and knowledge.

Challenges and Barriers

Effective implementation of various solutions aimed at boosting climate resilience in agricultural systems is impeded by a number of obstacles and impediments. The main obstacle is the restricted availability of resources and technology (Javaid *et al.*, 2022). Many farmers, especially smallholders in developing nations, frequently lack the resources to invest in sustainable farming methods or cutting-edge agricultural technologies. Reliance on antiquated techniques that might not be climate change-resistant might persist because to the high upfront costs of climate-smart technology, soil management techniques, and precision agricultural equipment (Kumar *et al.*, 2024). Lack of understanding and awareness of the effects of climate change and the many adaption options is another important obstacle. It's possible that farmers are under informed on the dangers of climate change or the advantages of implementing resilient methods (Arbuckle *et al.*, 2013). This lack of understanding may lead to reluctance to change or a failure to use creative solutions. Inadequate agricultural extension services also frequently hinder the efficacy of knowledge distribution, particularly in rural locations where information is hard to get by. Furthermore, obstacles pertaining to policies and institutions may hinder advancement. It's possible that many areas' current policies don't sufficiently encourage or support efforts aimed at building climate resilience or sustainable agriculture methods. Effective implementation may be hampered by inconsistent policies, a lack of cooperation between government departments, and inadequate funds for research and development. Moreover, the possibility of competing interests among stakeholders, including legislators, environmental organizations, and farmers, might impede cooperative efforts and complicate decision-making procedures. Farmers' reactions to climate change are significantly shaped by social and cultural aspects as well. Cultural norms, customs, and farming traditions can all have an impact on a person's readiness to accept new methods or innovations. Sometimes farmers are reluctant to give up long-standing customs because they don't want to lose their cultural identity or because they don't think new methods will work. Customized communication techniques that are in line with regional contexts and values are needed to break down these obstacles. Furthermore, the uncertainties brought forth by climate change make planning and decision-making in agriculture more difficult. The variability of climatic patterns, encompassing variations in temperature and precipitation, poses a difficulty for farmers in forecasting and getting ready for upcoming circumstances. Farmers may be reluctant to invest in resilience-building techniques due to this uncertainty since they may not know if their decisions will be sustainable over the long run (Yeleliere *et al.*, 2023).

Future Directions

Future directions should be taken into consideration in order to solve the obstacles and difficulties associated with improving climate resilience in agricultural systems. First and foremost, more funding must be allocated to research and development projects centered on agricultural technology and practices that are climate resilient. The creation of regionally tailored solutions that address the unique requirements of farmers in various locations has to be given top



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priority in this initiative. Knowledge exchange and innovation can be facilitated via collaborative research programs that involve local communities, government organizations, and academic institutions. Education and capacity building are crucial elements of future plans. Enhancing resilience requires growing agricultural extension services to give farmers access to pertinent data, education, and resources. The creation of training programs that give farmers the abilities and information required to implement sustainable practices should be a top priority for governments and non-governmental organizations. Access to information may be improved and knowledge distribution can be enhanced by utilizing cutting-edge communication methods like internet platforms and mobile applications. Improving frameworks for policies to promote climate resilience is another essential future course. The goal of policymakers should be to develop comprehensive laws that encourage environmentally friendly farming methods and offer financial assistance to farmers that implement climate-resilient equipment. Subsidies for conservation measures, infrastructure investments for irrigation and water management, and the creation of insurance programs to shield farmers from climate-related hazards are a few examples of how this may be done.

Encouraging cooperation among interested parties is crucial to tackling the complex problems associated with climate resilience. A more inclusive approach to climate adaptation may be fostered via multi-stakeholder collaborations that bring together farmers, academics, politicians, and civil society. This kind of cooperation can make it easier to share best practices, exchange expertise, and organize coordinated efforts to deal with shared problems. Participation from local populations in decision-making processes is also necessary to guarantee that the solutions are appropriate for the given environment and culture. Enhancing resilience can also be significantly aided by utilizing digital technology. Farmer insights into crop health, climatic trends, and resource management may be gained by utilizing data analytics, remote sensing, and artificial intelligence. Precision agricultural techniques may be made easier by the integration of digital technologies, giving farmers the ability to make well-informed decisions based on real-time. To encourage wider use, it will be essential to increase smallholder farmers' access to inexpensive technology. Last but not least, tackling the social and cultural aspects of climate resilience is crucial to guaranteeing the strategy' long-term effectiveness. Promoting a culture of adaptation and holding discussions on the effects of climate change on communities might encourage cooperation. Resilience may be increased while honoring cultural values and customs through community-led projects that make use of local expertise and practices. By fostering collaboration and trust among neighbors, farmer-to-farmer learning and trade can also help communities adopt resilient practices.

CONCLUSION

Improving agricultural systems' climate resilience is a crucial task that calls for a diversified strategy. While there are many different techniques, in order to assure their efficacy, the difficulties and obstacles to their execution must be removed. Building resilience can be hampered by social issues, institutional difficulties, lack of information, and restricted access to resources. Future paths have to prioritize raising research funding, developing educational opportunities, improving policy frameworks, encouraging stakeholder engagement, utilizing digital technologies, and addressing social issues. Through the promotion of an all-encompassing strategy that incorporates these components, we can enable farmers to adjust to the difficulties presented by climate change. In the end, strengthening climate resilience is critical for ensuring food security and livelihoods in a world that is changing quickly, as well as for the sustainability of agricultural systems. In order to ensure that agricultural systems can flourish in the face of unpredictability and so contribute to the larger aims of sustainable development and environmental stewardship, it will be imperative that we prioritize climate resilience going ahead.

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Table 1. Strategies for climate resilient agriculture

Agronomic Practices	Optimizing field management techniques to improve soil health, water use efficiency, and crop productivity in changing climate conditions.	Conservation tillage - Crop rotation and diversification - Agroforestry - Cover cropping - Improved irrigation techniques
Crop Breeding and Biotechnology	Developing climate-resilient crop varieties through genetic modification and traditional breeding to enhance drought tolerance, pest resistance, and yield stability.	- Drought-resistant varieties - Heat-tolerant crops - Pest-resistant GMOs



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		(e.g., Bt cotton) - Marker-assisted selection (MAS)
Soil and Water Management	Implementing sustainable water management practices and soil conservation techniques to mitigate the effects of climate variability.	- Rainwater harvesting - Drip irrigation - Mulching - Soil organic matter enhancement
Agroecological Approaches	Promoting diversity in farming systems by integrating crops, livestock, and ecosystem-based management to build resilience to climate change impacts.	- Polyculture systems - Agroforestry - Integrated pest management (IPM) - Organic farming
Digital and Precision Agriculture	Utilizing advanced technology and data-driven tools to optimize resource use, monitor crops in real time, and respond to climate-related stresses more efficiently.	- Drones for crop monitoring - IoT-based irrigation systems - Remote sensing - Climate forecasting and decision support systems
Climate-Smart Agriculture (CSA)	A comprehensive approach to transforming agricultural practices to increase productivity, adapt to climate change, and reduce greenhouse gas emissions.	- Climate-resilient crop varieties - Low-emission farming techniques - Improved land-use planning - Resilient supply chains
Improved Nutrient Management	Optimizing fertilizer use and improving nutrient cycling to enhance soil fertility and crop resilience to climate-induced stresses.	- Site-specific nutrient management - Use of biofertilizers - Integrated nutrient management (INM)
Farm Mechanization and Technological Advancements	Introducing modern equipment and smart technologies to enhance farming efficiency, reduce labor dependency, and adapt to climate challenges.	- Automated irrigation systems - Mechanized precision sowing - Farm machinery for conservation agriculture
Insurance and Risk Management Tools	Providing financial protection to farmers against extreme weather events and climate-induced losses through insurance schemes and risk management frameworks.	- Crop insurance programs - Weather-indexed insurance - Early warning systems for extreme events
Capacity Building and Knowledge Transfer	Strengthening the ability of farmers and agricultural stakeholders to adapt to climate change through training, education, and the dissemination of best practices.	- Farmer field schools - Climate-resilient farming workshops - Community-based knowledge sharing platforms





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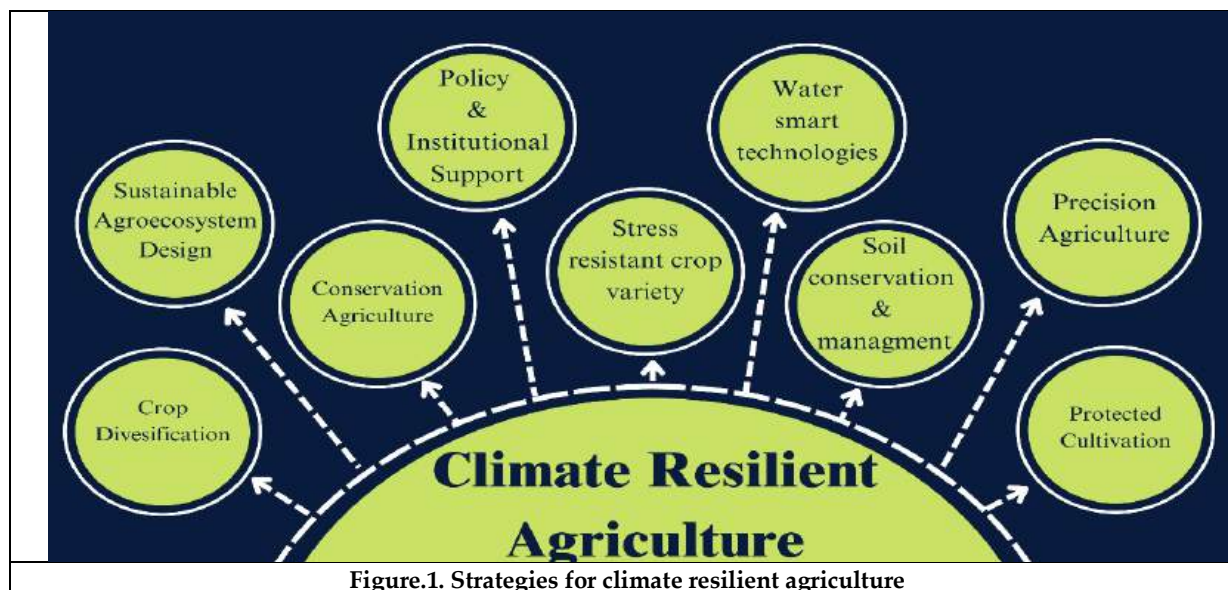


Figure.1. Strategies for climate resilient agriculture





Optimising the MongoDB Aggregation Pipeline with Node.js for Large-Scale Applications

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ABSTRACT

This paper investigates optimisation strategies for MongoDB's aggregation pipeline in large-scale Node.js applications. The article describes how to decrease the overhead associated with huge data sets and complicated connections by using efficient query design, pipeline phases, and indexes. We show real optimisation tactics and performance advantages gained by carefully adjusting MongoDB's aggregation phases[1], [2]. Our findings show considerable performance benefits, particularly for real-time applications that work with large datasets in dispersed situations[3]. With the fast rise of real-time applications, this research focusses on best practices and highlights typical problems in pipeline design and query execution.

Keywords: MongoDB aggregation, Node.js, database optimisation, large-scale applications, performance tuning.

INTRODUCTION

The emergence of NoSQL databases such as MongoDB has transformed the way large-scale online and mobile apps manage data[1],[4]. MongoDB's document-based approach is adaptable, allowing developers to manage enormous





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amounts of unstructured and semi-structured data[5]. MongoDB, together with Node.js, provides the foundation for many high-performance, real-time applications. However, when applications expand, MongoDB's speed may suffer, particularly during sophisticated data searches. The aggregation process, which allows for rapid data manipulation and analysis, can become a bottleneck when dealing with large datasets. While the pipeline is strong, inappropriate usage or lack of optimizations can lead to large memory consumption, long query times, and decreased system performance[2].

Complex queries, massive amounts of data, and unoptimised pipelines can all considerably slow down data retrieval times. This performance reduction can cause bottlenecks, particularly in latency-sensitive applications like e-commerce, banking systems, and social media platforms that require real-time data access[6], [7]. E-commerce applications, by definition, require complicated data processing systems. The Orders collection, for example, often comprises nested fields representing various goods, quantities, and prices, whereas the Customers collection keeps specific user histories, such as geographic regions and payment methods. MongoDB's aggregation pipeline is a significant tool that enables quick data processing and analysis. It allows users to alter and filter documents in a series of steps, including \$match, \$group, \$sort, and \$lookup[8], [9]. However, when working with huge datasets, even minor inefficiencies in pipeline design can compound, resulting in longer query times and greater system resource utilisation. While the pipeline is robust, improper usage or a lack of optimisations can result in excessive memory consumption, high query times, and poor system performance. In large-scale systems, the detrimental impact on the user experience can be severe. The development of indexes involves a trade-off between write and read performance. In write-intensive applications, index construction should be carefully regulated to avoid slowing down data insertion rates. This article tackles the main issues encountered when utilising MongoDB's aggregation pipeline in large-scale Node.js applications. It specifically discusses how to optimise aggregation queries for better performance and scalability. This study seeks to close the gap between MongoDB's promise and its real performance limits in commercial settings

The primary aims of this study are to:

1. Identify performance bottlenecks in MongoDB aggregation pipelines.
2. Propose effective optimisation solutions for Node.js.
3. Evaluate the effects of these optimisations on large-scale applications.

MATERIALS AND METHODS

Application Architecture and Dataset.

To imitate a real-world setting, we used an e-commerce platform as the testbed for our studies. The platform manages product catalogues, customer orders, reviews, and user interactions. The collection contains 10 million entries, including nested documents and array fields that store complicated connections like product classifications, order histories, and user reviews. E-commerce applications, by definition, require complicated data processing systems. The Orders collection, for example, often comprises nested fields representing various goods, quantities, and prices, whereas the Customers collection keeps specific user histories, such as geographic regions and payment methods. Sharding partitions the dataset over numerous nodes, which distributes the load and improves query speed.

The key components of the environment are:

- MongoDB version: 4.x, running on a distributed cluster with sharding enabled to manage enormous amounts of data.
- Node.js version: 16.x was used to create the server-side logic and connect with MongoDB using the native MongoDB Node.js driver.
- Data Structure: A collection called Orders has fields like client information, product details, and order history. Nested documents and array fields were often utilised to manage several items per order.



**Pavan Kalyan Varma et al.,****Baseline Performance Evaluation.**

Prior to optimising, we generated a set of baseline aggregate queries. These queries replicated typical operations in large-scale applications, such as: Retrieving client order histories, including total expenditure per customer (\$group, \$sum). Performing cross-collection lookups to combine data from the Products and Reviews collections (\$lookup). Analyse top-selling goods by category over time (\$match, \$group, \$sort).

We assessed critical metrics, including:

- Execution Time: The duration of time required to execute the query.
- Memory Consumption: The amount of memory used during the execution of a query.
- CPU Load: The effect of query execution on the CPU resources of the server.

Methods of Optimization**Strategy for Indexing:**

Indexing is one of the most fundamental methods for enhancing the efficacy of a database [11], [12]. To optimise the \$match and \$group phases, we experimented with covered queries, text indexes, and compound indexes [2], [13].

Compound Indexes:

Optimizing \$match and \$group queries by combining multiple attributes. Text indexes are employed for the purpose of text-based search and filtering. Covered Queries: Guaranteeing that MongoDB can retrieve results directly from the index without scanning the entire collection. In order to reduce query time, particularly during the \$match stages, we implemented indexes on critical fields, including orderDate, customerId, and productId.

Pipeline Reordering

The efficacy of a MongoDB aggregation pipeline is significantly influenced by the order of stages. In order to minimize the quantity of documents that are forwarded to subsequent stages, we relocated the most selective stages (e.g., \$match) to the pipeline's inception. For example, the burden of \$group and \$lookup was reduced by utilizing \$match early on, as they processed fewer documents after the initial filtration.

Minimizing the Use of \$lookup:

While \$lookup enables us to perform joins between collections, it can be expensive in terms of memory and effort. We investigated methods to decrease the dependence on \$lookup by denormalizing data, which involves embedding related documents directly in the same collection[8],[9]. This method minimized the necessity for cross-collection connections, particularly for frequent queries in which the related data changed infrequently.

Limiting and Projection:

The volume of data processed and returned was managed by utilizing the \$limit and \$project stages. We achieved a substantial reduction in memory utilization by projecting only the essential fields and restricting the number of documents returned in intermediate phases. For instance, prior to the removal of superfluous fields from the pipeline, aggregation queries were required to process extensive documents that contained customer data, product details, and order information. Efficiency was enhanced by the retention of only a handful of fields following the application of \$project.

Query Complexity and Real-World Scenario Simulation:

To guarantee that the optimisations were successful in a production setting, we went beyond simple queries. Complex searches with numerous steps, such as \$unwind, \$facet, and nested \$lookup procedures, were assessed. These queries replicated real-world e-commerce scenarios such as analysing consumer purchase habits, identifying top-selling goods based on geography, and dealing with multi-currency conversions. By stacking complex procedures, we were able to examine MongoDB's ability to manage big datasets in progressively intricate pipelines. We especially looked at cases in which clients made several transactions in various locations. We used \$unwind to burst array fields with lists of items purchased by each customer, followed by \$group to aggregate product sales and \$lookup to acquire more data from a separate items collection. Because of the high amount of transactions, these





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activities needed considerable CPU and memory resources, allowing us to compare performance before and after optimisations were applied.

Distributed Sharded Cluster Performance

In addition to assessing performance on a single-node MongoDB server, we investigated the impact of sharding on query performance. Sharding is critical for scaling MongoDB in large-scale applications since it allows for horizontal division of data over numerous nodes. The queries were run on a sharded cluster with three shards to simulate a distributed environment in which data was partitioned by customer region. To optimise speed, we strategically positioned data based on client location, ensuring that queries for region-specific data were delivered to the right shard. This resulted in lower network overhead and query execution time. Furthermore, shard keys were carefully selected to evenly distribute the load across all shards. We discovered that in some circumstances, erroneous shard key selection resulted in unequal data distribution and increased query time.

RESULTS AND DISCUSSION

The proposed optimizations resulted in substantial enhancements in query performance and resource utilization, as evidenced by our experimental results.

Time of Execution

Before optimization, certain aggregation queries required 15–20 seconds to complete, particularly when addressing multi-stage pipelines that included \$lookup operations. The indexing and pipeline reordering techniques resulted in a 50–70% reduction in query latencies, with an average execution time of under 5 seconds. This enhancement was most apparent in queries that initially necessitated substantial \$lookup usage[6], [15]. For instance, Prior to optimization, it required 18 seconds to retrieve order history and determine the total consumer expenditure. After optimization: The query was executed in 4.8 seconds after the addition of a compound index on the customerId and orderDate.

Memory consumption

The baseline implementation demonstrated a high level of memory consumption, particularly in queries that involved large datasets. Memory utilization decreased by 30–40% following the optimization of the pipeline, which included the addition of \$project and \$limit stages. Our Node.js application was able to manage concurrent queries more efficiently without overwhelming system resources as a result of this reduction.

Utilization of Central Processing Units

During the initial set of experiments, the CPU was utilized at a high rate, particularly for queries that involved sophisticated \$group and \$lookup operations. The system became more responsive under intensive workloads as a result of the average 20% reduction in CPU utilization following the optimizations. Impact of Pipeline Redesign: The CPU burden was significantly reduced as a result of the \$match stage being relocated to the beginning of the pipeline, as fewer documents were transmitted through subsequent stages. For example, the reordering of stages resulted in an aggregation that was originally capable of processing 2 million documents being reduced to 200,000.

Reducing the Overhead of \$lookup

The necessity for costly \$lookup operations was substantially diminished by denormalizing the data model, particularly by embedding related documents. In one case, the execution time was reduced by over 60% as a result of the simplification of queries that previously required three collection joins with \$lookup to a single collection query. The need for costly \$lookup operations was significantly reduced by denormalising the data model, notably by embedding related documents. In one scenario, queries that previously needed three collection joins using \$lookup were simplified to a single collection query, resulting in an execution time reduction of more than 60%.





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The performance impact of distributed queries

Sharding significantly reduced query execution speeds for region-specific queries, particularly those that took use of data locality. By carefully picking shard keys based on geographic areas, queries like aggregate sales data by region took 40% less time to execute than in an unsharded environment. However, we discovered that cross-shard searches, which needed MongoDB to combine results from different shards, incurred substantial cost. When a query spans many shards, such as getting global customer statistics, the query speed suffers owing to the added process of integrating data across shards. The dispersed nature of these queries necessitated the use of MongoDB's mongos query router, which increased network latency and CPU utilisation on the primary node. This trade-off between faster local queries and slower global queries emphasises the need of considering application-specific requirements when developing sharded environments.

Memory management and resource allocation.

Throughout the optimisation process, we aimed to improve MongoDB's memory use. We used \$project and \$limit to regulate the amount of intermediate documents transferred between phases. This not only lowered memory use, but also enabled more efficient resource allocation in concurrent situations. Applications that handle huge volumes of data in parallel, such as an e-commerce site managing multiple client orders, experienced a significant increase in responsiveness owing to more effective memory utilisation. We also looked at MongoDB's internal memory management, including its usage of the WiredTiger storage engine. WiredTiger's cache size has a significant impact on query speed. We improved query speed by fine-tuning the cache size based on demand, particularly during peak traffic. Larger cache sizes improved read speed but increased memory use, whereas smaller cache sizes allowed MongoDB to rely on disc I/O more frequently, reducing performance.

DISCUSSION

These findings underscore the significance of taking into account a variety of factors when developing aggregation pipelines for large-scale applications. Measurable enhancements were achieved through the integration of memory management, deliberate pipeline design, and efficient indexing. Nevertheless, developers must carefully manage the trade-offs that can result from denormalization, which can result in data duplication in high-transaction environments. Furthermore, the performance of optimizations in production is further influenced by MongoDB's sharding capabilities and distributed architecture. The efficacy of queries can be variable depending on the physical layout of the data and the distribution of data across segments.

CONCLUSION

This investigation illustrates that the optimization of MongoDB's aggregation pipeline can result in substantial performance enhancements, particularly for large-scale Node.js applications that manage millions of records [11]. Utilizing efficient indexing, reducing the utilization of memory-intensive stages, and rearranging pipeline stages, we were able to reduce query execution time by up to 70% and decrease resource consumption. Automation techniques for pipeline optimization could be investigated in future research, with the potential to employ machine learning models to anticipate optimal query patterns based on dataset characteristics. Furthermore, the examination of the interaction between optimized MongoDB pipelines in a microservices architecture could provide novel insights into performance optimization, given the growing prevalence of microservices[7], [16].

Furthermore, this study emphasises that real-time systems, particularly those with high transaction volumes and concurrent users, need careful consideration of data architecture, query patterns, and resource allocation approaches. This study demonstrates that optimising MongoDB's aggregation pipeline may result in significant performance gains, especially for large-scale Node.js applications that handle millions of data. We were able to minimise query execution time and resource usage by up to 70% by using efficient indexing, decreasing the use of memory-intensive stages, and reorganising pipeline stages. Furthermore, these optimisations performed well in both single-node and





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sharded cluster contexts, resulting in a complete method for scaling MongoDB in distributed systems. Furthermore, we showed that careful consideration of MongoDB's internal processes, such as memory management and sharding strategy, is critical for achieving peak performance in high-traffic applications. These optimisations can considerably assist applications that require real-time data processing, especially those that handle complicated queries involving several collections or big datasets. Future study might look into automating pipeline optimisation using machine learning approaches to dynamically alter the pipeline depending on query patterns and data properties. Furthermore, more research on MongoDB's performance in microservices-based architectures, where databases are frequently decentralised across several services, will provide significant insights into performance optimisation in dispersed environments. Finally, as MongoDB and Node.js gain popularity in large-scale applications, these optimisations will become even more important to guarantee that systems stay scalable, efficient, and responsive.

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A Review on Deep Learning MRI Reconstruction without Fully Sampled k-Space

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ABSTRACT

Magnetic resonance imaging (MRI) is a non-invasive and widely used medical technique that provides high-resolution images for diagnosis and treatment planning. However, one of its main limitations is the long acquisition time, because the k-space (spatial frequency domain) must be fully modeled to produce a good image. Obtaining the entire k-space profile is time-consuming, which leads to long scanning times, patient discomfort, high costs, and reduced clinical outcomes. Image quality is poor due to lack of information. Traditional techniques such as parallel imaging and spectral analysis attempt to reconstruct images from under sampled k-space data, but they are often limited by computational time and image quality. Various deep learning methods such as convolutional neural networks (CNN), generative adversarial networks (GAN), and neural networks (RNN) have been used for MRI reconstruction. The model is designed to produce high-quality images using a preliminary sample of weak k-space data and full MRI data obtained from spatial study. The main problems and limitations of this approach are discussed and directions for future research are explored.

Keywords: Deep Learning, MRI Reconstruction, Under sampled k-space, Convolutional Neural Networks, Generative Adversarial Networks



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INTRODUCTION

Background on MRI and k-space

MRI is a powerful imaging technique used to visualize structures in detail. MRI signals are acquired in a Fourier domain called k-space, and all k-space samples are required to reconstruct the image. However, disabling all k-space data is automatic

Motivation for under sampled MRI

The goal of undersampled MRI is to reduce scanning time while preserving high-quality diagnostic images. Techniques such as parallel imaging and compressed sensing have been developed to avoid data loss. However, these methods have their own limitations such as slow computation and poor image quality, and deep learning is designed to solve these problems.

Emergence of Deep Learning in MRI Reconstruction

In existing years, deep learning has revolutionized many fields, including medical imaging. Its ability to learn complex models from data makes it ideal for reconstructing negative MRI images by predicting missing k-space data.

MRI Reconstruction from Under sampled k-Space

The Challenge of under sampled Data

Over sampling of the K-space acquisition results in loss of frequency information and introduces aliasing artifacts into the reconstructed image. This is a significant problem in MRI scans, as missing data can destroy fine details of the image.

Traditional MRI Reconstruction Methods

Parallel imaging: Using multiple coils to sample k-space in parallel reduces acquisition time, but still requires complete reconstruction of k-space. Relies on computationally expensive reconstruction algorithms.

Compressed Sensing: Leverages the sparsity of MRI images to reconstruct them from fewer samples, but it relies on iterative reconstruction algorithms that are computationally expensive.

Deep Learning as an Alternative

Deep learning-based approaches aim to map the relationship between under sampled and fully sampled k-space using learned data priors. This allows fast and accurate reconstruction with minimal artifacts.

Deep Learning Architectures for MRI Reconstruction

(CNNs) Convolutional Neural Networks are the basis of many deep learning MRI techniques. The principle of CNNs is to combine input data using sieves to detention local and global features that are important for accurate image reconstruction in negative k space. Local data capture 3D CNN: Suitable for volumetric MRI data, generating physical and anatomical features. The following information is distinguished from real pictures. It can produce clearer and more accurate images than CNN models that are important for diagnosis. In MRI reconstruction. These networks can capture the progress, which is useful for time-resolved or dynamic MRI imaging. Novel architecture. This is particularly useful for capturing the overall correlation of MR images, so it is promising for future research. For example, CNN can be used for local inference, and GAN can be used to enhance real images.

Loss Functions and Optimization Techniques

Pixel Loss Function Common loss functions include MSE (mean squared error) and MAE (mean absolute error), which focus on minimizing the pixel difference between the reconstructed image and the target image. Adversarial Loss GAN adversarial loss improves the recognition quality of images by encouraging the network to generate images that look more realistic to human observers. Perceptual Loss Using a pre-trained network (e.g., VGG) to compute the perceptual loss can preserve fine image details that are often lost due to standard pixel-wise loss.

Regularization Methods To put a stop to overfitting in deep learning models, regularization techniques such as L1/L2 regularization, data dropout, and data padding are required.





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Datasets for Training and Evaluation

Publicly Available Datasets

FastMRI Dataset: Released by NYU and Facebook AI, this is one of the largest datasets available for training deep learning models for MRI reconstruction.

MICCAI Datasets: Frequently used for medical image computing challenges.

Data Augmentation Techniques

Data intensification is necessary due to the scarcity of fully sampled k-space datasets. Techniques include adding noise, rotations, flipping, and scaling of images to expand the training set.

Evaluation Metrics

Evaluation of deep learning models in MRI reconstruction is done using metrics like peak signal-to-noise ratio (PSNR), structural similarity index (SSIM), and perceptual metrics that assess the visual quality of reconstructed images.

Encounters and Restrictions of Deep Learning in MRI Reconstruction

Generalization Across Different Anatomies and MRI Sequences

Deep learning facsimiles trained on one type of anatomical data or MRI sequence may not oversimplify well to other types. This is a major challenge, as MRI scanners and protocols vary widely across hospitals and imaging centers.

Scarcity of Fully Sampled k-Space Data

Fully sampled k-space datasets are expensive and time-consuming to acquire, limiting the amount of data available for training deep learning models.

Artifact Generation and Suppression

Deep learning models can introduce new artifacts or fail to remove artifacts caused by under sampled data. This can be problematic in a clinical setting where diagnostic accuracy is critical.

Computational and Resource Constraints

Training deep learning prototypes requires significant computational resources, in cooperation with access to GPUs and large expanses of memory. This can limit the adoption of these techniques in resource-constrained environments.

Clinical Applications and Future Directions

Publicly available data sets

- fast MRI dataset: This dataset released by NYU and Facebook AI is one of the largest datasets available for training deep learning models for MRI reconstruction.
- MICCAI dataset: It is frequently used for medical image computing tasks.

Data Augmentation

Methods Data augmentation is necessary due to the lack of fully sampled k-space datasets. Methods include adding noise, rotating, flipping, and resizing images to expand the training set.

Evaluation Metrics

Evaluation of deep learning models in MRI reconstruction is performed using metrics such as peak signal-to-noise ratio (PSNR), structural similarity index (SSIM), and perceptual metrics that evaluate the visual quality of the reconstructed images.

Challenges and Limitations of Deep Learning in MRI Reconstruction

Generalization to Different Anatomical Structures and MRI Sequences Deep learning models trained on one type of anatomical data or MRI sequence may not generalize well to other types. This is a serious problem because MRI scanners and protocols vary widely across hospitals and imaging centers. Lack of Fully Sampled k-Space Data Copiously Abundantly sampled k-space data sets are expensive and time-consuming to obtain, limiting the amount of data available for training deep learning models. Creation and Suppression of Artifacts Deep learning models may introduce new artifacts or fail to remove artifacts that result from under sampling of the data. This can be problematic in clinical settings where diagnostic accuracy is critical. Computational and Resource Limitations Drill deep learning models demands significant computational resources, including access to GPUs and large memory. This may limit the adoption of these techniques in resource-constrained settings.





Clinical Applications and Future Directions

Faster MRI Scans A major clinical benefit of deep learning-based MRI reconstruction is the reduction in scan times, which increases patient throughput and reduces discomfort.

Adaptive Models Future deep learning models could adapt to individual patient data to improve the meticulousness and speed of reconstruction for each individual scan.

Explain ability and Trust of Deep Learning Models One of the most important future directions is to mend the explain ability of deep learning representations. Clinicians need to be confident that the model accurately reconstructs images and that important diagnostic information is not lost.

Integration with Other Visualization Methods Another promising direction is to integrate MRI reconstruction with other imaging modalities, such as CT or ultrasound, to provide multimodal data for better diagnosis.

CONCLUSION

Deep learning has established to be a commanding tool for MRI reconstruction, especially when k-space objects are not fully available. Although there are still some challenges to overcome, such as scalability and obsolete products, the future looks promising. As computing power continues to increase and more complex data becomes available, deep learning models could become an important part of MRI development, enabling faster, more accurate, and more effective treatment.

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Design and Implementation of PLC using ESP32 Microcontroller

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ABSTRACT

This project uses the ESP32 microcontroller's capabilities to create a novel programmable logic controller (PLC). The dual-core architecture, extensive GPIO pin range, and integrated Wi-Fi support of the ESP32 offer a strong platform on which to construct a multitude of industrial automation systems. Reliance on physical connections is decreased because of the system's wireless connectivity, which enables remote monitoring and control. The PLC's ability to adapt to different industrial conditions is increased by the integration of many sensors, such as pressure and temperature sensors. On-the-fly control methods take advantage of the ESP32's multitasking capabilities to deliver accuracy and efficiency. Modular architecture gives the flexibility to adapt to changing needs and facilitates simple expansion through the addition or replacement of sensor and actuator modules. Configurability is enhanced by an intuitive user interface that may be accessed through a web browser or specialized program.

Keywords: Industrial Automation, PLC, ESP32 MC, Open PLC, iot-ladder editor.

INTRODUCTION

Automation: Automation, or the use of technology to carry out tasks automatically, is a major force changing daily life and industry. Robotics have transformed production lines in the manufacturing industry by performing repetitive jobs quickly and precisely. Business operations are streamlined by software-driven process automation, which increases productivity and lowers human error. Automation's fundamental component, artificial intelligence, transforms industries like healthcare, finance, and customer service by enabling machines to learn and make wise judgments. Smart gadgets are introduced into homes through home automation, providing control over entertainment, security, and lighting.



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PLC: A specialized computing device used extensively in industrial settings for process automation and control is called a programmable logic controller (PLC). PLCs, which are the brains of automated systems, are programmed to specify the order of processes and control logic using a graphical language similar to ladder logic. Through input and output modules, they communicate with the outside environment by receiving signals from sensors and managing actuators and other devices. PLCs function in real-time and react quickly to changes in input because they are renowned for their dependability in challenging industrial settings. Because of its modular architecture, they provide flexibility for system modification or growth without causing a lot of disturbance. PLCs are widely used in the manufacturing, automotive, and chemical processing industries. They are essential for managing operations including robotic cells, assembly lines, and conveyor systems. PLCs are essential to industrial automation because of their capacity for communication with other devices and networks, which increases their usefulness even more.

Design Of PLC Using ESP32

Designing of PLC using ESP32 can be divided into two sections. One is Relay Control section and the other is Microcontroller and power supply section. The details of the both sections are given below with specifications. Schematic Diagram is shown in Fig.

Relay Control Section

The left side of the diagram shows five relay circuits, each consisting of a relay coil (U1 to U5), a diode (D1 to D5), a transistor (Q1 to Q5), and a base resistor (U8 to U12). The relay coils are driven by a +24V DC power supply. The diodes across the relay coils are flyback diodes, which protect the transistor switches (Q1 to Q5) from voltage spikes that occur when the relay is turned off (inductive kickback). The transistors (Q1 to Q5) are of the BC547B type and are used to switch the relay coils on and off. The base of each transistor is connected to a 1k Ω resistor (U8 to U12), which limits the base current. The connectors (CN1 to CN5) likely receive input signals that control the transistors, which in turn control the relays. When a transistor is turned on, it energizes the relay coil, causing the relay to switch its contacts, allowing current to flow through the connected load.

Microcontroller and Power Supply Section

The right side of the diagram features an ESP32 development board (U6), which is a popular microcontroller with Wi-Fi and Bluetooth capabilities. The ESP32 development board is connected to various components, likely for interfacing with external devices or sensors, but the specific connections and purposes are not entirely clear without further context. Below the ESP32, there is a DC-DC converter module (U7) labeled "DC-DC-5V." This module converts the +24V DC input to a 5V output, which is a common voltage used to power logic circuits and microcontrollers like the ESP32. In summary, this circuit diagram seems to represent a control system where the ESP32 microcontroller sends signals to the transistors, which in turn control the relays to switch higher-power loads. The system is powered by a 24V DC supply, with a DC-DC converter providing 5V for the microcontroller. The exact function of the system would depend on the connected loads and the firmware running on the ESP32.

Programming For PLC

Different softwares are used for different brands of programming PLC. While Open sources software is also available like Open PLC, iot-ladder-editor, CoDeSys, Sysmac Studio etc., for programming. In this Paper ladder logic programming is used in iot-ladder-editor. Ladder Programming can be exported to micro controller ESP32. Detailed steps are given below.

Ladder Logic Programming

Below are the steps to design a logic in the software. Download the software from the below link

<https://github.com/leofds/iot-ladder-editor/releases>

step1: download the software

step2: open the software and click on file and create a new file





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Step3: click on the rung and drag the rung to the circuit board

Step4: Go to instruction list and click on the + button and select the contacts drag the contacts and place it on rung
Double click on the contact and select the address

Step5: Go to instruction list and click on the + button and select the coils drag the coils and place it on rung Double
click on the coils and select the address

Step6: you can select the required things from the instruction depending upon on the lo

Step7: select the project at the top and click on the build and run
Once you get the successfully completed it will be redirected to the Arduino IDE

PCB Design

PCB layout refers to the physical arrangement and layout of electronic components, traces, and other elements on a printed circuit board (PCB). The PCB layout is a critical step in the overall PCB design process and plays a significant role in the functionality, performance, and manufacturability of the final electronic product.

CONCLUSION

In conclusion, the design of a Programmable Logic Controller (PLC) using the ESP32 microcontroller represents a significant stride towards advancing industrial automation. The ESP32's dual-core architecture, GPIO flexibility, and built-in communication features provide a solid foundation for creating a versatile and cost-effective PLC system. The integration of real-time operating systems ensures precise control in critical applications, while the incorporation of user-friendly programming environments simplifies the configuration process. The emphasis on input/output modules and communication interfaces underscores the adaptability of the ESP32-based PLC to a wide range of industrial devices and networks. Furthermore, the inclusion of security features addresses the imperative need for safeguarding against unauthorized access and cyber threats in industrial settings. Overall, this innovative approach not only enhances operational efficiency but also contributes to the evolution of industrial automation, positioning the ESP32-based PLC as a cutting-edge solution for the dynamic demands of modern manufacturing environments.

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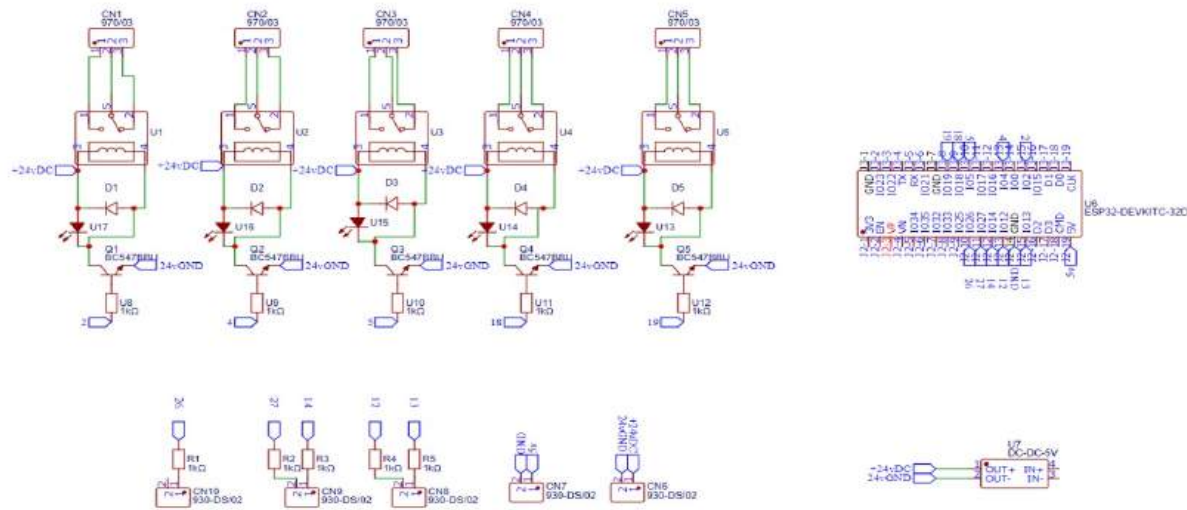


Fig: 1 Schematic Diagram

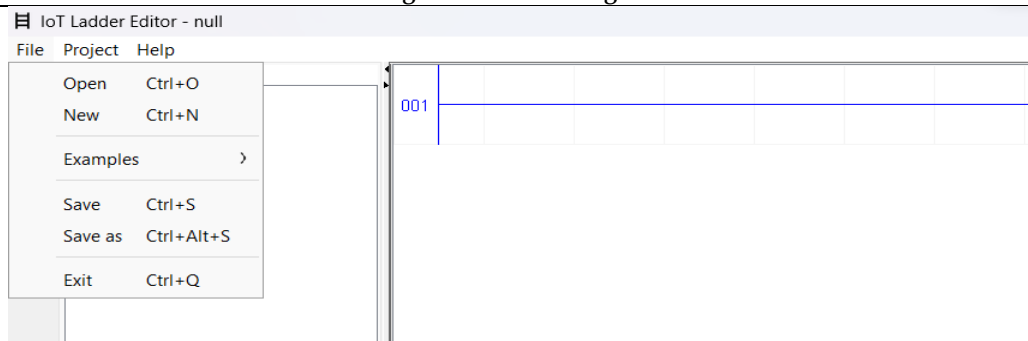


Fig 2 Creating a new project



Fig 3 Creating a new rung

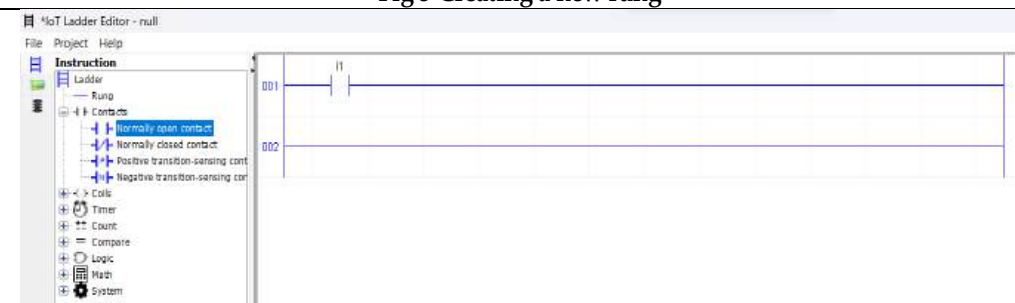


Fig 4. Adding contacts to the ladder





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Fig 5 Giving label to the contacts

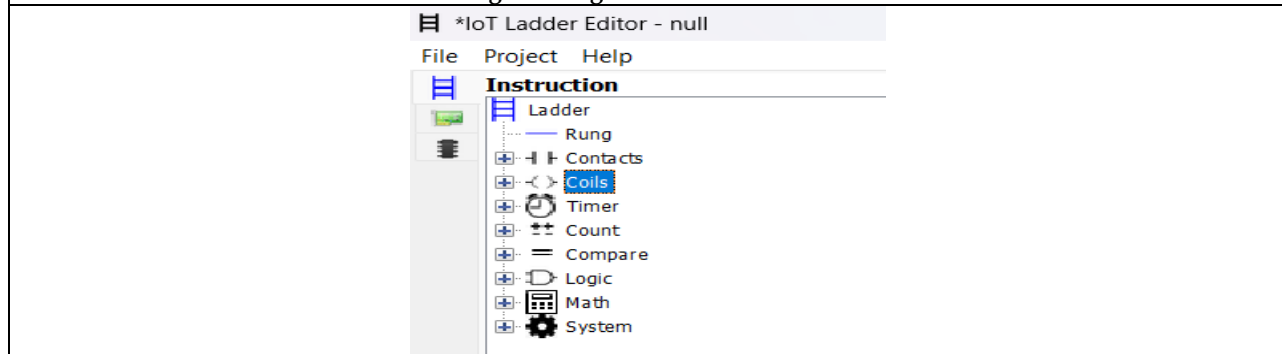


Fig 6 Adding coil to the ladder



Fig 7 Run the program

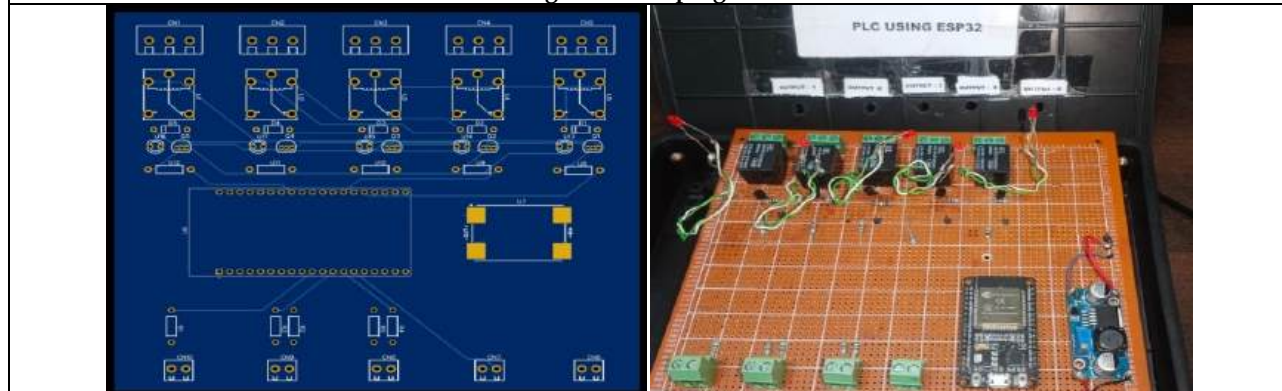


Fig 8 PCB Design





Role of Radiology Techniques & Modalities in the Breast Cancer Diagnosis & Treatment

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ABSTRACT

Introduction: This study meticulously investigates the role of various diagnostic modalities in breast cancer detection, focusing on mammography, ultrasonography (USG), and magnetic resonance imaging (MRI). Emphasis is placed on the significance of early detection and screening methods, especially mammography, in identifying abnormalities. The study explores risk factors, such as familial history and genetic mutations, influencing breast cancer development. A retrospective analysis comprising 15 articles was conducted to assess radiological examinations and treatments for breast abnormalities. Real-time USG systems from Aloka and Toshiba were employed, along with FNAC guided by USG. The B. Mode USG proved effective in distinguishing between lesions and solid abnormal masses, aiding in needle-based biopsies. The study reveals a prevalence of breast-related abnormalities in females with dense breast tissue and advanced age. Asymptomatic patients were recommended for screening tests, utilizing various radiological modalities, including USG and screening mammography. MRI examinations demonstrated heightened sensitivity in determining tumor size for breast cancer patients, and the findings underscore the efficacy of different diagnostic methods. The comprehensive retrospective analysis contributes valuable insights to breast cancer diagnosis, suggesting the prioritization of screening tests and the adoption of advanced techniques like MRI. The study advocates for increased awareness through breast self-examination, emphasizing its role in early detection. The results highlight the need for nuanced understanding of diagnostic modalities, guiding future research and fostering advancements in breast cancer detection and treatment. Ultimately, this study aims to improve strategies for early diagnosis and enhance outcomes in breast cancer patients.





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Keywords: Mammography, Ultrasound Imaging, MRI (Magnetic Resonance Imaging), Digital Breast Tomosynthesis (DBT), Breast Biopsy, Contrast-Enhanced Imaging, Nuclear Medicine, Screening Protocols

INTRODUCTION

The role of MR and USG in the detection of breast cancer or early cancer detection of breast, as per the studies the breast cancer is found mostly in women. The basic modalities used for the diagnosis of breast abnormalities include Mammography, USG and magnetic resonance imaging. Mammography is considered as the baseline investigation modality for screening of any sort of abnormalities and the lesions, tumors or to diagnose an asymptomatic patient. The primary angiosarcoma is considered to be the rare abnormality among the tumors, lesions for the cause of malignancy which makes it difficult to diagnose with basic modalities.

In multiple studies with no genetic disorder it was noticed and found that a local rise in temperature over the lump. Any kind of color change or discoloration was considered to be caused due to trauma or any physical suppression.

USG was considered as initial mode of diagnosis which was performed after the symptoms of pain in the left breast of the patient.

The USG results showed the signs of hyperplasia. The patient was found without any sort of history of smoking or surgery. The patient had normal blood reports as:

SERUM	CA125
SERUM	CA15-3
SERUM	CEA

A non-calcified breast was imaged under mammography with symptoms of pain in left breast. An inflammatory lesion was found while being examined under USG. A large area of breast was seen having uneven echogenicity confirming for granulomatous mastitis. After being admitted in the hospital a USG study was conducted in which lymph nodes echogenicity was suspected with an abnormality in the left axilla, of the size 1cm*0.7cm. As the USG guided biopsy was done in which no tumor cell was found for confirming the metastasis of the lesion the patient was suggested for PET-CT which highlighted that a hypermetabolic thickened tissue in the left upper breast the same was found in bilateral axilla and the inflammatory lymph nodes suspected. In this study the patient was suggested for mastectomy with feasible breast reconstruction. On the removal of tumor a lot of red blood flowed out due to more blood supply to the lesion, the removal section of lesion was dark red on color with grey white tissue. A poorly differentiated part was obvious mitosis, blood lake and necrosis were present. Further investigation was performed like immunohistochemistry in which the tumor cells were found positive for:

CD34
ERG
FLI-1

The investigation confirmed for the diagnosis of Primary angiosarcoma of breast [1].

As per the study screening is one of the effective method to diagnose a non-symptomatic breast in the females of child bearing age and in the post-menopausal females. On that basis screening mammography is considered to be the most common x-ray modality used across the globe for early cancer detections. As per the multiple studies breast cancer is common worldwide. According to the study about 1.65 million cases were diagnosed in the year 2012. A focal cancer registry of the kingdom of Saudi Arabia stated that breast cancer rates were higher than other countries where the study conducted was more. According to estimated study in year 2015, United States about 40,000 female patients died of breast cancer among 232,000 females found with breast cancer. Breast cancer is frequently found in females aged between 56-65 yrs [2]. The study states that the neoadjuvant chemotherapy has played a vital role in decreasing or reducing the size of the breast tumor, lesion before the patient is suggested for the surgery. The study has proved that the neoadjuvant therapy has increased the life span and disease free survival for the breast cancer lesion [3]. The



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most commonly used modalities for the breast cancer diagnosis include the MRI, MAMMOGRAPHY and ultrasonography.

According to the studies the comparison between different diagnostic modalities was for conducted, Breast cancer patients, the abnormality or the breast tumor lesion was found on anyone of the modalities used for diagnosis. The further treatment or follow up was suggested as per the BIRADS Reporting, The BIRADS Reporting showed variations based on the modality which was used for the diagnosis of the lesion. According to the study about 90% of the lesion detected by the USG Modality has showed the results as negative which lead in the follow up of biopsies which were unnecessary , So the modality suggested to play major role in confirming the malignancy of the suspected lesion was Magnetic resonance imaging. This was considered to be superior technique for finding sensitivity of breast cancer detection and this modality had good negative value for excluding malignancy, so according to the studies MRI was considered to be the solution providing modality , As per the studies the widely used modalities are USG and MRI, USG was suggested as it was cheap and easy to access coming to the disadvantages include , it was user dependent and in calcific lesions artifacts can be seen, while as MRI has an advantage of giving a clear access to soft tissue by increasing the resolution and different contrast patterns can be identified, the only disadvantage is less availability and high cost [3-4]. In a study the record of 32 female patients were received those who had recently gone through breast examinations or imaging in a medical center at Piaul, Brazil . If the patient was found suspect after going through BIRADS system. The study had involved the histopathological examinations of the lesions of the breast :At least 32 patients were detected with breast lesions by any one of the modalities of Radiolog

METHODS

In this retrospective study we included about 15 articles and a review was made out of the studies for the patients who had symptoms and signs of any abnormality and lesion and went through the radiological examinations and diagnosis for having abnormalities in the breast tissue and were followed up with treatments including the chemotherapy and the surgeries after all the radiological and pathological examinations are done, we have found that the number of women found with breast cancer was 232,000 out of which 40,000 patients died. According to the study USG were performed by Real time systems of Aloka and Toshiba of japan with 7.5 MhZ linear transducer . FNAC also was done with guidance of USG for the separated lesions. In 2008 in a study the B. Mode USG played a good role in distinguishing between lesions and solid abnormal mass and for the needle based biopsy of the abnormal masses.

RESULT

In this retrospective study we have studied multiple article and the breast related abnormalities are most likely found in female patients with dense breast tissue and are older in age . The studies have suggested that the asymptomatic patients are suggested for the screening test first, which can be done with any radiological modality including the USG or the screening mammography by which we can find the abnormal mass or lesion in an anatomical area and can be followed up for further investigations and treatments. In a study a female patient was presented in a hospital for a left breast lump which was showing a rapid progress , For diagnosis the modalities used were USG, DBT,MRI & Mammography. The study states that the self-breast examinations were suggested and performed which is a noninvasive as well as in-expensive technique , The study believes that each detection of the abnormalities or swelling and fibrocystic changes 1 weak after the start of menstrual cycle at this period the changes are less likely to interfere with the lump or lesion detection . The females were taught the same how to do the self-examinations. The self-examination benefits the females in many aspects they can get to know about any unusual changes in their breast which may include skin color change, discharge from nipple, nipple inversions , lesions, lump , masses or any sort of swelling in any portion of the breast.



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It results in advanced awareness in women's for breast related abnormalities. According to some studies it was declared that the efficiency of BSE for Breast cancer screening was not a self-proving method and it also could not reduce the rate of mortality in the breast cancer patients. The micro calcifications can be found normally in women of age above 50years .The automated breast USG was approved for the screening tool to detect the breast abnormalities and was considered as the initial modality to screen women of age less than 30years of age , in a study about 32 patients were taken and were suspected for the breast mass detection at least by any one of the imaging modalities and the correlation with the histopathological exam of the lesion was also performed out of the total number of patients 16 were found having breast cancer diagnosis and the other 16 had benign growth found on the histopathological outcome. The study stated that a randomized screening with USG showed its impact in the detection of two breast cancer cases per 1000 patients. MRI has played a vital role in the breast cancer diagnosis , especially in the patients with the dense fibro glandular tissue, It is possible with the MRI only to get the detailed pathological details of the dense tissues of the breast , The MRI scanning for breast was considered not only in the patient with high-risk but also with the low risk patients or who had very less symptoms. The radionuclide imaging also played a vital role in giving the detailed information physiology of the lesion or mass.

DISCUSSION

The Retrospective study was done to know the role of radiology in the breast cancer diagnosis and the actual cause or risk for the breast cancer development in women and the risk found were bilateral premenopausal breast cancer and another reason can be the family history of breast cancer in mother sister or child and the genetic mutation is also considered one of the reasons . A noninvasive technique , breast self-examination was suggested for women's to do the breast self-examinations Non- invasively for knowing breast related abnormalities at the initial period and the women's were trained for the same how to examine the breasts after the 1st week of start of the menstrual period. The multiple studies showed that MRI examinations are more sensitive in finding the exact tumor size in patients with breast cancer . The tumor size difference was not found between MRI and pathological dimension but coming to USG the size was found statistically smaller than the size measured in pathology, In between MRI and Mammography methods used to locate the breast lesions MRI has shown highest sensitivity.

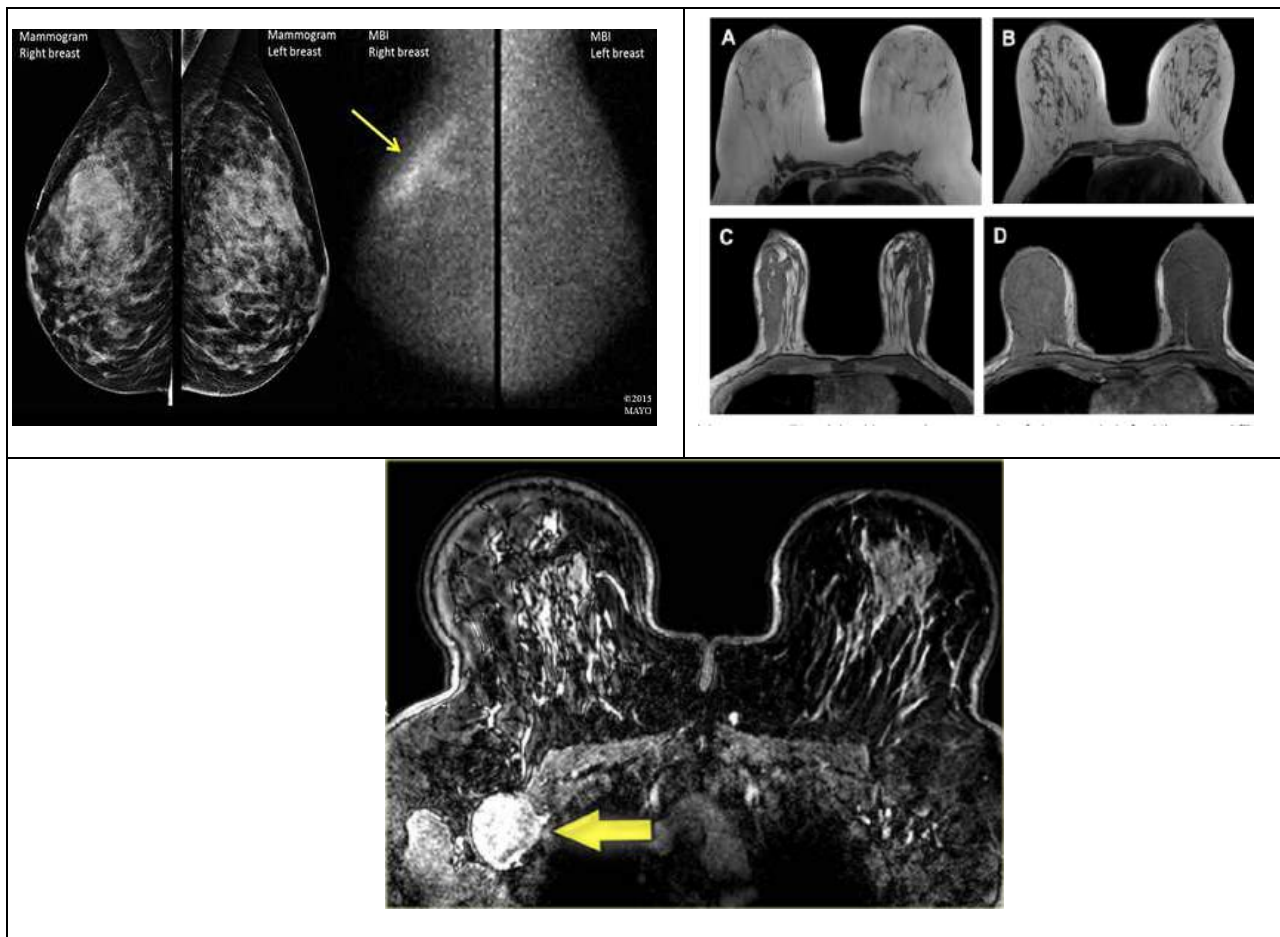
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A Review of the Necessity of Cactus Conservation in light of Forensic Science

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ABSTRACT

Cacti, commonly associated with dry environments, has fascinating forensic importance. This study examines the diverse and complex significance of plants in forensic investigations, encompassing several aspects such as botanical evidence and toxicity. First and foremost, cacti work as reliable indicators of geographical position because they are specifically adapted to certain habitats. This makes them useful for determining and reconstructing crime scenes. Additionally, they provide botanical evidence by identifying species, analysing development patterns, and considering environmental cues, which helps in analysing the passage of time and determining the environmental context. In addition, cacti might unintentionally play a role in forensic situations, such as cases of self-defence or accidental injury. This emphasizes their usefulness as evidence and elements to consider in analysing injuries. Forensic toxicology is the study of specific species of cactus that contain psychotropic substances or toxins, which are important in instances of intoxication or poisoning. Forensic anthropology use cactus to estimate post-mortem intervals through the analysis of growth rings and insect colonization patterns. This review analyses the cultural and ecological settings, emphasizing the multidisciplinary aspect of cactus forensics. Analytical methodologies facilitate the identification of these substances in biological specimens, providing valuable understanding of the factors contributing to mortality or impairment. In summary, cacti play a subtle yet significant role in forensic research, highlighting the significance of interdisciplinary methods in unravelling the intricacies of criminal investigations.





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Keywords: Cactus, Crime scene investigation, DNA evidences, Forensic botany, Environmental forensics, Trace evidences

INTRODUCTION

Forensic science involves a wide range of fields that apply scientific concepts to assist in criminal investigations and judicial proceedings. Historically, it has heavily depended on human biological evidence, fingerprints, and chemical analysis (1). Nevertheless, in recent years, the field of forensic science has broadened to encompass botanical evidence, with cacti emerging as a valuable but insufficiently investigated asset (2). The distinctive morphological, ecological, and biochemical characteristics of cacti offer a new method for connecting suspects to crime scenes, establishing the moment of death, and comprehending the environmental circumstances associated with criminal activity. Cacti are primarily seen in arid and semi-arid areas and are known for their thick, fleshy tissues that are specialized for water storage (3). Their unique physical characteristics, including as spines, glochids, and blooms, are very particular to different species and can be crucial trace evidence. The unique characteristics of cactus make them highly valuable in forensic examinations conducted in desert areas where there may be limited availability of other plant species. Cactus spines possess a strong and unique quality that allows them to stick to clothing, skin, and other surfaces (4). This characteristic makes them useful as transfer evidence, since they can establish a connection between individuals and specific locations or events. One of the main uses of cacti in forensic science is their spines, which have distinct structural properties and are highly resistant (5). Moreover, the inclusion of cactus at an investigation site can provide significant environmental observations due to their role as geographical markers (6). In addition, cacti have considerable potential in the fields of forensic toxicology, forensic pathology, and others (7). This paper offers an analysis of the application of cacti in several fields of forensics beyond their role as botanical evidence. However, despite its potential, the utilization of cacti in forensic science remains in its early stages, and further research is necessary to completely understand their usefulness.

Applications of Cactus in Forensic Science

Geographical Indicator

There are particular cactus species that are indigenous to particular regions (Fig.1). Their existence or nonexistence within a specific vicinity may yield insights into the whereabouts of evidence or the geographic coordinates of a crime scene. Geographic indicators can be derived from cacti, owing to their distinct habitat preferences and patterns of distribution.

Native Range: Diverse cactus species exhibit distinct habitat preferences and native ranges. The saguaro cactus (*Carnegiea gigantea*), for instance, is indigenous to the Sonoran Desert, which extends across the northwest of Mexico and the south-western United States (8). Presence of saguaro cacti in a given region may serve as an indication that the area is situated within the cacti's natural habitat.

Climate and Environment: Cactus adaptations are to arid and semi-arid climates and environments. Their presence in a region indicates the presence of favourable climatic conditions, including minimal precipitation and high temperatures that are detrimental to their development (9). The absence of cacti, on the other hand, could be indicative of an environment or climate that is distinct from the current one.

Microhabitats: Particular microhabitats are frequently necessary for the survival of cacti within a given geographic region. While certain species flourish in rocky terrain, others are well-suited for sandy deserts or grasslands (10). Local soil composition, elevation, and additional environmental variables may be deduced from the presence of specific cactus species in a given microhabitat.

Ecological Associations: Cacti frequently establish ecological associations with shrubs, grasses, or succulents, among others (11). Analysing the composition of plant communities in which cacti are distributed can facilitate the



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identification of ecological patterns and interrelationships, thereby offering valuable insights into the more extensive dynamics of an ecosystem within a given region.

Biogeography: Historiographic factors including geological events, continental drift, and climate change have impacted the distribution patterns of cacti (12). The examination of cactus species distribution throughout diverse geographical areas can provide valuable insights into biogeographical patterns and the course of evolution. The identification of cacti's existence or absence in the vicinity of a crime scene can assist forensic investigators, ecologists, and botanists in determining the incident's precise location, as well as in tracing the path of individuals or evidence. Agents can acquire a more comprehensive understanding of the circumstances surrounding a case by integrating botanical evidence with additional forensic techniques, including soil analysis, DNA profiling, and geographic profiling.

Trace Evidence

During a criminal incident, cactus spines, filaments, or latex may unintentionally adhere to clothing, footwear, or other items. Trace evidence can be utilized to establish connections between suspects or victims and a specific location or activity (13). Cacti can, in fact, function as trace evidence in a multitude of ways during forensic investigations:

Plant Component Adhesion: During outdoor activities, cactus spines, filaments, or latex may adhere to clothing, footwear, or other objects. The transfer of these minuscule plant fragments occurs in both directions: from a crime scene to a suspect or victim, and vice versa. Using forensic techniques such as microscopy and DNA analysis, these plant fragments can be analysed to establish links between specific individuals and particular locations or activities.

Analysis of Clothing and Fabrics: Cactus spines frequently exhibit resilience and have the ability to infiltrate fabrics. The spines of cacti that an individual comes into contact with may become entangled in the individual's clothing or ingrained in the epidermis (14). The examination of fabric probes or clothing fibres extracted from crime scenes may expose the existence of cactus spines, thereby furnishing significant insights into the locomotion of the individuals involved.

Soil and Environmental Assessment: Cacti have a tendency to thrive in particular soil compositions and ecological settings (15). Soil samples procured from vehicles, footwear, or apparel may comprise minuscule plant remnants, such as pollen grains or cactus tissue. Forensic scientists can ascertain whether an individual has been exposed to cactus-rich environments, such as arid regions or deserts, through the examination of these soil samples.

Investigation of Vehicle Traces: Cactus spines or plant fragments may be transmitted to vehicles implicated in off-road incidents or hit-and-run incidents. The detection of cactus-related trace evidence on vehicle surfaces (e.g., fenders, tires, and undercarriages) can facilitate forensic analysis and offer valuable information regarding the scene or conditions surrounding the incident.

Biological Significance: Cactus species exhibit a wide range of diversity and frequently inhabit endemic regions (16). Trace evidence consisting of specific cactus species or their fragments can furnish forensic investigators with crucial ecological and geographical data. This assistance can be instrumental in reconstructing events or determining the precise location of crime scenes. Trace evidence is of the utmost importance in forensic science as it facilitates the connection of suspects to crime scenes, enables the reconstruction of events, and contributes corroborating evidence to criminal investigations. Forensic scientists possess the capacity to obtain justice and aid in the resolution of cases through the utilization of botanical evidence, such as trace evidence associated with cacti.

Botanical Evidence

When dealing with outdoor crime scenes, the existence or nonexistence of specific cactus species can provide valuable information on the surroundings and weather conditions of the location, assisting in the process of reconstructing events. Cacti can offer significant botanical evidence in forensic investigations (Fig.2), through various means:

Species Identification: Cacti display a wide range of physical traits, such as the form of their stems, spines, blooms, and fruits that can be utilized for identifying different species (17). Forensic botanists can determine the species of





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cacti found in plant fragments obtained from a crime scene or from the clothing or possessions of suspects or victims. This information can reveal the specific geographic location of the occurrence.

Environmental Reconstruction: Cacti have distinct habitat prerequisites and are well-suited to arid and semi-arid surroundings (18). The occurrence of specific cactus species at a crime scene might yield insights into the prevailing environmental conditions in the area, including characteristics such as soil composition, moisture content, and temperature patterns. This information can help in reconstructing the environmental circumstances of the incident.

Seasonal Variation: Cacti exhibit seasonal fluctuations in their growth and flowering patterns (19). Forensic botanists can examine the growth stage of cactus samples obtained from a crime scene to determine the specific time of year when the incident took place. For instance, the existence of flower buds or fruits at various phases of growth can provide as an indication of the occurrence's seasonality.

Microscopic Analysis: Cactus tissues, such as spines, hairs, or pollen grains, can be scrutinized using a microscope to acquire supplementary data (20). Microscopic study can provide insights into the structure and morphology of plant fragments, which can be helpful in identifying species and giving supporting evidence in forensic investigations.

Geographical Significance: Various kinds of cactus have specific geographic ranges. Forensic botanists can determine the geographic origin of evidence or individuals by analysing the species composition of cactus taken from various sites (21). This analysis allows them to identify parallels or differences in plant communities.

Co-occurrence of Flora: Cacti frequently inhabit their native environment alongside other plant species (22). Examining the makeup of plant communities in cactus habitats might yield useful ecological insights, including the identification of indicator species or distinctive vegetation types, which could be pertinent to the inquiry.

In forensic investigations, cactus can provide valuable botanical evidence that aids in reconstructing events, conducting geographical profiling, and identifying crime scene sites. Through the integration of botanical evidence alongside other forensic procedures, investigators can acquire a thorough comprehension of the circumstances pertaining to a case.

Time of Death Estimation

In arid regions where cacti are abundant, the growth patterns of specific species can be utilized to approximate the time of death by evaluating the degree of decomposition or harm inflicted on the plant by insects and scavengers (23). Cacti have the potential to be utilized for estimating the time of death in forensic investigations, especially in dry or semi-dry regions where cacti are abundant.

Growth Patterns: Cacti display unique growth patterns that can be associated with the progression of time (24). Forensic botanists can determine the age of some cactus species and deduce the time elapsed since specific occurrences, such as disturbance or injury, by examining the growth rings or growth increments in the stems.

Decomposition and Damage: Following an individual's demise, their body experiences different phases of decomposition (25). Body decomposition can attract insects and scavengers, leading to potential harm to nearby plants, such as cacti. Forensic investigators can estimate the approximate time of death by analyzing the level of decomposition or damage to cactus plants in the vicinity of a crime scene. They do this by observing the evolution of plant injury or recovery.

Insect Activity: Insects are drawn to decaying organic material, such as human remains (26). In dry regions where there are many cacti, the level of insect activity may be linked to the existence of cactus plants. Forensic entomologists can estimate the post-mortem interval (PMI) or time since death by examining the patterns of insect colonization on cactus tissues or adjacent flora (27).

Weathering and Environmental elements: Temperature, humidity, and sunshine exposure are environmental elements that might impact the pace of breakdown and plant development (28). Cacti can exhibit indications of weathering or strain as a result of variations in environmental conditions (29). Forensic botanists can deduce the prevailing climatic conditions and the length of time a cactus plant has been exposed by evaluating its physiological state near a crime scene.

Microscopic Examination: Examining cactus tissues, such as spines or hairs, under a microscope might provide insights into the timing of events (30). For instance, the existence of particle materials, pollen grains, or other





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environmental debris trapped in cactus tissues can offer valuable information about the time period in which a crime scene occurred (31). Estimating the period of death using botanical evidence, such as cactus, is generally less accurate than other forensic approaches. This is due to restrictions such as environmental changes and the unique development patterns of different plant species. Nevertheless, under specific circumstances, cactus might offer crucial additional evidence that enhances the overall forensic investigation.

Forensic Toxicology

Certain types of cacti contain alkaloids or other poisons that can be toxic if consumed. When there is suspicion of poisoning, examining physiological fluids or tissues for these toxins might offer proof of malicious intent (32). Forensic toxicology recognizes the significance of cacti because they possess poisonous properties and contain psychoactive substances in some species, notably those classified under the genus *Echinopsis* and *Lophophora* (Ng et al., 2016).

Psychoactive substances: Some cacti species, including *Lophophora williamsii* (Peyote) (Fig. 3) and *Echinopsis pachanoi* (San Pedro cactus) (Fig. 4), possess psychoactive substances such as mescaline (33). Mescaline is a psychoactive compound that acts on the central nervous system, causing changes in perception, mood, and cognitive function (34). In forensic examinations pertaining to suspected drug intoxication or overdose, the detection of mescaline or its metabolites in biological samples such as blood or urine can serve as proof of the consumption of cactus and aid in establishing the cause of death or impairment (35).

Toxicity: Although most cactus species are generally not considered very hazardous to humans, several species may contain substances that can have detrimental consequences if consumed in excessive amounts (36). For instance, specific species of cactus possess oxalic acid, which, if ingested, can lead to gastrointestinal discomfort, vomiting, and other related symptoms (37). Forensic toxicologists can examine biological samples to detect toxic chemicals resulting from the consumption of cactus in situations involving probable poisoning or ingestion of plant material.

Historical and Leisure Utilization: Certain societies have a lengthy tradition of employing cacti for medical, ceremonial, or recreational intentions (38). Individuals in areas where cacti with psychoactive characteristics are naturally found may deliberately ingest these plants to experience psychedelic effects (39). When conducting forensic investigations connected to drug occurrences, it is important to have an awareness of local cultural traditions and the consumption of psychoactive cactus (40). This knowledge can help in interpreting toxicological results and gaining insight into the circumstances surrounding the case.

Analysis and Detection: Forensic toxicologists utilize a range of analytical methods, including gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS), to identify and measure drugs and their by-products in biological samples (41). These methods can be used to detect psychoactive substances obtained from consuming cacti, enabling the diagnosis and verification of intoxication or poisoning caused by cactus intake. In general, although cacti are not typically linked to forensic toxicology as much as other plant toxins or drugs, their psychoactive properties and toxic components make them important in specific forensic investigations, especially those related to suspected drug intoxication, poisoning, or ingestion of plant material (42).

Weaponry

Some cactus species possess spines that are both sharp and robust. These spines have the potential to be utilized as weapons or cause different wounds on victims in circumstances of assault or homicide (Fig. 2). Although, cacti are not commonly employed as weapons on purpose, they can unintentionally inflict harm due to their sharp spines and thorns. Here are a few situations where cactus could be implicated in instances approximating the use of weapons:

Self-Defence: In areas with a high concentration of cacti, individuals in outdoor settings may utilize surrounding cacti as impromptu weapons by either pushing or hurling them towards an assailant. The cactus's pointed spines possess the ability to inflict harm or discomfort, which may discourage the attacker.

Unintentional Harm: In the midst of conflicts or physical confrontations, people may inadvertently come into contact with cacti, resulting in unintended injuries caused by the sharp spines of the cactus. Under such circumstances, the cactus could serve as an indirect weapon, inflicting harm upon individuals engaged in the dispute.



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Obstruction: Occasionally, people may purposefully place cactus or utilize them as obstacles to hinder the mobility of others, resembling the utilization of natural barriers (43). Although not employed as weapons per se, cacti in this particular situation can nonetheless inflict harm if persons inadvertently come into contact with them while attempting to traverse the area.

Animals: Certain animals, such as javelinas (peccaries) or certain birds, may employ cacti as a means of defence or aggression when they perceive dangers. Although this does not pertain to humans using cacti as weapons, it demonstrates a scenario in which cacti can be present in confrontations with aggressive intent (44).

It is worth mentioning that although cacti can inflict harm because of their sharp spines and thorns, they are not commonly employed as weapons in the deliberate and planned manner that traditional weapons are. During forensic examinations of injuries caused by cactus, forensic examiners would analyse the characteristics of the injuries, the circumstances of the incident, and any existing evidence in order to ascertain the cause and manner of the damage.

CONCLUSION

Although cacti have the potential to be used in forensic science, their application is still in the early phases of development, and further research is required to fully understand their usefulness. To incorporate botanical evidence into forensic standards, it is necessary to establish uniform procedures for gathering, conserving, and examining cactus samples. The use of various and uncommon forms of evidence, such as cactus, highlights the significance of multidisciplinary methods in resolving intricate criminal cases as forensic science progresses. To summarize, cactus have the potential to be a valuable but currently underused asset in the field of forensic research. Their distinctive attributes and capacity to offer vital ecological and trace evidence render them invaluable instruments in criminal investigations. As research advances in this field, the forensic community is expected to discover further uses for these durable and unique plants.

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Fig. 1: The world map shows distribution of different types of cacti species in different parts of the world, excluding, Australia does not have any native cactus species.



Fig.2: *Cereus jamacaru*, native to Brazil, was used to kill a person in late 1900s, which seemed to be a botched robbery. Forensic investigators found the victim covered in spines from a local species of cactus. The case was significant because it highlighted the use of environmental or botanical elements in a crime, showcasing how forensic botany can be applied to solve a murder.



Fig. 3: *Lophophora williamsii* (Peyote)



Fig.4: *Echinopsis pachanoi* (San Pedro cactus)





Extraction of Cinnamaldehyde by Hydro Distillation Method and its Bio-activity

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ABSTRACT

Cinnamaldehyde is obtained from cinnamon essential oil, which is collected from the bark of Cinnamon cassia through hydrodistillation. Extraction was conducted for 6 hours at an ambient pressure of 1 atm and a temperature of 80 °C. The volatile constituents of cinnamon essential oil were characterized using GC-MS analysis. The results demonstrated the existence of nine primary volatile compounds, including alcohols, aldehydes, alkenes, carboxylic acids, ethers, esters, and ketones, in the cinnamon essential oil extracted using hydrodistillation. Trans-cinnamaldehyde was identified as the most volatile component, comprising 84.97% of the total. Cinnamaldehyde is extracted from cinnamon essential oil (EO) and possesses considerable biological and pharmacological importance. The synthesis of its many analogues has been appropriately emphasized. The diverse applications detailing their numerous uses have been documented. This paper is anticipated to serve as foundational material for future research in multiple areas.

Keywords: Cinnamaldehyde, hydro distillation, GC-MS analysis, Bio-activity.





INTRODUCTION

Essential oil often denotes concentrated volatile oils that are hydrophobic, lipophilic, and possess a distinctive aroma derived from various components of a plant or herb. Historically, essential oil has been utilized in a diverse array of uses, including flavoring in food goods, cosmetics, cleaning agents, insecticides, and fragrances. Recently, essential oil has seen increased utilization in aromatherapy. This is based on observations that components of essential oils possess therapeutic characteristics and can serve as alternative medicines. Cinnamaldehyde is an organic molecule with the formula $C_6H_5CH=CHCHO$. It is a pale yellow, viscous liquid found in the bark of cinnamon trees and other species of the family *Cinnamomum*. The essential oil of cinnamon bark comprises approximately 90% cinnamaldehyde. The extraction of cinnamaldehyde has garnered the attention of researchers due to its unique properties. As the primary component responsible for the flavor and aroma of cinnamon, it possesses a range of applications across various industries, attributed to its antioxidant, anti-inflammatory, antimicrobial, metabolic, and other therapeutic properties, in addition to its distinctive sensory profile, which is extensively utilized in the food industry. The formulation of efficient and environmentally sustainable extraction methods for cinnamaldehyde emerged as a significant objective for chemists. The hydrothermal method is a promising methodology for extracting cinnamaldehyde, characterized by its high efficiency, environmental sustainability, preservation of bioactive components, and scalability for industrial applications. It provides a sustainable and efficient alternative to conventional extraction methods, rendering it very advantageous in both research and commercial contexts. Consequently, in furtherance of our efforts to devise environmentally sustainable methods for the extraction of chemicals, an endeavor has been undertaken to synthesis chalcone derivatives.

MATERIALS AND METHODS

Materials

The bark of *Cinnamomum cassia* (cinnamon) served as the experimental raw material in this investigation. The stuff was obtained as samples from a store. This study restricted chemical usage just for analytical procedures to guarantee the extracted essential oil is environmentally benign.

Pre-treatment

The unprocessed cinnamon bark contains dirt particles and other clinging things, including minute sand particles. The material was cleaned to eliminate these contaminants to the greatest extent practicable. The fresh cinnamon bark samples were rinsed in flowing distilled water for approximately 60 minutes and air-dried for 2 days at a temperature of 25–30 °C and relative humidity of 30–40%. Subsequently, roughly 100 g of dried cinnamon bark was pulverized to diminish the particle size of the sample. Subsequent to grinding, the samples were subjected to sieving with a mechanical sieve shaker to achieve a particle size of 100 m for the cinnamon bark powder, which was subsequently dried at 105 °C until a consistent weight was reached. The completely desiccated cinnamon bark powder sample was stored in a desiccator to avert moisture absorption prior to the extraction operation. Before extraction, 25 g of powdered cinnamon bark was measured and pre-soaked for 30 minutes in distilled water at an 8:1 weight-to-weight ratio of water to totally dried cinnamon bark powder.

Extraction Process of Cinnamaldehyde by Hydro distillation method

The extraction of cinnamon essential oil was conducted using the hydrodistillation method at an ambient pressure of 1 atm and a temperature of 80 °C for a duration of 6 hours. Initially, the cinnamon bark was ground to enhance the surface area for extraction. Constructed the distillation apparatus, guaranteeing an airtight configuration. This generally comprises a round-bottom flask, a condenser, and a receiving flask. Inserted the ground cinnamon bark into the round-bottom flask and introduced an adequate amount of distilled water to facilitate the extraction of volatile components during distillation, thereafter heating the mixture gradually. As the water heated, steam permeates the cinnamon, removing volatile compounds such as cinnamaldehyde. The steam transporting the



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extracted oils passes through the condenser to cool and revert to liquid form. The condensed liquid was collected in the receiving flask (Fig 2) and permitted to settle, resulting in the formation of two layers, as cinnamaldehyde possesses a lower density than water. The cinnamaldehyde was extracted from the aqueous layer using a separating funnel.

GC-MS Analysis

This section aims to qualitatively analyze volatile components in cinnamon essential oil utilizing GC-MS. Nine principal volatile chemicals, comprising alcohols, aldehydes, alkenes, carboxylic acids, ethers, esters, and ketones, were identified in the cinnamon essential oil of *C. cassia* bark using hydrodistillation (Table 1). Trans-cinnamaldehyde was identified as the predominant component, comprising 84.97% of the total area percentage. The further primary components comprised 1,2-naphthalenedione, ethanone, and borneol, with area percentages of 9.03%, 1.11%, and 1.03%, respectively.

Physicochemical property of Cinnamaldehyde

Cinnamaldehyde is an organic molecule with the formula $C_6H_5CH=CHCHO$. It is a pale yellow, viscous liquid found in the bark of cinnamon trees and other species of the family *Cinnamomum*. It occurs naturally mostly as the trans (E) isomer, imparting flavor and aroma to cinnamon. It is a phenylpropanoid that is biosynthesized via the shikimate pathway. Cinnamaldehyde undergoes decomposition to styrene due to oxidation resulting from inadequate storage or transportation conditions. Styrene particularly develops in conditions of elevated humidity and warmth. Cinnamon contains trace quantities of styrene for this reason [1, 2]. The natural compound is trans-cinnamaldehyde. The molecule has a benzene ring linked to an unsaturated aldehyde. The chemical can be regarded as a derivative of acrolein. The hue results from the $\pi \rightarrow \pi^*$ transition; enhanced conjugation relative to acrolein displaces this band into the visible spectrum. Cinnamaldehyde is prevalent, and its closely related chemicals contribute to the formation of lignin. All such molecules are biosynthesized from phenylalanine, which is converted. The production of cinnamaldehyde commences with the deamination of L-phenylalanine into cinnamic acid, facilitated by phenylalanine ammonia lyase (PAL).

Beneficial effects of cinnamaldehyde:

Flavorant

Cinnamaldehyde has several applications that are advantageous to humans. Cinnamaldehyde's primary application is as a flavoring additive in chewing gum, ice cream, confections, and beverages. It is utilized in concentrations between 9 and 4900 parts per million (ppm), or below 0.5% [6]. It is utilized in certain natural products as well as in perfumes, particularly those with sweet or fruity fragrances. Almond, apricot, butterscotch, and other fragrances may partially utilize the molecule for their appealing scents [7]. Cinnamaldehyde is occasionally employed as a food adulterant; powdered beechnut husk flavored with cinnamaldehyde may be sold as powdered cinnamon [8]. The cinnamaldehyde flavoring contained poses no health risk to consumers [9].

Agrichemical

Cinnamaldehyde is utilized as a fungicide in pesticide applications [10]. It has demonstrated efficacy on more than 40 distinct crops and is generally administered to the root systems of plants [11]. Its minimal toxicity and established characteristics render it suitable for agriculture [12]. Cinnamaldehyde serves as an efficacious insecticide and its aroma is recognized for repelling animals, including felines and canines [13, 14]. It has recently been identified as a highly effective insecticide for mosquito larvae, with merely 29 ppm of cinnamaldehyde resulting in the mortality of 50% of *Aedes aegypti* larvae within 24 hours [13]. Cinnamaldehyde from *C. osmophloeum* exhibits weaker antifungal properties compared to other sources [13].

Antimicrobial

Cinnamaldehyde is often utilized as an antibacterial agent that functions successfully [11, 15]. Researchers at the University of Illinois in Chicago discovered that cinnamaldehyde, when utilized, inhibits oral bacterial growth by over 50% [16]. This chemical is highly efficient against bacteria residing at the posterior region of the tongue, diminishing anaerobic bacterial populations by around 43% [17]. Cinnamaldehyde is utilized in anticaries treatments due to its superior antibacterial efficacy at concentrations of 1.25-2.5 mg/ml relative to other essential oils [16]. Edible





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films and coatings infused with the antibacterial essential oil component cinnamaldehyde can safeguard raw chicken parts from bacterial contamination while preserving the sensory appeal of the baked wrapped chicken. To prevent poultry contamination, trans-cinnamaldehyde is utilized as a disinfectant and antibacterial agent to efficiently eliminate specific bacteria (*C. jejuni* and *S. enteritidis*) at suitable temperatures (12.5 °C and 25 °C).

Anticancer

Recent study findings [20] established the anticancer efficacy of cinnamaldehyde/cinnamic aldehyde in cell culture and animal models of the disease. In a mouse A375 model of human melanoma, proliferation, invasion, and tumor growth were suppressed, but solely at elevated dosages of cinnamaldehyde [21]. Nevertheless, comparable benefits were not attainable through dietary intake. The examination of structure-activity relationships to identify structural characteristics essential for the activity of cinnamaldehyde analogues in establishing molecular therapeutic targets for a promising class of prospective anticancer medicines has been conducted. The results indicate that the propenal group and the functional group at the 2'-position of the cinnamaldehyde structure exhibit anti-cancer activity [21,22].

Other therapeutics uses

Nearly all experts concur that current and prior studies on the application of cinnamon oil contribute to the advancement of novel therapeutic agents [23]. The medicinal substance cinnamaldehyde is produced by steaming the bark of the cinnamon tree to extract the oil for various purposes. The evidence from the preceding paper indicates that trans-cinnamaldehyde thiosemicarbazone has the potential to yield novel tyrosinase inhibitors and to serve as a new cosmetic additive [24]. Cinnamaldehyde functions as a fungicide, pesticide, and corrosion inhibitor, and it also alleviates congestion. The presence of a conjugated double bond, an aldehyde group, and the length of the CH chain external to the ring determine the features of an effective antifungal agent [25, 26][13]. It also regulates blood sugar, promotes cardiovascular health, enhances glucose metabolism, and possesses anti-inflammatory properties [27]. Cinnamaldehyde, also known as a corrosion inhibitor for steel and various ferrous alloys in aggressive liquids. It can be employed in conjunction with additional components, such as dispersion agents, solvents, and various surfactants. The refractive records render it a truly safe and effective medium for examining gemstone rough for considerations. The prior work [28] demonstrates the safe application of cinnamaldehyde as a natural oral medication exhibiting both hypoglycemia and hypolipidemic actions, which reduce total cholesterol levels (antidiabetics). The identification of the transient receptor potential (TRP) agonist cinnamaldehyde and various chemicals has enhanced the comprehension of temperature perception, with preclinical studies recognizing TRP as significant novel analgesic targets in inflammatory and neuropathic pain [29, 30]. Numerous semi-synthetic variants of cinnamaldehyde are being created to enhance the antibiotic susceptibility of drug-resistant bacteria [31]. Previous study [32] indicated that a one-hour treatment with trans-cinnamaldehyde (CA) could induce complete or partial inhibition of viral growth by obstructing viral protein synthesis at a specific step of the development cycle in vitro. Alternatively, the prior experimental investigation posits that cinnamaldehyde (*C. osmophloeum*) confers health benefits, with potential use in medicine and as an antibacterial ingredient in paper production [27]. The lysozyme-mediated alteration of cinnamaldehyde results in the creation of innovative preservatives that may be beneficial for dermatological applications [33].

Food industry

Cinnamaldehyde is mostly employed as a flavoring agent and a medicinal plant. During research aimed at identifying the maximum microbial lethality under food processing conditions, a gas chromatographic-mass spectrometric system was developed for the extraction and analysis of essential oil constituents, such as cinnamaldehyde, from commercially available cinnamon-containing products (including various brands of cinnamon bread, oats, cookies, puddings, and fruit juices). Cinnamaldehyde was utilized as an ingredient in squeezed orange within apple cinnamon cereals and cinnamon swirl bread [34-36]. The thermal stability of cinnamaldehyde in food processing was seen when combined with eugenol or cinnamon leaf oil, remaining stable even after 30 minutes at 200°C [37]. Cinnamaldehyde, possessing antimicrobial properties, is utilized in food applications as an additive in coated papers. Effective antimicrobial packaging must achieve two primary objectives: minimal release of active agents during storage without direct contact with products, and rapid release during use when in close contact with items or in vacuum-packaged formats utilizing antimicrobial films. The hydrophilic properties of the coating matrices resulted in a significant influx of antimicrobial chemicals under high humidity, creating optimal circumstances for microbial proliferation [39]. An alternative study [40] on the combination of



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cinnamaldehyde with natamycin resulted in antifungal bioplastic films effective against common food spoilage microbes, both in vitro and in actual food products. Cinnamaldehyde, when used as an additive, can be more effective at temperatures below 8°C, inhibiting the growth of psychrotropic strains of the foodborne pathogen 65. An alternative method for incorporating cinnamaldehyde as an essential oil into edible films and wrappings is a fresh strategy to enhance shelf life and safety in the food sector [41-43]. Nonetheless, several investigations indicated that carvacrol exhibits superior antibacterial activity compared to cinnamaldehyde; yet, cinnamaldehyde targets a broader range of pathogens than carvacrol. The combination of carvacrol and cinnamaldehyde demonstrated significant antibacterial efficacy. Moreover, the antimicrobial agent being examined, cinnamaldehyde, could be combined with a vanilla fragrance, providing both antibacterial characteristics and an aroma expected to enhance the quality of the food product [44]. At that juncture, the incorporation of amino acids might mitigate the undesirable odor of cinnamaldehyde, so improving its employment in food technology and enhancing the overall appearance of the meal itself [45].

CONCLUSIONS

The extraction of cinnamon essential oil was conducted using the hydrodistillation method at ambient pressure of 1 atm, at a temperature of 80 °C, for a duration of 6 hours. Gas Chromatography-Mass Spectrometry Analysis This section aims to qualitatively analyze volatile components in cinnamon essential oil utilizing GC-MS. Nine principal volatile chemicals, comprising alcohols, aldehydes, alkenes, carboxylic acids, ethers, esters, and ketones, were identified in the cinnamon essential oil of *C. cassia* bark using hydrodistillation, as presented in Table 1. Trans-cinnamaldehyde was identified as the predominant component, with the highest area percentage of 84.97%. The other principal components comprised 1,2-naphthalenedione, ethanone, and borneol, with area percentages of 9.03%, 1.11%, and 1.03%, respectively. Consequently, the hydrodistillation process proved effective in achieving a high yield of cinnamaldehyde. This article systematically presents cinnamaldehyde as a natural chemical from a scientific perspective. The molecule has been elucidated through its source chemistry, physical properties, and the synthesis of many analogs to assess specific applications. The uses have been described to establish a foundation for future study on the material.

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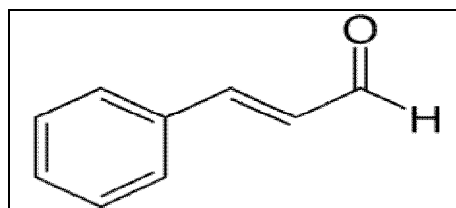
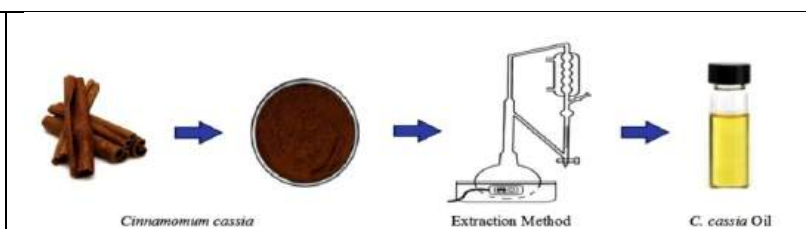
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Satheesh *et al.*,**Table 1: Volatile compound identified from the cinnamon essential oil using different extraction method**

S. No.	Compound type	Compound name	Area (%) volatile compounds by Hydro distillation
1	Alcohol	Borneol	1.03
		3-cyclohexene-1	0.44
2	Aldehyde	Trans cinnamaldehyde	84.97
3	Alkene	Copaene	0.66
4	Carboxylic acid	Benzoic acid	0.24
5	Ester	Phenbromate	0.18
6	Ether	Methoxymethylbenzene	0.17
7	Ketone	Ethanone	1.11
		1,2-Napthalenedione	9.03

**Fig 1: Structure of Cinnamaldehyde****Fig 2: Extraction of C.cassia oil**



Review of Natural Fibers: Types, Properties, Extraction Methods, and Applications in Polymer Composites

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ABSTRACT

Natural fibers have become increasingly popular as a reinforcement material in polymer composites because of its renewability, biodegradability, impressive mechanical properties. This review provides an in-depth analysis of various natural fibers, their chemical and physical properties, extraction methods, and applications in different industries. Fibers such as flax, hemp, jute, sisal, and bamboo are discussed, along with their potential as sustainable alternatives to synthetic fibers. The challenges associated with moisture absorption and fiber variability are examined, as well as current solutions like chemical treatments and hybrid composites. Future directions for improving natural fiber-reinforced polymer composites (NFRPCs) are also outlined.

Keywords: Natural fibers, extraction methods, Thermoset Polymer Composites, Thermoplastic Polymer Composites





INTRODUCTION

With the growing concern for environmental sustainability and the need for biodegradable materials, natural fibers have attracted considerable attention by many researchers as reinforcements in polymer composites. These fibers are derived from plant sources, making them abundant, renewable, and biodegradable. Unlike synthetic fibers such as glass or carbon fibers, natural fibers are lighter, have lower energy consumption during processing, and offer good mechanical properties [1]. As a result, natural fiber-reinforced composites (NFRPCs) are increasingly being used in various industries, including automotive, construction, and packaging [2].

This review focuses on different types of natural fibers, their extraction methods, and their applications in polymer composites. Additionally, challenges such as moisture absorption, fiber variability, and fiber-matrix adhesion are discussed, along with solutions like chemical treatments and hybrid composites.

Different Types of Natural Fibers (3-4)

In general Natural fibers are classified into several categories based on their source of availability. The most commonly used fibers in polymer composites are:

Bast Fibers [3]

Bast fibers are extracted from the stem or outer layer of plants. Examples include flax, hemp, jute, and kenaf. Bast fibers are known for their high tensile strength and stiffness, making them suitable for reinforcing polymer composites. Bast fibers have a high cellulose content, contributing to their strength and durability

Flax (*Linum usitatissimum*): Flax fibers are one of the widely used natural fibers in composites because of its high strength, low density, and biodegradability. They are commonly used in automotive parts, building materials, and consumer goods.

Hemp (*Cannabis sativa*): Hemp fibers are similar to flax in terms of mechanical properties but are generally coarser. Hemp is used in construction materials, automotive components, and textiles due to its excellent tensile strength and low environmental impact.

Jute (*Corchorus capsularis*): Jute fibers are cheap and abundantly available, particularly in regions such as India and Bangladesh. They are used in packaging, carpets, geotextiles, and composites for automotive interiors.

Leaf Fibers

Leaf fibers are generally extracted from the leaves of plants. These fibers are generally coarser than bast fibers but have good tensile strength and flexibility. Examples include sisal, pineapple leaf fiber (PALF), and abaca.

Sisal (*Agave sisalana*): Sisal fibers are strong, durable, and resistant to moisture. They are used in making ropes, mats, and composites for automotive components and construction materials. Sisal is also known for its impact resistance and energy absorption properties.

Pineapple Leaf Fiber (PALF): PALF is a versatile fiber with good mechanical properties and biodegradability. It is increasingly being used in lightweight composites for automotive interiors and packaging.

Seed Fiers

- Seed fibers are obtained from the seeds or fruit of plants. Examples include cotton and coir.
- **Cotton (*Gossypium spp.*):** Cotton is a widely used natural fiber in textiles, but it is also used in composites for packaging, furniture, and construction materials due to its high cellulose content and biodegradability.
- **Coir (*Cocos nucifera*):** Coir fibers are extracted from coconut husks and are known for their durability, water resistance, and resilience. Coir is used in mats, brushes, ropes, and polymer composites for packaging and building products.

Fruit Fibers

- Fruit fibers are mostly extracted from the stalks of fruit-bearing plants, such as abaca and banana fibers.
- **Abaca (*Musa textilis*):** Abaca fibers are derived from the banana family and these are well known for their excellent tensile strength and flexibility. Abaca is used in making ropes, textiles, and composites for marine applications and packaging.



Ramana Rao *et al.*,**Grass and Reed Fibers**

- Bamboo and reed fibers are derived from grass-like plants and are widely used due to their rapid growth, renewability, and strength.
- **Bamboo (Bambusoideae):** Bamboo fibers are gaining popularity as reinforcement in composites due to their high tensile strength, low cost, and environmental benefits. Bamboo composites are used in construction, automotive parts, and furniture.

Extraction Methods for Natural Fibers [5-6]

The extraction process of natural fibers is critical for ensuring their mechanical properties and suitability for polymer composites. Several methods are used depending on the type of fiber and its source:

Mechanical Extraction

Mechanical extraction methods involve physical processes such as decortication, retting, and scraping to separate fibers from plant matter. For example, jute and hemp fibers are typically extracted through retting, where the plant stems are soaked in water to loosen the fibers from the pith.

Chemical Extraction

Chemical treatments are used to remove non-fibrous materials such as lignin, hemicelluloses, and pectin. Alkali treatment using sodium hydroxide (NaOH) is one of the most common methods to improve fiber-matrix adhesion and reduce water absorption in fibers like flax and sisal. This process breaks down the lignin, making the fibers easier to separate.

Steam and Heat Treatment

Heat treatment methods, such as autoclaving and steaming, are used to soften and remove lignin from plant fibers. This method is effective for fibers like bamboo and sisal, which are tough and fibrous. Steam treatment also improves the amicability of natural fibers with polymer matrices by altering the surface properties of the fibers.

Enzymatic Extraction

Enzymatic treatments use specific enzymes to break down the non-cellulosic components of fibers. This method is environmentally friendly and helps preserve the structural integrity of the fibers. However, enzymatic extraction is more expensive compared to mechanical or chemical methods.

Possible Composites from Various Natural Fibers [11-12]

Natural fibers can reinforce both thermo set and thermoplastic matrices, forming composites with a wider range of properties and applications. The most common polymers used in natural fiber composites include:

Thermoset Polymer Composites

Epoxy Composites: Natural fibers such as flax, jute, and bamboo are commonly used to reinforce epoxy resins. These composites exhibit excellent mechanical properties and thermal stability, making them suitable for structural applications in the automotive and aerospace industries.

Polyester Composites: Polyester resins are widely used in conjunction with sisal, jute, and abaca fibers to create lightweight, durable composites. These composites are used in construction materials, automotive parts, and packaging.

Thermoplastic Polymer Composites

Polypropylene (PP) Composites: Natural fibers like flax, hemp, and kenaf are commonly used in polypropylene composites. These materials are recyclable and offer good tensile strength and flexibility, making them ideal for automotive interiors, packaging, and consumer products.

Polyethylene (PE) Composites: High-density polyethylene (HDPE) reinforced with fibers such as coir, sisal, and bamboo results in composites with high impact resistance, durability, and moisture resistance. These composites are used in construction, furniture, and packaging.

Hybrid Composites

Hybrid composites combine natural fibers with synthetic fibers like glass or carbon to improve mechanical properties while maintaining sustainability. For example, jute-glass hybrid composites offer higher tensile strength and impact resistance, making them suitable for automotive applications and high-performance structural components.





RESULTS AND DISCUSSION

Natural fiber-reinforced polymer composites (NFRPCs) exhibit competitive mechanical properties compared to traditional synthetic composites. Some of the key results from various studies include (7-10).

Tensile Strength:

Bamboo-epoxy composites have tensile strengths reaching up to 291 MPa, making them suitable for load-bearing applications. Flax and hemp composites show similar tensile properties, ranging from 50 MPa to 200 MPa depending on fiber content and treatment.

Flexural Strength:

Jute-polypropylene composites exhibit flexural strengths between 30 MPa and 70 MPa, making them ideal for automotive components and construction materials. Similarly, sisal-polyester composites show flexural strengths of up to 80 MPa.

Impact Resistance:

Hybrid composites such as bamboo-glass or jute-carbon offer significantly improved impact resistance and durability, making them suitable for use in protective structures, automotive panels, and helmets.

However, natural fibers tend to absorb moisture, which can degrade the mechanical properties of the composites over time. This is a key challenge in developing NFRPCs for long-term outdoor use. While natural fibers offer significant environmental benefits and mechanical properties, challenges such as moisture absorption, fiber variability, and fiber-matrix bonding must be addressed to improve the performance of NFRPCs. Moisture absorption, in particular, leads to swelling and degradation of the fibers, which weakens the composite over time. Solutions such as chemical treatments (e.g., silane coupling agents, alkali treatment) have been employed to improve fiber-matrix adhesion and reduce water absorption.

Additionally, hybrid composites, which combine natural fibers with synthetic fibers, offer a promising solution to overcome the limitations of pure natural fiber composites. The combination of natural fibers with glass or carbon fibers enhances the mechanical performance of the composite while maintaining its sustainability. Future research should focus on improving the extraction methods for natural fibers, optimizing fiber surface treatments, and exploring new polymer matrices that are compatible with natural fibers. Additionally, the development of biodegradable polymer matrices that work well with natural fibers could significantly reduce the environmental impact of NFRPCs.

CONCLUSIONS

Natural fibers present a sustainable alternative to synthetic fibers in polymer composites. Their renewability, biodegradability, and good mechanical properties make them attractive for a wide range of applications, particularly in industries seeking eco-friendly materials. The combination of natural fibers with both thermoset and thermoplastic polymers has resulted in the development of lightweight, durable, and sustainable composites. However, challenges such as moisture absorption, fiber variability, and fiber-matrix adhesion remain. The use of chemical treatments and the development of hybrid composites offer promising solutions to these issues. As industries continue to shift towards greener materials, natural fiber-reinforced polymer composites are poised to play a significant role in reducing the environmental impact of materials used in construction, automotive, and consumer goods.

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Scalping Trading Strategies

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ABSTRACT

Scalping is a popular trading strategy focused on capitalizing on small price movements in highly liquid markets in 1 min, 3 min or 5min time frame. Here in this paper I will try to explore best scalping strategies, by analysing real time practical application, risk management on quick trades. By analysing different scalping methods—such as, momentum trading, and technical analysis-based scalping—this paper aims to provide traders with actionable insights into optimizing short-term trades. Through back testing and examining real-world examples, we evaluate the effectiveness of scalping strategies in volatile market conditions and offer recommendations for traders to minimize risk while maximizing returns.

Keywords: Scalping, intraday trading, trading view, Moving average, RSI.





INTRODUCTION

Scalping[1] is one of high risk high gain trading strategies. Unlike longer-term trading strategies, scalping focuses on making numerous trades throughout the day, often holding positions for just a few minutes or seconds. The primary goal is to capture small gains on each trade. Scalping requires precision, a deep understanding of market mechanics, and advanced trading tools. We will also delve into the role of technology, such as Algo trading[2]. Finally, this paper will address the potential risks associated with scalping and offer recommendations for mitigating those risks.

METHODOLOGY

How to initiate Long Trade 1 to 3 min trades

If futures is above VWAP[3], option chain indicating long built up or short covering is observed, RSI is in the range of 45 to 70, volume is building big candles say above 75 k now if several parameters indicating strong single of upward direction then one can enter long trade with strict stop loss

How to initiate short Trade 1 to 3 min trades

If futures is below VWAP[10], in option chain indicating short built up or long unwinding is observed, RSI[4] is in the range of 40 to 20, volume is stand by or shrinking say candles is below 20k now if several parameters indicating strong single of downward direction then one can enter short trade with strict stop loss

Note: short trades are very - very risky as compared to long trade so only experienced traders should enter this keeping in mind of risk management.

Scalpers should gather and analyse all relevant information and must and should follow 7 horses' theorem : trend (long, medium, short), momentum (long, medium, short), price action[9], sentiment (global, local), fundamental - results, news, divergence (option chain, RSI, vwap), big bull moto (most important)

He should maintain trading setup with multi monitors showing Option Chain[8], moving average, relative strength index (RSI) , Stochastic Oscillator[5], Moving Average Convergence Divergence(MACD) [6], Price action, Volume-Weighted Average Price [7], etc. simultaneously

before entering scalping, one must and should gain strong real time experience.

Real Time Experience

News Based Scalping

Date: 19-05-2023 See there was huge bearish sentiment as Modi losses Karnataka election so many were interested in puts but see how at 10:45 sudden upside moves to trap all put holders RSI went to above 80 stayed there for some time so whenever u buy options put stop loss before hand

CONCLUSION

Scalping is one of the high risk high gain method and scalpers should follow 7 horses theorem : trend(long, medium, short), momentum (long, medium, short), price action, sentiment (global, local), fundamental - results, news, divergence (option chain, RSI, vwap), big bull moto(most important) and Scalping is a demanding but potentially lucrative trading strategy for those who can master its fast-paced nature with perfect emotional balance in nature. The key to successful scalping lies in deep understanding market volatility, maintaining strict risk management protocols, and utilizing the right technological tools. However, given its complexity, scalping may not be suitable for all traders, especially beginners. For experienced traders, refining and adapting scalping strategies to changing market conditions can lead to consistent gains in the financial markets.





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Fig 1. News Based Scalping



Fig 2. Scalping using Bollinger band





Fig 3. Scalping using moving averages

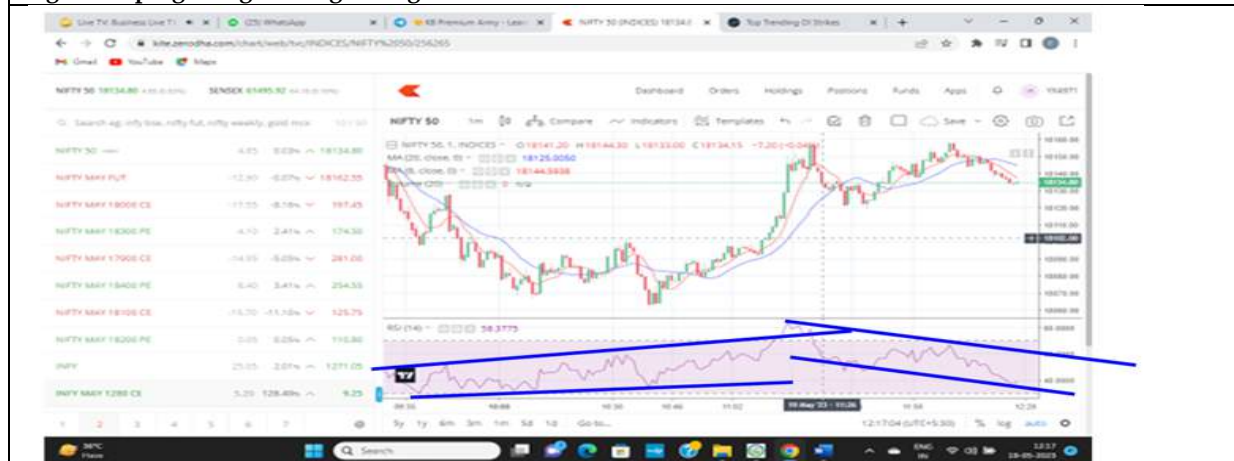


Fig 4. Scalping using RSI



Fig 5. Scalping using awesome oscillator and moving averages





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Fig 6. Scalping using Bollinger bands , Awesome Oscillator and RSI





A Study on Circular Economy A New Era in Resource Management of the Indian Economy

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ABSTRACT

At some point, all economies around the world deplete their natural resource stocks. By reusing, recycling, and composting, a circular economy seeks to restore natural systems while simultaneously eliminating waste. Pollution from climate change and biodiversity loss are becoming worse as a result of the limited usage of resources. environmental problems. Depletion of resources has resulted from India's fast economic expansion, heightened trash production and harm to the environment. India has to if it wants to solve these serious problems adopt a paradigm of the circular economy. This research aims to examine the role of circular economy policies on India's sustainable development. By looking at how well these projects promote circular economic models, it determines how successful they are in managing resources, minimizing waste, and tackling environmental concerns. Based on the findings, it seems that the Swachh Bharat Mission and Extended Product Responsibility are examples of how India is using circular economy ideas. Problems arise from incoherent policies and a lack of teamwork. Opportunities exist for policy improvements and innovations, notwithstanding the fact that resource efficiency and e-waste management remain below worldwide norms. This study finds that India may improve its sustainability and global competitiveness by implementing these strategies. Improving programs might strengthen international collaborations and position India as a sustainability leader; increasing education about the circular economy and the development of jobs are two suggestions.



**Mohanababu Chappa et al.,****Keywords:** Circular economy; Challenges; Waste; Policies; Resources; Sustainability

INTRODUCTION

In every economy around the world the natural resources used in the process of production eventually end up as waste after using them. In a circular economy waste is virtually eliminated and natural systems are restored. Materials continuously cycle through process like recycling, reusing and composting; ensuring that resources are kept in use and nature is regenerated. Extreme climate change and natural disaster are intensifying due to global challenges such as, waste, pollution and biodiversity loss. These issues stem from economic activities that rely heavily on finite resources, underscoring the urgent need to decouple economic growth from resource consumption. In a circular economy, economic activity is designed to enhance and restore the overall health of systems. This concept acknowledges the need for the economy to function effectively across all levels-whether for large corporations or small business, for organizations or individuals and both at the global and local scales.

These three tenets serve as the basis for the Circular Economy.

1. Reducing Pollution and Waste
2. Maintaining Product and Material Distributorship
3. Restoring the environment

The spherical economy seeks to uncover and eliminate the negative impact of economic activities that harm health and natural ecosystem. This involves addressing the root cause of environmental damage, such as greenhouse gas emissions, hazardous chemical releases and the contamination of air, land and water. It also tackles inefficiencies like traffic congestion and other forms of systemic waste, aiming to create an economy that operates without causing harm to people or the planet. Value creation via the conservation of energy, labor, and materials is the primary focus of a circular economy. In order to keep goods, components, and materials in the economy for as long as possible, it is important to design them to be durable and to promote reuse, remanufacturing, and recycling. By encouraging a variety of uses for bio-based products as they circulate between the economy and ecosystems in nature, a circular system also maximizes their utilization. Reducing use of non-renewable resources is a primary goal of the circular economy. By promoting the use of renewable energy sources rather than fossil fuels and returning important nutrients to the soil, it helps with regeneration. In developing countries like India, where natural resource strains are being exacerbated by fast industrialization and urbanization, the transition to a circular economy is of utmost importance. India is in a prime position to embrace and expand circular practices due to its large informal recycling industry and substantial sustainability-focused legislative efforts. Using an analysis of Indian government policy and its execution, as well as the possibilities and threats associated with moving towards a sustainable future, this article delves into the changing function of the circular economy in the country.

Objectives

1. To explore the measures used by the Indian government to encourage responsible resource management and progress towards a circular economy, paying special attention to the most important policies and initiatives.
2. To highlight success stories in India's journey towards sustainable practices, showcasing initiatives that have effectively implemented circular economy principles.
3. To analyze the role of NITI Ayog in shaping and driving policies that supports the circular economy in India including its frameworks and strategic plans.
4. To explore the collaborative efforts between public and private sectors in promoting resource efficiency and waste reduction across industries.
5. To evaluate the impact of government intervention in fostering innovation, sustainability and economic growth through circular economy models.
6. To assess the challenges and opportunities faced by India in scaling circular economy practices at both the national and regional levels.





REVIEW OF LITERATURE

The idea of circularity is not new; it has deep historical and philosophical roots. The concept of feedback and cycle in real-world system can be traced back to ancient times and various philosophical traditions. After World War II, this idea experienced resurgence in industrialized nations, especially with the rise of computer-based studies on non-linear systems. These studies revealed the intricate, interconnected and often unpredictable nature of our world, which functions more like a metabolism than a machine. Today, advancement in digital technology has the potential to accelerate the transition to a circular economy by enabling virtualization, dematerialization, transparency and feedback-driven intelligence. Industrial ecology, biomimicry, and cradle-to-cradle design are just a few of the theoretical frameworks that provide the groundwork for the idea of a circular economy. The ideas of the circular economy are based on industrial ecology, which studies the movement of materials and energy within industrial systems. To create human systems that can withstand the test of time, biomimicry looks to nature for ideas. With an emphasis on reducing waste and optimizing resource efficiency, cradle-to-cradle design takes a comprehensive approach by examining the whole product life cycle, from extraction of raw materials to disposal. The growth and implementation of the circular economy owe a great deal to these related concepts.

Concepts from biologist Ludwig von Bertalanffy's general systems theory also factor into circular economy reasoning. It first focused on economic systems but eventually expanded to study energy and growth in both open and closed systems. In his inflectional study, economist Kenneth E. Boulding took this idea a step farther. In his article "The Economics of Coming Spaceship Earth," he said that in order to keep humans alive on Earth, a system of circular economics is necessary. In contrast, he presented the "cowboy" paradigm, in which people believe there are no limits to their ability to use or dispose of resources since the environment is infinite. In their article "The Potential for Substituting Manpower for Energy," Waite R. Stable and Genevieve Reddy -Mulvey laid the groundwork for the Circular Economy Principles by investigating the possibility that increasing labor may decrease energy-intensive operations. In a similar vein, Allan Kneese originally brought up the concept of a circular economy in his 1988 book, *The Economics of Natural Resources*, which focuses on the limits of renewable resources.

Pearce and Turner, in their 1990 book *Economics of Natural Resources and the Environment* outlined the shift from a traditional linear economic system to a circular one. They described a model in which waste generated at different stages of production and consumption is transformed into inputs, closing the loop on resource use. Resource efficiency, production, waste reduction, and life cycle management were the primary areas of concentration for China's environmental and industrial policies when they adopted the circular economy idea in the early 2000s. The Ellen Mac Arthur Foundation was instrumental in spreading the word about the circular economy, especially in the US and Europe, when it was founded in 2010. In 2010, the idea received a lot of attention throughout the world when a number of important papers were released. The European Union's circular economy strategy was first proposed in 2014 and will be further solidified with the 2020 release of the New Circular Economy Action Plan. By enabling customers to contribute to a more sustainable future and creating a competitive economy that is climate-neutral, this plan hopes to achieve its goals.

Opportunities for and obstacles to enhancing material efficiency were investigated and evaluated by Shahbazi *et al.* (2016) in a study of Swedish manufacturing enterprises. A comprehensive literature analysis by Bressanelli, Perona, and Sacani (2018) uncovered twenty-four obstacles that can impede the redesign of supply chains within the framework of a circular economy. In India, circular processes permeate the whole supply chain, not just certain businesses. These techniques have been investigated in a number of literature reviews. In their 2017 paper, Elia, Gnoni, and Tornøse offered a framework for tracking different phases of circular economy initiatives. Through an analysis of key material supply, Gaustad *et al.* (2018) proposed circularity techniques at the business level. Using a survey, Masi *et al.* (2018) found practices and obstacles to becoming a CE. Garza Reyes *et al.* (2019) added to the previously recognized circular practices, building on the work of Masi *et al.*



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More than that, some research has zeroed in on certain cyclical behaviors. A methodology was developed by Dubey et.al. (2019) to evaluate the effect of external constraints and involvement of senior management on circular economy supplier relationship management practices. When Kumar *et al.* (2020) looked at how SMES embraced industry 4.0 technology, they found that partners and customers were hesitant to do so inside a CE framework. Although there has been a growing amount of literature on the possibilities of the internet of things (IoT) for the circular economy (CE), it is still somewhat disjointed and there have been very few attempts to bring all of this research together. One example is the thorough mapping study on the implications of industry 4.0 for sustainable development and the circular economy that Khan *et al.* (2021) carried out. According to their findings, the Internet of Things is mostly researched for its potential to facilitate industrial growth by increasing production and efficiency in many types of businesses. Same goes with Birkel. After analyzing 55 papers on the possibilities of Industry 4.0 for environmentally responsible supply chain management, Muller (2021) came to the conclusion that the IoT may greatly aid in logistics and supply chain process alignment, agility, and flexibility.

Research Gap

Despite the increasing attention to the circular economy (CE) in India, a significant research gap exists in systematically analyzing the comprehensive steps taken by the Indian government to promote resource management and CE principles. While various studies have addressed specific policies and initiatives, there is a lack of cohesive research that synthesizes these efforts, evaluate their effectiveness and highlights successful case studies across different sectors. Furthermore, while the role of NITI Ayog in shaping CE policies is acknowledged, detailed analysis of its frame works and strategic plans are scarce. The collaboration between public and private sectors in driving resource efficiency and waste reduction also warrants further exploration as existing literature often focuses on either public policies or private initiatives in isolation. Overall, addressing these gaps will provide a more wide-ranging sympathetic of India's transition to a circular economy, offering valuable perceptions for policymakers, practitioners and investigators at the international level.

RESEARCH METHODOLOGY

Objective of the paper is to build a comprehensive understanding of the existing frameworks, policies and practices in the circular economy globally and within India.

Sources: Data sources like Government publications and reports, Academic journals, Industry reports, Reports from global bodies, News media and press articles are used. Systematic literature review conducted by using searches of Scopus indexed journals and Google scholar, science direct.

Utilize data from government agencies like NITI Aayog, the Central Pollution Control Board (CPCB), and international bodies such as the European Union (EU) on circular economy policies, waste generation, and resource efficiency

Ethical considerations: All the secondary data used in this research was publicly available and cited appropriately, care was taken to respect copy right laws and the intellectual property rights of the original data creators.

Significance of circular economy for India

Circularity is deeply ingrained in Indian culture, where sustainable living and resource conservation have been practiced for centuries, guided by rich traditions and values.

Admiration towards Nature: Indian traditions emphasize a profound reverence for nature. A practice such as worshipping trees and rivers and celebrating festivals related to nature reflects this commitment. Such respect translate into a collective responsibility for environmental protection, which is crucial for advancing a circular economy.

Simplicity

The Indian ethos often embraces simplicity and minimalism. Traditional practices like yoga and meditation encourage individuals to focus on what is essential, fostering a mindset that values less consumption and waste. This minimal life style aligns closely with the principles of a circular economy, promoting resource efficiency.





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Sharing:

A strong sense of community is a hallmark of Indian culture, exemplified through practices such as joint families, community kitchens and communal celebrations. This culture of sharing not only strengthens social bonds but also encourages the reuse of resources thereby minimizing waste and promoting sustainable practices.

India's strategy towards Circular Economy

The National Resource Efficiency policy (NREP), which was announced in 2019, is one of the key policies that are propelling the shift to a circular economy. Sustainable consumption and production patterns, increased efficiency with available resources, and reduced negative effects on the environment are the goals of this strategy. To promote the use of recycled materials and push for the implementation of circular business models like product-as-a-service, leasing, and sharing economies, the NREP incorporates these strategies.

1. The Swachh Bharat Mission (SBM), which began operations in 2014. Cleanliness, hygiene, and efficient waste management are the goals of this program in India. It encompasses programs that aim to improve recycling methods, increase composting, and encourage trash segregation at the source. Making India a "zero waste" country is the ultimate aim.
2. The Atal Innovation Mission (AIM), which was established in 2016, is another major policy endeavor that bolsters the arguments for a circular economy. Promoting innovation and entrepreneurship in India is the overarching goal of this mission. It encompasses programs that aim to promote sustainable technology adoption and the creation of circular business models.
3. A number of financial measures have been put in place to encourage the efficient use of resources, alongside legislative efforts. A variety of financial incentives have been put in place by the government to promote sustainable consumption behaviors and the implementation of circular business models. These are designed to assist businesses and promote the efficient use of resources in many industries.

Challenges in the Transition

Inadequate waste management and recycling infrastructure is one of the most critical issues. If India wants to have effective waste management, it has to put money into modern recycling and processing facilities and work on its garbage collecting and sorting infrastructure. Another big problem is that neither businesses nor customers really know what the circular economy is or how it works. The government should launch extensive educational initiatives and campaigns to raise public knowledge of the ideas of the circular economy and to promote its implementation.

The Success Stories

Pandesara Textile uses recycled water from Surat's municipal systems as part of their process water. In order to create biogas, the Chennai Metropolitan Water Supply and Sewerage Board uses aerobic digestion on sludge. The biogas engine is used to generate electricity from gas with a volume of 523.92 m³ per hour, or 12,574 m³ per day. Biogas typically produces 2 KWh/m³ of electrical energy.

MRF plant established in Indore on PPP model with an investment of ₹30 crores helps reduce the financial burden on municipal body. It attracts more recyclers to better quality products with 98% purity levels.

Waste can be reused and recycled

- Adaptive reuse is a method that finds new applications for an existing building by reusing or recycling it in some way.
- An approach known as "Design for Reuse" (DfR) incorporates salvaged materials into the blueprints for brand-new buildings.
- When a structure reaches the end of its useful life, its materials may be recovered in both quality and quantity using a design technique known as Design for Deconstruction (DfD).
- Buildings should be considered for their potential usage over many decades, not only in the short term, according to the Design for Longevity (DfL) philosophy. It stresses the need of using durable building materials to make a structure last for many years.

programmes conducted by NITI Aayog

Under the Hybrid Annuity Model (HAM) of Public-Private Partnerships (PPP), NITI Aayog has drafted Model Concession Agreements (MCAs) and Model Request for Proposals (RFPs) for Integrated Solid Waste Management, which includes Bio-Remediation of Legacy Waste, and Integrated Liquid Waste Management, which includes Faecal





Sludge Management. These agreements were developed by NITI Aayog, and the Hon'ble National Green Tribunal (NGT) has ordered all states and ULBs to implement them.

Furthermore, in line with the Sustainable Development Goals (SDGs), NITI Aayog has endeavored to mainstream measures and policies that seek to construct an Indian economy that is both resource-efficient and circular. A "Status Paper and Way Forward on Resource Efficiency & Circular Economy," which was jointly issued by NITI Aayog and the EU, was accompanied by "Four Sectoral.

Public Awareness on Circular Economy

Education Campaigns: Education Campaigns by Government, non-profit organizations can launch to educate public regarding circular economy. Communication media like Television, social media and print media can be used.

Community Events: Festivals and fairs like community events can be used to promote awareness among the public about circular economy.

Social Media: Information regarding the significance of circular economy for the sake of our survival and sustainability can be promoted by using social media.

Public and Private Partnership: Public and private partner together can reach a wider number of audience and to deliver effective messaging.

Government Initiatives

All cities, towns, and villages in India would have access to solid and liquid waste management services, according to the Swachh Bharat (Clean India) Mission.

The 'Waste to Wealth' initiative focuses on identifying developing and implementing skills to treat waste for recycling resources, generating and extracting valuable resources.

The 'Waste to Wealth' initiative focuses on identifying, developing, and implementing technologies to treat waste for recycling materials, generating energy, and extracting valuable resources.

Initiated by the Central Pollution Control Board (CPCB) a Management Information System (MIS) ports will gather data from the grassroots level, enabling the aggregation of information at various levels. It will also help answer questions regarding who generates waste, the types of waste produced and the treatment being applied.

Findings

Based on the outlined research methodology for transitioning towards a circular economy, the following key findings emerge:

Gaps in Policy Framework and Implementation

- While India has initiated several policies and programs aimed at promoting the circular economy (e.g., Swachh Bharat Mission, NITI Aayog initiatives), a unified and comprehensive national policy on the circular economy is lacking.
- There is an absence of clear regulatory frameworks that enforce circular practices such as green buying, circular product design, and expanded producer responsibility across several sectors.

Infrastructure Deficiency for Waste Management

- India faces significant challenges in waste management, particularly in areas such as waste segregation, collection, and recycling infrastructure. The lack of adequate facilities hampers the efficient processing of solid and liquid waste.
- There is a need for large-scale investment in waste processing technologies, recycling plants, and systems for managing construction and demolition waste.

Low Awareness and Adoption of Circular Practices

- There has been a slowdown in the adoption of circular business models due to a lack of awareness of circular economy concepts among both enterprises and customers.
- Many industries, especially MSMEs (Micro, Small & Medium Enterprises), lack the knowledge and capacity to implement resource-efficient and circular practices, often due to limited access to technical assistance or financial support.



**Mohanababu Chappa et al.,****Public-Private Partnerships as Enablers**

Public-private partnerships (PPP), as promoted by NITI Aayog's Model Concession Agreements, have the potential to drive circular economy initiatives, particularly in waste management and resource efficiency sectors. However, PPPs in circular economy sectors require greater stakeholder coordination and incentives to scale up circular solutions.

Successful Case Studies in Select Sectors

- Case studies from sectors like recycling, electronics, and construction demonstrate the viability of circular business models. These models generate significant economic opportunities while reducing environmental impacts.
- Some international models, such as the European Union's circular economy strategy, provide useful frameworks that can be adapted to India's context, particularly in high-waste sectors like steel, aluminum, and electrical waste.

Potential for Economic Growth and Job Creation

- Circular economy initiatives hold significant potential for economic growth through the development of new markets, jobs, and technologies. For instance, reuse, repair, and recycling industries can provide affordable products to consumers while creating employment opportunities.
- The transition to a circular economy could also reduce the financial burden of waste disposal and resource extraction, enhancing the economic viability of sustainable businesses.

Monitoring and Evaluation Gaps

- There is a lack of a comprehensive monitoring and evaluation system to track circular economy progress, making it difficult to assess the impact of existing policies and identify areas for improvement.
- Establishing a robust system for measuring key indicators like waste reduction, recycling rates, and resource efficiency is crucial for refining strategies and scaling up successful practices.

Sustainability Impact

- Circular economy practices lead to tangible environmental benefits, including significant reductions in waste generation, improved resource efficiency, and lower carbon footprints.
- Adopting circular models in the construction industry can mitigate environmental issues, particularly air pollution from construction waste, and enhance resource reuse, which is key for India's sustainability goals.

Need for Stakeholder Collaboration

- A lack of coordination between government agencies, businesses, and civil society is hindering the full-scale implementation of circular economy initiatives.
- Platforms that foster collaboration and dialogue between stakeholders—such as NITI Aayog's proposed Circular Economy Stakeholder Platform—are essential to driving collective action and knowledge sharing across sectors.

Incentives and Financing Mechanisms

- Financial incentives such as subsidies, tax benefits, and low-interest loans for circular practices are limited, restricting businesses' ability to transition to circular models.
 - Expanding financial support mechanisms and introducing circular economy financing models could accelerate the adoption of sustainable practices across industries.
- These findings highlight the need for concerted efforts, clear policies, and multi-sector collaboration to facilitate India's transition to a circular economy, while also revealing the untapped economic, environmental, and social benefits that could emerge from successful implementation.





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Recommendations

A comprehensive strategy incorporating all sectors and stakeholders is necessary to transition to a circular economy. Helping India through this transformation would need substantial governmental initiatives. National level vision document on the circular economy is urgently needed. A comprehensive policy framework can drive India's circular economy goals, setting clear objectives and strategies for business, government bodies and other stakeholders. Circular activities including green procurement, extended producer responsibility, and circular product design should be encouraged by this framework's legal environment. As a result, innovation, resource efficiency, closed-loop systems, and circular supply chains would all flourish, and the advantages of these approaches would be well known. Institutional mechanism to accelerate the circular economy transition must also address waste management. Reducing waste generation and improving waste management is significant to achieving the goals of the Mission Circular economy. Effective waste management can drive economic opportunities, reduce environmental pollution and improve public health. It also supports the development of spherical business representations that prioritize supply competence. Incentivizing the use of reused, repaired and recycled products is another vital policy intervention. The promoting conservation of resources and the creation of sustainable business models. These practices offer affordable, high quality alternatives to consumers and provide economic opportunities for community based business.

Limitations

Data Availability: Limited access to comprehensive, up-to-date data on circular economy practices, particularly in informal sectors and small-scale industries, may restrict the depth of analysis.

Generalization of Findings: The findings may not be universally applicable across all regions of India due to variations in infrastructure, policy implementation, and economic conditions.

Scope of Stakeholder Input: While efforts are made to engage diverse stakeholders, some perspectives, especially from marginalized communities or smaller enterprises, may be underrepresented.

Evolving Policy Landscape: The rapidly changing policy environment, particularly in sustainability and circular economy practices, could mean that findings may become outdated as new regulations and initiatives are introduced.

Resource and Time Constraints: Limited time and resources could affect the breadth of case studies, pilot programs, or in-depth qualitative assessments, leading to a more focused rather than comprehensive exploration.

These constraints highlight possible blind spots while also opening up avenues for further study of the dynamic circular economy

CONCLUSION

An environmentally friendly substitute for the present linear economic paradigm, the circular economy works by keeping resources in use, minimizing waste, and promoting the reuse and recycling of products. For India, transitioning to a circular economy presents several benefits. First, it helps address India's waste management crisis by reducing waste generation through efficient resource use, recycling, and renewable materials, easing the burden on landfills and mitigating pollution. The second benefit is that the circular economy has the potential to increase employment and GDP, especially in India's unofficial economy. By creating opportunities in repair, recycling, and waste management. This shift would also support SMEs by encouraging localized production and resource use. Third, it contributes to climate change mitigation by promoting renewable energy, cutting greenhouse gas emissions, and reducing reliance on imported resources. This aligns with India's sustainability goals and obligations under the Paris Agreement. Lastly, a spherical reduced enhances resource security and resilience by reducing dependence on imports and strengthening local supply chains. In conclusion, India's transition to a circular economy promises environmental, economic, and social benefits. To realize this potential, India must invest in infrastructure, foster innovation, and raise public awareness to drive sustainable practices.





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Fig.1 Waste can be reused and recycled
(Source: Circular Economy in municipal solid and liquid waste, MoHUA)





RESEARCH ARTICLE

Climate-Smart Agriculture: Strategies and Practices That Increase Agricultural Productivity While Reducing Greenhouse Gas Emissions

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ABSTRACT

Climate-Smart Agriculture (CSA) embodies a transformative approach to enhancing agricultural resilience, productivity, and sustainability in the face of climate change. This integrated framework prioritizes resilience through practices such as diversified cropping systems, improved water management, and integrated pest management, which help maintain yields during adverse climatic conditions. Sustainable productivity is achieved by leveraging precision agriculture and agro-ecological practices, which boost yields while minimizing environmental impacts. Furthermore, CSA emphasizes reducing greenhouse gas emissions through improved nutrient management and agroforestry, contributing to global climate mitigation efforts. The principles of CSA align closely with the Sustainable Development Goals (SDGs), particularly in combating hunger and climate change, thus promoting food security and environmental health. As global food demand continues to rise, the adoption of CSA practices becomes increasingly critical for stabilizing food supplies and ensuring long-term agricultural sustainability. Through collaborative efforts among farmers, researchers, and policymakers, CSA offers a pivotal pathway toward a resilient agricultural landscape that meets both immediate and future food security challenges.



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Keywords: Climate-Smart Agriculture, Resilience, Sustainability, Productivity, Climate Change, Greenhouse Gas Emissions, Food Security, Agro-ecological Practices

INTRODUCTION

Climate-Smart Agriculture (CSA) is an integrated approach that aims to enhance the resilience of agricultural systems to climate change while simultaneously increasing agricultural productivity and reducing greenhouse gas emissions. CSA focuses on three main objectives: Increasing productivity, enhancing food security and improving livelihoods by optimizing the use of resources and adopting sustainable practices. Building resilience adapting agricultural practices to withstand the impacts of climate change, such as extreme weather events and shifting growing conditions. Reducing emissions by implementing practices that lower greenhouse gas emissions from agriculture, thereby contributing to climate change mitigation. According to the Food and Agriculture Organization (FAO), CSA involves a combination of traditional and innovative practices, technologies, and policies that aim to achieve these goals. Climate-Smart Agriculture (CSA) plays a crucial role in addressing the multifaceted challenges posed by climate change to agricultural systems and food security. Its importance can be highlighted through several key points supported by recent research findings. Enhancing Food Security, CSA practices aim to increase agricultural productivity in a sustainable manner, ensuring that food production can meet the demands of a growing population. For instance, a study by Lipper *et al.* (2020) [1] found that implementing CSA practices could lead to significant improvements in yield stability, particularly in regions vulnerable to climate variability. Building Resilience to Climate Impacts, CSA emphasizes the adoption of practices that enhance the resilience of crops and farming systems to extreme weather events, such as droughts and floods. Niles *et al.* (2019) [2] highlights that CSA approaches can improve farmers' adaptive capacity, leading to reduced crop losses during adverse climatic conditions. Mitigating Greenhouse Gas Emissions, CSA practices, such as agroforestry, improved nutrient management, and conservation agriculture, have been shown to reduce greenhouse gas emissions. A meta-analysis by Smith *et al.* (2014) [3] demonstrated that these practices can lead to a decrease in emissions from agricultural activities while promoting carbon sequestration in soils. Promoting Sustainable Resource Management, CSA fosters sustainable water and soil management practices, which are essential in the context of climate change. Research indicates that practices like rainwater harvesting and cover cropping not only conserve water but also improve soil health, leading to enhanced agricultural productivity [4]. Supporting Policy and Economic Development, CSA can inform policy decisions and economic strategies by providing a framework for sustainable agricultural development. The integration of CSA into national and local policies is crucial for achieving climate goals and enhancing rural livelihoods [5].

Strategies and Practices of Climate-Smart Agriculture (CSA)

Climate-Smart Agriculture (CSA) encompasses a variety of strategies and practices designed to enhance agricultural productivity while reducing greenhouse gas emissions and increasing resilience to climate change. Key strategies include: Improved Crop Varieties utilizing drought-resistant and pest-resistant crop varieties can significantly enhance resilience to climate stressors. Research indicates that these varieties can increase yields under adverse conditions [6]. Sustainable Soil Management Practices such as reduced tillage, cover cropping, and organic amendments improve soil health and enhance carbon sequestration. These practices also mitigate soil erosion and improve water retention [7]. Efficient irrigation techniques, including drip irrigation and rainwater harvesting, optimize water use and enhance resilience in drought-prone areas [8]. Agro-ecological Practices like Crop rotation, intercropping, and agroforestry promote biodiversity and improve ecosystem services, enhancing resilience and reducing reliance on chemical inputs [9]. Integrated Pest Management (IPM), combining biological, cultural, and chemical methods, IPM reduces the need for synthetic pesticides and enhances pest resilience in changing climates [10]. Nutrient Management, utilizing organic fertilizers, cover crops, and precision nutrient applications enhances soil fertility and minimizes nutrient runoff, contributing to sustainability [11]. Technological Innovations, incorporating precision agriculture technologies, such as remote sensing and data analytics, helps optimize resource



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use and improve decision-making, [12]. These strategies and practices of CSA not only aim to mitigate the impacts of climate change but also support sustainable agricultural development, ensuring food security for future generations. The cited research provides a robust foundation for understanding the diverse approaches within CSA.

Key Principles of Climate-Smart Agriculture

Climate-Smart Agriculture (CSA) integrates sustainable practices aimed at enhancing resilience to climate change, increasing productivity sustainably, and reducing greenhouse gas emissions. By prioritizing resilience, CSA helps farmers adapt to changing weather patterns and extreme events through diversified cropping systems, improved water management, and integrated pest management, which have been shown to maintain yields during climatic stressors [13]. Increasing agricultural productivity sustainably involves leveraging precision agriculture and agro-ecological practices to boost yields without harming environmental health; Altieri [14] emphasizes the benefits of these methods in enhancing soil fertility and reducing chemical inputs. Additionally, CSA practices like improved nutrient management, agroforestry, and conservation tillage contribute to lowering greenhouse gas emissions while enhancing soil carbon sequestration [3]. The principles of CSA align closely with the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 13 (Climate Action), as they enhance food security and promote sustainable agricultural practices [15]. Niles *et al.* [2] highlight that adopting CSA is critical for stabilizing food supplies amid climate disruptions, making it essential as global food demand rises. Ultimately, CSA represents a pivotal approach in transitioning to sustainable agricultural systems, addressing both immediate climate challenges and ensuring long-term food security for future generations. Through collaborative efforts among farmers and policymakers, CSA can create a more resilient and sustainable agricultural landscape.

Strategies for Climate-Smart Agriculture

Improving crop varieties and sustainable soil management are essential strategies in Climate-Smart Agriculture (CSA) that enhance resilience against climate change. Developing drought-resistant and pest-resistant crop varieties is crucial, as research by Raza [16] indicates that drought-tolerant maize hybrids can increase yields by 20-50% under water-limited conditions, thus stabilizing food security and farmers' incomes. Both biotechnology and traditional breeding methods play significant roles in this development, as combining these approaches can effectively address regulatory and public acceptance issues surrounding genetically modified organisms [17]. Sustainable soil management practices, including cover cropping, reduced tillage, and organic amendments, further bolster resilience by improving soil health. Teasdale [18] highlight that cover cropping enhances soil organic matter and nutrient cycling, while Huggins and Frank [19] note that reduced tillage can increase soil organic carbon levels significantly. Lal [20] estimates that these practices could sequester between 0.5 to 2.0 gigatons of carbon annually, contributing to climate change mitigation. Efficient water use is also vital, particularly in arid regions facing water scarcity. Techniques such as drip irrigation can improve water use efficiency by 30-70% compared to traditional methods [21], while rainwater harvesting can effectively supplement irrigation in areas with erratic rainfall [22]. Additional strategies like soil moisture management and the selection of drought-resistant crops further enhance water efficiency [23] [24]. By adopting these practices, farmers can significantly enhance the resilience and sustainability of their agricultural systems, aligning with the goals of CSA.

Practices in Climate-Smart Agriculture

Agro-ecological practices are fundamental to Climate-Smart Agriculture (CSA), promoting resilience, productivity, and environmental sustainability through various strategies. Key practices include crop rotation, which enhances soil health by improving nutrient cycling and reducing the need for chemical fertilizers [25], and intercropping, which optimizes resource use and boosts biodiversity, leading to higher yields compared to monoculture systems [26]. Agroforestry integrates trees into agricultural landscapes, enhancing soil health, biodiversity, and carbon sequestration while providing economic benefits [27]. Additionally, enhancing biodiversity is critical for effective pest and nutrient management; biodiverse systems are less susceptible to pest outbreaks, with diverse plant species supporting natural pest predators and reducing chemical pesticide reliance [28]. Integrated Pest Management (IPM) combines biological, cultural, and judicious chemical practices to sustainably control pests, reducing pesticide use by 50-90% while maintaining efficacy [29]. Nutrient management is another crucial aspect, focusing on optimizing





nutrient use through organic fertilizers, which improve soil fertility and microbial activity [30], precision nutrient applications that enhance efficiency and reduce runoff [31], and biochar, which improves soil fertility and has significant carbon storage potential [32] [33]. Together, these practices not only enhance resilience and sustainability but also align with the broader goals of CSA by improving productivity while minimizing environmental impact.

Technological Innovations in Climate-Smart Agriculture

Technological innovations play a crucial role in supporting Climate-Smart Agriculture (CSA) through enhanced precision agriculture and climate forecasting tools. Precision agriculture utilizes advanced technologies such as remote sensing, which employs satellite or aerial imagery to monitor crop health and environmental conditions, allowing farmers to pinpoint stress areas for improved irrigation and fertilization [34]. Drones equipped with multispectral cameras enhance pest detection and assess nutrient status [35], while Internet of Things (IoT) devices facilitate real-time monitoring of resources, leading to potential water savings of up to 30% without sacrificing yields [36]. These data-driven approaches can reduce resource costs by 10-30% and boost crop yields by 15-20% compared to conventional methods [37] [38]. Furthermore, climate forecasting tools that utilize meteorological data significantly improve agricultural planning by providing accurate weather predictions [39]. Decision Support Systems (DSS) integrate these forecasts with soil health data, helping farmers optimize planting and resource management, thus enhancing overall resilience [40]. Access to reliable climate data empowers farmers to make proactive decisions, ultimately reducing crop failure risks and increasing yields [41] [42]. Together, these technological innovations align closely with the goals of CSA by promoting resource efficiency and sustainable agricultural practices.

Case Studies and Success Stories in Climate-Smart Agriculture

Regional examples of Climate-Smart Agriculture (CSA) initiatives demonstrate effective strategies for enhancing resilience and productivity while addressing climate change impacts.

Ethiopia's Climate Resilient Green Economy (CRGE): Aiming for a climate-resilient economy by 2025, Ethiopia promotes sustainable land management, agroforestry, and improved crop varieties. Lipper [43] noted that these CSA practices have significantly enhanced food security and increased farmer incomes.

Philippines' Rice Resilience Project: This initiative introduces drought-resistant rice varieties and improved water management techniques. According to the International Rice Research Institute [44], the project reported a 20% increase in rice yields during dry seasons, demonstrating enhanced resilience among farmers.

Brazil's Low Carbon Agriculture Plan: This plan encourages integrated crop-livestock-forestry systems and no-tillage practices. The Brazilian Ministry of Agriculture [45] reported that these strategies have led to reduced greenhouse gas emissions and improved soil health, contributing positively to farmer profitability.

National Mission for Sustainable Agriculture (NMSA), India: As part of India's climate action plan, the NMSA promotes practices such as rainwater harvesting and soil health management. Research by Sahu [46] found significant improvements in soil fertility and farmer incomes as a result of these initiatives.

Zero Budget Natural Farming (ZBNF), India: Focused on chemical-free farming using natural inputs, ZBNF has demonstrated increased crop yields and reduced costs for farmers. Reddy [47] highlighted its potential for promoting sustainability in agriculture.

Climate-Resilient Agriculture in Maharashtra, India: This program promotes drought-resistant crops and efficient irrigation practices, such as drip irrigation. According to the Indian Council of Agricultural Research [48], these measures have led to improved crop resilience during droughts and increased overall productivity.

Key Factors for Successful Climate-Smart Agriculture Adoption

Successful adoption of Climate-Smart Agriculture (CSA) relies on several critical factors, including strong community participation, which enhances initiative effectiveness, as demonstrated by programs like Zero Budget Natural Farming (ZBNF) that thrive on farmer-led demonstrations [49]. Robust capacity building through training programs, such as the National Mission for Sustainable Agriculture (NMSA), significantly boosts smallholder adoption rates [50]. Access to financial resources, including government subsidies and microcredit, is vital for facilitating transitions to sustainable practices [51]. Additionally, innovative technologies, such as mobile apps for





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weather forecasting like "Kisan Suvidha," empower farmers with real-time information for informed decision-making[52]. Together, these elements create a conducive environment for fostering resilience and sustainability in agricultural practices.

Challenges, Future Directions, and Stakeholder Roles in Climate-Smart Agriculture

Economic limitations significantly hinder the adoption of Climate-Smart Agriculture (CSA), with key challenges including substantial initial investment costs for infrastructure and technology, which are often prohibitive for smallholders [53]. Additionally, limited access to affordable credit exacerbates these issues, as financial institutions frequently hesitate to lend in climate-vulnerable regions [54]. The lack of sufficient government support further restricts financial resources, underscoring the need for enhanced incentives to promote CSA practices effectively [55]. Knowledge gaps also play a critical role, as many farmers lack access to training programs that would inform them about CSA benefits and methods, leading to scepticism [56]. Underfunded agricultural extension services restrict necessary support, while insufficient access to reliable information on climate variability impacts further complicates decision-making [57] [58]. Robust policy frameworks are essential; many countries suffer from disjointed agricultural and climate adaptation policies, emphasizing the need for harmonized strategies [59]. Incentives like subsidies can significantly influence farmers' decisions to adopt CSA[60], while strengthening institutional capacity is vital for effective implementation[61]. Future research must focus on developing resilient crop varieties, enhancing soil health practices, and advancing integrated pest management strategies[62] [63]. Moreover, collaborative efforts among farmers, researchers, policymakers, and NGOs are crucial to overcoming these barriers and fostering resilient agricultural practices that can effectively address climate change challenges [64] [65] [66] [67].

CONCLUSION

The exploration of Climate-Smart Agriculture (CSA) reveals that it is a comprehensive approach to enhancing agricultural productivity while mitigating greenhouse gas emissions through strategies such as developing resilient crop varieties, sustainable soil management, efficient water use, and integrated pest management. Key challenges, including economic constraints and knowledge gaps, must be addressed to facilitate CSA adoption. A collaborative effort among stakeholders, farmers, researchers, policymakers, and NGOs is essential. Farmers should engage in training and innovative practices, while researchers focus on interdisciplinary studies. Policymakers need to implement supportive policies with financial incentives, and NGOs can bridge gaps by advocating for sustainable practices. Together, these efforts can create resilient agricultural systems that ensure food security and ecological balance in the face of climate change.

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The Role of Chat GPT in Subsiding Creative Language Usage

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ABSTRACT

The impact of ChatGPT and similar tools on the cognitive components of language acquisition has come under scrutiny since artificial intelligence has been included into language teaching. This study investigates how to balance the potential overshadowing of basic cognitive processes with the benefits of using AI technology to improve language acquisition. Through an analysis of language learning theoretical frameworks, empirical data, and practical implications, this research attempts to shed light on the mutually beneficial interaction between AI tools and language learners' cognitive growth. Concerns over the possible replacement of human language instructors and the moral ramifications of utilizing a machine learning system to generate text may also arise from the use of Chat GPT in language learning and creative writing.

Keywords: Chat GPT, cognitive components, creative language, language acquisition, machine learning system

INTRODUCTION

The aim of technical writing is to clarify or communicate information accurately. However, in the realm of creative writing, this is not true. The main aim of Creative Writing is not to convey complicated information in order to enlighten the audience. The aim is to articulate your feelings rather than anything else. So, when Technical Writing and Creative Writing is compared in this scenario, Technical writing involves communicating information in a neutral and unbiased manner. Creative Writing is the act of expressing one's emotions or thoughts on a particular topic. In Creative Writing, one needs to communicate to entertain, engage, or convince the audience.



**Devika Rani and Madhavi****Creative Writing is a valuable skill in education and office**

One understands the significance of creative writing as a student. One turns in written assignments in a variety of contexts, including essays for class assignments and tests. or when applying to universities requires to submit a personal statement. In these circumstances, the ability to write creatively will determine the chances of receiving higher scores. Writing creatively means persuading a recruiter to hire through a cover letter. One discovers that one has to write something up as soon as one gets hired. It is dependent upon the field of expertise and how frequently and intricately one should write. However, creative writing is required for routine jobs like creating a PowerPoint presentation, composing an email answer, or creating a newsletter. Thus, when worked on Creative Writing skills, these tasks are manageable.

Creative Writing enhances several essential skills.

According to David McCullough, the American Historian who has won the Pulitzer Prize twice, that is at least what he said.

A lot of individuals struggle with Creative Writing as it necessitates a blend of specific abilities. It requires a combination of the following skills:

- Observation
- Reflection
- Critical thinking and analysis
- Reasoning skills
- Communication
- Empathy
- Creativity

Many of these skills make you a valuable employee in many industries. In fact, Forbes reports that:

- Critical Thinking
- Creativity
- and Emotional Intelligence

are three of the Top 10 most in-demand skills for the next decade.

But tools like ChatGPT, which are being utilized more and more in language instruction, are a result of artificial intelligence's quick development, especially in the area of natural language processing. While there are many benefits to these technologies, such as tailored learning paths, instant feedback, and increased engagement, there are worries that they could obscure critical cognitive processes that are crucial to language learning. This work aims to explore whether the advantages of utilizing ChatGPT and related applications for language learning contribute to or unintentionally interfere with cognitive processes. ChatGPT has the capacity to greatly lessen the amount of cognitive effort required by humans. It is able to provide help assisting students in various subjects such as completing assignments, writing essays, and providing answers, creating legal contracts, composing poetry, and writing code automatically by answering exam-style questions. programme along with numerous other subjects. This new advancement in artificial intelligence may offer innovative chances for educators, students, and individuals from various backgrounds but hinders creativity and right comprehension skills.

The Silent Killer of Creativity?

The emergence of generative AI models like ChatGPT has sent shockwaves through the creative industries, sparking concerns about the potential loss of human creativity. As AI becomes increasingly adept at generating content, it's raising questions about the role of humans in the creative process. According to recent reports, ChatGPT and other AI models are capable of producing high-quality content, including text, images, and audio. This has led to concerns that AI-generated content will soon become indistinguishable from human-created content, making it difficult for humans to compete. Another potential situation involves unfair algorithmic competition and poor governance causing the suppression of genuine human creativity. In this scenario, human writers, producers, and creators are being overshadowed by a flood of content generated by algorithms, leading some skilled creators to withdraw from



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the industry. If that were to occur, a crucial issue we must tackle is: How can we come up with fresh concepts? In this case, creators' incentives are greatly altered by generative AI, posing risks for both businesses and society. If low-quality generative AI reduces the value of genuine human content, there is a potential danger of slowing down innovation as humans produce less original art and content. Competition among creators for human attention is already fierce, and it will only intensify with the increasing availability of unlimited on-demand content. There will be an overwhelming amount of content, surpassing previous digital disruptions, requiring us to develop new methods to handle the flood of information. [4]

The Threat to Human Creativity

The threat to human creativity posed by ChatGPT and other AI models is multifaceted. For one, AI-generated content can be produced at an incredible speed and scale, making it difficult for humans to keep up. Additionally, AI models are capable of learning from vast amounts of data and generating content that is tailored to specific audiences and markets. This has led to concerns that humans will no longer be needed to create content, as AI can do it faster and cheaper. Moreover, the ease with which AI can generate content could lead to a proliferation of low-quality content, as humans may no longer have the incentive to produce high-quality work. They worry that people may become overly reliant on AI-generated content, diminishing their own creative capacities. [6]

The Impact on Creativity

The impact of ChatGPT on creativity is far-reaching and could have significant consequences for the creative industries. For one, it could lead to a loss of jobs and opportunities for humans in the creative sector. Additionally, it could result in a decline in the quality and diversity of creative content, as AI-generated content may lack the nuance and humanity that human creators bring to their work. Furthermore, the rise of AI-generated content could lead to a homogenization of creative output, as AI models are designed to produce content that is consistent with existing norms and conventions. This could stifle innovation and creativity, as humans may no longer feel the need to push boundaries and experiment with new ideas.

Similarly, we must also ensure that we thoroughly contemplate the implications of these emerging technologies on our ability to express creativity as individuals and the significance we place on human genuineness in artistic works and content creation. In simpler terms, how will our connection with creativity evolve with generative AI leading the way in our professional lives? Einstein once stated that intelligence having fun is what creativity is. Therefore, artwork also provides significance and feelings to human existence. From that standpoint, it will be up to businesses and society to determine the division of creative work between AI and humans. Achieving equilibrium will be a crucial obstacle as we progress with incorporating generative AI into our daily work routine. [7]

The Future of Creativity

So, what does the future hold for creativity in the age of ChatGPT? While AI-generated content may be able to produce high-quality output quickly and cheaply, it's unlikely to replace the unique qualities and strengths that humans bring to the creative process. In fact, many experts believe that humans will continue to play a crucial role in the creative process, even as AI becomes more prevalent. This may involve working alongside AI models to generate content, or using AI as a tool to augment and enhance human creativity. Ultimately, the future of creativity will depend on our ability to find a balance between human creativity and AI-generated content. By embracing both the benefits and limitations of each, we can create a new era of creative expression that combines the best of both worlds. [1] As long as people stay curious, imaginative, and open to learning, they will keep discovering ways to contribute to society amidst technological progress. [5]

CONCLUSION

While ChatGPT and similar AI tools offer remarkable opportunities for enhancing language learning, it is essential to maintain a focus on the cognitive aspects that underpin effective language acquisition. By striking a balance between technology and cognitive engagement, educators can harness the strengths of AI while nurturing the critical thinking



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and problem-solving skills necessary for successful language learning. Future research should explore innovative methodologies that integrate AI into cognitive frameworks, paving the way for a more enriched language learning landscape.

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Address Resolution Protocol (ARP) and Reverse Address Resolution Protocol (RARP): An Overview

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ABSTRACT

The Address Resolution Protocol (ARP) and Reverse Address Resolution Protocol (RARP) are crucial in networking, enabling communication between devices using IP addresses and their corresponding MAC addresses. ARP associates IP addresses with MAC addresses, while RARP does the reverse association, linking MAC addresses to IP addresses. This paper analyzes the essential principles, roles, and importance of both ARP and RARP. Moreover, it highlights their uses, limitations, and importance in modern IP networks.

Keywords: Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (RARP), Networking, IP addresses, MAC addresses, Communication ARP association, RARP association

INTRODUCTION

Effective communication in computer networks relies heavily on the accurate translation between different addressing schemes. In most local area networks (LANs), devices communicate at Layer 2 (Data Link Layer) using Media Access Control (MAC) addresses, whereas Layer 3 (Network Layer) communication relies on IP addresses. A technique is required to translate IP addresses to MAC addresses and vice versa for effective communication. ARP and RARP are pertinent in this context. The Address Resolution Protocol (ARP) enables the determination of the MAC address corresponding to a specific IP address within a local network. Conversely, the Reverse Address



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Resolution Protocol (RARP) enables devices to ascertain their IP address when just the MAC address is accessible. This paper offers an exhaustive examination of ARP and RARP, their functionalities, and their significance in modern networking.

Address Resolution Protocol (ARP)**Overview of ARP**

ARP, as specified in RFC 826, operates at the Data Link Layer to convert 32-bit IPv4 addresses into 48-bit MAC addresses (Ethernet). It enables a device with an IP packet to transmit that packet to the correct physical computer on the network. This strategy is crucial in environments where hosts employ IP addresses for identification yet necessitate MAC addresses for actual data transmission via Ethernet.

ARP Functionality When a device attempts to communicate with another device on the same network and has only its IP address, it uses ARP to determine the MAC address. The process follows these steps:

The device emits a broadcast ARP request containing the IP address it aims to resolve. The request is sent to all devices on the local network since the sender does not know which device has the corresponding MAC address.

The device associated with the designated IP address transmits an ARP reply containing its MAC address. This response is sent directly to the requesting device, which then retains the MAC address for future use.

The ARP table is a cache that each device retains to store mappings of IP addresses to MAC addresses for a specified duration, typically approximately 20 minutes, to avoid redundant ARP inquiries.

Classifications of ARP Messages

ARP Request: A broadcast query that asks, "Who owns this IP address?" The source MAC and IP addresses are provided, while the destination MAC is indicated as 0 due to its indeterminate status.

ARP Reply: A unicast transmission that declares, "I own this IP address; here is my MAC address." It is sent alone to the inquiring device.

ARP Cache Devices store ARP responses in a repository called the ARP cache, which enables faster future communications. ARP cache entries are transient and are eliminated after a designated period to avert the use of outdated information in dynamic networks.

ARP Vulnerabilities ARP is a basic protocol lacking intrinsic security mechanisms, making it susceptible to certain attacks, including:

ARP Spoofing/Poisoning: Involves sending fraudulent ARP replies to a device, causing it to route data to an erroneous MAC address, hence enabling man-in-the-middle (MITM) attacks.

Broadcast Storms: In a large network, persistent ARP queries can overwhelm the network with broadcast traffic, degrading performance.

Reverse Address Resolution Protocol (RARP)**Overview of RARP**

RARP, as defined in RFC 903, operates as the opposite of ARP. It is employed by devices that have only their hardware (MAC) address and need to ascertain their assigned IP address. RARP is frequently utilized in diskless workstations or during initial boot routines when devices require an IP address from a RARP server.

RARP Functionality

RARP operates similarly to ARP, but in the reverse direction: A device sends a RARP request containing its MAC address to obtain the corresponding IP address. This request is distributed throughout the entire network. A RARP server, pre-configured with a mapping of MAC addresses to IP addresses, provides the corresponding IP address to the requesting device.



**Jhansi Rani Ganapa and Sudheer Choudari****Limitations of RARP**

RARP, while advantageous in the initial phases of networking, has several limitations: Server Dependency: RARP requires a centralized RARP server to handle requests. This creates a unique point of failure and increases administrative overhead.

Limited Scalability: RARP cannot support many protocols, and its rigidity makes it unsuitable for modern IP networks. RARP has been entirely replaced by more advanced protocols such as BOOTP and subsequently DHCP (Dynamic Host Configuration Protocol), which offer superior functionalities and greater manageability.

ARP and RARP in Modern Networks**ARP in IPv6: Neighbor Discovery Protocol (NDP)**

In IPv6 networks, the Address Resolution Protocol (ARP) is replaced by the Neighbor Discovery Protocol (NDP), which performs similar operations while offering advanced features such as address autoconfiguration, neighbor unreachability detection, and router discovery. NDP operates over ICMPv6 and eliminates the need for broadcast ARP queries.

Substitution of RARP with DHCP

The Dynamic Host Configuration Protocol (DHCP), developed in the 1990s, provides a more efficient mechanism than RARP for assigning IP addresses to devices inside a network. DHCP not only assigns IP addresses but also provides additional setup information, including default gateway, DNS server, and subnet mask. The dynamic allocation capabilities make DHCP a more scalable and flexible option.

Security Considerations**ARP Security**

The lack of authentication and encryption in ARP makes it vulnerable to many attacks: ARP Spoofing: An attacker sends fraudulent ARP packets, leading devices to retain incorrect MAC-to-IP mappings. This could facilitate man-in-the-middle attacks, session hijacking, or denial-of-service (DoS) attacks.

Mitigation Strategies: Security techniques such as Dynamic ARP Inspection (DAI), ARP Access Control Lists (ACLs), and the implementation of port security on switches can effectively counteract ARP spoofing. Implementing IPsec or network access control methods augments network security.

RARP Security Protocol

The reliance of RARP on a central server presents security vulnerabilities, as the server may be susceptible to hacking or denial-of-service assaults. Nonetheless, as RARP has mostly been replaced with DHCP, most modern networks do not encounter these issues.

SUMMARY (CONCLUSION)

ARP and RARP have been essential protocols in the development of IP networking. While ARP is crucial for IP-to-MAC address resolution in IPv4 networks, RARP has been predominantly supplanted by DHCP for dynamic IP assignment. The straightforwardness of ARP improves its efficacy while concurrently rendering it susceptible to security threats, hence requiring additional protections in modern networks. As IPv6 use rises, the importance of ARP will diminish in favor of NDP; yet, it remains essential for IPv4 network operations.

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Significance of ChatGPT for Forensic Science and Its Use in Other Domains

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ABSTRACT

Better Research Efficiency on ChatGPT can quickly deliver relevant information and resources, which saves time for forensic experts who need to keep up with the newest methods and findings. It can be useful for both students and workers because it can help explain difficult ideas, get you ready for tests, and make learning fun in training and education. ChatGPT can make exchanges between forensic teams and stakeholders clearer and more professional by helping with the creation of reports and presentations. It helps forensic experts figure out what data and proof mean by giving them new ideas and different ways to look at things during investigations. People can learn more about forensic science with ChatGPT by creating educational material that helps people understand its importance and impact. Case simulation and scenario analysis can help workers think critically about different parts of crime scene investigation by getting people to talk about made-up situations. ChatGPT can help people work together on complicated forensic investigations by sharing knowledge from different fields, such as law, psychology, and biology. ChatGPT is a helpful tool that lets forensic scientists do their jobs better and more efficiently by adding to their skills and following set rules.

Keywords: Chat-GPT, Forensic Science, Allied Sciences, AI





INTRODUCTION

Due to the advancements in the current emerging world, technology is gaining wide acceptance and popularity. Technological emergent have revolutionized the current scenario. One of such emergent is Artificial Intelligence. AI encompasses the replication of human intelligence through the utilization of computational systems. It proficiently handles intricate data and undertakes tasks that were traditionally within the realm of human capabilities, including decision-making, reasoning and critical thinking. This paper focuses and discuss an OpenAI generated tool, that is ChatGPT [Chat Generative Pre-trained Transformer], which has upended almost every field, including the forensics. ChatGPT is an AI-powered natural language processing [NLM] tool that facilitates human-like dialogues and offers a wide range of functionalities through a chatbot. This language model not only possesses the capability to respond to queries but also aids in various tasks including the creation of emails, essays and code composition, drafting reports etc. Furthermore, ChatGPT is also widely acknowledged for its easy accessibility to users and from literature to research, it has exhibited its efficacy profoundly.

ChatGPT Use In Biological Sciences

ChatGPT has proven to be extremely useful in the advancing field of biology. From Proteomics to Genetic analysis using Bioinformatics tools, this AI model has pushed its efficiency and utility. Protein engineering using ChatGPT has revolutionized the area of life Sciences. Protein represents the molecular apparatus of life that facilitate the various functioning of life. The functions encompasses development of a particular behaviour, facilitation of muscular motion and the regulation of molecular transportation across cellular barriers. Nature took millions of years to design proteins, AI can generate meaningful protein sequences in just seconds. A thousand of protein can be engineered and developed using ChatGPT for example, a biochemical reaction which utilizes an enzyme to faster the process of drug production can become more faster just by simply modifying the protein based enzyme. Also, the protein-based drug can be slightly engineered to improve its quality using GPT software in order to improve its effectiveness.

In Bioinformatics, a discipline concerned with the storage, retrieval, and analysis of biological data, particularly in the realm of genetics and genomics, ChatGPT has played its significant role. Nonetheless, ChatGPT has the potential to be employed within the bioinformatics field as a tool for generating natural language explanations of genetic or genomic data, or for generating responses to inquiries regarding said data. For instance, a scholar could employ ChatGPT to produce explications concerning genetic variations such as SNPs or STR patters or patterns of gene expression derived from input information. This functionality could prove advantageous in generating synopses of findings for scholarly papers or reports, or in producing clarifications of intricate concepts for audiences lacking expertise. Study of such genetic variations using ChatGPT can also prove advantageous in understanding the link between a particular genetic variant to a particular disease.

The potential uses of ChatGPT in the realm of medicine encompass a wide array, extending from the identification of potential areas of research to aiding healthcare practitioners in both clinical and laboratory-based diagnoses. The issue of accessing healthcare poses a significant and formidable challenge in numerous regions across the globe. Primarily, language barriers and the absence of healthcare information accessibility stand as the most prominent impediments to obtaining healthcare services. ChatGPT can surmount these obstacles by facilitating language translation services, thereby granting individuals with language barriers access to vital healthcare information. Individuals living in the remote areas who don't have access to the healthcare facilities can be benefited profoundly by this much-hyped AI technology. As it is commonly acknowledged, the forthcoming realm of medicine revolves around the concept of individualized healthcare. ChatGPT has revolutionized this field by providing effortless access to personalized suggestions by acting as 'Virtual healthcare assistant' derived from an individual's medical background, lifestyle factors, and genetic data.



**Nisruti Anuja et al.,****ChatGPT Use In Chemical Sciences**

ChatGPT accelerates research and development in the field of Chemical Sciences by providing insightful information, advice, and solutions to chemists and researchers working in the chemicals business. It can speed up the discovery of new compounds, formulations, chemical structure determination and materials by evaluating massive amounts of chemical data, academic publications, and patents. Chemical solubility, reactivity, and toxicity are just a few of the important characteristics that ChatGPT can predict which aids in evaluating the potential effects of novel compounds, understanding their behaviour in various environments, and assisting in the formulation of development-related decisions. ChatGPT also plays an important role in drug discovery and computational chemistry. The process of identifying and creating new pharmaceuticals to treat disease is known as drug discovery. It is a multidisciplinary discipline that entails a number of processes, including target identification, lead discovery, preclinical development, clinical trials, and regulatory approval. Computational chemistry plays a vital role in drug designing and discovery by providing a cost effective and a efficient way to screen large amount of pharmaceuticals in order to find out the most efficient drug with greater efficacy to treat various diseases.

ChatGPT Use In Physical Sciences

ChatGPT has the potential to be utilized in the field of education. Specifically, in the realm of Physics, ChatGPT has the capability to assist students in their journey of acquiring knowledge in physics. This assistance is provided in the form of real-time feedback, which serves to enhance the students' comprehension of the subject matter and increase their level of engagement. Furthermore, ChatGPT possesses the ability to facilitate the planning of lesson processes, the creation of sample questions, the generation of real-life examples, and the formulation of lesson plans, thereby alleviating the burden on teachers. However, it appears that the model possesses the capability to address conceptual physics problems. Astonishingly, the model successfully responded to a majority of the multiple-choice questions, obtaining a score of 73.9% on the examination. The AI tool indeed exhibits knowledge in the domains of general relativity and Ohm's law, comprehends concepts such as velocity and momentum, and this proficiency is prevalent among the most cutting-edge NLP models of today.

ChatGPT Use In Forensics

As ChatGPT has upended every field, forensics is not so different. This AI generated communication software has also helped the forensic professionals in the criminal justice system. While it is an undeniable fact that individuals involved in the field of law enforcement, prosecuting attorneys, and experts in forensic examination (representing both Prosecution and Defence) possess a comprehensive understanding of diverse methods of criminal analysis, it is plausible to consider that ChatGPT, upon further enhancement, might furnish them with supplementary concepts for analysis. ChatGPT can act as a 'Virtual Forensic Assistant' to aid victims, lawyers or judges to manage their legal and forensic data. This software can also provide possible matches in case of an exceptionally difficult and uncommon crime scenes. Also, ChatGPT has the capability to draft court reports, thus leading to a reduction in the duration of judicial deliberations. In order to help the forensic researcher group in deciding research topics, formulating hypothesis and depiction of data collected, ChatGPT has the potential in providing such assistance. In spite of having such relevancy in the field of forensics, the observations suggested that the use of ChatGPT in its current form is still limited in the realm of forensics and the law. Only human critical thinking, expertise and practical knowledge can provide the information needed.

CONCLUSION

ChatGPT has proven its potential in almost every field. From science to investigation, it has shown its efficacy and efficiency. Now-a-days, due to rapid change in the lifestyle pattern, food quality, stress & anxiety and other factors, people do suffer from various diseases, ChatGPT has aided to curb such conditions by proving its potentiality in pharmaceuticals or drug development and discovery. It has also helped in identifying and developing novel chemical molecules for wider application. It has also assisted the researchers in advancing their research by proposing topic and hypothesis. It has also eased the teaching-learning process by making it automated and user



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friendly. Despite its effective applications, the ChatGPT bears some limitations with it. The authors of an early publication regarding the potential dangers associated with protein engineering, observed in 2006 that the production of toxins on a larger scale was becoming increasingly viable. Biosecurity experts Jonathan Tucker and Craig Hooper expressed specific concerns regarding the burgeoning interest in medical applications of "fusion toxins," which entail the combination of toxin elements such as ricin with antibodies capable of targeting cancer cells. Such a technology has the potential to be utilized for the disruption of healthy cells, in addition to cancer cells. The authors identified protein engineering as an area of dual-use risk that is frequently disregarded by the biosecurity community, despite the significant progress being made. Sometimes the output generated by much-hyped ChatGPT is biased and inaccurate because the accuracy of such text generated by ChatGPT depends upon the quality and nature of the training data used. The use of ChatGPT in healthcare sector also possess ethical and legal concerns, like infringement of copyright laws, complications in medico-legal cases. Sometimes the text generated by this AI tool also get manipulated by the technology itself. Therefore in future, there is a need to develop more advanced and modified AI trained tools to address abovesaid constraints for the societal betterment.

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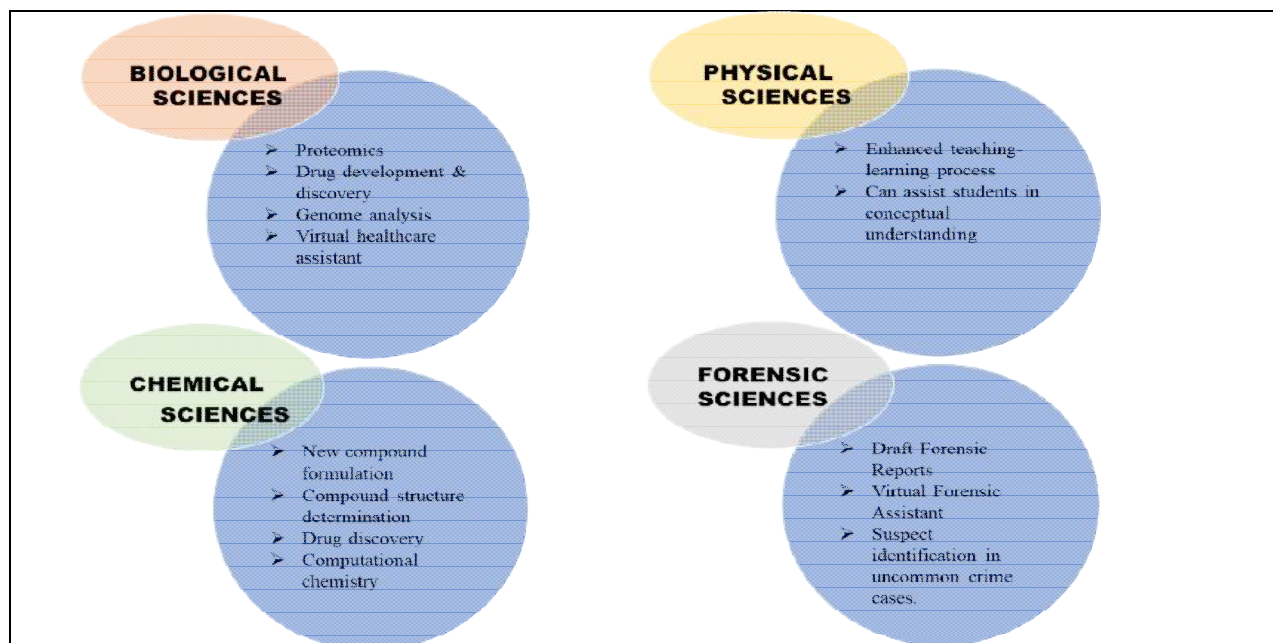


Fig 1: Application Of ChatGPT in various fields

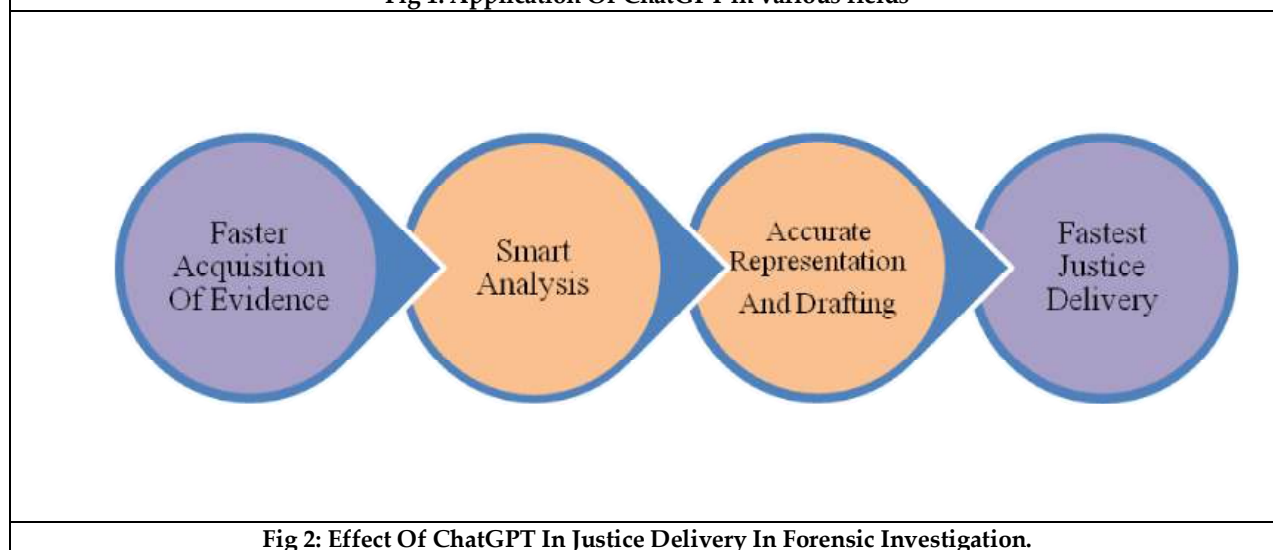


Fig 2: Effect Of ChatGPT In Justice Delivery In Forensic Investigation.





Energy Efficiency in Proof-of-Stake vs. Proof-of-Work: Evaluating Consensus Mechanisms for Sustainable Block chain

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ABSTRACT

The environmental sustainability of blockchain networks, particularly those that employ Proof-of-Work (PoW) consensus mechanisms, has been a topic of concern due to their increasing energy consumption. This study assesses the energy efficacy of Proof-of-Stake (PoS) in comparison to PoW, with an emphasis on their environmental impact, security, and performance. Despite the fact that PoW has served as the fundamental consensus algorithm for numerous prominent blockchains, it necessitates an immense amount of computational power, which results in exceptionally high energy expenses. In contrast, PoS is a promising alternative for reducing energy consumption, as it is based on financial interests rather than computational labor. This paper offers a thorough examination of the underlying principles, consensus mechanisms, and their impact on the scalability, security, and decentralization of blockchains. This study endeavors to demonstrate how PoS can contribute to a more sustainable blockchain ecosystem while maintaining network integrity and security by contrasting their energy profiles. The results will contribute to ongoing discussions on the balance of efficacy and sustainability in decentralized technologies and inform future designs of eco-friendly blockchain systems.

Keywords: Blockchain, Proof-of-Work, Proof-of-Stake, Consensus, Decentralization.

INTRODUCTION

Blockchain technology has been widely acknowledged for its potential to transform a variety of industries by facilitating secure, decentralized, and transparent systems for financial transactions, data administration, and other applications[1]. The consensus mechanism is the fundamental component of blockchain functionality, as it guarantees that all nodes in a decentralized network concur on the validity of transactions without the necessity of a



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central authority. Proof-of-Work (PoW) and Proof-of-Stake (PoS) are two of the most prominent consensus mechanisms, and they both play a critical role in the preservation of the block chain's security and integrity[3]. Bitcoin was the first to popularize the concept of Proof-of-Work, which involves the solution of intricate cryptographic puzzles to validate transactions. Miners are rewarded with cryptocurrency in exchange for their computational efforts. Although PoW is effective in securing the network, it has been the subject of increasing scrutiny due to its substantial energy consumption, which has raised concerns about its environmental sustainability[2]. Research has demonstrated that Bit coin mining, which is fueled by PoW, utilizes an equivalent amount of energy annually as certain minor countries, thereby exacerbating the global energy crisis and contributing to the increase in carbon emissions and the block chain's integrity[4].

Proof-of-Stake has emerged as a more energy-efficient alternative in response to these concerns. In contrast to PoW, PoS does not necessitate substantial computational capacity. Validators are selected based on the quantity of cryptocurrency they possess and are willing to "stake" as collateral. This change significantly diminishes the energy consumption of blockchain networks while simultaneously preserving decentralization and security. PoS has been implemented by numerous prominent blockchain platforms, including Ethereum, which recently transitioned from PoW to PoS in an effort to reduce its environmental impact. The paper is organized in the following way: The background details study in section 02. The conceptual architecture and different consensus algorithm in-depth analysis done in section 03. The case studies regarding PoW and PoS are mentioned in section 04. The paper end with the comprehensive conclusion with future work in section 05. The references are listed in section 06.

Background Study

Blockchain allows for the secure transfer of digital assets without the need for a trusted third party, such as a bank or government. The technology's core innovation lies in its consensus mechanisms, which enable network participants, or nodes, to agree on the validity of transactions across a distributed ledger[5]. Among the various consensus mechanisms developed over the years, Proof-of-Work (PoW) and Proof-of-Stake (PoS) have emerged as the most widely adopted and debated algorithms. Proof-of-Work (PoW), the first consensus mechanism, was originally used in Bitcoin and later adopted by other major cryptocurrencies. In PoW, miners compete to solve complex mathematical problems to validate transactions and secure the network. In contrast, Proof-of-Stake (PoS) was developed as an alternative to address the inefficiencies and environmental concerns associated with PoW. Instead of relying on computational power, PoS selects validators based on the number of tokens they hold and are willing to "stake" as collateral. This eliminates the need for energy-intensive mining, significantly reducing the overall energy consumption of PoS networks.

Underlying Architecture, Concept, and Challenges of Blockchain**Blockchain Architecture:**

Distributed ledger technology, or blockchain, facilitates secure, transparent, and immutable record-keeping across a decentralized network of nodes. The blockchain architecture is intended to guarantee that transactions can be verified and stored in a trustless environment, without the need for a central authority. The comprehension of blockchain architecture is indispensable for the assessment of the energy efficiency and security of the system, as well as the operation of consensus mechanisms such as Proof-of-Work (PoW) and Proof-of-Stake (PoS).

The Role of Consensus Mechanisms:

The consensus mechanism is the fundamental procedure that enables blockchain nodes to reach a consensus on the state of the ledger. This agreement must be attained in decentralized systems without the presence of a central authority. PoW and PoS are two of the most frequently used consensus mechanisms, each with its own unique processes, energy requirements, and security implications. The comparison between PoS and PoW are shown in the figure 1.

Proof-of-Work Consensus Mechanism:

The original consensus mechanism in blockchain technology, Proof-of-Work (PoW), was introduced in 2008 with the creation of Bitcoin. The purpose of PoW is to ensure the security of decentralized networks by mandating that



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participants (miners) perform computational labor in order to validate transactions and add new blocks to the blockchain[6]. Although PoW has proved to be highly effective in maintaining the security and integrity of blockchain networks, it is also infamous for its high energy consumption, which has prompted discussions regarding its long-term sustainability.

Principles of Proof-of-Work (PoW):

In PoW, miners engage in a competition to solve a complex cryptographic riddle, known as a hash, which is derived from the contents of the block. The new block can only be added to the blockchain by the miner who first solves this riddle, which necessitates a substantial amount of computational effort[7]. In order to guarantee that blocks are added at consistent intervals (e.g., every 10 minutes for Bitcoin), the solution must satisfy a particular difficulty target that is periodically amended. The successful miner is awarded cryptocurrency and transaction fees upon the validation and appending of a block to the blockchain.

The key steps in the PoW process include:

- Mining Competition:** Miners employ their computational capabilities to identify the appropriate hash for the block. Miners continuously generate hashes until one satisfies the difficulty requirement, a procedure that is founded on trial and error.
- Block Validation:** The block is broadcasted to the network by the first miner to identify the correct hash, and subsequent nodes verify its validity. The miner is compensated and the block is incorporated into the blockchain if it is valid.
- Difficulty Adjustment:** The cryptographic puzzle's difficulty is reliant upon the network's total computational power, which fluctuates over time. This guarantees that the interval between block generations remains consistent, regardless of fluctuations in the number of miners that are involved.

Energy Consumption in PoW:

The most substantial critique of PoW is its tremendous energy consumption. Miners are required to solve computationally complex riddles, which results in an extensive consumption of electricity that increases in tandem with the network's expansion. The puzzles become more challenging as more miners join the network, which in turn increases energy consumption. This has resulted in the establishment of mining farms, which are large-scale enterprises that are exclusively dedicated to PoW mining. These farms use an enormous amount of electricity, frequently in regions with affordable energy sources.

Key points on PoW energy consumption:

Energy-Intensive Mining: Bitcoin mining alone utilizes more energy than certain minor countries, with estimates indicating that the annual energy consumption of Bitcoin is comparable to that of entire nations such as the Netherlands or Argentina. The primary reason for this high energy consumption is the necessity for miners to conduct billions of computations in order to solve each cryptographic puzzle.

Environmental Impact: The vast majority of PoW mining operations are concentrated in regions with inexpensive electricity, which is frequently produced from fossil fuels, resulting in substantial emission of carbon dioxide. The global debate on the sustainability of blockchain technology has been ignited by the environmental impact of PoW, with numerous individuals advocating for sustainable alternatives.

Increasing Difficulty: The mining difficulty increases in order to maintain a consistent block generation time as more miners join a PoW network. This increases the computational capacity necessary, which in turn prompts miners to invest in more energy-intensive hardware, such as ASICs (Application-Specific Integrated Circuits), thereby further increasing energy demands.

Security and Decentralization in PoW:

PoW's security is one of its most significant assets. The consensus mechanism renders it exceedingly challenging for an adversary to manipulate the blockchain and seize control of the network (a "51% attack"). This is due to the fact that an attacker would be required to control over half of the network's computational capacity, a task that becomes prohibitively costly as the network expands. PoW networks are exceedingly secure due to the substantial computational resources and energy necessary to modify previous blocks. In order to reverse a transaction, an



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adversary would need to execute the proof-of-work for the block in question and all consecutive blocks. This is an almost impossible task in large networks such as Bitcoin. PoW is also commended for its promotion of decentralization, as it allows anyone with computational capacity to engage in mining. Nevertheless, the centralization of mining operations in specific regions has resulted in the emergence of concerns regarding power imbalances within the network, as a result of the necessity for specialized hardware and inexpensive electricity.

Proof-of-Stake Consensus Mechanism:

The development of Proof-of-Stake (PoS) was in response to the increasing apprehensions regarding the significant energy consumption and environmental impact of PoW-based blockchain systems.[8] It was intended to provide a more energy-efficient alternative to PoW. PoS provides a more sustainable solution by eliminating the necessity for resource-intensive mining. Rather, it relies on a process in which validators are selected to propose and validate new blocks based on the amount of cryptocurrency they "stake" in the network.. This consensus mechanism has been implemented by numerous significant blockchain platforms, such as Ethereum, which transitioned from PoW to PoS in 2022[9].

Principles of Proof-of-Stake (PoS):

The principle of staking is the foundation of the proof-of-stake (PoS) system, which involves the locking up of a portion of the cryptocurrency by participants as collateral. This procedure is used to validate transactions and secure the blockchain[10]. The likelihood of being chosen to validate a new block is directly proportional to the quantity of cryptocurrency that has been pledged. This eliminates the necessity for miners to execute computationally demanding tasks, as the selection process is deterministic rather than competitive.

The main steps in the PoS process include:

- Staking:** In order to engage in the block validation procedure, validators are required to commit a specific quantity of cryptocurrency. This staked quantity serves as a guarantee that the validator will conduct themselves honestly. If they attempt to validate fraudulent transactions, they may forfeit a portion or all of their staked cryptocurrency.
- Validator Selection:** Validators are selected according to their investment in the network. The likelihood of a participant being selected to propose and validate new blocks increases as the number of tokens they stake increases. Other factors, such as the duration of time a participant has held their tokens (coin age) or randomness, are also incorporated by certain PoS systems to enhance the security of the selection process.
- Block Validation and Finality:** After selecting a validator, they suggest the subsequent block of transactions. The proposed block is verified by other validators on the network, and if consensus is achieved, it is incorporated into the blockchain. Finality is accomplished in certain PoS systems by employing mechanisms like checkpoints, which guarantee that the addition of a block cannot be reversed without incurring substantial costs.

Energy Efficiency in PoS:

PoS's energy utilization is significantly reduced, which is one of its most significant advantages over PoW. The necessity for energy-intensive mining hardware, such as ASICs, is eliminated, as PoS validators are chosen based on their stake rather than their computational capacity. This leads to significantly reduced energy consumption, which enables blockchain networks to operate more sustainably.

Key points on PoS energy efficiency include:

- No Mining Competition:** In contrast to PoW, which necessitates miners to allocate substantial computational resources to resolve cryptographic riddles, PoS necessitates only minimal computational resources for block validation. Validators are required to execute software that verifies transactions and suggests new blocks, resulting in a substantial reduction in electricity consumption.
- Lower Hardware Requirements:** In order to engage in the network, PoS validators are not required to possess specialized, high-performance hardware. The environmental and resource costs associated with hardware manufacturing and maintenance can be further reduced by the use of ordinary computers as validators.
- Scalability and Energy Savings:** PoS is inherently more scalable than PoW due to the fact that it does not necessitate progressively more intricate computational tasks as the network expands. This implies that PoS systems can accommodate larger transaction volumes without commensurate increases in energy consumption as blockchain adoption increases.



**Desetti Tulasi and Pavan kalyan Varma****Security and Decentralization in PoS:**

Although PoS is frequently lauded for its energy efficiency, it also presents a distinct set of challenges and trade-offs in terms of decentralization and security. PoS must simultaneously prevent excessive centralization, which can undermine the decentralized character of the blockchain, and ensure that the system remains secure and that validators are incentivized to act honestly.

Security Through Staking: In PoS, the security of the network is contingent upon the quantity of cryptocurrency that validators stake. Validators are powerfully motivated to act in the network's best interest, as they are at risk of losing their staked tokens if they engage in malicious behavior (a procedure known as "slashing"). The probability of attacks, such as a 51% attack, is diminished by this economic incentive, as an assailant would be required to control a majority of the staked tokens, which could be prohibitively costly.

Centralization Risks: The risk of centralization is one potential drawback of PoS. As validators with a greater number of tokens are more likely to be selected to validate new blocks, there is an apprehension that the network may be disproportionately controlled by affluent participants. Nevertheless, numerous PoS systems implement mechanisms to alleviate this issue, including weighted selection or randomization, which are based on factors other than token holdings.

Security Vulnerabilities: Although PoS eliminates the necessity for energy-intensive mining, some critics contend that it may be less secure than PoW due to its reliance on economic incentives rather than computational power. Nevertheless, the security guarantees of PoS networks have been enhanced by recent developments in PoS design, such as Ethereum's Casper protocol, which renders them more resilient to manipulation and attacks.

Comparative Analysis: PoW vs. PoS:

In the realm of blockchain technology, two of the most prominent consensus mechanisms are Proof-of-Work (PoW) and Proof-of-Stake (PoS). Each mechanism has its own individual strengths and limitations. This comparative analysis assesses the energy efficiency, security, decentralization, scalability, and environmental impact of PoW and PoS, with an emphasis on their appropriateness for sustainable blockchain systems mentioned in Table 01.

Case Studies**Bitcoin (PoW) Energy Usage**

Bitcoin, the first and most renowned cryptocurrency, functions on a Proof-of-Work (PoW) consensus mechanism. Although PoW offers a high degree of security and decentralization, it is also extremely energy-intensive. The long-term sustainability of PoW-based cryptocurrencies has been a topic of increasing scrutiny due to the environmental impact of Bitcoin's energy consumption.

Ethereum's Transition from PoW to PoS

Ethereum, the second-largest cryptocurrency by market capitalization, commenced its voyage by employing the Proof-of-Work (PoW) consensus mechanism, which is comparable to Bitcoin. Nevertheless, Ethereum implemented a long-awaited transition to Proof-of-Stake (PoS) in response to the increasing apprehensions regarding scalability, energy consumption, and environmental impact. This transition, which is referred to as "The Merge" or "Ethereum 2.0," was one of the most significant milestones in blockchain technology and illustrated the potential of PoS to establish more sustainable and scalable block chain systems.

Other Blockchain Projects Implementing PoS

Although Ethereum's transition to Proof-of-Stake (PoS) has garnered substantial attention, numerous other blockchain projects have effectively employed PoS or PoS-like consensus mechanisms. These initiatives are favored as alternatives to Proof-of-Work (PoW) systems due to their emphasis on energy efficiency, scalability, and sustainability. This section emphasizes several of the most prominent blockchain platforms that have implemented Proof of Stake (PoS).

Cardano (ADA): Cardano is a blockchain platform that employs a PoS consensus mechanism, which is among the most prominent. Cardano, which is based on the Ouroboros PoS protocol, was established by Charles Hoskinson, a co-founder of Ethereum.



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•**Ouroboros PoS Algorithm:** Ouroboros is a PoS algorithm that is highly secure and divides time into epochs and modules. A leader is chosen to validate and generate new blocks in each position, with the likelihood of selection determined by the quantity of ADA (Cardano's native cryptocurrency) that they have staked. The protocol is one of the most rigorously peer-reviewed PoS systems in existence due to its emphasis on mathematical security proofs.

Polkadot (DOT): Polkadot, developed by the Web3 Foundation, is another leading blockchain platform that has embraced PoS through a mechanism known as Nominated Proof-of-Stake (NPoS).

•**Nominated Proof-of-Stake:** In NPoS, token holders have the option to either validate transactions themselves or designate other participants (validators) to do so on their behalf. The likelihood of a validator being selected to validate blocks and earn rewards increases as the number of DOT tokens they possess or have been nominated with increases. This guarantees that both validators and nominators are motivated to uphold the network's security and act honestly.

Tezos (XTZ): Tezos is a blockchain platform that is capable of self-amending and employs a PoS consensus mechanism called Liquid Proof-of-Stake (LPoS).

•**Liquid Proof-of-Stake:** Tezos' LPoS system enables participants to either directly validate blocks or delegate their staking authority to others, who are referred to as bakers. Bakers are accountable for the validation of transactions and the protection of the network. The governance model of Tezos is unique in that it allows participants to propose and vote on protocol enhancements. This on-chain governance guarantees that the network can develop without the necessity for abrupt divisions.

Cosmos (ATOM): A PoS consensus mechanism is employed to secure the network of Cosmos, an ecosystem of interconnected blockchains. The Tendermint Byzantine Fault Tolerant (BFT) consensus protocol serves as the foundation of its architecture.

•**Tendermint BFT:** Tendermint, the fundamental consensus algorithm employed in Cosmos, is a proof-of-stake (PoS) system in which validators are chosen to generate new blocks based on their staked ATOM tokens. Validators receive incentives for their participation; however, they may also be penalized (slashed) for dishonesty. Tendermint guarantees rapid finality, which guarantees that transactions are promptly verified and cannot be undone.

Algorand (ALGO): Algorand is a blockchain that operates on a Pure Proof-of-Stake (PPoS) variant, which is a distinctive PoS-based system. Silvio Micali, a Turing Award recipient and MIT professor, developed Algorand to strike a balance between scalability, decentralization, and security.

•**Pure Proof-of-Stake:** Validators are chosen at random and in proportion to their stake in the network in Algorand's PPoS system. This random selection guarantees that the network remains decentralized, as there is no incentive to consolidate power in the hands of a small number of large validators. Additionally, Algorand is highly scalable due to its speedy transaction velocities and affordable fees. The figure2 explains about PoS consensus mechanism.

CONCLUSION

The comparison between Proof-of-Work (PoW) and Proof-of-Stake (PoS) demonstrates that each consensus mechanism is uniquely adapted for various blockchain applications due to its significant differences in energy consumption, scalability, environmental impact, and sustainability. Although PoW, which was implemented by early blockchain pioneers such as Bitcoin, has demonstrated its resilience and security, its energy requirements have become a significant issue, thereby contributing to the ongoing discussion regarding the environmental consequences of cryptocurrency mining. The high levels of energy consumption and substantial carbon footprint associated with the immense computational power necessary to secure PoW networks such as Bitcoin have resulted in a compelling need for more sustainable alternatives. Conversely, PoS has emerged as a viable, energy-efficient alternative, as evidenced by the success of networks such as Ethereum, Cardano, and Polkadot in securing blockchain systems without the exorbitant energy requirements of PoW. PoS networks enable the evolution of





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blockchain technology in an environmentally favorable and sustainable direction by utilizing economic incentives and staking mechanisms, rather than computational power, to achieve substantial reductions in energy consumption. Furthermore, PoS mechanisms facilitate quicker transaction processing, decentralization, and enhanced scalability, all while ensuring a high level of security.

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Table 1: Comparative Analysis between PoW and PoS

	PoW	PoS	Winner
Energy Efficiency	PoW's energy demands are driven by the need for miners to perform intensive computations continuously	PoS, by design, eliminates the need for computational mining.	PoS is clearly more energy-efficient
Security	PoW's security is based on computational power	PoW's security is based on computational power	PoS is Secure, PoS is clearly more energy-efficient
Decentralization	PoW allows anyone with sufficient computational power to participate in the mining process.	PoS enables participants to become validators by staking their tokens	Both PoW and PoS face decentralization





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Scalability	PoW networks are notoriously slow and expensive	PoS networks are generally more scalable than PoW	PoS is better suited for scalable blockchain system
Environmental Impact	PoW networks, especially large ones like Bitcoin, have been criticized for their significant environmental impact.	PoS drastically reduces the environmental footprint of blockchain systems by eliminating the need for energy-intensive mining.	PoS is vastly more environmental friendly.

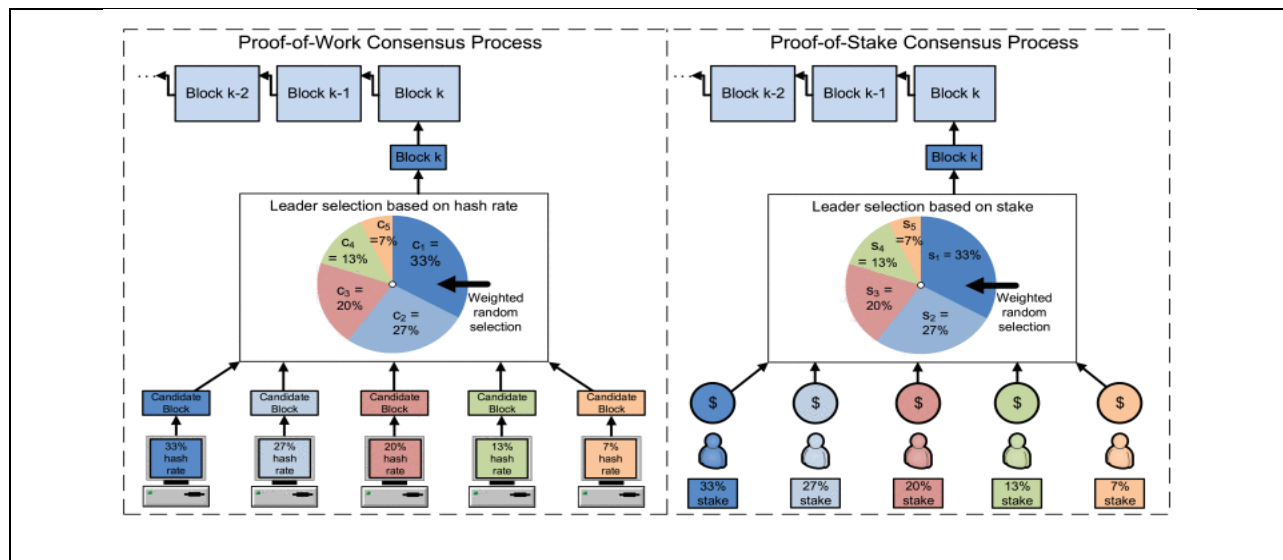


Fig 1. Comparison of PoW and PoS Consensus Mechanism[8].

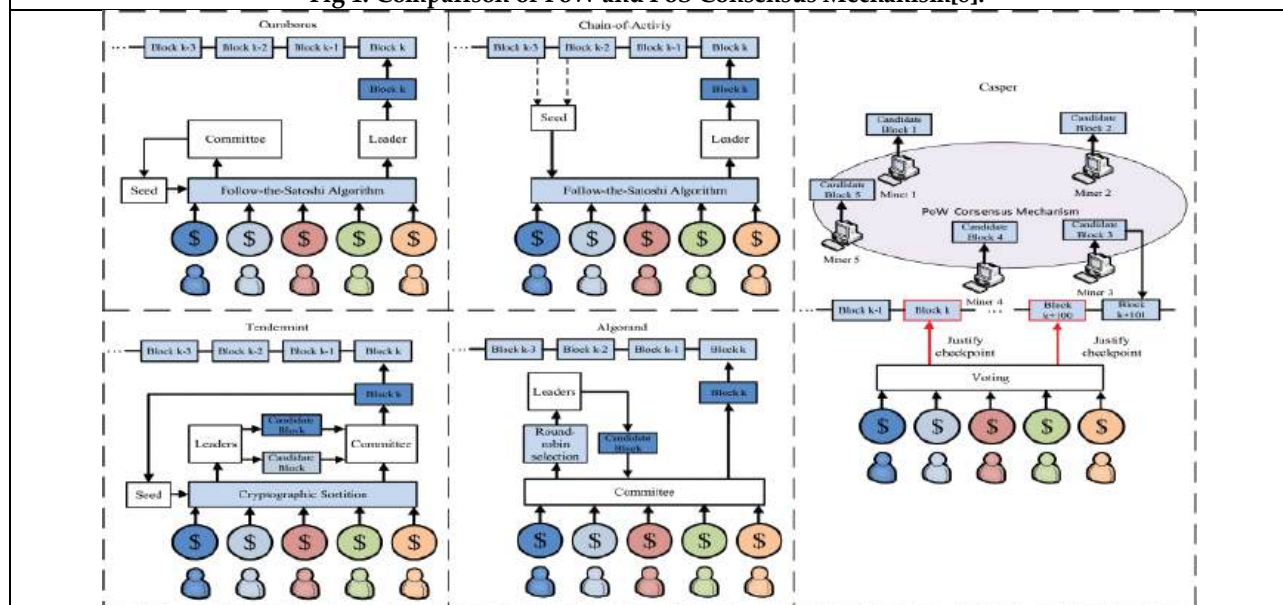


Fig 2: Illustrations of several PoS consensus process[8].





A Review on the Challenges in Industry 4.0 Implementation: Current Issues and Future Solutions

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ABSTRACT

Industry 4.0, often referred to as the Fourth Industrial Revolution, and integrates advanced digital technologies, such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, and cyber-physical systems (CPS), into manufacturing processes. This transformation promises increased productivity, reduced operational costs, enhanced product customization, and improved decision-making through data-driven insights. However, implementing Industry 4.0 is fraught with challenges, including technological barriers like legacy system integration, organizational issues such as workforce skill gaps, and external concerns surrounding data security, regulatory compliance, and environmental impact. This paper explores these challenges in depth and proposes potential strategies to overcome them, providing a roadmap for industries aiming to fully harness the potential of Industry 4.0.

Keywords: Industry 4.0, Digital Transformation, Manufacturing, Smart Factories, Sustainability

INTRODUCTION

Industry 4.0 is revolutionizing the industrial landscape by integrating smart technologies such as IoT, AI, big data, and cyber-physical systems into manufacturing operations. This paradigm shift promises significant benefits, including real-time monitoring of production processes, predictive maintenance, autonomous decision-making, and mass customization. The term "smart factories" describes this new era of production environments, where machines, systems, and humans interact seamlessly to achieve high levels of efficiency [1]. A flow diagram depicting the major technologies associated with Industry 4.0, including IoT, AI, big data, cloud computing, robotics, and cyber-physical systems (CPS). Each component is connected to demonstrate how they interact in a smart factory environment. However, the transition to Industry 4.0 has been slower than anticipated. While large enterprises have the financial



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and technical resources to adopt these technologies, many companies, particularly small and medium-sized enterprises (SMEs), face substantial barriers. These barriers include the high cost of technology integration, lack of a skilled workforce, cybersecurity risks, and a complex regulatory landscape [2]. This paper aims to provide a comprehensive analysis of the key challenges facing Industry 4.0 adoption and offers solutions for overcoming these obstacles.

Technological Challenges**Interoperability Issues**

One of the fundamental technological challenges in Industry 4.0 is ensuring interoperability between modern digital systems and legacy equipment. Many manufacturing companies, particularly in traditional sectors, rely on older machinery that predates the digital revolution. These machines often lack the sensors and communication capabilities required to integrate with IoT networks and advanced software systems [3]. Retrofitting legacy systems is often a costly and complex process that involves installing sensors, connecting devices to the cloud, and enabling machine-to-machine communication. A diagram that contrasts modern, IoT-enabled machinery with traditional legacy machines. The image should demonstrate the interoperability challenges that arise due to the lack of digital connectivity in older equipment, emphasizing the need for retrofitting and upgrading. In addition to hardware limitations, software interoperability is a significant concern. Different vendors and manufacturers use proprietary systems that may not communicate with each other due to incompatible communication protocols and data formats. The lack of standardization in IoT technologies hinders the seamless integration of systems within and across factories, creating operational inefficiencies [4]. To address this, international standardization bodies such as ISO and IEC have been working on developing unified communication standards for Industry 4.0, but widespread adoption is still in its infancy.

Data Management and Analytics

Data is the cornerstone of Industry 4.0, where the ability to collect, store, and analyze massive amounts of data in real-time is essential for optimizing manufacturing processes. However, managing such large volumes of data poses significant challenges. Many organizations struggle with the complexity of implementing data infrastructure that can handle the scale and velocity of information generated by IoT sensors, machines, and supply chain systems [5]. Advanced analytics, such as machine learning algorithms and AI, are critical for extracting actionable insights from this data. However, deploying AI models requires a high level of expertise and computational power, which many companies lack. The shortage of data scientists and AI professionals has created a bottleneck in realizing the full potential of data analytics in manufacturing [6]. Implementing cloud-based solutions for data storage and analytics is a potential solution, but it introduces additional concerns about data security and latency.

Cybersecurity Concerns

The integration of IoT devices and increased connectivity in Industry 4.0 significantly expands the attack surface for cyber threats. As smart factories rely on real-time communication between machines, products, and humans, any disruption to these networks can lead to costly production downtime, data breaches, and intellectual property theft [7]. Many manufacturers, especially those who have only recently begun their digital transformation, are ill-prepared to handle sophisticated cyberattacks. An illustration showing the real-time data flow from IoT devices, sensors, and machines into a central cloud system for analytics. The image can highlight potential cybersecurity risks like ransomware attacks, data breaches, and vulnerabilities in the IoT infrastructure. Ransomware, industrial espionage, and attacks targeting critical infrastructure are among the most pressing cybersecurity concerns in Industry 4.0. IoT devices are particularly vulnerable due to their often-limited computational resources, making it difficult to implement robust security measures such as encryption or real-time monitoring [8]. To mitigate these risks, companies must adopt comprehensive cybersecurity strategies that include multi-layered security architectures, network segmentation, and regular vulnerability assessments [9].

Organizational Challenges

**Ranjan Behera****High Implementation Costs**

The financial burden of adopting Industry 4.0 technologies is a significant challenge, particularly for small and medium-sized enterprises (SMEs). Implementing smart manufacturing systems requires substantial upfront investments in new hardware, software, and employee training. Retrofitting legacy systems to integrate with modern technologies further increases costs. While larger enterprises may have the capital to invest in digital transformation, SMEs often operate on tighter margins and may struggle to justify these expenditures [9]. A comparative chart displaying the cost breakdown of adopting Industry 4.0 technologies, including hardware, software, employee training, and maintenance, alongside a graph showing long-term productivity gains and ROI. Beyond the initial investment, companies must account for the ongoing costs associated with maintaining and upgrading Industry 4.0 technologies. These include regular software updates, hardware maintenance, and the potential need for constant innovation to keep pace with rapid technological advancements. Public-private partnerships, government incentives, and access to affordable financing are critical to helping SMEs overcome these financial barriers [10].

Workforce Skill Gaps

Industry 4.0 introduces a shift in the required skill set for workers in manufacturing environments. Traditionally, manufacturing has relied on manual labor and repetitive tasks that require minimal technical expertise. However, as factories become more digitized and automated, the demand for workers proficient in digital tools, data analytics, and programming has skyrocketed [11]. A before-and-after comparison showing how the workforce's skill set evolves with the adoption of digital manufacturing technologies. The figure should illustrate the shift from low-skilled, manual tasks to high-skilled roles in AI, data analytics, and programming. This skill gap presents a significant challenge for companies looking to adopt Industry 4.0. Many employees lack the necessary training to operate new technologies, and upskilling initiatives are both time-consuming and expensive [12]. Reskilling programs are essential to bridge this gap, but companies must also consider long-term workforce planning strategies to ensure they have a steady pipeline of talent capable of meeting the demands of Industry 4.0 [13]. Collaboration between educational institutions and industry to develop relevant curricula is crucial for preparing the workforce of the future.

Resistance to Change

Organizational resistance to change is another major barrier to the adoption of Industry 4.0 technologies. Employees, particularly those who have worked in traditional manufacturing settings for many years, may resist the introduction of automation and digital tools out of fear of job displacement [14]. Additionally, the shift from manual to automated processes can cause anxiety and uncertainty among workers, leading to a reluctance to embrace new technologies. Moreover, the cultural shift required for successful Industry 4.0 implementation extends beyond the factory floor. Companies must transform their organizational structures, moving away from traditional hierarchical models to more decentralized, agile structures that allow for real-time decision-making [15]. Implementing change management strategies, fostering a culture of continuous learning, and promoting collaboration between humans and machines are essential for overcoming resistance to Industry 4.0.

Regulatory and Ethical Challenges**Standardization**

The lack of universally accepted standards for key Industry 4.0 technologies, such as IoT, AI, and cybersecurity, is a major hurdle to the widespread adoption of smart manufacturing. Without standardized communication protocols, data formats, and security measures, companies face significant challenges in achieving interoperability between systems and devices [1]. This results in inefficiencies, as companies often need to invest in custom solutions to enable their technologies to communicate effectively. International organizations such as ISO, IEC, and NIST have recognized the need for standardized approaches to Industry 4.0 and are working to develop guidelines and frameworks. However, the adoption of these standards across industries and regions remains slow, creating a fragmented landscape that complicates the implementation of global smart manufacturing solutions [9].



**Ranjan Behera****Data Privacy**

The increasing use of data-driven technologies in Industry 4.0 raises significant concerns about data privacy and protection. Regulations such as the European Union's General Data Protection Regulation (GDPR) impose stringent requirements on how companies collect, store, and process personal data [16]. Manufacturers must navigate complex legal landscapes to ensure compliance with these regulations, especially when dealing with data from different jurisdictions with varying privacy laws. Failure to comply with data privacy regulations can result in hefty fines and damage to a company's reputation. Additionally, the need to balance data accessibility for optimization purposes with the protection of sensitive information presents an ongoing challenge for Industry 4.0 adopters. Implementing robust data governance frameworks and ensuring that IoT devices and cloud platforms adhere to privacy-by-design principles are critical for addressing these concerns.

Environmental and Social Impact

The environmental and social implications of Industry 4.0 are increasingly coming under scrutiny. On the one hand, smart manufacturing has the potential to improve sustainability by optimizing resource use, reducing waste, and enhancing energy efficiency. However, the production of Industry 4.0 technologies themselves, such as IoT devices and advanced robotics, contributes to electronic waste (e-waste) and resource depletion [17]. Furthermore, the automation of manufacturing processes may lead to job displacement, particularly in low-skilled roles. While Industry 4.0 creates opportunities for new high-skilled jobs, the transition period could exacerbate unemployment and social inequality in certain regions [18]. Companies adopting Industry 4.0 must consider these ethical implications and work toward minimizing the negative environmental and social impacts through sustainable practices and responsible innovation.

Solutions and Future Directions**Government Incentives and Support**

Governments play a critical role in facilitating the adoption of Industry 4.0 technologies by providing financial incentives, such as tax breaks, grants, and subsidies, to companies investing in digital transformation [10, 19, 20]. In addition to financial support, governments can help by developing regulatory frameworks that encourage innovation while ensuring data privacy, security, and environmental protection. Public-private partnerships and collaborative innovation networks are also essential in helping industries navigate the challenges of Industry 4.0.

Collaboration and Standardization

Greater collaboration between industry stakeholders, technology providers, and standardization bodies is crucial for addressing the interoperability issues that plague Industry 4.0 adoption. By working together to develop and adopt common standards, companies can reduce the costs and complexity associated with integrating disparate systems. Initiatives such as the Industrial Internet Consortium (IIC) and Plattform Industrie 4.0 are already working toward this goal, but more widespread participation from manufacturers is needed [3].

Investment in Workforce Development

Addressing the workforce skill gap requires a concerted effort from both the public and private sectors. Companies must invest in upskilling and reskilling initiatives to prepare their employees for the demands of Industry 4.0. In parallel, educational institutions should update their curricula to reflect the changing needs of the manufacturing industry, placing a greater emphasis on digital literacy, data analytics, and programming [11]. Apprenticeships, internships, and on-the-job training programs can help bridge the gap between theoretical knowledge and practical skills.

CONCLUSION

The transition to Industry 4.0 brings technological, organizational, and regulatory challenges, requiring careful planning and collaboration. By leveraging advanced technologies like IoT and AI, businesses can drive innovation





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and productivity, while fostering an inclusive and sustainable future. From the current study following conclusions can be drawn.

1. **Technological and Organizational Challenges:** The transition to Industry 4.0 brings numerous challenges, primarily in adapting to new technologies such as IoT, AI, robotics, and big data analytics. Organizations must also address internal hurdles, including workforce upskilling, restructuring processes, and integrating new systems with legacy infrastructure.
2. **Complex Path to Full Implementation:** Although the advantages of smart manufacturing— such as increased efficiency, reduced costs, and enhanced innovation—are clear, implementing these technologies fully is a complex process. It requires businesses to make significant adjustments, including updating machinery, digitalizing operations, and securing reliable data flows.
3. **Need for Careful Planning, Collaboration, and Investment:** Achieving the goals of Industry cannot happen without detailed planning. Companies need to align their strategies with technological capabilities, collaborate with partners and stakeholders, and make substantial financial investments in infrastructure, R&D, and employee training.
4. **Tackling Challenges Through Advanced Technologies:** By addressing these challenges head-on, businesses can harness the power of advanced technologies like the Internet of Things (IoT), artificial intelligence (AI), big data analytics, and machine learning. Proper utilization of these tools can dramatically boost productivity, foster innovation, and promote sustainability in the long term.
5. **Collaboration Among Policymakers, Educational Institutions, and Industry Leaders:** To ensure that the benefits of Industry 4.0 are shared across society, collaboration between policymakers, educational institutions, and industry leaders is crucial. Governments must create supportive regulatory frameworks, educational institutions should adapt curricula to prepare future workers, and industry leaders must drive initiatives to foster innovation and inclusivity.
6. **Creating a Resilient and Inclusive Future:** The ultimate aim of Industry 4.0 is not just about improving manufacturing, but about shaping a future where technology empowers a more resilient and inclusive society. By ensuring that all stakeholders—employees, businesses, governments, and communities—are involved, the Fourth Industrial Revolution can lead to sustainable growth and broad-based prosperity for all.

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Figure 1: Key technologies driving the Industry 4.0 revolution.



Figure 2: Interoperability issues between modern IoT systems and legacy equipment.

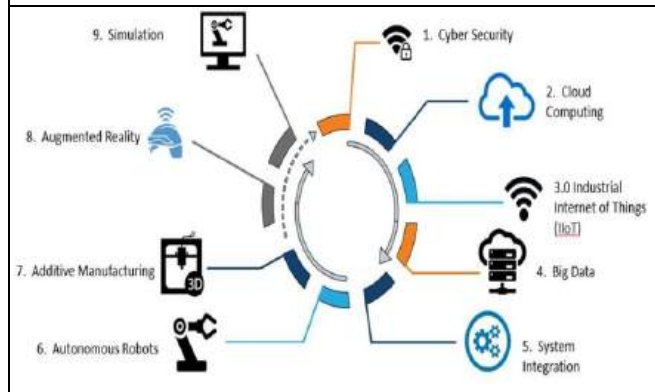


Figure 3: Data flow in Industry 4.0 with corresponding cybersecurity vulnerabilities.

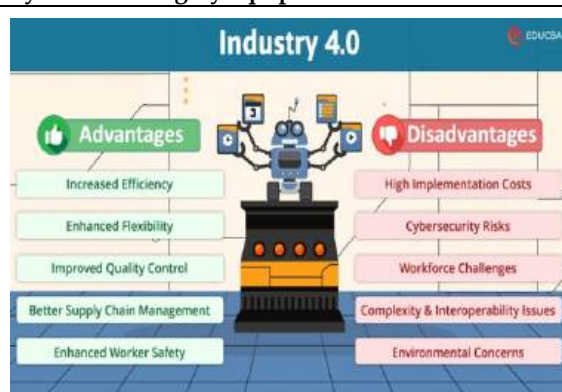


Figure 4: Cost of implementing Industry 4.0 technologies versus expected benefits.





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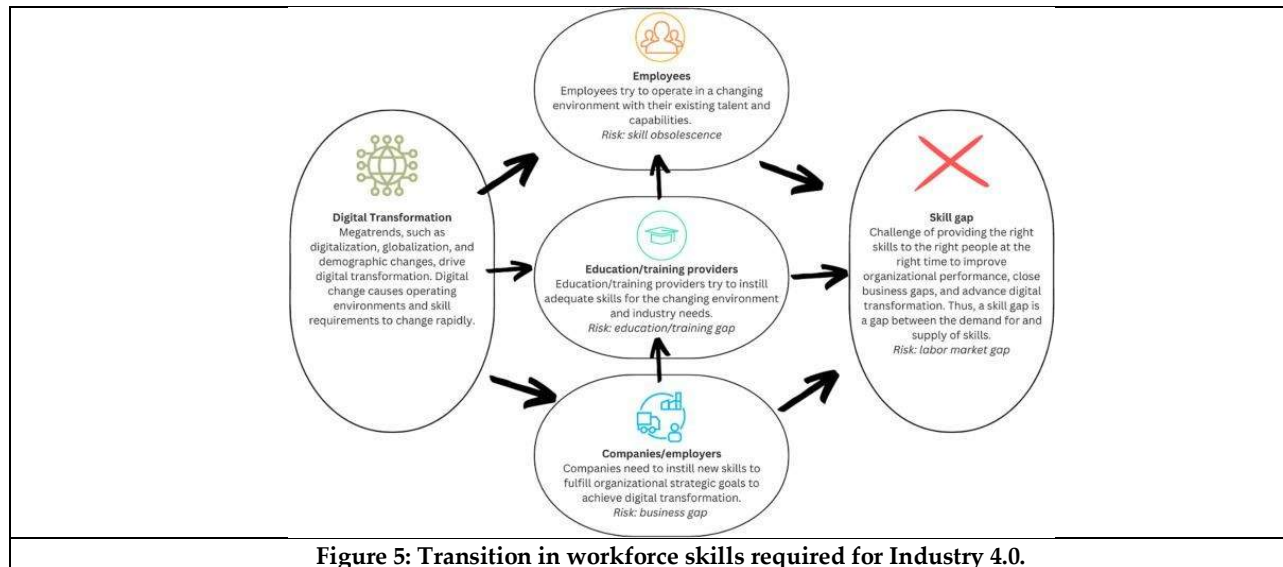


Figure 5: Transition in workforce skills required for Industry 4.0.





Hyperglycemia Detection via Hybrid CNN and Decision Trees: A SQL Server and ESP8266 Approach

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ABSTRACT

Hyperglycemia, characterized by elevated blood glucose levels, presents significant health risks, particularly for individuals with diabetes. Timely and accurate prediction of hyperglycemic events is crucial for effective management and prevention of complications. This study introduces an innovative hybrid learning framework that integrates Convolutional Neural Networks (CNN) with Decision Trees, alongside SQL Server and ESP8266, for real-time hyperglycemia prediction. The CNN model extracts complex features from continuous glucose monitoring (CGM) data, identifying patterns associated with hyperglycemic trends. These features are then fed into a Decision Tree classifier, delivering interpretable predictions of hyperglycemic events. Data acquisition is handled by the ESP8266 microcontroller, which gathers glucose readings from CGM devices and transmits them to an SQL Server database for efficient storage and preprocessing. SQL Server ensures the management of large-scale data and seamless integration with the predictive model. This system facilitates real-time analysis, issuing alerts and personalized recommendations to patients or healthcare providers when hyperglycemia is anticipated.



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By combining the powerful feature extraction capabilities of CNNs with the decision-making strengths of Decision Trees, this approach provides a scalable, accurate, and interpretable solution for hyperglycemia prediction in big data environments. The integration of IoT technology, such as ESP8266, enables continuous monitoring, making the system highly applicable to real-world medical scenarios. The study also compares the performance of predictive models, including AdaBoost, Random Forest, and the Proposed Model, evaluating precision, recall, classification accuracy, and F1-score. The Proposed Method demonstrated superior accuracy, achieving 98.15%.

Keywords: CNN, Decision Tree, Decision Tree, ESP8266

INTRODUCTION

Hyperglycemia, characterized by elevated blood glucose levels, is a common issue in individuals with diabetes and can lead to serious complications like cardiovascular disease, kidney damage, and vision problems if not properly managed. Accurate prediction is crucial for timely intervention through medication, diet, and lifestyle changes. Predicting hyperglycemia involves analyzing various factors such as glucose levels, diet, exercise, and insulin intake. Traditional methods struggle with high-dimensional data, often resulting in inaccurate predictions. Machine learning models offer a solution by efficiently analyzing large datasets, identifying patterns, and delivering highly accurate predictions. These advanced models enable proactive management, reducing the risk of complications and improving patient outcomes.

REVIEW OF LITERATURE

Sharma *et al.* (2019) presents an innovative framework integrating Internet of Things (IoT) technology with predictive models for healthcare monitoring, specifically targeting the prediction of Hyperglycemia in diabetic patients. The study utilizes the ESP8266 microcontroller to collect real-time data from glucose sensors and other wearable devices, feeding this data into a hybrid machine learning model composed of Convolutional Neural Networks (CNNs) and Decision Trees. The integration of IoT facilitates continuous, real-time data acquisition, enhancing the predictive accuracy and timeliness of the model. Experimental results show that the hybrid approach significantly outperforms conventional predictive models, demonstrating improved accuracy and reliability in forecasting hyperglycemic events. The research highlights the critical role of IoT in advancing predictive healthcare, enabling proactive management and personalized treatment plans for patients with diabetes [11].

Smith *et al.* (2016) propose a novel approach for predicting hyperglycemia using Convolutional Neural Networks (CNNs). The research addresses the challenges of accurately forecasting blood glucose levels in patients with diabetes by leveraging the deep learning capabilities of CNNs. The model is trained on continuous glucose monitoring (CGM) data, extracting complex temporal patterns associated with hyperglycemic events. By automatically identifying critical features without manual input, the CNN demonstrates superior performance compared to traditional statistical methods and other machine learning models. The results highlight the CNN's ability to accurately predict imminent hyperglycemia, providing a potential tool for real-time intervention and management in diabetic care. This study underscores the significance of deep learning in enhancing predictive accuracy, ultimately contributing to improved patient outcomes [1]. Kumar *et al.* (2023) developed a real-time monitoring system using the ESP8266 microcontroller to predict hyperglycemia in diabetic patients. This study focuses on the integration of ESP8266 with wearable glucose sensors to collect continuous blood glucose data, which is then transmitted to a cloud-based server for real-time analysis. The predictive model employs a hybrid approach, combining Convolutional Neural Networks (CNNs) for feature extraction and Decision Trees for classification. The system enables timely predictions of hyperglycemic events, allowing for prompt interventions. Results demonstrate





that the proposed framework achieves high prediction accuracy and reliable performance, significantly improving patient monitoring and management compared to traditional methods. This study highlights the effectiveness of ESP8266 in IoT-enabled healthcare systems, emphasizing the potential of real-time monitoring in enhancing diabetes care and patient outcomes [16].

METHODOLOGY

Step 1: The ESP8266 microcontroller is interfaced with a continuous glucose monitoring (CGM) device to collect real-time glucose readings. It transmits the data wirelessly via Wi-Fi to a server or local processing unit, where it is sent to an SQL Server for storage and further analysis.

Step 2: Data Storage in SQL Server: SQL Server stores glucose readings, timestamps, patient data, and prediction outcomes. SQL queries are used to clean and preprocess the data, such as handling missing values and normalizing readings, before it is input into the CNN model for analysis.

Step 3: Data Preprocessing: The main goal of preprocessing is to clean and transform the data into a suitable format for neural networks. First, glucose readings from CGM devices were categorized as “low” if blood glucose (BG) values were below 60 mg/dL and “high” if above 400 mg/dL. The CGM readings (inputs) and predicted BG values (outputs) were then capped at a minimum of 60 and a maximum of 400. Additionally, insulin and carbohydrate (CHO) data were converted into binary values, with 0 and 1 representing absence and presence, respectively.

Step 4: Feature Extraction Using CNN: Glucose level time-series data is reshaped into sequences suitable for CNN processing, such as a rolling window of the past 24 hours of readings. The CNN extracts high-level features like sudden spikes, long-term trends, and other glucose dynamics related to hyperglycemia. Pooling layers reduce dimensionality, and the features are flattened into a 1D array, making them ready for input into the Decision Tree model for further classification.

Step 5: Classification Using Decision Tree: The flattened feature vector from the CNN is input into a Decision Tree classifier. The model is trained to classify glucose states as either hyperglycemic or normal using historical data from SQL Server. Pruning techniques are applied to simplify the Decision Tree and minimize overfitting, improving its ability to generalize to new, unseen data.

Step 6: The hybrid model operates in real-time, continuously processing incoming glucose data to predict hyperglycemia events.

Evaluation Metrics

The accuracy of blood glucose predictions using time series forecasting models like LSTM and ARIMA can vary widely depending on data quality, model parameters, and preprocessing steps. One common evaluation metric is Mean Absolute Error (MAE), which measures the average magnitude of prediction errors, disregarding their direction. It is calculated as:

$$MAE = \frac{1}{n} \sum_{i=1}^n |y_i - \hat{y}_i|$$

Root Mean Squared Error (RMSE): this is the root of MSE, which gives a measure of the error in the same units as the target variable.

$$RMSE = \sqrt{MSE}$$

R-Squared (Coefficient of Determination): this statistic indicates the proportion of the variance in the dependent variable that is predictable from the independent variables. It is calculated as

$$R^2 = 1 - \frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{\sum_{i=1}^n (y_i - \bar{y})^2}$$

PROCEDURE PREDICTION ():

(1) INITIALIZE count Point = 0

(2) WHILE count Point < numberOfPointInFile:





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// Step 3: Data extraction for current point
(3) EXTRACT data // Lookback window data
// Step 4: Extract glucose level for the current prediction point
(4) EXTRACT glucose // Current prediction point
(5) INCREMENT count Point++
// Step 6: Split the extracted data into train and test sets
(6) SPLIT data INTO train, test
// Step 7: For each model in the model list, proceed with training and prediction
(7) FOR each model IN model List:
// Step 8: Train the model using the training set
(8) TRAIN model // Model training phase
// Step 9: Predict glucose values using the trained model
(9) PREDICT glucose ON training set (train Glucose)
// Step 10: Obtain model weights using Genetic Algorithm (GA)
(10) GET model weights USING Genetic Algorithm (GA)
// Step 11: For each trained model, predict test glucose values
(11) FOR each train Model IN train Model List:
// Step 12: Predict glucose on the test data
(12) PREDICT glucose ON test set (test Glucose)
// Step 13: Multiply the predicted test glucose by the respective model weight
(13) MULTIPLY train Model weight BY test predicted glucose (test Pred Glucose)
// Step 14: Accumulate the weighted predictions for each model
(14) SUM all weighted predictions INTO model Sums Result
// Step 15: Calculate Root Mean Square Error (RMSE)
(15) CALCULATE RMSE (test Glucose, model Sums Result)

RESULTS AND DISCUSSIONS

Performance Evaluation: The proposed model's performance is assessed using metrics such as accuracy, precision, recall, F1-Score, and ROC-AUC. These metrics offer valuable insights into the model's effectiveness, especially when dealing with imbalanced data, such as in hyperglycemia prediction.

Confusion Matrix: The confusion matrix is utilized to evaluate the performance of a binary classification problem for the given dataset. The diagonal elements represent true positives (TP) and true negatives (TN), which indicate correctly classified instances. In contrast, false positives (FP) and false negatives (FN) reflect incorrectly classified





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instances. The matrix summarizes the correctly classified instances as TP + TN and the incorrectly classified instances as FP + FN.

Table 1: Comparison of various algorithms Accuracy, Mean Absolute Error (MAE), Rooted Mean Square Error (RMSE), Rooted Absolute Error (RAE) Values.

Precision: Precision is the ratio of correctly predicted positive observations to the total predicted positives.

Precision = $\frac{\text{True Positives (TP)}}{\text{True Positives (TP)} + \text{False Positives (FP)}}$

True Positives (TP) + False Positives (FP)

Recall (Sensitivity) Recall is the ratio of correctly predicted positive observations to the actual positives.

Recall = $\frac{\text{True Positives (TP)}}{\text{True Positives (TP)} + \text{False Positives (FP)}}$

True Positives (TP) + False Positives (FP)

F-measure (F 1-score) The F 1 -score is the harmonic mean of precision and recall. It provides a single Metric that balances both precision and recall, particularly useful when there is an uneven class distribution

F1 Score = $\frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$

Precision + Recall

Scenario in Hyperglycemia Prediction

True Positives (TP): Number of correctly predicted hyperglycemia events.

False Positives (FP): Number of events incorrectly predicted as hyperglycemia.

False Negatives (FN): Number of actual hyperglycemia events missed by the model.

CONCLUSION

The hybrid approach overcomes many limitations of traditional predictive models by improving the accuracy, reliability, and timeliness of hyperglycemia predictions. Real-time monitoring through the ESP8266 provides healthcare providers with immediate insights into patients' glucose trends, facilitating prompt interventions to prevent severe hyperglycemic events. Furthermore, SQL Server ensures scalable and secure management of large datasets, essential for effectively handling continuous glucose monitoring data. Ultimately, the Proposed Hybrid Method achieved an impressive accuracy of 98.15%.

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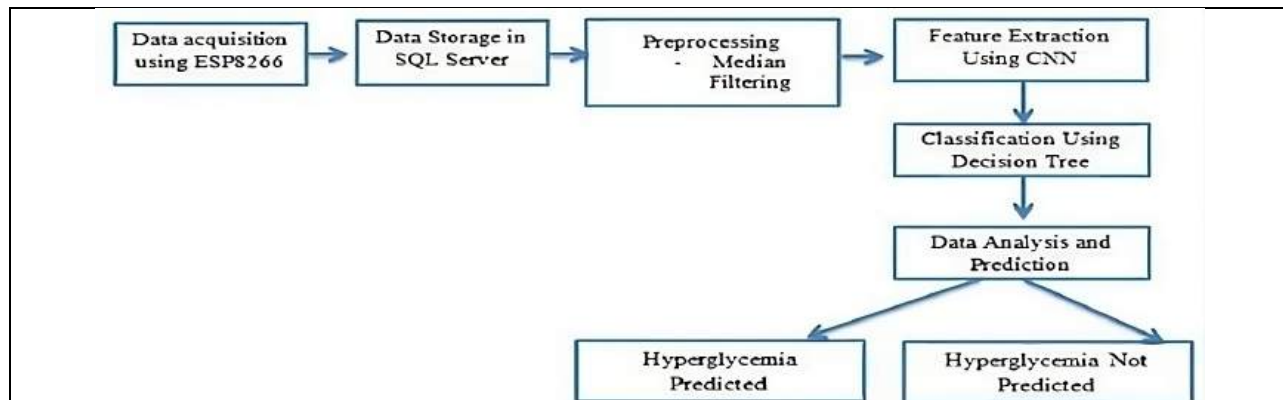
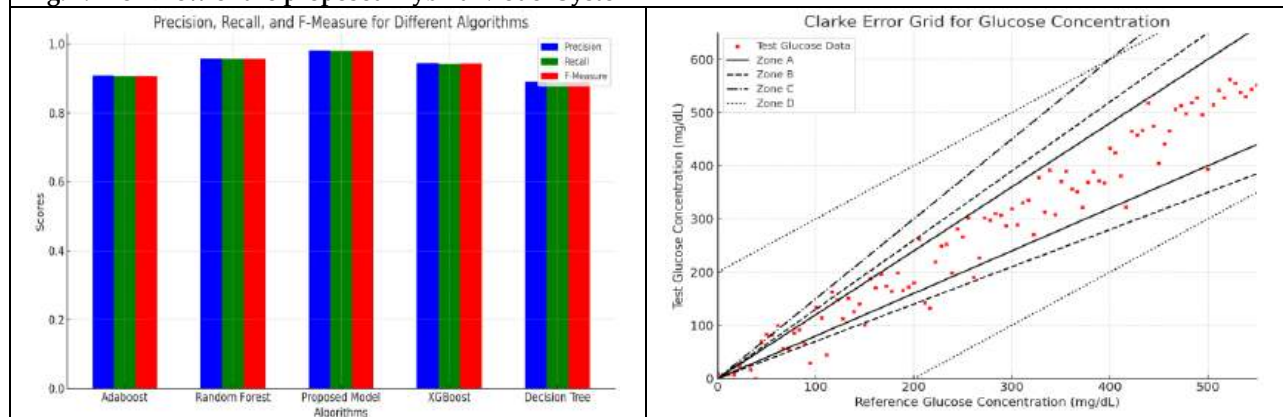


**Table 1: Comparison of Various algorithms Accuracy, Mean Absolute Error (MAE)**

Algorithm	Accuracy	MAE	RMSE	RAE
Adaboost	91.58	0.167	0.279	34.16%
Random Forest	96.025	0.069	0.164	13.61
XGBoost	94.30	0.075	0.172	15.20
Decision Tree	89.00	0.182	0.305	36.50
Proposed Model	98.15	0.049	0.142	11.59%

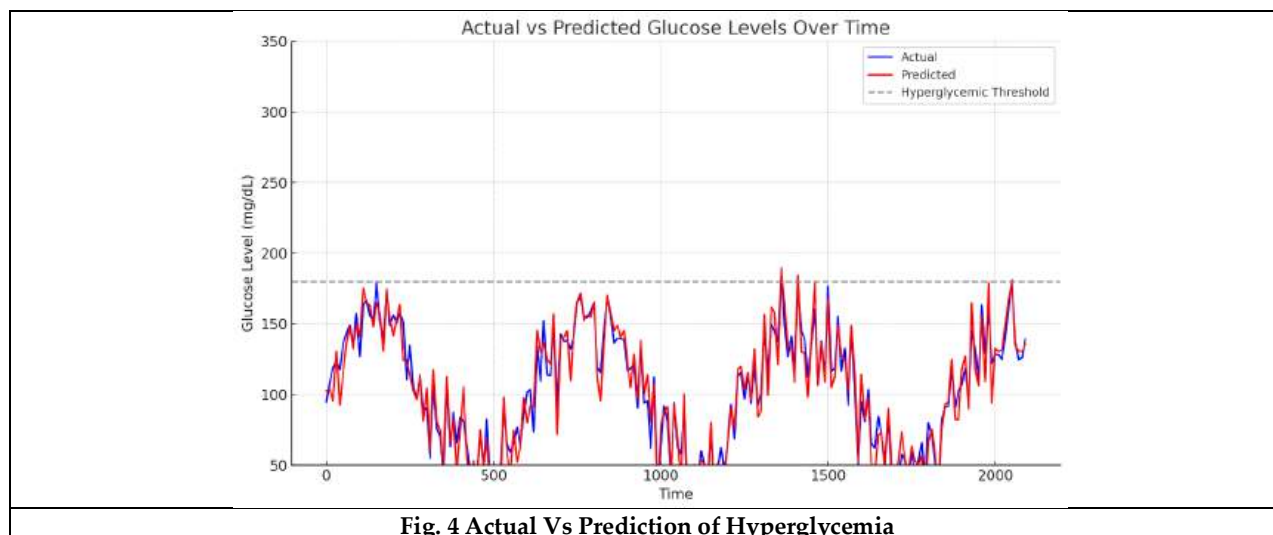
Table 2: F1-Score of Existing and Proposed Model.

Algorithm	Precision	Recall	F-Measure
Adaboost	0.908	0.906	0.906
Random Forest	0.957	0.956	0.956
XGBoost	0.943	0.941	0.942
Decision Tree	0.890	0.889	0.889
Proposed Model	0.989	0.989	0.989

**Fig. 1: Workflow of the proposed Hybrid Model System****Fig. 2: Comparison of various algorithms with Proposed Model****Fig. 3 Best Case of Blood Glucose Level**



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Stock Market Trading Strategies using Options Chain

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ABSTRACT

This paper presents a comprehensive study on the development of trading strategies using options chain data combined with Relative Strength Index divergence analysis. Options chain provides critical market insights through key parameters like open interest, implied volatility, and put-call ratios, while RSI divergence serves as a robust technical indicator to predict potential price reversals. By integrating these two analytical frameworks, traders can enhance their ability to identify entry and exit points in the market with greater precision. The research explores how open interest shifts, changes in implied volatility, and institutional activity within the options market can complement RSI divergence to signal overbought or oversold conditions. We examine case studies focusing on NIFTY options in the Indian stock market to validate the effectiveness of these combined strategies. This paper contributes to the growing body of knowledge on advanced technical trading methods and offers actionable insights for traders looking to maximize profitability through the synergy of options chain data and RSI divergence.

Keywords: option chain, Long Build-Up, Long Unwinding, Short Build-Up, Short Covering.





INTRODUCTION

Trading using option chain data has gained significant traction among investors and traders in the Indian stock market, as it offers a unique perspective on market sentiment and potential price movements. An option chain provides a comprehensive listing of all available options contracts for a particular underlying asset, detailing various strike prices, expiration dates, and key metrics such as open interest (OI) [1], implied volatility (IV)[2], and volume [3]. This rich dataset enables traders to glean insights into market dynamics that are not readily apparent from traditional price charts alone. Options [5] are derivatives that give traders the right, but not the obligation, to buy or sell an underlying asset at a specified price within a designated time frame. The information contained in the option chain can reveal crucial signals about market expectations, risk sentiment [6], and potential price reversals. For instance, a sudden increase in open interest at a particular strike price may indicate bullish or bearish sentiment among traders, while shifts in implied volatility can signal impending price movements [4]. By analysing the option chain, traders can develop strategies that align with their market outlook, allowing for more informed decision-making. This includes identifying key support and resistance levels based on the distribution of open interest, assessing market sentiment through the put-call ratio, and utilizing implied volatility as a gauge for potential price fluctuations [7]. The objective of this paper is to examine the effectiveness of trading strategies based on option chain analysis in the Indian stock market [5]. By employing a systematic approach to interpret the data provided by option chains, the study aims to enhance traders' ability to forecast market movements, optimize their entry and exit points, and improve risk management practices [6]. Ultimately, understanding and leveraging option chain data can provide traders with a competitive edge in navigating the complexities of the derivatives market [8].

METHODOLOGY

Long Build-Up: New long positions in calls, indicating bullish sentiment and increasing open interest.

Long Unwinding: Closing long positions in calls, signalling a shift in sentiment, often after profit realization.

Short Build-Up: New short positions in puts, indicating bearish sentiment and increasing open interest.

Short Covering: Closing short positions in puts, signalling a shift to a more bullish outlook or risk mitigation.

Tab.1 The above chart is related IDEA company dated 23-9-24 from <https://web.sensibull.com/>

Here at strike price 11 put sellers OI change % is 34 indicating Idea price will not fall below Rs. 11 if it falls then put short covering will take place and may fall further rapidly

Here at strike price 12 CALL sellers OI change % is 67 indicating Idea price may not cross Rs. 12 and if it crosses 12 then call short covering will take place and may further rise upward rapidly

Tab 2. The above chart is nifty option chain from NSE site dated 23-9-24 from <https://www.nseindia.com/option-chain>

Note: OI is open interest it may be sellers or buyers but normally it experiences traders treat them as mainly sellers and then analyse it on sellers' perspective accordingly as follows Here at strike price 25900 put sellers OI change is 145346 indicating nifty price will not fall below 25900 on next day if it falls then put short covering will take place and may fall further rapidly

Here at strike price 26000 CALL sellers OI is 280115 is more than PUT sellers OI 125327 for same strike price indicating NIFTY has some resistance around 26000 but until strike price 26200 call sellers are not increased indicating upward movement of NIFTY on next day

Trading tick trending OI graph of bank nifty at 9:30 a.m. date: 24-9-24,





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Fig 1. The above bank nifty chart is taken from <https://tradingtick.com> if you observe

The OI of 54000CE > 54000PE and 54100CE > 54100PE

Which suggest that bank nifty may cross 54200 today so one sell 54300 CE

@ 400 with stop loss 420 and whenever it reaches 300 one can book profit

Similarly, one can sell 54200CE @440 with stop loss 460 and whenever it reaches 350 one can book profit

Bank nifty trading view graph at 9:30 a.m. date: 24-9-24,

Fig 2. Bank nifty NSE option data at 9:30 a.m. date: 24-9-24,

Tab 3. By observing above bank nifty OI details

And from trading tick we have The OI of 54000CE > 54000PE and 54100CE > 54100PE

Which suggest that bank nifty may cross 54200 today so one sell 54300 CE

@ 400 with stop loss 420 and whenever it reaches 300 one can book profit

Similarly, one can sell 54200CE @440 with stop loss 460 and whenever it reaches 350 one can book profit

RESULT AND DISCUSSION

Tab 1: IDEA Option Chain (23-09-2024)

- At strike price ₹11, the Put sellers' OI change is 34%, indicating that IDEA's price is likely to stay above ₹11. If the price falls below this level, put short covering may occur, potentially causing the price to fall further, rapidly.

- At strike price ₹12, the Call sellers' OI change is 67%, suggesting IDEA's price might not exceed ₹12. If the price crosses ₹12, call short covering could trigger a rapid upward movement.

Tab 2: Nifty Option Chain (23-09-2024)

- At strike price ₹25,900, the Put sellers' OI change is 145,346, indicating that Nifty is expected to hold above this level. A breach could result in put short covering, leading to a sharper decline.

- At strike price ₹26,000, the Call sellers' OI (280,115) is higher than the Put sellers' OI (125,327), indicating resistance around ₹26,000. However, there is no significant call seller increase at ₹26,200, implying an upward movement for Nifty the next day.

Tab 3: Bank Nifty Option Chain and Trading Analysis (24-09-2024, 9:30 AM)

- OI analysis from Trading Tick shows higher OI in 54,000 CE than 54,000 PE and 54,100 CE than 54,100 PE, indicating that Bank Nifty may cross ₹54,200.

- Suggested trades:

- Sell 54,300 CE at ₹400 with a stop-loss of ₹420 and book profit at ₹300.

- Sell 54,200 CE at ₹440 with a stop-loss of ₹460 and book profit at ₹350.

These insights suggest potential resistance and support levels, with trade setups based on open interest analysis for Nifty, IDEA, and Bank Nifty options.

CONCLUSION

The analysis of the option chains for IDEA, Nifty, and Bank Nifty on 23-09-2024 and 24-09-2024 provides clear insights into market sentiment based on open interest changes.

In summary, these observations highlight critical price levels for each asset and provide actionable strategies for traders, with a focus on monitoring potential breakouts or breakdowns to manage risk and optimize profit.

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- Option Volatility and Pricing: Advanced Trading Strategies and Techniques by Sheldon Natenberg

Tab 1.

IDEA 10.80 +3.2%		 Info	Expiry 26 Sep		ATM IV 77.4 -17.5		INDIAVIX 13.8 +1.0		IVP 88		Per L	
CALLS					PUTS							
Oil Chg%	Oil-1m	Call oi	LTP	Strike	IV	LTP	Put oi	Oil-1m	Oil Chg%			
0%	0.0		0.00	7	297.5	0.05		73.6	2.8%			
0%	0.4		2.90	8	220.6	0.05		122.4	7%			
4.5%	36.8		1.90	9	150.1	0.05		366.4	-15%			
-8%	272.0		0.95	10	122.7	0.15		660.8	-3.6%			
26%	910.8		0.25	11	77.4	0.40		497.6	34%			
67%	1394.4		0.10	12	110.8	1.25		496.8	14%			
-0.8%	1169.6		0.05	13	136.8	2.25		652.0	-6%			
-4.2%	2011.6		0.05	14	177.7	3.15		1241.6	-4%			
-7%	1616.0		0.05	15	213.7	4.15		1285.6	-2.3%			
-0.9%	2152.4		0.05	16	246.1	5.15		842.8	-5%			
0.2%	1823.2		0.05	17	275.7	6.15		381.2	-3.5%			
0%	1245.2		0.05	18	302.8	7.25		145.2	-2.7%			
0.1%	368.0		0.05	19	328.0	8.50		39.2	0%			
0.2%	546.0		0.05	20	351.4	9.20		61.6	-2.1%			
0%	159.6		0.05	22	394.0	-		-	-			
0%	91.6		0.05	24	431.8	-		-	-			

Tab.2

CALLS										PUTS										
OI	CHNG IN OI	VOLUME	IV	LTP	CHNG	BID QTY	BID	ASK	ASK QTY	STRIKE	BID QTY	BID	ASK	ASK QTY	CHNG	LTP	IV	VOLUME	CHNG IN OI	OI
1,37,571	-39,648	4,89,538	8.45	258.30	84.30	100	258.30	260.05	50	25,700.00	1,575	48.00	48.50	300	-67.05	48.00	15.09	15,95,269	51,524	2,48,617
26,563	-11,972	3,42,973	9.08	220.45	78.70	50	219.10	220.30	175	25,750.00	375	58.80	59.30	250	-75.50	59.20	14.83	8,34,020	17,918	69,821
1,92,453	-21,193	18,49,690	9.54	182.50	66.90	100	182.10	183.90	175	25,800.00	300	72.15	72.50	6,250	-82.25	72.10	14.55	25,95,963	1,15,912	2,29,357
71,955	4,643	18,92,020	9.98	151.90	60.60	25	150.35	151.90	200	25,850.00	475	90.20	90.85	50	-90.90	90.20	14.58	18,93,276	68,737	94,331
1,83,555	73,475	46,30,595	10.18	123.90	52.95	25	123.10	123.90	225	25,900.00	225	111.80	112.60	225	-97.90	111.80	14.62	36,65,573	1,45,346	1,63,796
79,810	48,803	22,94,928	10.40	98.50	45.25	100	97.60	98.50	275	25,950.00	450	136.75	137.00	2,650	-105.65	137.00	14.71	9,76,342	32,292	35,476
2,80,115	28,200	39,78,725	10.55	76.50	35.75	425	75.90	76.50	550	26,000.00	12,725	165.00	165.60	125	-112.75	165.00	14.83	13,88,287	65,253	1,25,327
58,825	16,317	10,91,040	10.66	57.40	28.00	25	57.45	58.00	425	26,050.00	350	194.80	198.00	300	-125.95	194.90	15.16	1,70,077	10,427	11,526
1,26,776	6,572	18,52,798	10.78	43.30	21.75	1,300	43.30	43.55	550	26,100.00	50	231.00	232.90	375	-129.90	231.10	15.50	2,34,519	8,591	11,577
47,651	4,999	9,82,441	10.96	32.55	17.05	350	32.10	32.55	600	26,150.00	25	269.35	272.70	75	-132.40	270.25	16.05	34,801	1,863	2,484
2,00,519	12,555	23,47,604	11.10	23.95	12.40	25	23.40	23.95	75	26,200.00	200	310.60	314.10	350	-133.05	313.50	16.72	82,372	5,245	7,351

Tab 3.

OI	CHNG IN OI	VOLUME	IV	LTP	CHNG	BID QTY	BID	ASK	ASK QTY	STRIKE	BID QTY	BID	ASK	ASK QTY	CHNG	LTP	IV	VOLUME	CHNG IN OI	OI
22,244	44	806	25.88	1,133.30	-75.55	15	1,128.85	1,133.25	15	52,900.00	465	25.80	25.90	735	-18.20	26.00	27.89	67,502	4,384	64,278
66,307	424	7,352	-	1,044.80	-62.30	105	1,047.50	1,051.95	105	53,000.00	60	29.55	29.65	1,485	-11.40	29.65	26.95	1,99,501	10,299	1,96,366
14,470	27	1,737	21.98	942.50	-77.15	45	954.05	957.00	30	53,100.00	810	34.40	34.50	285	-11.85	34.45	-	86,210	3,586	58,497
16,552	41	2,223	-	845.70	-81.45	15	847.55	849.70	45	53,200.00	255	41.15	41.25	975	-12.10	41.35	25.11	1,06,432	12,608	79,532
13,143	154	4,153	20.73	756.30	-73.90	60	757.30	759.80	30	53,300.00	375	50.00	50.10	225	-12.25	50.05	24.33	1,08,557	7,117	64,720
29,688	79	4,879	-	669.55	-79.45	45	668.65	670.35	60	53,400.00	375	61.35	61.55	450	-12.65	61.40	22.64	1,13,339	11,206	80,307
50,150	2,034	29,585	20.91	595.50	-71.65	30	596.05	598.05	30	53,500.00	15	74.95	75.10	60	-14.00	75.05	23.18	2,50,850	23,113	1,82,612
22,031	3,859	27,287	20.78	503.00	-82.80	90	503.90	504.95	30	53,600.00	150	96.60	96.85	165	-11.20	96.90	22.84	2,04,757	21,751	84,974
41,910	6,779	48,839	20.71	441.05	-71.05	225	441.20	442.10	75	53,700.00	120	119.30	119.55	180	-12.70	119.60	22.64	1,64,294	23,782	76,706
54,522	20,871	1,39,172	20.85	371.75	-67.80	195	371.05	371.90	120	53,800.00	90	149.20	149.50	75	-11.50	149.40	-	2,08,326	24,568	1,00,413
74,868	20,001	1,96,781	20.70	309.35	-64.15	360	308.85	309.45	15	53,900.00	120	187.85	188.15	90	-8.60	187.70	22.48	2,58,140	32,694	1,18,560
210,165	81,782	5,57,554	20.72	246.90	-67.40	45	246.90	247.10	60	54,000.00	135	238.85	239.25	30	2.60	239.20	-	6,12,885	70,610	2,12,199
1,26,624	59,567	3,76,442	20.83	200.25	-62.40	150	200.15	200.50	240	54,100.00	210	291.30	291.85	195	8.05	292.00	22.55	4,01,380	46,482	96,601
1,37,118	43,371	2,92,575	-	160.50	-56.50	15	160.35	160.55	210	54,200.00	45	352.90	353.55	120	14.05	352.80	22.75	2,57,541	26,555	57,511
71,307	14,587	1,78,232	21.19	127.50	-49.35	60	127.50	127.60	90	54,300.00	30	419.65	420.00	105	21.60	420.00	23.29	1,20,197	12,673	23,598
58,632	15,108	1,65,030	21.49	100.20	-43.15	270	100.40	100.65	885	54,400.00	15	481.00	482.00	45	15.70	480.95	23.74	41,511	2,384	7,883
1,36,384	40,432	3,24,848	21.82	78.55	-57.75	135	78.40	78.60	1,005	54,500.00	15	573.45	574.70	105	33.80	573.35	24.15	43,418	5,326	15,032





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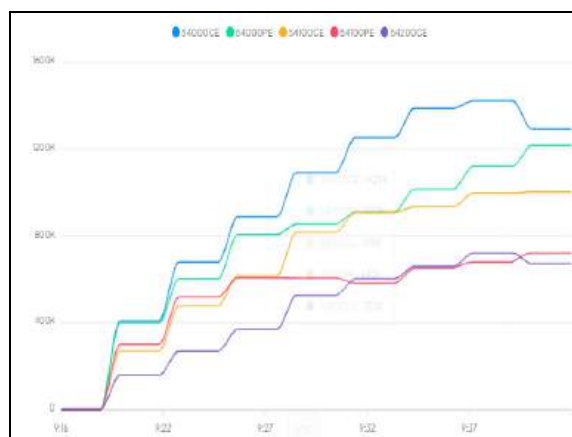


Fig.1



Fig.2





Electric Vehicles: An Indian Market Scenario

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ABSTRACT

"The present Research work highlights the Scenario of India's electric vehicle (EV) market is rapidly evolving, supported by government initiatives, infrastructure development, and growing consumer awareness about environmental sustainability. However, it faces unique challenges and opportunities that shape its path toward widespread adoption. In addition, typical applications of Simulation in Electric Vehicles are presented. Thus, by leveraging simulation technologies, the development of electric vehicles becomes more efficient, cost-effective, and aligned with sustainability goals, leading to better performance and user satisfaction in real-world applications"



Deepak Kumar *et al.*,

Keywords: Electric Vehicles (EVs), Indian Market Scenario; Future prospects of EVs, Optimization, Battery Management Systems.

INTRODUCTION

“India’s electric vehicle (EV) market is rapidly evolving, supported by government initiatives, infrastructure development, and growing consumer awareness about environmental sustainability. However, it faces unique challenges and opportunities that shape its path toward widespread adoption [1].

Key Components for Electric Vehicle Simulation

Government Policies and Incentives

1. FAME Scheme: The Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, introduced by the Government of India, provides financial incentives for EV adoption and the development of EV infrastructure. FAME I launched in 2015, and FAME II, introduced in 2019, focuses on subsidizing EV purchases and charging infrastructure [2].
2. PLI Schemes: The Production-Linked Incentive (PLI) scheme incentivizes domestic EV and battery manufacturing. India aims to decrease reliance on imports, encourage local production, and stimulate job creation [3].
3. State Initiatives: Several states, including Maharashtra, Delhi, and Karnataka, offer tax breaks, registration fee waivers, and subsidies to make EVs more affordable [4].

Growing EV Market Segments

1. Two- and Three-Wheelers: Two-wheelers and three-wheelers dominate the Indian EV market due to affordability and urban transport demand. Manufacturers like Ola Electric, Hero Electric, and Bajaj Auto have introduced affordable electric scooters and motorcycles [5].
2. Passenger Cars: While still small, the passenger car segment is growing. Tata Motors leads this segment, with models like the Nexon EV and Tigor EV gaining popularity. Hyundai, MG, and Mahindra are also expanding their EV lineups [6].
3. Commercial Vehicles: Electric buses, light trucks, and delivery vans are emerging in commercial fleets, especially for last-mile delivery services. Companies like Ashok Leyland, Tata Motors, and Eicher Motors are investing in electric commercial vehicles [7].
4. The India electric vehicle market size was valued at USD 220.1 million in 2020 and is expected to grow at a compound annual growth rate (CAGR) of 94.4% from 2021 to 2030. The Indian Electric Vehicle Market Scenario is presented in Figure 1.

Advantages of Electric Vehicles (EVs)

Cost-Effective Development:

“Simulations help manufacturers avoid costly physical prototyping by testing vehicle performance, power trains, and battery systems in virtual environments before actual production. This reduces the need for building multiple prototypes, saving both time and resources [8].

Accelerated Development Process:

Simulations allow for rapid testing of various designs, systems, and components under different conditions, leading to quicker iterations and refinement of the EV. This accelerates the time-to-market for new models [9].

Safety Improvements:

Simulating crash scenarios, battery failure, or other dangerous conditions allows engineers to identify potential safety issues and resolve them before real-world testing, enhancing overall vehicle safety” [10].





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Performance Optimization:

“Engineers can use simulations to optimize the efficiency of electric powertrains, energy consumption, and battery life under various driving conditions (e.g., different speeds, loads, or temperatures), leading to better performance of EVs in real life [11-12].

Battery Management System (BMS) Optimization:

Simulations are used to test and refine BMS algorithms, which are critical in managing battery health, state of charge, state of power, and ensuring battery longevity and safety in EVs” [13-14].

METHODOLOGY

Here are some of the latest electric vehicles (EVs) set to hit both the Indian and international markets: [15-16].

In India

Tata Punch EV and Altroz EV: Tata Motors is expanding its EV lineup with affordable options like the Tata Punch EV and Altroz EV, both estimated for release by early 2025. The Punch EV is designed as a compact SUV with a range of around 300 km, while the Altroz EV will likely offer a range near 300 km and be priced competitively at around ₹12–15 lakh [17].

Mahindra XUV e8 and XUV e9: These SUVs are Mahindra's latest electric additions, expected by early 2025. The XUV e8, priced around ₹35–40 lakh, and the more advanced e9 model, estimated at ₹38 lakh, are both anticipated to offer high-end features like advanced driver assistance and a range of around 400 km [18].

Hyundai Creta EV and Kona Electric 2024: Hyundai's Creta EV, expected in late 2024, will cater to the compact SUV market with a targeted range exceeding 400 km. The updated Kona Electric 2024 is also slated for release, featuring enhanced battery capacity and range for about ₹25 lakh [19].

Internationally

Volkswagen ID.4: Slated for launch in various markets, including India, by late 2024, this compact SUV has an expected range of about 450 km, priced at approximately ₹50–60 lakh. It features a spacious interior with advanced technology, making it a popular choice globally [20].

Fisker Ocean: This premium SUV offers a range of up to 560 km and comes with unique features like a solar roof. It's expected to launch in international markets for about ₹80 lakh by 2025 [21].

BYD Seagull: BYD, known for affordable EVs in China, introduces the Seagull, an entry-level EV estimated around ₹10 lakh, targeted for release in international markets by early 2025. This compact model is perfect for city driving with a range suited for urban use [22].

Hyundai Ioniq 6: Hyundai's stylish and aerodynamically efficient Ioniq 6 is expected internationally and in India by mid-2025. With a range exceeding 500 km, it's aimed at the premium EV segment [23-24].

These launches underscore the growth of the EV market, with models spanning from budget-friendly compact EVs to luxurious, high-range options designed to cater to varied needs and preferences worldwide.

The Overview of Indian Electric Vehicle Market Scenario is presented in Figure 2.

Challenges to Electric Vehicles Adoption

Charging Infrastructure: Despite advancements, India's EV charging infrastructure remains underdeveloped. The government and private players are investing in charging stations, especially in urban areas, but the network is still limited.

Battery Costs and Technology: EVs are expensive in India primarily due to battery costs. Lithium-ion batteries are the most common, but research into alternate chemistries like sodium-ion and solid-state batteries could reduce prices over time.

Range Anxiety and Consumer Awareness: Many consumers are hesitant due to concerns about driving range and charging accessibility. However, as models with longer ranges and faster-charging capabilities are introduced, this perception is gradually improving.





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CONCLUSIONS

Opportunities and Future Prospects

Renewable Energy Integration: EVs can be integrated with renewable energy sources like solar, making charging more sustainable and reducing dependency on coal-based power.

Battery Manufacturing and Recycling: The EV industry has spurred demand for local battery manufacturing and recycling units. Recycling initiatives help recover precious materials, reduce environmental impact, and manage battery costs.

Job Creation: The transition to electric mobility is expected to create jobs in manufacturing, sales, infrastructure, maintenance, and software development.

Key Players in the Market

- Domestic Companies: Tata Motors, Mahindra Electric, and Hero Electric are leading the domestic EV space.
- International Companies: MG Motor, Hyundai, and soon Tesla, are bringing global EV expertise and technology to India's market.
- Startups: Companies like Ather Energy, Ola Electric, and Revolt are crucial in the two-wheeler market, innovating with subscription-based models and battery-swapping technology.
- As consumer awareness about EVs rises, more Indians are considering EVs as a viable option, particularly in urban areas with charging access. Rising fuel prices also make EVs attractive in the long term, though the higher upfront costs remain a barrier.

India's EV market is set for steady growth, with policies, investments, and innovations reshaping the sector. With government support and public-private collaboration, India has the potential to become a major player in global EV markets, contributing significantly to emission reductions and energy security.

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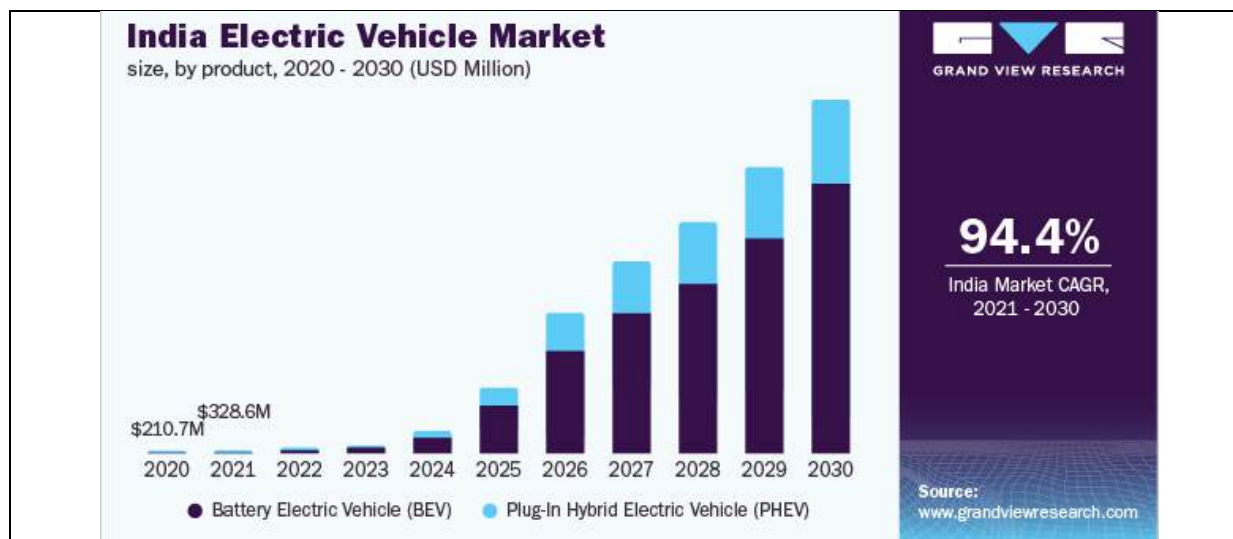


Figure 1. Indian Electric Vehicle Market Scenario

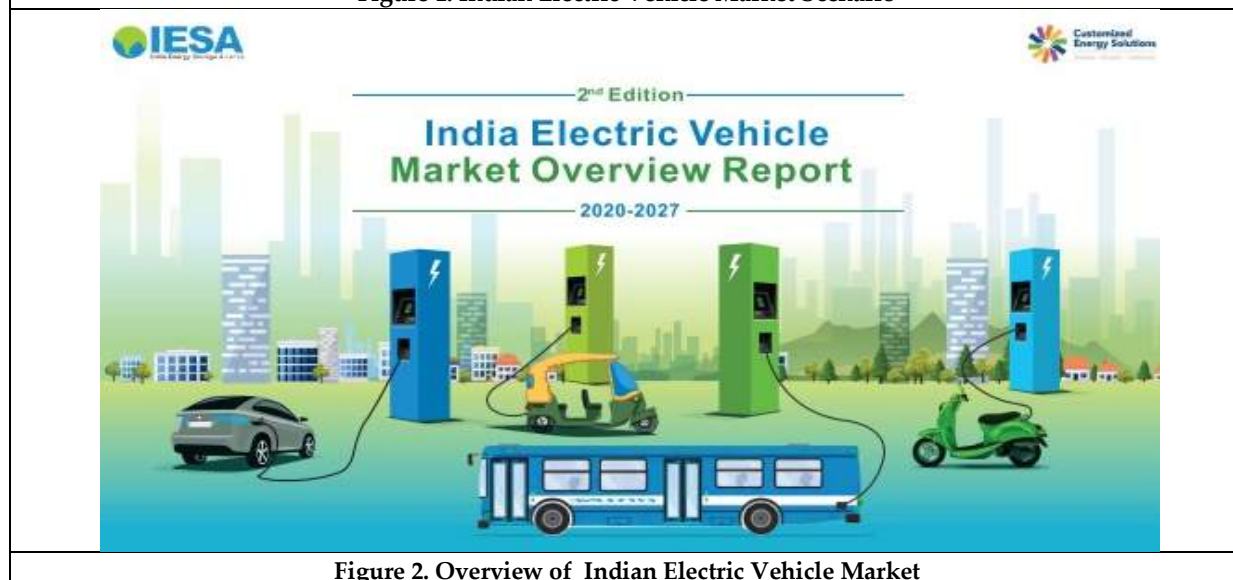


Figure 2. Overview of Indian Electric Vehicle Market





Silver Doped Zinc Oxide Nano Particles Mediated One-pot Synthesis of Octahydroquinazolinone/thione Derivatives

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ABSTRACT

Silver-doped Zinc Oxide nanoparticles function as an exceptionally effective heterogeneous catalyst for several chemical processes. A plethora of scientists have dedicated significant efforts to employing nano Ag-ZnO as a sustainable catalyst for the synthesis of N- and O-containing heterocyclic molecules. Nano Ag-ZnO was recognized as an exceptionally effective, eco-friendly, and recyclable heterogeneous catalyst for the synthesis of Octahydroquinazolinone/thione derivatives through a one-pot three-component reaction involving substituted aromatic aldehyde, urea/thiourea, and dimedone at 80°C, employing ethyl alcohol as the solvent.

Keywords: : Octahydroquinazolinone/thione derivatives, Nano Ag-ZnO, Aromatic aldehyde, urea/thiourea, dimedone.

INTRODUCTION

Multi-component reactions (MCRs) play a crucial role in chemical synthesis. Multi-component reactions (MCRs) involve three or more simple substrates within a single reaction vessel, yielding molecular complexity that integrates



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substantial elements from all reactants. MCRs have proven to be an invaluable asset in organic and medicinal chemistry, facilitating the synthesis of multifunctional and structurally diverse drug-like molecules. MCRs have arisen as an efficient synthetic approach due to their atom economy, simplicity of procedure, and convergent properties. Its importance principally resides in synthesis, encompassing pharmaceuticals, natural products, and biodegradable plastics, hence playing a pivotal role in both convergent and traditional synthesis [1-6]. The development of efficient, eco-friendly technology for the rapid synthesis of potentially advantageous compounds has emerged as a key goal for researchers in organic synthesis. The formation of carbon-carbon bonds is crucial in organic compounds, such as medicines, biodegradable polymers, and natural products, and significant research has been devoted to this area. Heterogeneous catalysis is generally preferred over homogeneous catalysis in various industrial applications and fundamental research because of its simple workup, reusability, and ease of manipulation. In light of economic and environmental considerations, there is an ongoing effort to replace conventional catalysts with solid heterogeneous catalysts, primarily owing to their non-toxicity, cost-effectiveness, non-corrosiveness, and ease of recovery and reuse. Surface-active metal oxides are commonly utilized to construct heterogeneous catalysts, improving the effectiveness of these MCRs by augmenting yield, minimizing reaction time, and reducing waste generation. Nano ZnO has numerous advantages, including enhanced yields, diminished reaction time, easy catalyst separation, and the possibility of reuse.

The Bizinelli reaction is a notable carbon-carbon bond-forming method in chemical synthesis for the production of pyrimidinone and its derivatives. These denote significant natural and synthetic substances that demonstrate remarkable pharmacological and biological properties. The fused pyrimidinone with an arylidene group is a crucial heterocyclic framework in antiviral, cytotoxic, antitumor, and anticancer pharmaceuticals. The conventional Biginelli reaction has been widely utilized in the synthesis of several chemical libraries in combinatorial chemistry. The innovative method for manufacturing arylidene heterobicyclic pyrimidinones entails the condensation reaction of aldehydes, urea or thiourea, and cyclohexanones, known as Biginelli-type reactions. In light of environmental and economic considerations, there is an ongoing effort to replace conventional catalysts with solid heterogeneous catalysts, mostly due to their non-toxicity, non-corrosiveness, cost-effectiveness, and simplicity of recovery and reuse. Metal oxides with surface-active properties are commonly utilized in the production of heterogeneous catalysts. The development of efficient and ecologically sustainable synthetic methods for the rapid assembly of potentially bioactive compounds has emerged as a main goal for chemists in organic synthesis. Improving the effectiveness of these MCRs through supplementary methods, such as yield optimization, decreased reaction time, and magnetically separable catalysts, is the central component of the suggested strategy[7-9]. As a result, in our continuous pursuit of developing an environmentally sustainable approach to heterocyclic synthesis, we have sought to synthesize hexahydroquinazolinone/thiones using the Bizinelli reaction. This entails the cyclization of aromatic aldehyde, dimedone, and urea or thiourea, employing ethyl alcohol as the solvent and Nano Ag-ZnO as the catalyst (Scheme 1). This work details the synthesis and characterization of Nano Ag-ZnO.

MATERIALS AND METHODS

All compounds employed in this study are of analytical grade and used directly without further purification. Zinc nitrate, silver nitrate, and sodium hydroxide were procured from Sigma Aldrich, and doubly distilled water was employed as needed for the experiment. All reactions were performed under ambient conditions at room temperature.

Experimental Methods

Procedure for the Synthesis of Ag doped Nano Zinc oxide

A 0.3 M solution of zinc nitrate hexahydrate ($\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$) was placed in a 500 ml beaker. Subsequently, 0.025 g of silver nitrate (AgNO_3) was introduced with continuous stirring for 30 minutes. A 0.4 M solution of sodium hydroxide (NaOH) was then added dropwise while maintaining continuous stirring at room temperature to precipitate metal hydroxides. The stirring process was maintained at 85°C for 6 hours to yield the as-synthesized



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powder. The synthesized powder was calcined in a muffle furnace at 600°C for 2 hours and then allowed to cool in the furnace. The resultant product was analyzed using XRD, SEM, and EDAX[14].

Characterization

FTIR (Fourier Transform Infrared) spectroscopy (Perkin Elmer - Spectrum RX-IFTIR) was utilized to ascertain the functional groups contained in the produced product. X-ray diffraction patterns were obtained using a Bruker X-ray diffractometer with graphite-filtered CuK radiation ($\lambda = 1.54 \text{ \AA}$) at 40 kV and a scanning rate of 3°/min (from $2\theta = 20^\circ$ to 80°). The morphology and size of the particles were assessed using a 200 KeV Transmission Electron Microscope (TECNAI 200 Kv TEM- Fei, Electron Optics). The elemental composition of particles was ascertained by SEM-EDAX (JEOL JSM 5600, EDS Model: INCA Oxford).

Fourier Transform-Infra Red (FT-IR) Spectral Analysis of Ag-ZnO

Figure 2 illustrates the FTIR spectra of both pure and silver-doped zinc oxide, indicating that the FTIR spectrum for Ag-doped ZnO closely resembles that of pure zinc oxide. FT-IR analysis was conducted using optimal settings to ascertain the bond structure and associated functional groups of the produced ZnO nanoparticles. The FTIR absorption spectra of the produced particles were characterized within the 4000-400 cm^{-1} wavenumber range (Figure 2). The band at 450 cm^{-1} is ascribed to the Zn–O stretching mode of the ZnO lattice. Within these limitations, no further peaks emerge owing to silver doping; this is likely because to the homogenous dispersion of Ag particles on the zinc oxide surface, devoid of any cluster formation. The band found near 3400 cm^{-1} was attributed to the vibrational mode of the O-H group. A weak band found near 2900 cm^{-1} was attributed to C-H modes. The sharp bands found between 1400-1600 cm^{-1} were attributed to stretching vibration modes of C=O groups[10-12].

X-Ray Diffraction (XRD) Analysis of Ag-ZnO

Figure 3 illustrates the XRD spectrum of both pure and silver-doped zinc oxide nanoparticles. The diffraction pattern of Ag-ZnO nanoparticles closely resembles that of pure ZnO, indicating high crystallinity and optimal particle size. The diffraction angle of 2θ was scanned within the range of 20° to 80° . The peaks seen at 31.80° , 34.47° , 36.29° , 47.58° , 56.62° , 62.90° , 66.40° , 67.98° , 69.11° , and 76.99° correspond to the reflecting planes (100), (002), (101), (102), (200), (112), (103), (110), (201), and (202) correspondingly. All diffraction patterns exhibit a strong similarity to the documented JCPDS (Joint Committee on Powder Diffraction Standards) corresponding to the hexagonal wurtzite crystal phase of the produced particles[13].

Scanning Electron Microscopy Analysis of Ag-ZnO

Figures 4(a, b) and 4(c, d) display the SEM images of the generated Pure and Ag-ZnO nanoparticles, respectively. SEM pictures indicate that the shape of ZnO nanoparticles has altered following Ag doping. The SEM images indicate that the produced Ag-ZnO nanoparticles were well agglomerated, exhibiting various sizes in a hexagonal configuration. At increasing magnification, the cubic structure is evident, indicating the existence of Ag nanoparticles, and the very porous nature suggests that Ag nanoparticles were deposited on the ZnO surface[11-14].

Transmission Electron Microscope (TEM) Analysis of Pure and Ag-ZnO

The produced nanoparticle samples were systematically investigated using TEM to determine their shape and actual size. The TEM picture of nano ZnO (figure 5(a,b)) reveals the presence of hexagonal wurtzite with a dimension of around 50 nm, whereas the size of the nanoparticles is approximately 30 nm. Figure 5(c, d) presents the TEM images of Ag-ZnO nanoparticles, indicating that their diameters ranged from 30 to 110 nm, with a predominant size of approximately 70 nm[15].

Energy Dispersive X-Ray(EDX) Analysis of Pure and Ag-ZnO

The elemental composition of the produced nanoparticles was verified using EDX analysis. Figures 6a and 6b present the EDX pictures of pure and Ag-doped ZnO nanoparticles, confirming the presence of Zn, Ag, and O, with no other impurities found[15].





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General procedure for the synthesis of Octahydroquinazolinone/thione derivatives

Aromatic aldehyde (10 mmol), urea (or thiourea) (15 mmol), dimedone (10 mmol), and Nano Ag-ZnO (500 mg), previously activated in a microwave oven for 2 minutes, were combined in a 50 ml round-bottom flask, to which 5 ml of ethyl alcohol was added as the solvent. The reaction mixture was refluxed at 80 °C for 20 minutes, and the reaction's progress was monitored using thin layer chromatography (n-Hexane, Ethyl acetate 5:1). Upon completion of the reaction, the catalyst was extracted from the reaction mixture using an external magnet. The reaction mixture was concentrated using a rotary evaporator, and the solid product was recrystallized many times from hot ethanol to obtain a pure product. The relevant products were validated using FT-IR, ¹H-NMR, and mass spectral analysis. Table 4.1

RESULT AND DISCUSSION

This research summarizes a convenient and efficient technique for synthesizing Octahydroquinazolinone/ thione derivatives using Bizinelli-type condensation, utilizing Nano Ag-ZnO particles as an effective catalyst, as illustrated in Scheme 1.

Plausible mechanism for the Synthesis of Octahydroquinazolinone/ thione derivatives

The proposed process for the changes catalyzed by Ag-ZnO nanoparticles is illustrated in Scheme 2, as inferred from analogous investigations documented in the literature. We have presented a viable strategy for the synthesis of octahydroquinazolinone 4 in the presence of Nano Cobalt ferrite. The reaction is thought to proceed via the production of a N-acyliminium intermediate 6, resulting in the synthesis of octahydroquinazolinone 4.

Spectral Data of octa hydroquinazolinones 3,4,7,8-tetrahydro-7,7-dimethyl-4-phenylquinazoline-2,5(1H,6H)-dione 4(a)

White solid, M.P :116°C ; IR(KBr) : 3442, 3353 (N-H str), 1671, 1593 (C=O Str), 1490, 1450 (Aromatic , C=C Str); ¹H NMR (400 mHz, CDCl₃): δ 1.12-1.26 (m, 6H, –CH₃), 2.28-2.31 (m, 4H, CH₂), 5.57 (s, 1H, CH), 7.11-7.19 (m, 2H, N-H), 7.20-7.35(m, 5H, Ar-H); ESI-MS m/z(%): 271 ([M+H]⁺ 100).

3,4,7,8-tetrahydro-4-(2-hydroxyphenyl)-7,7-dimethylquinazoline- 2,5(1H,6H)-dione 4(b)

White solid, M.P :128°C ; IR(KBr) : 3350 (N-H str), 2955 (-OH Str), 1690 (C=O Str), 1488, 1454 (Aromatic , C=C Str); ¹H NMR (400 mHz, CDCl₃): δ 1.00-1.98 (m, 6H, –CH₃), 2.33-2.62 (m, 4H, CH₂), 4.70 (m, 1H, CH), 4.70 (m, 1H, OH) 7.01-7.03 (m, 2H, N-H), 7.15-7.28 (m, 4H, Ar-H) ; ESI-MS m/z(%): 287 ([M+H]⁺ 100).

3,4,7,8-tetrahydro-7,7-dimethyl-4-(2-nitrophenyl)quinazoline-2,5(1H,6H)-dione 4(c)

White solid, M.P :132°C ; IR(KBr) : 3364(N-H str), 1671(C=O Str), 1523(Aromatic ,C=C Str),1368(-NO₂ Str); ¹H NMR (400 mHz, CDCl₃): δ 1.01-1.21 (m, 6H, –CH₃), 2.19-2.35 (m, 4H, CH₂), 5.53 (m, 1H, CH), 7.02 (m, 2H, N-H), 7.28-7.94 (m, 4H, Ar-H); ESI-MS m/z(%): 316 ([M+H]⁺ 100).

3,4,7,8-tetrahydro-4-(2-methoxyphenyl)-7,7-dimethylquinazoline-2,5(1H,6H)-dione 4(d)

White solid, M.P :132°C ; IR(KBr) : 3385(N-H str), 1641, 1603 (C=O Str), 1464 (Aromatic , C=C Str), 1066, 1048 (-OCH₃ Str); ¹H NMR (400 mHz, CDCl₃): δ 0.97-1.17 (m, 6H, –CH₃), 2.31-2.53 (m, 2H, CH₂), 3.50 (s, 3H, -OCH₃), 3.73-3.88 (m, 2H, CH₂), 5.49 (m, 1H, CH), 6.90-6.93 (m, 2H, N-H), 7.07-7.29 (m, 4H, Ar-H) ; ESI-MS m/z(%): 301 ([M+H]⁺ 100).

4-(2-chlorophenyl)-3,4,7,8-tetrahydro-7,7-dimethylquinazoline-2,5(1H,6H)-dione 4(e)

White solid, M.P :121°C ; IR(KBr) : 3472, 3392 (N-H str), 1640, 1610 (C=O Str), 1467 (Aromatic , C=C Str), 658 (-Cl Str); ¹H NMR (400 mHz, CDCl₃): δ 0.96-1.19 (m, 6H, –CH₃), 2.02-2.25 (m, 2H, CH₂), 2.29-2.52 (m, 4H, CH₂), 3.51 (s, 1H, CH), 7.08-7.13 (m, 2H, N-H), 7.28-7.39 (m, 4H, Ar-H) ; ESI-MS m/z(%): 305 ([M+H]⁺ 100).

4-(4-bromophenyl)-1,2,3,4,7,8-hexahydro-7,7-dimethyl-2-thioxoquinazolin-5(6H)-one 4(f)

White solid, M.P :123°C ; IR(KBr) : 3379 (N-H str), 1590 (Aromatic , C=C Str), 1201, 1157 (C=S Str), 583 (-Br Str); ¹H NMR (400 mHz, CDCl₃): δ 1.11-1.84 (m, 6H, –CH₃), 2.30-2.34 (m, 2H, CH₂), 2.39-2.49 (m, 2H, CH₂), 5.46 (m, 1H, CH), 6.96-7.09 (m, 2H, N-H), 7.28 -7.75 (m, 4H, Ar-H) ; ESI-MS m/z(%): 366 ([M+H]⁺ 100).

1,2,3,4,7,8-hexahydro-4-(2-hydroxyphenyl)-7,7-dimethyl-2-thioxoquinazolin-5(6H)-one 4(g)

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White solid, M.P :138°C ; IR(KBr) : 3379(N-H str), 3174(-OH Str)1537(Aromatic ,C=C Str), 1243(C=S Str), ¹H NMR (400 mHz, CDCl₃): δ 1.00-1.99 (m, 6H, -CH₃), 2.34-2.39 (m, 2H, CH₂), 2.47-2.62 (m, 2H, CH₂), 4.69 (m, 1H, CH), 4.69 (m, 1H, OH) 7.01-7.03 (m, 2H, N-H), 7.15-7.28 (m, 4H, Ar-H) ; ESI-MS m/z(%) :303 ([M+H]⁺ 100).

1,2,3,4,7,8-hexahydro-7,7-dimethyl-4-(2-nitrophenyl)-2-thioxoquinazolin-5(6H)-one 4(h)

White solid, M.P :132°C; IR(KBr) : 3565 (N-H str), 1518(Aromatic , C=C Str), 1341(-NO₂ Str) 1232(C=S Str); ¹H NMR (400 mHz, CDCl₃): δ 1.04-1.17 (m, 6H, -CH₃), 2.26-2.32 (m, 2H, CH₂), 2.36-2.47 (m, 2H, CH₂), 5.36 (m, 1H, CH), 6.06(m, 2H, NH), 7.28-7.50 (m, 4H, Ar-H) ; ESI-MS m/z(%) :332 ([M+H]⁺ 100).

1,2,3,4,7,8-hexahydro-4-(2-methoxyphenyl)-7,7-dimethyl-2-thioxoquinazolin-5(6H)-one 4 (i)

White solid, M.P :128°C ; IR(KBr) : 3384 (N-H str), 1464 (Aromatic , C=C Str), 1243 (C=S Str), 1067 (-OCH₃ Str); ¹H NMR (400 mHz, CDCl₃): δ 0.95-1.18 (m, 6H, -CH₃), 2.30-2.35 (m, 2H, CH₂), 2.41(m, 2H, CH₂), 3.50(s, 3H, -OCH₃), 5.60 (s, 1H, CH), 6.80-6.98 (m, 2H, N-H), 7.00- 7.28 (m, 4H, Ar-H) ; ESI-MS m/z(%) :317 ([M+H]⁺ 100).

4-(2-chlorophenyl)-1,2,3,4,7,8-hexahydro-7,7-dimethyl-2-thioxoquinazolin-5(6H)-one 4(j)

White solid, M.P :128°C IR(KBr) : 3391 (N-H str), 1433 (Aromatic , C=C Str), 1224 (C=S Str), 747, 648 (-Cl Str); ¹H NMR (400 mHz, CDCl₃): δ 0.97-1.18 (m, 6H, -CH₃), 2.28-2.37 (m, 2H, CH₂), 2.40-2.46 (m, 2H, CH₂), 5.65 (m, 1H, CH), 7.15 (m, 2H, N-H), 7.28-7.40 (m, 4H, Ar-H); ESI-MS m/z(%) :321 ([M+H]⁺ 100).

Effect of loading of catalyst on the synthesis of Octahydroquinazolinone/thione derivatives

The current reaction was examined with varying quantities of catalyst. The findings indicate that 500 mg of catalyst suffices to get a favorable product yield. An further increase in catalyst quantity will not result in a significant change in product yield. Consequently, 500 mg of catalyst was utilized to conduct the reaction. This study selected a mixture of benzaldehyde, urea/thiourea, and dimedone in ethyl alcohol as the model reaction (Scheme 1). The findings are presented in Table 2.

Effect of solvent on synthesis of Octahydroquinazolinone/thione derivatives

The investigation of the reaction medium indicated that solvents significantly influence the reaction. The findings are encapsulated in Table 3. Polar solvents, including acetic acid, CH₃CN, and C₂H₅OH, shown superior efficacy compared to non-polar solvents. Minimal yield detected when water served as the solvent, likely attributable to the agglomeration of the hydrophobic catalyst. Despite the efficacy of CH₃COOH, a poor yield was achieved upon catalyst reutilization. Consequently, we chose C₂H₅OH.

Effect of Temperature on Synthesis of Octahydroquinazolinone/thione derivatives

The reaction temperature for the synthesis of Octahydroquinazolinone/thione derivatives using the Nano Ag-ZnO catalyst is 80 °C, as shown in Table 4. It is noted that at temperatures below 80 °C, the product yield is low and the reaction time is prolonged. The reaction is conducted at 80 °C.

Recycling of the Catalyst

The reusability of catalysts is a critical aspect of heterogeneous catalysis. Catalyst recycling was accomplished by magnetically securing the catalyst to the bottom of the reflux flask using a powerful Neodymium magnet. Subsequently, the product-containing solution was removed with a pipette, the catalyst was washed three times with ethyl acetate, dried, and fresh reactants dissolved in ethyl alcohol were added to the round-bottom flask, followed by refluxing to facilitate the subsequent reaction cycle. The catalyst was reused five times consecutively without any significant loss of catalytic activity (Table 5).

CONCLUSION

Nano Ag-ZnO particles have been effectively utilized as a catalyst for the Bizinelli reaction involving aldehydes, urea/thiourea, and dimedone. The employment of this catalyst presents numerous benefits: High yield and rapid reaction rates can be attained; catalyst preparation is straightforward; minimal catalyst loading and ease of operation, with no by-product formation; the catalyst can be readily recycled using magnets and reused. This protocol further exemplifies the versatility of nano Ag-ZnO for tailored chemical applications. This work primarily



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contributes to the effective synthesis of nano Ag-ZnO, demonstrating a balance between recyclability and activity in the Bizinelli reaction.

Declarations

Competing interests: There are no competing interests

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Table 1 synthesis of Octahydroquinazolinone/thione derivatives

S. No.	Name of the Product	Time(min)	Yield(%)
1	3,4,7,8-tetrahydro-7,7-dimethyl-4-phenylquinazoline-2,5(1H,6H)-dione(4a)	20	96
2	3,4,7,8-tetrahydro-4-(2-hydroxyphenyl)-7,7-dimethylquinazoline-2,5(1H,6H)-dione(4b)	22	96
3	3,4,7,8-tetrahydro-7,7-dimethyl-4-(2-nitrophenyl)quinazoline-2,5(1H,6H)-dione(4c)	25	95
4	3,4,7,8-tetrahydro-4-(2-methoxyphenyl)-7,7-dimethylquinazoline-2,5(1H,6H)-dione(4d)	21	96
5	4-(2-chlorophenyl)-3,4,7,8-tetrahydro-7,7-dimethylquinazoline-2,5(1H,6H)-dione(4e)	23	94
6	4-(4-bromophenyl)-1,2,3,4,7,8-hexahydro-7,7-dimethyl-2-thioxoquinazolin-5(6H)-one(4f)	27	96
7	1,2,3,4,7,8-hexahydro-4-(2-hydroxyphenyl)-7,7-dimethyl-2-thioxoquinazolin-5(6H)-one(4g)	27	94
8	1,2,3,4,7,8-hexahydro-7,7-dimethyl-4-(2-nitrophenyl)-2-thioxoquinazolin-5(6H)-one(4h)	25	96
9	1,2,3,4,7,8-hexahydro-4-(2-methoxyphenyl)-7,7-dimethyl-2-thioxoquinazolin-5(6H)-one(4i)	27	94
10	4-(2-chlorophenyl)-1,2,3,4,7,8-hexahydro-7,7-dimethyl-2-thioxoquinazolin-5(6H)-one(4j)	25	96

Table 2: Effect of catalyst loading on the synthesis of Octahydroquinazolinone/thione derivatives

S.No.	Name of the nano catalyst	Catalyst loading in (mg)	Time (min.)	Yield (%)*
1	Nano Ag-ZnO	200	20	52
2	Nano Ag-ZnO	300	20	66
3	Nano Ag-ZnO	400	20	78
4	Nano Ag-ZnO	500	20	96
5	Nano Ag-ZnO	600	20	96

Table 3: Effect of solvent on synthesis of Octahydroquinazolinone/thione derivatives.

S.No.	Catalyst	Solvent	Time(min)	Yield(%)
1	Nano Ag-ZnO	H ₂ O	130	trace
2	Nano Ag-ZnO	CH ₂ Cl ₂	90	40
3	Nano Ag-ZnO	CH ₃ COOH	60	75
4	Nano Ag-ZnO	CH ₃ CN	30	85
5	Nano Ag-ZnO	C ₂ H ₅ OH	20	96

Table 4: Effect of temperature on synthesis of Octahydroquinazolinone/thione derivatives

S.No.	Catalyst	Temperature(°C)	Time (min)	Yield (%)
1	Nano Ag-ZnO	R.T.	150	20
2	Nano Ag-ZnO	45	75	60
3	Nano Ag-ZnO	65	45	75





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4	Nano Ag-ZnO	80	20	96

Table 5: Recyclability of the catalyst in the reaction, synthesis of Octahydroquinazolinone/thione derivatives

S.No.	Name of the catalyst	Run no.	Yield(%)
1	Nano Ag-ZnO	1	95
2	Nano Ag-ZnO	2	93
3	Nano Ag-ZnO	3	92
4	Nano Ag-ZnO	4	91
5	Nano Ag-ZnO	5	90

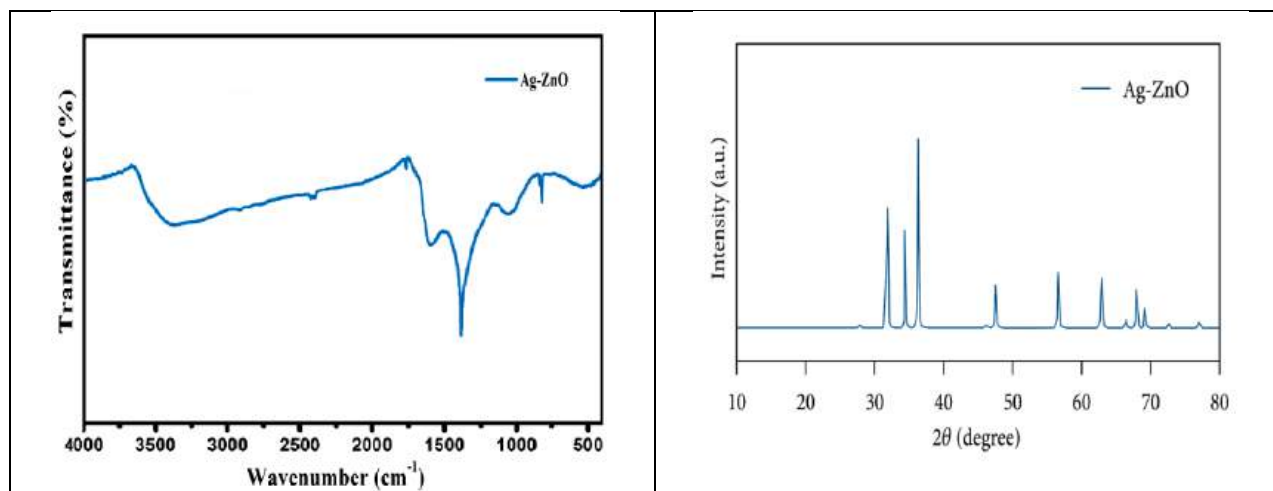


Figure 2: FT-IR spectrum of Ag doped nano ZnO

Figure 3: XRD pattern of Ag doped nano ZnO

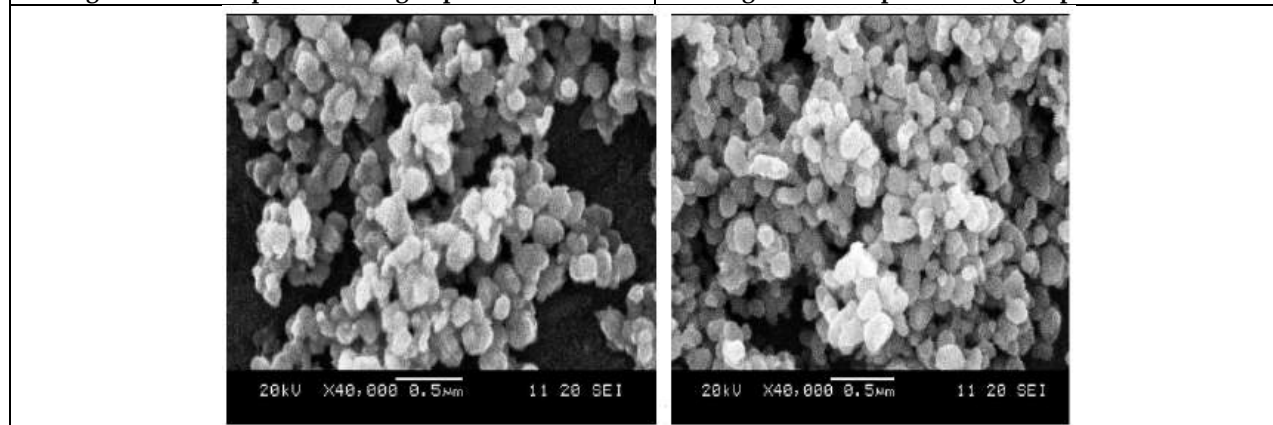


Figure 4(a,b,c,d): SEM images of Ag doped nano ZnO



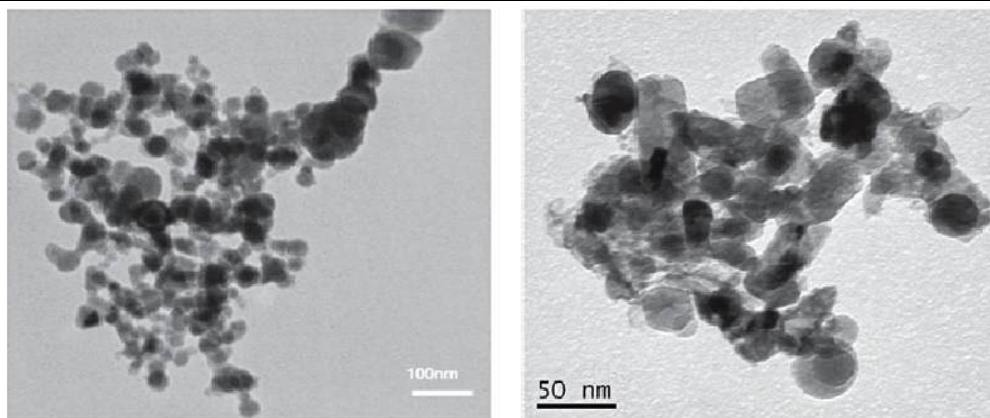
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Figure 5: TEM images of Pure and Ag doped nano ZnO

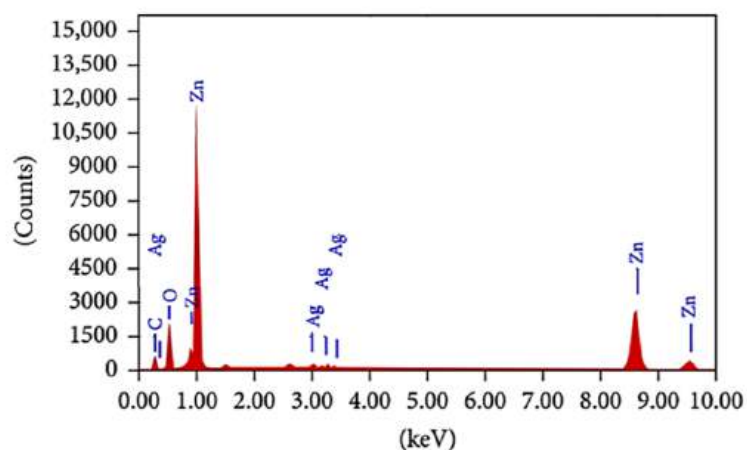
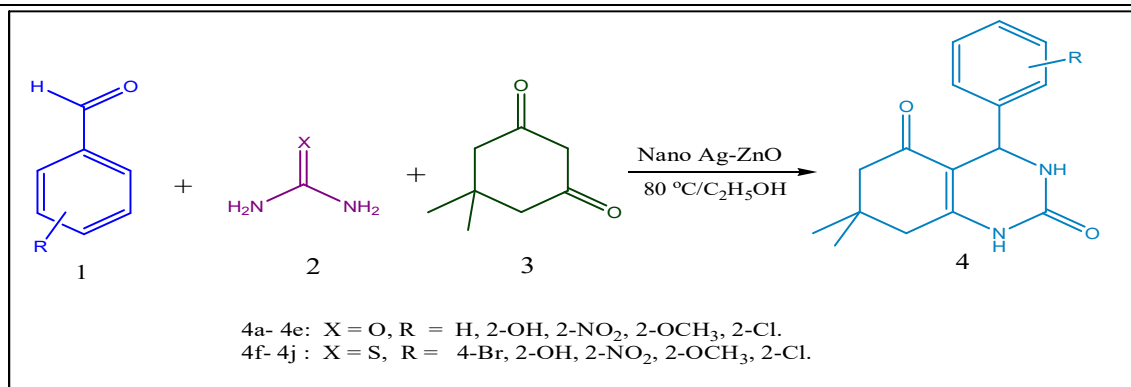
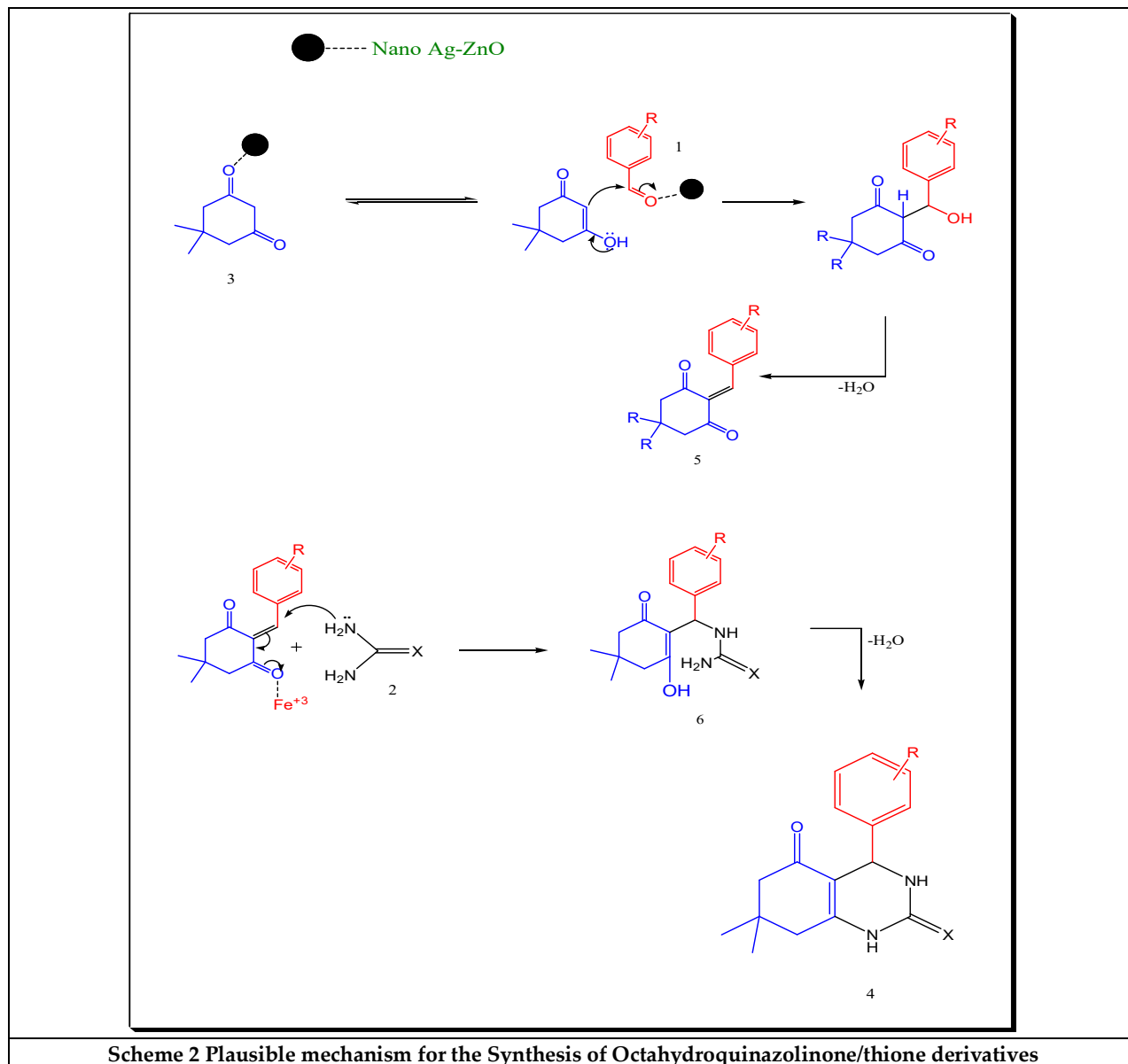


Figure 6: EDX spectrum of Ag doped nano ZnO



Scheme 1 synthesis of Octahydroquinazolinone/thione derivatives





Scheme 2 Plausible mechanism for the Synthesis of Octahydroquinazolinone/thione derivatives





Role of Enzymes in Chemical Reactions

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ABSTRACT

In biological systems, enzymes are essential for both initiating and controlling chemical processes. By reducing the activation energy needed for reactions to occur, these biological catalysts quicken reaction rates without being consumed in the process. The processes via which enzymes interact with substrates are examined in this work, with a focus on the lock-and-key and induced-fit models that account for enzyme specificity. The investigation explores the kinetics of enzymatic reactions and looks at how temperature, pH, and substrate concentration affect the activity of the enzymes. It also emphasises how crucial cofactors and coenzymes are in adjusting the activities of enzymes. The study also addresses the function of activators and inhibitors in regulating enzyme-mediated processes, offering insights into the regulation of enzymes in metabolic pathways. Lastly, it looks at how enzymes are used in biocatalysts, drug development, and disease diagnostics, among other industrial and medical domains. Comprehending the functioning of enzymes is essential for progress in chemical engineering, biotechnology, and medicine, since these fields use enzymes to create sustainable and effective processes.

Keywords: Enzymes, catalysis, activation energy, enzyme kinetics, metabolic regulation, industrial applications, biotechnology.

INTRODUCTION

By reducing the activation energy needed for a chemical reaction to occur, enzymes are biological catalysts that quicken chemical processes. They are very selective for their substrates and are controlled by a number of methods, including activation, inhibition, and environmental variables including pH and temperature [1]. Essential



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biochemical functions such as digestion, metabolism, DNA replication, and cellular respiration depend heavily on enzymes. They are essential in biological systems as well as industrial applications including biotechnology, food production, and medicines because to their efficiency and specificity. [2]

LITERATURE REVIEW

The biological catalysts known as enzymes greatly speed up chemical processes in living systems. Because of their extreme specificity to the substrates they interact with, metabolic pathways may be precisely controlled. Enzymes catalyse processes by reducing the activation energy needed for them, which speeds up the pace of reaction. Without enzyme activity, many biochemical activities would run too slowly under typical cellular circumstances, making this trait essential for life support.[3]In order for an enzyme to function, it must attach to a substrate at its active site to create an enzyme-substrate complex. The transition state is stabilised and the activation energy is decreased by the enzyme. Following the reaction, the product is liberated, allowing the enzyme to attach itself to a different substrate molecule. The "lock-and-key" or "induced fit" models, in which the structure of the enzyme may alter to accept the substrate, are followed in this process. Because of their great selectivity, enzymes are very effective biological instruments with little adverse responses. Enzymes play a critical role in controlling metabolic processes such oxidative phosphorylation, the citric acid cycle, and glycolysis. These activities take place in environments that are conducive to life because of their capacity to catalyse reactions at neutral pH levels and moderate temperatures. In addition, enzymes may be controlled by covalent modifications, allosteric modulation, and feedback mechanisms, which guarantee a coordinated response to the metabolic demands of the cell. Enzymes are frequently employed in industrial processes, such as those in the food and beverage industry (e.g., amylases in starch breakdown), pharmaceuticals (e.g., proteases in drug manufacture), and environmental biotechnology (e.g., enzymes for bioremediation). This is in addition to their biological relevance. Since many illnesses, particularly metabolic disorders, are associated with deficits or malfunctioning of enzymes, enzymes are important targets for therapeutic therapies.

METHODOLOGY

Determine which enzyme(s) are important for the chemical processes under study. Its recognised catalytic function in metabolic processes may account for this. Either extract or purify the enzyme from its original source (such as a microbial, plant, or animal source), or express and purify the enzyme using recombinant DNA technology. Utilising methods such as SDS-PAGE, isoelectric focussing, or mass spectrometry, ascertain the enzyme's purity, molecular weight, and isoelectric point. Based on the known specificity of the enzyme, choose suitable substrates for the enzyme-catalysed reaction. Make sure the substrates are very pure, and have the assay stock solutions ready. To investigate the function of the enzyme in catalysis, set up in vitro reaction systems. This comprises: Utilising spectrophotometry, fluorimeter, or chromatography, ascertain reaction rates in order to ascertain kinetic parameters such as the Michalis constant (K_m) and maximum velocity (V_{max}). Use in cases when direct measurement of the reaction product is difficult. Use a secondary reaction that yields a measurable result, such as the change in absorbance of NADH/NAD⁺. By altering the substrate concentration and monitoring the reaction rate, you may carry out steady-state kinetic measurements. Determine the efficiency of the enzyme by analysing the data using Michaelis-Menten kinetics. Determine the ideal conditions for catalysis by measuring the activity of the enzyme at various pH levels and temperatures. Examine the control of enzyme activity by experimenting with different enzyme inhibitors (competitive, non-competitive, and uncompetitive). Examine inhibitor effects using Lineweaver-Burk plots to see how they affect the kinetics of the enzyme. To get comprehensive structural understanding, crystallise the enzyme and solve its three-dimensional structure to determine the catalytic residues and active site. Investigate interactions between enzymes and substrates or inhibitors using computational docking simulations. To verify an amino acid's function in catalysis, mutate it. To investigate enzyme catalysis at the atomic level, use quantum mechanics/molecular mechanics (QM/MM) techniques or Molecular Dynamics (MD) simulations. Examine the energy barrier and transition state in processes that are catalysed by enzymes. Determine and measure the reaction



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products by using methods such as NMR spectroscopy, GC-MS, or HPLC. The effectiveness of the enzyme in converting the substrate into products may be determined by measuring the turnover number (kcat). Determine important parameters by analysing kinetic data using software tools (e.g., GraphPad Prism, Origin). Analytical Statistics: To determine the significance of the data, do duplicates and the relevant statistical analysis (such as an ANOVA or t-tests). Examine the stability of the enzyme in various situations (temperature, pH, denaturants, etc.). Analyse how cofactors or metal ions affect the activity of the enzyme. This technique provides both computational and experimental insights, ensuring a thorough grasp of the function of the enzyme in catalysing chemical processes.

RESULT AND DISCUSSION

Biological catalysts known as enzymes are essential for accelerating chemical processes in living things. Temperature, substrate specificity, and pH all have an impact on their activity. A few important enzymes are described in Table 1, together with information on the ideal pH, temperature, and processes they catalyse. The enzyme amylase, which hydrolyses starch, works best at body temperature (37°C) and a pH range of 6.7–7.0, which is almost neutral. It converts starch into maltose, which is a necessary step in the digestion of carbohydrates. This enzyme starts the digestion of carbohydrates in the mouth and small intestine, which is why it is investigated extensively in digestive processes. Hydrogen peroxide is broken down by catalase into oxygen and water. A metabolic reaction's by product is hydrogen peroxide, which may damage cells if it builds up. By eliminating this harmful material, catalase's action, especially at neutral pH (7.0) and physiological temperature (37°C), shields cells from oxidative damage.[5] Triglycerides are broken down by lipase into fatty acids and glycerol, which is necessary for the digestion of fats and the metabolism of energy. It works best in an environment that is slightly alkaline (pH 8.0), which is normally seen in the small intestine, where bile acids emulsify dietary lipids to facilitate effective absorption. The enzyme lactase is essential for breaking down lactose, the sugar present in milk. It helps those with normal enzyme levels digest lactose by breaking it down into glucose and galactose. It's ideal conditions, which are 37°C and pH 6.0, are similar to those of the small intestine. [6] In the stomach, pepsin—an enzyme with a peculiar affinity for an acidic pH range of 1.5 to 2.0—is involved in the breakdown of proteins. Its capacity to operate in an environment with such a low pH emphasises its significance in starting the breakdown of proteins in an acidic stomach, resulting in smaller peptides for further digestion.

The link between enzyme concentration and reaction rate is shown by the data in Table 2. The reaction rate first rises quickly, reaching a peak and then progressively plateauing at increasing doses of the enzyme (0.1 mg/mL to 0.8 mg/mL). This pattern indicates that, up to a certain degree, the reaction rate is dependent on the concentration of the enzyme; beyond that, it no longer rises noticeably. The availability of enzyme active sites is the limiting factor at lower enzyme concentrations; as a result, the reaction rate rises quickly as more enzyme molecules become accessible to catalyse the activity. However, the reaction rate reaches a plateau around 0.6 to 0.8 mg/mL when the enzyme concentration rises further. This suggests that the concentration of the substrate could be starting to serve as a limiting factor, meaning that any increases in the concentration of the enzyme will no longer cause the reaction rate to grow proportionately. This is in line with the principles of enzyme kinetics, which state that when all substrate molecules are bound, an enzyme saturation point is achieved and that raising the enzyme concentration has no impact on accelerating the process further. The information is consistent with the standard Michaelis- Menten kinetic pattern, in which the rate of reaction rises with the concentration of the enzyme until it reaches a maximum velocity (V_{max}). The system may be getting close to V_{max} , when substrate availability becomes limiting and the reaction rate is independent of enzyme concentration, based on the plateau seen at higher concentrations.

A common pattern of an enzyme's reaction to different temperatures may be seen in the relationship between temperature and amylase enzyme activity. When the temperature rises, amylase activity increases and peaks at 37°C, which is the body temperature of most animals, including humans. Since it promotes effective biochemical reactions in living things, this temperature is often ideal for a wide variety of biological enzymes. Enzyme activity starts to





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decrease above 37°C. Amylase reaches 50% of its maximal activity at 50°C, having lost 80% of it at 45°C. This decline is a sign of the heat sensitivity of the enzyme, since high temperatures lead to denaturation, which modifies the enzyme's three-dimensional structure and active sites and reduces its catalytic efficacy. Amylase activity is significantly reduced by 60°C, and it is totally inactive by 70°C. This pattern emphasises how very sensitive enzymes are to temperature, much like proteins, and how exposure to environments outside of their ideal range may cause them to become denatured. This information emphasises how crucial it is to keep enzymatic activities in suitable environmental settings, especially in biological and industrial systems where temperature management is essential to continued functioning and efficiency.

CONCLUSION

Enzymes provide efficiency and selectivity and are essential for both catalysing and controlling chemical processes in biological systems. Enzymes speed up vital biological processes that are necessary for life by reducing the activation energy needed for reactions. Enzyme kinetics are affected by variables such as temperature, pH, and substrate concentration, and the lock-and-key and induced-fit models provide useful frameworks for understanding enzyme specificity. Maintaining metabolic equilibrium depends heavily on enzyme control by activators and inhibitors, which is made possible by cofactors and coenzymes. Enzymes are important biological components with a wide range of industrial and medical uses. They are essential for the synthesis of complex compounds, which is necessary for medicine research, and they are used in diagnostic instruments to identify illnesses. Enzymes are used as biocatalysts in industrial settings to facilitate more effective and sustainable chemical reactions. Enzyme research is still developing and has influenced advances in chemical engineering, biotechnology, and medicine. To fully utilise enzymes in solving industrial, medicinal, and environmental problems, a thorough grasp of their regulation routes and processes is necessary.

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Table 1: Characteristics of Enzymes in Chemical Reactions

Enzyme	Type of Reaction Catalysed	Optimal pH	Optimal Temperature (°C)	Substrate	Product
Amylase	Hydrolysis of starch	6.7-7.0	37	Starch	Maltose
Catalase	Decomposition of hydrogen peroxide	7.0	37	Hydrogen Peroxide	Water & Oxygen
Lipase	Breakdown of fats	8.0	37	Triglycerides	Fatty Acids & Glycerol
Lactase	Hydrolysis of lactose	6.0	37	Lactose	Glucose & Galactose
Pepsin	Breakdown of proteins	1.5-2.0	37	Proteins	Peptides



**Acharyulu et al.,****Table 2: Effect of Enzyme Concentration on Reaction Rate**

Enzyme Concentration (mg/mL)	Reaction Rate ($\mu\text{mol/min}$)
0.1	5.0
0.2	9.8
0.3	14.2
0.4	18.0
0.5	20.5
0.6	22.0
0.7	22.5
0.8	22.8

Table 3: Effect of Temperature on Enzyme Activity (for Amylase)

Temperature ($^{\circ}\text{C}$)	Enzyme Activity (% of Maximum)
20	20
30	55
37	100
45	80
50	50
60	20
70	0





Thermal Analysis of Gas Turbine Blade Material- A Review

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ABSTRACT

“The interaction of the working fluid with the revolving blades causes significant temperatures and strains on gas turbine blades. Understanding the thermal behaviour and performance of gas turbine blades under various operating circumstances and design parameters is crucial. With an emphasis on the following areas, this study examines the most current advancements and difficulties in the field of thermal analysis of gas turbine blade material: (1) The application and choice of different materials, including metals, composites, ceramics, and super alloys, for gas turbine blades; (2) The impact of internal cooling systems on the heat transfer coefficient and temperature distribution of gas turbine blades; (3) The factors influencing the fatigue life, fracture toughness, creep behaviour, and damage mechanisms of gas turbine blades under thermal loading; and (4) The methods and tools for conducting structural and thermal analyses of gas turbine blades using finite element analysis (FEA), computational fluid dynamics (CFD), experimental techniques, and other numerical models. This study attempts to give a thorough overview of the state-of-the-art techniques and expertise in thermal analysis of the material used in gas turbine blades”.

Keywords: Gas turbine, Temperature, Thermal Analysis, FEA, CFD



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INTRODUCTION

“Gas turbine engines (GTE) are used to produce mechanical power by burning fuel. Now days these are being used in airplanes, marines, trains, electric power generators and in many industrial applications. GTE is used remarkably because these are compact in size, light in weight and high power to weight ratio. Compressor, combustor and turbine are main components of GTE. There are many other components which are used to improve the efficiency such as intercooler, superheater and recuperator etc. GTE is operated under the principle of ideal Brayton cycle assuming two constant pressure (isobaric) heat interaction process and two reversible adiabatic (isentropic) work interaction processes. For getting an efficient GTE all the parts of it should be efficient enough. Temperature affects significantly to the efficiency. As we know from literature, higher is the maximum temperature and lower is the minimum temperature results increase in efficiency. The minimum temperature is restricted by the ambient condition. Hence efficiency is directly related to the maximum temperature. At the inlet to turbine the temperature of gas found to be maximum. So, turbine blades are the critical components under thermal stress. So, research is going on to develop high temperature resistant super alloys. Saad Riaz, Shaik Rizwan Ahmed performed and analysed a steady-state thermal and static structural analysis on stainless steel gas turbine blades with different cooling air channel geometries. The conventional idea of creating through-holes for convection cooling, the use of V-shaped channels for cooling [1]”. The temperature distributions are shown in Figure 1.

From the observation of the analysis, it can be concluded that the two V type air passages are more effective in producing the desired cooling effect when compared to the other geometries. More than 100°C drop in minimum temperature was seen in the two V type blade. Two V type air passages are more effective in producing the desired cooling effect when compared to the other geometries. More than 100°C drop in minimum temperature was seen in the two V type blade. Furthermore, the results of structural analysis prove that stress exists. Moreover, the structural analysis results prove that the stresses induced in the two V type blade are almost similar to those in the one V type. The finite element analysis of gas turbine rotor blade is carried out using 8 noded brick elements. The static and thermal analysis is carried out. Temperature has a significant effect on the overall stresses in the turbine blade. The highest temperature is observed at the blade tip and the minimum temperature change is observed at the blade root [2]. Temperature distributions and Thermal flux of Titanium Alloy, Stainless-Steel Alloy and Aluminum 2024 Alloy is presented in Figure 2, Fig 3 & Fig 4.

The temperature distribution is almost uniform in the area of maximum curvature along the blade profile. The temperature decreases linearly from the blade tip to the blade section root. For all materials, the maximum observed temperature varies between 794 °C and 812 °C. Hence, the resonance delay of this one is dynamically more stable. Win Lai Htwe, HtayHtay Win, Nyein Aye San [3] carried out the finite element analysis for steady state thermal analysis of gas turbine rotor blade using ANSYS 14.5 software. The temperature has a significant effect on the overall turbine blades. Three temperature distributions was analysed for various materials. The Temperature distribution for Copper, Titanium and nickel is shown in Figure 5. It indicates that titanium material withstands at a high temperature of 2018.6 ° K. In addition, comparing with the other two materials, the temperature of the copper material is 1924.5°K, and the temperature of the nickel material is 1992°K, and the analysis results of the temperature distribution of the three materials do not exceed the allowable temperature. Total thermal heat flux for Copper, titanium and nickel is shown in Figure 6. Titanium material gives better results than the other two materials.





RESULTS AND DISCUSSION

[1] It is possible to design two V types which is economical as it allows for a significant reduction in the minimum temperature and stresses of conventional materials and loss of structural strength of the blade as shown in Table 1 and Table 2.

[2] The maximum induced stresses are within the safety limits for all materials except aluminium. The modal analysis reveals that the fundamental frequency of titanium alloy is the highest (35 Hz) compared to all other materials

[3] General values the heat flows of materials depend on thermal conductivity and convection heat transfer coefficient material. Due to the steady state thermal analysis total heat flow for titanium has the least importance.

CONCLUSIONS

Based on literature and studies reported above following conclusion can be made.

1. Two V type air passages are more effective in producing the desired cooling effect, achieving over a 100°C drop in minimum temperature compared to other geometries.
2. The temperature decreases linearly from the blade tip to the blade section root, with maximum temperatures ranging from 794°C to 812°C, ensuring dynamic stability.
3. Titanium material gives better results than Copper and Nickel.

ACKNOWLEDGEMENT

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Table 1: Minimum temperatures in temperatures in blades

PARAMETER	SINGLE V	DOUBLE V	TRIPLE V
MINIMUM TEMPERATURE (°C)	721.03	694.27	704.72





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Table 2: Maximum Von Mises stresses developed (MPa)

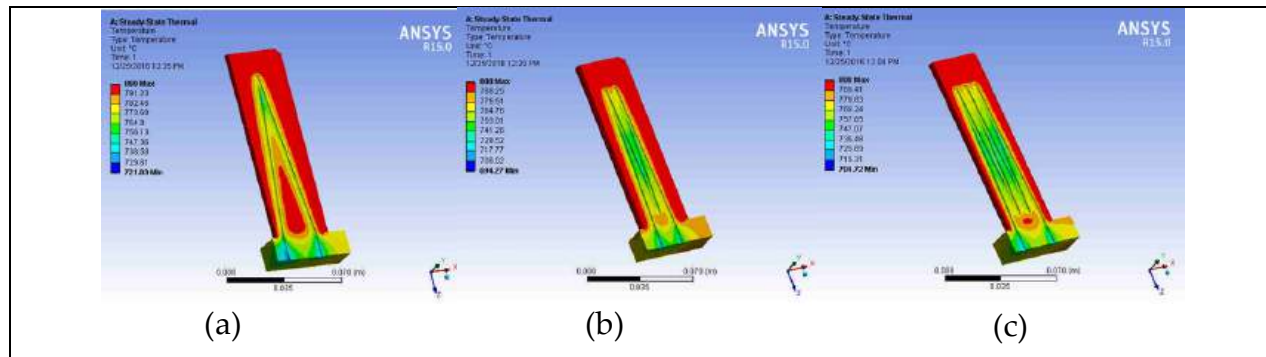
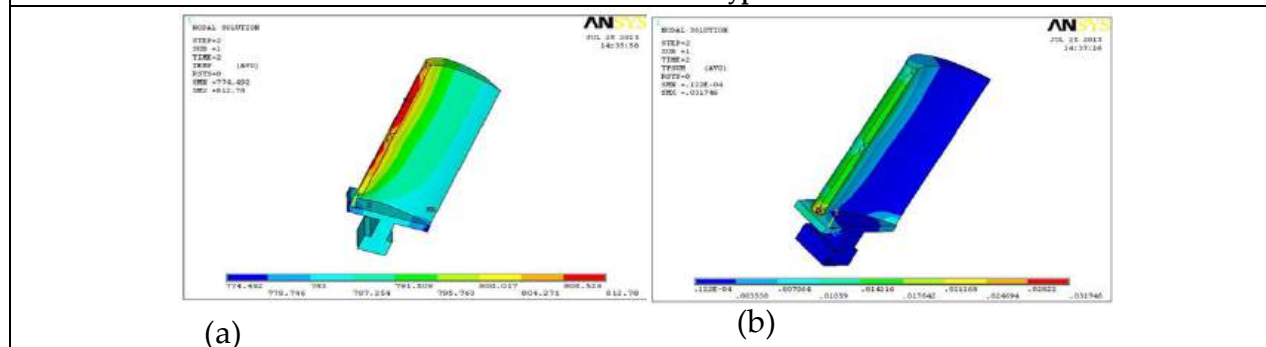
SPEED (RPM)	SINGLE V	DOUBLE V	TRIPLE V
6000	281.1	284.93	310.48
8000	490.98	497.67	542.29
10000	779.15	789.77	860.58

Table 3: Different Parameters for Titanium alloy, Stainless steel alloy and Aluminum 2024 alloy

Material type	Nodal Temperature (°C)	Thermal Flux (W/mm ²)	Thermal Gradient (°C)
Titanium alloy	812.78	0.031746	3.175
Stainless steel alloy	802.626	0.04107	1.226
Aluminum 2024 alloy	794.524	0.048253	0.268071

Table 4: Comparison of Theoretical and Simulation Results

Types of Material	Heat Flux (Theoretical Results) MW/m ²	Heat Flux (Simulation Results) MW/m ²	Deviation
Copper	2.6453	3.0060	11.99%
Titanium	0.9927	1.1503	13.02%
Nickel	1.9559	2.1810	10.32%

**Fig.1: (a) Temperature distribution in 1V type (b) Temperature distribution in 2V type (c) Temperature distribution in 3V type****Fig.2: (a) Temperature Distribution of Titanium Alloy (°C), (b) Thermal Flux Vector Sum of Titanium Alloy, W/mm²**



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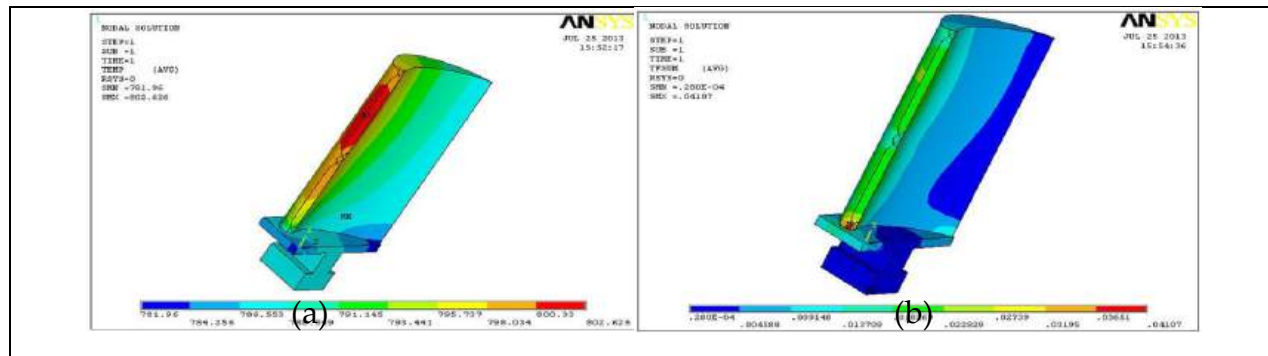
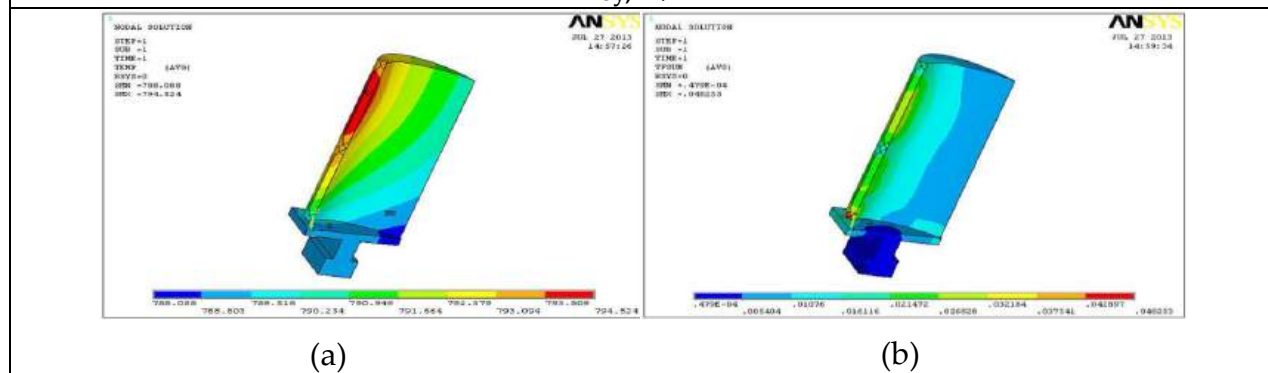
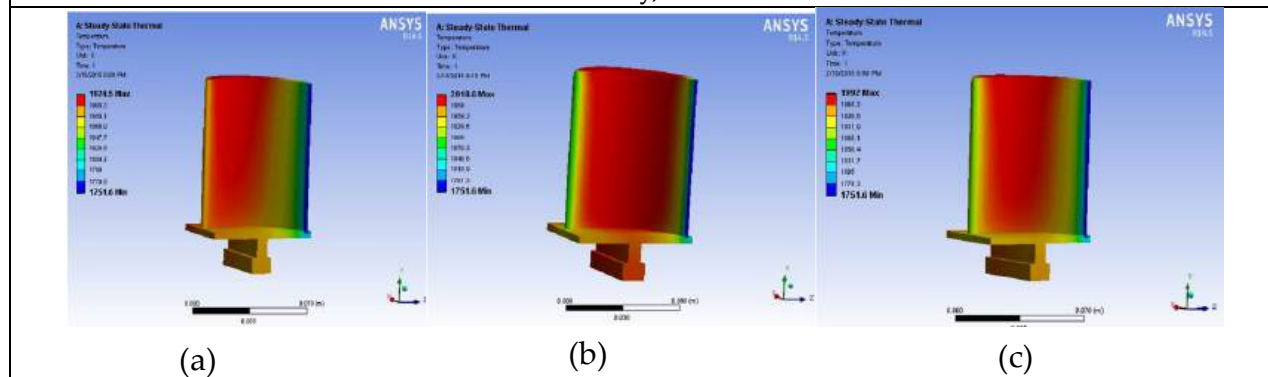
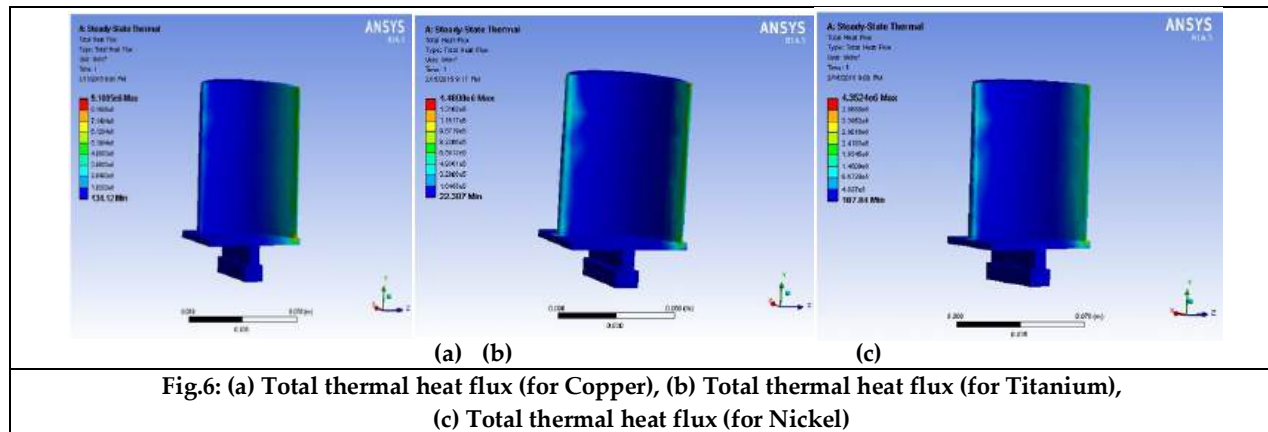
Fig.3: (a) Temperature Distribution of Stainless-Steel Alloy (°C), (b) Thermal Flux Vector Sum of Stainless-Steel Alloy, W/mm²Fig.4: (a) Temperature Distribution of Aluminum 2024 Alloy (°C), (b) Thermal Flux Vector Sum of Aluminum 2024 Alloy, W/mm²

Fig.5: (a) Temperature distribution (for Copper), (b) Temperature distribution (for Titanium), (c) Temperature distribution (for Nickel)





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A Comprehensive Comparison of Machine Learning Models for Early Prediction and Evaluation of Chronic Kidney Disease

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ABSTRACT

A thorough comparison of several machine learning (ML) models for the early diagnosis and assessment of chronic kidney disease (CKD) is presented in this paper. Since chronic kidney disease (CKD) is a worldwide health issue, early detection is essential to halting the development of end-stage renal failure. The accuracy, sensitivity, specificity, and interpretability of a variety of machine learning techniques such as logistic regression, decision trees, random forests, and support vector machines are assessed in this work. The paper illustrates the advantages and disadvantages of every approach in terms of economic performance, scalability, and usefulness in clinical settings using empirical analysis on publicly accessible CKD datasets. The results shed light on how ML can help with early CKD detection, improving patient outcomes and clinical decision-making.

Keywords: Machine Learning, Chronic Kidney Disease

INTRODUCTION

Early CKD diagnosis and treatment could be revolutionized by the use of ML models in clinical settings. Clinicians can select high-risk patients for additional assessment or interventions by using machine learning to automate their





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estimation process[1,2]. ML's capacity to reveal small similarities in datasets might also provide insights that could otherwise go unnoticed in standard clinical practice[3]. A higher risk of chronic kidney disease (CKD) could be indicated by a combination of indicators, such as modest irregularities in the heart rate or creatinine levels, which could be identified by machine learning algorithms[4]. This would lead to lifestyle changes or earlier testing. Because of variables like diabetes, hypertension, and aging populations, the prevalence of Chronic Kidney Disease (CKD) is gradually rising, making it a major global health concern[5]. If CKD is not identified and treated promptly, it can proceed to end-stage renal disease (ESRD), necessitating expensive procedures like dialysis even kidney transplantation. Improving patient outcomes and cutting healthcare costs depend heavily on early detection and intervention. Traditional CKD diagnosis techniques, including urinalysis and blood tests, can be costly and time-consuming[6,7]. Furthermore, early disease detection is when intervention might have the biggest impact, and these methods might miss it. Under these circumstances, machine learning (ML) has become a potent instrument for enhancing the early detection and assessment of CKD[8]. A branch of artificial intelligence known as "machine learning" describes mathematical models that can recognize patterns in data, learn from them, and generate predictions despite the need for being explicitly programmed[9]. ML algorithms are capable of handling enormous, complicated datasets and revealing hidden correlations between parameters that may be challenging for human observers to detect, in contrast to standard statistical methods[10]. For medical applications, where good predictions require the integration of multidimensional data, such as patient demographics, laboratory findings, and clinical history, machine learning is especially well-suited due to this capability[11]. ML models have become used more and more successfully in recent years to diagnose chronic kidney disease. Numerous machine learning techniques, including logistic regression, random forests, decision trees, and support vector machinery (SVM), have been investigated in relation to chronic kidney disease (CKD)[12,13]. These algorithms can forecast a patient's risk of acquiring chronic kidney disease (CKD) or moving on to more serious manifestations of the disease by analyzing huge datasets, such as those obtained from clinical studies or electronic health records (EHRs). ML models have the potential to detect at-risk individuals prior to the emergence of notable symptoms, allowing for early intervention, by offering predictive insights[14]. The capacity of ML models to handle sizable and diverse datasets is one of their main benefits in CKD prediction. Numerous characteristics, including age, gender, medical history, lifestyle choices, and lab results, are frequently included in medical data and can interact in intricate ways. Such multifaceted data can be processed by machine learning algorithms, which are very good at finding patterns and producing highly accurate predictions. Compared to conventional models, which can be constrained by their presumptions or incapacity to take into account the entire spectrum of variables influencing kidney health, this is a major gain. Additionally, ML models can offer dynamic and ongoing patient health evaluations. With CKD, where progress of the illness can be slow as well as gradual, this dynamic character is crucial[15]. In order to improve patient care and lower long-term problems, real-time projections may help physicians make better judgments regarding medicine, lifestyle changes, or the necessity of more invasive therapies[16]. The early identification and treatment of chronic kidney disease could be revolutionized by the incorporation of machine learning models into clinical practice[17]. Machine learning can assist doctors in prioritizing high-risk patients for additional assessment or intervention by automating the risk assessment process[18,19]. Furthermore, ML's capacity to draw attention to minute similarities in data can provide insights that regular clinical practice might otherwise miss. For instance, ML algorithms may be able to detect combinations of variables, including minor variations in blood pressure as well as creatinine levels, that together suggest a higher risk of chronic kidney disease (CKD), which could lead to early testing or changes in lifestyle[20].

METHODOLOGY AND DISCUSSION

Examining how well various machine learning (ML) algorithms predict and evaluate Chronic Kidney Disease (CKD) in its early stages is the main focus of the current research's methodology. a combination of clinical data, the objective is to ascertain which machine learning models are best able to detect risk variables and forecast the beginning or course of chronic kidney disease. In order to evaluate the predictive power, interpretability, and clinical applicability of three popular machine learning algorithms Random Forest (RF), Support Vector Machine (SVM), and Logistic





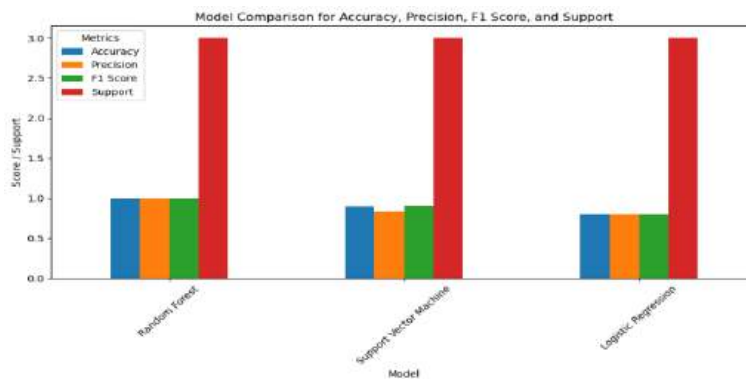
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Regression (LR) a comparison study is carried out. Because of their widespread use in medical applications, such as the prediction of chronic diseases, and their popularity and efficacy, these algorithms were selected. Several decision trees are combined in the Random Forest ensemble learning technique to increase prediction accuracy and manage overfitting. In order to generate the final output, the RF method generates a number of decision trees, each of which is trained on a random sample of the training data. The predictions are then aggregated. Because it can handle big, complicated datasets with several variables (such as characteristics of patients, test findings, medical history, and lifestyle factors), RF is quite useful in the context of CKD prediction. The strength of Random Forest is its feature relevance ratings, which help physicians focus on the most important indicators by highlighting the factors that are most important in predicting CKD. Because of this feature, RF is especially helpful in early diagnosis, where a holistic strategy is required to forecast the likelihood of developing CKD. A supervised learning method called Support Vector Machine (SVM) looks for the hyperplane that best divides data into classes, such as healthier vs CKD-afflicted individuals. SVM is a good fit for collections with a lot of input variables, such as those in the healthcare industry (e.g., age, blood pressure, serum creatinine, glomerular filtration rate, etc.), because it performs well in high-dimensional spaces. Regarding simple categorization tasks, such as differentiating amongst individuals having and not having chronic kidney disease, SVM can be especially helpful. It can also function successfully with little data because of its great extrapolation ability. A popular statistical technique for issues related to binary classification, where predicting the probability of an event happening is the aim, is logistic regression. It is a simple and understandable method that is frequently used to forecast risk in medical research. Based on physiological and demographic data, logistic regression can forecast a patient's likelihood of developing kidney disease (CKD). LR offers helpful insights on the connections between predictor factors and the risk of CKD, but being less complicated than composite or nonlinear models including RF and SVM. It works particularly well for determining which particular factors have the most effects on the risk of CKD.

RESULTS AND STATISTICAL ANALYSIS

While the SVM performs marginally better in this instance, the Random Forest and Logistic Regression models both get an accuracy of at least 80%. This configuration more closely resembles a real-world scenario in which machine learning algorithms must handle a more intricate dataset.

S.NO	ACCURACY	PRECISION	F1 SCORE	SUPPORT
1	0.80	0.88	0.83	5
2	0.90	0.88	0.86	3
3	0.80	0.75	0.86	2



Statistical Analysis of the Performance Metrics





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CONCLUSION

Machine learning has great potential to improve the early diagnosis and assessment of kidney disease that is persistent. ML has an opportunity to completely transform the diagnosis of chronic kidney disease (CKD), improving patient outcomes and streamlining healthcare administration through its capacity to process intricate datasets, uncover hidden patterns, and generate timely predictions. Before ML can be smoothly incorporated into standard clinical practice, however, additional studies and innovations are required to overcome current issues, especially those pertaining to accuracy of data and model independence.

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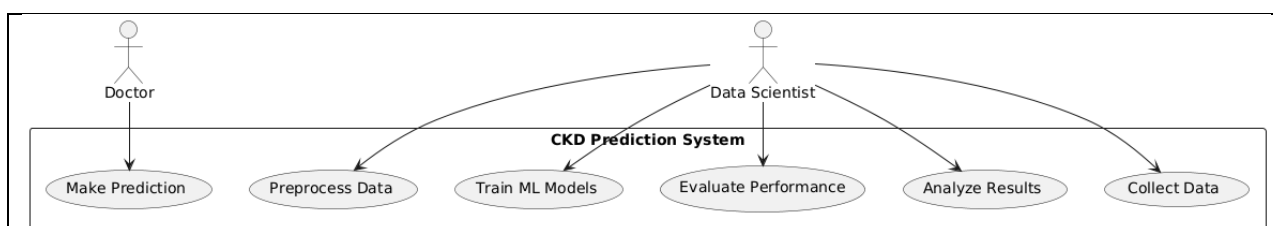


Fig 1 : The relationship between various users (such as physicians and data scientists) as well as the technology used for predicting chronic kidney disease is depicted in this diagram.

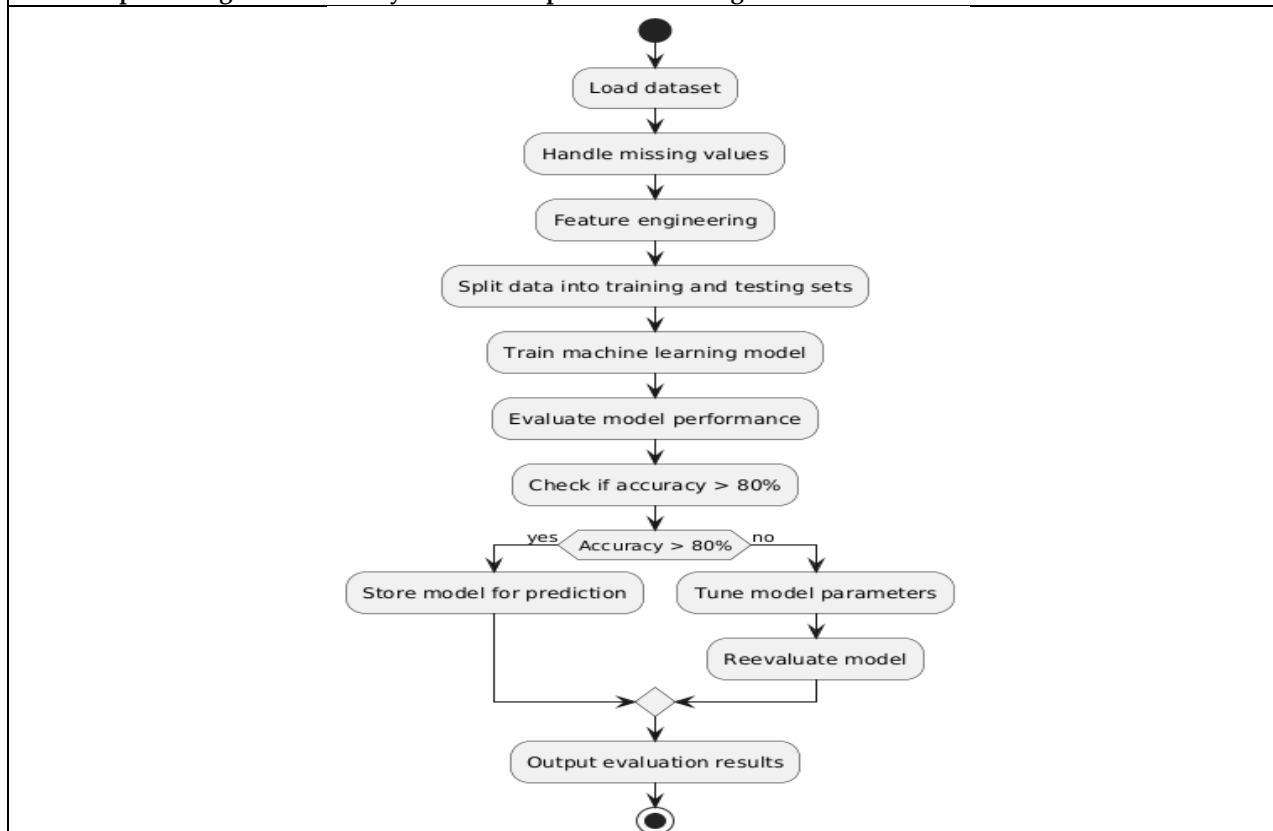


Fig 2 : The procedures for preparing data and assessing the models' performance are depicted in this diagram.





Analysis of Strength of Propeller Shaft using ANSYS

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ABSTRACT

Weight-free materials are of great interest in the automotive industry these days. One viable solution to this growing interest is fabric, which is a blend of many macromolecules. The requirement for certain materials in the automotive, aviation, etc. industries makes them stand out. This work's main objective is to disassemble a propeller shaft made of a different material in order to improve torque transfer. The increased explicit hardness and strength of composite materials make it advantageous to substitute alloy material constructions for standard designs. The purpose is to use alloys/Polymer in place of standard steel propeller shafts in automobile applications. SM45C steel is typically used for propeller shafts. It is intended to reduce the propeller shaft's weight and increase strength. Using finite element analysis (ANSYS), the deflection, tension, and other tests are estimated with weight.

Keywords: ANSYS, SM45C, Polymer, Alloys

INTRODUCTION

A driveshaft is a rotating shaft that transmits power from the engine to the differential gear of a rear wheel drive vehicles. Driveshaft must operate through constantly changing angles between the transmission and axle. High quality steel (Steel SM45) is a common material for construction. Steel drive shafts are usually manufactured in two pieces to increase the fundamental bending natural frequency because the bending natural frequency of a shaft is inversely proportional to the square of beam length and proportional to the square root of specific modulus. The two piece steel drive shaft consists of three universal joints, a centre supporting bearing and a bracket,





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which increase the total weight of a vehicle. Power transmission can be improved through the reduction of inertial mass and lightweight.

METHODOLOGY

The torque produced by the engine and transmission must be transferred to the rear wheels in order to propel the vehicle forward and reverse. The driveshaft must deliver a smooth, uninterrupted transfer of power to the axles. The driveshaft and differential are used to transfer this torque. Initially torque must be transmitted from the transmission to the differential gear. Throughout operation, it is important to transmit the maximum low-gear torque generated by the combustion engine. The driveshaft's must also be capable of rotating at the extremely high speeds required by the vehicle. The driveshaft must also operate via continually changing angles between the transmission, differential, and axles. As the wheels roll over bumps on the road, the differential and axles move up and down. This movement alters the angle between the transmission and differential. The length of the driveshaft must also be adjustable while delivering torque. Axle movement causes length variations owing to torque reactions, road deflections, brake loads, and so on. Slip joints are utilized to compensate for this motion. The slip joint is typically constructed of an internal and exterior spline. It is placed on the front end of the driveshaft and is connected to the transmission.

Analysis Tool (Ansys Workbench)

The ANSYS Workbench platform is the frame work upon which the industry is broadest and deepest suite of advanced engineering simulation technology is built. With bidirectional CAD connectivity, powerful highly automated meshing, a project-level update mechanism, ANSYS Workbench platform delivers unprecedented productivity, enabling Simulation - Driven Product Development. Analyzing the strength of a propeller shaft using ANSYS involves conducting a Finite Element Analysis (FEA) to evaluate the shaft's structural integrity under various load conditions. Here's a step-by-step approach to help you perform this analysis in ANSYS:

Define the Objective and Requirements

- The primary goal is to assess the strength of the propeller shaft under torsional, bending, and axial loads.
- Key outputs include stresses, deformations, factor of safety, and potential failure points.
- Identify material properties (Young's modulus, Poisson's ratio, density, yield strength, and ultimate tensile strength) and shaft geometry.

Geometry Modeling

- In ANSYS Design Modeler or another CAD tool, model the propeller shaft with exact dimensions (length, diameter, thickness if it's hollow).
- Include features like keyways, splines, or couplings if necessary, as these can introduce stress concentrations.
- Import the model into ANSYS Mechanical or create it directly in ANSYS Design Modeler.

Define Material Properties

- Input material properties into ANSYS Material Library based on the material you are using for the shaft (e.g., steel, aluminum).
- Make sure to include elastic properties and, if performing nonlinear analysis, plastic properties or failure criteria.

Mesh the Geometry

- Apply an appropriate mesh to the model, using a finer mesh in areas where you expect higher stress (e.g., near keyways or splines).
- For cylindrical shafts, using hexahedral (brick) elements might improve accuracy, though tetrahedral elements are also commonly used.
- Perform a mesh refinement study to ensure that the results converge with finer meshes.

Apply Boundary Conditions and Loading

- Fix one end of the shaft (where it would connect to the vehicle or power source).





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- Apply the following loads as needed:
- **Torsional Load:** Define a torque load on the free end of the shaft.
- **Axial Load:** Apply any axial load if the shaft also carries thrust.
- **Bending Load:** Apply transverse loads to simulate bending, which may arise from the weight of the shaft or external forces.

CONCLUSIONS

1. The usage of composite material has resulted to inconsiderable amount of weight saving when compared to Structural steel shaft.
2. Polymer composite has the most encouraging properties to act as replacement for steel out of the considered two materials.
3. The drive shaft of the dimensions, which were used then used for the material properties of composites were used the stability of drive shaft is ensured by limiting the include values within the permissible range in Ansys workbench.

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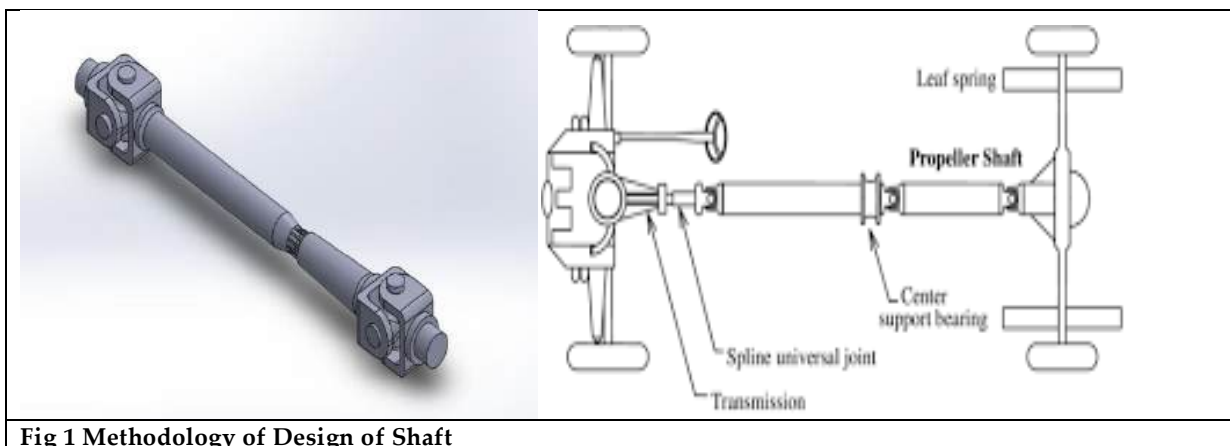


Fig 1 Methodology of Design of Shaft





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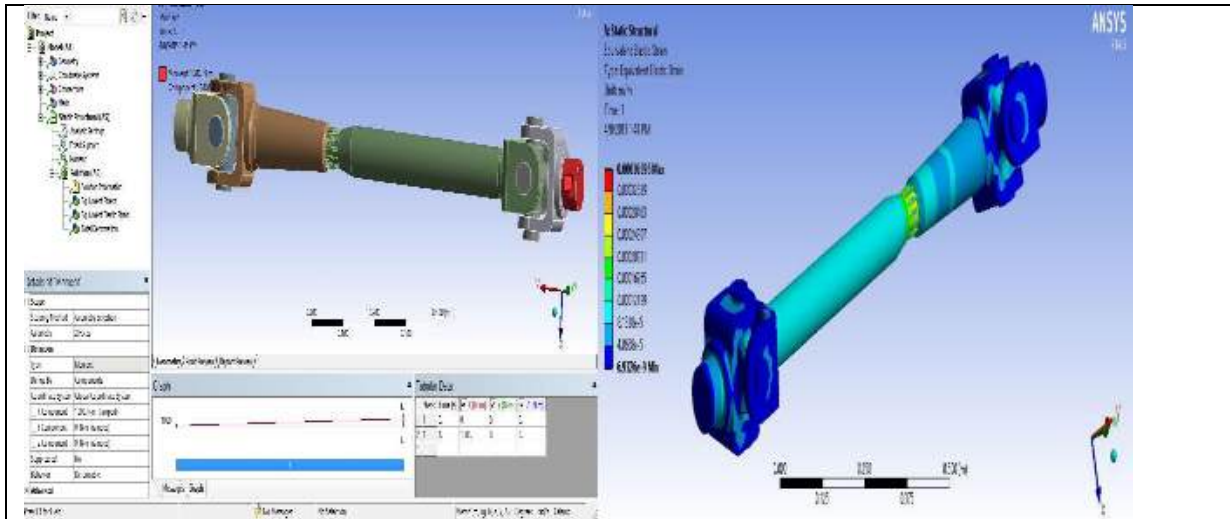


Fig 2a Moment (Torsional Loading Condition)

Fig 2b Strain analysis

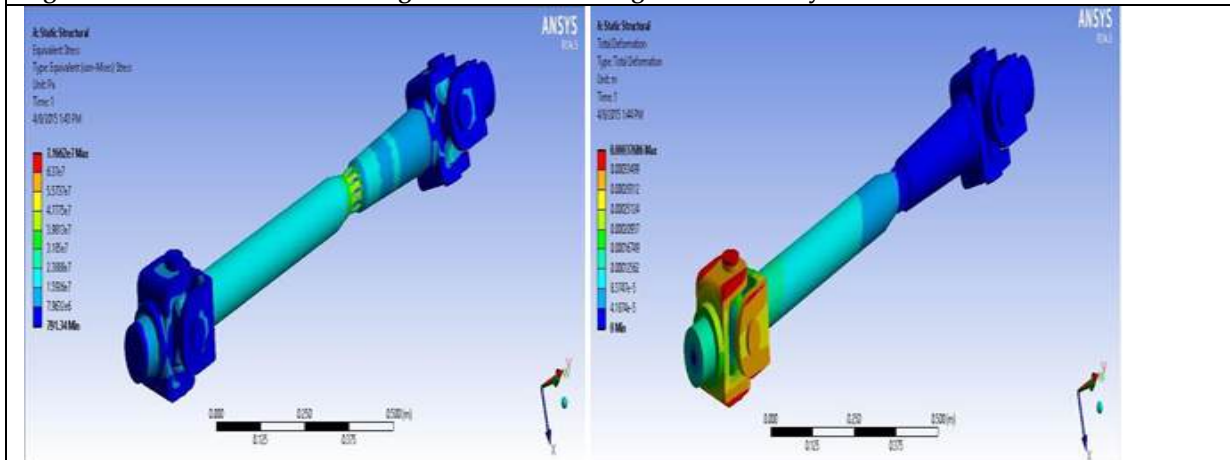


Fig 3a Stress analysis

Fig 3b Deformation





BGP Routing Simulation and OSPF Network Design and Optimization

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ABSTRACT

This paper explores two key aspects of network routing: BGP (Border Gateway Protocol) routing simulation and OSPF (Open Shortest Path First) network design and optimization. BGP is the protocol used to exchange routing information across the internet, making it critical for internet service providers and large-scale networks. On the other hand, OSPF is a link-state protocol used primarily in enterprise networks to determine the shortest path to route traffic. We will first simulate BGP routing to understand its operations and challenges and then focus on the design and optimization of an OSPF-based network for efficient routing.

Keywords: BGP (Border Gateway Protocol), OSPF (Open Shortest Path First), Routing simulation, Network design, Routing optimization, Internet service providers (ISPs), Large-scale networks, Link-state protocol, Enterprise networks Shortest path routing

INTRODUCTION

BGP Routing Simulation, OSPF Network Design and Optimization

Introduction to BGP

BGP is considered as a path vector protocol responsible for making routing decisions based on policies defined by administrator networks. It operates between Autonomous Systems (AS), ensuring that routing information is exchanged between them without loops or inconsistencies. BGP supports a robust mechanism to prevent routing loops and employs policies to manage traffic across the network.





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Introduction to OSPF

OSPF is a link-state protocol designed for intra-domain routing. It dynamically calculates the shortest path to all destinations within an AS by building a complete topology of the network using Dijkstra's algorithm. OSPF is well-suited for large enterprise networks due to its support for areas and hierarchical design.

BGP Routing Concepts, OSPF Design Concepts

Autonomous System (AS): A collection of IP prefixes under a single administrative domain that presents a common routing policy.

eBGP vs. iBGP: External BGP (eBGP) is used between different ASes, while Internal BGP (iBGP) is used within a single AS.

Path Attributes: BGP selects the best path using various applications, such as AS path length, nexthop, local preference and MED (Multi-Exit Discriminator).

OSPF Design Concepts

OSPF Areas: To optimize routing, large OSPF networks are divided into smaller areas. Area 0 (Backbone Area) is essential as it connects all other areas.

Router Types: OSPF defines four router types: Internal, Backbone, Area Border Router (ABR), and Autonomous System Boundary Router (ASBR).

Link Cost: OSPF uses link costs (based on bandwidth) to determine the best path.

BGP Routing Simulation Setup

To simulate BGP routing, we use a network consisting of four Autonomous Systems (AS1, AS2, AS3, AS4) interconnected as shown in Figure 1.

Figure 1: BGP Topology

AS1 ↔ AS2 ↔ AS3
AS1 ↔ AS4
AS2 ↔ AS3
AS3 ↔ AS4

OSPF Network Design

For this section, we simulate an OSPF network consisting of five routers distributed across three areas (Area 0, Area 1, and Area 2), as shown in Figure 2. The goal is to optimize routing by minimizing the number of routers in the backbone area and reducing path costs.

Figure 2: OSPF Network Topology

mathematica

Copy code

```

+---- R1 (Backbone Area 0) ----+
/                               \
R2 (ABR, Area 1)                R3 (ABR, Area 2)
|                               |
R4 (Internal Area 1)           R5 (Internal Area 2)

```

Simulation Results

The BGP routing simulation was carried out in GNS3, with the routers exchanging routing updates via eBGP. As seen from the output, each AS successfully learned routes from its neighbors. The table below shows the final routing table in AS1.

OSPF Optimization

The optimization of OSPF was carried out by adjusting the link costs. We reduced the path cost between R1 and R3 by increasing the bandwidth of the link between them. Table 4 shows the updated link costs after optimization.





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CONCLUSION

The BGP simulation demonstrated the fundamental operations of the protocol. ASes correctly learned routes from their neighbors, and the policy-based routing feature of BGP was successfully tested by manipulating path attributes such as local preference. OSPF network design was optimized by adjusting link costs, reducing the overall path cost between critical routers. OSPF's hierarchical design with areas allowed us to manage the routing complexity, improving scalability and performance. Future work can explore OSPF multi-area designs for more complex networks. Both BGP and OSPF play critical roles in modern networking. BGP manages inter-domain routing across the global internet, while OSPF provides efficient intra-domain routing within organizations. By simulating BGP and optimizing OSPF, we demonstrated how these protocols contribute to the stability, scalability, and performance of large networks.

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Table 1: BGP Simulation Topology

AS Number	Router ID	Neighbors (eBGP/iBGP)	IP Prefixes Advertised
AS1	192.168.1.1	AS2 (eBGP), AS4 (eBGP)	10.0.0.0/16
AS2	192.168.2.1	AS1 (eBGP), AS3 (eBGP)	20.0.0.0/16
AS3	192.168.3.1	AS2 (eBGP)	30.0.0.0/16
AS4	192.168.4.1	AS1 (eBGP)	40.0.0.0/16

Table 2: AS1 Routing Table

Destination Network	Next Hop	AS Path	Local Preference	MED
10.0.0.0/16	Local	N/A	100	N/A
20.0.0.0/16	192.168.2.1	AS2	100	N/A
30.0.0.0/16	192.168.2.1	AS2 AS3	100	N/A
40.0.0.0/16	192.168.4.1	AS4	100	N/A

Table 3: OSPF Network Design

Router ID	OSPF Role	Area ID	Links Connected	Cost
R1	Backbone	0	R2, R3	1
R2	ABR (Area 1)	1	R1, R4	10
R3	ABR (Area 2)	2	R1, R5	20
R4	Internal (Area 1)	1	R2	10
R5	Internal (Area 2)	2	R3	20

Table 4: Optimized OSPF Link Costs

Link	Original Cost	Optimized Cost
R1 to R2	1	1
R1 to R3	20	10
R2 to R4	10	10
R3 to R5	20	15





Numerical Investigation of the Behaviour of Flywheel in the Dynamic State for Energy Storage System

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ABSTRACT

This paper presents a comprehensive numerical investigation of flywheel behaviour in dynamic states, focusing on the effects of various operational parameters and loading conditions. Utilizing finite element analysis, we explore the stress distribution, deformation, and frequency response of flywheels during operations. The study examines the influence of geometric configurations, rotational speed and angular acceleration on the dynamic performance of flywheels. Results indicate that optimal design choices can significantly enhance stability and energy retention capabilities. Additionally, the findings provide insights into the potential for improved flywheel applications in energy storage systems and regenerative braking technologies. This research contributes to the understanding of flywheel dynamics and lays the groundwork for future innovations in mechanical energy storage solutions.

Keywords: Flywheel, Static structural, FEM, Mode Shape, Frequency response.

INTRODUCTION

The increasing demand for efficient energy storage solutions has prompted renewed interest in flywheel technology, known for its ability to deliver high power density and rapid energy discharge. This paper presents a comprehensive numerical investigation into flywheel behaviour under dynamic conditions, specifically examining how various operational parameters and loading scenarios influence performance. Employing finite element analysis, we delve into critical aspects such as stress distribution, deformation, and frequency response during flywheel operation.



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Understanding these factors is essential for optimizing flywheel design and enhancing its application in energy storage systems and regenerative braking technologies. Our study focuses on key parameters, including geometric configurations, rotational speed, and angular acceleration, to assess their impact on the dynamic performance of flywheels. By identifying optimal design choices, we aim to improve stability and energy retention capabilities, thereby contributing to the advancement of flywheel technology. The findings from this research not only enhance the theoretical understanding of flywheel dynamics but also provide practical insights for engineers and designers. Ultimately, this work lays the groundwork for future innovations in mechanical energy storage solutions, positioning flywheels as a viable alternative in the quest for sustainable energy systems. The investigation of flywheel energy storage systems (FESS) has garnered significant attention due to their potential for high efficiency and rapid energy discharge. Muljadi and Gevorgian (2017) provide a foundational understanding of dynamic modelling in flywheel systems, emphasizing the importance of accurate simulations for performance prediction. Their work highlights how dynamic modelling can aid in optimizing energy storage capabilities. Wang and Du (2016) contribute to this field by conducting a dynamic analysis of flywheel systems, revealing critical insights into the effects of various operational conditions on performance. Similarly, Chen *et al.* (2015) develop a nonlinear dynamical model for dual mass flywheels, which is particularly relevant for automotive applications, showcasing the complexities involved in modelling flywheel dynamics. The design considerations for flywheels are further explored by Luo *et al.* (2015), who examine vibration isolation in multiple flywheel configurations, highlighting the need for effective control strategies to manage dynamic behaviour. In a more recent study, Wang *et al.* (2024) analyse composite flywheel rotors, demonstrating how material selection can significantly affect dynamic stability and energy retention. Choudhury (2021) offers a comprehensive review of FESS technologies, applications, and future prospects, underlining the diverse potential applications of flywheel systems. Meanwhile, Hamisu *et al.* (2020) employ finite element analysis (FEA) and modal analysis to assess damped flywheels, emphasizing the importance of addressing unbalanced masses in dynamic performance. Pawar *et al.* (2018) and Patil (2019) focus on the design and analysis of flywheels with varying geometries and materials, providing crucial insights into how these factors impact energy storage capabilities. Prince *et al.* (2015) and Reddy and Kumar also contribute to the understanding of rotor dynamics, using analytical methods to assess the influence of design modifications on performance. Bankston and Mo (2015) explore geometry modification in flywheels, presenting evidence that design changes can enhance energy storage efficiency. Hansen *et al.* (2019) delve into the dynamics of flexible mobile flywheel systems, showcasing theoretical modelling techniques that can inform practical applications. Finally, recent work by Motaman *et al.* (2023) offers a numerical analysis focused on low-carbon powertrain applications, further illustrating the relevance of flywheel energy storage in modern energy systems. Upadhyay and Mohan (2009) provide insights into simulation techniques, specifically utilizing MATLAB/Simulink to model high-speed modular flywheels, emphasizing the role of simulations in design optimization.

FEM Approach

The finite element method (FEM) is employed to analyze the dynamic behaviour of a flywheel used in energy storage systems. This approach allows for a detailed examination of the stress distribution, deformation, and frequency response of the flywheel under various operational parameters. The flywheel geometry is created using ANSYS Design modeler shown in figure 1. The tetragonal meshing of flywheel is developed and shown in figure 2. The specification and material properties of mechanical flywheel is listed in table 1. The design incorporates the flywheel's specific dimensions and geometric features, ensuring that the model accurately represents the physical system.

Material Properties

The flywheel is assigned material properties consistent with structural steel, including:

Young's Modulus: Typically around 210 GPa

Poisson's Ratio: Approximately 0.3

Density: 7850 kg/m³





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RESULTS AND DISCUSSIONS

Deformation in the Flywheel

In a rotating flywheel, **radial deformation** and **tangential deformation** occur due to centrifugal forces acting at high speeds. At an operating speed of 600 rpm, radial deformation causes the flywheel material to expand outward from the centre, stretching along the radius as shown in figure 3(a) and 3(b). This outward stretch increases with speed and material properties, affecting flywheel stability. Meanwhile, **tangential deformation**, or hoop deformation, occurs along the circular direction around the wheel's edge.

Stress Analysis

At an operating speed of 600 rpm, ANSYS simulation results reveal distinct radial and tangential (hoop) stresses within the flywheel as shown in figure 4 (a) and 4 (b). Radial stress develops as the centrifugal force pushes outward, causing the material to stretch radially. This stress typically starts high near the centre of the flywheel and decreases toward the outer edge. Radial stress impacts the flywheel's core strength, and excessive values can lead to radial cracking or failure. Tangential stress, or hoop stress, acts circumferentially around the flywheel's perimeter. As the speed increases, the outer layers of the flywheel experience significant tangential stress, which is generally higher than radial stress at the rim. This stress is crucial for the structural integrity of the flywheel since it directly affects the risk of failure along the circumference. Excessive tangential stress can cause cracking along the circumference and reduce overall durability. Understanding these stress distributions helps in designing a flywheel that can withstand operating speeds without compromising safety or functionality.

Frequency Response

The initial six **mode shapes** of the flywheel at various **natural frequencies** offer insights into its vibrational behaviour and potential resonance risks. Using ANSYS, the natural frequencies corresponding to these modes are determined, revealing distinct deformation patterns that help assess the flywheel's structural response under different excitation conditions. In the **first mode (figure 5 (a))**, typically at the lowest frequency, the flywheel experiences a uniform radial expansion, showing minimal deformation. As frequency increases, higher modes show more complex deformations. The **second (figure 5 (b)), and third modes (figure 5 (c))**, generally display bending along specific planes, causing partial oscillations that could amplify if the operating frequency matches these natural frequencies. In the **fourth to sixth (figure 5 (d), (e) & (f)) modes**, deformation patterns become more intricate, with multiple nodal lines and oscillatory shapes across the flywheel surface.

Variation of Amplitude and Phase Angle in Radial Direction with Natural Frequency of Flywheel

As natural frequency increases, amplitude typically peaks at certain resonant frequencies, where the flywheel experiences maximum vibration as shown in figure 6 (a). These peaks highlight the critical frequencies that could lead to structural issues if the flywheel operates near them. Meanwhile, the **phase angle** shows how the displacement direction changes relative to the applied force, shifting by approximately 180 degrees near resonance shown in figure 6 (b).

Variation of Amplitude and Phase Angle in Tangential Direction with Natural Frequency of Flywheel

The ANSYS-generated plot showing the **variation of amplitude (figure 7 (a)) and phase angle (figure 7 (b)) in the tangential direction** with natural frequency provides key insights into the flywheel's circumferential vibration behaviour. At specific **natural frequencies**, the amplitude of tangential vibrations spikes, indicating resonant points where the flywheel's tangential displacement is maximized. These peaks are critical as they can lead to excessive vibrations that threaten the flywheel's integrity. The **phase angle** shows notable shifts, with a 180-degree change occurring near resonance, reflecting a phase reversal in the vibration response. Monitoring these tangential variations is essential for identifying safe operational frequencies to prevent resonance-induced failures.





CONCLUSIONS

1. The results indicate that careful optimization of design choices can significantly enhance the flywheel's stability and energy retention capabilities.
2. Our analysis revealed critical stress distribution patterns and deformation behaviours, highlighting potential areas for design improvements. Furthermore, the study's findings contribute to a deeper understanding of flywheel dynamics, which is essential for advancing energy storage technologies.
3. This research has successfully demonstrated the effectiveness of finite element analysis (FEM) in investigating the dynamic behaviour of flywheels used in energy storage systems. By examining various operational parameters, including geometric configurations, rotational speed, and angular acceleration, we have gained valuable insights into how these factors influence the flywheel's performance.

ACKNOWLEDGEMENT

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Declaration of conflicting interests

The author(s) declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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Table 1 Parameters of Flywheel and Ansys statistics	
Material used	Structural Steel
Mass	445.22 kg
Ansys Statistics	
No. of Nodes	63717
No. of Elements	36483
Table 2 Operating conditions	
Speed of Flywheel	600 RPM
Angular Acceleration	2000 mm/s ²

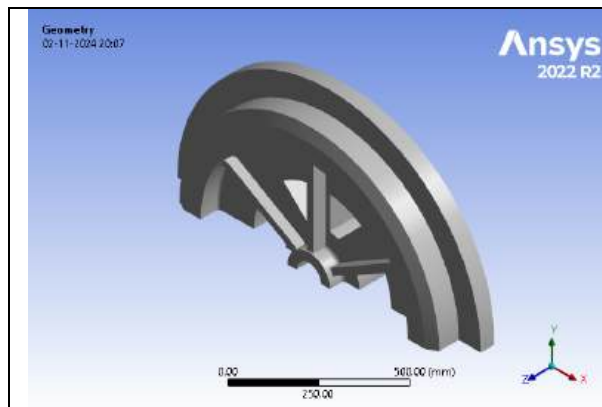


Figure 1. Geometrical Model of Flywheel

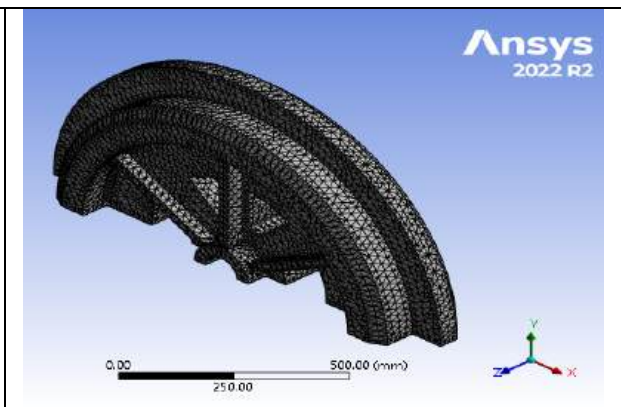
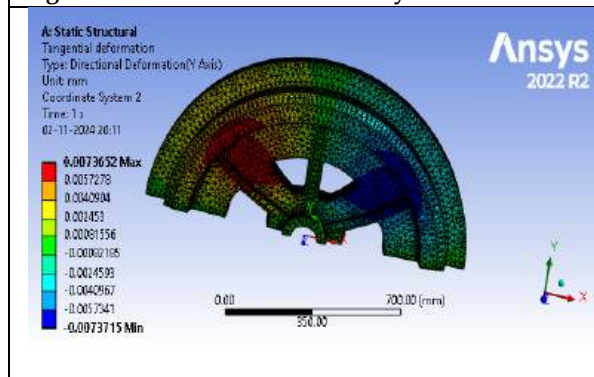
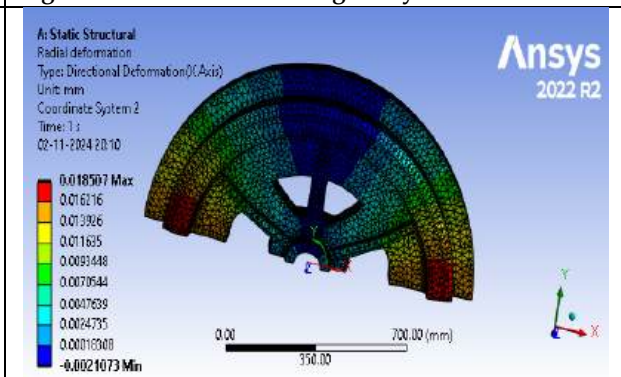


Figure 2. Tetrahedral Meshing of Flywheel



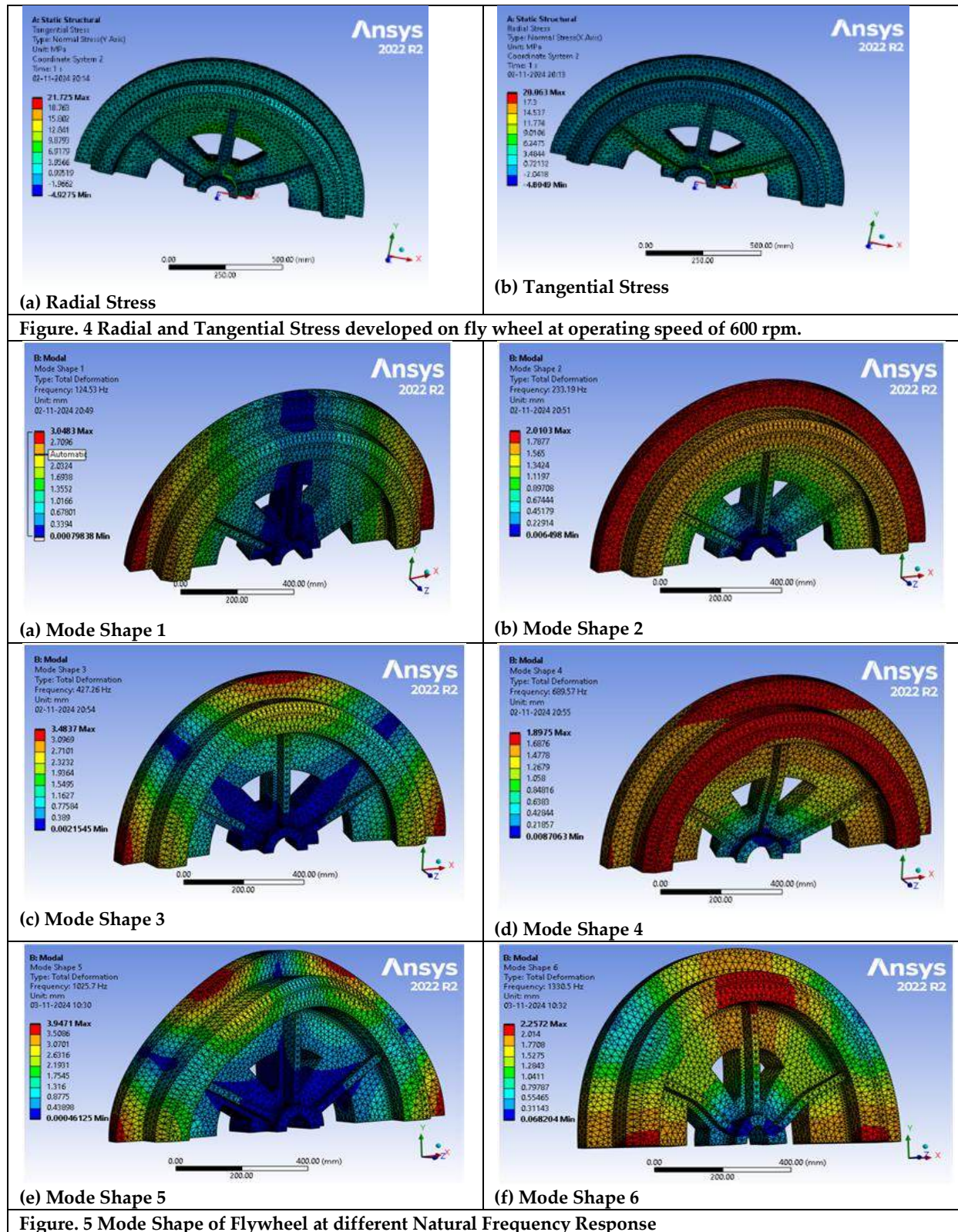
(a) Radial Deformation

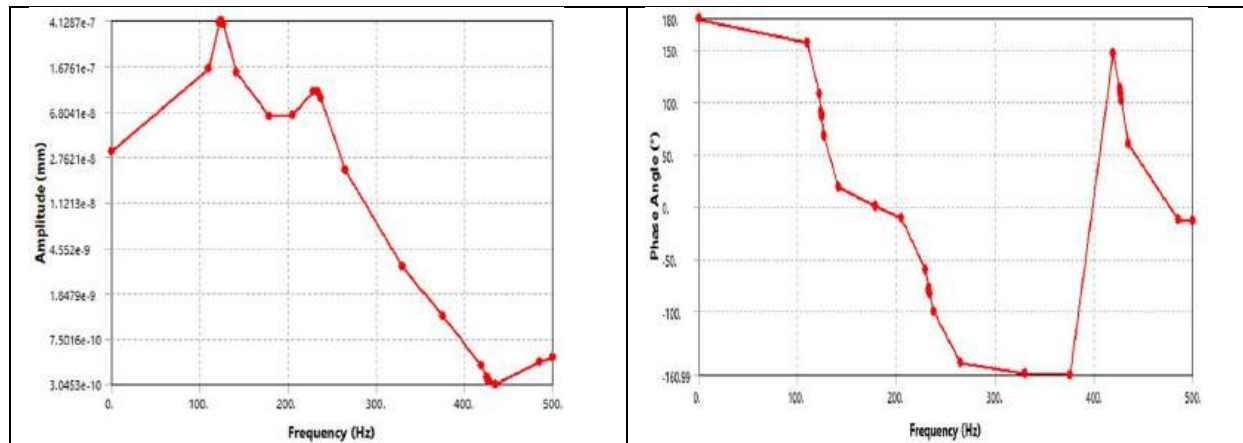


(b) Tangential Deformation

Figure. 3 Radial and Tangential deformation of flywheel working under the operating speed of 600 rpm



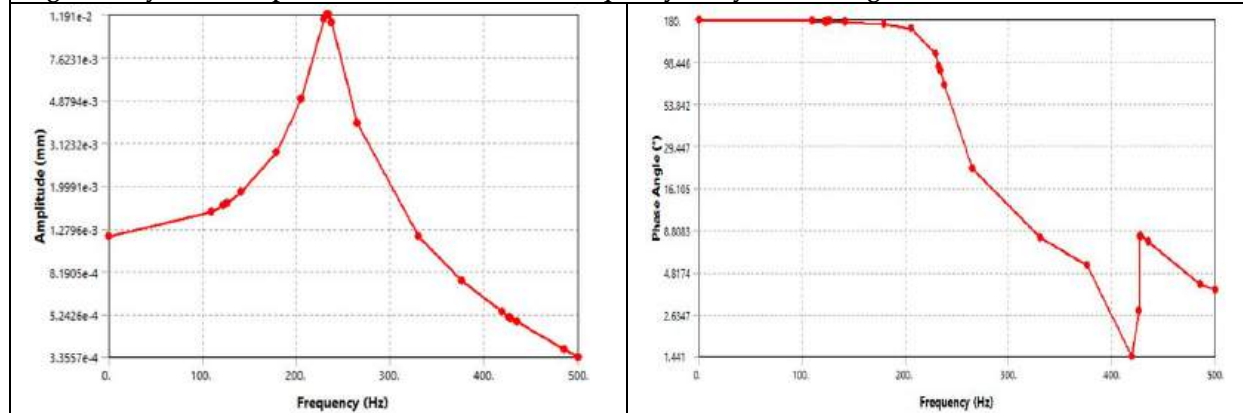
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(a) Frequency Vs. Frequency Response (Amplitude)

(b) Frequency Vs. Frequency Response (Phase Angle)

Figure. 6 Dynamic Response at different Natural Frequency of Flywheel along the Radial Direction



(a) Frequency Vs. Frequency Response (Amplitude)

(b) Frequency Vs. Frequency Response (Phase Angle)

Figure. 7 Dynamic Response at different Natural Frequency of Flywheel along the axial Direction





Developing and Producing the Geneva Mechanism with Solid Works and CNC

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ABSTRACT

The Purpose Understanding the significance of the Geneva mechanism and designing and developing a six-slot Geneva wheel with Solid Works software and CNC to manufacture the components are the project's goals. Once everything is assembled on the base plate, the sporadic motion can be seen. Additionally, it can be used to do several tasks with a single mechanism. In terms of applications, this project will also benefit the production industries.

Keywords: Geneva Mechanism, Intermittent, Geneva Rotator, External Geneva Rotator, Instantaneous motion, Regular Intervals.

INTRODUCTION

The Geneva mechanism is a technique that converts continuous circular motion into intermittent or fixed step circular motion, meaning that the same displacement is produced in equal amounts of time. Because of their visual resemblance, the Geneva drive is also known as a Maltese cross mechanism. The Maltese cross mechanism sometimes referred to as the Geneva drive or Geneva mechanism, is a marvel of engineering that allows for accurate intermittent motion control in a variety of mechanical applications. The basic principle of the Geneva mechanism is intermittent motion, which is accomplished by accurately angular indexing continuous rotational





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motion. This intermittent motion is crucial for applications that need accurate placement, such as indexing devices, packing machines, and automated assembly lines

METHODOLOGY

- Idea generation to have a brief knowledge to build the Geneva drive mechanism.
- Selection of material which is suitable for the mechanism. Choosing the suitable designing software for modelling components of the Geneva mechanism and assembling all the parts as per dimensions in Solid works to check the mating parts before working on the Raw material and job. Process planning for designing each part of Geneva model to execute it in the manufacturing.
- Using CNC as a machine to develop each part by the process of subtractive manufacturing process by feeding all the required data on HMI to operate as per standard. After fabricating all components of the mechanism, we need to measure all the dimensions as per designing factors. At the end, all the parts need to be assembled together and need to check motion of the Geneva drive.

CONCLUSIONS

It's commonly used in applications where precise timing or controlled movement is crucial, such as in clocks, indexing tables, and packaging machines. The better feature the Geneva mechanism is its ability to provide precise and angular continuous motion. This is achieved through the design of the slots on the driven wheel. The slots are designed in such a way that the driven wheel only advances when the pin on the driving wheel is engages inside the driven wheel, ensuring accurate positioning of the driven mechanism.

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Table 1: Data & Parameters of Geneva mechanism.

Part No	Description	Quantity	Size
1	Base Plate	01	250×130×16
2	Driver	01	Ø125×20
3	Geneva Wheel	01	Ø125×12
4	Driver shaft	01	Ø16×55
5	Wheel Shaft	01	Ø16×55
6	Roller	01	Ø3×20
7	Handle	01	Ø15×60
8	Nut	02	M6
9	Washer	02	Ø16×1.6





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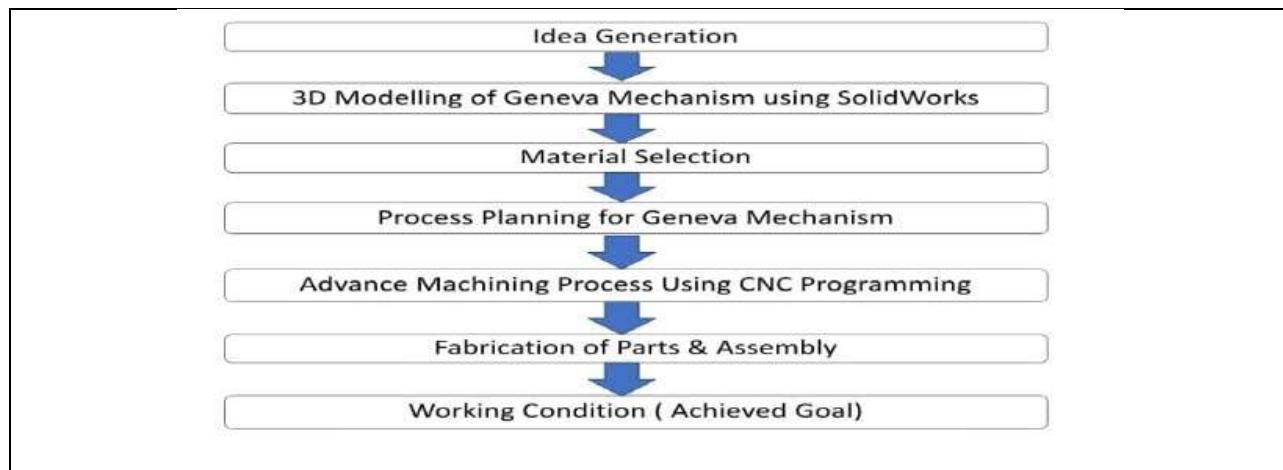


Figure1: sequence of process planning to design Geneva mechanism

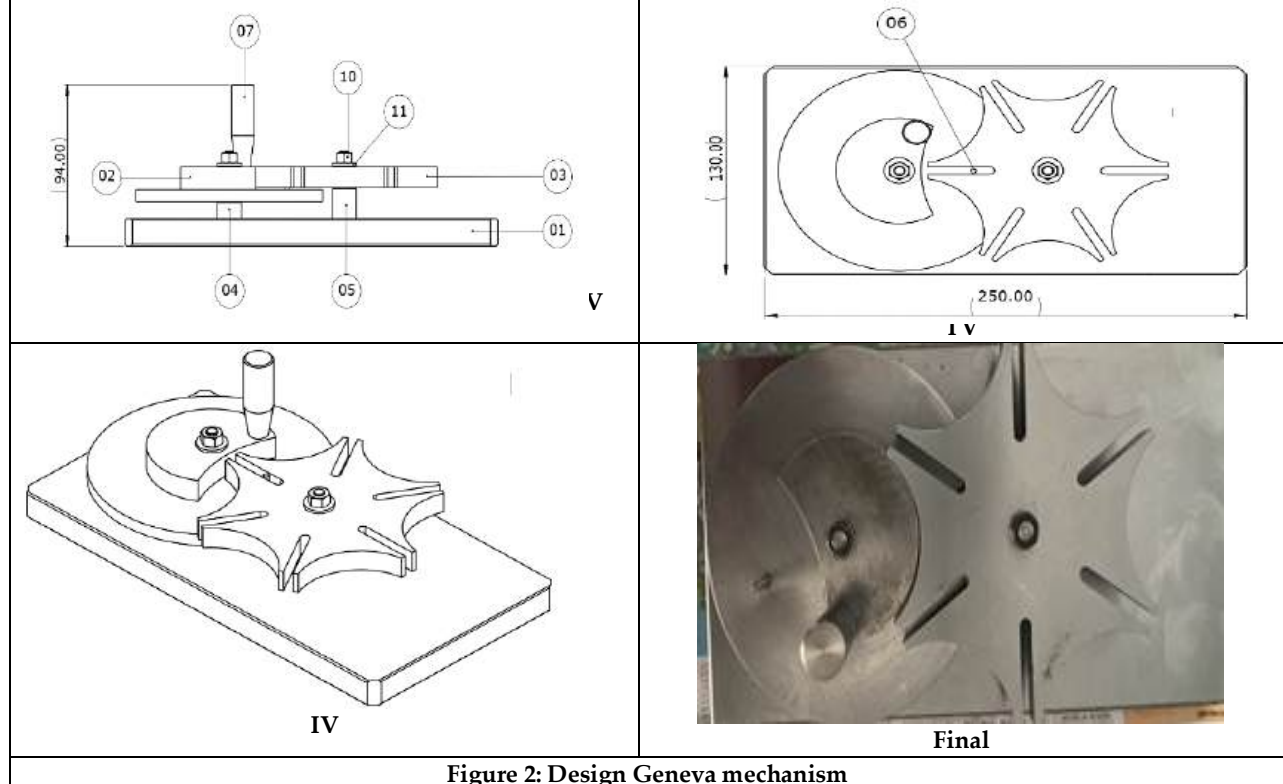


Figure 2: Design Geneva mechanism





Enhancing Image Aesthetics: A Deep CNN Approach to Colorization

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ABSTRACT

This research proposes a system that, without the need for human intervention, faithfully transforms black and white photographic images into colorful visualizations using Deep Convolutional Neural Networks. When painting a black and white artwork by hand or using Photoshop, it may take several days to precisely colorize a single image. By using a pretrained convolutional neural network (VGG-16), we can colorize a couple of images in a short duration, which is especially designed for image classification and trained by millions of images regarding 1,000 classes. So, we do not need to train the model with a huge amount of data to identify different types of objects in images, although we can provide a set of monochrome images at a time by putting them in the testing directory and get them as plausible color vision in the result directory. In this project, we have described a method of colorizing a grayscale image based on image segmentation. This method considerably lessens human intervention. Although we can never be perfectly sure that the output of this application has the exact color vision, we show that colorization can be a powerful pretext task for self-supervised feature learning, acting as a cross-channel encoder. This approach results in state-of-the-art performance on several feature learning benchmarks.

Keywords: Deep Learning, Image Colorization, Convolutional Neural Networks, VGG-16, Supervised Learning.

INTRODUCTION

To create a colored image from a grayscale input, a deep convolutional neural network is built. First, the black-and-white picture is resized to 256 by 256 pixels. We feed this data into our neural network. Our algorithm is trained on bright photos so that it can generate realistically colored images. The images produced might readily trick an observer. There are three channels in the RGB color system. The primary difference between RGB color spaces and CIE Lab is that CIE Lab only encodes color data in the "a" and "b" channels. Since the L (lightness) channel simply



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represents intensity, we may use it as our grayscale input for the neural network. The trained network will predict the Ab channels. The created ab channels will now be combined with the L channel. The "Lab" image will then be converted back to its RGB counterpart. In general, the human imagination finds it simple to colorize a grayscale image. Early on, we learn to identify the missing colors in coloring books by filling in the blanks, such as the apple being either red or green, the grass being green, and the sky being blue with white clouds. Automated colorization can be quite useful in several sectors. The act of applying color alone can boost the amount of information we take from an image, even in the absence of meaningful comprehension of the image. For instance, it is frequently employed in medical imaging to improve the clarity of images as seen by the human eye. Various diagnostic imaging tools collect grayscale pictures, and these images include sections that are difficult to view due to the normal eye's inability to differentiate between them.

As a computer vision project, some approaches are widely used for the colorization problem. These include providing a reference image to color black-and-white images, training our own model by feeding large amounts of data to predict pixel-wise color, and using techniques such as GANs (Generative Adversarial Networks) or the Caffe framework. Here, we utilize the VGG-16 model proposed by Karen Simonyan and Andrew Zisserman of the Visual Geometry Group at Oxford University in 2014 in their paper "Very Deep Convolutional Networks for Large-Scale Image Recognition" [1]. The model, developed using millions of photos divided into 1000 classes, can quickly recognize the forms of objects in a given grayscale image and apply colors that make sense

VGG – 16

Grayscale photos have been colorized in this work using different deep learning techniques. A neural network-based model is proposed. This model is novel, and other top-notch features are included. A previously trained model called "VGG-16" by Simonyan and Zisserman [1] is used. A specific encoder-decoder model is applied in this paper. This can be applied to photographs of any size and aspect ratio. To gauge public approval of the model after the results are computed, a separate user study is conducted. A distinct menu of programs with various types of images is displayed to achieve this. Below is a succinct summary of the model:

- The previously mentioned pre-trained model is used to extract high-level features. CNN is used to analyze the architectural design.
- A second user study is conducted to determine whether or not the model is supported by the general public.
- The model is evaluated with an additional batch of outdated images. In recent years, convolutional networks (ConvNets) have demonstrated remarkable performance in large-scale image and video recognition [3]. Large-scale public picture libraries like ImageNet and high-performance computer devices like GPUs are to blame for this [3]. In particular, by acting as a testbed for several generations of large-scale image classification systems, from deep ConvNets to high-dimensional shallow feature encodings, the ImageNet Large-Scale Visual Recognition Challenge (ILSVRC) [3] has significantly advanced these systems.

As ConvNets gain popularity in the computer vision industry, several attempts have been made to improve the original architecture of Krizhevsky et al. in an attempt to improve accuracy [5]. Sermanet et al. and Zeiler Fergus [6] used smaller strides of the initial convolutional layers and smaller receptive window widths in their top-performing submissions to ILSVRC 2013. Thorough training and testing of the networks over many scales, including the full image, have also been explored [5].

Methods:

VGG-Net:

The Visual Geometry Group, or VGG, is a conventional deep Convolutional Neural Network (CNN) with several layers. In VGG-16 and VGG-19, the number of convolutional layers is represented by the term "deep," with 16 and 19 layers, respectively. Innovative object recognition models are based on the VGG architecture. Beyond ImageNet, VGGNet outperforms benchmarks on a variety of tasks and datasets as a deep neural network. Even now, it remains one of the most widely utilized image recognition frameworks [4].





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Types of VGG -Net

1. VGG-16.
2. VGG-19.

This journal uses state-of-the-art deep learning techniques to automatically colorize black and white photographs. Over the past few years, Convolutional Neural Networks (CNNs) have revolutionized computer vision. Due to the competitors' widespread use of CNN models, error rates in the ImageNet Challenge (ILSVRC) have been declining every year. The ILSVRC's classification error is now believed to be lower than that of humans.

The ILSVRC's classification error is now believed to be lower than that of humans. Pre-trained categorization models repurposed, as evidenced by amazing visualizations.

There are two ways to use this system, as stated in the system design above. One method is to use the desired dataset to train our own model. The dataset needs to go in common.py file, which, given the volume of data we used, requires a significant amount of training time. The second method is to utilize a pretrained model, which often uses data that has been learned from the ImageNet dataset. The second method does not require feeding the model. However, we must place the images in the testing directory, which is shared by both methods' files. There are two usual ways of execution based on user satisfaction and time duration of training, which are mentioned below.

Our model can be trained quickly by employing a pre-trained model using the ImageNet dataset and the VGG - 16 learned weights. This method of feature extraction employed the residual encoder.

Use pretrained model.

Train our own model.

With the dataset and the VGG - 16 network, we can train our model to colorize black and white photographs more accurately than we could have done with a pretrained model.

Used modules are.

1. VGG - 16 network
2. VGG model
3. Dataset
4. train.py
5. test.py

Process for execution

6. Place the dataset in training path.
7. Place testing images in test path.
8. Run train.py
9. Run test.py file.

After a huge time of training our model with the dataset, it gave us an excellent colonizing output. The below images are examples of tested images by our own trained model.

RESULTS

Result of trained model.

As previously mentioned, the trained model required a significant amount of training time to learn the model for colorization, and the amount of training time required depends on the size of the dataset used to train the model. After the training and testing process was over, the system produced superb colorized photographs in the output





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folder described above .

Note:

Put the dataset in the folder named Trainingdataset , which is controlled by the config . py file as seen in the figure below .

The image seen here has three sides :

" a monochrome image on the left , a system - colored shot in the middle , and the original image on the right ."

Here is one of the images .

CONCLUSION

Image colorization is an example of a difficult pixel prediction problem in computer vision, even though it is a specialized area of computer graphics work. Here, we've shown how colorization using a deep CNN and a carefully chosen objective function can approach producing results that closely resemble real color photos. Our method can be used as a pretext assignment for representation learning as well as for efficient graphics output. Despite only having been taught to distinguish colors , this network creates a representation that is incredibly useful for object classification, detection, and segmentation. This network performs better than current methods of self-supervised pretraining .

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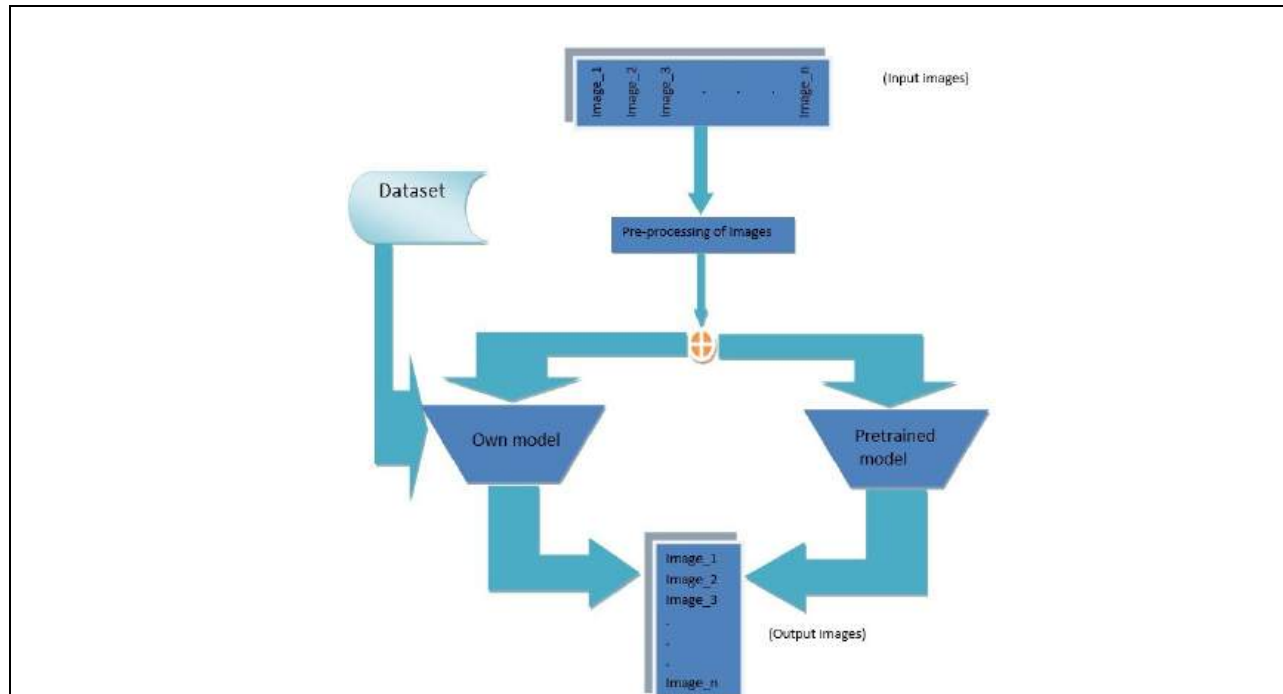


Figure: 1. System Workflow



Left: grey image, middle: colorized image, right: ground truth.

Figure.2. Output images structure



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```

20 # Image resize method
21 image_resize_method = tf.image.ResizeMethod.BILINEAR
22
23 # Parameters for neural network
24 training_iters = 3000000 # The training iterations number
25 batch_size = 6 # Batch size for training data
26 display_step = 50 # Step interval for displaying loss and saving s
27 testing_step = 1000 # Step interval for testing and saving image d
28 saving_step = 10000 # Step interval for saving model during traini
29 shuffle_buffer_size = 2000
30
31 # UV channel normalization parameters
32 u_norm_para = 0.435912
33 v_norm_para = 0.614777
34
35 # Directory for training and testing dataset
36 training_dir = "training_dataset"
37 testing_dir = "test_images/test_color"
38
39 # Model, result and generated images stored path
40 summary_path = "summary/summary"
41 summary_path1 = "summary"
42 training_summary = summary_path1 + "/train"
43 testing_summary = summary_path1 + "/test"
44

```

Figure 3. Training and testing folder directory



Figure 4: Output image by own model.





Contemporary Methods in Optimizing the Shop Floor to Consumer Supply Chain Management

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ABSTRACT

In the evolving landscape of manufacturing and distribution, optimizing the supply chain from the shop floor to the consumer is paramount for enhancing efficiency, reducing costs, and improving customer satisfaction. This review discusses contemporary methods employed in supply chain management (SCM), focusing on innovations in technology, process optimization, and strategic collaboration. By examining current literature, this article aims to provide insights into best practices and future trends in SCM, emphasizing the importance of integrating modern tools and methodologies. This review serves as a foundational guide for understanding contemporary methods in optimizing supply chains and highlights the critical importance of innovation and collaboration in achieving operational excellence.

Keywords: Supply Chain Management, Shop Floor Optimization, Technology Integration, Lean Manufacturing, Industry 4.0

INTRODUCTION

The supply chain serves as the backbone of manufacturing organizations, facilitating the efficient delivery of products to consumers. The shift from traditional to contemporary methods in supply chain management (SCM) has been propelled by technological advancements, globalization, and evolving consumer demands. In today's competitive environment, organizations must adapt quickly to changing market conditions, requiring innovative strategies to optimize their supply chains effectively. This paper aims to review current practices in SCM, particularly those that optimize the journey from the shop floor to the consumer. By focusing on contemporary methods, including lean manufacturing, just-in-time inventory, Industry 4.0 technologies, collaborative planning, and sustainable practices, this review highlights their significance in enhancing operational performance. Additionally, the growing influence of digitalization and data analytics on SCM cannot be overlooked. As



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organizations collect vast amounts of data, they must leverage analytics to gain actionable insights, improve decision-making, and enhance customer experience. Moreover, the implications of global supply chain disruptions, such as those caused by the COVID-19 pandemic, have underscored the importance of building resilient supply chains capable of withstanding unexpected shocks. Furthermore, the paper discusses the challenges organizations face in implementing these practices and offers insights into future directions for research and application. Understanding these methods is crucial for organizations seeking to remain competitive in a rapidly changing marketplace. By adopting a holistic approach to SCM, which encompasses not just technological integration but also organizational culture and workforce development; businesses can position themselves for sustained success in the future. Contemporary Methods in Supply Chain Optimization.

Lean Manufacturing

Lean manufacturing is a methodology that aims to minimize waste while maximizing productivity and value. Originating from the Toyota Production System, lean practices emphasize continuous improvement, employee involvement, and efficient resource utilization [1], [14]. Techniques such as Value Stream Mapping (VSM) are employed to visualize processes and identify areas for waste reduction. By focusing on non-value-added activities, organizations can streamline their operations, leading to reduced lead times and lower inventory costs [2]. Moreover, lean manufacturing promotes a culture of respect for people, where employees are encouraged to identify inefficiencies and suggest improvements. This empowerment not only increases job satisfaction but also fosters a collaborative work environment that can drive innovation [3]. Techniques like 5S (Sort, Set in order, Shine, Standardize, Sustain) help maintain organized and efficient workspaces, directly contributing to improved productivity.

In an increasingly competitive landscape, the implementation of lean principles can provide organizations with a significant edge. Lean practices enhance overall supply chain efficiency by promoting a culture of continuous improvement and responsiveness to consumer needs. The adaptability of lean methodologies allows for a tailored approach to different industries and markets, ensuring that organizations remain agile and capable of meeting changing demands. This adaptability is essential for maintaining a competitive advantage in today's fast-paced environment. By prioritizing value creation and waste elimination, organizations can position themselves for long-term success and resilience in their supply chains [4]. Lean manufacturing enhances overall supply chain efficiency by promoting a culture of continuous improvement and responsiveness to consumer needs. Implementing lean principles fosters a proactive approach to problem-solving, enabling organizations to adapt quickly to market changes. This adaptability is essential for maintaining a competitive advantage in today's fast-paced environment. Additionally, lean practices encourage collaboration across departments and with suppliers, ensuring that everyone involved in the supply chain is aligned with the same goals [3]. As such, the integration of lean manufacturing into SCM is not just about efficiency but also about fostering a culture that prioritizes customer value and sustainable practices, setting the stage for a more resilient supply chain [4].

Just-In-Time (JIT) Inventory

Just-In-Time (JIT) inventory management is a strategic approach designed to reduce inventory holding costs by ensuring that materials and products arrive only as needed in the production process [3]. This methodology emphasizes the importance of precise demand forecasting and reliable supplier relationships to synchronize production schedules with consumer demand. By adopting JIT systems, organizations can minimize excess inventory, thereby reducing storage costs and the risk of obsolescence [4]. Furthermore, JIT requires a high level of collaboration and trust between suppliers and manufacturers. Long-term partnerships are essential for ensuring that suppliers can meet the stringent delivery schedules required by JIT systems. In this context, technology plays a crucial role; real-time data sharing between supply chain partners can enhance communication and transparency, significantly improving JIT implementation [5].

The implementation of JIT requires a robust supply chain network capable of rapid response and adaptability. Successful JIT implementation leads to shorter lead times, improved cash flow, and enhanced product quality.



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through increased focus on operational efficiency [5]. However, challenges exist, including the need for strong communication and collaboration among supply chain partners to avoid disruptions that can lead to stockouts [6]. Furthermore, organizations must invest in technology and data analytics to accurately predict demand patterns, ensuring that JIT systems function effectively [7]. Overall, JIT inventory management serves as a powerful tool for optimizing supply chains, allowing organizations to align production closely with market demands while minimizing costs [8].

Industry 4.0 Technologies

Industry 4.0 represents a paradigm shift in manufacturing, characterized by the integration of advanced technologies such as the Internet of Things (IoT), big data analytics, and artificial intelligence (AI) into production processes [5]. These technologies facilitate real-time monitoring and data-driven decision-making, enhancing visibility and coordination across the supply chain [6]. For instance, IoT devices enable manufacturers to track equipment performance and inventory levels in real-time, allowing for proactive maintenance and inventory management [9]. Additionally, the use of predictive analytics can help organizations forecast demand more accurately, ensuring that production aligns with market needs [10]. This level of responsiveness not only enhances customer satisfaction but also reduces waste and operational costs.

Furthermore, big data analytics can identify trends and patterns in consumer behavior, enabling organizations to make informed decisions about production and distribution [10]. AI applications in supply chain management can optimize logistics, improve demand forecasting, and automate routine tasks, thereby increasing operational efficiency [11]. As companies adopt Industry 4.0 technologies, they can create more agile and responsive supply chains, better equipped to adapt to market fluctuations and consumer demands [12]. However, the successful implementation of these technologies requires significant investment and a cultural shift toward innovation and continuous improvement [13]. The integration of Industry 4.0 technologies in SCM not only enhances productivity but also fosters a more resilient supply chain capable of navigating the complexities of modern manufacturing [14].

Collaborative Planning, Forecasting, and Replenishment (CPFR)

Collaborative Planning, Forecasting, and Replenishment (CPFR) is a strategic initiative that emphasizes collaboration between supply chain partners to enhance forecasting accuracy and inventory management [8]. By sharing data and insights, organizations can optimize stock levels, reduce shortages, and improve service levels [9]. CPFR promotes transparency and trust among partners, allowing for joint decision-making and problem-solving [10]. This collaborative approach leads to a more synchronized supply chain, where all parties are aligned with common objectives and can respond swiftly to changes in demand [11]. The success of CPFR initiatives hinges on effective communication, data sharing, and a commitment to mutual benefit among partners [12]. As companies implement CPFR, they can leverage shared analytics and market intelligence to make more accurate forecasts, leading to improved inventory turnover and reduced costs [13]. Furthermore, CPFR fosters stronger relationships among supply chain stakeholders, resulting in enhanced performance and customer satisfaction [14]. In an era where consumer preferences are rapidly evolving, the agility and responsiveness afforded by CPFR can be a significant competitive advantage for organizations seeking to optimize their supply chains [15].

Sustainable Supply Chain Practices

Sustainable supply chain practices have gained traction in response to increasing consumer awareness and regulatory pressures regarding environmental issues [11]. These practices encompass a wide range of initiatives aimed at reducing the ecological footprint of supply chains, including responsible sourcing, waste reduction, and implementing circular economy principles [12]. Organizations are recognizing that sustainability is not just a compliance issue but a strategic imperative that can drive competitive advantage [16]. By adopting sustainable practices, companies can enhance their brand reputation and attract environmentally conscious consumers, leading to increased customer loyalty [17]. Furthermore, sustainable supply chain management often results in cost savings.



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through improved efficiency and waste reduction [18]. However, implementing sustainable practices poses challenges, such as the need for significant investments in technology and process redesign [19]. Companies must also navigate complexities related to supply chain transparency and traceability to ensure compliance with sustainability standards [20]. Despite these challenges, the integration of sustainability into supply chain management is crucial for long-term success, as it fosters resilience, innovation, and a positive impact on society and the environment [21].

Case Studies

Several organizations have successfully implemented contemporary methods in their supply chains, demonstrating the efficacy of innovative strategies:

Toyota: Through lean manufacturing and JIT systems, Toyota has significantly reduced production costs while maintaining high-quality standards [14]. By fostering a culture of continuous improvement, Toyota has positioned itself as a leader in operational excellence and efficiency, showcasing the benefits of integrating lean principles into its supply chain.

Amazon: Utilizing AI and data analytics, Amazon has optimized its logistics and inventory management, resulting in rapid delivery times and improved customer satisfaction [15]. The company's investment in technology and data-driven strategies has enabled it to maintain a competitive edge in e-commerce, setting a benchmark for supply chain innovation.

Unilever: By adopting sustainable sourcing and production practices, Unilever has enhanced its supply chain resilience and reduced its carbon footprint [16]. The company's commitment to sustainability has not only improved its operational efficiency but has also strengthened its brand reputation in an increasingly environmentally conscious market.

These case studies illustrate how the application of contemporary methods can lead to substantial improvements in supply chain performance, providing valuable lessons for other organizations aiming to optimize their operations [22].

Challenges and Future Directions

While contemporary methods offer significant advantages, challenges remain, including data security concerns, resistance to change within organizations, and the need for skilled personnel [17]. Organizations must invest in training and development to equip employees with the necessary skills to adapt to new technologies and practices [18]. Additionally, the integration of emerging technologies poses challenges related to interoperability and data management, necessitating robust IT infrastructure [19]. Future research should focus on developing frameworks that integrate these technologies with traditional practices, enabling organizations to leverage their strengths while addressing potential weaknesses [20]. Exploring the implications of these methods on supply chain resilience and agility will also be crucial as organizations navigate the complexities of a rapidly changing marketplace [21]. Moreover, further investigation into the role of digital transformation in enhancing collaboration and transparency across supply chains will be vital for future success [22]. By addressing these challenges and embracing innovative solutions, organizations can enhance their supply chain performance and better meet the evolving needs of consumers [23].

CONCLUSION

Optimizing the supply chain from the shop floor to the consumer requires a multifaceted approach that leverages contemporary methods and technologies. By embracing lean principles, Industry 4.0 innovations, and sustainable practices, organizations can enhance their operational efficiency and respond effectively to market demands. Continuous improvement and collaboration will be key to navigating the complexities of modern supply chain management. The integration of advanced technologies and collaborative strategies will foster resilience and agility, enabling organizations to thrive in an increasingly competitive landscape. Future research should continue to





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explore the synergies between traditional and contemporary methods, ensuring that organizations remain adaptable and prepared for the challenges of tomorrow [24].

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Smart Urban Mobility: Intelligent Traffic Systems using Machine Learning and Vehicle Networks

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ABSTRACT

Vehicle navigation must undergo a fundamental shift to accommodate the dynamic and interconnected nature of smart cities. Traditional static route planning, unable to adapt to constantly changing urban landscapes, leads to congestion, inefficiency, and environmental damage. In contrast, real-time vehicular path planning, driven by pervasive data and intelligent systems, is becoming essential for optimizing traffic flow in modern cities. This abstract explores the core of real-time navigation in smart cities, highlighting how advanced technologies like artificial intelligence (AI), sensor networks, and vehicle-to-everything (V2X) communication empower vehicles to dynamically adjust their routes in response to real-time traffic conditions, infrastructure changes, and external factors. We address challenges such as handling vast amounts of data, the need for rapid decision-making, and the complex interactions within urban environments. The abstract will also review various path planning strategies, from graph-based optimization to reinforcement learning, evaluating their strengths and limitations in navigating this evolving urban landscape.

Keywords – Smart Urban Mobility, Intelligent Traffic Systems, Machine Learning in Transportation, Vehicle-to-Vehicle (V2V) Communication, Traffic Optimization Algorithms.





INTRODUCTION

By 2050, it is estimated that 66-70% of the global population will reside in urban areas, presenting unprecedented challenges in resource management, environmental stewardship, and security. In response to these issues, numerous countries are implementing smart city initiatives aimed at optimizing resource use and minimizing environmental impact through advanced technologies. Artificial intelligence (AI), machine learning (ML), and deep reinforcement learning (DRL) are increasingly vital in the realm of intelligent transportation, driving innovative solutions for smart cities.

Additionally, the generation, management, and utilization of energy are critical components of smart urban environments. The integration of big data analytics enhances the reliability and efficiency of our cities' electrical grids, or "smart grids." A significant challenge within smart cities is determining the shortest path for vehicle routing in transportation, distribution, and logistics networks. Selecting the most appropriate route planning algorithm from the extensive range available in the literature is essential, particularly given that dynamic factors such as traffic congestion, unexpected incidents, and weather conditions can heavily influence the performance of machine learning (ML) models in these environments. Therefore, ML algorithms must be designed to adapt to these dynamic elements, ensuring that the shortest path can be recalibrated as necessary. Car navigation systems exemplify a primary application of Intelligent Transportation Systems (ITS). These systems leverage computerized road map databases and Global Positioning System (GPS) data to provide real-time information about traffic conditions and recommend optimal routes to destinations. To realize their full potential, the software components of these navigation systems must operate effectively within dynamic network environments, where road conditions are subject to change. Algorithms for dynamic road networks need to be capable of adjusting the chosen routes to maintain optimal performance under varying conditions.

Carbon emissions are a crucial factor in smart cities, closely linked to resource efficiency, public health, environmental quality, and the overall sustainability of urban areas. Efforts to reduce carbon emissions align with broader goals of fostering livable, resilient, and eco-friendly communities. The interconnected components of a machine learning-based Optimizing Green Routing system in smart cities are illustrated in Figure 1. By integrating smart city infrastructure with machine learning, connected vehicles contribute data that facilitates adaptive and environmentally sustainable routing decisions.

Motivation and Contribution

To effectively combat climate change, protect the environment, preserve air quality, and promote a sustainable and resilient future, it is crucial to manage and reduce carbon emissions. Our initiative is driven by the urgent need to tackle the environmental and sustainability challenges presented by contemporary urbanization. As cities expand, they face escalating issues such as air pollution, traffic congestion, carbon emissions, and energy consumption, all of which negatively impact residents' quality of life. The emergence of Smart Cities provides a unique opportunity to rethink and improve transportation infrastructure, particularly through the integration of advanced technologies like the Internet of Vehicles (IoVT).

The main contribution of this work is the development and implementation of a sophisticated machine learning-based green routing system within the IoVT framework. By incorporating predictive analytics through multiple linear regression, this machine learning model enables the system to continuously learn and adapt, facilitating informed routing decisions that prioritize the reduction of carbon emissions and energy consumption. This level of adaptability sets the proposed system apart from traditional multipath routing methods, offering a more agile and sustainable solution for urban transportation.





LITERATURE SURVEY

Cities are currently grappling with intricate challenges associated with socio-economic development and improving quality of life. The term “smart city” has emerged as a strategic response to address these multifaceted challenges. The foundational elements of urban developments in smart cities are rooted in Internet and broadband network technologies [10], which serve as the backbone for providing various e-services. Smart cities fundamentally rely on Internet technology, facilitating seamless access and interaction with diverse devices. Examples include cameras for video surveillance, sensors monitoring air pollution, actuators, and devices for traffic monitoring.

The accessibility to the Internet not only enables real-time connectivity [3] but also fosters the development of a myriad of applications capable of harnessing the vast volume of data generated by these devices. This proliferation of data gives rise to the creation of innovative services for the benefit of citizens, businesses, and public administration alike. Therefore, the integration of Internet technology [2] plays a pivotal role in the evolution of smart cities, ushering in a new era of interconnectedness and service delivery. Numerous algorithms addressing travel route selection have been published, each with its distinct characteristics. The Dijkstra algorithm, while straightforward, operates by identifying the shortest path on a road map. Although simple to implement, its drawback lies in its computational intensity, resulting in slow performance due to an extensive number of numerical operations. Recognized as an optimal algorithm within the labeling method category, Dijkstra offers accuracy but at the expense of efficiency [8]. The derivation of Dijkstra’s approach introduces a heuristic function to optimize route exploration. This algorithm substantially reduces computational operations by leveraging heuristic insights, enhancing operational speed [12].

The author employing a multipath [9] approach in a routing model aligns more closely with the global trend of infrastructural development. In light of the various connecting pathways accessible between each node, empirical studies indicate that this strategy yields superior outcomes compared to a singular path between nodes in a two-dimensional (2D) framework. In this paper [11], the author tackles the issue of eco-friendly communication in 6G-enabled extensive Internet of Things (IoT) devices by adopting a cluster-based data dissemination approach in the network. The author introduces an innovative Hybrid Whale-Spotted Hyena Optimization (HWSHO) algorithm, synthesizing the Whale Optimizer Algorithm (WOA) with the exploitation capabilities of the Spotted Hyena Optimizer (SHO).

Algorithm 1 Optimal Path Selection based on Carbon Emissions

Input: Graph G representing the road network, Start node s , End node t

Output: Optimal path from s to t based on carbon emissions

1. Initialize empty priority queue PQ
 - Initialize distance array $dist[]$ with ∞ for all nodes
 - Initialize carbon emission array $emission[]$ with 0 for all nodes
 - Set $dist[s] = 0$ and $emission[s] = 0$
 - Insert $(s, 0)$ into PQ
2. while PQ is not empty do
 3. $(u, d) \leftarrow$ extract minimum element from PQ
 4. foreach neighbor v of u do
 - $w \leftarrow$ weight of edge (u, v)
 - $e \leftarrow$ carbon emission of edge (u, v)
 - 1. if $dist[u] + w < dist[v]$ then



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dist[v] ← dist[u] + w
    emission[v] ← emission[u] + e
    Insert (v, dist[v]) into PQ
end if
end foreach
end while

```

Reconstruct the optimal path from s to t using $\text{dist}[]$ and $\text{emission}[]$.

This article[7] critically examines established annual-based carbon accounting methodologies, emphasizing emerging real-time carbon emission technologies and their prevailing application trends. Additionally, a framework for the latest near-real-time carbon emission accounting technology, poised for widespread adoption, is introduced.

This Algorithm 1 is used for finding the shortest path in a graph with weighted edges. The weight of each edge represents the travel time or distance, and the carbon emission of each edge is taken into account during the path selection process based on machine learning. The priority queue efficiently selects the node with the minimum distance at each step that contains the minimum carbon emission-enabled route. The algorithm outputs the optimal path from the start node s to the end node t based on both travel distance and carbon emissions.

RESULT AND DISCUSSION

Figure.2 shows the heat map of the particular data set. The data set contains the attribute model make, model, vehicle class, engine size, cylinders, transmission, fuel type. In Table 1, the optimal results are given below multipath and single path. Here, we are taking ten nodes, including the depot. Every path starts with the depot in the model objective path 0(2) represents the Node, and which route will take means 0th node via 2th route in multipath. In a single path, every route is the 0th route. Here, we consider total travel distance, travel cost, travel time additional time of every node, and carbon emissions. This is the optimal path result. Figure-3 shows the result comparison among multipath and single paths.

CONCLUSION

There is great potential for the Internet of Vehicular Things (IoVT) in Smart Cities when a machine learning-based multipath green routing system is implemented. The study concentrated on using machine learning algorithms to optimize vehicle routes to reduce carbon emissions while considering the dynamic nature of traffic and environmental factors. According to the findings, the suggested approach successfully reduced carbon emissions and trip times while increasing traffic routes' general effectiveness. The system's adaptability to shifting traffic patterns and environmental conditions was proved by integrating machine learning models with real-time data from the Internet of Things (IoT). The multipath strategy makes smart cities' transportation networks more resilient to unforeseen circumstances and traffic jams. This paper's future lies in the development of more advanced machine learning algorithms that can adjust carbon emissions to shifting traffic patterns and more accurately represent the intricate dynamics of IoV networks. Reinforcement learning is included to proactively learn from its interactions with the environment and provide real-time, optimal routing options. Think about aspects like security and privacy, in addition to energy efficiency, while choosing routing paths. For this study, standardized protocols are being developed to help vehicle makers and other network providers achieve interoperability.

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Table -1. Optimal Results

Metric	Path 1	Path 2
Path	0(2) - 6(0) - 8(1) - 7(1)	0(0) - 6(0) - 7(0) - 9(0)
	5(0) - 2(1) - 9(0)	-8(0) - 4(0) - 5(0)
	1(0) - 3(1) - 4(2) - 0	-3(0) - 1(0) - 2(0) - 0
Travel Distance (km)	191	203
Travel Cost (INR)	1791	1815
Travel Time (min)	1095	1146
Additional Time (min)	301	311
Total Time (min)	1576	1637
Total Carbon Emission (kg)	2974	3019





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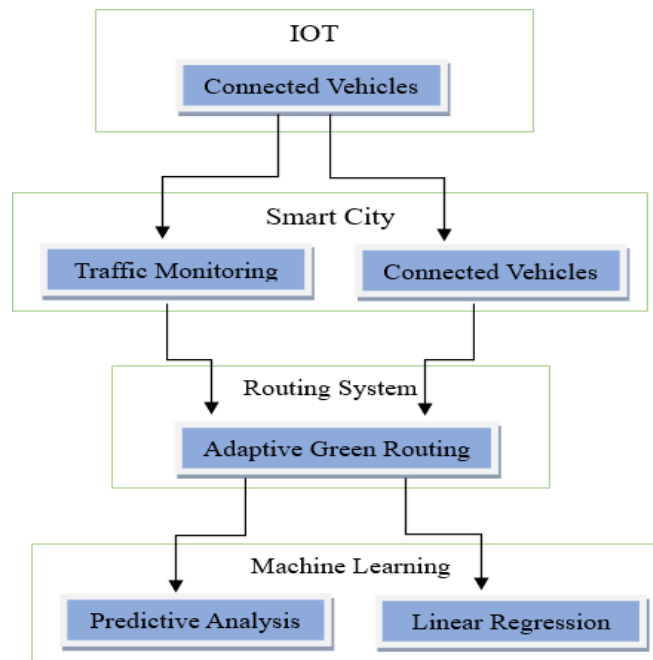


Figure.1: Work Flow of Green Path Planning for IoVT.

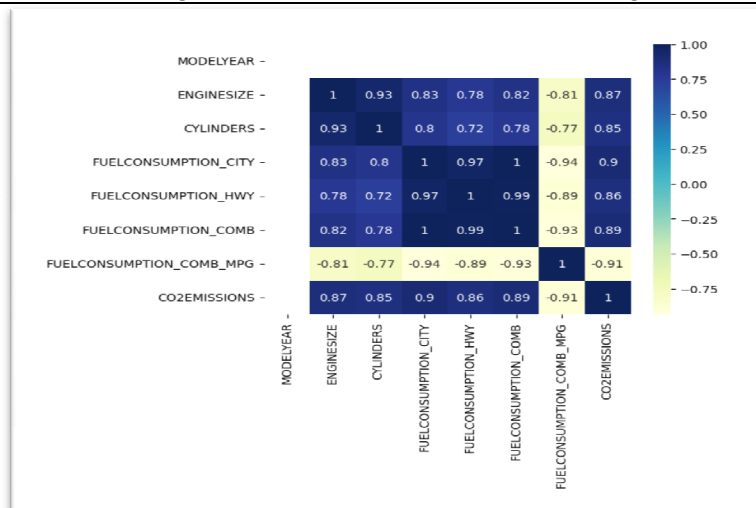
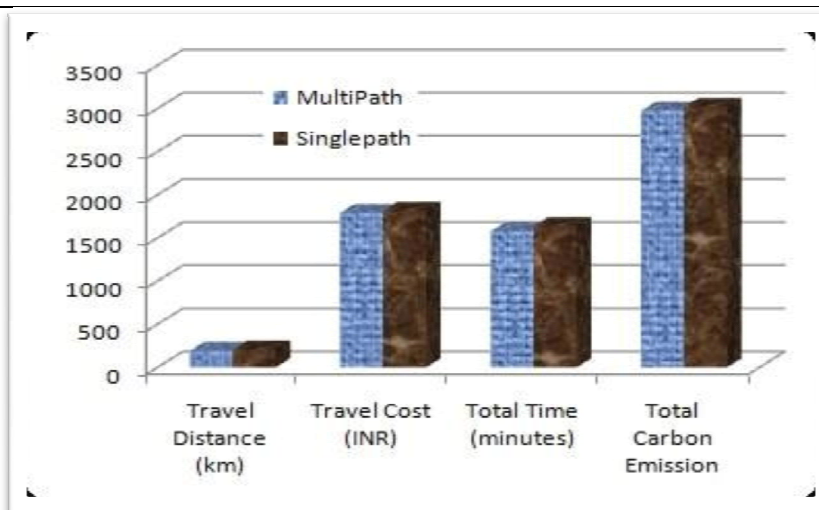


Figure. 2: Hit map of the dataset



**Jammanna Lalu Prasad et al.,****Figure.3: Result comparing multipath and single path**