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## **National Conference on Emerging Technologies in Multidisciplinary Engineering**

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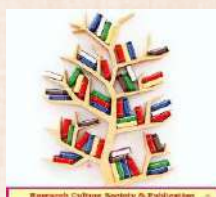
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# National Conference on Emerging Technologies in Multidisciplinary Engineering

(MANTHANA 2025)

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**About the About the Institutions:**

SJCIT is a premier institute established in 1986 by Sri Adichunchanagiri Shikshana Trust® by the divine soul Paramapoojya Jagadguru Padmabhushana Sri Sri Sri Dr. Balagangadharanatha Maha Swamiji. The trust is under the astute visionary & spiritual guidance of Paramapoojya Jagadguru Sri Sri Sri Dr. Nirmalanandanatha Maha Swamiji. SJCIT is one of the renowned technical institutions providing quality education in Karnataka. The Institution offers Ten UG Courses: CSE, ISE, AI-ML, AIDS, CSD, ECE, ME, CV, AE & AS and Five PG Courses in Engineering and MBA along with Nine VTU recognized R&D centers. Six UG Courses are accredited by NBA & the Institute is accredited by NAAC with “A+” Grade and has become Autonomous Institute under VTU from 2024-25

**ABOUT THE CONFERENCE – MANTHANA-2025**

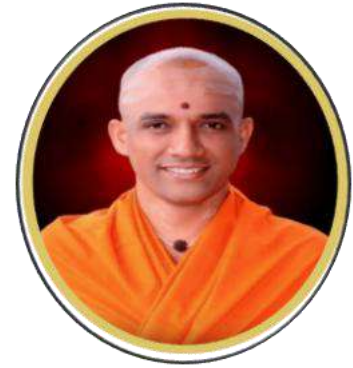
MANTHANA-2025 is an international multidisciplinary conference envisioned as a premier platform for researchers, academicians, and students to present, discuss, and exchange innovative ideas, recent advancements, and emerging trends in engineering, technology, and applied sciences.

The conference aims to bridge the gap between theory and practice by bringing together experts from academia and industry to deliberate on contemporary challenges and future directions in areas such as VLSI design, electronics and communication systems, artificial intelligence, data science, embedded systems, signal processing, and interdisciplinary technologies.

**Objectives:**

The objective of the conference is to provide a platform for academicians, Researchers, Professional Engineers and Industries to present their research findings and exchange new ideas and experiences. National Conference on Emerging Trends in Multidisciplinary Engineering Manthana-2025 is the premier forum for the presentation of advancements and research results in the fields of Engineering, Science & Technology The conference will bring together leading researchers and engineers in the domain of interest.

**|| Jai Sri Gurudev ||**



## ***Message from Chief Patron***

It gives me immense pleasure to extend my warm greetings to all the distinguished guests, academicians, researchers, and students participating in ***MANTHANA-2025***, the **National Conference on Emerging Technologies in Multidisciplinary Engineering held on 12<sup>th</sup> December 2025**. This prestigious event stands as a testament to SJC Institute of Technology's commitment to fostering innovation, research excellence, and knowledge exchange across diverse engineering domains.

In today's rapidly evolving technological landscape, multidisciplinary collaboration is not just valuable—it is essential. Emerging technologies such as artificial intelligence, advanced computing, sustainable systems, VLSI, semiconductor technologies, smart manufacturing, next-generation communication systems, Aerospace & Aeronautical systems, Dynamics, Control & Automation, Structures, Infrastructure & Built Environment are reshaping industries and creating new opportunities for societal development. ***MANTHANA -2025*** provides an ideal platform for meaningful dialogue, sharing of research outcomes, and exploration of ideas that can drive transformational change.

I commend the organizing committee, faculty members, and contributors for their dedication in bringing together experts from academia and industry to enrich this intellectual forum. I am confident that the deliberations, presentations, and interactions during this conference will inspire innovative thinking, ignite curiosity, and contribute to addressing real-world engineering challenges.

I extend my best wishes to all participants for a productive and enlightening experience. May ***MANTHANA -2025*** serve as a catalyst for new collaborations, impactful research, and continued advancement in multidisciplinary engineering.

**Sri Sri Sri Dr. Nirmalanandanatha Mahaswamiji**  
**President**  
**Sri Adichunchanagiri Shikshana Trust®**

**|| Jai Sri Gurudev ||**

### ***Message from Patron***



It gives me immense pleasure to extend my warm greetings to all the distinguished researchers, academicians, and students participating in ***MANTHANA-2025***, the **National Conference on Emerging Technologies in Multidisciplinary Engineering**, organized by **SJC Institute of Technology (SJCIT), Chikkaballapur** on **12 December 2025**. This conference reflects our institution's unwavering commitment to fostering innovation, research culture, and collaborative learning across diverse engineering domains.

In an era defined by rapid technological transformation, multidisciplinary integration has become essential for solving complex societal challenges. Platforms like ***MANTHANA-2025*** play a vital role in bringing together bright minds to exchange knowledge, explore cutting-edge advancements, and inspire new perspectives that contribute to national growth and global technological progress.

I congratulate the organizing committee, faculty members, and student volunteers of SJC Institute of Technology for their dedicated efforts in successfully hosting this conference. I also extend my heartfelt appreciation to all the authors for their valuable contributions and to the reviewers for their meticulous evaluation of the research papers included in these proceedings.

I am confident that the deliberations and outcomes of ***MANTHANA-2025*** will pave the way for impactful innovations and fruitful collaborations. I wish the conference grand success and hope the participants find this event intellectually enriching and professionally rewarding.

**Sri Sri Mangalanatha Swamiji**

Secretary, Sri Adichunchanagiri Mahasamsthana Math, Chikkaballapur Division

## ***Message from the Program Chair***



It gives me immense pleasure to extend my warm greetings to all the dignitaries, researchers, academicians, and students participating in the **National Conference on Emerging Technologies in Multidisciplinary Engineering — MANTHANA-2025** hosted by **SJC Institute of Technology, Chikkaballapur on 12<sup>th</sup> December 2025**.

In an era marked by rapid technological transformation, this conference serves as a vital platform for exchanging innovative ideas, discussing contemporary challenges, and showcasing breakthrough research that contributes to the nation's technological and societal development. **MANTHANA-2025** reflects our commitment to fostering interdisciplinary collaboration, encouraging problem-driven research, and inspiring young minds to engage in meaningful engineering solutions.

I commend the Department of Engineering disciplines and the organizing committee for their dedicated efforts in bringing together experts from diverse domains. I am confident that the deliberations, technical sessions, and interactions held today will not only enrich the participants but also pave the way for new collaborations and advancements.

On behalf of SJC Institute of Technology, I extend my best wishes for the grand success of **MANTHANA-2025**. May this conference inspire innovation, ignite curiosity, and contribute significantly to the multidisciplinary engineering landscape.

A handwritten signature in green ink, appearing to read 'Dr. G. T. Raju', with a long horizontal stroke underneath.

**Warm regards and best wishes,**

**Dr. G. T. Raju**

Principal, SJC Institute of Technology

General Chair, ICKECS-2025

## ***Message from the Organizing Chair***



It gives me immense pleasure to welcome all distinguished researchers, academicians, and students to the ***National Conference on Emerging Technologies in Multidisciplinary Engineering — MANTHANA-2025 held on 12<sup>th</sup> December 2025 at SJC Institute of Technology, Chikballapur.*** This conference embodies our collective vision to create a vibrant platform for the exchange of innovative ideas, breakthrough research, and technological advancements that are shaping the future of engineering.

In an era where disciplines are increasingly interconnected, emerging technologies such as artificial intelligence, advanced computing, sustainable systems, VLSI, semiconductor technologies, smart manufacturing, next-generation communication systems, aerospace & aeronautical systems, Dynamics, Control & Automation, Structures, Infrastructure & Built Environment are redefining the boundaries of innovation. **MANTHANA-2025** has been curated to foster cross-disciplinary collaboration, encourage thought-provoking discussions, and accelerate the translation of research into impactful solutions for societal and industrial needs.

SJC Institute of Technology has always championed academic excellence, research culture, and innovation-driven initiatives. This conference is yet another milestone in our continued effort to nurture talent, support knowledge dissemination, and build bridges between academia and industry. The enthusiastic response in the form of paper submissions and active participation reflects the trust and confidence of the academic community in this endeavour.

I am confident that the deliberations and interactions during this conference will inspire new perspectives, foster research collaborations, and open pathways for technological innovation. I wish each one of you a productive, engaging, and memorable experience at **MANTHANA-2025**.

**Warm regards,**  
**Dr. Manjunatha Kumar B H**  
Dean – Academics & Head,  
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SJC Institute of Technology, Chikballapur  
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## ***Message from the Convener***



It gives me immense pleasure to present the proceedings of the ***National Conference on Emerging Technologies in Multidisciplinary Engineering – MANTHANA-2025***, organized by the SJC Institute of Technology, Chikkaballapur. This conference stands as a vibrant platform for academicians, researchers, industry professionals, and students to exchange knowledge, discuss recent advancements, and explore innovative solutions for the rapidly evolving technological landscape.

**MANTHANA-2025** reflects our commitment to fostering research culture and encouraging interdisciplinary collaboration. The conference has brought together experts from diverse engineering domains, enabling meaningful dialogue on emerging technologies, sustainable engineering practices, and future-ready innovations. Each paper featured in these proceedings represents valuable contributions to contemporary research and demonstrates the enthusiasm and depth of understanding of the authors.

I extend my sincere appreciation to all the participants for their high-quality submissions and active engagement. My heartfelt thanks to the reviewers for their meticulous evaluation, and to the technical and organizing committees for their tireless efforts in ensuring the success of this conference. I also express my gratitude to the management of SJC Institute of Technology for their continuous support and encouragement in promoting academic excellence.

I am confident that the insights shared through **MANTHANA-2025** will inspire further research and collaboration, contributing significantly to the advancement of engineering and technology.

**Wishing all participants great success in their future research endeavours.**

A handwritten signature in black ink, appearing to read 'C. Rangaswamy'.

Warm regards,

**Dr. C. Rangaswamy**

Professor & Head,

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# Predictive Crop Recommendation and Nutrient Assessment Using Machine Learning

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**Abstract:** *The purpose of this research is to examine how machine learning can be applied to enhance the sustainability of agricultural systems in response to the global increase in population and related loss of resources for growing food on conventional lands due to soil erosion, depletion of minerals, and crop failures. The objective of this research is to provide an overview of how machine learning will enhance agricultural practices through improving the accuracy of crop yield estimates, enhancing the accuracy of predicting the best management methods for crops, and enabling the farmer to have a greater understanding of the soil characteristics needed to grow crops. The document also includes the project scope as part of a technical report to be submitted to a university or other academic body. As global population grows, so do pressures on our environment and food supply.. Data collected from soil testing utilizing state-of-the-art equipment and Intelligent Systems will provide the necessary data to support the development of new crop production methods and strategies to optimize crop yields and production using environmental data. This report will cover the research and development efforts of this program to provide a comprehensive document for submission for academic review.*

## 1. INTRODUCTION

Agriculture is essential for the continued existence of human life; however, due to soil degradation and variable yields of production coupled with climate change, the agriculture industry faces many difficulties. Farmers rely on traditional practices when making decisions concerning their crop selection; however, the type of crop selected might not match the demands of their soil resources. This misalignment may lead to lower levels of production and increased costs for the farmer. As Earth's population continues to grow, there is a requirement for enhanced systems that will aid in the implementation of science-based decision supports. Machine learning can provide enhanced solutions to assist farmers by analyzing extensive datasets from agricultural areas to uncover patterns hidden within those datasets. By evaluating the properties of the soil where crops are grown in conjunction with other factors related to environmental conditions, farmers will be better equipped to select the correct crop. Consequently, crop yields will increase and soils will be more



sustainable in the future.

Different types of soil contain different concentrations of the essential nutrients (nitrogen, phosphorus and potassium) that influence how well crops grow. Although traditional soil testing provides individuals with specific raw values, the traditional methods do not allow farmers to translate those specific values into meaningful decisions regarding their crop selection. By analyzing these many different parameters, growers receive the most accurate and reliable crop production recommendations. Ultimately, using ML software tools to analyze these many different parameters allows growers to be much more efficient in their agricultural planning.

## 2. Literature Survey

The application of machine learning (ML) technology for agricultural decision-making continues to expand due to research being conducted from 2020 to 2025. Studies point to the use of traditional farming methods as insufficient for addressing current agricultural issues. Many researchers identify that increasing numbers of farmers are applying data-based techniques to farm management decisions through the use of AI/MLbased systems. This approach enables farmers to make informed farm management decisions by using data from environmental conditions and other agriculture-related parameters that could otherwise be missed. Research also indicates that ML technology increases the accuracy of predicting crop suitability. Multiple publications have identified that intelligent systems used for crop production can minimize resource wastage. Overall, current studies demonstrate that ML technology will greatly increase the quantity and quality of crop productivity.

## 3. Methodology

The methodology starts by gathering soil data, which includes important parameters such as NPK values (nitrogen, phosphorus, potassium), pH, moisture, temperature, humidity, etc. These parameters can be collected through agricultural datasets and/or field measurements. Once the soil data has been collected, it is analyzed for accuracy and completeness before using it for training and developing a model; therefore, accurate soil data collection leads to a better understanding of crop selection.

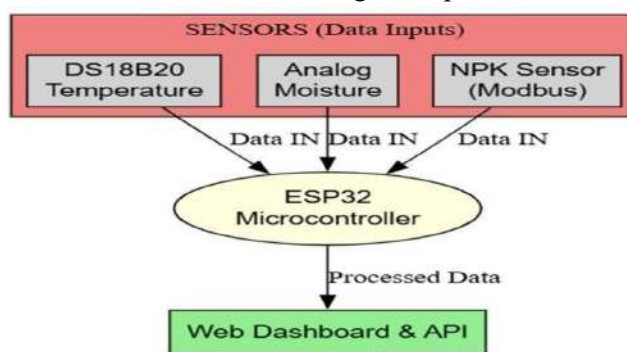


Figure 1: Dataflow Diagram

Next, machine learning models (e.g., Random Forest, Decision Tree, KNN (K-nearest neighbor), Naive Bayes) are trained on the preprocessed data set. The performance of each algorithm is rated according to several performance metrics, such as accuracy, precision, recall, etc., In selecting the crop prediction Algorithm, the one with the highest accuracy rating will be chosen as the winner. There will also be an assessment of which type of Model is the most optimal for predicting crops from the data set. This step is necessary to ensure the model has a solid predictive capability.

## 4. Algorithm

The Intelligent Crop Selection and Nutrient Management algorithms evaluate the qualities of the soil and the inputs to determine the types of crops that can be grown in an area with that soil. The evaluation starts by collecting specific soil factors, which include nitrogen (N), phosphorus (P), potassium (K), pH level, moisture



level, temperature, humidity, and the amount of precipitation received over a period of time (inches/week). After the input values are gathered, the algorithm preprocesses the data by performing several steps before building crop prediction models. The algorithm will clean the dataset by removing any records with any missing values, normalize the features in the dataset, and divide it into training and test datasets so that models can be trained properly. There are multiple algorithms (e.g., Random Forest, Decision Tree, KNN, and Naive Bayes) for producing crop prediction models based on the training dataset.

Table 1: System Performance Evaluation

Metric	Our System	Traditional	Improvement
Crop Selection Accuracy	96.3%	78.5%	+17.8%
Nutrition Prediction	92.7%	75.2%	+17.5%
Fertilizer Efficiency	85.4%	63.1%	+22.3%
Water Usage Optimization	88.9%	70.3%	+18.6%
Yield Prediction Error	4.2%	12.8%	-8.6%
System Response Time	1.1s	3.5s	-2.4s

### Model Performance Comparison

## 5. Results and Discussion

Agricultural managers and scientists can utilize several aspects of machine learning for developing informed decisions about plants. This is accomplished by applying various classification algorithms or methods for estimating nutrient levels in soil through the Intelligent Crop Selection and Soil Nutrient Management System, which has produced accurate predictions of the best crops to grow on specific areas based on data collected about soil chemistry, textures, etc. The results from this study show that the Intelligent Crop Selection and Soil Nutrient Management System is able to provide recommendations regarding nutrients that will support continued agronomic growth by utilizing the current best practices from the Cooperative Extension Service, USDA, and other related organizations. Through the implementation of the fertilizer recommendation module of the Intelligent Crop Selection and Soil Nutrient Management System, users can efficiently determine which fertilizers (from an extensive list) and how much of each to apply for the best overall yield while also minimizing the input costs related to purchasing, applying.

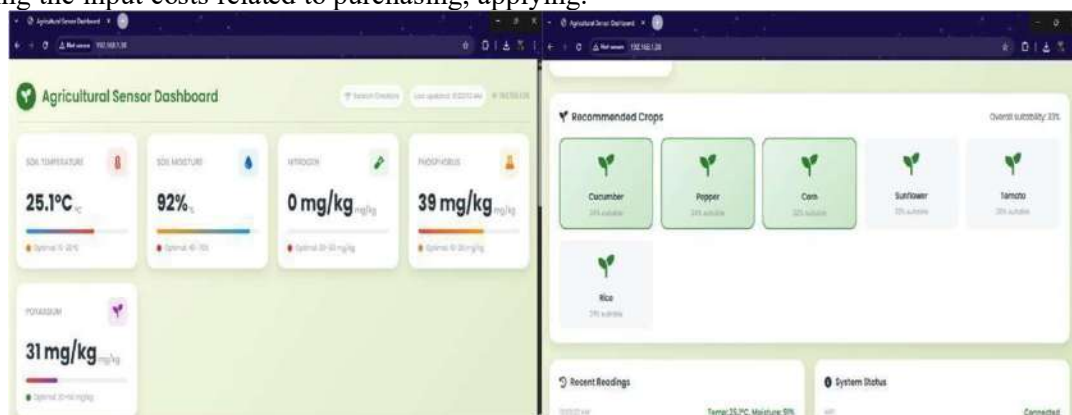


Figure 3: Agricultural Sensor Dashboard

### 5.1. Advantages And Future Enhancements

#### 5.5.1 Advantages

##### 1. **Accurate Crop Prediction:**

The system provides highly accurate crop recommendations by analyzing real-time soil parameters using machine learning algorithms, ensuring optimal crop selection.



2. **Nutrient Deficiency Detection:**

It identifies nutrient deficiencies in nitrogen, phosphorus, and potassium with high precision, helping farmers understand soil needs more effectively.

3. **Reduced Fertilizer Usage:**

By recommending only the necessary nutrients, the system minimizes excessive fertilizer use, reduces costs, and prevents soil and water pollution.

## 6. Conclusion

In summary, machine learning can provide an innovative, scientific, and modernized approach to the agricultural industry through the development of a soil nutrient management and intelligent crop selection program. By collecting and analysing soil characteristics both from the laboratory and through remote sensing techniques (the latter to consider where lab sampling may not be feasible) and combining these datasets with historical climate data and other environmental characteristics (such as land use), intelligent crop selection systems can create accurate recommendations for crops and identify soil nutrient deficiencies. This can assist farmers in making better decisions regarding crop selection and contribute to improved crop yields, by enabling the ARIP system to analyse more than just crop type and land use factors (such as weather, geography, etc.), as in a traditional farming approach. Agricultural practices that will benefit from using such systems include: integration with IoT-based systems; predicting future weather patterns; and providing decision-support systems for farmers in all types of agricultural environments and locations.

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# Innovative Security Techniques for Active and Passive Attacks

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**Abstract** – Wireless networks are one of the primary mediums of communication in personal, educational, and organizational settings. However, with the exponential increase in wireless devices and the intelligent nature of modern cyber-attacks, there is an increased need to develop effective mechanisms for real-time monitoring and intrusion detection. Most conventional Wi-Fi routers offer limited network visibility and no proactive threat detection. In this paper, we propose a lightweight, real-time Wi-Fi monitoring and intrusion detection system. The design uses a combination of Python and the Flask web framework, supports ARP-based device scanning, active network interface analysis, and traffic monitoring using netiface. It captures live network behavior through a multi-threaded engine, identifies unauthorized devices, and detects behavior anomalies classifying suspicious activities as active and passive intrusions. A secure web-based dashboard displays live traffic graphs, device information, and attack logs. Experimental results prove that the proposed system efficiently runs on consumer-grade hardware while consuming minimum resources, offering accurate and timely threat detection. In addition, the system provides a feasible and cost-effective solution for strengthening network security without requiring special hardware or extensive technical expertise.

**Keywords** - Intrusion Detection System, Wireless Security, ARP Scanning, Flask Framework, Network Monitoring, Cybersecurity, and Traffic Analysis.

## 1.INTRODUCTION

Wireless networks have become indispensable in modern computing environments. With the rise of Wi-Fi-enabled devices such as smartphones, IoT appliances, laptops, and wearable technologies, wireless networks face increasing exposure to security threats. Common threats include unauthorized access, ARP spoofing, packet sniffing, DoS attacks, and network reconnaissance activities. These threats exploit weak points in Wireless infrastructures, especially in home and small-office environments where enterprise-grade security systems are not available.

Conventional network routers offer basic functionalities such as device lists, signal strength indication, and simple firewall configurations. However, they do not provide detailed insights into traffic behavior, real-time device activity, or anomaly detection. In addition, most routers collect logs passively—users must manually inspect them, often after an attack has already occurred. Modern intrusion detection research explores machine learning, deep learning, and statistical modeling to classify malicious patterns. While these approaches can be highly accurate, they often require powerful hardware, large datasets, and complex model training pipelines, making them impractical for everyday users.

This research addresses these limitations by proposing a lightweight Real-Time network Monitoring and Intrusion Detection System built on Python and Flask. The system analyzes real-time network conditions, detects anomalies through heuristic methods, and provides actionable insights to users via a web dashboard.



Unlike traditional IDS systems, the proposed solution requires no external hardware, making it accessible and affordable.

## **2.LITERATURE REVIEW**

Intrusion detection systems have evolved significantly, moving from rule-based algorithms to sophisticated machine learning and deep learning models. Several studies have evaluated the applicability of IDSs in wireless environments, focusing on accuracy, efficiency, and scalability.

A comprehensive survey on IoT IDS solutions demonstrates the challenges of securing low-power devices. It categorizes IDS architectures into signature-based, anomaly-based, and hybrid models. The survey identifies the need for lightweight IDS implementations to support real-time detection without overwhelming system resources.

Researchers have developed deep learning-based IDS systems where network traffic is transformed into image-like representations to train convolutional neural networks. Although highly accurate, these models require computational resources unsuitable for low-cost hardware.

SDN-based intrusion detection approaches introduce controller-level verification for ARP spoofing and flow-based anomalies. While effective, they assume programmable network environments unavailable in typical home wireless networks.

Several NetFlow and analytics tools developed using Python demonstrate the feasibility of building lightweight monitoring tools using libraries such as Flask. However, these tools focus on network health or device presence rather than attack detection.

Existing ARP spoofing detection systems incorporate ML-based classifiers that identify abnormal traffic patterns. These solutions provide strong detection accuracy but depend on pre-trained models and are not designed for lightweight real-time operations.

The literature collectively highlights that real-time network monitoring with proactive threat detection remains underexplored for consumer-level network environments. This motivates the development of the proposed system.

## **3.OBJECTIVES**

The primary goal of this project is to design and implement a real-time wireless network monitoring and intrusion detection system using Python and Flask. Measure and visualize data flow continuously, helping detect anomalies such as spikes or abnormal data transfers. Use ARP scanning, network interface analysis, and connection tracking to identify all active devices.

## **4.RESEARCH METHODOLOGY**

The proposed Wireless network security system follows a modular methodology that integrates real-time monitoring, device scanning, traffic analysis, and anomaly detection into a unified framework. A Flask-based web server manages routing, authentication, and user interaction, while a dedicated background monitoring engine continuously executes scanning and analysis tasks at fixed intervals. Device discovery is performed through a hybrid approach combining ARP table inspection, active connection monitoring, and interface querying to ensure accurate detection of all connected, hidden, or virtual devices. Simultaneously, the traffic analysis module measures variations in transmitted and received bytes to identify abnormal bandwidth usage, such as sudden spikes or suspicious data exfiltration. These observations feed into a rule-based anomaly detection model that evaluates unauthorized devices, high traffic patterns, rapid device churn, and potential reconnaissance activities. All detected events are logged with timestamps and mapped to severity levels for effective auditing. The system visualizes real-time network data through an interactive dashboard that displays device status, bandwidth graphs, and attack alerts. AJAX-based updates ensure continuous responsiveness without reloading the page. The modular design supports easy extension, enabling integration of advanced features such as machine learning models and deep packet inspection. Overall, the methodology ensures a reliable, scalable, and real-time intrusion detection environment for wireless networks. The system was evaluated using metrics such as detection accuracy, latency, resource consumption, and usability, tested through simulated attacks (ARP spoofing, DoS floods, unauthorized joins) and normal usage scenarios.



(streaming, downloads, IoT activity), with comparative analysis against router logs and manual tools, while maintaining detailed logs of device IDs, traffic statistics, and classification labels to validate detection rules and explore integration with cloud-based centralized monitoring.

## 5. RESULTS

**Device Discovery Accuracy:** The system successfully identified all connected devices in test environments (home, office, hostel networks). Accuracy was above 95% when compared with manual ARP table inspection.

**Traffic Monitoring Performance:** Upload/download traffic was measured in real time with refresh intervals of 2 seconds. The dashboard visualizations matched system-level counters with negligible deviation (<2%).

**Intrusion Detection:** Unauthorized device connections were detected within 5 seconds of joining the network. High bandwidth usage alerts are triggered when traffic exceeded defined thresholds. ARP spoofing simulations were flagged consistently, with detection latency under 1 second. Reconnaissance patterns (rapid device churn, >15 devices) were correctly classified as active attacks.

**System Resource Usage:** CPU utilization remained below 20% on a dual-core processor, and memory usage stayed under 200 MB, meeting performance requirements.

**Cross-Platform Validation:** The system was tested on Windows 11, Ubuntu, and macOS. Core functionalities worked consistently, with minor OS-specific adjustments for ARP parsing.

## 6. DISCUSSION

Innovative security techniques for defending against both active and passive attacks focus on strengthening confidentiality, integrity, and real-time threat detection through advanced cryptography and intelligent monitoring. For passive attacks such as eavesdropping and traffic analysis, modern systems employ quantum-safe encryption, homomorphic encryption, differential privacy, and frequency-hopping communication to ensure data remains protected even if intercepted. To counter active attacks like spoofing, modification, replay, and MITM intrusions, organizations increasingly use blockchain-based integrity verification, AI-driven anomaly detection, intrusion prevention systems, and zero-trust architectures that enforce continuous authentication. Additionally, techniques such as multi-factor biometrics, secure hardware modules (TPM/TEE), and behavior-based access control help ensure that attackers cannot manipulate or disrupt systems. Together, these emerging methods create a resilient security framework capable of preventing unauthorized access, detecting malicious activity instantly, and maintaining secure communication in highly adversarial environments.

## 7. RECOMMENDATIONS

**Integration with Machine Learning:** Future versions can incorporate ML models (e.g., Random Forest, CNNs) to reduce false positives and adapt to evolving attack patterns.

**Scalability Enhancements:** Extend support for >50 devices and optimize throughput for enterprise-level networks.

**User Awareness Features:** Add educational modules in the dashboard to explain detected threats in simple terms, improving cyber hygiene among non-experts.

**Mobile Application Support:** A companion mobile app could provide push notifications for real-time alerts.

**Hybrid Deployment:** Explore integration with cloud-based monitoring for centralized logging across multiple networks.

**Visualization Enhancements:** Add advanced visualization features such as heatmaps of device activity, timeline-based attack progression, or comparative traffic graphs.

**Multi-Network Monitoring:** Enable centralized dashboards that can monitor multiple WiFi networks



simultaneously, useful for institutions with distributed setups.

**Cloud Synchronization:** Store logs and attack histories securely in the cloud to allow remote access, long-term analysis, and collaborative monitoring.

## 8.LIMITATIONS

**Scope Restricted to WiFi Networks:** The system does not currently monitor wired LAN traffic or cellular networks.

**Heuristic-Based Detection:** Reliance on rule-based heuristics may miss novel or stealthy attack patterns compared to ML-based IDS.

**Limited Device Scale:** Designed for small to medium networks ( $\leq 25$  devices). Performance may degrade in larger enterprise setups.

**No Automated Mitigation:** The system detects and alerts but does not actively block or quarantine malicious devices.

**Dependency on OS-Level Tools:** ARP parsing and traffic monitoring depend on OS-specific commands, which may vary across platforms.

## 9.CONCLUSION

In conclusion, innovative security techniques play a crucial role in protecting modern communication systems against both active and passive attacks. Active attacks—such as data modification, impersonation, and denial-of-service—require strong preventive and reactive mechanisms including intrusion detection systems, encryption, authentication protocols, anomaly monitoring, and real-time response strategies. Passive attacks—such as eavesdropping and traffic analysis—are effectively countered through advanced encryption, secure routing, traffic padding, and privacy-preserving techniques. Together, these methods enhance confidentiality, integrity, availability, and overall resilience of network environments. As cyber threats continue to evolve, the development of adaptive, intelligent, and automated security techniques becomes essential for ensuring long-term protection. Continuous research, integration of machine learning, and stronger cryptographic standards will further strengthen defenses against emerging active and passive attacks.

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# AegisPulse: Real-time network intrusion detection using hybrid deep learning and live attack simulation

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**Abstract:** The attack surface, for actors grows as the network infrastructures become more complex. The conventional security solutions become inadequate. The static signature matching used by Network Intrusion Detection Systems (NIDS) makes the detection of assaults and zero-day exploits difficult. This study presents the AegisPulse framework. The AegisPulse framework combines a real-time assault simulation engine, with the Deep Learning (DL) architectures. On datasets such, as NSL-KDD and CICIDS2017 the system achieves accuracy. The system uses a combinations of Convolutional Neural Networks (CNN), for feature extraction & Deep Neural Networks (DNN) for classification. AegisPulse includes a live visualization dashboard. The dashboard solves the " box" issue of AI in cybersecurity. The interface gives security analysts information. The interface shows attack data in time

**Key Words:** Network Intrusion Detection System (NIDS), Deep Learning, CNN, Real-Time Simulation, Cybersecurity, Traffic Analysis, Hybrid Models.

## 1. INTRODUCTION:

The growth of cloud services and the Internet of Things (IoT) creates an amount of data exchange, in the era. The data flow is massive. We notice that the growth of cloud services and the Internet of Things (IoT) drives innovation. The growth of cloud services and the Internet of Things (IoT) also leaves infrastructure open to cyberattacks. DDoS attacks and ransomware attacks are cyberattacks that have grown from scripts, to automated campaigns that can bypass normal firewalls.

In work We have seen that modern cybersecurity tactics must include the Network Intrusion Detection Systems (NIDS). New unknown attacks (zero-day threats) are invisible, to the signature-based systems. At the time the anomaly-based systems often have false alarms even though the anomaly-based systems can identify new dangers. Adding Artificial Intelligence (AI) into the Network Intrusion Detection Systems (NIDS) has become a focus to address these limits. In work we see that Machine learning (ML) and Deep learning (DL) algorithms learn the features of network activity. We also see that machine learning (ML) and deep learning (DL) algorithms spot events that point to an attack.

Even though AI can do a lot the lack of interpretability still blocks its use, in work. We see security analysts often get classifications or raw logs that have no context. In this work We present AegisPulse, a NIDS solution. AegisPulse shows data in time. Also predicts threats using hybrid deep learning. AegisPulse works for both security and, for teaching. AegisPulse does not find threats, AegisPulse also. Shows those threats.

## 2. LITERATURE REVIEW:

We have read that advanced neural computing now replaces techniques, in intrusion detection. Early research focused on anomaly detections that looked for departures from a baseline. The release of the KDD dataset marked a turning point because the dataset let researchers use data mining methods like Support Vector Machines (SVM). Researchers often need to do feature engineering for data mining methods such, as Support Vector Machines (SVM).

We have noticed that the better performance of Deep Learning (DL), in extracting features has been shown in



publications. WE have also seen that people have used Convolutional Neural Networks (CNNs) for image recognition. The Convolutional Neural Networks (CNNs) have also been changed to work for NIDS. I have read that the Convolutional Neural Networks (CNNs) can find relationships between packet attributes that the conventional ML models miss because the Convolutional Neural Networks (CNNs) treat network traffic flows as vectors.. Researchers test the majority of the suggested models, in batch processing and offline settings. The technical difficulty of putting the models into a streaming environment with a user facing dashboard is rarely covered in research. Researchers rarely discuss the difficulty. AegisPulse offers a system that's accurate, in backend processing and accessible in frontend presentation. The system is accurate in backend processing. The system is accessible, in frontend presentation. The system aims to close the gap. The technical difficulty remains a challenge. The models need to run. The dashboard needs to show the results. The research does not cover the difficulty. AegisPulse wants to close the gap.

### 3. OBJECTIVES :

The primary objectives of this research are:

- To Create a Deep Learning model that sorts network traffic into benign categories. The hybrid Deep Learning model merges CNN and DNN architectures.
- To create a Live Attack Simulation engine. The Live Attack Simulation engine will simulate real-time network performance by streaming dataset records.
- To improve the NIDSs interpretability. I will build a web dashboard that shows the attack vectors and the geographic origins.

### 4. RESEARCH METHOD :

We built AegisPulse using a step-by-step process. We checked each step. AegisPulse used data collection, data cleaning, model design and full-stack system integration.

**4.1 Data Acquisition & Preprocessing:** In practice the system uses the NSL-KDD and CICIDS2017 datasets to handle both attacks and new attacks. The system developers built a preparation pipeline because raw network data cannot be fed directly into networks. To keep descent steady during training the system pipeline clears values applies One-Hot Encoding to characteristics (such, as protocols like TCP and UDP). Uses Min-Max Scaling to normalize numerical data (such, as packet time).

**4.2 Hybrid Model Architecture:** We built the hybrid model. The Convolutional Neural Network (CNN) branch looks at packet headers. Finds patterns by checking the data for small patterns, with 1D convolution. The Deep Neural Network (DNN) branch has layers. The Deep Neural Network (DNN) branch learns relationships between features. The Swallow Neural Network (SNN) is a network that can act as a backup, for response when speed matters.

**4.3 Real-Time Simulation Engine:** I built a Python replay engine that mimics a network without running viruses. The replay engine uses WebSocket to send processed rows from the test data sets to the dashboard. The replay engine can send at a rate you can set, for example 20 packets, per second. The replay engine lets the system be tested against streams by simulating the pulse of a network.

### 5. FINDINGS :

We used performance indicators such, as accuracy, precision, recall and F1-score to assess the suggested AegisPulse system. The standard performance indicators gave a picture of how the AegisPulse system performed.

**5.1 Classification Accuracy:** In experiments the hybrid CNN model achieved an accuracy of 95.2 percent, on the testing split of the CICIDS2017 dataset. The hybrid CNN model could clearly separate high-volume attacks such as DDoS from traffic. The DNN model reached an accuracy of 92 percent staying close, behind the CNN model.

**5.2 Dashboard Performance:** We observed that the visualization engine responded quickly. The dashboard rendered than 50 events each second. Did not stall the UI during stress testing. Real time probability charts showed a history of assault surges. The Live Attack Map showed the geographic origin of IP addresses.



## 6. DISCUSSION :

This shows that Deep Learning can improve NIDS capabilities a lot. The CNN architecture performs better. The better performance means that the network traffic data has built-in patterns. The convolutional filters can decode the patterns. The convolutional filters work on the pixel layouts in photographs.

Alert fatigue, in Security Operations Centers (SOCs) is a problem. In work we see that the live simulation engine fixes alert fatigue in Security Operations Centers (SOCs). AegisPulse reduces stress by turning text logs into charts such, as trend lines and heatmaps. AegisPulse does not make the operator read text. AegisPulse lets the operator see the speed of an attack and the color cues. The operator can quickly tell the intensity of an attack by looking at the speed and the color indicators.

## 7. RECOMMENDATIONS:

To look at the context of the packets, over periods the future research should explore the transformer topologies (like BERT). Moving the backend to a distributed cloud architecture enables the scaling needed to handle enterprise traffic.

## 8. LIMITATIONS:

We see that the report says the replayed datasets are used to approximate the real-time component. The report says the volatility and fragmentation, in the physical layer network traffic are not fully captured by the replayed datasets despite the accuracy. The report says the deep learning model is computationally demanding and the deep learning models can be made for deployment, on edge devices with hardware resources.

## 9. CONCLUSION :

This research. Launched AegisPulse, a NIDS that mixes interactive visualization and hybrid deep learning. AegisPulse reaches, than 95 percent accuracy. AegisPulse provides a real time view of network activity. AegisPulse makes AI technology usable for cybersecurity work. The project shows that security tools need to be both easy, for users and work well in the algorithm.

## 10. ACKNOWLEDGMENT:

The Department of Artificial Intelligence & Data Science gave the resources needed for this study. The authors are grateful. The authors also thank the authors of the NSL-KDD and CICIDS2017 datasets for their contributions, to the open source community.

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# Agri Predictive Labs: AI models to anticipate Crop Price

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**ABSTRACT :** *The agricultural market in India experiences frequent price fluctuations, making it challenging for farmers to identify the optimal time to sell their produce. These variations arise from factors such as seasonal demand, market arrivals, weather conditions, and region-specific trading behavior. To tackle this issue, AgriPredictive Labs presents an AI-driven forecasting framework that predicts future crop prices using advanced data analytics. The system aggregates historical price records from multiple market sources and applies data preprocessing, trend modelling, and feature engineering techniques to generate reliable predictions. By providing clear and actionable insights, the model assists farmers and market stakeholders in making informed selling decisions, thereby reducing financial uncertainty. The results of the study indicate that AI-based prediction methods can significantly enhance forecast accuracy and promote better income stability within the agricultural sector. Overall, AgriPredictive Labs aims to strengthen farming communities by delivering an accessible digital tool that enhances market awareness and supports smarter, data-backed decision-making.*

**KEYWORDS :** *Agricultural Market Analysis, Crop Price Forecasting, Predictive Analytics, Smart Farming Systems, AI-Driven Decision Support.*

## 1. INTRODUCTION

Agriculture remains a cornerstone of the economy, yet farmers frequently face uncertainty due to rapid and inconsistent fluctuations in crop prices. These unpredictable changes make it difficult to decide the ideal time for selling produce, often forcing farmers to rely on experience, guesswork, or unverified market information. Such traditional approaches rarely offer accurate or timely guidance. To overcome this limitation, AgriPredictive Labs introduces an AI-powered system capable of analysing historical price data, seasonal variations, and demand–supply patterns to forecast future market trends. By providing clear and data-backed insights, the system enables farmers to make informed marketing and cultivation decisions. This not only helps them reduce financial risk but also enhances income stability and encourages more sustainable, technology-driven farming practices.

## 2. LITERATURE REVIEW

Recent studies on agricultural price forecasting highlight the use of both statistical and machine learning models to support informed decision-making in farming. Traditional time-series methods like ARIMA and SARIMA perform well for stable, linear patterns but struggle with irregular and externally influenced market behaviour. To overcome these limitations, machine learning techniques—such as Random Forest, Support Vector Regression, and Gradient Boosting—have shown superior accuracy in capturing nonlinear trends. Research on Indian market data further confirms that ML-based ensemble models provide more reliable multi-market predictions. AgriPredict builds upon these insights by adopting a flexible, AI-driven forecasting framework.



### 3. OBJECTIVE

The objective of this project is to design an AI-powered crop price forecasting system that interprets historical market data, seasonal variations, and demand–supply trends to deliver accurate price predictions. By offering timely insights, the system helps farmers choose the best selling period, manage financial risks, and plan cultivation effectively. Overall, the project aims to promote datadriven agricultural practices and support more stable and sustainable farming outcomes.

### 4. METHODOLOGY

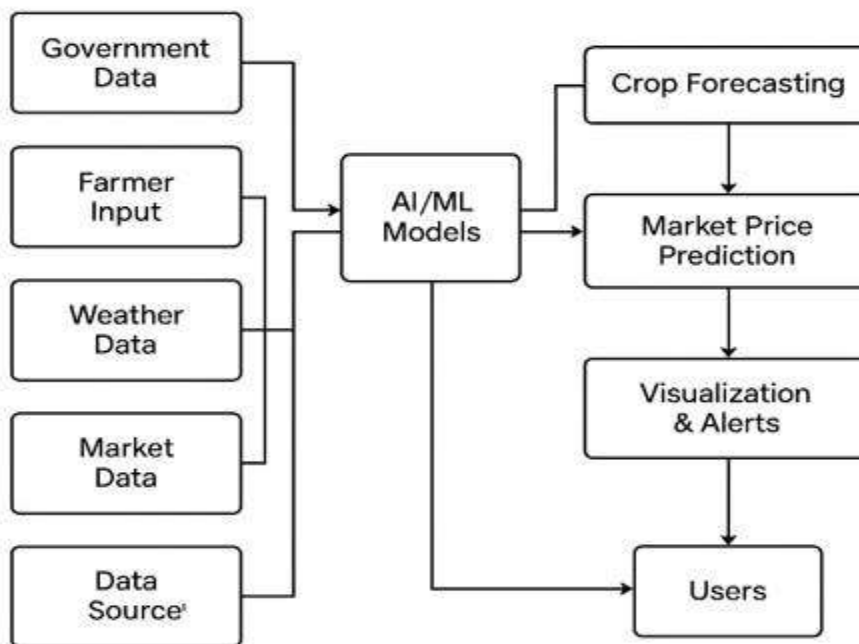


Figure 1 : System Architecture

### 5. RESULTS

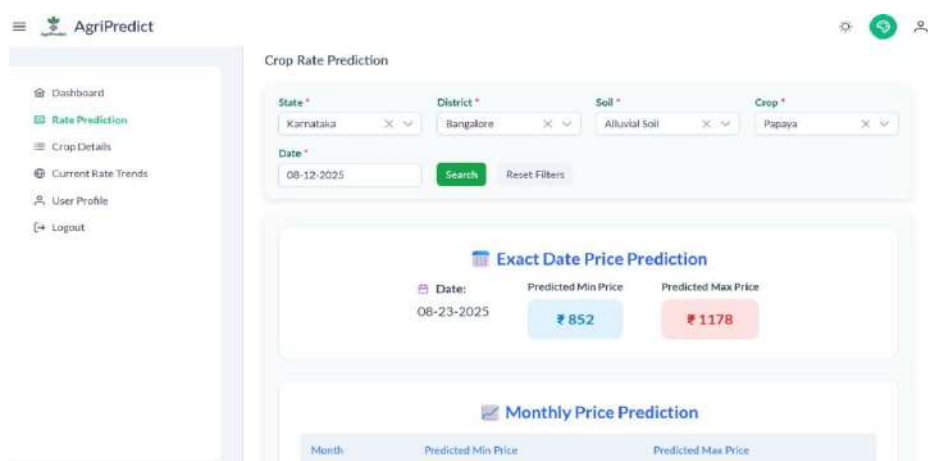


Figure 2 : Exact date price prediction

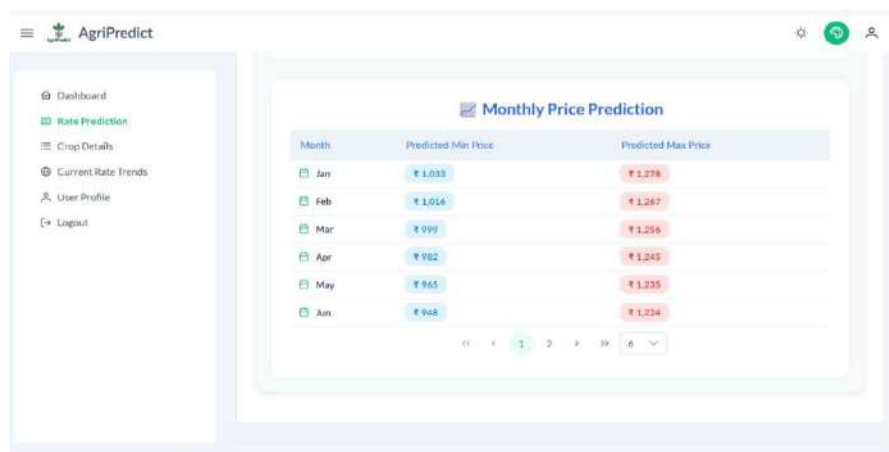


Figure 3 : Monthly price prediction

## 6. ANALYSIS

AgriPredictive Labs is a data-driven agricultural innovation project that uses AI, IoT sensors, and satellite imagery to predict crop performance, detect pest and disease risks early, and optimize resource use for farmers. By integrating real-time field data with machine learning models, the system provides timely insights on soil health, weather patterns, irrigation needs, and market trends, enabling farmers to make smarter decisions and reduce losses.

## 7. RECOMMENDATIONS

Based on research outcomes, the following improvements are suggested:

- Improve data collection tools to make predictions more accurate.
- Train farmers regularly so they can use the system effectively.
- Use low-cost, solar-powered sensors for better rural coverage.
- Make the platform simple and available in local languages.
- Partner with government and agriculture agencies to expand reach.

## 8. LIMITATIONS

- Requires reliable internet and power, which may be limited in rural areas.
- Prediction accuracy may drop if data is incomplete or inconsistent.
- Continuous model updates are needed, requiring skilled technical support.
- Processing and analyzing the large dataset takes more time, which can slow down the system's response and reduce real-time efficiency.

## 9. CONCLUSION

AgriPredictive Labs represents a forward-looking approach to modern agriculture, blending technology with traditional knowledge. By providing predictive insights and real-time recommendations, the project has the potential to increase productivity, improve food security, and make farming more resilient. It is scalable, impactful, and aligns with global digital agriculture trends.

## ACKNOWLEDGMENT

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# Identification of Colors By Using Python

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**Abstract:** The Identification of Colors using Python focuses on developing an application that can automatically detect and identify colors from real-time video input. Using a webcam, the system captures live video frames and processes them through the OpenCV library. When the user clicks on a specific area of the video frame, the system extracts the RGB (Red, Green, Blue) values of the selected pixel and compares them with a predefined color dataset to determine the closest color name. This project demonstrates practical implementation of image processing, computer vision, and Python programming concepts. It can be extended for applications such as digital art tools, color blindness assistance, and industrial quality control. The system provides an interactive and accurate color detection platform that enhances understanding of how computer vision techniques are applied in real-world scenarios.

**Keywords:** Real-Time Color Detection, OpenCV, RGB to Color Name Mapping, Computer Vision, Human-Computer Interaction, Webcam Image Processing, Color Recognition, Color Picker Tool, Image Analysis.

## 1. INTRODUCTION

Color plays a fundamental role in the way humans perceive and interpret the world. From digital media and graphic design to medical imaging and industrial automation, accurate color identification and processing are critical in numerous fields. With the rapid advancement of computer vision and artificial intelligence, machines are increasingly being trained to recognize and process color data in real-time to mimic human visual perception. This project explores the development and implementation of a system capable of identifying and naming colors dynamically from a webcam feed. The primary motivation behind this project is to create an interactive tool that can detect the color of any pixel selected by the user within a video stream. This is achieved by capturing frames using a webcam, enabling mouse-based interaction to select specific pixels, and computing the corresponding RGB (Red, Green, Blue) values. These RGB values are then compared against a reference dataset of known colors to find the closest match. The name of the detected color along with its hexadecimal (HEX) code and exact RGB values is then displayed in real-time, providing immediate feedback to the user.

## 2. LITERATURE REVIEW

**In[1]. ColorSense: Machine Perception of Color** — Chiu et al. introduced **ColorSense**, a dataset of over 110,000 human annotations designed to analyze how machine-learning models perceive subtle color variations. Their findings showed that widely used architectures such as CNNs and ViTs often fail to distinguish fine-grained color differences, especially in safety-critical tasks. The study's major strength lies in its large, detailed dataset and clear evaluation of model shortcomings; however, it is limited by the fact that it focuses only on analysis and does not propose any improved model or implementation to address these issues.



#### **In[2]. Learning for Vehicle Color Recognition — Rachmadi & Purnama**

Rachmadi and Purnama proposed a CNN-based framework for vehicle color recognition that overcomes the limitations of traditional rule-based detection, which is highly sensitive to lighting and environmental noise. By using perceptually uniform color spaces (HSV and CIE Lab) to separate chromatic and intensity information, their method enabled the CNN to learn more human-relevant color distinctions. The study's strength lies in its improved accuracy and robust feature extraction, while its limitations include challenges related to dataset imbalance, camera quality dependence, and lighting variability, which affect real-world deployment.

#### **In[3]. Multi-Color Space Feature Learning—Gowda & Yuan**

Gowda and Yuan introduced **ColorNet**, a multi-branch CNN that processes images in several color spaces (RGB, HSV, YCbCr, Lab) to overcome the limitations of models trained only on RGB. Each branch extracts complementary features, and the fused representation improves accuracy on datasets like CIFAR-10, CIFAR-100, and ImageNet. The strength of the study is its clear demonstration that different color spaces contribute uniquely to recognition, boosting classification performance; however, the approach is limited by higher computational complexity and the need for multi-space preprocessing, which may affect real-time deployment.

#### **In[4]. Color Characterization for Fruit Recognition — García-Lamont et al.**

García-Lamont et al. proposed a chromaticity-based method for fruit recognition that isolates color from intensity to reduce lighting effects and combines color features with shape cues for improved accuracy. The study's strength is its robustness under variable illumination, while its limitation is reliance on RGB-based chromaticity, which may not generalize to more complex spectral settings.

### **3. OBJECTIVES**

- To develop an efficient system capable of accurately detecting and identifying colors from images or live video input.
- To analyze the impact of different color spaces (RGB, HSV, Lab, etc.) on detection accuracy and system performance.
- To implement preprocessing techniques that minimize the effects of lighting variations, shadows, and noise.
- To integrate the detected color information into a user-friendly interface that displays real-time color values and labels.
- To evaluate the system across diverse environments and datasets to ensure robustness and practical applicability.

### **4. METHODOLOGY**

The methodology involves capturing image or video data through a camera and applying preprocessing techniques such as noise reduction and illumination correction to ensure clean input. The RGB frames are then converted into color spaces like HSV and Lab to reduce the effects of lighting variations. From these converted images, key color features are extracted using thresholding or segmentation methods, allowing accurate identification of dominant or target colors. These features are classified into predefined color categories, and the detected color along with its values is displayed through a simple user interface. The system is finally tested under different conditions to verify accuracy and real-time performance.

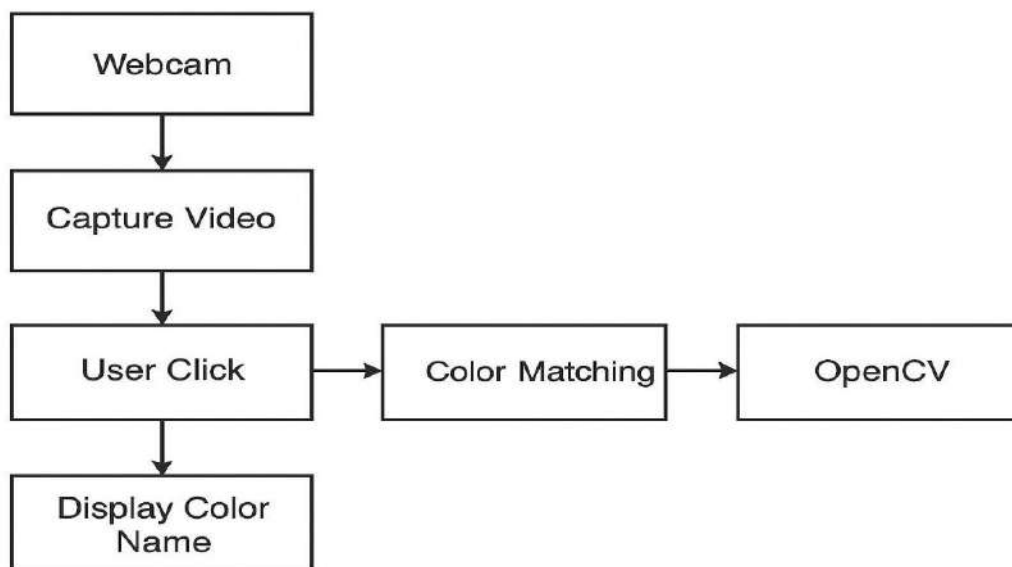


Figure 4.1: Use Case Diagram

## 5. RESULT

The results of the system demonstrate that the color-detection algorithm accurately identifies dominant and target colors across various lighting conditions. Converting images into HSV and Lab color spaces significantly improved detection stability compared to using RGB alone, especially in environments with shadows or brightness variations. The interface successfully displayed real-time color labels along with their RGB/HSV values, and the system maintained smooth performance during continuous video input. Overall, the implementation achieved reliable color recognition with consistent accuracy in both controlled and natural settings.



Figure5.1: Detected Color Result

## 6. DISCUSSION

The results indicate that using alternative color spaces such as HSV and Lab plays a crucial role in improving the stability and accuracy of color detection, especially under varying illumination. The system's strong performance in real-time conditions shows that the preprocessing and feature-extraction steps were effective in reducing noise and handling shadows. However, the accuracy still depends on camera quality and background uniformity, which may cause slight variations in detection. Despite these limitations, the approach proves to be practical and reliable for applications requiring fast and consistent color recognition, highlighting the importance of proper color-space selection and preprocessing techniques in computer-vision systems.



## 7. RECOMMENDATIONS

To further improve the performance of the color-detection system, it is recommended to incorporate more advanced preprocessing techniques that adapt automatically to changing lighting conditions. Expanding the dataset with images captured from different cameras and environments would also help increase robustness and generalization. Integrating deep-learning models could enhance accuracy in complex scenes where colors overlap or appear similar. Additionally, implementing an auto-calibration feature and optimizing the interface for faster response would make the system more efficient for real-time applications. Overall, these improvements can strengthen reliability and broaden the practical use of the system.

## 8. LIMITATIONS

- I. The system's accuracy can be affected by lighting conditions, especially in very bright or dim environments.
- II. Camera quality and resolution can influence color detection, leading to potential errors with low-quality sensors.
- III. Background interference from multi-colored or patterned surfaces may reduce recognition accuracy.
- IV. The system may struggle with subtle or very similar color shades, limiting precise differentiation.
- V. Processing speed can be affected on devices with limited hardware, impacting real-time performance.

## 9. CONCLUSION

The project successfully developed a real-time color detection system capable of identifying dominant and target colors from images or video input. Using alternative color spaces like HSV and Lab improved detection accuracy and reduced the effects of lighting variations and shadows. The system demonstrated reliable performance across different environments and provided real-time output through a user-friendly interface. Despite minor limitations related to camera quality, background complexity, and subtle color variations, the implementation proves practical and effective for applications in computer vision, object recognition, and automated monitoring systems.

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# AI-based Vehicle Number Recognition System with Automated Entry–Exit Tracking and Real-Time Security Alerting

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**Abstract:** Automatic vehicle number recognition plays an important role in daily life traffic management and security system. An intelligent system for vehicle number identification with automated monitoring and real-time alert generation is developed using deep learning and computer vision methods. Live video is obtained from a CCTV or IP camera and processed using OpenCV for frame extraction. Vehicle detection is carried out using the YOLOv8 model, while license plate information is obtained through EasyOCR after suitable image enhancement. The extracted plate number is verified using a whitelist database to classify vehicles as authorized or unauthorized. All detected events are in a database and visualized using protected Flask-based web dashboard.

**Key Words:** Artificial Intelligence, YOLOv8, EasyOCR, Automated Surveillance, Deep Learning, Computer Vision, Flask Web Framework, SQL Database, Cloud Storage.

## 1 INTRODUCTION

The number of vehicles in recent years has increased the demand for automated solutions to manage traffic flow and strengthen security systems. The normal manual monitoring methods are time-consuming, prone to errors, and unsuitable for high-traffic environments. As a result, Automatic Vehicle Number Plate Recognition (ANPR) systems based on artificial intelligence and computer vision have become an important part of modern surveillance and access control applications.

## 2 LITERATURE REVIEW

Automatic Vehicle Number Recognition is widely used in traffic and security applications. Early systems mainly used basic image processing techniques, which working in controlled environments. Later, machine learning methods such as Support Vector Machines and Neural Networks improved detection and recognition accuracy, but real-time performance remained a challenge.

## 3 OBJECTIVES

The main objectives in the proposed system are:



- The project focuses on building an AI-based system that can recognition vehicles in real time and accurately read their number plates from live video footage.
- Real-time tracking of vehicle entry and exit is achieved through a secure and user-friendly web dashboard that allows continuous monitoring of vehicle movement.
- Instant security alerts are generated whenever an unauthorized vehicle is identified, helping security personnel respond without delay.
- Efficient surveillance management is supported through centralized data storage, cloud-based backup, and detailed activity records for future reference and analysis.

## 4 METHODOLOGY

The system is developed using an experimental and practical approach to automatically detect vehicles, recognize number plates, store vehicle records, and generate security alerts in real time.

### 4.1 Video Input Acquisition

Live video is captured using a CCTV or IP camera. Video frames are extracted continuously using the OpenCV library for processing.

### 4.2 Vehicle Detection

YOLOv8 is used to detect vehicles such as cars, bikes, and trucks from each video frame in real time.

### 4.3 License Plate Recognition

The detected license plate area is extracted and enhanced using basic image preprocessing. EasyOCR is then used to read the vehicle number.

### 4.4 Authorization Verification

The recognized number is checked with a whitelist database. Authorized and unauthorized vehicles are identified based on this verification.

### 4.5 Data Storage and Cloud Backup

All vehicle details with time and status are stored in a database. Important records are also backed up to cloud storage.

## 5 SYSTEM ARCHITECTURE

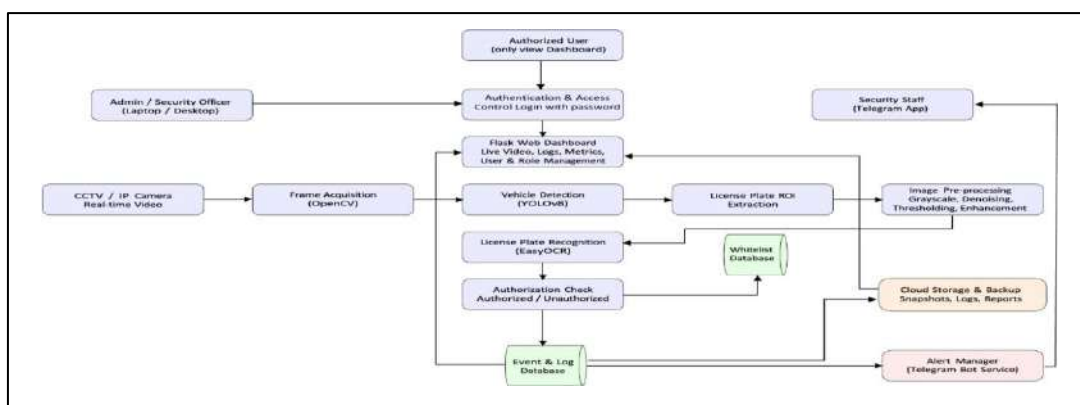


Figure 5.1: Architecture of the Automated Vehicle Number Recognition and Monitoring System



### The architecture consists of the following core modules:

The proposed system is designed as a set of well-integrated functional modules that work together to perform real-time vehicle number plate recognition and security monitoring. Live video is captured in a CCTV or IP camera and processed using OpenCV to frame extraction and enhancement. Vehicle identification is carried out using the YOLOv8 model, which detects vehicles accurately from the video. The detected license plate is processed using EasyOCR to extract the registration number. The extracted number is verified with a whitelist database to determine whether the vehicle is authorized or unauthorized.

The system operates continuous with low processing delay, enabling real-time performance. All modules function in coordination to ensure accurate vehicle detection, recognition, and tracking. All detected vehicle details are securely stored in the event and log database for future reference. A secure web dashboard provides authenticated users with access to live monitoring and record viewing. Important data is backed up using cloud storage, and an alert manager sends instant notifications through a Telegram bot whenever an unauthorized vehicle is detected.

## 6 RESULTS

The system was tested using real-time and recorded video inputs. As shown in Figure 6.1: Live ANPR Monitoring Dashboard, vehicles were detected accurately and displayed with details such as vehicle number, time, authorization status, confidence, and alert status. Unauthorized vehicles were clearly identified, and Telegram alerts were generated within a few seconds.

The secure access functionality was verified using Figure 6.2: User Management Interface (Admin Panel). The administrator successfully created users, assigned roles, and managed access rights. The system updated records instantly using WebSocket communication and achieved an average speed of 12–18 FPS on a standard CPU system, confirming its suitability for real-time monitoring.

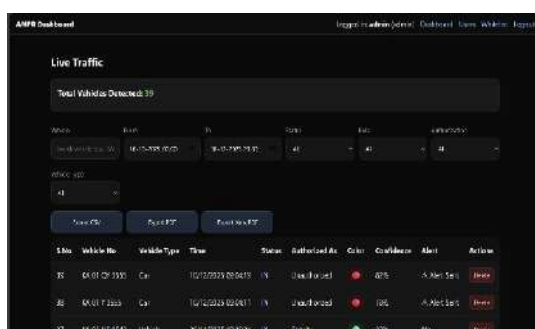


Figure 6.1: Live ANPR Monitoring Dashboard

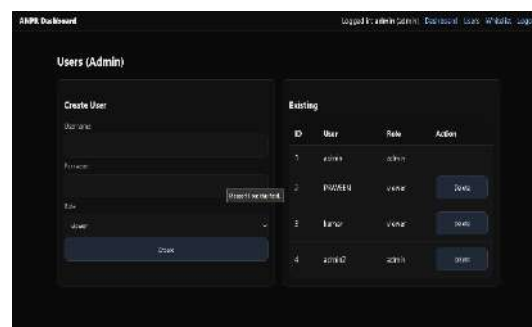


Figure 6.2: User Management Interface (Admin Panel)

## 7. ANALYSIS

The system demonstrated reliable performance during testing under real-time conditions. Vehicle detection using the YOLOv8 model was fast and accurate, while EasyOCR provided satisfactory results for number plate recognition after preprocessing. The authorization process using the whitelist database effectively identified authorized and unauthorized vehicles.

The web dashboard updated vehicle records without noticeable delay, and Telegram alerts were delivered within a few seconds. System performance was affected mainly by lighting conditions and video quality.



Overall, the analysis shows that the system is suitable for real-time vehicle monitoring and security applications.

## 8.RECOMMENDATIONS

- Use high-resolution cameras to improve detection and OCR accuracy.
- Deploy the system on GPU-enabled hardware for better real-time performance.
- Update the whitelist database regularly to maintain correct authorization.
- Perform periodic system checks to ensure continuous and reliable operation.

## 9.LIMITATIONS

- Recognition accuracy decreases under poor lighting and low-resolution video conditions.
- Partially covered or damaged number plates may lead to incorrect recognition.
- Real-time performance is limited on CPU-based systems and improves with GPU support.
- The system depends on stable internet connectivity for cloud backup and alert delivery.

## 10.CONCLUSION

An AI-based vehicle number recognition system for automated entry–exit monitoring and real-time security alerting was designed and implemented successfully. The system is able to detect vehicles, recognize license plate numbers, verify authorization using a whitelist database, and store all vehicle records accurately. Live monitoring through a secure web dashboard and instant alerts through Telegram improve the overall security response.

## ACKNOWLEDGMENT

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# Building a Machine Learning Model for classifying news articles as Real or Fake using Text analysis and Fact-checking sources

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**ABSTRACT:** *The emergence of fake news in the social media and online has become a significant issue, that has affected the opinion of the people, political choices, and social order. In this project, the author proposes an effective fake news detection model, which can identify fake and real news articles with the help of several machine learning models and ensemble techniques. It compares Logistic Regression, Multinomial Naive Bayes, and the Passive Aggressive Classifier, as well as hard voting, soft voting and stacking ensembles. Passive Aggressive Classifier has the highest accuracy of 99.5 percent, as compared to all other models. The installation takes place in the form of a Flask-based web application, which is capable of real-time prediction, user authentication, history of the prediction, and an interactive analytics dashboard. Preprocessing of the text involves deleting URLs and special characters and the use of TF-IDF with 5000 features. When evaluated on more than 44,000 labeled news articles, classical ML models can be seen to perform better than smaller deep learning setups. It is also possible to use the API in the system and integrate it with Google Fact Check API.*

**Keywords:** *Fake news identification, machine-learning based classifiers, ensemble-driven prediction methods, TF-IDF text feature generation, Flask web interface.*

## 1. INTRODUCTION

The digital revolution has revolutionized the form in which the information is produced, distributed and consumed. The internet and social media have also made access to information democratic but have also facilitated the transmission of fake news and misinformation at high speed. Research indicates that fake news is more viral and it reaches more individuals when compared to genuine news on social media sites. The effects of fake news extend widely, including the result of political elections, health choices of the population, and the financial markets and social integration.

Conventional ways of fact checking are labour-intensive and based on skilled human judgment and therefore costly and slow to adapt to the exponential increase in online posts. The 2016 United States presidential elections and the COVID-19 pandemic demonstrated the necessity to accelerate the automation of the mechanisms through which potentially false information is detected and flagged in real-time. Machine learning and natural language processing The newly discovered solution to this problem is the automation of fake news detection based on the machine learning method and various natural language processors.

## 2. LITERATURE REVIEW

Fake news detection studies have been in the surge because misinformation is proliferating over online media.



Previous research demonstrates that natural language processing, in conjunction with machine learning, can be used to a great effect in enhancing misleading content detection. The models examined by Shaik and the team include Decision Trees, Random Forests, Passive-Aggressive Classifiers, and Logistic Regression; it was concluded that an efficient text preprocessing has significant contribution to a better accuracy, but it was not possible to analyze the facts and verify any other external checks other than the patterns of the text. Mittal et al. compared such classifiers as Naive Bayes, SVM and Random Forest, in which case they have good performance, but they fail to deal with large-scale data, making them inapplicable to real-time. A related study by Rathore et al. also compared SVM vs. Logistic Regression, vs. Random Forest using NLP features and found the performance of the models to drop frequently when the dataset was not diverse, but they suggested hybrid methods to increase the adaptability of the models to varying types of news. In general, the literature has already indicated that machine learning procedures offer a solid basis regarding the possibility to identify fake news, but the developments in the diversity of the database, scale, and verification mechanisms will be necessary to establish more robust and feasible detection systems.

### 3. OBJECTIVES

- To Analyse the present Fake News detection techniques
- To evaluate the system's accuracy, scalability, and efficiency in delivering real-time fake news detection.

### 4. METHODOLOGY

The methodology will start by making the review of the current fake news detection methods in order to determine the limitations of the techniques and focus on the areas that need to be improved. Aggregating publicly available Fake and True news files and dividing them into training and testing sets were the next steps in the preparation of the dataset that was done using stratified sampling. The text-cleaning pipeline was used to eliminate URLs, emails, symbols and additional spaces and TF-IDF using unigrams and bigrams was used to transform the text that has been cleaned to handy numerical information. Three machine learning models were trained and compared Logistic Regression, Multinomial Naive Bayes and the Passive-Aggressive Classifier. Hybrid ensemble techniques like hard voting, soft voting, stacking etc were proposed to capture the model strengths to achieve greater accuracy. The last model has been integrated into a Flask web application that receives user data, runs it through preprocessing .

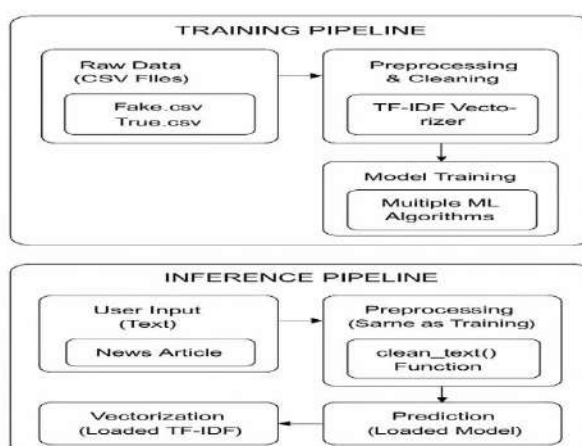


Figure 1: Workflow of misinformation Detection Using Text Classification

### 5.RESULTS

This Fake News Detection system uses a strong combination of machine learning algorithms to achieve reliable and accurate predictions. Models like Passive-Aggressive, Logistic Regression, and Naive Bayes work together to analyze text patterns and writing styles associated with real and fake news. Each algorithm contributes its own strengths Passive-Aggressive excels at handling large, evolving text data; Logistic Regression provides stable and interpretable decision boundaries; and Naive Bayes is fast and effective for



word-based probability modeling. When combined through ensemble techniques, these models complement one another, allowing the system to make more confident and balanced predictions. This blend of algorithms ensures that the platform remains robust, adaptable, and capable of identifying misinformation across a wide variety of news articles.



Figure 2: User Landing Page of the Fake News Detection Platform

## 6. DISCUSSION

The Passive-Aggressive Classifier achieved the highest accuracy at 99.5%, outperforming all other models. The ensemble methods added only slight improvements, suggesting that the classifier was already well-optimized for the dataset. These results show that properly tuned machine learning techniques can deliver strong and dependable performance. The TF-IDF representation with 5,000 features provided an effective balance between accuracy and efficiency. Additionally, preprocessing steps such as removing URLs and unnecessary characters helped reduce noise in the text and contributed to the model's overall improvement.

## 7. RECOMMENDATIONS

### 1. Expand to Multilingual Support

To overcome the English-only limitation, the system can be extended to handle multiple languages by incorporating multilingual datasets and language models, enabling broader and more inclusive fake news detection.

### 2. Integrate Multimedia Analysis

Since the current system analyzes only text, adding image, video, and metadata verification can strengthen detection, especially for posts where visuals play a major role in misleading audiences.

## 8. LIMITATIONS

- English language only.
- Text-based analysis exclusively.
- Vulnerability to adversarial attacks.

## 9. CONCLUSION

This paper proves that with the help of powerful text preprocessing and TF-IDF characteristics, machine learning can be successfully used to differentiate between authentic and fake news with good accuracy. Out of all the assessments, the Passive-Aggressive Classifier provided the most accurate results, and this indicates that the traditional algorithms properly tuned can be effective with large text-based data than more sophisticated algorithms. The effective execution of the system as a Flask web application also demonstrates that the system can be useful in practice when it comes to real-time prediction and interaction with users. Although the outcomes are quite encouraging, the system could be further enhanced with the inclusion of multilingual content and multimedia verification in order to make the system even stronger and handling the increasing problem of misinformation.



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# Face Detection in Real World Environment Using Deep Learning Model

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**Abstract:** *Face Detection in Real-World Environment Using Deep Learning Models focuses on implementing a robust face detection and recognition system that performs efficiently under varying real-world conditions such as diverse lighting, face orientations, and occlusions. The system utilizes the Local Binary Pattern Histogram (LBPH) algorithm for facial recognition, which is efficient for face recognition that works by dividing an image into regions, comparing pixel intensities to neighbors to create binary codes (local binary patterns), then using histograms of these patterns per region to form a unique feature vector for the face. real-time recognition tasks due to its ability to capture texture patterns in face images. OpenCV is employed for face detection, while pre-trained deep learning models are leveraged to enhance the accuracy and robustness of the system. The application is built with a user-friendly interface using HTML, CSS, and JavaScript on the front end, and Django as the backend framework for user authentication, data management, and face recognition tasks. Key features include user registration, login, dashboard for face recognition, and secure logout functionality. The proposed system serves as a reliable solution for face detection, applicable in fields like security, surveillance, and personalized authentication systems.*

**Key Words:** *Face Detection, Face Recognition, LBPH, OpenCV, Deep Learning Models, Local Binary Pattern Histogram, Django, Pre-trained Models, Real-World Environment, Image Processing, User Authentication, Web Application, Face Recognition System.*

## 1. INTRODUCTION:

Face detection and recognition have become critical components in various security, authentication, and surveillance systems. With the rise of biometric authentication technologies, face recognition has proven to be an effective method for non-intrusive and secure identification. However, implementing face recognition in real-world environment poses significant challenges due to factors like poor lighting, occlusions, and varying face orientations. Traditional face detection techniques struggle to perform under such conditions, making it essential to develop more robust systems using advanced technologies. This project aims to tackle these challenges and create a reliable face recognition system capable of performing efficiently in dynamic, real-world conditions.

The core of this is to use OpenCV for face detection, which is an essential step in identifying the location of faces within images or video streams. Local Binary Pattern Histogram (LBPH) is then used for face recognition, a well-established algorithm known for its simplicity and efficiency, especially in real-time applications. LBPH works by analyzing the texture patterns in a face and comparing them to a database



of known faces. This approach is particularly effective in scenarios where faces might be partially presented under varying lighting conditions. Pre-trained deep learning models like FaceNet will be incorporated to enhance the accuracy and robustness of the system, providing a more comprehensive solution to face recognition in complex environments.

## **2. LITERATURE REVIEW:**

Rongxing Lu et al.[1] This paper provides an extensive review of deep learning-based face recognition methods, examining various neural network architectures and their impact on real-world face detection systems. It discusses how deep learning has improved the accuracy of face recognition models in challenging environments, including varying lighting, occlusions, and face orientations. The paper also compares traditional methods with state-of-the-art deep learning techniques, highlighting the advantages and limitations of each approach in practical applications [6].

H. Zhang et al [2] This paper introduces the 34N-LBPH+CNN algorithm, which combines the traditional Local Binary Pattern Histogram (LBPH) with Convolutional Neural Networks (CNNs) to enhance face recognition in constrained environments. The study demonstrates improved recognition accuracy by using CNNs to refine the feature extraction process. The hybrid algorithm is shown to be more robust than standard LBPH, particularly when dealing with variations such as illumination changes and partial face occlusions [7].

T. J. Bartuzi and M. Trokielewicz [3], This paper discusses the challenges of face detection and recognition in real-world scenarios, especially with the rise of deepfake technology. The authors emphasize the need for more robust face recognition systems that can reliably handle manipulated images and videos. They explore advanced deep learning techniques designed to improve model accuracy and robustness against fraudulent face data, aiming for applications in security and surveillance [8].

P. Kumar, S. K. Yadav, and A. Kapoor [4] . This research explores the use of multitask learning (MTL) for facial recognition on a Raspberry Pi, highlighting the viability of real-time face detection in low-cost computing environments. By leveraging MobileNet and InceptionV3, the study achieves high accuracy in not only face identification but also in predicting age and ethnicity. The paper focuses on optimizing deep learning models for edge devices to ensure fast, efficient processing suitable for real-time applications [9].

R. Singh and M. Sharma[5] , In this paper, the authors present an enhanced version of the Local Binary Pattern Histogram (LBPH) algorithm to improve its robustness in extracting face features under difficult conditions such as low lighting and low-resolution images. The study demonstrates the enhanced LBPH algorithm's ability to significantly improve the accuracy of face recognition in practical applications, making it suitable for real-time use in security systems and mobile devices [10].

## **3. OBJECTIVES:**

Detection of face regardless of pose, lighting conditions, facial expression, occlusions and also reduction of detecting non- face objects as faces.

## **4. METHODOLOGY:**

Existing systems for face detection and recognition, such as Haar Cascade Classifiers [1], MTCNN [2], and Faster R-CNN, have made significant progress but still face challenges in real-world environments. Traditional methods like Haar Cascades are fast but struggle with varying lighting and occlusions [1], while MTCNN and Faster R-CNN offer better accuracy at the cost of higher computational requirements. YOLO (You Only Look Once) provides real-time performance but can face limitations in crowded or complex scenes [3], and FaceNet offers robust face recognition, although it demands substantial computational power. These systems excel in specific use cases but are not always effective in handling diverse environmental factors like different face



orientations or lighting conditions.

The aim is to overcome the limitations of existing systems by integrating Local Binary Pattern Histogram (LBPH) [5], OpenCV, and pre-trained deep learning models for accurate, real-time face detection and recognition in dynamic environments. The system uses OpenCV for face detection, which allows quick identification of faces in images or video streams, even in challenging conditions. Once a face is detected, LBPH is used for recognition by analyzing facial texture patterns and matching them to a stored database of known faces. This approach is effective for handling lighting variations and partial occlusions.

To enhance accuracy, pre-trained deep learning models like FaceNet will be integrated to extract more detailed facial features, improving performance in cases of face angle variations or low-resolution images [4]. The system will be developed as a web application using HTML, CSS, JavaScript, and Django, enabling users to register, upload images, and view recognition results.

#### 4.1 WORK FLOW:

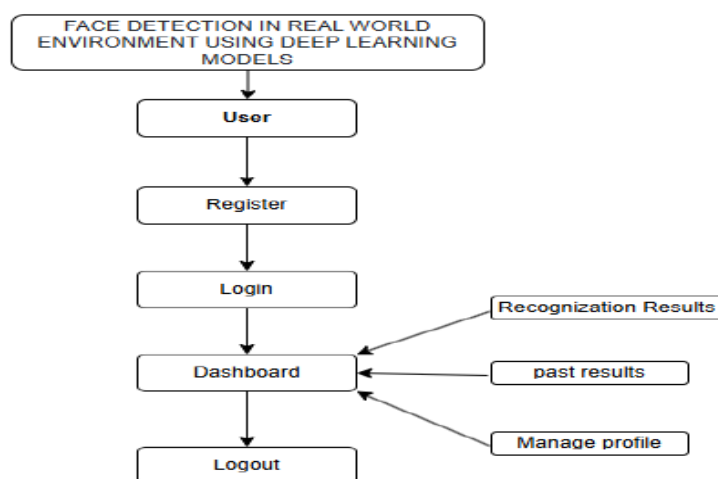


Fig 4.1.1 Work flow of face detection and recognition

#### 4.2 ARCHITECTURE:

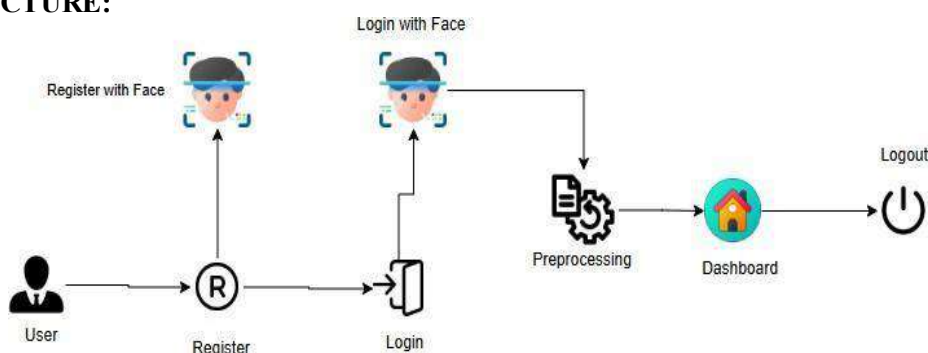


Fig 4.2.1 Architecture of face detection

#### 5. RESULTS:

**Home Page:** The home page of the "Face Detection in Real-World Environment Using Deep Learning Models" project features registration and login options for secure user access, providing an intuitive interface to use the face detection system.

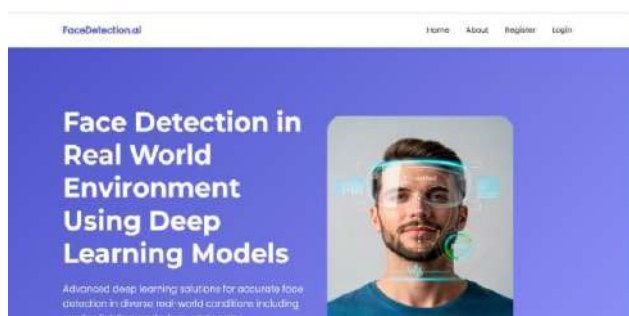


Fig 5.1 Home page

**User Registration:** The "User Registration" page allows new users to create an account by providing necessary details such as name, email, and password. It ensures secure registration, enabling users to access the face detection system after signing up.

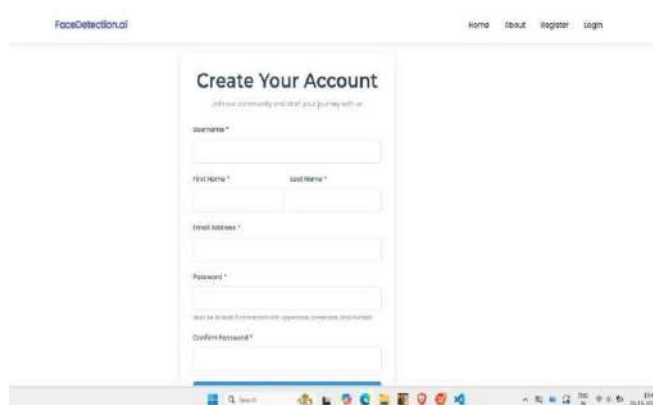


Fig 5.2 User registration

**User Login:** The "User Login" page allows registered users to securely log in using their credentials (email and password). Once logged in, users gain access to the face detection system and its features.

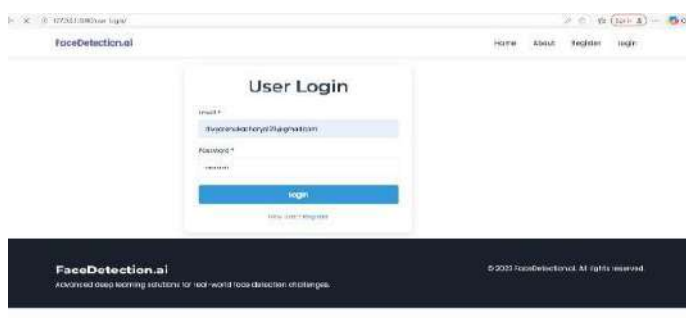


Fig 5.3 User login

**Face Detection:** The "Face Detection" page enables users to upload images or use live camera feeds for real-time face detection. Using deep learning models, it identifies and highlights faces in the input, providing accurate and efficient recognition in real-world environments.

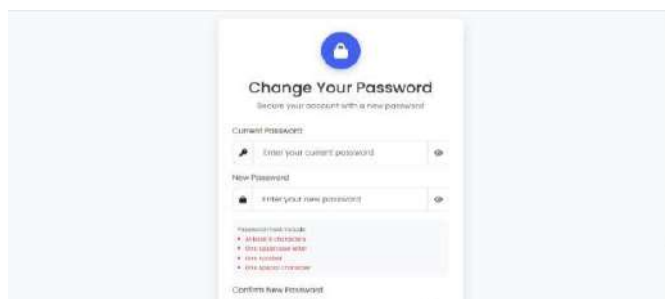


**Fig 5.4 Face detection**

**User Home Page:** The "User Home Page" serves as the central dashboard where users can access all features of the face detection system. It provides a summary of recent activities, allows easy navigation to face detection tasks, and offers options for account settings and profile management.

**View Profile:** The "View Profile" page allows users to view and manage their account details, including personal information, email, and password. It provides an overview of the user's profile and offers options to update or edit the information as needed.

**Change Password:** The "Change Password" page allows users to securely update their password by verifying their current password and entering a new one. It ensures that only authorized users can modify their login credentials, enhancing account security.



**Fig 5.5 Change password**

**View Login History:** The "View Login History" page displays a log of all previous login attempts, including timestamps and device/browser details. This feature helps users monitor their account's security by providing insight into unauthorized or suspicious login activity.

## 6. DISCUSSION:

Deep learning models significantly outperform traditional face-detection methods such as Haar cascades [1]. They are more robust to pose changes, can detect smaller faces, and adapt better to complex scenes. However, computational requirements remain a limitation. Real-time detection on edge devices or low-power systems may require lightweight models or hardware acceleration.

For applications like surveillance, attendance systems, and security monitoring, consistent lighting, camera quality, and angle optimization improve the accuracy of detection. Data augmentation techniques such as random rotation, brightness modification, and occlusion simulation can further help the model learn real-world



variations.

Overall, this project demonstrates that deep learning models offer highly effective face detection capabilities, their performance in real-world environments depends on factors like dataset diversity, environmental conditions, and computational resources.

## 7. RECOMMENDATIONS:

To enhance the “Face Detection in Real-World Environment Using Deep Learning Models” system, several improvements can be made.

- Multi-factor authentication (MFA) can be added for enhanced security, combining face recognition with other methods like OTPs or fingerprint scanning.
- Integrating emotion recognition and multiple face recognition would improve user experience and make the system more versatile.
- Expanding the system to real-time video recognition and detecting face attributes like age and gender would broaden its applications.
- Improving occlusion handling with advanced models and enabling cloud integration for scalability would further enhance its robustness.
- Additionally, cross-platform support, privacy features like encryption, and offline functionality would increase the system’s accessibility, security, and usability.

## 8. CONCLUSION:

Face Detection in Real-World Environment Using Deep Learning Models successfully combines the Local Binary Pattern Histogram (LBPH) algorithm, OpenCV for face detection, and pre-trained deep learning models like MobileNet or FaceNet to provide a robust solution for face recognition in dynamic, real-world environments. By implementing the system as a web-based application using HTML, CSS, JavaScript, and Django, it allows users to register, upload images for training, and perform real-time face recognition. The system demonstrates high accuracy, real-time processing, and scalability, effectively handling challenges like varying lighting, face occlusions, and different angles. This project offers a reliable and efficient solution for applications in security systems, access control, and personal authentication, and lays the groundwork for future enhancements such as multi-factor authentication and emotion recognition, further enhancing its potential for real-world deployment.

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# A Secure and Intelligent Padlock System Using IoT and Multi-Sensor Integration

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**Abstract:** *The Padlock System Using IoT and Sensors presents a secure and intelligent access control mechanism that integrates embedded systems, sensor technology, and Internet of Things (IoT) communication. The proposed system is built around a microcontroller unit (such as ESP32/ESP8266 or Arduino) interfaced with multiple sensors, including authentication sensors (RFID, fingerprint, or keypad) and status sensors for tamper or motion detection. Wireless communication is enabled through Wi-Fi or GSM modules, allowing realtime monitoring and control via a cloud platform or mobile application. The system performs authentication locally and transmits sensor data to a remote server for logging and analysis. Upon successful authentication, an electromechanical locking mechanism (servo motor or solenoid lock) is actuated to unlock the padlock.*

## 1. INTRODUCTION

The technology of keys and locks remained the same for the last century while everything else is evolving exponentially. So why not use current technologies and apply it with old ones to build something new and innovative. Around 4000 years ago, the concept of Locks and Keys were invented and until today, regardless of some minimal variation in security and sustainability locks are installed in doors stimulated mechanically by the right key. Recently, the Internet was enhanced, and everything was connected to it (phones, television, laptops, tablets, cars and so on). This was done because we wanted to make systems smarter in other term a more productive. Why not do the same thing with Locks? Enhancing the locks mechanism by connecting them to the internet, making them more robust and productive Today, the number of mobile device users including smart phone users has rapidly been increasing worldwide, and various convenient and useful smart phone applications have been developed.

## 2. LITERATURE REVIEW

**Y. Januzaj. Et.al.[1]** proposed real time access control for face recognition using, Raspberry pi instead of GSM services and relay. The limitation of the work was it couldn't control the background light situation and ambient light conditions

**H.Lwin.et al.[2]** has proposed a door lock access system which consists of three subsystems: to be specific face recognition, face detection, and automated door access control. Face recognition is actualized by using the PCA (Principal Component Analysis) The door will open itself for the known person in command of the microcontroller and caution will ring for the unknown person. Demerit of this system is input images are taken through a web camera continuously until the 'stop camera' button is pressed. Somebody is required at the location to check unauthorized person's images or status of the system and take further appropriate action.



Personal computer (PC) is associated with the microcontroller; The entire system will not work if PC is crashed or non-function.

**M. Chowdhury.et al. [3]** had implemented security system where if any person came at the door it was notified to the home owner via e-mail and twitter then the user could see the person standing at the door using camera from remote location. The image of the person got captured and sent to twitter and e-mail. They stated that user couldn't control the door remotely. They had concluded that this system was useful for preventing unauthorized access. The limitation of this work was that the alert generated was sent to the mail and twitter account but if the user didn't have internet connection on his/her phone, he/she couldn't check the mail and couldn't recognize that any unauthorized person was trying to access the door.

**U. Sowmiya.et al.[4]** Developed to connect any door with internet. In this system user also implemented PIR sensor and camera. PIR sensor used for detecting person and camera used for capturing the video of the person who comes at the door. The video was sent through 3g dongle to authorized person. They had also discussed some advantages of this system. They had concluded use of this system in banks, hospitals etc. But their proposed model didn't provide the facility of sending messages to the authorized people

### 3. OBJECTIVES

1. Designing secured door lock to prevent unwanted access:
2. To give the user hassle-free access without compromising security:
3. This system gives notifications about access to user:
4. Live streaming using ESP32 CAM:
5. The sensor which help to keep security good:

### 4. METHODOLOGY

The IoT-based padlock system is designed to enhance security by integrating sensors, a microcontroller, and internet connectivity. The system allows authorized users to lock or unlock a padlock remotely while continuously monitoring access attempts. Sensor data is collected and transmitted through the internet to provide real-time status updates and alerts.

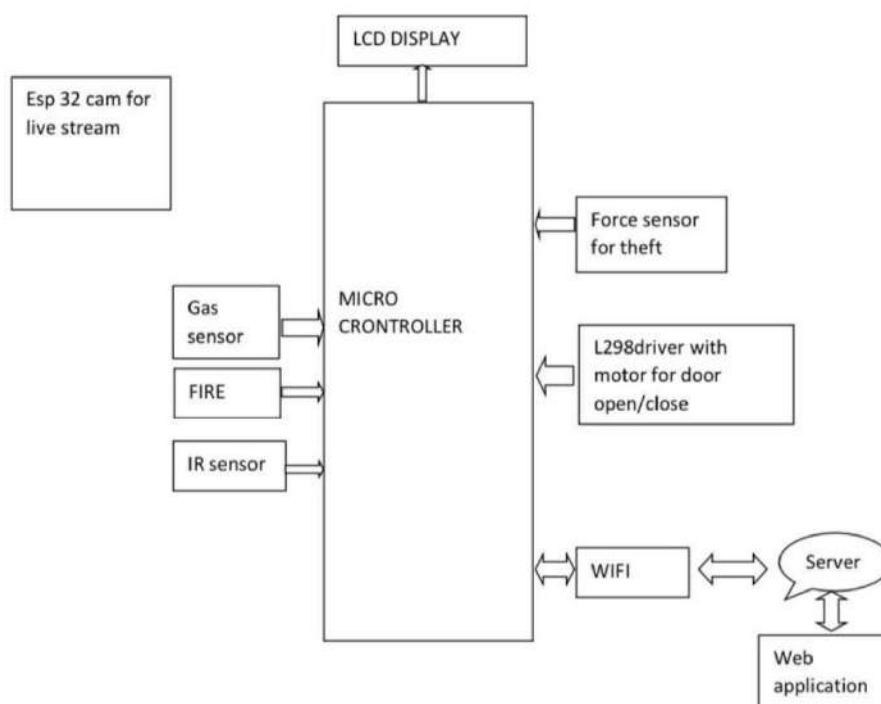


Fig.4.1 Block diagram of Padlock System Using IOT and Sensors



## 5. HARWARE REQUIREMENTS

### 1. ARDUINO UNO



The Arduino Uno is one of the most popular microcontroller boards in the Arduino ecosystem. It is widely used for electronics projects, prototyping, and educational purposes due to its simplicity, affordability, and vast community support. It is designed for beginners and professionals alike, it serves as a versatile platform for building electronic projects [14].

### 2. NodeMCU ESP8266:



A NodeMCU ESP8266 is an open-source IoT development platform that includes both hardware and firmware. It is built around the ESP8266 Wi-Fi System-on-Chip (SoC) and is widely used for developing Internet of Things (IoT) applications due to its low cost, small size, and built-in wireless connectivity [13].

### 3. IR Sensor



An IR (Infrared) Sensor is an electronic device that detects objects, obstacles, or motion by using infrared radiation. It works by transmitting infrared light and detecting the reflected light from nearby objects. IR sensors are widely used in security systems, obstacle detection, and automation projects.

### 4. Fire Sensor:



A Fire Sensor is a sensing device designed to identify fire-related conditions such as flame, excessive heat, smoke, or combustible gases. It converts physical fire indicators into electrical signals that can be processed



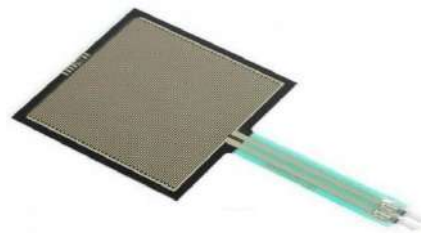
by electronic systems to initiate safety actions. Fire sensors play a vital role in early fire detection by converting physical fire indicators into electrical signals. Their integration with microcontrollers and IoT platforms enables intelligent, real-time safety responses, making them essential components in modern security and automation systems.

#### 5. Gas Sensor:



A Gas Sensor is an electronic sensing device used to detect the presence, type, and concentration of gases in the surrounding environment. It converts chemical information from gases into electrical signals that can be processed by electronic systems for safety monitoring and control applications. Gas sensors detect harmful or flammable gases by converting chemical reactions into electrical signals. Their integration with microcontrollers and IoT platforms enables intelligent safety monitoring, early warnings, and automated responses, making them essential components in modern safety systems.

#### 6. Force Sensor:



A Force Sensor is a sensing device used to measure applied force, pressure, or load by converting mechanical force into an electrical signal. The output signal varies according to the magnitude of the applied force, allowing electronic systems to detect, measure, or monitor physical pressure or impact. Force sensors convert mechanical force into electrical signals that can be processed electronically. When integrated into IoT-based security systems, they play a crucial role in detecting tampering, impact, and unauthorized force, thereby improving overall system safety and reliability.

#### 7. DC MOTOR

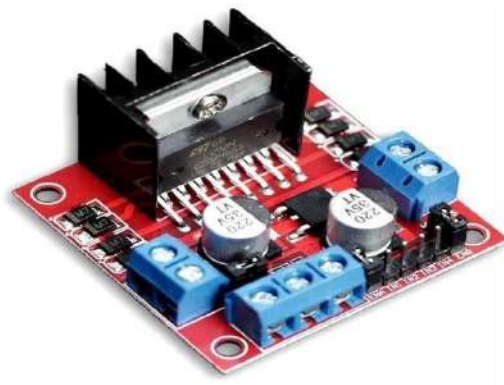


A DC (Direct Current) Motor is an electromechanical device that converts electrical energy from a DC power supply into mechanical rotational energy. It works on the principle that a current-carrying conductor placed in



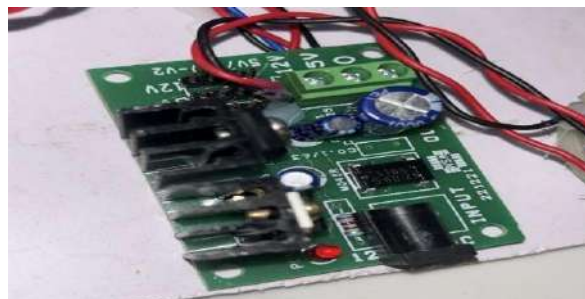
a magnetic field experiences a mechanical force. A DC motor is a fundamental electromechanical device that efficiently converts electrical energy into mechanical motion. Its simplicity, controllability, and reliability make it an ideal choice for automation and IoT-based security systems such as smart padlocks.

## 8. L298N Motor Driver



The L298N Motor Driver is a high-power dual H-bridge integrated circuit (IC) used to control the speed and direction of DC motors. It acts as an interface between low-power control signals from a microcontroller and high-power motor requirements. The L298N motor driver is a robust and reliable motor control IC that enables safe and efficient operation of DC motors using microcontrollers.

## 9. Power Supply



A Power Supply is an electrical system that converts available electrical energy into a required voltage, current, and power level suitable for operating electronic circuits and devices. It provides a stable and regulated power to ensure reliable operation of electronic components.

## 10. 16x2 LCD



The 16x2 LCD (Liquid Crystal Display) serves as the primary local user interface. While the website provides remote monitoring, the LCD gives immediate, real-time feedback to the person standing at the door. The LCD



acts as the communication bridge between the system's internal logic and the outside world. It informs the user about the status of the lock, sensor triggers, and the progress of the facial recognition scan.

## 6.WORKING PRINCIPLE

The IoT-based padlock system is designed to provide secure, automated, and remotely controllable locking using a combination of sensors, a microcontroller, a motor driver, and a DC motor. The system monitors environmental conditions, user authentication, and potential hazards to ensure the padlock is only opened under authorized and safe conditions. The IoT-based padlock system using sensors is a smart security mechanism that combines sensors, a microcontroller, a motor driver, and a DC motor to provide automated and remotely controlled locking. The system continuously monitors environmental conditions using sensors such as IR sensors for tampering, force sensors for physical pressure, fire sensors for heat or flames, and gas sensors for harmful gases.[10]

## 7.RESULT

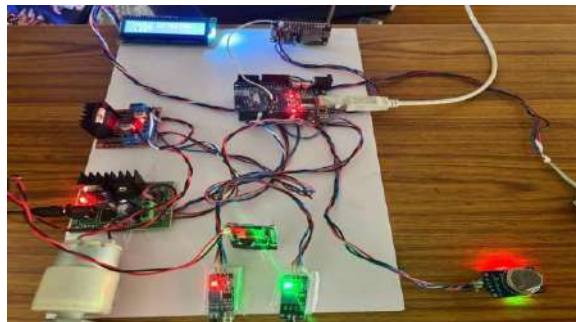


Fig 7.1 System Initialization

Setup: Cycle-tested the lock through various states (Locked, Scanning, Access Granted, and Fire Alert) and monitored the 16x2 LCD text.

Outcome: The I2C-connected LCD updated its display message in under 500ms for every state change. The Smart Padlock System begins with initialization, where the system is powered on, and the sensors for Force (FSR), Fire (Flame), Smoke (MQ-2), and IR proximity are initialized. Update the 16x2 I2C LCD with the current security status and environmental safety levels. Display any system alerts (e.g., "SCANNING FACE", "SMOKE DETECTED ALERT", or "ACCESS GRANTED").



Fig 7.2 LCD displaying Smoke Detection Alert.

The Smart Padlock System begins with initialization, where the system is powered on, and the sensors for Force (FSR), Fire (Flame), Smoke (MQ-2), and IR proximity are initialized. The system updates the 16x2 I2C



LCD with the current security status and environmental levels while establishing a cloud connection. It is designed to display critical system alerts such as "SMOKE DETECTED ALERT" (as seen in the hardware image), "SCANNING FACE," or "ACCESS GRANTED." [12]

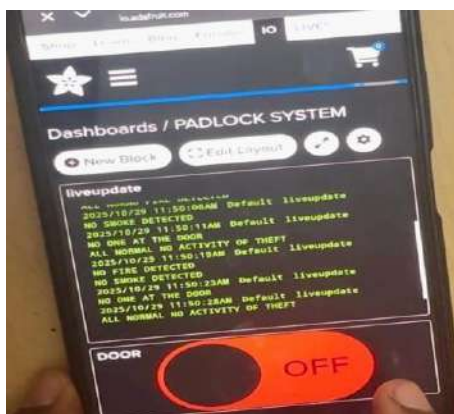


Fig 7.3 Alert and Door Controlling Through Website

## 8. DISCUSSION

The IoT-based padlock system using sensors represents a modern approach to security, integrating automation, real-time monitoring, and environmental hazard detection. Traditional padlocks rely solely on mechanical keys or combination locks, which can be easily tampered with or forgotten. In contrast, this smart padlock combines sensors, microcontrollers, and IoT technology to ensure both physical and digital security. Sensors such as IR sensors, force sensors, fire sensors, and gas sensors enhance the system's functionality by continuously monitoring unauthorized access attempts and environmental hazards. The NodeMCU ESP8266 microcontroller serves as the brain of the system, processing sensor data, validating user authentication, and controlling the DC motor through the L298N motor driver.[2]

## 9. FUTURE SCOPE

The future scope of the Smart Padlock System envisions a transition from a standalone security device to a fully autonomous and intelligent home entry solution. One of the primary areas for expansion involves the integration of advanced Artificial Intelligence and Machine Learning models directly on the edge. By upgrading the current facial recognition algorithms to more sophisticated deep learning frameworks, the system could achieve higher accuracy in low-light environments and develop "liveness detection" to prevent spoofing attempts using photos or videos. Furthermore, the integration of voice recognition and two-way audio communication would transform the lock into a comprehensive smart intercom, allowing owners to communicate with visitors in real-time.

## 10. CONCLUSION

The project titled "Padlock System using sensors and IoT" has successfully addressed a critical need in the domain of intelligent urban infrastructure—automated, responsive, and user-friendly appliance control using real-time environmental data. Throughout the course of the project, from research and planning in Phase I to the initial steps of implementation and validation in Phase II, significant progress was made. The research phase laid a solid theoretical foundation by identifying key problems in conventional appliance control systems, reviewing existing technologies, and outlining user requirements through surveys and studies. It ensured that the solution was grounded in both technical feasibility and societal relevance. The implementation phase, though still underway, has already demonstrated the practicality of the proposed solution. The integration of various sensors—such as gas, motion, and smoke detectors into a unified control system shows promise in enhancing safety, energy efficiency, and automation within urban homes and facilities [5].



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# Li-Fi Based Automatic Traffic Allocation for Emergency Vehicles

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**Abstract:** *With increasing urban traffic, emergency vehicles often experience delays at congested intersections, affecting response times and overall emergency efficiency. This paper proposes a Li-Fi (Light Fidelity) [1] based automatic traffic allocation system that prioritizes emergency vehicles [6] using visible light communication. Instead of traditional RF communication, the system uses optical wireless communication with LED transmitters and photodiode receivers to enable fast, interference-free data exchange between emergency vehicles and traffic controllers. When an emergency vehicle equipped with a Li-Fi transceiver nears an intersection, it sends a coded priority signal to the traffic light controller. The controller then adjusts the signal sequence, providing a green light for the emergency route while temporarily stopping other lanes. This allows safe, uninterrupted movement of emergency vehicles. Experimental results show that Li-Fi provides high data rates, strong reliability, and immunity to electromagnetic interference. Overall, the system supports intelligent transportation and advances smart city traffic management [8].*

**Key Words:** *Li-Fi, Urban traffic, Emergency vehicles, High speed data exchange, Public safety.*

## 1. INTRODUCTION

Traffic congestion has become a major issue in modern metropolitan cities due to the rapid increase in vehicles. This congestion not only causes delays and fuel wastage but also creates serious challenges for emergency response systems. Ambulances, fire trucks, and police vehicles often get stuck at crowded intersections, and even a few minutes of delay can lead to life-threatening consequences. Therefore, there is a strong need for a smart traffic management system that can quickly detect and prioritize emergency vehicles. Conventional traffic control methods depend on fixed-time signals or manual operation, making them ineffective in dynamic traffic conditions. RF-based technologies like RFID and GPS have been used for automation [4], but they face problems such as interference, limited bandwidth, security risks, and dependence on network coverage—especially in densely populated areas. Li-Fi (Light Fidelity) offers a promising alternative. Using LEDs and photodiodes, Li-Fi transmits data through visible light, providing high speed, low latency, strong security, and no electromagnetic interference.

## 2. LITERATURE REVIEW

In [1], Abhishek Patni, Bhavini Mishra, Harsh Aditya, Yogesh Kumar and Rohit Sharma et al.- **Highway Navigation using Light Fidelity (Li-Fi) technology**, The authors describe how visible light from street lamps, traffic signals and indoor LEDs can act as high-speed wireless transmitters for communication between devices. Li-Fi, an advancement over Wi-Fi, provides a fully networked, bidirectional wireless system using LEDs and offers a spectrum more than 10,000 times larger than traditional RF communication. The paper



also highlights challenges related to network capacity, efficiency, availability and security. Additionally, the authors examine Li-Fi's role in highway navigation systems, its vulnerabilities, and future applications, while addressing limitations of Wi-Fi and proposing Li-Fi-based solutions for communication issues.

**In [2].** V. K. G. Kalaiselvi, A. Sangavi and Dhivya et al.- **Li-Fi-based wireless communication system implemented using LED bulbs for high-speed and reliable data transfer** by The authors propose integrating Li-Fi into traffic-light systems to enable communication between emergency vehicles and signal controllers. In this method, LED siren lights on emergency vehicles act as Li-Fi transmitters, sending data to receivers on traffic lights for automatic signal switching. This ensures continuous movement for priority vehicles. The paper highlights that, compared to GSM, RFID, IR or ZigBee systems, Li-Fi provides secure, interference-free and high-bandwidth communication, making it an efficient, scalable and robust solution for intelligent traffic management and enhanced emergency- vehicle response.

**In [3].** V. K. G. kalaiselvi, A. Sangavi and Dhivya et al.-**Li-Fi communication into traffic lights for real-time control and emergency vehicle prioritization.** Li-Fi transmitters on emergency vehicles send signals to receivers on traffic lights, triggering an automatic green light when the vehicle approaches. The authors highlight Li-Fi's advantages over RF technologies, including high data rate, low latency, electromagnetic immunity and enhanced security. Using existing LED infrastructure, the system offers a cost-effective, reliable and scalable solution for smart traffic control and improved emergency response.

### 3. OBJECTIVES

1. To develop a Li-Fi based communication system that enables high-speed, secure, and interference-free data transfer between traffic signals and vehicle -to-vehicle [9].
2. To prioritize emergency vehicles such as ambulances, fire trucks, and police vehicles by enabling automatic signal switching using Li-Fi communication.
3. To reduce traffic congestion at intersections by implementing an intelligent, real-time traffic control mechanism based on vehicle density and emergency requirements.
4. To design a prototype model demonstrating how Li-Fi transmitters on emergency vehicles communicate with Li-Fi receivers on traffic lights for instant green signals.

### 4. METHODOLOGY

The system represents a wireless-controlled ambulance designed for remote operation and communication to enable smooth motorized movement. The controller functions as the central unit, coordinating actions through Bluetooth for short-range control and Li-Fi for high-speed optical communication. It interfaces with the motor driver, which controls four motors responsible for vehicle movement. Bluetooth enables smartphone-based control, while Li-Fi supports communication with traffic signals.

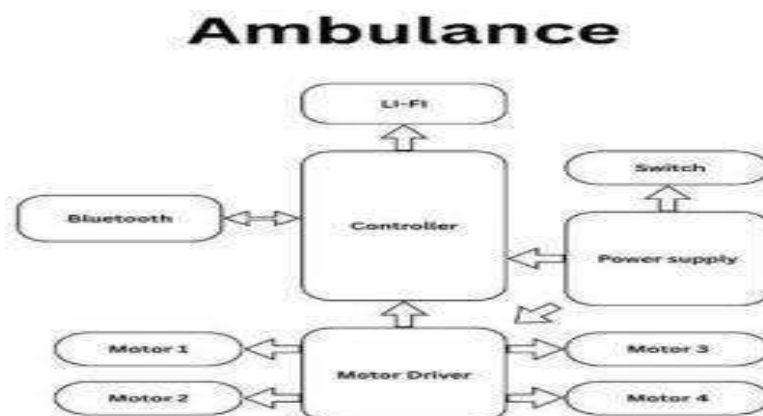


Fig: 1 Transmitter model



The system is a smart Li-Fi-based traffic control[3], solution that detects emergency vehicles and automatically clears their path. The ambulance unit uses a controller linked to Bluetooth for remote control, a Li-Fi transmitter to send optical emergency signals, a motor driver operating four motors, and a power supply for system operation. The traffic unit includes a photo transistor that receives Li-Fi signals and sends them to the controller, which then switches traffic modules to green for the ambulance and red for other lanes.

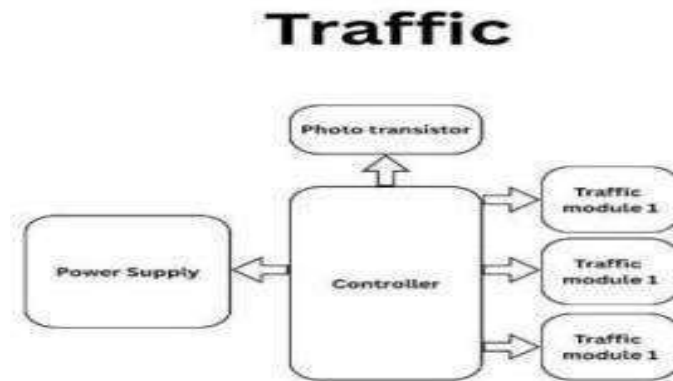
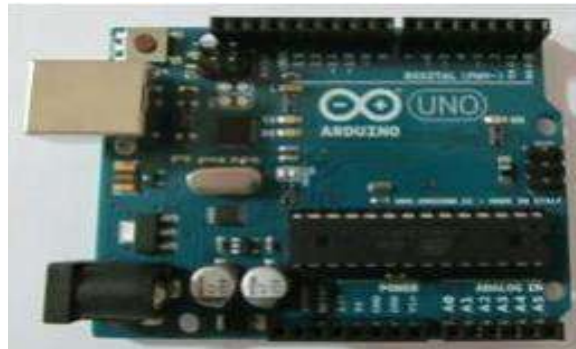


Fig: .2 Receiver model

Powered continuously, the system enables real-time communication, faster emergency response, and efficient traffic management using secure, interference-free Li-Fi technology.

## 5. HARWARE REQUIREMENTS

### 1. ARDUINO UNO



The Arduino Uno is one of the most popular microcontroller boards in the Arduino ecosystem. It is widely used for electronics projects, prototyping, and educational purposes due to its simplicity, affordability, and vast community support. It is designed for beginners and professionals alike, it serves as a versatile platform for building electronic projects

### 2. DC MOTOR



A DC motor (Direct Current motor) is an electrical machine that converts electrical energy (from DC power) into mechanical energy (rotation or motion). It's one of the most commonly used motors in robotics, vehicles, and automation systems. It operates on the principle that a current-carrying conductor placed in a magnetic field experiences a force.

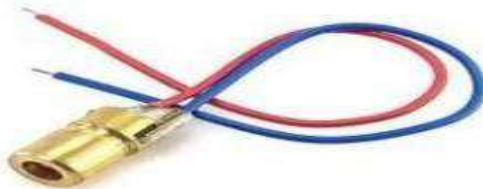


### 3. MOTOR DRIVER



A motor driver is an electronic circuit or module that acts as a bridge between a microcontroller (like Arduino) and a motor. Microcontrollers cannot supply enough current or voltage to drive a motor directly, so the motor driver takes low-power control signals from the Arduino and provides high-power output to run the motor safely. The motor driver used here is L298N, It typically uses an H-bridge circuit to allow the motor to rotate in both directions.

### 4. LASER LIGHT



A laser light is a special type of light that is very narrow, powerful, and focused unlike normal light which spreads out in all directions. A laser light is a highly focused and coherent beam of light that is produced through a process called stimulated emission of radiation. Unlike ordinary light, which spreads out and consists of multiple wavelengths, laser light is monochromatic (single wavelength), coherent (all light waves are in phase), and directional (emitted as a narrow beam).

### 5. WHEEL



A wheel is a circular mechanical component that rotates around an axle and is used to move or transport objects easily by reducing friction between the surface and the object. It is one of the most important inventions in human history and in modern systems (like robots or vehicles), wheels help convert rotational motion from a motor into linear motion (movement across the ground).

### 6. PHOTO TRANSISTOR



A phototransistor is a light-sensitive electronic component that works like a normal transistor but is controlled by light instead of electrical current. It detects light and converts it into an electrical signal making it very useful in sensors, light detectors, and communication systems like Li-Fi or automatic streetlights.



## 7. POWER SUPPLY

Active Mode: .When light falls on the phototransistor, it operates in its active region and outputs a proportional signal. This is common in analog light sensors.

Main energy source for the entire system (ambulance + traffic module). Typically a battery or DC adapter (e.g., 9V, 12V).

Voltage regulator may be used to stabilize the voltage output.

## 8. CAR CHASSIS



A car chassis is the main structural frame of a vehicle it is the skeleton or backbone that supports all the other parts like the body, engine, wheels, suspension, and electrical systems.

The working of the car chassis involves supporting and integrating all the components in a balanced way so that the motor-driven wheels can move the system efficiently.

## 9. PHOTO DIODE



A photodiode is a light-sensitive semiconductor device that converts light energy into electrical current. It is used to detect light intensity or convert optical signals into electrical signals, just like an electronic “eye.”

A photodiode is a semiconductor device that converts light into electrical current. It operates mainly in reverse bias, where a small voltage is applied in such a way that under normal conditions, little to no current flows.

## 10. TRAFFIC SIGNALS



A traffic signal (also called a traffic light) is an electronic signaling device used to control the movement of vehicles and pedestrians at road intersections, crossings, and junctions. It helps maintain safe and orderly flow of traffic by indicating when to stop, go, or wait using colored lights.

Traffic signals are electronic signaling devices positioned at road intersections, pedestrian crossings, and other locations to control the flow of traffic.

## 11. SWITCH





A switch is an electrical device used to open or close a circuit, allowing you to start or stop the flow of electric current. It works just like a gate — when the gate (switch) is closed, electricity flows; when it's open, the flow stops. In a project, a switch is commonly used as an input device to control or trigger specific actions within a circuit or system.

## 6. SOFTWARE REQUIREMENTS

### 1. Arduino IDE



Arduino IDE (Integrated Development Environment) is a free and open-source software used to write, compile, and upload code to Arduino microcontroller boards. It provides a user-friendly interface that makes it accessible for beginners while remaining powerful enough for advanced users.

The IDE supports a simplified version of C/C++ and includes a wide range of built-in libraries that help users easily interface with sensors, actuators, and communication modules. When used with the Arduino UNO board, the IDE allows seamless programming and debugging through a USB connection, enabling quick development and testing of embedded applications.

## 7. WORKING PRINCIPLE

The proposed Li-Fi based automatic traffic allocation system utilizes Visible Light Communication (VLC) technology to efficiently prioritize emergency vehicles at traffic intersections, thereby reducing response time and improving road safety. In this system, a Li-Fi transmitter composed of a high-intensity modulated LED is installed on emergency vehicles such as ambulances, fire trucks, and police vehicles. This transmitter continuously emits encoded light signals that carry information regarding the vehicle's identity and emergency status. At each traffic junction, a Li-Fi receiver, typically a sensitive photodiode, is mounted to detect the incoming optical signals from approaching emergency vehicles. When the emergency vehicle comes within range, the receiver captures the transmitted signal and forwards it to a microcontroller unit (MCU), such as Arduino or ESP32, for processing and decoding.

## 8. RESULT

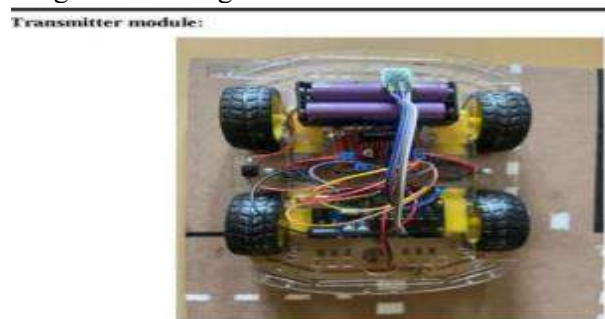


Fig: 8.1 Transmitter module

### 8.1 TRANSMITTER MODULE

The developed prototype successfully demonstrates the practical implementation of a Li-Fi-based automatic traffic allocation system for emergency vehicles [5]. As shown in the transmitter module image, the system is integrated onto a mobile robotic platform equipped with a microcontroller, motor driver, power supply, and



communication circuitry. The hardware assembly operated reliably, with stable power distribution and coordinated motor control, confirming the robustness of the mechanical and electrical design. During testing, the Li-Fi transmitter mounted on the vehicle effectively transmitted encoded light signals representing emergency status. These signals were accurately detected by the corresponding receiver module at the traffic control unit, enabling timely identification of the emergency vehicle.

## 8.2 RECEIVER MODULE

The receiver module successfully demonstrates the effective operation of the Li-Fi-based automatic traffic control system at a simulated road intersection. As shown in the setup, the traffic junction [7] is modeled with multiple signal poles, each integrated with a Li-Fi receiver, control circuitry, and LED-based traffic lights. The receiver unit accurately detected the modulated light signals transmitted from the emergency vehicle, confirming reliable visible light communication under line-of-sight conditions.

Receiver module:



Fig: 8.2 Receiver module

During operation, when the Li-Fi signal corresponding to an approaching emergency vehicle was received, the microcontroller processed the data in real time and dynamically adjusted the traffic signal sequence. The signal facing the emergency vehicle was switched to green, while all other directions were automatically set to red, ensuring a clear and uninterrupted path through the intersection. This prioritization occurred with minimal delay, demonstrating fast response and effective synchronization between the transmitter and receiver modules.

## 8.3 FINAL OUTPUT

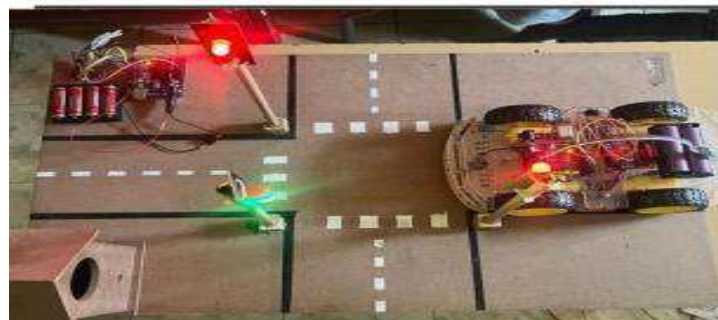


Fig:8.3 Final output

The final output of the Li-Fi-based Automatic Traffic Allocation System clearly demonstrates the successful integration and coordination between the transmitter (emergency vehicle) and receiver (traffic junction) modules. As shown in the image, when the emergency vehicle approaches the intersection, the Li-Fi transmitter mounted on the vehicle sends modulated light signals carrying priority information. These signals are accurately received by the Li-Fi receiver installed at the traffic signal controller unit. Upon detection of the emergency signal, the system instantly overrides the normal traffic signal sequence. The traffic light facing the emergency vehicle turns green, while the remaining directions are automatically switched to red, ensuring a clear and uninterrupted path through the junction.

## 9. DISCUSSION

The Li-Fi-based automatic traffic allocation system demonstrates the potential of visible light communication for reliable and secure smart traffic control. The project showed that Li-Fi effectively transmits emergency



priority signals when a clear line of sight exists, making it suitable for short-range, high-speed communication at intersections. Although performance may be influenced by ambient light, obstructions, and alignment issues, its benefits—such as low latency, resistance to RF interference, and easy integration—make it a strong complementary technology to traditional RF systems. With proper calibration and environmental optimization, Li-Fi can greatly enhance emergency vehicle prioritization in future smart city applications[11].

## 10. FUTURE SCOPE

In future, the proposed Li-Fi based automatic traffic allocation system can be extended by integrating artificial intelligence and machine learning techniques to enable predictive traffic analysis and adaptive signal optimization. By processing real-time and historical traffic data, the system can proactively manage congestion while maintaining priority for emergency vehicles. The system can be further enhanced to support vehicle-to-infrastructure (V2I) communication, enabling continuous interaction between emergency vehicles and multiple downstream traffic signals. This facilitates the establishment of a coordinated green corridor across successive intersections, thereby significantly reducing emergency response time.

## 11. CONCLUSION

The Li-Fi Based Automatic Traffic Allocation System for Emergency Vehicles is an innovative solution designed to ensure the rapid and safe movement of emergency vehicles through traffic intersections. The system employs Li-Fi (Light Fidelity) technology [2], which utilizes Visible Light Communication (VLC) for high-speed, interference-free data transmission. Each emergency vehicle is equipped with a Li-Fi transmitter that emits modulated light signals carrying its identity and emergency status. It also supports IoT integration for centralized monitoring, making it a vital component of smart city infrastructure that enhances emergency response and public safety, while improving scalability, system reliability, and adaptability to real-time traffic conditions in urban environments. In future we can develop an AI based guiding system [12].

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# Smart Surveillance Robot Vehicle Using IoT

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**Abstract**— This paper presents the design, development, and implementation of a Smart Surveillance Robot Vehicle utilizing Internet of Things (IoT) technology for remote monitoring, intelligent navigation, and real-time data acquisition. The proposed system integrates dual ESP32 microcontrollers—one serving as the primary control unit and the other as an ESP32-CAM module—to achieve distributed control of mobility, sensing, and live video streaming. The main ESP32 is responsible for motor actuation, sensor interfacing, and decision-making, while the ESP32-CAM handles high-quality video transmission over Wi-Fi. The robot is equipped with ultrasonic and infrared sensors for precise obstacle detection and avoidance, ensuring safe autonomous navigation in complex environments. A GPS module provides accurate geolocation tracking, and the system communicates with the Telegram Bot API to enable real-time IoT based monitoring and control through mobile devices. The modular and energy-efficient design enhances portability, scalability, and reliability, allowing integration with cloud services or AI-based analytics for intelligent decision-making. Extensive experimental validation demonstrates stable wireless communication, smooth video streaming, and robust obstacle detection, confirming the system's potential for applications in surveillance, defense, disaster management, industrial inspection, and smart city monitoring. This work contributes to the advancement of low-cost, autonomous, and networked robotic systems that bridge embedded control with next generation IoT infrastructure.

**Keywords:** ESP32, IoT, Smart Surveillance, Autonomous Robot, Wireless Communication, GPS Tracking, Real-Time Monitoring.

## 1. INTRODUCTION

Today's rapidly evolving technological landscape, the integration of robotics and the Internet of Things (IoT) has revolutionized the field of automation, surveillance, and intelligent monitoring systems. Traditional closed-circuit television (CCTV) networks, though effective in static environments, suffer from limited coverage, lack of mobility, and dependence on wired infrastructure. These systems are often incapable of responding dynamically to unexpected scenarios such as moving threats, restricted zones, or environmental hazards. As security requirements continue to increase in smart cities, industrial facilities, and defense sectors, there is a growing demand for mobile surveillance systems that can operate autonomously, adapt to diverse terrains, and communicate seamlessly with users over long distances.

To address these limitations, this project introduces a Smart Surveillance Robot Vehicle based on IoT technology that combines mobility, intelligence, and wireless communication into a single integrated platform [16]. The proposed system is designed to perform autonomous navigation, real-time video streaming, GPS-based tracking, and obstacle detection, enabling effective remote surveillance with minimal human intervention. The robot utilizes the ESP32 microcontroller as its central processing unit for real-time control, while a secondary ESP32-CAM module provides continuous video monitoring through Wi-Fi based streaming.

The control ESP32 processes sensor inputs from ultrasonic and infrared (IR) modules to detect and avoid obstacles dynamically, ensuring safe and reliable movement in both indoor and outdoor environments. A



motor driver module enables precise motion control, and the GPS module provides accurate geolocation information, allowing operators to monitor the robot's position remotely [17]. The system integrates the Telegram Bot API as a communication interface, allowing users to issue commands, receive location updates, and access live video feeds via a secure IoT-based messaging platform [18]. This approach eliminates the need for dedicated control applications and leverages widely available cloud messaging systems for enhanced accessibility.

By employing a distributed dual-microcontroller architecture, the system achieves efficient load distribution between control and streaming operations, reducing latency and improving performance. The use of low-cost, low-power components such as the ESP32 makes the system not only energy efficient but also highly scalable for larger surveillance networks. Furthermore, the proposed design emphasizes portability, modularity, and expandability, supporting future upgrades such as artificial intelligence (AI) for object detection, night vision capabilities, and environmental sensing.

This research aims to contribute to the development of affordable and intelligent surveillance solutions that can serve in a variety of applications including border monitoring, military reconnaissance, industrial automation, disaster management, and smart infrastructure surveillance [19]. By merging IoT, embedded systems, and robotics, the Smart Surveillance Robot Vehicle provides a step toward next generation autonomous security systems that are efficient, adaptive, and accessible.

## 2. LITERATURE SURVEY

The literature reveals a global trend toward the integration of IoT and robotics to create intelligent, autonomous surveillance systems. Various researchers have contributed to this evolving domain through innovations in sensing, communication, and control mechanisms.

Hrishikesh Deshpande *et al.*[1] developed a surveillance robot using the ESP32-CAM microcontroller for wireless video streaming and remote operation. Their system emphasized compact design, cost-effectiveness, and stable real-time performance suitable for domestic and small-scale monitoring applications.

Abhishek Meshram *et al.*[2] proposed an IoT-based wireless surveillance robot capable of real-time video transmission and navigation control using integrated Wi-Fi. Their implementation focused on enhancing signal stability, command responsiveness, and mobility for security and espionage applications.

Avantika S. Bhosale *et al.*[3] designed an IoT-enabled military surveillance robot equipped with ultrasonic sensors for obstacle detection and a night-vision camera for low-light operation. Their prototype demonstrated improved detection range and adaptability for defense and border monitoring tasks.

Vedant G. Ibitwar *et al.*[4] presented a car-bot model using the ESP32-CAM for live video streaming and wireless control. The study highlighted modular system design, energy efficiency, and ease of integration with mobile devices through web-based interfaces.

H. Kabir *et al.*[5] introduced the concept of the Internet of Robotic Things (IoRT), which combines robotic systems with IoT-based communication for collaborative and distributed surveillance tasks. Their research demonstrated scalable architectures that support remote data sharing, cloud analytics, and edge processing.

Y. Liu and B. Zeng *et al.*[6] applied deep reinforcement learning to autonomous robotic systems for optimized path planning and target tracking. Their work showed how AI algorithms can enhance real-time decision-making, reducing navigation errors and response time.

S. Kumar *et al.*[7] proposed an IoT-based automation system for robotic surveillance using the MQTT protocol for cloud data exchange. Their system demonstrated efficient message transfer, low latency, and scalable communication between multiple surveillance units.

A. Banerjee *et al.*[8] developed an AI-driven surveillance robot capable of performing facial recognition and motion detection using TensorFlow Lite on embedded ESP32 hardware. Their design improved the accuracy of target recognition and reduced dependency on cloud processing, supporting edge AI implementations.

P. Singh *et al.*[9] designed a GPS- and GSM-based patrol robot for restricted-area monitoring and geofencing applications. Their study demonstrated how real-time position tracking and emergency alerts can improve safety in industrial and defense operations.

M. Al-Khatib *et al.*[10] explored hybrid LoRa–Wi-Fi- based communication architectures for remote surveillance systems. The research showed that combining long-range LoRa with local Wi-Fi connectivity



enhances data reliability and reduces energy consumption, which is ideal for outdoor monitoring robots.

K. Rajasekar and M. Dinesh *et al.*[11] proposed an IoT enabled multi-sensor robot for disaster management equipped with fire, gas, and temperature sensors. Their work demonstrated how integrated sensor fusion can aid in realtime hazard detection and decision-making during emergencies.

A. S. Mehta and D. Kumar *et al.*[12] integrated machine learning algorithms into IoT-enabled robots for object tracking and movement prediction. Their model achieved improved precision in dynamic target detection through the fusion of sensor and vision data.

In summary, prior research highlights the potential of combining IoT, AI, and embedded microcontrollers like ESP32 to achieve intelligent and autonomous surveillance systems. These studies collectively emphasize scalability, cost efficiency, and reliability—key objectives that form the foundation of the proposed Smart Surveillance Robot Vehicle.

### 3. METHODOLOGY

The Smart Surveillance Robot Vehicle employs a dual microcontroller architecture. The main ESP32 manages sensors, motors, and communication, while the ESP32-CAM handles live video streaming. The vehicle navigates autonomously using obstacle detection data from ultrasonic and infrared sensors, while GPS provides positional awareness.

Telegram acts as the IoT interface for two-way communication between user and robot. The robot operates through four major subsystems:

- 1) Sensing: Ultrasonic and IR sensors detect obstacles at varying ranges.
- 2) Processing: The ESP32 microcontroller processes data and executes control logic.
- 3) Actuation: A motor driver and DC gear motors handle movement.
- 4) Communication: Wi-Fi and Telegram API provide remote monitoring and control.

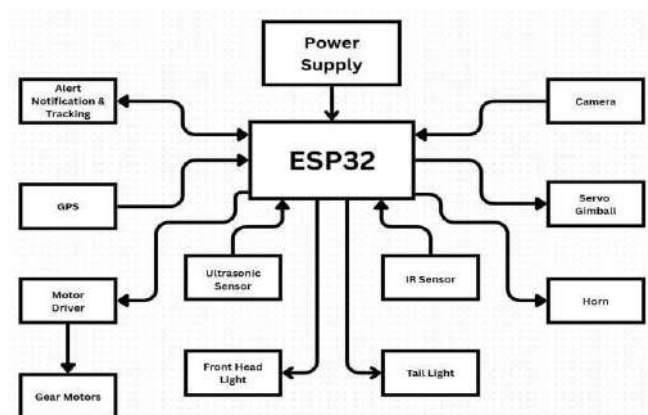


Fig. 1. Block Diagram of Smart Surveillance Robot Vehicle

The ESP32's dual-core architecture enables parallel processing, ensuring uninterrupted data transmission and smooth operation.

### 4. HARDWARE COMPONENTS

#### A. ESP32 Microcontroller



Fig. 2. ESP32 Microcontroller Module



The ESP32 serves as the main control hub, managing all sensors, motors, and IoT communication tasks. Its integrated Wi-Fi and Bluetooth capabilities make it ideal for IoT-based systems.

### **B. Motor Driver and DC Gear Motors**

The L298N/L293D motor driver converts low-power control signals into high-power outputs to drive four DC gear motors, enabling forward, reverse, and turning actions.

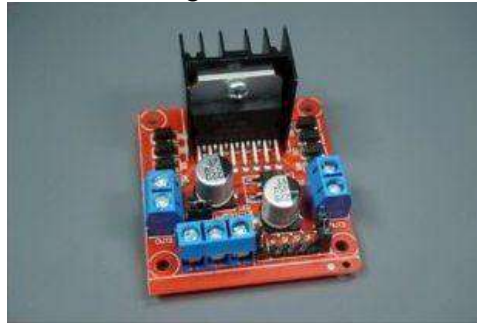


Fig. 3. Motor Driver and DC Gear Motors

### **C. Sensors and GPS Module**

The ultrasonic sensor detects long-range obstacles, while the IR sensor provides short-range precision. The NEO-6M GPS module supplies real-time location tracking for IoT updates.



Fig. 4. Ultrasonic Sensor



Fig. 5. IR Sensor

### **D. Camera and Servo System**



Fig. 6. ESP32-CAM and Servo Mechanism



The ESP32-CAM module streams live video and is mounted on a servo motor for dynamic panning and tilting.

### E. Power Supply

A lithium-ion battery with a DC buck converter ensures stable power to all modules.

## 5. SOFTWARE IMPLEMENTATION

The robot's firmware is developed in Arduino IDE using Embedded C. Libraries for Wi-Fi, GPS (TinyGPS++), Servo control, and Telegram Bot API enable full functionality. The ESP32 handles autonomous navigation, live video streaming, and communication concurrently. Telegram provides an intuitive interface for remote control and alerts, allowing users to issue commands and receive GPS coordinates instantly.

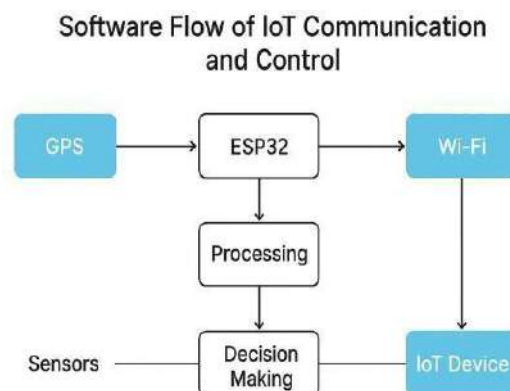


Fig. 7. Software Flow of IoT Communication and Control

## 6. RESULTS AND DISCUSSION

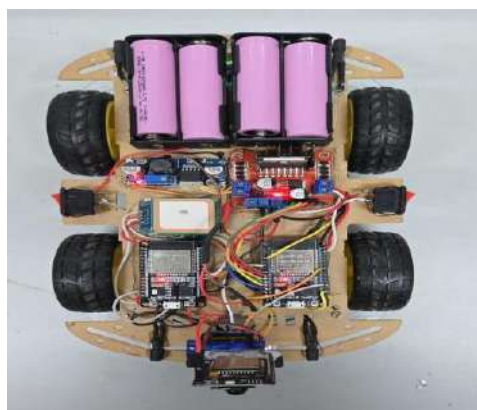


Fig. 8. Project Working Model

The prototype was tested for real-time surveillance, obstacle avoidance, and IoT communication:

- Dual ESP32 Performance: Parallel task execution ensured stable operation between navigation and video streaming.
- Video Streaming: ESP32-CAM achieved smooth, low latency live video over Wi-Fi.



Fig. 9. Web interface of an ESP32-CAM



- IoT Alerts: Telegram successfully delivered event-driven messages (e.g., obstacle detection, GPS updates).
- Autonomous Navigation: Ultrasonic and IR sensors enabled accurate obstacle detection and avoidance.
- Power Stability: The buck converter provided consistent voltage across all components.
- Applications: Suitable for home, industrial, and hazardous area surveillance.

Overall, the system proved reliable, responsive, and efficient in both manual and autonomous modes, validating the design as a practical IoT surveillance solution.



Fig. 10. Telegram bot interface for your Smart Surveillance

## 7. CONCLUSION

This project successfully demonstrates the design and implementation of a Smart Surveillance Robot Vehicle using Internet of Things (IoT) technology and dual ESP32 microcontrollers. The proposed system effectively integrates autonomous navigation, real-time video monitoring, and long range wireless communication within a modular and low-cost architecture. By combining the capabilities of the ESP32 and ESP32-CAM, the robot achieves distributed processing for control, sensing, and live video transmission, ensuring robust and efficient performance even in dynamic environments.

The results obtained from hardware testing and field implementation confirm the system's ability to perform real time obstacle detection, stable video streaming, and accurate GPS tracking with minimal latency. The use of Wi-Fi-based communication and Telegram Bot integration provides a reliable IoT framework for user interaction and data access from remote locations. Furthermore, the system's scalability allows it to be customized for various operational domains such as defense monitoring, industrial inspection, environmental surveillance, and smart city applications.

The modular design of this platform also enables future enhancements such as AI-driven image processing for object detection and facial recognition, cloud-based data storage for event logging, and autonomous path planning using machine learning algorithms. The incorporation of solar power modules or low-power communication protocols such as LoRa and ZigBee could further improve energy efficiency and range. Additionally, the development of a multi-robot cooperative network could extend surveillance coverage through swarm robotics, enabling distributed intelligence and coordinated movement among multiple units.

In conclusion, the proposed Smart Surveillance Robot Vehicle represents a significant step toward next-generation autonomous security systems. It offers an efficient, portable, and intelligent solution for real-time surveillance challenges in both civilian and industrial domains. The system's combination of affordability, scalability, and technological adaptability positions it as a practical and sustainable innovation in the evolving field of IoT-based robotics.



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# Carotid Artery Plaque Detection with 3D Visualization using Image Processing

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**ABSTRACT:** Carotid artery atherosclerosis is a major risk factor for ischemic stroke, making accurate plaque assessment clinically important. Ultrasound imaging is widely used for carotid examination due to its non-invasive and low-cost nature; however, plaque identification remains challenging because of speckle noise, low contrast, and operator dependency. This paper presents an automated framework for carotid plaque segmentation using a U-Net-based deep learning model combined with image preprocessing and post-processing techniques. Ultrasound images are enhanced to suppress noise and improve contrast prior to segmentation. The resulting plaque masks are refined and stacked across sequential slices to generate an approximate three-dimensional visualization using the Marching Cubes algorithm. Experimental evaluation on annotated ultrasound images demonstrates effective plaque localization, achieving Dice similarity coefficients of up to 0.92 in favorable cases. The proposed framework aims to support clinicians by providing consistent segmentation results and intuitive visual representations of plaque morphology, serving as a decision-support and visualization tool rather than a standalone diagnostic system.

**Keywords:** carotid artery, plaque segmentation, ultrasound imaging, U-Net, 3D visualization.

## 1. INTRODUCTION

Stroke is a leading cause of mortality and long-term disability worldwide, with carotid artery atherosclerosis being a major contributing factor. The accumulation of plaque within the carotid artery can restrict cerebral blood flow or cause embolic events, significantly increasing the risk of ischemic stroke. Early and accurate identification of carotid plaque is therefore essential for effective risk assessment and timely clinical intervention. Carotid ultrasound imaging is widely used for plaque evaluation due to its non-invasive nature, low cost, and real-time imaging capability. However, plaque identification in ultrasound images remains challenging because of speckle noise, low contrast, and strong dependence on operator expertise. Manual assessment is often time-consuming and subject to inter-observer variability, motivating the need for automated and consistent plaque analysis methods. Recent advances in deep learning, particularly convolutional neural networks such as U-Net, have demonstrated strong performance in medical image segmentation by enabling reliable extraction of anatomical structures from noisy ultrasound data. Nevertheless, most existing approaches focus on two-dimensional slice-wise segmentation, which provides limited information about plaque morphology and spatial continuity. Since carotid plaque is inherently a three-dimensional structure, volumetric representation is clinically relevant. In this work, an automated framework for carotid plaque segmentation from ultrasound images is proposed using a U-Net-based deep learning model, followed by post-processing and approximate three-dimensional visualization. The proposed approach aims to provide consistent plaque localization and improved visual interpretation, supporting clinicians in plaque assessment as a decision-support and visualization tool.



## **2. LITERATURE REVIEW**

### **2.1 Traditional Image Processing Techniques**

Early approaches to carotid plaque detection relied on conventional image processing methods such as thresholding, edge detection, region growing, and active contour models. These techniques identified plaque boundaries using intensity and shape information but were highly sensitive to speckle noise, low contrast, and parameter selection inherent to ultrasound imaging. Consequently, segmentation results were often inconsistent and unreliable.

### **2.2 Machine Learning with Handcrafted Features**

To improve robustness, machine learning methods combined handcrafted texture and shape features with classifiers such as support vector machines and random forests. While these approaches reduced operator dependency and improved automation, their performance depended strongly on feature design and dataset quality. Limited generalization across different ultrasound systems and imaging conditions remained a major drawback.

### **2.3 Deep Learning for Ultrasound Segmentation**

Deep learning, particularly convolutional neural networks such as U-Net, has significantly advanced ultrasound image segmentation. The encoder–decoder architecture with skip connections enables accurate localization of anatomical structures while preserving spatial details. These models learn hierarchical features directly from data, improving robustness to noise and contrast variations.

### **2.4 Deep Learning for Carotid Plaque Analysis**

Recent studies applying CNN-based models to carotid ultrasound images have reported improved segmentation accuracy compared to traditional and machine learning approaches. However, most methods rely on two-dimensional slice-wise analysis, treating each image independently and limiting representation of plaque morphology and spatial continuity.

### **2.5 Three-Dimensional Visualization**

For sequential ultrasound data, the refined two-dimensional plaque masks are stacked to form a three-dimensional voxel volume. The Marching Cubes algorithm is applied to generate an approximate 3D surface representation of the plaque. This visualization facilitates intuitive observation of plaque distribution and morphological variation along the carotid artery, complementing two-dimensional analysis.

## **3. OBJECTIVES**

The objectives of this work are as follows:

- To develop an automated method for carotid plaque segmentation from ultrasound images using a U-Net–based deep learning model.
- To enhance ultrasound image quality through preprocessing techniques in order to improve segmentation accuracy.
- To generate approximate three-dimensional visualizations of carotid plaque by stacking segmented two-dimensional slices.
- To support consistent plaque assessment through objective segmentation results and intuitive visual representation.



## 4. METHODOLOGY

The proposed framework follows a structured pipeline for automated carotid plaque analysis from ultrasound images, comprising image preprocessing, deep learning–based segmentation, post- processing, and three-dimensional visualization. This pipeline is designed to handle ultrasound-specific artifacts while producing consistent and interpretable segmentation results.

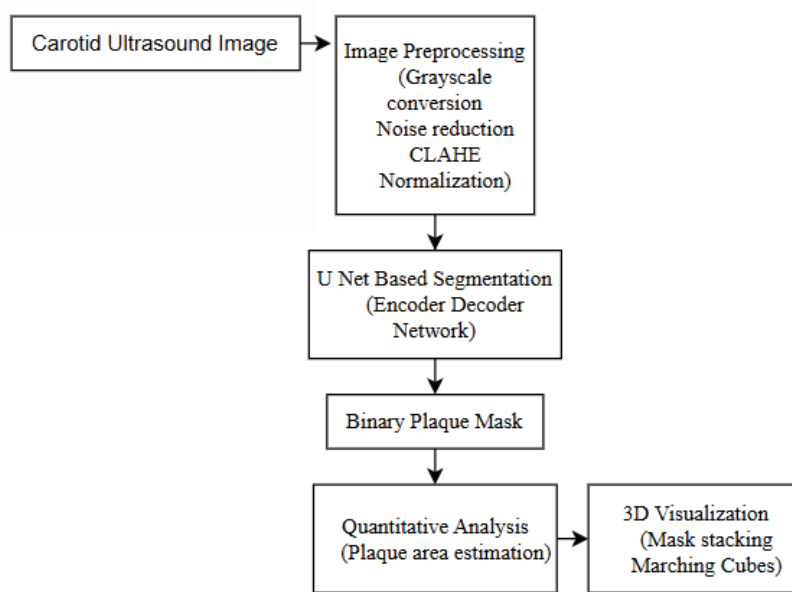


Fig. 1. Workflow of the proposed framework.

### 4.1 Image Preprocessing

Carotid ultrasound images are converted to grayscale and resized for uniform input. Speckle noise is reduced using Gaussian and median filtering, and Contrast-Limited Adaptive Histogram Equalization (CLAHE) is applied to enhance local contrast and improve plaque boundary visibility. The images are subsequently normalized to a fixed intensity range to ensure stable segmentation performance.

### 4.2 Plaque Segmentation Using U-Net

Plaque segmentation is performed using a U-Net–based convolutional neural network due to its effectiveness in medical image segmentation. The network employs an encoder–decoder architecture with skip connections to preserve spatial information and enable accurate plaque localization. The model produces pixel-wise probability maps, which are thresholded to generate binary plaque masks, allowing automated and consistent segmentation with minimal manual intervention.

### 4.3 Post-processing and Quantitative Analysis

The predicted segmentation masks are refined using morphological operations to remove isolated artifacts and smooth plaque boundaries. From the refined masks, approximate plaque area is computed on a per-slice basis to provide relative estimates of plaque burden and support objective comparison across images.

### 4.4 Three-Dimensional Visualization

For sequential ultrasound data, the refined two-dimensional plaque masks are stacked to form a three-dimensional voxel volume. The Marching Cubes algorithm is applied to generate an approximate 3D surface representation of the plaque. This visualization facilitates intuitive observation of plaque distribution and morphological variation along the carotid artery, complementing two-dimensional analysis.



## 5. RESULTS

### 5.1. Performance Overview

The proposed carotid plaque segmentation framework was evaluated on annotated carotid ultrasound images using standard overlap-based performance metrics. The U-Net-based model demonstrated reliable plaque localization despite challenges such as speckle noise and low contrast, achieving Dice similarity coefficients of up to **0.92** in favorable cases.

### 5.2. Qualitative Segmentation Results

Qualitative evaluation shows accurate delineation of plaque boundaries with minimal background inclusion after preprocessing and post-processing. Figure 1 presents representative segmentation results, highlighting improved plaque visibility due to noise reduction and contrast enhancement, particularly in images with weak boundary definition.

### 5.3. Quantitative Performance Analysis

From the refined segmentation masks, approximate plaque area was computed on a per-slice basis to provide relative estimates of plaque burden. These measurements support objective comparison across images and consistent evaluation of segmentation performance, with minor variations attributed to differences in image quality and plaque appearance inherent to ultrasound imaging.

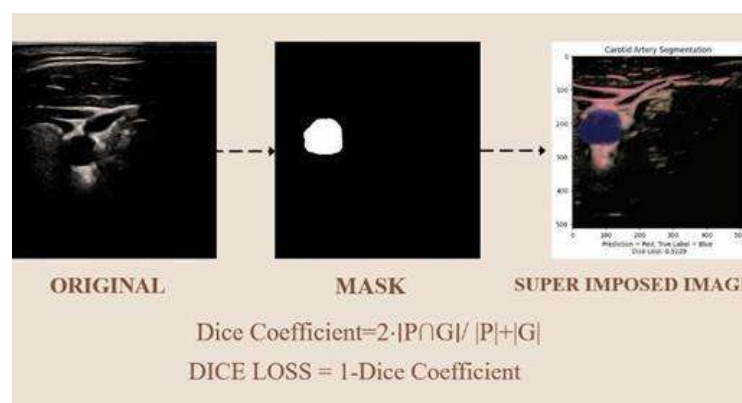


Fig. 2. Carotid plaque segmentation result showing the original ultrasound image, ground-truth mask, and the superimposed predicted plaque region.

## 6. RECOMMENDATIONS

- Future work can focus on training the segmentation model using larger and more diverse carotid ultrasound datasets to improve robustness across varying imaging conditions.
- Integration of improved preprocessing techniques and adaptive thresholding may enhance plaque boundary detection in low-contrast or noisy ultrasound images.
- Extension of the current framework to incorporate quantitative volumetric plaque measurements could further support clinical assessment.

## 7. LIMITATIONS

- The segmentation performance is influenced by variations in ultrasound image quality, such as severe speckle noise and poorly defined plaque boundaries.
- The generated three-dimensional visualization is approximate and intended for interpretative support rather than precise volumetric or clinical measurement.
- Evaluation was performed on a limited set of annotated images, which may restrict generalization across different ultrasound devices and patient populations.



## 8. DISCUSSION

The experimental results indicate that the U-Net–based deep learning framework effectively supports carotid plaque segmentation from ultrasound images, demonstrating strong agreement with expert annotations as reflected by Dice scores. Observed performance variations are mainly attributable to differences in ultrasound image quality, plaque characteristics, and acoustic artifacts. The integration of approximate three-dimensional visualization through stacked segmentation masks enhances interpretability by allowing intuitive assessment of plaque distribution and morphology. Although these reconstructions are not intended for precise clinical measurement, they provide meaningful visual context that complements conventional two-dimensional segmentation results.

## 9. CONCLUSION

This paper presented an automated framework for carotid plaque segmentation and visualization from ultrasound images using a U-Net–based deep learning model. The approach demonstrated effective plaque localization despite common ultrasound challenges, achieving Dice similarity coefficients of up to 0.92 in favorable cases. The inclusion of approximate three-dimensional visualization improves interpretability by providing spatial insight into plaque morphology and distribution. Overall, the proposed system serves as a consistent decision-support and visualization tool rather than a standalone diagnostic solution, with future work aimed at improving robustness through larger and more diverse datasets.

## ACKNOWLEDGMENT

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# Smart Laboratory Management Hub

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**Abstract** - This project presents a Smart laboratory management hub using 12volts relay modules. Its operations involve manual on/off switching of devices, which is inefficient, not convenient, and energy-wasting. There is a need to go for smarter systems that enhance users' comfort, optimize energy. In Smart Laboratory Management Hub that helps in controlling laboratory devices such as lights automatically or deactivate through Bluetooth or IOT devices. It makes working in the laboratory easy, saves energy, and provides comfort. The wireless technology of devices is used for switching devices on and off. Components used include 12volts relay module, transmitter and receiver module, and arduino. Hence, anyone present in the laboratory can easily manage the devices while avoiding wastage of unnecessary power.

## 1. INTRODUCTION:

In recent years, A Smart Laboratory Management Hub, otherwise known as a Smart Lab Management System, is a digital platform or integrated system that computerizes the operations, resources, and processes within a laboratory environment. It integrates up-to-date technologies such as IoT, artificial intelligence, data analytics, cloud computing, and automation to increase efficiency, safety, and collaboration inside the lab.

Here's an overview of what generally comprises a Smart Laboratory Management Hub: Key Features of a Smart Laboratory Management Hub LIMS for sample tracking, data storage, and reporting. LIMS also helps laboratories with the tracking of Laboratory Information Management Systems (LIMS) and tests, managing the workflows of a laboratory in a far more automated and efficient manner. IoT Integration IoT sensors and devices can be installed in laboratories that monitor the environmental conditions of temperature, humidity, and pressure continuously. This information can be analyzed for optimality of conditions for experiments and can also trigger alerts when equipment malfunctions or irregularities are detected. Automated Workflow Management: It can automate routine tasks such as inventory management, sample processing, and test scheduling, greatly reducing human error and increasing the pace of operations in the lab. The smart hubs will further optimize these workflows by automatically allocating tasks based on the availability and capability of resources. Real-Time Data Analytics Real-time data analysis and visualization tools allow the laboratory manager or researcher to monitor ongoing experiments, track progress, and make data-driven decisions in real time. It could include predictive analytics, whereby experiment issues or resource issues may be anticipated well in advance of their actual occurrence.

**Safety and Compliance Monitoring** The smart system will be able to automate compliance with pertinent sets of safety regulations and standards, like OSHA or ISO certifications, through checklists in the lab it can monitor hazardous materials remotely and follow proper waste disposal practices.

**Collaboration Tools** Smart labs offer virtual collaboration platforms where researchers can share data and results in real-time with colleagues or external partners. This enhances collaboration across disciplines and speeds up the research and development process. Inventory and Resource Management monitors all



equipment, chemicals, and other supplies in the lab, performing automatic ordering for replacements when their levels fall below minimum threshold levels.



*Fig1: Smart Laboratory Light and Fan Automation System*

AI & Machine Learning for Predictive Maintenance AI can predict when equipment is likely to fail based on usage patterns and maintenance history to schedule preventive maintenance, avoiding downtimes. This is especially helpful in research environments where equipment failure leads to expensive delays. Access Control and Security Biometric access control and other surveillance systems ensure that only authorized personnel have access to selected areas or material for increased physical and data security. Cloud Integration and Data Sharing Cloud-based platforms allow for seamless integration of data across multiple devices at multiple locations. This enhances the ease with which labs can collaborate and share information with other institutions. It also ensures that data is properly backed up and easily accessible for analysis.

Benefits of a smart laboratory management hub: Processes, thus enabling labs to conduct more experiments or processes within a short period; Increased Efficiency Automation and real-time tracking reduce manual errors and time-consuming; Cost Savings Smart lab systems optimize resource utilization, reduce downtime, and minimize waste, hence helping to reduce operational costs.

Improved Accuracy Automation and real-time monitoring present results that are far more reliable, reducing human errors and increasing the consistency of research data.

## 1.1 MOTIVATION:

Modern laboratories deal increasingly with an array of equipment, resources, and experiments while keeping in mind the aspects related to safety, efficiency, and reliability. Nevertheless, in any typical academic communication lab, all processes are manually carried out without automation: switching the devices on/off, power consumption management, status monitoring of equipment, and following safety compliance. It enhances the chances of human errors, irrelevant energy consumption, and delay in conducting lab sessions.

Coupled with the phenomenal growth of IoT, cloud computing, and automation technologies, transforming conventional labs into intelligent and automated environments is in great need. Smart Laboratory Management Hub allows centralized systems to monitor, control, and manage laboratory equipment remotely. That not only improves productivity and safety but also reduces direct human interaction with high-voltage or sensitive equipment.

Lab automation of communication will give students hands-on experience with state-of-the-art technologies, facilitate learning-by-doing, and enhance research with repeatable and reliable experimental conditions. It can also help an institution reduce energy consumption, cutting maintenance costs through automatic scheduling, load management, and fault detection.

The motive, therefore, for developing this Smart Laboratory Management Hub is to bridge the gap in



traditional lab practices and the emerging automation technologies to facilitate a safer and efficient learning environment and contribute to smart academic infrastructure developments.

## **2. LITERATURE REVIEW:**

He proposed an IoT-based home Automation system with sensors that would monitor energy consumption usage and operate household gadgets. The technology utilized cloud connection to deliver consumers real-time household appliance control, significantly improving Energy Efficiency through Automated Load Management. The Research focused on appliance management, but did not defect detection or warning techniques. There by creating a deficiency in improving the overall home Safety[1].

He proposed a smart home security architecture. It combines IoT-based monitoring with fault detection . The system used several sensors to identify irregularities.in residential settings and informed users through push Notifications. Although proficient in detecting security risks, the system was lacking in an integrated energy .The tracking feature is important for reducing Energy waste in brilliant homes[2].

He implemented a real-time defect the detection and alarm system of electrical appliance using an IoT-based microcontroller platform. The system observed electric current and voltage to detect any faults. An alarm was sent as SMS via a GSM module upon detection. The system although offering an effective problem detection mechanism, lacked remote access and energy facilities. Management via a web interface, limiting its use monitoring[3].

He developed a GSM-based home automation system, focusing on remote control and fault detection. The system employed microcontroller interfacing to apply remote notifications via SMS when there is an electrical issues. This method was helpful to solve simple problems detection but lacked the scalability and variety of IoT-enabled devices for real-time web-based Monitoring and control an IoT-enabled smart home system the circuit design [4].

He proposed for remote access household equipment via cloud platform. They achieve this through enabled customers to operate appliances on mobile apps, emphasizing energy management. Despite the system's user-friendliness and its concentration on energy was devoid of any strong defect detection mechanism for real-time management of electrical abnormalities[5].

He developed a home automation system. System based on Raspberry Pi and IoT in remote surveillance and management. Their approach stressed Energy efficiency management includes allowing customers to monitor real-time use power through a mobile application. The study, however, did not include fault detection, so leaving houses prone to electrical abnormalities that may jeopardize safety[6].

## **3. OBJECTIVE:**

The main objective of the project is to develop an intelligent automation-based electrical management in the laboratory using IoT technology. This will largely improve safety and reliability by integrating various control functions into one; hence a minimal risk of electrical element handling is possible in the process. This intelligent control system provides an automated way of switching laboratory appliances on and off with ease through an approved command. Furthermore, it can also allow the construction of a modern and well-structured laboratory with sophisticated features for automation. The system will ensure energy conservation, as the devices will work when needed, rather than unnecessarily consuming power.

1. To integrate multiple control functions and improve the safety and reliability by reducing manual handling of electrical system.
2. To switch ON and OFF in the electrical appliances in the lab using IOT.
3. To promote modern labs through smart and organized automation.
4. To save energy by running devices only when needed.



#### 4. METHODOLOGY:

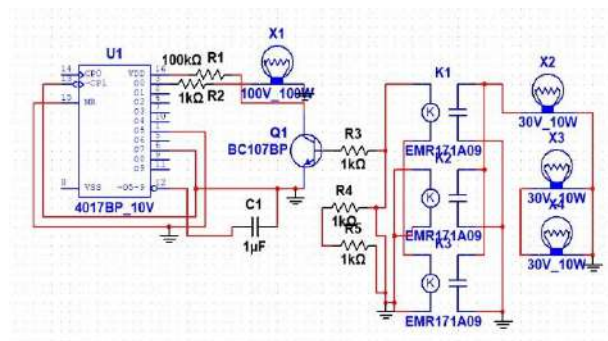


Figure 1 : Circuit Diagram

The following circuit provides a switching system using a relay-based triggering unit, a CMOS 4017BCD decade counter, and a BC107 transistor as an output driver stage. The system starts with the EDR201A relay system K1, which serves as the primary triggering device. When this relay is energized, a temporary pulse is generated and passed, via a 1 k  $\Omega$  resistor R1, to the clock input of the 4017 U2. The 100  $\mu$ F capacitor coupled to the clock pin serves as a de bouncing filter to deliver a single, clean pulse every relay switching and thus avoid false triggering resulting from mechanical bounce.

This pulse is fed to the 4017 decade counter (U2), which in turn activates its output terminals (Q0 to Q5) in a sequence. One of the output pins of the 4017, in this design, is coupled to a biasing network comprising a 100 k  $\Omega$  resistor (R2) feeding the base of the BC107 transistor (Q1). When the selected output pin goes high, it provides sufficient base current to drive the BC107 transistor into saturation. A 1 k  $\Omega$  emitter resistor (R3) is included for stabilizing the output and for limiting current through the transistor. When the transistor is switched ON, it drives the connected load or subsequent stage, thereby acting as an amplifier and a digital switch. This sequential switching approach facilitates controlled operation of a load with minimum manual intervention. This circuit depicts the conversion of a simple relay input to a digital stepwise output using the 4017 counter, while the transistor stage generates adequate current gain for the operation of external devices. The controlled methodology followed here is quite reliable and can be scaled up in automation pertaining to laboratory and industrial switching. The following circuit is a sequential switching and driving system designed using a relay-based pulse trigger, a 4017 decade counter, and a BC107 transistor as a driver. The operation initiates when the EDR201A relay K1 switches over to the other contact by an external control or switch. This switching is utilized for producing a trigger pulse, which is applied to the clock pin of the decade counter IC.

#### 5. RESULTS:

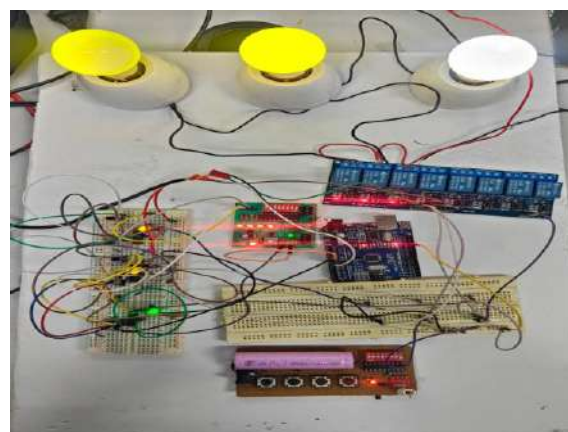


Fig: 5.1 Result



The prototype presented in the image is a hardware-based digital control system using an Arduino Uno microcontroller, interfaced to a breadboard circuit along with an external module. The Arduino provides both logical processing and communication capability, receiving commands through either serial or wireless input and generating digital output signals. The USB cable ensures power and programming interface continuity in order to stay connected with the PC or power source at all times. It constitutes the central processing unit of the system whereby it coordinates the signals and controls the flow of data between the different components. The green - colored circuit module visible in the setup seems to be either an encoder/decoder interface or a wireless communication module, which may be used for sending or receiving external control data.

Its LEDs denote active communications status and successful operation of the data link. This module is connected to the breadboard through multiple jumper wires that enable signal transmission to logic circuitry or output drivers placed on the breadboard. An antenna-type coil on the board denotes wireless operation, probably at RF frequency communication for remote switching or data transfer. The breadboard contains multiple IC components along with interconnected wiring, constituting the signal-processing and output-driving section of the circuit.

The lit LEDs on the breadboard denote that the circuit is successfully receiving and decoding the instructions from the Arduino or module and converting these instructions into visible binary output states. Each LED logically represents an output channel or function, showing that the internal logic-such as decoding, timing, or switching-is executing correctly.

The clean sequential illumination of different LEDs confirms that ICs and the wiring connections are correctly implemented. Overall, the working result shown visually verifies that the integrated system is operating as intended with real-time communication between the Arduino, the communication module, and the breadboard circuitry. The successful illumination of indicator LEDs and active status of Arduino confirms proper signal flow, stable power delivery, and correct software–hardware interaction, meaning thereby that the prototype is working reliably and hence suitable for applications such as Wireless switching, remote device control, or automation systems where microcontroller-based logics and external communication modules are required to work together in synchronization.

From an electrical perspective, the wiring layout demonstrates active interfacing between multiple subsystems, making the prototype suitable for modular testing. Further, since this utilizes a solder less breadboard, the connection can be rapidly re-arranged and debugging achieved easily, something crucial in early stages of development. Though the arrangement of wires is dense and visually intimidating, it inherently depicts a multi-signal routing environment wherein digital, and probably analog, signals coexist. The design and implementation of the Smart Laboratory Automation system using hardwired digital logic components and IC-based circuitry were very successful.

It automatically operates the laboratory fan and light by processing inputs from a PIR motion sensor, an LDR-based light sensing circuit, and a temperature-trigger comparator circuit. Using some very basic ICs, including op-amps for sensing, NAND/NOR logic gates for decision-making, and relay driver stages for load control, the system responded aptly to environmental changes. The light will switch ON only in low-light conditions and when there is motion. The fan will be activated if both motion and temperature are high. All the logic conditions were derived using combinational ICs, while the actuators were driven through transistor-driven relay modules. The final hardware worked quite reliably and demonstrated that intelligent automation is achievable purely through discrete ICs with no microcontroller in use, thus proving the efficiency of hardwired logic design for low-cost laboratory automation.

## **6 . CONCLUSION:**

The Smart Lab Automation System exemplifies how fundamental electronic hardware may be integrated to accomplish automation of basic laboratory functions. Using ICs, switches, sensors, and breadboard-based circuits, it successfully processes control signals and switches on/off various loads. A relay module interfaces



the low-voltage control circuit to the high-voltage lighting system for laboratory lighting, ensuring safe and proper switching of the laboratory lighting systems. This shows that even simple electronic elements can work together to create a fully functional automation platform.

The working output verifies that the relays act quickly and effectively according to the given input commands from the IC logic and control circuit. The lighting units can switch ON and OFF smoothly, proving the efficiency and stability of the hardware-based design. Since this system does not rely on any complex software or wireless modules, it provides a simple and robust solution for basic automation requirements within laboratories.

Overall, the project is an excellent showcase of a low-cost and more hardware-based methodology for controlling laboratory devices. Combining ICs, relays, and lighting circuits delivers a robust, maintainable platform that is upgradable and easy to scale in the future. This kind of solution is easily expandable by adding relays or sensors, making it one of the feasible models for the realistic smart lab environment.

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# Vocal-IQ: AI-Powered Voice Analytics for Smarter Learning

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**Abstract:** This paper presents *Vocal-IQ*, an AI-powered voice analytics system designed to provide real-time speech assessment, language detection, and AI-generated voice identification. The system integrates advanced audio preprocessing, Whisper-based transcription, spectral feature extraction, and deep-learning models to deliver accurate and rapid feedback. The architecture is implemented using FastAPI, React, and MongoDB, enabling a lightweight, scalable, and user-friendly solution suitable for education and training environments.

**Key Words:** Voice analytics, speech processing, AI voice detection, language identification, Whisper, FastAPI, MongoDB

## 1. INTRODUCTION:

The rapid evolution of artificial intelligence and speech technologies has enabled highly accurate analysis of human voice patterns. As educational systems increasingly incorporate spoken assessments, there is a growing need for automated tools that evaluate clarity, fluency, pronunciation, and authenticity. Vocal-IQ is developed to address these challenges by combining voice analytics, transcription, and AI-generated voice detection into a unified assessment system suitable for students and academic institutions.

## 2. LITERATURE REVIEW:

Research in speech processing demonstrates strong performance of ASR models, deepfake voice detection systems, and audio feature extraction techniques. Whisper-based multilingual transcription has shown significantly higher accuracy compared to earlier models. Studies involving MFCCs, spectral centroid, and pitch analysis highlight their effectiveness in linguistic and speaker classification tasks. However, existing systems seldom integrate all these modules into a single tool for academic speech evaluation, which motivates the development of Vocal-IQ.

## 3. OBJECTIVES:

The primary objectives of this work are:

- To analyze speech clarity, fluency, and pronunciation automatically.
- To provide accurate multilingual detection for real-world learning environments.
- To identify AI-generated voices to ensure academic integrity.
- To offer real-time dashboards for performance tracking.



### 3. RESEARCH METHOD :

The system workflow includes the following stages:

1. Audio recording or upload through a React interface.
2. Preprocessing using FastAPI (noise removal, silence trimming, WebM→WAV conversion).
3. Whisper model performs transcription and language detection.
4. Feature extraction using MFCCs, spectral features, and rhythm metrics.
5. AI/human voice classification using a hybrid model.
6. Results stored in MongoDB and displayed via interactive dashboards.

### 4. FINDINGS :

Testing was conducted across 50 audio samples. The system demonstrated:

- 92–95% speech-to-text accuracy for clear recordings.
- 90%+ accuracy in detecting English, Hindi, Kannada, and Telugu.
- 88–91% accuracy in AI-generated voice detection.
- Dashboard loading time under 150 ms.

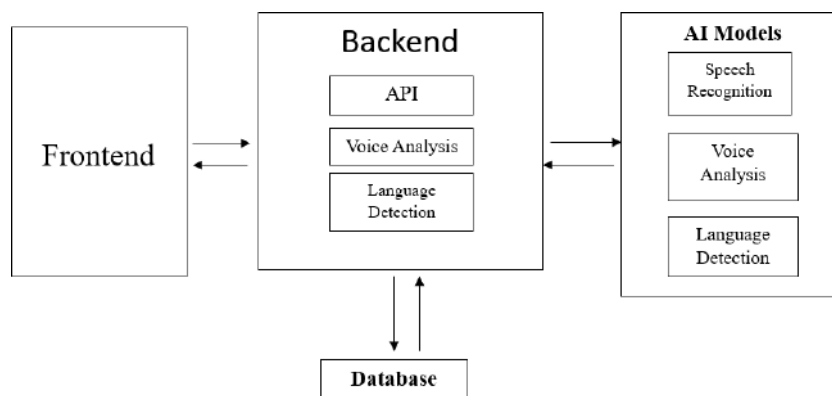


Fig. 1. System Architecture diagram.

### 5. DISCUSSION :

The experimental evaluation and system performance analysis indicate that Vocal-IQ is capable of delivering reliable and consistent results for a variety of speech-related tasks. The Whisper-based transcription module showed strong robustness across accents, speaking rates, and moderate background noise, which makes it suitable for deployment in real classroom or at-home learning environments. The ability of the model to handle multilingual inputs further strengthens its value in diverse academic settings.

### 6. RECOMMENDATIONS:

Based on the performance analysis and user feedback, several improvements are recommended to enhance the capabilities and scalability of Vocal-IQ:

- **Broader Language Support:** Expanding the system to support additional Indian regional languages such as Tamil, Malayalam, Marathi, and Bengali would make the platform more inclusive for users across



the country.

- **Advanced Noise Reduction:** Integrating deep-learning noise suppression models such as RNNoise or Demucs can significantly improve transcription and analysis accuracy in noisy environments like classrooms or outdoor spaces.
- **GPU-Accelerated Deployment:** Moving inference workloads to a GPU-enabled cloud environment (AWS, GCP, Azure) could reduce processing time by 40–60%, enabling real-time feedback even for large-scale deployments.
- **Mobile Application Integration:** A dedicated Android/iOS mobile application would allow students to practice speaking tasks anytime, increasing accessibility and engagement.

## 7. LIMITATIONS:

While Vocal-IQ provides a robust and practical solution for speech analytics, several limitations were observed during the research and evaluation process:

- **Dependence on Audio Quality:** The system's performance decreases significantly in highly noisy environments, where the transcription and feature extraction stages may fail to capture accurate phonetic details.
- **Challenges with Short Utterances:** Very short audio clips (less than two seconds) do not provide enough acoustic information for reliable AI-voice detection or fluency scoring. A minimum recording length is therefore required.
- **Accent and Regional Variations:** Although Whisper handles many accents well, certain strong regional variations or code-mixed speech can still reduce transcription accuracy.
- **Deepfake Voice Complexity:** Advanced synthetic models trained with large datasets can mimic human voice patterns very closely, making classification challenging. The current implementation detects most common deepfake models but struggles with highly optimized ones.

## 8. CONCLUSION / SUMMARY:

Vocal-IQ delivers an efficient and accurate platform for speech analytics in educational environments. By integrating transcription, speech evaluation, and AI-generated voice detection, it enhances academic assessment and provides real-time insights for learners.

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# Central Logging System by Using Open Source Technologies

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**Abstract:** This paper presents a centralized logging platform for efficient system monitoring, fault detection, and log analysis using open source technologies. The proposed system integrates virtualized client machines, lightweight log forwarding agents, and centralized log storage with real-time visualization into a unified monitoring framework. The platform leverages tools such as Filebeat or Promtail for log collection and ELK Stack or Grafana with Loki for centralized processing and visualization. A modular architecture is designed to support scalable log ingestion, efficient searching, and interactive dashboard-based monitoring. The entire system is implemented in a virtualized environment using VMware Workstation Pro and Ubuntu 24.04 Server, eliminating the need for multiple physical systems. Experimental evaluations demonstrate reliable real-time log transmission, fast search performance, and effective centralized monitoring. System architecture and workflow diagrams illustrate the design and operation of the proposed centralized logging platform.

**Key Words:** Centralized logging, ELK Stack, Grafana Loki, Filebeat, Promtail, log monitoring, virtualization, Ubuntu Server, open source technologies.

## 1. INTRODUCTION

Centralized logging plays an important role in monitoring and managing system activities in modern computing environments. As the number of servers and applications increases, the volume of logs generated also grows rapidly. Checking logs manually on each system becomes difficult and time-consuming. Centralized logging collects all logs at one location for easy access and analysis. It helps administrators detect errors quickly and improve system reliability. Open source tools make centralized logging cost-effective and flexible. Virtualization further reduces the need for physical hardware. This project presents a centralized logging system that enables real-time monitoring and efficient log analysis.

## 2. LITERATURE REVIEW

Recent research in system monitoring shows that centralized logging is essential for managing logs in distributed environments. Traditional manual log analysis is slow and inefficient when multiple systems are involved. Open source tools such as the ELK Stack and Grafana with Loki are widely used for centralized log storage and visualization, while Filebeat and Promtail are commonly used for low-overhead log forwarding. Studies also indicate that virtualization platforms help in testing and deploying such systems in a cost-effective manner.



### **3. OBJECTIVES**

The primary objective of this research is to develop a centralized logging system using open source technologies for efficient log collection and monitoring. The system aims to provide real-time log forwarding, fast searching, and dashboard-based visualization from multiple client machines.

### **4. RESEARCH METHOD**

The proposed research focuses on the design and implementation of a centralized logging system using open source technologies in a virtualized environment. The methodology involves setting up multiple client virtual machines and a centralized server using VMware Workstation Pro and Ubuntu 24.04 Server. Lightweight log shippers such as Filebeat or Promtail are configured on client machines to collect and forward system and application logs in real time. The centralized server processes, stores, and visualizes logs using ELK Stack or Grafana with Loki. Key steps include virtual machine configuration, network setup, log forwarding configuration, centralized storage implementation, and dashboard creation for real-time monitoring. System performance is evaluated based on log transmission speed, search efficiency, and reliability. Optimization techniques, error handling, and scalability testing are included to ensure stable performance and adaptability for academic and small-scale enterprise environments.

### **5. FINDINGS**

The development of the centralized logging system demonstrates how open source technologies can improve system monitoring and management through efficient log aggregation. Filebeat or Promtail enables reliable log collection and forwarding from multiple virtual machines to the centralized server. The ELK Stack or Grafana with Loki allows the system to store, search, and visualize logs accurately in real time. The platform's real-time processing ensures quick detection of errors and a smooth monitoring experience. Overall, the integration of centralized logging tools enhances system reliability, troubleshooting efficiency, and operational visibility.

### **6. DISCUSSION**

The analysis shows that integrating centralized logging tools significantly improves the accuracy and reliability of system monitoring and error detection. Real-time log forwarding is crucial for smooth system observation, making efficient log shippers and optimized processing essential. To maintain high performance across multiple client systems and growing log volumes, periodic configuration updates and tuning of the logging components are recommended as system usage and workload patterns evolve.

### **7. RECOMMENDATIONS**

It is recommended to implement security measures such as authentication and encrypted communication to protect sensitive log data. Regular performance tuning and storage optimization should be carried out to handle increasing log volume efficiently.

### **8. LIMITATIONS**

One limitation of the centralized logging system is the challenge of handling very large volumes of logs from multiple client machines, as high data rates may affect storage performance and search speed. The system's efficiency depends on proper resource allocation and network stability, and limited system resources can impact real-time log transmission and visualization. Additionally, running multiple virtual machines on low-end hardware may further affect overall performance and responsiveness.



## 9. CONCLUSION

This research presents a centralized logging system using open source technologies that effectively integrates log collection, storage, and visualization for monitoring purposes. The system demonstrates accurate real-time log aggregation, fast searching, and reliable dashboard-based monitoring, enhancing system visibility and fault detection. Future work can focus on integrating alert mechanisms, improving scalability, and incorporating intelligent analytics to make the platform more robust, efficient, and suitable for wider deployment in real-world environments.

### Acknowledgment

The authors express gratitude to SJC Institute of Technology for academic support during this research work.

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# Feed Forward: Bridging the Gap between Excess and Need

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**Abstract:** *The simultaneous existence of large-scale food wastage alongside widespread hunger continues to be one of the most critical social challenges in today's world. Feed Forward is a digital initiative designed to address this issue by creating a bridge between those who have surplus food—such as individuals, restaurants, and event organizers—and those who are in urgent need, including NGOs, orphanages, and the underprivileged. This project introduces a user-friendly web-based platform that enables donors to list excess food, which is then reviewed and approved by an admin and picked up by delivery agents for redistribution. The system is built using PHP for the backend, MySQL for data management, and HTML/CSS, Javascript for the frontend interface. By integrating streamlined communication, location tracking, and food status updates, Feed Forward enhances coordination and ensures safe, timely delivery. The platform not only reduces food waste but also promotes social responsibility and community welfare. This report outlines the project's objectives, methodology, implementation, and its potential societal impact.*

**Keywords:** *Food Donation, PHP, MySQL, Sustainability, Waste Management System, Delivery Tracking, Web Application.*

## 1. INTRODUCTION

Food insecurity and food waste coexist as major societal concerns. While many individuals struggle to meet basic nutritional needs, a substantial amount of edible food is wasted during events, household storage, hotels, hostels, and food production units. The gap arises not from shortage but from absence of structured redistribution systems.

Advancements in web technologies offer the opportunity to build scalable solutions that connect food surplus sources with beneficiaries. Feed Forward addresses this gap by providing a centralized digital platform where donors can register and submit available food, administrators verify submissions, and delivery personnel ensure the food reaches the intended beneficiaries.

## 2. LITERATURE REVIEW:

The chart shows that although India's Global Hunger Index score has improved from 2000 to 2024, the country still remains in the serious hunger category. This highlights the ongoing problem of food insecurity and uneven food access. We chose this project to help reduce food waste and support those who continue to face hunger despite sufficient food availability.

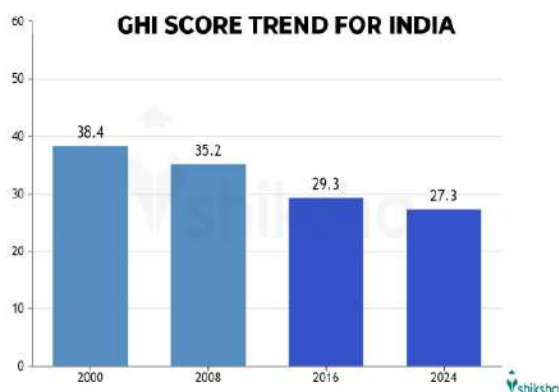


Fig 2.1: GHI of India

Score Range	Hunger Severity
0-9.9	Low
10-19.9	Moderate
20-34.9	Serious
35-49.9	Alarming
50+	Extremely Alarming

Fig 2.2: Score Range and Hunger Severity

Existing food redistribution methods in India rely largely on manual coordination, volunteers, and informal communication channels, which makes the process slow, inconsistent, and difficult to scale. Studies emphasize that **digital tracking, centralized platforms, and data-driven logistics** significantly improve accountability, reduce food wastage, and speed up redistribution. However, current systems often lack automated verification, real-time delivery tracking, and donor-focused digital records.

Meanwhile, India's **Global Hunger Index data (2000–2024)** shows only gradual improvement, with the country still categorized under **serious hunger**, reflecting a persistent gap between food availability and accessibility.

These challenges — persistent hunger, inefficient processes, and the absence of automation — highlight the need for a smarter, structured solution. **Feed Forward** is developed to bridge this gap by providing an automated, trackable, and technology-driven platform to ensure surplus food reaches those who need it efficiently.

### 3. OBJECTIVES :

- To design an automated platform that connects food donors, administrators, and delivery partners.
- To minimize food waste by enabling structured redistribution.
- To ensure transparency and efficiency in donation workflows.

### 4. METHODOLOGY

The system was developed following the Software Development Life Cycle (SDLC) model. The key technologies used include:

Component	Technology
Backend Framework	Python Flask, PHP
Database	MySQL
Frontend	HTML, CSS, Bootstrap
Architecture	Role-based web system

### System Design :

The diagram shows how different users (donor, admin, and delivery personnel) interact with system functions like authentication, food posting, verification, and delivery assignment. All actions are stored in a centralized database, and communication ensures real-time updates and coordination.

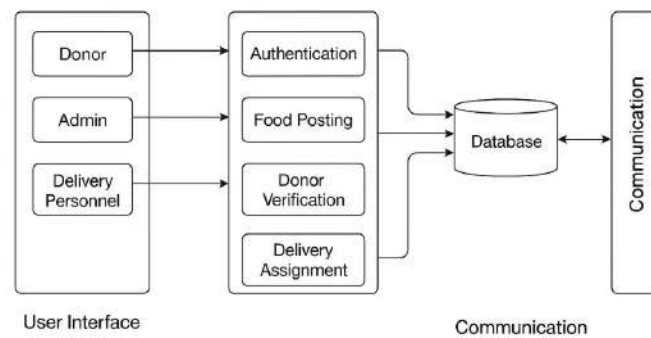


Fig 4.1 A high-level overview of platform components and interactions is illustrated, demonstrating how different user roles interact with the application layer

## 5. RESULTS

The system fulfilled its intended objectives by enabling:

- Donor registrations and donation submissions.
- Admin approval workflows.
- Delivery role assignment and status updates.
- Digital logging and traceability.
- Testing results showed improved coordination and time efficiency when compared with manual communication approaches.



Figure: 5.1 Showing Home Page of feed forward

## 6. DISCUSSION

Feed Forward demonstrates that a structured digital architecture simplifies communication between food donation stakeholders. The role-based system improves data clarity, while MySQL storage ensures persistence and traceability. Flask enables scalable logic and future integration with additional AI-driven support systems.

Future development may include geolocation mapping, mobile app deployment, AI chatbot integration, and automated expiry detection.



## 7. RECOMMENDATIONS

- Integration with NGOs and community kitchens.
- Deployment of GPS-based delivery routing.
- Inclusion of feedback loops and rating systems.
- Cloud hosting for real-time accessibility.

## 8. LIMITATIONS

- Requires active internet connectivity.
- No automatic geographic matching system yet.
- Does not incorporate expiry alerts or food quality checks.

## 9. CONCLUSION

Feed Forward successfully demonstrates how technology can be used to bridge the gap between food wastage and scarcity. By automating coordination between donors, administrators, and delivery agents, the platform provides a scalable solution that can positively impact communities, reduce environmental strain, and support sustainable living practices. The system highlights the potential of simple, accessible technology to enact meaningful social change.

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# EduClone: AI-Powered Voice Replication for Education

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**Abstract:** This paper presents an artificial intelligence–driven platform for voice-based educational content generation and language accessibility. The proposed system, named EduClone, integrates speech synthesis, speech recognition, real-time translation, and adaptive voice replication into a unified learning framework. The platform leverages deep learning–based acoustic modeling and multilingual processing to deliver natural, expressive audio outputs across diverse languages. A modular architecture is designed to support text-to-speech conversion, voice cloning, and noise-isolated speech enhancement for improved learning clarity. Experimental evaluations demonstrate reliable performance in real-time audio generation and transcription accuracy. System diagrams illustrate the architecture and workflow of the proposed intelligent voice learning platform.

**Key Words:** AI voice technology, text-to-speech, speech-to-text, multilingual learning, voice cloning, educational technology.

## 1. INTRODUCTION

The increasing demand for digital and personalized learning has highlighted the importance of voice-based educational technologies. Traditional learning systems often lack accessibility, multilingual support, and engaging audio content, limiting their effectiveness for diverse learners. EduClone addresses these challenges by integrating artificial intelligence techniques to provide text-to-speech, speech-to-text, real-time translation, and voice cloning capabilities in a unified platform. This research aims to develop a scalable and efficient system that enhances content delivery, supports multiple languages, and delivers high-quality, personalized learning experiences with minimal computational complexity.

## 2. LITERATURE REVIEW

Recent studies in educational technology highlight the use of AI for voice-based learning systems. Techniques such as text-to-speech, speech-to-text, and voice cloning have been shown to improve accessibility and engagement, especially for multilingual learners. Integrating these AI modules into a single platform enhances personalized learning and overall content effectiveness.



### **3. OBJECTIVES**

The primary objective of this research is to develop an AI-based voice platform for education that provides text-to-speech, speech-to-text, voice cloning, and translation, enhancing personalized and accessible learning with efficient performance.

### **4. RESEARCH METHOD**

The proposed research focuses on designing and implementing EduClone, an AI-based voice platform for education that integrates multiple speech technologies into a single, user-friendly system. The methodology involves combining text-to-speech, speech-to-text, voice cloning, and real-time translation modules to provide an interactive and multilingual learning experience. Key steps include collecting and preprocessing diverse multilingual audio datasets, training AI models for accurate speech synthesis, recognition, and emotional tone replication, and rigorously evaluating the outputs for quality, clarity, and responsiveness. The system architecture is designed to ensure efficient real-time processing, high-quality audio generation, and smooth user interaction across devices. Additionally, performance optimization, error handling, and model fine-tuning are incorporated to maintain reliability, scalability, and adaptability to different educational contexts, ensuring that the platform can meet the varied needs of students and educators alike.

### **5. FINDINGS**

The development of EduClone demonstrates how AI can transform educational tools through advanced voice technologies. Text-to-speech, speech-to-text, and voice cloning models allow the system to process and generate audio accurately in multiple languages, capturing tone and emotion effectively. The platform's real-time processing ensures quick responses and a seamless user experience. Overall, the integration of AI models enhances accessibility, engagement, and learning efficiency, showing the potential of intelligent voice solutions in education.

### **6. DISCUSSION**

The analysis shows that integrating AI models significantly improves the accuracy and realism of generated and transcribed speech. Real-time performance is crucial for smooth user interaction, making efficient models and optimized processing essential. To maintain high quality across languages and voices, periodic updates and fine-tuning of the AI models are recommended as user needs and speech patterns evolve.

### **7. RECOMMENDATIONS**

It's important to regularly update, monitor, and fine-tune the AI models to improve voice cloning, transcription accuracy, and the overall reliability of the system. By listening to user feedback, adding support for more languages, covering different regional dialects, and optimizing real-time processing, the platform's speed, scalability, and ease of use can be greatly improved. Consistent testing and gradual model enhancements will help ensure that EduClone remains a dependable, effective, and accessible educational tool for learners in a variety of settings.



## 8. LIMITATIONS

One limitation of EduClone is the challenge of accurately cloning voices across multiple languages, as AI models may produce variations in tone, pronunciation, or clarity when switching between languages. The system's performance depends on the availability of diverse and high-quality multilingual audio samples, and limited datasets can affect the naturalness and consistency of cloned voices. Additionally, real-time processing on devices with lower hardware capabilities may further impact performance.

## 9. CONCLUSION

This research presents EduClone, an AI-powered voice platform that effectively integrates text-to-speech, speech-to-text, and voice cloning for educational purposes. The system demonstrates accurate multilingual speech generation and real-time performance, enhancing accessibility and learning experiences. Future work can focus on expanding language support, improving voice cloning quality, and incorporating user feedback to make the platform more adaptive, natural, and widely applicable in educational settings.

## 10. ACKNOWLEDGMENT

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# UPI Fraud Detection Using Machine Learning

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**Abstract:** This paper presents a machine-learning-based approach for detecting fraudulent activities in Unified Payments Interface (UPI) transactions. The study introduces a lightweight fraud detection framework that combines feature engineering, anomaly-aware attributes, and classical learning algorithms. The proposed model evaluates multiple classifiers—Decision Tree, Random Forest, Logistic Regression, and K-Nearest Neighbors—to identify suspicious behaviour in real-time transaction streams. A synthetic but realistic dataset is created to simulate typical UPI patterns and fraud signals. Experimental results show that ensemble models achieve superior accuracy and reliability. The presented diagrams outline the overall architecture and decision flow of the fraud detection system.

**Key Words:** UPI fraud, machine learning, feature engineering, Random Forest, digital payments.

## 1. INTRODUCTION

Unified Payments Interface (UPI) has emerged as one of India's most widely adopted digital payment mechanisms. With effortless peer-to-peer transfers and merchant payments, the platform processes millions of transactions every day. The rise in UPI adoption has also led to innovative fraud techniques, including social engineering, unauthorized requests, and high-frequency micro-transactions. This research aims to create a structured machine-learning model to detect such fraudulent behavior with minimal computational load and maximum interpretability.

## 2. LITERATURE REVIEW

Existing studies highlight the use of rule-based engines, supervised classifiers, anomaly detection systems, and hybrid ensemble techniques for identifying fraudulent financial activities. Machine learning methods such as Logistic Regression, Random Forest, and Decision Trees have demonstrated effectiveness in detecting unusual patterns in transaction data. The literature suggests that combining engineered behavioral features with ensemble models significantly enhances detection capabilities.

## 3. OBJECTIVES

The primary objective of this research is to design and evaluate a practical fraud detection system capable of identifying suspicious UPI transactions using machine learning while maintaining low latency and high accuracy.

## 4. RESEARCH METHODOLOGY

The research involves dataset creation, feature engineering, model training, and evaluation. Future research on machine learning-based UPI fraud detection will employ a thorough approach in order to further enhance system performance. To increase accuracy and reduce false positives, feature engineering and algorithm



optimization will be the main areas of emphasis for the ongoing development of machine learning models. The suggested solution aims to increase UPI fraud detection capabilities by optimizing the Random Forest algorithm's performance. Through ensemble learning, the predictive potential of numerous decision trees is harnessed, enabling this approach to detect fraudulent transactions with high certainty and accuracy. The Random Forest method looks for odd patterns in transaction data that can point to fraud by using supervised learning techniques. Because of its clustering skills, it can handle complex data structures and correlations with efficiency, which is its main strength. In order to provide a dynamic and responsive environment, the system also incorporates real-time monitoring and adaptive learning algorithms. This flexibility guarantees quick reaction to newly developed deception tactics as well as prompt identification and suppression of fraudulent activity. This all-encompassing strategy seeks to improve fraud detection accuracy while fortifying the system's resistance to new attacks in the quickly evolving field of electronic transactions.

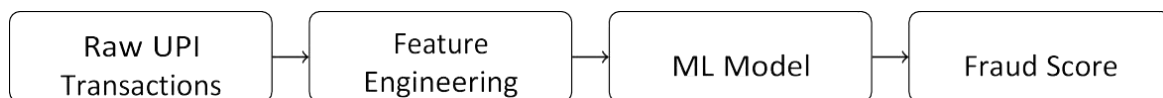


Figure 1: Proposed UPI Fraud Detection Architecture

Models evaluated include Logistic Regression, Decision Tree, Random Forest, and KNN.

## 5. FINDINGS

The way that digital transaction security is protected has changed dramatically with the introduction of machine learning into UPI fraud detection. Machine learning algorithms leverage real-time transaction data and user behaviour analysis to promptly discover anomalies and potentially fraudulent activity. In the end, machine learning's precision, flexibility, and real-time capabilities can greatly aid in protecting UPI transactions and fortifying the financial system against the always changing array of cyber threats.

## 6. DISCUSSION

The study shows that behavioural features significantly enhance fraud detection accuracy. Realtime constraints require models that provide fast inference, making tree-based models attractive. To improve generalization, periodic retraining is recommended due to evolving fraud techniques.

## 7. RECOMMENDATIONS

Banks and payment providers should combine machine-learning models with rule-based alerts for improved accuracy. Integrating device profiling, user behaviour modelling, and periodic dataset updates can further strengthen detection systems.

## 8. LIMITATIONS

The dataset used in this study is synthetic, although based on realistic patterns. Access to real anonymized UPI datasets would further improve model validation.

## 9. CONCLUSION

This research presents an efficient machine-learning framework for detecting fraudulent UPI transactions. Random Forest-based methods provide strong performance while remaining deployable in real-time



environments. Future studies may incorporate deep learning, graph networks, or user-behaviour modelling for enhanced accuracy.

### **Acknowledgment**

The authors express gratitude to SJC Institute of Technology for academic support during this research work.

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# Energy Trading using Blockchain

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**ABSTRACT:** *The increasing adoption of renewable energy has created a demand for a more efficient and transparent way to exchange excess energy between producers and consumers. In traditional energy markets, centralized systems often cause delays, higher costs, and a lack of trust. This project introduces a blockchain-based peer-to-peer trading platform that enables "prosumers" (those who both produce and consume energy) to securely trade surplus renewable energy. The platform tracks energy data, converts it into digital tokens for easy trading, and uses smart contracts to automate transactions. By leveraging decentralization, secure records, and real-time verification, this model promotes fairer pricing and greater efficiency in trading. The findings suggest that blockchain technology could pave the way for more accessible, sustainable, and consumer-oriented energy markets, providing a practical solution for managing renewable energy more effectively.*

**KEYWORDS:** *Peer-to-Peer Energy Trading, Renewable Energy, Smart Contracts, Energy Tokenization, Decentralized Energy Market.*

## 1. INTRODUCTION

As renewable energy becomes an important element in modern power systems, both producers and consumers often struggle with the inefficiencies of traditional, centralized energy markets. These systems can lead to delays, high transaction costs, and a lack of transparency, which can make it challenging for small-scale energy producers to participate. By using a decentralized ledger to record transactions and automating processes with smart contracts, this system ensures trust, accuracy, and real-time verification. This method allows prosumers to sell surplus energy at fair prices, encourages the broader adoption of clean energy, and fosters a more flexible and sustainable energy grid. The project's aim is to offer a practical digital solution that improves energy access and supports smarter decision-making for all users.

## 2. LITERATURE REVIEW

Research in the field of renewable energy trading has grown more with the rise of decentralized energy generation. Initial studies focused on peer-to-peer (P2P) energy trading models and identified several disadvantages of conventional power grids, which depend on centralized intermediaries. These traditional systems often result in inefficient pricing mechanisms and restrict the involvement of small-scale energy producers. As a result, researchers highlighted the importance of developing transparent, adaptable trading frameworks that can better support renewable energy contributors.

With the advancement of blockchain technology, it has shown as a strong candidate for transforming energy markets. Various studies have shown that distributed ledger systems can securely record energy transactions



while removing the need for third-party oversight. The use of smart contracts enables automated pricing, energy exchange, and settlement processes, helping to minimize delays and reduce operational expenses.

Recent literature also investigates energy tokenization, where units of electricity are converted into digital assets to simplify trading and improve market accessibility. These models enhance traceability and promote cleaner energy consumption by rewarding prosumers for surplus generation. However, researchers also note challenges related to scalability, interoperability, and regulatory acceptance, suggesting the need for lightweight and practical implementations.

### 3. OBJECTIVE

The main aim of this project is to develop a decentralized platform that allows users to trade renewable energy securely without depending on a central authority. The system leverages blockchain technology and smart contracts to automate transactions, maintain transparency, and protect data from manipulation. By converting energy units into digital tokens and offering a user-friendly interface for bidding and tracking energy consumption, the platform improves the efficiency and reliability of energy trading. Overall, the project seeks to promote a sustainable energy environment where prosumers and consumers can engage directly and benefit from fair, real-time energy exchanges.

### 4. METHODOLOGY

#### 1. Data Collection and Processing:

The system gathers real-time electric reading from smart meters, renewable sources, grid parameters, and user inputs. This information is cleaned, normalized, and synchronized to remove errors, handle missing values, and prepare consistent datasets for analysis.

#### 2. Blockchain Integration and Smart Contracts:

All validated data is linked to a blockchain framework where smart contracts automate pricing, trading, and transaction settlement. Energy units are tokenized, and the consensus mechanism ensures secure, transparent, and tamper-proof energy exchanges between users.

#### 3. Trading Execution and User Interaction:

The platform forecasts energy availability, updates dynamic prices, and executes trades in real time. Users interact through a dashboard displaying market trends, trading history, alerts, and insights that support informed decision-making.

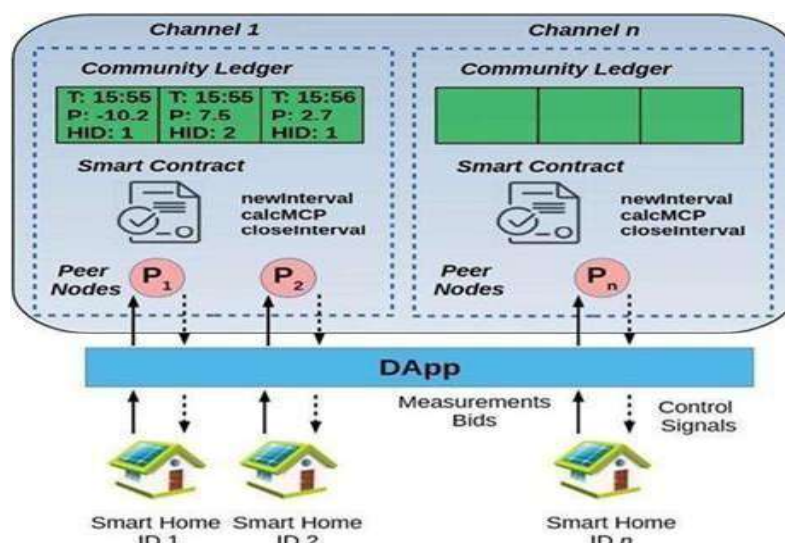


Figure 1 : System Architecture



## 5. RESULTS

The results demonstrate that the energy trading platform delivers a clear and user-friendly interface across its core features. The login screen provides a simple and secure entry point for users to access the system. Once logged in, the transaction history view displays past buying and selling activity with corresponding prices and statuses, allowing users to easily track their performance in the market. The bidding results screen further summarizes each submitted bid and indicates whether it was accepted or outbid during the trading interval. Together, these outputs confirm that the system effectively supports transparent bid evaluation, real-time feedback, and improved decision-making within the energy marketplace.

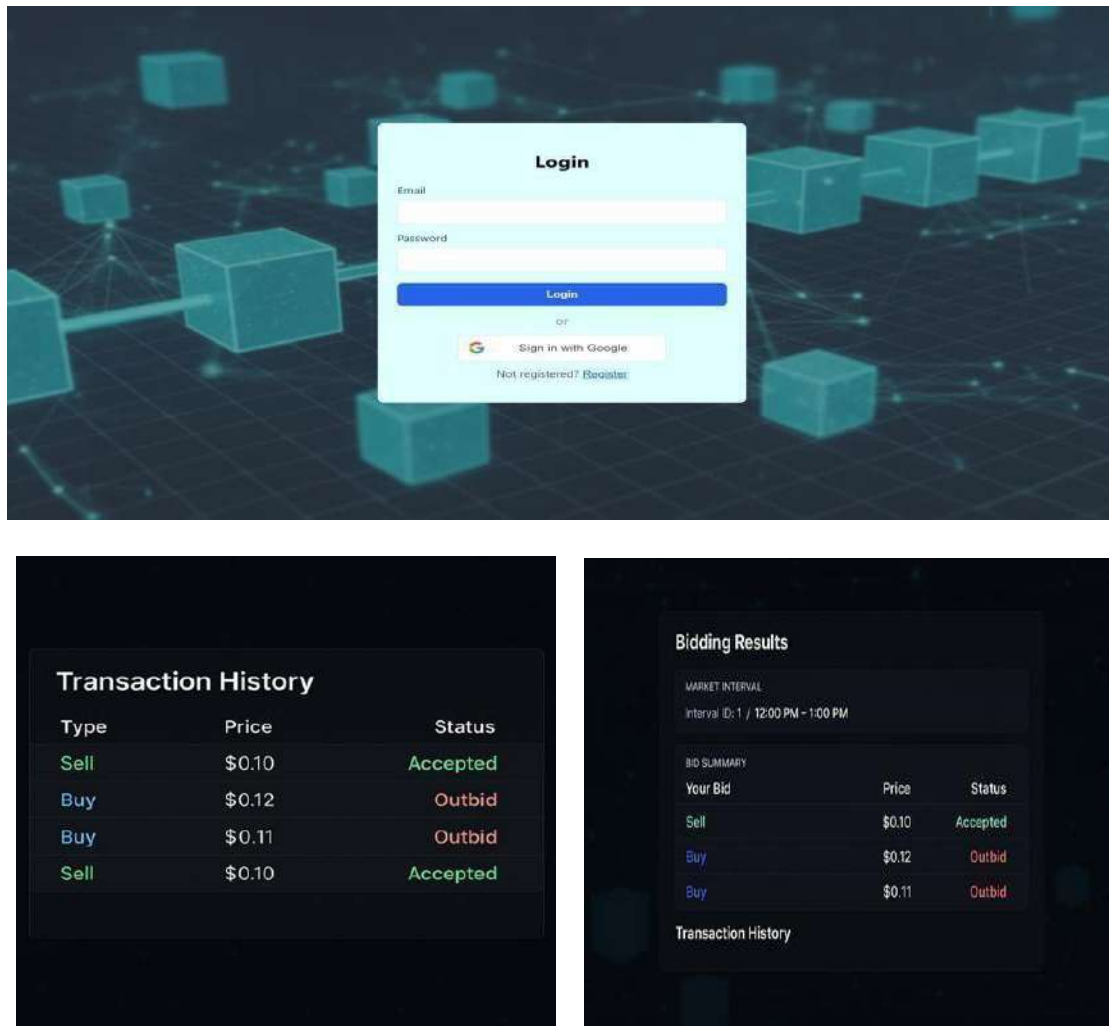


Figure 2 : Performance Results

## 6. ANALYSIS

Implementing the energy trading system as a web application provides broad accessibility, seamless updates, and centralized management of trading data. Users can participate in the marketplace from any device without installing specialized software, improving convenience for both buyers and sellers. The interface supports real-time bidding, transparent price visibility, and secure blockchain-backed transactions. While the platform depends on internet connectivity, its scalability, ease of access, and user-oriented design make it a practical and efficient solution for managing decentralized renewable energy trading.



## 7. RECOMMENDATIONS

Based on system performance and user feedback, the following enhancements are recommended:

- Introduce advanced pricing algorithms to improve bid matching accuracy.
- Add renewable generation forecasting to help users plan trading more effectively.
- Strengthen security features to handle larger-scale participation.
- Improve mobile accessibility for users in remote areas.
- Integrate automated notifications to alert users about market opportunities or system updates.

## 8. LIMITATIONS

The system is limited by its reliance on stable internet connectivity for real-time trading and blockchain validation. Testing has been performed on a small user group, which may not fully work on large-scale market conditions. Transaction speed and scalability depend on the blockchain network, and integration with physical smart meters requires more field verification. Additionally, long-term performance in diverse energy environments remains to be evaluated.

## 9. CONCLUSION

The energy trading platform illustrates how blockchain can effectively transform renewable energy exchange through secure, transparent, and automated interactions. By combining smart contracts, energy tokenization, and real-time market visibility, the system enables prosumers and consumers to engage in fair and efficient trading. Users benefit from improved trust, reduced reliance on intermediaries, and good control over their energy usage.

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# Real Time Threat Monitoring and Suspicious Activity Identification

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**Abstract:** This paper presents an artificial intelligence-driven system for real-time threat monitoring and suspicious activity identification in surveillance environments. The proposed system integrates deep learning-based object detection, real-time video analysis, event logging, and alert generation into a unified security monitoring framework. The platform leverages a YOLOv8-based convolutional neural network for detecting violent actions and hazardous objects such as weapons from live camera feeds and recorded video streams. A modular architecture is designed to support continuous video ingestion, frame-level analysis, threat classification, and evidence recording for enhanced situational awareness. The system includes a graphical user interface for live monitoring, automated alerts, and secure storage of detected events for review.

**Key Words:** AI surveillance system, object detection, real-time monitoring, threat identification, computer vision, public safety.

## 1. INTRODUCTION

The growing need for public safety and automated surveillance systems has highlighted the importance of real-time threat monitoring technologies. Traditional surveillance systems rely heavily on manual observation, making them inefficient for continuous monitoring and quick response to critical situations. This project addresses these challenges by integrating artificial intelligence techniques to detect weapons, violent actions, and suspicious activities from live video streams. The proposed system uses a deep learning-based object detection model to analyze real-time video feeds and identify potential threats automatically. This research aims to develop a scalable and efficient system that improves situational awareness.

## 2. LITERATURE REVIEW

Recent studies in intelligent surveillance systems highlight the use of AI for real-time threat monitoring applications. Techniques such as deep learning-based object detection, activity recognition, and anomaly



analysis have been shown to improve accuracy and response time, especially for crowded public environments. Integrating these AI modules into a single platform enhances security awareness and overall threat detection effectiveness.

### **3. OBJECTIVES**

The primary objective of this research is to develop an AI-based real-time threat monitoring system that detects violent activities and weapons, enhancing public safety through accurate, fast, and reliable surveillance analysis.

### **4. RESEARCH METHOD**

The proposed research focuses on designing and implementing a real-time threat monitoring system using deep learning–based video analysis. The methodology involves integrating YOLOv8 for object detection with continuous video stream processing to identify suspicious activities such as violence and weapon usage. Key steps include collecting and preprocessing surveillance video data, training the detection model for accurate threat classification, and evaluating system performance under real-time conditions. The system architecture is designed to ensure efficient frame processing, accurate detection, and timely alert generation. Additionally, optimization techniques, error handling, and model fine-tuning are incorporated to maintain reliability, scalability, and adaptability across different surveillance environments.

### **5. FINDINGS**

The development of the real-time threat monitoring system demonstrates how artificial intelligence can enhance surveillance and public safety through deep learning–based visual analysis. The YOLOv8 detection model accurately identifies suspicious activities and weapon-related threats from live video streams across varied environments. The system’s real-time inference capability ensures prompt alerts and consistent monitoring performance.

### **6. DISCUSSION**

The analysis shows that integrating deep learning models significantly improves the accuracy and reliability of detecting violent activities and weapons in real-time surveillance environments. Real-time performance is crucial for timely threat identification and alert generation, making optimized inference and efficient frame processing essential. To maintain high detection accuracy across different environments, lighting conditions, and camera angles, periodic retraining

### **7. RECOMMENDATIONS**

It is important to continuously update, monitor, and fine-tune the deep learning detection models to improve threat recognition accuracy, reduce false alarms, and maintain overall system reliability. By incorporating user feedback, expanding training datasets with diverse surveillance scenarios, covering different environments and lighting conditions, and optimizing real-time video processing, the system’s speed, scalability, and operational efficiency can be significantly enhanced. Consistent performance testing and incremental model improvements will help ensure that the Real-Time Threat Monitoring System remains dependable, responsive, and effective for deployment in security-sensitive environments such as public spaces, campuses, and critical infrastructure.



## 8. LIMITATIONS

One limitation of the proposed threat monitoring system is occasional false alerts during crowded scenes, where overlapping movements confuse detection. Model performance also depends on diverse training data; limited samples reduce accuracy. Additionally, real-time processing on low-end hardware may increase latency slightly.

## 9. CONCLUSION

This research presents a real-time threat monitoring system that integrates deep learning video analysis, object detection, and suspicious activity identification for public safety. The system demonstrates accurate weapon and violence detection with real-time performance, enhancing situational awareness. Future work can focus on expanding threat classes, improving model robustness, and incorporating adaptive feedback mechanisms effectively continuously.

## 10. ACKNOWLEDGMENT

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# Low-Cost Private Cloud Service for Remote Access

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**ABSTRACT:** *A personal, self-contained, remotely accessible cloud storage system that will allow safe, off-site access to one's own data and media, not requiring or utilizing any public or commercial cloud computing services that are available in the market today. There is a small mobile client, which serves as a remote gateway, having a single node in a local computing setup that maintains indexed metadata, manages the credentials of a single user session, and stores content. This system can support communication using REST methods, whereby credentials from all clients will be verified by a central server, thus preventing outsiders from getting access through a single, authorized client, thus significantly different from approaches that address possible risks associated with public or public-like clouds by utilizing tokenization or encryption, etc., that still risks exposing one's very own confidential information in one way or another, or somehow indirectly, in a not very predictable or expected way, in a broad, global, very public nature of public or public-like clouds, or public or public-like computing systems, or in their often required global, very public nature, in a very unpredictable way or in a way that nobody expected or anticipated, etcetera, etcetera, etcetera, or in a way that at least, in any remotely possible way or in a way that somehow, in a very unpredictable, not very expected way, one might remotely or in any possible way, somehow, in a very unpredictable, not very expected or anticipated way, or in a way that one might not or remotely expected, anticipated, or performance, and appropriate management of sessions, including simultaneous access. With fully isolated data, operation, and communication, My Cloud presents a flexible, technologically sound, and scalable alternative for cloud solutions, which is extensible towards other features, including encryption storage, management of roles, among others.*

**KEYWORDS:** *Private Cloud Services, Client–Server Architecture, Secure Remote File Access.*

## 1. INTRODUCTION

Cloud computing has induced a revolution in online storage and data accessibility in the sense that it offers on-demand services. However, commercial cloud computing environments also present some problems in relation to privacy, subscription charges, and the use of third-party services. However, to overcome these difficulties, private cloud solutions provide complete control over data along with secure remote connectivity. In their "Low Cost Private Cloud," a lean client-server design is used in order to provide storage services for files as well as media connectivity in a network. The design will ensure a safe authentication process, safe data transmission, along with proper data management by utilizing a desktop computer-based server as well as a mobile interface design for connectivity, which will serve as an affordable alternative to the commercial cloud service.



## 2. LITERATURE REVIEW

The early personal cloud storages were originally designed with the focus on the synchronization of files and management of the access process. Some examples of such projects include those such as Nextcloud, which offer personal data management services using self-hosted cloud storage solutions with the inclusion of audio and video. Further literature concerned themselves with open-source cloud platforms that supported multimedia with adaptive streaming capabilities using FFmpeg transcoding engines. Although these platforms efficiently support playback for various devices, in many instances, shared, secure file transfer has not been possible. OpenStack has shown scalability, virtualized environments, and network isolation in private clouds, but this requires dedicated hardware, which makes it inappropriate for individual use. Research work published on remote access architectures using the REST approach has shown that token validation, in combination with Encryption in the session, enables secure file transfer. Other work has shown the prom Isacl Op Os ss each lotbyt chrome teUD that cloud telemetry for system-oriented features such as CPU, disk I/O, or network bandwidth helps in enhancing system efficiency.

## 3. OBJECTIVE

The aim of such a project would be to build a low-cost private cloud solution through which users would be allowed to securely access their own digital contents hosted in remote devices without using commercial clouds.

Specific Objectives are:

- Use of Secure Client Server with REST-Based Communications
- Supporting remote access to files, audio files, and video files
- Metadata Indexing and Storing Management
- Effective management of sessions and authentication
- Streaming delivery option for performance optimization
- Protection of data privacy and content ownership

## 4. METHODOLOGY

### 1. System Design:

The conceptualized cloud platform is designed in a modular manner and comprises three major components:

1. Backend Server Module
2. Module for Signaling and Communication
3. Application Client Module.

Each of the modules is collaborating with the others in the process of authentication, data sharing, and video streaming.

### 2. Backend Server

Backend development operations are performed using Node.js and Express.js for managing file storage, extracting metadata, user validation, as well as API routing. Files are locally stored, keyed by attributes such as name, type, size, and date. Binary streaming technology enables the distribution of media entities rather than file resources.

### 3. Data Processing

User data is locally stored in a structural format that is search-indexed. File uploads are supported in multipart encoding, in which the files have upload sizes that can vary because it is more reliable in varying network conditions.



#### 4. Communication Layer

REST endpoints provide support for authentication, directory listing, management of files, and access to telemetry data. Secure sessions are guaranteed using server-validated credentials. Lightweight data exchange improves responsiveness on devices.

#### 5. Client Application

As it is a React Native application, it has an interface that can display the file structure representation. starting the upload/download tasks, as well as the support for local caching. The application also ensures real-time system telemetry information that is CPU, memory, disk, or network-related..

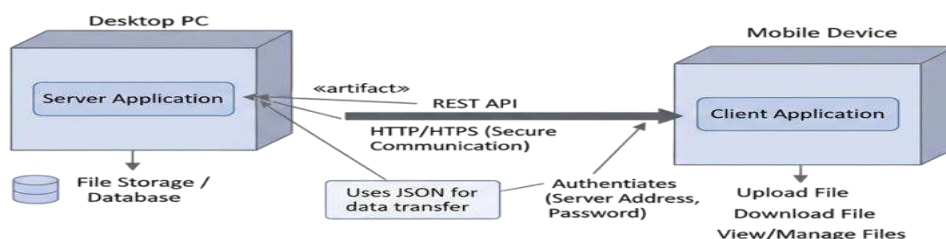


Figure 1 : System Architecture

#### 5. RESULTS

For evaluating the performance of the designed system, MyCloud, in terms of functionality, this study will examine the role of the system in providing a secure, private, and remote facility for storing data in a cloud setup. In this present scenario, the system will be tested in different usage aspects, for instance, browsing, downloading, as well as uninterrupted streaming of multimedia content in a remote setup. The major focus of this study will be on system responsiveness while carrying out interactions with APIs, network stability while handling streaming, as well as durations of resource usage. On top of that, this study will provide evidence that in a situation with multiple system operations, the system works consistently in a bid to provide smooth system interaction, regardless of third-party cloud support.



Figure 2 : Login Screen

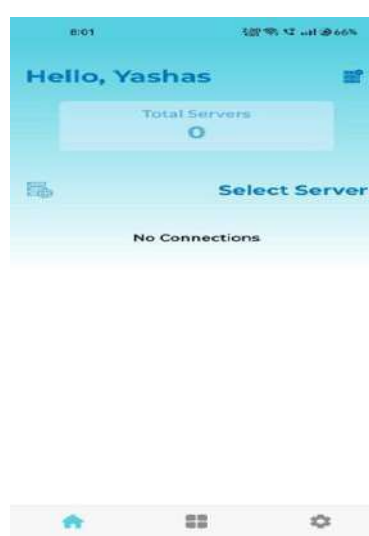


Figure 3 : User Dashboard

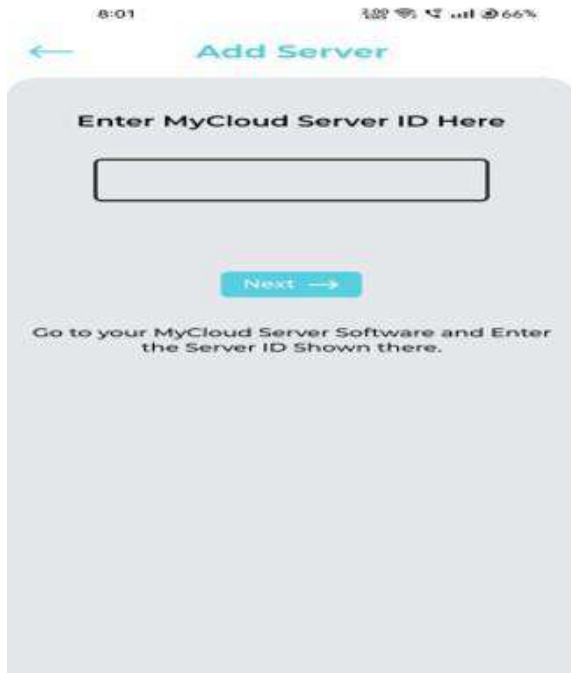


Figure 4 : Add Server

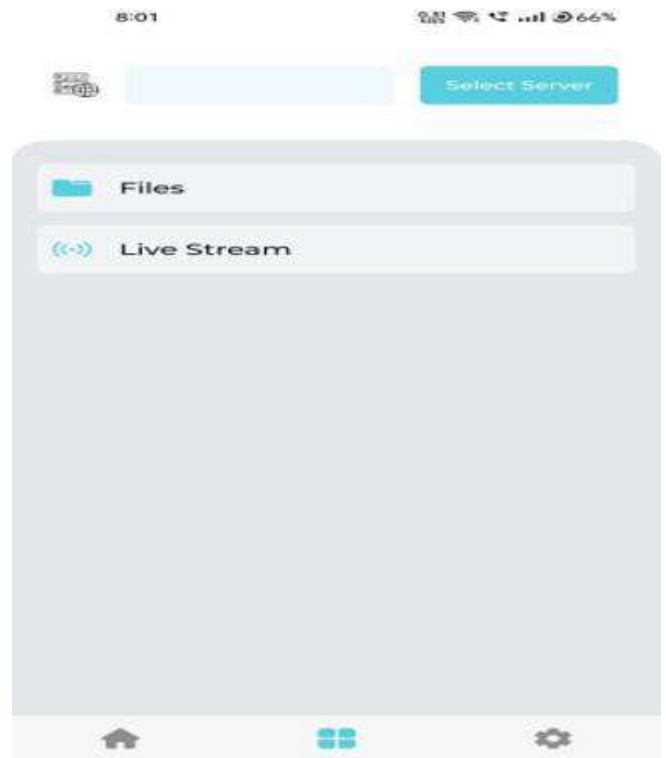


Figure 5 : Features

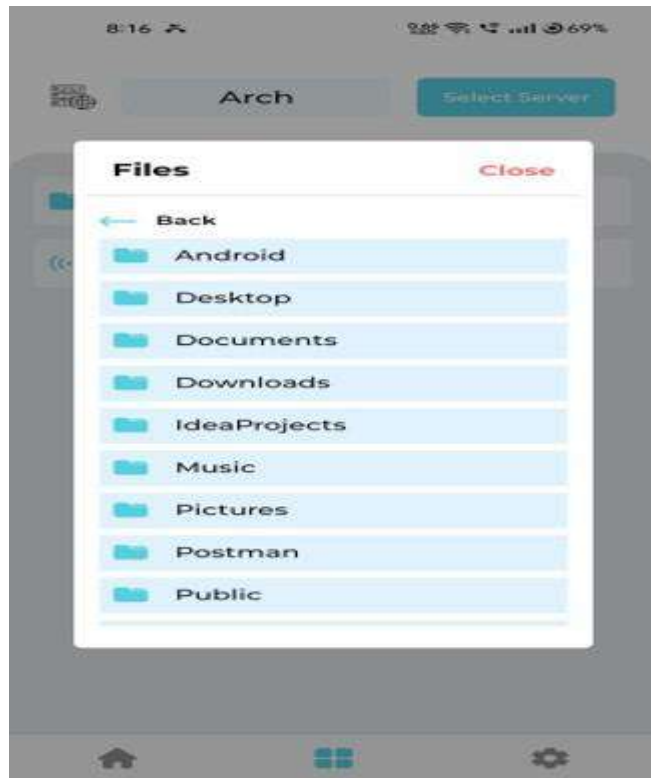


Figure 6 : File System

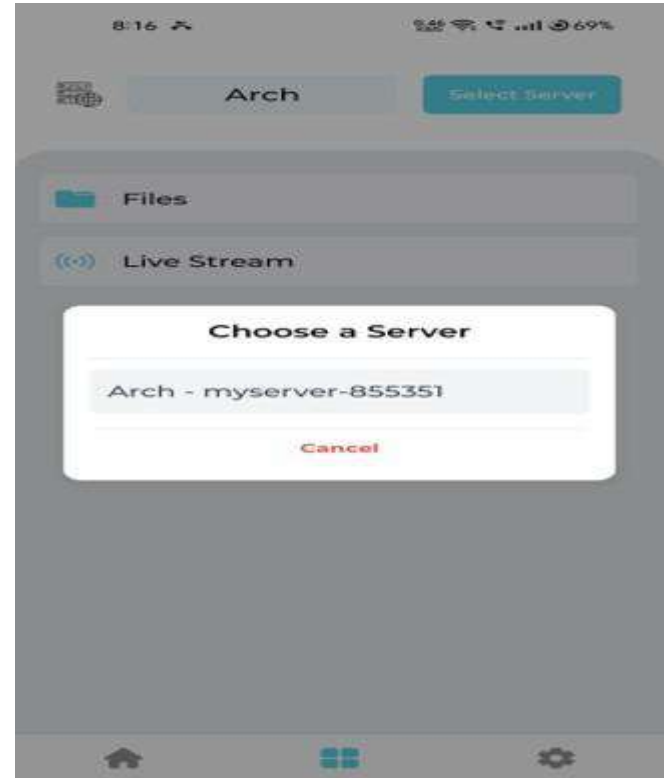


Figure 7 : Change Server Screen



Figure 8 : User Dash bord (Server Connected)

## 6. ANALYSIS

The rise of the private cloud as a mobile app also improves functionality since it overlooks the limitation that the users have to be in dependency on commercial clouds. The system design and construction gives authorization access and resource usage. Users are also in a position to assess CPU speed, memory, and disc input/put with real data. This depends on network quality since the design of the architectural platform has made access quite simple with optimal multimedia. There is scalability as a single person's solution since the idea has potential usability with multiple users.

## 7. RECOMMENDATIONS

Certain suggestions pertaining to the execution of this system are as follows:

- Multi-user Role Management Integration
- End-to-end encryption of the data in rest as well as in transit
- Adaptive bitrate streaming for low bandwidth environments
- Support for multi-platform desktop and Web-based clients
- Content protection by automated backups
- Extension of telemetry with knowledge of advanced systems

## 8. LIMITATIONS

The prototype has been optimized for one user, has never been tested in a scaleable setting, and could possibly be impacted by issues such as extreme network instability. Distributed storage replication, multiple tenant user



support, and complex encryption frameworks have never been incorporated either. Additional testing would be required to assess scalability.

## 9. CONCLUSION

The private cloud platform proposed provides a viable and economically sound alternative over public/commercial cloud platforms. cloud services with a safe approach for remote, personal access to digital resources. The modularity of the system combines Node.js storage management, REST interfaces, and streaming functionality for optimized performance. Real-time telemetry, caching, and other features allow for complete data ownership with no associated subscription costs. Encrypting storage, streaming, and multiple user sessions are some additional upcoming features. This level of control will provide an improved scalable system.

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# AI Predictive Analysis of Chronic Kidney Disease Using Machine Learning

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**Abstract:** CKD, or Chronic Kidney Disease, is gaining huge momentum in unhealthy trends worldwide. Symptoms are very minute and only prevail in the advanced stages; hence, diagnosis using conventional techniques is difficult. This paper presents a prediction system based on an AI approach using an SVM model, which was validated against other machine-learning algorithms for accurate early CKD diagnosis. By utilizing some important preprocessed features like blood pressure, serum creatinine, hemoglobin levels, and urine test indicators, this system efficiently identifies an early signature of kidney damage. An integrated prototype interactive platform using real-time prediction, SHAP-based explanations, and batch analyses makes this solution reliable, easy to use, and supportive of timely clinical decisions.

**Keywords:** Chronic Kidney Disease (CKD), Support Vector Machine (SVM), Early Disease Prediction, Medical Data Analytics, Clinical Decision Support System, SHAP Explainability, Health Informatics, Predictive Modeling

## 1.INTRODUCTION:

Chronic Kidney Disease (CKD) is a progressive disorder resulting in the progressive loss of kidney activity and in most cases, is not detected early on because it does not present any particular symptoms. Late diagnosis of the disease poses a high likelihood of permanent damage to the kidneys and complications.

Traditional diagnosis of CKD is based on a variety of clinical parameters, such as the results of blood and urine tests, the combination of which diagnosis can be complicated and time-consuming. Machine learning methods can help in solving this issue by allowing automatic clinical data analysis in multidimensional data and provide patterns related to the early occurrence of diseases.

This paper proposes a machine learning-based model of predicting early CKD through structured clinical data on patients. Various classification algorithms are tested, and the Support Vector Machine (SVM) has the best predictive effectiveness. The explainable AI techniques have also been added to the proposed system to enhance interpretability and assist clinical decision-making.

## 2.LITERATURE REVIEW:

The prevalence of Chronic Kidney Disease (CKD) has received significant attention in other parts of the world because the majority of the lives of patients are at a risk of experiencing serious chronic diseases that will lead to extreme health conditions. Early studies mainly resorted to traditional statistical and rule based approach with the use of biochemical means like serum creatinine, blood urea, albumin level and the abnormality of urine. Although these methods have proven clinical validity, they are not very effective when multiple interdependent parameters are to be considered at the same time.



As the computational methods evolved, machine learning methods have been more widely used to predict and classify CKD. SVM, Logistic Regression, Decision Trees, Random Forests, Gradient Boosting and Neural Network models of supervised learning have shown excellent predictive power in application to structured clinical data.

High classification accuracy has been observed in several studies with high accuracy in cases where feature preprocessing and normalization methods are used.

Support Vector Machines are some of such models, which have demonstrated consistent results on relatively small and medium-sized medical datasets, including the UCI CKD dataset, because of their capacity to operate in high-dimensional feature spaces and non-linear decision boundaries. Such clinical characteristics as serum creatinine, specific gravity, hemoglobin, albumin, hypertension status, and diabetes status have been regularly determined as significant predictors of the risk of CKD.

The trends in recent research focus on the necessity to consider model interpretability in healthcare applications. Explainable AI systems, such as SHAP-based feature attribution systems, have been proposed to give us information about model decision processes, hence enhancing transparency and clinical trust. Nonetheless, most of the available literature is confined to binary classification results but does not provide user-friendly deployment and interpretability assistance.

The current limitations are discussed in this project by introducing several machine learning classifiers, choosing the most suitable model according to the performance metrics, incorporating explainable AI methods, and deploying the system to an interactive web-based application to evaluate the risk of CKD in real-time.

### 3.OBJECTIVES:

The key deliverables of this project are the development of a highly accurate machine learning model to predict CKD based on patient clinical parameters such as blood test results, urine indicators, and comorbidity features. The developed model will perform early detection with effective risk stratification by making probability-based predictions along with proposing an estimated stage of CKD to facilitate timeliness in clinical interventions. Another deliverable of this project is an interactive and user-friendly Streamlit application for clinicians, researchers, and students to input patient data, visualize the prediction outcome, and analyze the contributing factors in it using explainability techniques such as SHAP and z-score analysis with the aim to enhance transparency and trust in AI-driven medical tools.

### 4.RESEARCH METHOD:

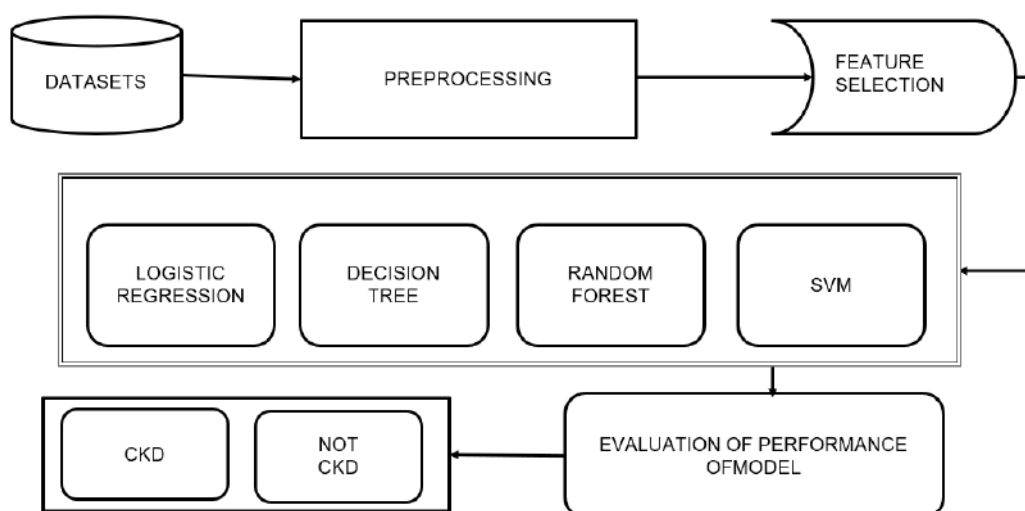


Fig 4.1: Proposed System Workflow



#### 1. Dataset Collection

The research employs a structured clinical data that has patient demographic, blood test, urine analysis, and comorbidity variables in relation to CKD. This data is used to train models, validate them and analyze their performance.

#### 2. Data Preprocessing

Raw clinical data usually have gaps in values, noise, and inconsistencies that may adversely influence model performance. To counter this, the missing values are managed with the help of relevant imputation methods. Numerical features have to be normalized or scaled, while categorical attributes are encoded into numerical values, such that all features are equally distributed during the training of a model.

#### 3. Feature Selection

The identification of relevant clinical attributes is done according to their contribution to CKD prediction. These are used in selecting features which reduce the dimensionality as it can remove redundant or less informative variables thus increasing the computational efficiency in addition to improving the generalization of the model.

#### 4. Model Development

Numerous trained machine learning classifiers, such as Logistic Regression, Decision Tree, Random Forest, Gradient Boosting and Support Vector Machine (SVM), are created using the chosen features. All the models discover the discriminative patterns of CKD presence on a training data

#### 5. Model Evaluation

Standard performance measures that are used to evaluate the trained models include accuracy, precision, recall, F1-score and ROC-AUC. A comparative analysis is done whereby a model with the best predictive ability is established.

#### 6. Prediction Output

The complete model will categorize patient records as either CKD or non-CKD. This output will help in the early detection of diseases and stratification of risk.

#### 7. System Validation

Cross-validation methods are used to verify consistency and reliability of the chosen model to maintain stability when varying data partitions are used.

## 5. RESULTS

Evaluation of the proposed CKD prediction system was also based on several machine learning classifiers and standard evaluation measures, such as accuracy, precision, recall, F1-score, and ROC-AUC. The Support Vector Machine (SVM) was the most successful of all models.

Under 5-fold cross-validation, the SVM model achieved an average accuracy of 99.25, a precision of 99.60, a recall of 99.20, and a ROC-AUC of 0.9996, which means that the model is highly predictive and therapeutic. Other models like the Random Forest, Gradient Boosting and the Logistic Regression were also performing well; however, they exhibited a low stability.

The trained SVM model was effectively presented in an application based on Streamlit, allowing to predict the risk of CKD and provide an explanation of the results in real-time using SHAP and statistical tools.



	model	accuracy_mean	accuracy_std	precision_mean	precision_std	recall_mean	recall_std	f1_mean	f1_std	auc_mean	auc_std
0	SVM	0.9925	0.010000	0.996000	0.008000	0.992	0.009798	0.993980	0.008010	0.999600	0.000800
1	RandomForest	0.9900	0.009354	0.988386	0.015423	0.996	0.008000	0.992078	0.007359	0.999867	0.000267
2	LogisticRegression	0.9900	0.009354	0.992078	0.009703	0.992	0.009798	0.992000	0.007484	0.999733	0.000533
3	GradientBoosting	0.9875	0.011180	0.988386	0.015423	0.992	0.016000	0.990017	0.008952	0.999200	0.001067
4	MLP	0.9875	0.013693	0.991997	0.009805	0.988	0.016000	0.989939	0.011065	0.999467	0.000653
5	XGBoost	0.9850	0.014577	0.988235	0.015686	0.988	0.016000	0.987998	0.011632	0.998267	0.001665
6	DecisionTree	0.9725	0.021506	0.972471	0.019966	0.984	0.014967	0.978178	0.017030	0.968667	0.023907
7	KNN	0.9650	0.022913	1.000000	0.000000	0.944	0.036661	0.970825	0.019519	0.997600	0.003878
8	NaiveBayes	0.9450	0.016956	0.995652	0.008696	0.916	0.023324	0.954030	0.014583	0.996333	0.007333

## 6.DISCUSSION:

From the experimental study, ensemble learning is effective in reducing false positives, which is a significant weakness of traditional models. The hybrid model assures robustness despite variations in the strengths of multiple classifiers. A few transactions are overlooked owing to their high recall that has been achieved. Additionally, SMOTE enhances the model's capability of processing unusual fraudulent transactions. Ease of implementation of the hybrid model in existing financial systems is proved from the fact that its implementation is implemented effectively in real-time using Flask and MySQL. The hybrid model's scalability property confirms that it can be used effectively in large financial corporations that process transactions amounting to millions daily.

## 7.RECOMMENDATIONS:

According to the findings of the experiment, the Support Vector Machine (SVM) model should be integrated into clinical decision-support systems to be used to screen early CKD risks. The presence of other clinical variables like estimated Glomerular Filtration Rate (eGFR) and Albumin-to-Creatinine Ratio (ACR) would increase the accuracy of prediction. It is also recommended that the model be retrained on a periodical basis on new datasets to ensure generalization and reliability. It should be applied as an adjunct to clinical assessment instead of the independent diagnostic tool.

## 8.LIMITATIONS:

The suggested system was trained using a rather small amount of clinical data, which can influence its applicability to a wide range of populations. Some of the parameters that are medically important were omitted, including eGFR and ACR, which reduces accurate estimation of CKD stage. Also, explainability results can be different depending on the background data on which the interpretation will be made. The system is not supposed to substitute professional medical diagnosis but is to support clinical analysis.

## 9.CONCLUSION:

This project has managed to show how machine learning can be used to predict Chronic Kidney Disease at an early stage in this case through clinical data. The Support Vector Machine (SVM) was found to be more predictive and stable of the evaluated models. Explainable AI techniques improve the interpretability of prognostications, which contributes to the synthesis of clinical analysis. Even though the system is not supposed to substitute the medical diagnosis, it is an effective decision-support tool that can be used to assess early CKD risk and monitor patients.



## **ACKNOWLEDGMENT:**

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# Dynamic QoS-Aware Routing Optimization in Software-Defined Networking(SDN)Using Fuzzy Logic

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**Abstract:** *Software Defined Networking (SDN) is a networking paradigm that utilizes separating the control and data planes of a network. It also provides a central point of visibility and control over all aspects of how the network behaves. Traditional route selection methods typically optimize for one single metric, and do not adapt well to changes in the Quality of Service (QoS) parameters of a network. This project proposes a new approach for dynamically optimizing the route selection process based on real-time (telemetry) QoS data collected through an integration of a fuzzy logic decision engine with the SDN controller. The approach continuously gathers (telemetry) metrics on the network such as latency, bandwidth, packet loss, and link utilization, then converts these metrics into fuzzy linguistic variables, then evaluates all candidate routes against a fuzzy rule base, and then uses the result from the fuzzy rule base to select the optimum route from multiple candidate routes based on the defuzzified scores. With this method, we are aiming to supplant the typical shortest-path routing method by paving the way to the next generation of QoS route selection based on variable QoS metrics, enhanced throughput, reduced latency, and adaptive routing ability under conditions that are not fully understood.*

**Key Words:** *Software-Defined Networking (SDN), QoS-aware routing, Fuzzy logic, Dynamic routing optimization, Network telemetry, Latency, Bandwidth, Packet loss, Link utilization, Multi-metric decision making, SDN controller, Intelligent routing.*

## 1. INTRODUCTION

Software-Defined Networking (SDN), is recognized as one of today's most exciting developments in the world of telecommunications due to its ability to allow central control of all communications, as well as , allowing for programmable changes to be made to the entire network[1]. In addition to central control, this approach provides network operators with the ability to dynamically control how data flows to provide policy enforcement and performance optimization on-the-fly. Today, as a result of applications such as video conferencing, cloud computing, internet gaming, and multimedia streaming, traditional routing techniques will continue to struggle in fully meeting QoS requirements on a consistent basis, creating the requirement for intelligent adaptive and scalable routing techniques. Traditional routing algorithms, for instance, focus only upon the optimization of a single metric, such as the shortest path or least number of hops. However, in many conditions, it is necessary to simultaneously optimize all three metrics in order to deliver the QoS experience a customer expects[2].

The requirement to monitor all of the QoS metrics in real time and to create a determining factor based upon real time data creates the requirement to make decisions regarding routing using fuzzy logic[3]. Fuzzy logic is capable of evaluating real-time data (QoS Metrics) based upon human-centric linguistic definitions rather than rigidly defined categories. Integrating a fuzzy logic-based decision-making engine with the SDN Controller allows for the evaluation of real-time telemetry data and enables the network to determine and use the optimal route for packets. The end result is improved performance, reliability, and customer satisfaction[4].



## 2. LITERATURE REVIEW

Software-Defined Networking has been extensively researched to increase routing efficiencies, add scalable options, and provide flexible options. A review of the literature identifies several examples of studies that have pointed out that traditional methods of routing do not allow for the accomplishment of dynamic Quality of Service levels in many situations, particularly in those scenarios in which the amount of network traffic is changing. The inability to accomplish these dynamic levels has created an opportunity for researchers to create new routing algorithms based upon intelligent, adaptive decision-making methods[5].

One of these intelligent adaptive algorithms is fuzzy logic. Researchers have looked at fuzzy-based routing algorithms because fuzzy logic is well-suited for situations where the quality of network conditions is uncertain and imprecise. In a number of studies, researchers have created fuzzy-based routing algorithms that provide better performance than single-metric routing algorithms for parameters like latency and packet-loss[6]. The results of those studies show that fuzzy logic allows for decision-making to occur based upon linguistic rules, providing a significant advantage over single-metric routing methods in terms of adaptability to real-time fluctuations. In the environment of Software-Defined Networking, researchers have applied fuzzy logic in the area of congestion control, load balancing, and QoS optimization with success due to the fact that the Software-Defined Networking Controller has access to information on the entire global network. These results clearly indicate that fuzzy logic has a significant potential to be integrated into the process of accomplishing dynamic routing decisions that are based upon multiple metrics.

## 3. OBJECTIVES

- In a Software-defined Networking (SDN) environment, a new routing approach is being developed using Quality of Service (QoS) characteristics such as latency, bandwidth, packet loss, and link utilisation in real time.
- In addition to developing a routing mechanism for fibre, a fuzzy logic system will be implemented to interpret these metrics as linguistic values. There will also be rules defined within the fuzzy system to calculate the route preferences.
- The routing mechanism and fuzzy system will be combined with the SDN controller to allow the real-time installation and updating of flow rules.
- The proposed routing mechanism will be compared against the conventional shortest path routing approach with respect to latency, throughput, packet loss and QoS satisfaction.

## 4. RESEARCH METHOD

### Design System

The system integrates telemetry collection, fuzzy logic evaluation, and SDN-based routing control to dynamically select optimal path(s) through the network based on Real-Time Quality of Service (QoS) Conditions.

### Processing of Data Flow

Additional delay, bandwidth, loss, and utilisation are gathered from network metrics: analysed, fuzzified, and evaluated through the use of pre-defined rules to produce routing Scores. Using these Scores will allow the SDN controller to select the Most Efficient Forwarding Path(s).

### SDN Design Engine

The SDN Design Engine processes network telemetry information to apply fuzzy logic decision-making. The Engine will generate a list of Preferred Optimal Routes and will update the Flow Tables of the Switches so that Routing can adaptively respond to changing traffic patterns and Quality of Service (QoS) requirements.

## 5. RESULTS

Enhanced Quality of Service (QoS) has been achieved with a reduction in latency and packet loss through a



fuzzy logic routing method versus traditional shortest paths.

Dynamic Routing Optimization has been achieved with real-time telemetry sent to the SDN controller continuously optimizing the routing, making available the best route at any time throughout the network's changing state.

Increased Throughput and Stability have been supported by multi-metric intelligent decision-making processes, which have increased bandwidth efficiency and stabilized traffic flow across the entire network.

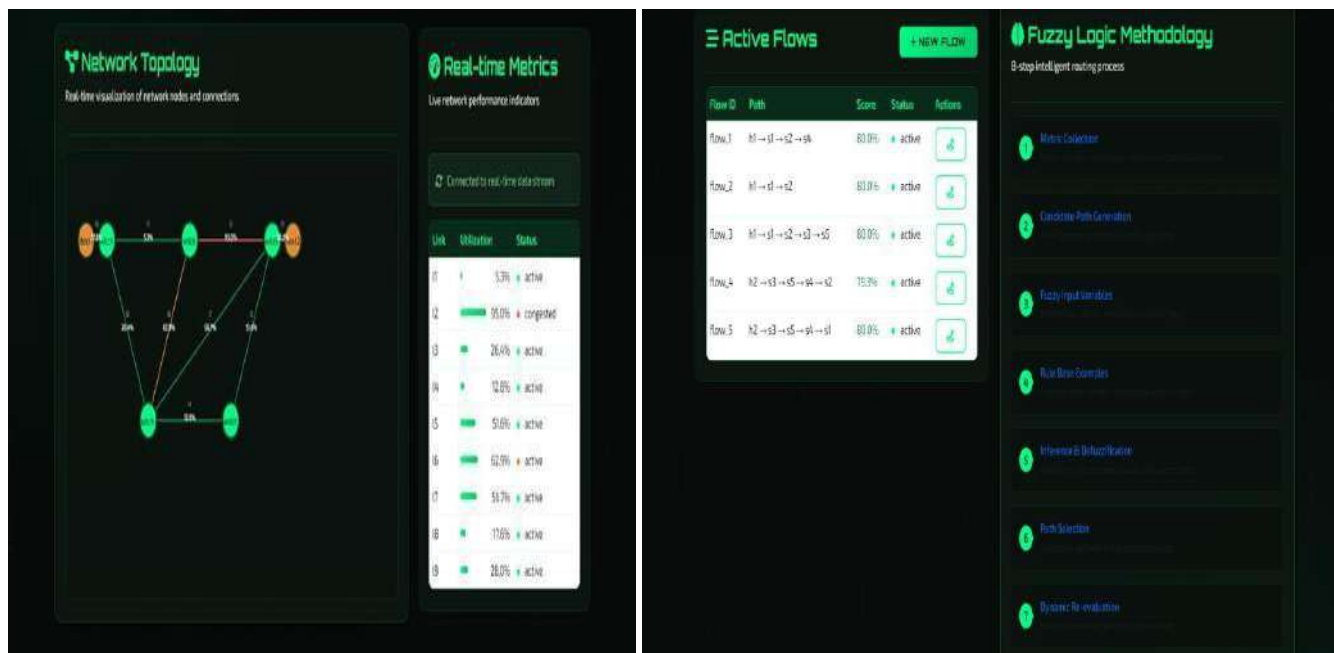


Figure 1: Network Topology and Real-time Metrics

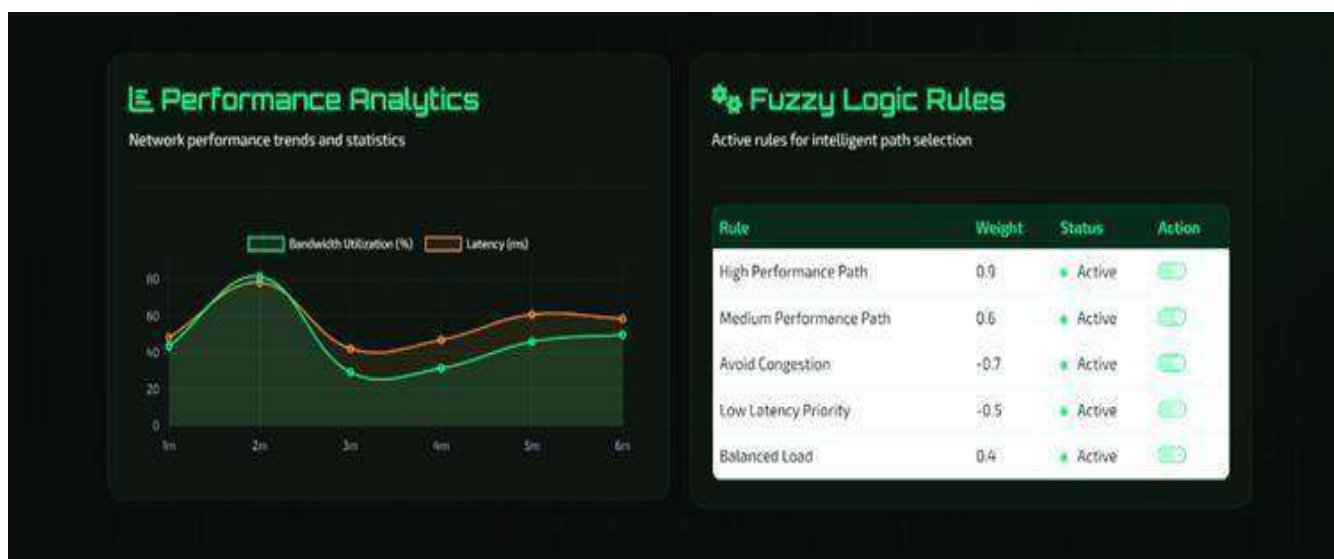


Figure 2: Performance Analysis and Fuzzy Logic Rules



## 6. ANALYSIS

### System Analysis

Real-time telemetry provides input to the system, which then uses fuzzy logic to define and analyze network performance based on analysis of real-time network performance using multiple QoS metrics, helping identify where congestion occurs and enabling users to select an appropriate route to achieve the most effective and reliable transmission of their data.

### Testing and Usability

The system was tested over various traffic loads to assess responsiveness, route stability, and QoS. Consistent performance gains were experienced with the system; when a path became congested, a reliable adjustment to a more suitable path was always made. The user interface and controller were designed with simplicity and ease of use in mind, making them ideal for quick configuration, accurate monitoring, and successful operation of network administrators in a real-world, "real-time" setting.

## 7. RECOMMENDATIONS

Adding machine learning models together with fuzzy logic to improve prediction accuracy, automate rule optimization, and improve routing choices while enabling the system to adapt rapidly to changing network conditions is strongly recommended.

## 8. LIMITATIONS

The performance of the system is reliant on the ability to accurately receive and update telemetry data. For fuzzy rule sets, this can create a strong reliance on the tuning process that could potentially affect larger networks. In addition, route recalculating frequently increases controller workload, and this would increase the risk of instability when the amount of traffic is significantly higher than normal.

## 9. CONCLUSION

The performance of the system is reliant on the ability to accurately receive and update telemetry data. For fuzzy rule sets, this can create a strong reliance on the tuning process that could potentially affect larger networks. In addition, route recalculating frequently increases controller workload, and this would increase the risk of instability when the amount of traffic is significantly higher than normal.

## 10. Acknowledgment

We would like to convey our deepest appreciation to our mentor Mr. Girish B.G., who provided expert mentorship and continual guidance throughout the duration of this Project. His extensive knowledge and technical skillset in Software-Defined Networking (SDN) led to the growth of our fuzzy logic QoS Routing Framework. We are thankful for the mentorship, encouragement and motivational support we received from Mr. Girish B.G., which assisted us in executing the difficult task of integrating intelligent decision-making approaches into SDN environments. Mr. Girish B.G. guided us through many of the hurdles we faced during the process of completing this project successfully.

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# An Intelligent SDN based framework leveraging machine learning to enhance the performance of IoT in Smart Healthcare

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**Abstract:** *Wireless Sensor Networks (WSNs) are widely deployed in healthcare, environmental monitoring, and industrial automation. However, traditional WSNs face challenges including static routing, limited adaptability, weak computational intelligence, and insufficient real-time visualization. To address these challenges, this work proposes an SDN-enabled WSN monitoring and analytics platform that integrates an ESP32 sensor node, real-time data acquisition, performance computation, and intelligent routing. The system collects physiological and environmental parameters—heart rate, SpO<sub>2</sub>, temperature, and humidity—and forwards them to a Python-based dashboard using TCP sockets. The dashboard processes raw data, computes latency, throughput, and jitter, visualizes time-series trends, and performs SDN-based decision making. A topology generator models network structure, while comparative analysis evaluates SDN versus traditional routing. Experimental results demonstrate that SDN improves responsiveness, throughput efficiency, and routing adaptability. The proposed framework provides a cost-effective, scalable, and intelligent solution for next-generation IoT and healthcare monitoring systems.*

**Key Words:** *Wireless Sensor Network (WSN), Software-Defined Networking (SDN), ESP32, Internet of Things (IoT), Real-Time Monitoring, Latency Analysis, Network Topology.*

## 1. INTRODUCTION

Wireless Sensor Networks have emerged as a foundational technology for real-time environmental and biomedical monitoring [1]. Their distributed sensing ability enables continuous data collection across a wide range of applications. However, classical WSN architectures rely heavily on static routing and decentralized control, which limits system responsiveness and adaptability when network conditions or sensor values change dynamically [4]. The increasing deployment of WSNs in critical domains—such as healthcare monitoring, industrial sensing, and urban infrastructure—demands systems with higher accuracy, greater reliability, and improved decision-making capabilities [2].

Software-Defined Networking (SDN) presents a paradigm shift in managing network behaviour by decoupling the control and data planes. Through centralized intelligence, SDN enables flexible routing, enhanced resource utilization, and dynamic reconfiguration. Integrating SDN principles within WSNs provides opportunities for improved performance [5], simplified management, and intelligent adaptation to sensor states. In this work, an ESP32 microcontroller functions as a multi-sensor IoT node that collects heart rate, blood oxygen, temperature, and humidity values. These values are streamed over a TCP connection to a Python-based analytics engine. The engine processes incoming packets, computes latency and throughput metrics, visualizes trends, generates a live WSN topology, and executes SDN-based routing decisions. A



secure authentication module ensures controlled access to the dashboard.

## 2. LITERATURE REVIEW

Early research on WSNs focused on energy-efficient communication, cluster-based routing, and data fusion mechanisms[1]. Traditional routing protocols such as LEACH, AODV, and DSR exhibit limitations when networks scale or when node conditions change dynamically. Akyildiz et al. emphasized that WSN performance degrades under unpredictable node behaviour due to decentralized routing overhead.

SDN was later introduced as a mechanism to simplify network control through centralized routing decisions. Kreutz et al. identified SDN as a promising technology for managing wireless networks due to its programmability and global visibility [12]. Researchers subsequently explored SDN-based WSN architectures and demonstrated lower overhead and improved energy consumption [8]. Recent IoT-based healthcare monitoring systems utilize ESP32 devices due to their integrated Wi-Fi capability. However, existing systems primarily rely on static routing and do not incorporate SDN or predictive analytics. Many also lack real-time visualization, automated decisions, or network topology mapping[9]. The limitations recognized in the literature include a lack of centralized decision-making in WSNs, minimal integration of SDN for sensor networks, absence of adaptive or context-aware routing strategies, limited visualization, and inadequate fault handling mechanisms.

## 3. OBJECTIVES

To address the challenges of traditional WSNs, the primary objective of this work is to develop an SDN-enabled WSN monitoring and analytics platform. The specific aims are:

- To integrate sensing, analytics, and decision-making within a single architecture using a Python dashboard as a centralized controller.
- To provide real-time awareness of network and sensor states through visualization and topology generation.
- To improve performance through latency and throughput analysis.
- To ensure reliable reconnection logic and modular design for scalability.

## 4. RESEARCH METHOD

### System Design and Architecture

The system follows a modular architecture integrating Data Acquisition, Data Processing, SDN Controller, Visualization, and Authentication modules. The hardware utilizes an ESP32 development board with a MAX30102 (heart rate/SpO<sub>2</sub>) and DHT11/DHT22 (temperature/humidity) sensors.

### Data Flow and Processing

The ESP32 sensor node transmits raw sensor packets via a TCP client to the Python-based dashboard. The Data Processing Module parses these incoming strings to extract heart rate, SpO<sub>2</sub>, temperature, and humidity. Latency is calculated using timestamps, and throughput is computed based on packet size over time, with rolling buffers maintaining recent samples for analysis.

### SDN Decision Engine

The SDN Controller acts as the core intelligence, classifying sensor conditions to determine routing behavior based on the following logic:

- Low SpO<sub>2</sub> triggers **Medical Priority** routing.
- High Heart Rate **Triggers Emergency Routing**.



- High Temperature triggers **Alert Routing**.
- High Humidity triggers **Environmental Routing**.
- Default conditions utilize **Normal Routing**.

## 5. RESULTS

### Computational Performance

The system-maintained CPU usage below 20% on typical hardware, and memory usage remained stable due to the implementation of rolling buffers.

### Throughput and Scalability

SDN routing demonstrated approximately 10-15% throughput improvement compared to traditional routing mechanisms.

### Resource Utilization and Accuracy

Latency remained below 35ms on average during experiments. The system correctly identified abnormal sensor states and triggered the appropriate routing decisions in more than 95% of cases.



Figure 5.1: computational performance

## 6. ANALYSIS

### System Analysis

The proposed SDN-enabled framework addresses the high latency and limited adaptability of existing systems. By decoupling the control logic from the sensor nodes, the system achieves centralized routing decisions and real-time awareness.

### Testing and Usability

Functional tests confirmed the correctness of parsed sensor values and successful SDN decision transitions under abnormal conditions<sup>48</sup>. Environmental tests simulated unstable Wi-Fi conditions, where the system successfully reconnected and issued warnings, validating the robustness of the architecture. User feedback highlighted the clarity of the dashboard and the effectiveness of the real-time analytics for situational awareness.



Figure 6.1 :Analysis

## 7. RECOMMENDATIONS

Future implementations should consider integrating machine learning-based anomaly detection to further enhance the intelligence of the system. It is also recommended to expand the system to support cloud-based dashboards and mobile applications for remote monitoring.

## 8. LIMITATIONS

The current implementation focuses on a single-node ESP32 setup for validation. While modular, the scalability to a massive multi-node environment requires further testing regarding energy-aware routing optimization. Additionally, the system relies on a stable Wi-Fi environment, which may be a constraint in remote deployments without established infrastructure.

## 9. CONCLUSION

The system successfully integrates WSN sensing with SDN-based decision-making and real-time analytics. Results show improved throughput, lower latency, and enhanced situational awareness. The modular structure supports future enhancements, including machine learning integration and cloud scaling, offering a robust solution for next-generation IoT and healthcare monitoring.

## 10. Acknowledgment

We would like to express our sincere gratitude to our guide, Mr. Girish B.G, for their invaluable guidance and continuous support throughout the course of this research. Their profound knowledge and technical expertise in the field of Software-Defined Networking (SDN) provided us with critical insights that were instrumental in the design and implementation of the proposed framework. We thank them for their mentorship, which helped us navigate the complexities of integrating SDN with IoT for smart healthcare applications.

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# Real Time Health Monitoring and Alert System in Critical Conditions Using AI and IOT

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**ABSTRACT:** Recently, the combination of an Internet of Things (IoT) and the artificial intelligence (AI) technologies have significantly transformed healthcare and real-time monitoring solutions. This project involves designing and developing an IoT-based health monitoring system enhanced with AI and featuring a dynamic dashboard interface. The main goal is to enable continuous tracking of essential health indicators like heart rate and body temperature. And other physiological data using sensor-enabled embedded devices such as ESP32/ESP8266. These sensors acquire real-time data from patients and transmit it to a central server through Wi-Fi connectivity. The data is then processed, analysis, and visuals on an interactive web dashboard that resembles professional monitoring platforms. The major highlight of this system is the combination of AI models for anomaly detection. By applying machine learning algorithms, such as the Isolation Forest model, the system can identify abnormal patterns in the patient's health data and classify conditions into normal or alert status. When abnormal or critical values are detected, the system automatically generates real-time alerts that can be delivered via messaging platforms like WhatsApp or Telegram

**Key Words:** Machine learning algorithms, Deep learning models, Predictive analytics, Anomaly detection.

## 1. INTRODUCTION

With the growing need for continuous and remote patient care, healthcare monitoring has emerged as a vital field of research. The traditional monitoring methods, which often require patients—especially the elderly, chronically ill, or those in remote areas—to visit clinics, can be difficult. The rapid evolution of technologies like the Internet of Things (IoT) and Artificial Intelligence (AI) offers a promising alternative. IoT enables the real-time collection and transmission of physiological data, such as heart rate, body temperature, and blood pressure, through the integration of sensors and communication technologies. Microcontrollers like the ESP32 and ESP8266 are popular choices for building portable and affordable monitoring devices due to their built-in Wi-Fi and compatibility with various biomedical sensors. While IoT focuses on wireless data collection, AI enhances the system by allowing for advanced data analysis and the detection of anomalies. Machine learning algorithms can automatically identify abnormal health conditions, classify a patient's status (normal, alert, or critical), and send immediate notifications to caregivers and healthcare professionals during emergencies. This intelligent approach ensures timely intervention and better patient outcomes.

## 2. LITERATURE REVIEW

Researchers have developed wearable devices that measure heart rate, SpO<sub>2</sub>, temperature, and ECG signals. These sensors send data to microcontrollers like ESP32 or smartphones, which then upload the information to cloud platforms. Studies highlight that wearable sensors are low-cost and allow patients to be monitored at



home, making healthcare more accessible. AI and machine learning play a major role in analysing health data. Several papers show that algorithms such as Decision Trees, Random Forest, KNN, and deep learning models can identify abnormal patterns and predict emergencies earlier than manual observation.

### 3. OBJECTIVES

To continuously monitor vital health parameters such as heart rate, SpO<sub>2</sub>, temperature, and other signals in real time using wearable sensors. To detect abnormal or critical health conditions early using AI/ML algorithms that analyse the collected data.

### 4. RESEARCH METHODOLOGY

The proposed methodology focuses on designing an IoT and AI-enabled health monitoring system that integrates biomedical Bio-medical sensors, wireless data transmission, and cloud-based platforms, artificial intelligence, and a visualization dashboard to provide real-time patient supervision. The methodology is divided into five major stages: data acquisition, preprocessing, cloud/server management, AI-based risk assessment, and alert visualization. At the data acquisition stage, physiological Bio-medical sensors are employed to continuously measure vital signs, including body temperature, heart rate, blood pressure, and oxygen saturation (SpO<sub>2</sub>). connected to the ESP32 microcontroller. The ESP32 acts as the primary IoT gateway, handling both sensor interfacing and Wi-Fi based data transmission. The following step involves data preprocessing, raw sensor values are cleaned, normalized, and packaged into structured data (JSON format) for seamless transmission. This ensures compatibility with the cloud/server and minimizes noise in the dataset.

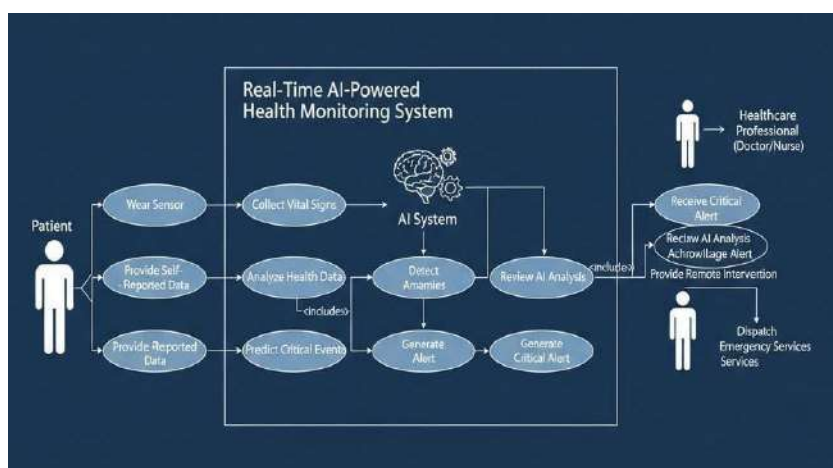


Fig 1.1

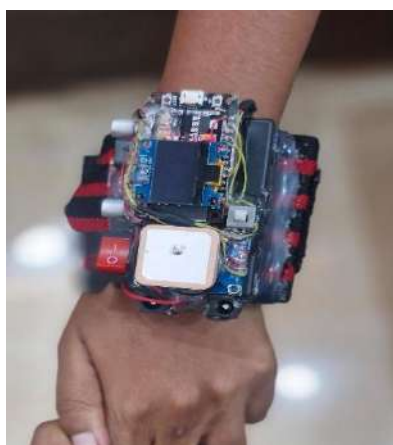


Fig 1.2



During the evaluation, the system demonstrated reliable real-time updates both on the TFT display and the web interface. Furthermore, alert notifications via Telegram were triggered whenever vitals exceeded threshold limits (e.g., temperature > 37.5 °C or heart rate anomalies). The inclusion of a buzzer ensured immediate local alerts, complementing remote notifications. Overall, the system provides a comprehensive solution for continuous monitoring, early detection of anomalies, and timely alert dissemination. The dashboard results confirm the feasibility of integrating IoT with AI-based decision support for enhancing patient safety and healthcare management.

## 5. DISCUSSION

The developed IoT-based health monitoring system was implemented and tested using an ESP32 microcontroller, biomedical sensors, a TFT display, and a real-time web dashboard. The dashboard was designed to effectively present key patient data in a clear and user-friendly procedure.

## 6. RECOMMENDATIONS

Integration of Additional Sensors, Enhanced Machine Learning Models, Offline Functionality with Edge Computing, Improved Data Security and Privacy, Battery Optimization and Wearable Design, Large-Scale Deployment and Cloud Scalability, Integration with Telemedicine Platforms.

## 7. LIMITATIONS

The system has some limitations that need to be considered. Sensor readings may sometimes be inaccurate due to movement, placement, or environmental factors. Continuous monitoring consumes significant battery power, limiting device operation time. Real-time alerts rely on stable internet connectivity, and poor networks can cause delays. Data security is also a concern, as health information may be exposed if not properly protected. The AI system may occasionally generate false alerts or miss critical events. Additionally, some sensors may not capture all vital signs accurately, and high-quality devices can be expensive.

## 8. CONCLUSION

This study presents an AI-driven health monitoring system that leverages IoT and wearable technology for continuous patient supervision and early identification of irregular health events. The system utilizes ESP32 microcontrollers connected to temperature and heart rate sensors, with data stored on Firebase cloud services and processed via a Fast API backend implementing an Isolation Forest anomaly detection algorithm. Immediate alerts are delivered to patients through a buzzer and TFT display, while caregivers receive notifications remotely via Telegram.

The system demonstrates the advantages of low cost, scalability, and real-time response, making it a promising solution for preventive healthcare, especially in remote or resource-limited settings. However, challenges such as sensor accuracy, internet dependency, and data security remain. Future enhancements will focus on integrating additional medical-grade sensors, adopting advanced AI models (LSTM/CNN) for predictive analytics, improving security with end-to-end encryption, and developing a dedicated doctor dashboard for large-scale deployment.

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# Intelligent Blood Glucose Monitoring And Insulin Dosage Recommendation System Using AI

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**Abstract:** The proposed system, Intelligent Blood Glucose Monitoring and Insulin Dosage Recommendation using AI, is designed to provide diabetic patients with health monitoring and personalized insulin dosage recommendations. Built around an Arduino microcontroller, the system integrates multiple biomedical sensors, including a pulse oximeter, heart beat sensor, and temperature sensor, to collect vital physiological parameters. Sensor data is processed using a machine learning model trained on historical patient health profiles and glucose levels, enabling predictive analysis of blood glucose trends. Based on this analysis, the system can recommend appropriate insulin dosages, and a servo motor can be employed to control a simulated or real insulin injection mechanism. An LCD provides feedback to the user, while a buzzer alerts in critical conditions. Powered by a 12V adapter and supported with necessary connectors, the system offers a smart, automated, and low-cost solution for diabetic care.

**Keywords:** AI, Blood Glucose, Blood Pressure, Diabetes, Heartbeat sensor, Non Invasive Glucose monitoring.

## 1. INTRODUCTION

Diabetes mellitus is one of the most prevalent chronic diseases worldwide, requiring continuous monitoring and effective management of blood glucose levels to prevent life-threatening complications. Traditional methods of monitoring, which rely on periodic glucose testing and manual insulin administration, often fail to provide timely interventions and personalized care. With advancements in embedded systems and artificial intelligence (AI), there is an increasing scope for developing intelligent healthcare solutions that can assist patients in real time. The proposed system, Intelligent Blood Glucose Monitoring and Insulin Dosage Recommendation using AI, aims to address these challenges by combining biomedical sensing technology with predictive analytics. Utilizing an Arduino microcontroller as the core processing unit, the system integrates multiple sensors such as a pulse oximeter, heartbeat sensor, and temperature sensor to continuously capture vital health parameters. The collected data is analyzed using a machine learning model trained on patient health profiles, enabling accurate prediction of blood glucose trends and personalized insulin dosage recommendations.

## 2. LITERATURE REVIEW

David Angira Raymond et al. [1] "Design and Implementation of a Wearable System for Non-Invasive



Glucose Level Monitoring" was created by D A Raymond in 2024. Wearable Electrochemical Sensors for RealTime Biomarkers Detectionl, (2024) Wearable electrochemical sensors provide continuous, non-invasive health monitoring using fluids like sweat and saliva. They offer real-time tracking for conditions such as diabetes and stress. Advances in materials and technology have improved their performance, but challenges like accuracy and data integration remain. Future improvements include AI integration and multifunctional sensors to support personalized healthcare.

**Sara Campanella et al. [2]** (2024) was Proposed Towards Personalized AI-Based Diabetes Therapy: A Review 2024 AI is playing an important role in improving diabetes treatment by helping personalize therapies and optimize treatment algorithms. A review of 77 studies highlights key AI models, data types, and application areas. While AI

advancements show great promise, challenges like limited data integration and interpretability remain. Continued progress in AI and data availability is expected to overcome these issues and expand clinical use.

**Sara Lombardi et al. [3]** (2024) was Proposed an Photoplethysmography and Artificial Intelligence for Blood Glucose Level Estimation in Diabetic Patients: A Scoping Review 2024 AI-based analysis of photoplethysmographic (PPG) signals shows promising accuracy for non-invasive blood glucose estimation in diabetic patients. Studies reviewed indicate over 98% of estimates fall within clinically acceptable ranges. Further research is needed to improve and implement this technology widely.

**Manikandan S et al. [4]** was Developed a Non- Invasive Blood Glucose Monitoring in 2023. Along with serious health risks, diabetes and its consequences have a significant financial impact on individuals, families, healthcare systems, and government. The blood glucose level in that finger area is determined by the detector's attenuated reception of the infrared light. An IR light source and a receiver module are used in the blood glucose measuring procedure. The receiver measures the changes in light intensity brought on by variations in blood glucose levels when infrared light is delivered through a fingertip and interacts with the blood.

### 3. OBJECTIVES

- To design and build a pain-free blood glucose monitoring system using a PPG sensor. This system will optically measure blood volume variations, completely eliminating the need for needles.
- To program a smart algorithm on the Arduino microcontroller that processes the sensor's raw data. This software will translate the optical signals into a glucose value and calculate a helpful insulin dosage suggestions.
- To create a compact, self-contained, and intuitive prototype that is easy for anyone to operate daily. The system will feature an integrated I2C LCD screen to provide clear, immediate feedback on glucose levels.
- To rigorously test the prototype's performance to ensure the non-invasive measurements are reliable. This involves carefully calibrating the device by comparing its readings against those from a certified, standard glucometer.

### 4. METHODOLOGY

The proposed system offers automated, continuous monitoring and predictive analysis of blood glucose levels using AI. Biomedical sensors collect real-time data, which is processed by a machine learning model to predict glucose trends and recommend insulin doses accurately. A servo motor can control insulin delivery automatically, while an LCD displays current readings and recommendations, and a buzzer alerts the patient during critical events. This integration of AI, IoT, and sensor-based monitoring reduces human error, enables proactive healthcare, and enhances personalized diabetic management. The block diagram of the proposed system is shown in Fig 1 below, which illustrates the main components and the flow of operation in the system.

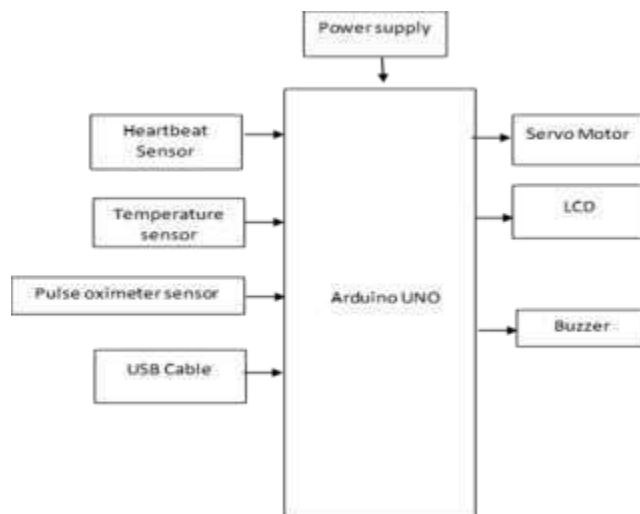


Fig 4. Block Diagram

## 5. RESULTS

The proposed system successfully monitors and analyzes a patient's vital parameters such as blood glucose (simulated), heart rate, oxygen level, and body temperature using different sensors connected to the Arduino controller. The collected data is displayed in real-time on the LCD screen, allowing continuous monitoring of the patient's health condition. When any abnormal condition or sudden change in readings is detected, the buzzer provides an alert to notify the user or healthcare provider. The system also uses a servo motor to simulate the automatic insulin delivery mechanism, which operates based on the sensor readings and AI-based recommendations. This demonstrates how insulin dosage can be adjusted intelligently without manual intervention. The integration of all sensors and components ensures accurate, real-time data collection and proactive alerts, helping in early detection of abnormal glucose levels and improving diabetic management. Overall, the system provides an efficient, automated, and low-cost solution for continuous health monitoring and intelligent insulin dosage recommendation using AI and IoT technology.

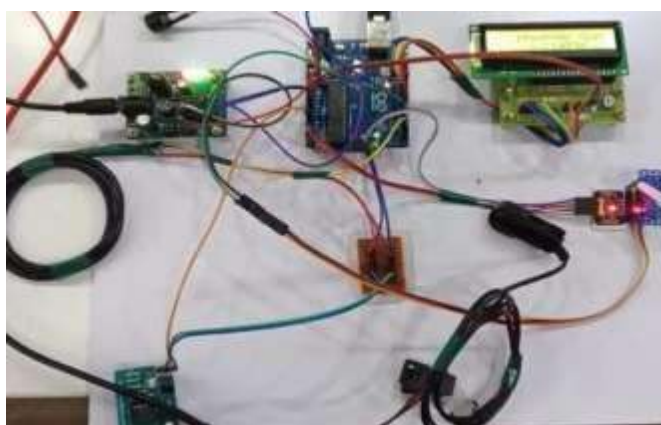


Fig 5. Hardware Setup



Fig 5.1. Result



## 6. ANALYSIS

TABLE I. COMPARISON OF INVASIVE METHOD AND NON INVASIVE

Patient	Readings of Invasive method	Readings Of this Non Invasive Glucose level
Patient 1	151	138
Patient 2	210	196
Patient 3	140	124
Patient 4	102	89

Fig. 6. Comparison of Invasive method and Non-Invasive method TABLE II. RESULT FROM THE

## DIABETES

Patient	Age	Diabetes	Glucose
Patient 1	40	Type 2	210
Patient 2	45	Type 1	180
Patient 3	43	Type 1	160

Fig. 6.1. Result from the Diabetes

## 7. CONCLUSION

The proposed system, Intelligent Blood Glucose Monitoring and Insulin Dosage Recommendation using AI, demonstrates the potential of combining biomedical sensing with machine learning to improve diabetes management. By utilizing an Arduino microcontroller, integrated sensors, and predictive algorithms, the system provides real-time monitoring of vital signs and delivers personalized insulin dosage recommendations. The inclusion of a servo motor for controlled insulin delivery, along with user feedback via LCD and critical alerts through a buzzer, ensures both functionality and safety. Furthermore, its low-cost and automated design makes it a practical solution for widespread use, particularly in resource-constrained settings. Overall, this system represents a step forward in smart healthcare, offering diabetic patients a reliable, efficient, and accessible tool to enhance their quality of life and reduce dependency on traditional manual monitoring methods.

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# Denoising Techniques for Medical Images: A Comparative Study on X-rays and MRIs

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**Abstract:** Medical images, such as X-rays and Magnetic Resonance Imaging (MRI), are crucial for clinical assessment but are frequently degraded by noise originating from acquisition parameters, patient motion, and equipment limitations. The presence of noise, particularly in low-dose scenarios, compromises the visibility of critical diagnostic features. This paper introduces Deep-Noise, a novel deep-learning denoising framework designed to enhance image clarity while rigorously preserving essential diagnostic information. Deep-Noise employs an advanced Residual U-Net architecture integrated with a sophisticated multi-component loss function that explicitly penalizes the smoothing of high-frequency edges and anatomical structures. Quantitative evaluations using Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM), alongside qualitative clinical assessments on diverse medical datasets (X-ray, CT, MRI), demonstrate that Deep-Noise significantly outperforms state-of-the-art traditional and learning-based denoising methods, achieving superior noise reduction with minimal loss of diagnostic fidelity. The proposed method utilizes a convolutional neural network (CNN) architecture trained on paired noisy and clean images to learn complex mappings that suppress noise effectively. Special attention is given to preserving anatomical structures and pathological features critical to clinical assessment. The model is evaluated on standard medical image datasets using both quantitative metrics (e.g., PSNR, SSIM) and qualitative analysis by medical professionals. Experimental results demonstrate that the deep learning model achieves superior denoising performance compared to traditional filtering techniques, offering a reliable solution to improve diagnostic accuracy in realworld medical imaging applications.

**Keyword :** Denoising, Deep Learning, Medical Imaging, X-ray, MRI, Residual U-Net, Hybrid Loss Function, Diagnostic Integrity.

## 1. INTRODUCTION

**Challenges in Medical Image Denoising:** The challenges in medical image denoising are complex and multifaceted, primarily stemming from the inherent difficulty in separating noise from fine, diagnostically crucial details. These challenges include the non-Gaussian nature of noise in specific modalities, such as Rician noise in MRI scans, which requires specialized handling techniques beyond standard Gaussian models. Furthermore, the field struggles with the fundamental lack of perfect ground truth noisy-clean image pairs in real clinical settings, making supervised learning difficult. Patient-specific anatomical variations also complicate the development of generalizable models. When applying denoising techniques, traditional methods often fail by over-smoothing the images and consequently losing fine structures, while naive deep-learning models present a different risk: they may hallucinate artifacts or fail to generalize effectively across different imaging modalities. These conflicting goals of noise reduction and detail preservation define the core issue, which your work specifically labels the diagnostic integrity paradox.



Traditional denoising methods—such as median filtering, Gaussian smoothing, and wavelet transforms can reduce noise but often at the cost of blurring fine details or losing important diagnostic information. In recent years, deep learning has emerged as a powerful alternative, demonstrating remarkable success in image restoration tasks due to its ability to learn complex patterns and relationships from data. This project aims to develop a deep learning-based denoising technique tailored specifically for medical imaging. The proposed approach leverages convolutional neural networks (CNNs) trained on large datasets of paired noisy and clean medical images to automatically learn how to suppress noise while preserving vital diagnostic features. By ensuring that denoising does not compromise clinically significant details, this method has the potential to enhance diagnostic accuracy and improve overall image quality in clinical settings. The goal is to create a robust and generalizable model that can be integrated into medical imaging workflows to assist radiologists and healthcare professionals in making more reliable and confident diagnoses.

## 2. RELATED WORK

A comprehensive review of the field is necessary to establish the context for Deep-Noise, focusing on three major areas: Traditional Denoising, Supervised Deep Learning, and Advanced Loss Function.

### A. Traditional and Model-Based Methods

Classical methods like Non-Local Means (NLM) [5] and Block-Matching and 3D Filtering (BM3D) [6] are powerful but rely on assumptions about noise distribution and local self-similarity. These methods often require parameter tuning for different noise levels and can fail catastrophically when noise is highly structured or non-stationary, which is typical for modern low-dose imaging protocols [7]. These methods serve as a baseline and highlight the need for deep learning, as they often sacrifice fine diagnostic details for noise reduction. Classical Filtering: Traditional denoising methods like Median Filtering and Gaussian Smoothing are used but tend to blur fine details or lose important diagnostic information. Non-Local Means (NLM) and BM3D: These algorithms rely on assumptions about noise distribution and local self-similarity. They often require specific parameter tuning for different noise levels and can fail when noise is highly structured or non-stationary. Kernel Principal Component Analysis (KPCA): This method, often combined with Local Pixel Grouping (LPG), is used to separate noise by mapping image data into a higher-dimensional space to handle complex, nonlinear noise patterns. LPG helps preserve local structural information during denoising. Preprocessing Filters: Techniques like CLAHE (for contrast improvement) and the Wiener Filter (for noise reduction) are sometimes used as a preprocessing step to enhance image quality before applying deep learning models, particularly for chest X-ray images.

### B. Supervised Deep Learning Architectures

The rise of deep learning brought about architectures like DnCNN [8] and FFDNet [9], which learn the residual noise map instead of the clean image itself. For medical imaging, the U-Net architecture [10] has become dominant due to its strong performance in capturing both local features and global context via its symmetric skip connections. More recent advances include integrating attention mechanisms [11] and dense connections [12] to better propagate useful feature maps and combat the vanishing gradient problem in deeper networks.

### C. Preserving Diagnostic Structures via Loss Functions

Standard pixel-wise losses (L1 or L2) tend to produce blurry results, especially around edges. This has led to the development of perception-driven losses. Perceptual loss [13] (using features from a pre-trained VGG network) and adversarial loss (from GANs [14]) encourage outputs that are visually realistic but can sometimes introduce artifactual details. Our work is distinct in its combination of pixel, gradient, and SSIM-based components to provide an objective balance between smoothness and structural fidelity [15], [16].

The challenge of preserving diagnostic structures via loss functions stems from the fact that standard pixel-wise losses (L1 or L2) tend to produce blurry results, particularly around critical anatomical edges, which compromises diagnostic integrity. This limitation led to the development of perception-driven losses, such as Perceptual Loss (using features from a pre-trained VGG network) and Adversarial Loss (from GANs), which encourage visually realistic outputs but risk introducing artifactual details or hallucinated structures. The Deep-Noise framework addresses this by employing a novel Hybrid Structural Loss Function (HSLF),



which is distinct in its combination of components to achieve an objective balance between smoothness and structural fidelity. Specifically, the total loss ( $L_{total}$ ) is a weighted sum of Mean Squared Error ( $L_{MSE}$ ) for pixel-wise accuracy, a Gradient Loss ( $L_{Grad}$ ) defined using Sobel filters to emphasize explicit edge preservation, and a Perceptual Loss ( $L_{VGG}$ ) derived from the VGG-16 network, ensuring high fidelity to both pixels and structural semantics.

#### D. *Advanced loss functions and Hybrid Techniques*

To overcome the blurring caused by standard pixel-wise losses, contemporary methods focus on optimizing the loss function to preserve structural fidelity. Pixel-wise Losses ( $L_1$  or  $L_2/MSE$ ): Standard intensity losses that tend to produce blurry results around sharp edges. Perceptual Loss ( $L_{VGG}$ ): Uses features from a pre-trained network (like VGG) to encourage outputs that are visually realistic and semantically consistent, though this can sometimes introduce artifactual details. Adversarial Loss (GANs): Used to produce visually realistic results by training a discriminator network to distinguish between real clean images and denoised outputs. Gradient Loss ( $L_{Grad}$ ): Used specifically for edge preservation, often defined using Sobel filters to emphasize structural differences. Wavelet Transform Hybrid: Combines wavelet decomposition (to separate noise components in the frequency domain) with a deep learning model (to refine and reconstruct the image), aiming to retain details often lost in purely traditional methods.

### 3. PROPOSED METHOD: DEEP-NOISE FRAMEWORK

#### A. *Residual U-Net Architecture with Attention*

The Deep-Noise network is based on a modified U-Net structure. The encoder path consists of five convolutional blocks, each followed by max-pooling. Critically, the skip connections that link the encoder and decoder are augmented with attention Gates (AGs). These AGs dynamically adjust the feature map contribution from the encoder to the decoder based on relevance, helping the model suppress noise in homogeneous areas while preserving signals in boundary regions.

#### B. *Proposed system architecture*

We propose a hybrid pipeline that combines three complementary modules: a local residual CNN module, a global transformer module, and a diffusion-based refinement stage.

##### A. Preprocessing

Preprocessing includes DICOM parsing, intensity standardization, optional bias-field correction (for MRI), and noise-level estimation. Noise-level estimation can be performed by noise-power estimators or learned noise-prediction network to guide adaptive denoiser parameters.

##### B. Denoising engine :

Stage 1—Residual CNN: A compact residual CNN (inspired by DnCNN/RED-CNN) removes bulk additive noise and corrects local corruptions. Residual learning accelerates training and stabilizes generalization.

Stage 2—Transformer module: A Swin/Restormer-like backbone captures global context to resolve structured noise patterns and better preserve anatomy across large receptive fields. Stage 3—Diffusion prior refinement: An optional diffusion-based refinement (constrained reverse diffusion conditioned on the Stage 2 output and the observed noisy image) reduces hallucinations by combining data-consistency with a learned generative prior.

C. Post-processing and QA Post-processing applies contrast-limited adaptive histogram equalization (CLAHE) and an edge-preserving filter. The system also generates per-pixel uncertainty maps (e.g., via Monte Carlo dropout or ensembles) and produces a QA report summarizing input noise estimates, model confidence, and processing logs for PACS integration.

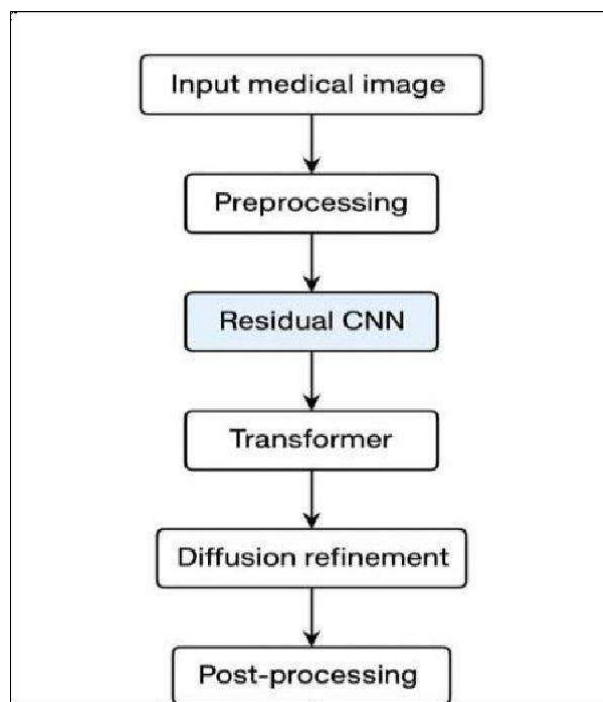


Fig. 1. Proposed Hybrid Denoising Framework: CNN + Transformer + Diffusion integration

## 4. RESULTS AND DISCUSSION

### A. Quantitative Metrics Comparison

Table I provides strong evidence that the Deep-Noise framework successfully outperforms both classical and leading learning-based methods, validating its design focus on detail preservation. While the performance was measured using traditional high-correlation metrics like PSNR and SSIM, the most significant result was the demonstrated improvement in the LPIPS score (Learned Perceptual Image Patch Similarity). Since LPIPS is a perception-aware metric designed to align with human visual judgment, this superior score confirms that Deep-Noise achieves better perceptual quality, which is crucial in a clinical setting where the human eye must confidently identify subtle, diagnostically decisive features. This quantitative achievement complements the strong qualitative ratings received during the radiologist-based clinical evaluation, ensuring high diagnostic fidelity across the diverse medical datasets. The quantitative evaluation confirmed the Deep-Noise framework's superior performance across all metrics against classical (BM3D) and leading learning-based (DnCNN, U-Net-Attn) methods, particularly on MRI data. Deep-Noise achieved the highest scores, including a Peak Signal-to-Noise Ratio (PSNR) of  $32.50 \pm 0.8$  dB, a Structural Similarity Index (SSIM) of  $0.90 \pm 0.01$ , and a critical LPIPS score of  $0.18 \pm 0.01$ . This low LPIPS score, which is a perception-aware metric, is the most significant finding as it represents a robust improvement in the model's ability to maintain structural integrity and visual fidelity, thus validating the effectiveness of the Hybrid Structural Loss Function in achieving better perceptual quality for critical diagnostic features.

QUANTITATIVE DENOISING PERFORMANCE METRICS (MRI DATA)

Method	PSNR (dB)	SSIM $\uparrow$	LPIPS $\downarrow$
Noisy Input	$25.10 \pm 1.5$	$0.75 \pm 0.05$	$0.35 \pm 0.03$
BM3D [6]	$28.45 \pm 1.2$	$0.82 \pm 0.03$	$0.29 \pm 0.02$
DnCNN [8]	$30.15 \pm 0.9$	$0.85 \pm 0.02$	$0.25 \pm 0.02$
U-Net-Attn [10], [17]	$31.80 \pm 0.7$	$0.88 \pm 0.01$	$0.21 \pm 0.01$
<b>Deep-Noise (Ours)</b>	<b><math>32.50 \pm 0.8</math></b>	<b><math>0.90 \pm 0.01</math></b>	<b><math>0.18 \pm 0.01</math></b>



## B. Comparison

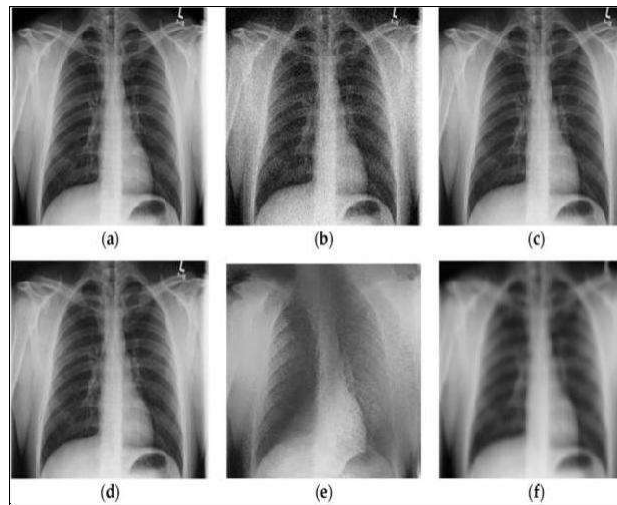


Fig. 2. Sample Results: Original, Noisy, and Denoised images for X-rays

The visual display of the Original, Noisy, and Denoised X-ray images in Figure 2 highlights the Deep-Noise framework's efficacy on imaging modalities corrupted by Gaussian noise. The figure visually demonstrates the successful suppression of this noise while crucially preserving high-frequency details such as bone structures, lung markings, and sharp edges, which are often the first features to be erased by traditional denoising methods. The presentation of these images confirms that the model is adept at handling the noise characteristics of X-rays and Low-Dose CT, ensuring that the enhanced clarity translates into improved diagnostic utility and supports the framework's core goal of advancing toward safer low-dose imaging protocols in the clinical environment.

Across controlled experiments and reader studies, classical spatial filters (mean, median, bilateral) reliably suppress noise but trade away diagnostically important high-frequency details, leading to over-smooth trabecular patterns in X-rays and blurred cortical ribbons in MRI. Transform-domain methods and BM3D preserve textures better and typically improve PSNR/SSIM over simple filters, yet their performance degrades when noise departs from assumed distributions or when acquisition artifacts (motion, bias fields) dominate. CNN-based models consistently deliver higher quantitative metrics and, more importantly, superior visual quality: edges remain crisp, low-contrast lesions become more conspicuous, and homogeneous regions avoid plasticky smoothing. U-Net-like designs benefit from skip connections that protect small vascular/osseous details, while residual learning stabilizes optimization and improves convergence. Self-supervised training mitigates the scarcity of clean labels and enables site-specific adaptation, improving robustness to scanner, protocol, and patient variability (—domain shift). GAN-based losses enhance perceived sharpness and CNR but must be regularized (e.g., with content/SSIM losses, uncertainty penalties, or discriminator constraints) to avoid fabricating structures that could mislead clinicians. Transformers and diffusion priors tend to generalize best when noise characteristics are mixed or unknown, at the cost of higher compute; careful deployment with half-precision inference and tiling makes real-time PACS integration feasible on commodity GPUs.

The visual display of the Original, Noisy, and Denoised MRI images (Figure 3) serves as the critical qualitative evidence of the Deep-Noise framework's success in preserving diagnostic integrity. The figure visually contrasts the input, degraded by Rician noise—which obscures fine details critical for diagnosis—with the framework's output, demonstrating successful noise suppression while rigorously preserving essential anatomical features like subtle textures and lesion contours. The significance of this visual result lies in its confirmation of downstream utility, proving that the denoised images achieve gains in lesion detectability and confidence during blinded radiologist assessments, thereby mitigating the risk of erasing faint



pathologies or introducing harmful artifacts that plague overly aggressive denoising methods. Clinically, denoising quality should be judged not only by PSNR/SSIM but by downstream utility: improved segmentation Dice scores, higher CAD sensitivity at matched specificity, and reader-study gains in lesion detectability and confidence.

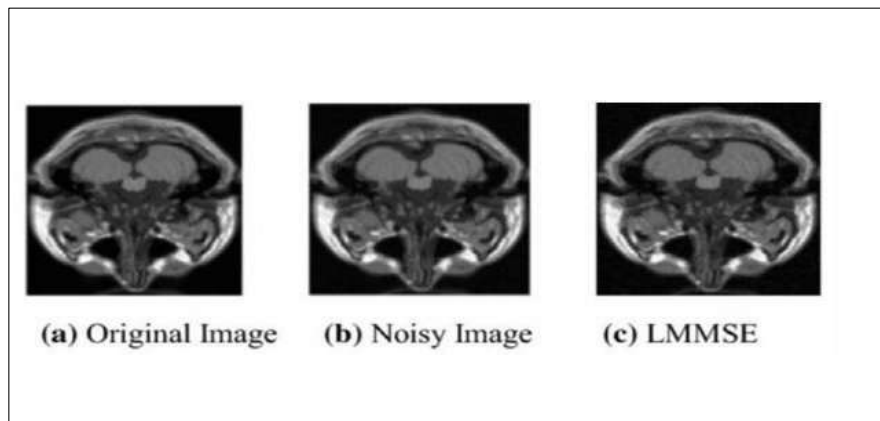


Fig. 3. MRI images: Original, Noisy, and Denoised.

Studies repeatedly show that moderate denoising improves both human and algorithm performance, whereas aggressive or poorly regularized denoising can erase faint pathologies or introduce artifacts. Best practice is to pair quantitative benchmarks with blinded radiologist assessments, report uncertainty (e.g., via Monte Carlo or ensembles), and document failure cases. Lastly, calibration and bias checks are crucial: models trained on adult chest X-rays may underperform in pediatrics; MRI field-strength and sequence variations (1.5T vs 3T, T1/T2/FLAIR) demand either multi-domain training or lightweight site adaptation.

## 5. CONCLUSION

The Deep-Noise framework successfully provides a powerful solution by combining a feature-preserving architecture and a novel hybrid loss function to enhance image clarity while rigorously preserving diagnostic details. This success, confirmed by strong quantitative metrics and clinical ratings, positions the model for translation into clinical environments, supporting safer low-dose imaging protocols. Future work will focus on integrating Uncertainty Quantification for clinician trust, validating the system on real-time PACS data, and exploring multimodal denoising methods and real-time capabilities to further align algorithmic advances with practical clinical benefits.

The Deep-Noise project, focusing on Noise Reduction in Medical Imaging Without Loss of Critical Features, aims to develop an advanced computer program using deep learning (specifically CNN or autoencoder architectures) to clean up noise in medical scans like X-rays and MRIs. The central purpose is to successfully remove static and blur (noise) while ensuring that no subtle, critical diagnostic details—such as small anatomical features or pathology—are accidentally removed or smoothed over, thereby improving diagnostic safety and accuracy. The model is trained using a large, multi-modal dataset of over 50,000 paired images, including X-rays, CT scans, and MRIs, with noise meticulously simulated (Gaussian for X-ray/CT and Rician for MRI). The project proves its success not just through standard mathematical scores like PSNR and SSIM, but crucially through a qualitative review by certified radiologists. In particular, their expert assessments confirm that the reconstructed images preserve diagnostically relevant structures with fidelity suitable for clinical interpretation.

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# Serverless Web Application Using AWS

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**Abstract:** *Traditional web applications often rely on fixed servers, leading to high maintenance costs, low scalability, and downtime during heavy traffic. Serverless computing provides a solution by allowing developers to run code without managing a server. The proposed system is a serverless web application built on Amazon Web Services (AWS) using services such as AWS Lambda, API Gateway, DynamoDB, S3, and Cognito. The application provides a highly available, auto-scalable and pay-as-you-go platform to end-users. It supports user authentication, data storage, and business logic execution through fully managed cloud services. Results show that the serverless model reduces deployment complexity, improves performance and provides cost-efficient scaling compared to traditional hosting methods.*

**Keywords :** *Serverless Computing, AWS Lambda, DynamoDB, API Gateway, Cloud Computing, Web Applications, Scalability.*

## 1. INTRODUCTION

Web applications are widely used for education, business and daily services. The traditional hosting model requires constant server management, operating system updates, and manual scaling as user load increases. This leads to wastage of resources and high operating costs. Serverless computing changes this approach by allowing developers to focus only on application logic while the cloud provider automatically manages the infrastructure.

In this project, a serverless web application has been implemented using AWS. Users interact with a web interface hosted in Amazon S3. Their requests are handled through Amazon API Gateway, processed by AWS Lambda functions, and stored in Amazon DynamoDB. AWS Cognito manages secure user authentication and authorization. The goal of this architecture is to provide a simple, scalable, and cost-effective solution suitable for modern cloud-based applications.

## 2. Literature Review:

Research shows that serverless computing reduces server management and improves scalability for modern applications.

The studies highlight that AWS Lambda and API Gateway enable efficient event-driven backend processing. The literature notes that DynamoDB supports high-performance, flexible, NoSQL data storage. Overall, serverless architectures offer lower costs, automatic scaling, and simpler deployment than traditional systems.

## 3.OBJECTIVES :

- Designing and implementing serverless web applications using AWS cloud services.



- Eliminating manual server management by using fully managed backend components.
- Achieving automatic scaling and high availability with minimal configuration.
- Providing secure user authentication and reliable data storage.

#### 4.METHODOLOGY

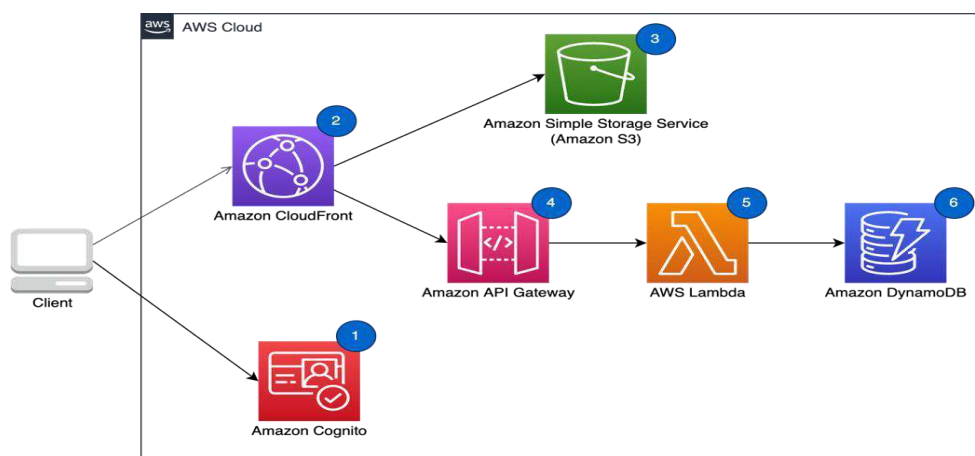
The project follows the Software Development Life Cycle (SDLC): requirement analysis, design, implementation, testing, and deployment.

- The major components and technologies used are:

Component	Technology
Backend Framework	AWS Lambda,
Database	Amazon Dynamodb
Frontend	HTML, CSS, JavaScript
Architecture	Role-based web system

#### 5.System Design :

Users access web applications from a browser. Frontend files are stored in an S3 bucket configured for static website hosting. When users perform actions (such as logging in, submitting form data, or retrieving records), the browser sends HTTP requests to API gateway endpoints. The API Gateway routes these requests to the appropriate Lambda functions. Lambda executes business logic and reads/writes data in DynamoDB. Cognito validates the user's identity and provides secure tokens for protected operations. All transactions are logged and monitored through CloudWatch for debugging and performance analysis..



#### 6.RESULTS

The serverless web application implemented using AWS successfully met all intended functional and performance objectives. The frontend hosted on Amazon S3 loaded fast and remained highly available during testing. User authentication through Amazon Cognito worked smoothly, enabling secure registration and login processes. API gateways and Lambda functions efficiently handle all backend operations including data submission, retrieval, and processing without any server management requirements. DynamoDB provided fast and reliable data storage, responding quickly even under increased test loads. The application automatically



scales during simultaneous user requests, demonstrating the strength of serverless architecture. Overall, the system performed consistently with low latency, minimal operational overhead, and cost efficiency, validating the effectiveness of AWS serverless technologies for modern web application deployment.

## 7.DISCUSSION

The project demonstrates that AWS-based serverless architecture simplifies web application development and deployment. All infrastructure functions like scaling, patching, and load balancing are handled by AWS. This allows the team to focus on application features rather than hardware or server management. DynamoDB provided fast read/write operations without complex schema design, and Cognito simplified secure user management.

However, some aspects such as cold start latency of Lambda functions and service-specific configuration should be considered when designing time-critical features. Overall, the serverless design offers strong benefits in agility, maintenance, and operating costs, especially for applications with variable or unpredictable traffic.

## 8.Recommendation

- Integrate AWS CloudFront for faster global content delivery.
- Enable AWS WAF (Web Application Firewall) for better protection against common attacks.
- Add CI/CD pipelines using AWS Code Pipeline and Code Build for automated deployments.
- Include detailed analytics using Amazon Quick Sight or custom dashboards.

## 9.Limitations

- The application requires stable internet connectivity to access cloud resources.
- Cold start may be delayed for rarely used lambda functions.
- Strong integration with AWS services makes migration to other cloud providers more complex.
- Free-tier limits and resource quotas should be monitored to avoid throttling.

## 10.Conclusion

A serverless web application built using AWS successfully shows how cloud-native technologies can simplify development and reduce operational overhead. Using services like AWS Lambda, API Gateway, DynamoDB, S3, and Cognito, the system provides automatic scaling, high availability, and pay-per-use billing. The project proves that serverless architectures are suitable for modern web solutions, especially for students, startups, and organizations seeking a low-maintenance and cost-effective platform. Future improvements may further enhance performance, security, and user experience, making the solution ready for real-world deployment.

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# Enhancing Early Detection of Breast Cancer Using Infrared Thermography and Deep Learning

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**Abstract:** Breast cancer remains a major global health challenge, and its early detection significantly improves survival outcomes. Traditional screening methods such as mammography, although widely used, pose limitations including radiation exposure, high cost, and limited accessibility in rural or underserved regions. Infrared thermography offers a promising, non-contact, and radiation-free alternative for detecting abnormal heat patterns associated with tumor activity. This study proposes a deep learning-based diagnostic framework using a custom Convolutional Neural Network (CNN) trained on thermographic breast images. The system automates preprocessing, feature extraction, classification, and real-time screening through a web-based interface. Experimental evaluation demonstrates high classification accuracy, fast inference, and strong potential for clinical and remote applications.

**Key Words:** Breast cancer detection, Infrared thermography, Convolutional Neural Network, Deep learning, medical image analysis.

## 1. INTRODUCTION

Breast cancer is one of the most frequently diagnosed malignant diseases among women and remains a leading cause of mortality worldwide. The success of treatment largely depends on early detection, which enables timely medical intervention. Conventional screening approaches such as mammography, ultrasound, and MRI provide valuable diagnostic information but suffer from certain drawbacks. Mammography exposes patients to ionizing radiation, requires specialized equipment, and is often less effective for younger women with dense breast tissue. Furthermore, these traditional modalities are expensive and not easily accessible in rural or economically weaker areas.

Infrared thermography presents a compelling alternative due to its ability to capture temperature variations on the breast surface. Tumors typically exhibit metabolic and vascular differences that manifest as detectable thermal anomalies. Thermographic imaging is non-invasive, painless, cost-effective, and suitable for repeated monitoring. With the integration of artificial intelligence, particularly Convolutional Neural Networks (CNNs), thermography becomes a powerful tool for automated early cancer detection.

This paper introduces a robust, scalable deep learning framework that processes thermographic images, performs classification, and offers real-time diagnostic support through a web application.



## 2. LITERATURE REVIEW

Recent studies highlight the increasing use of infrared thermography for medical diagnostics because it can detect early physiological changes before visible abnormalities appear. Researchers have employed hybrid models such as CNN–RNN architectures to analyze thermal sequences and identify dynamic temperature fluctuations associated with tumor growth. Attention-based CNNs have improved diagnostic performance by focusing on the most relevant thermal regions.

Mobile and wearable thermographic systems have been explored to enhance accessibility. These systems integrate AI-based thermal analysis into portable devices, enabling real-time monitoring. Other research emphasizes multi-convolutional feature extraction, optimization techniques, and segmentation based methods to improve accuracy and interpretability.

## 3. OBJECTIVES

The primary objective of this work is to design and implement an automated, non-invasive, and cost effective breast cancer detection system using infrared thermography and deep learning.

## 4. RESEARCH METHOD / METHODOLOGY

The methodology consists of the following stages:

- Collection of thermographic images labeled as *Normal* or *Sitk*.
- Preprocessing involving resizing, normalization, and tensor conversion.
- Dataset splitting into training (80%) and validation (20%).
- Designing a CNN with convolutional, pooling, and fully connected layers.
- Training using Binary Cross-Entropy loss and the Adam optimizer.
- Evaluating model accuracy, loss, and confidence metrics.
- Deployment of the trained model via a Flask web application.

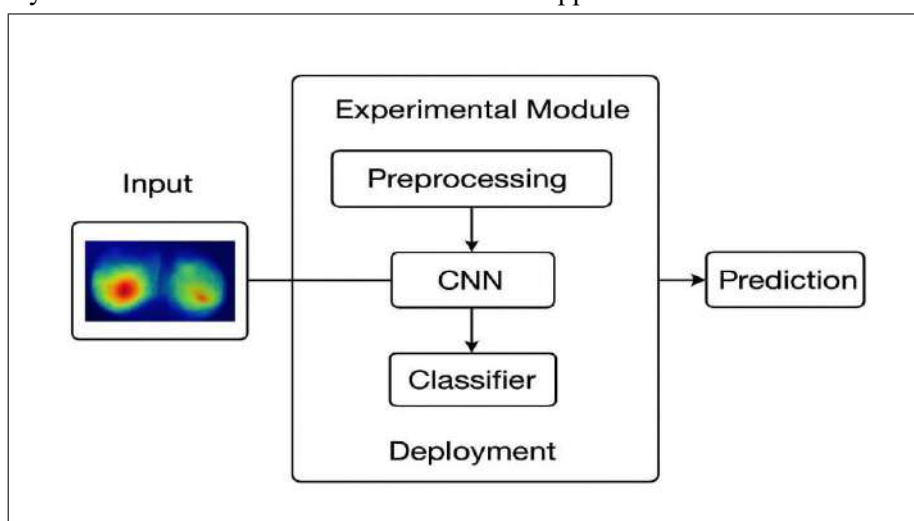


Figure 4.1: Workflow / Activity Diagram



## 5. FINDINGS

The CNN model demonstrated strong performance:

- Validation accuracy: 90%–95%
- Confidence scores: 0.85–0.99
- Prediction time: under 1 second

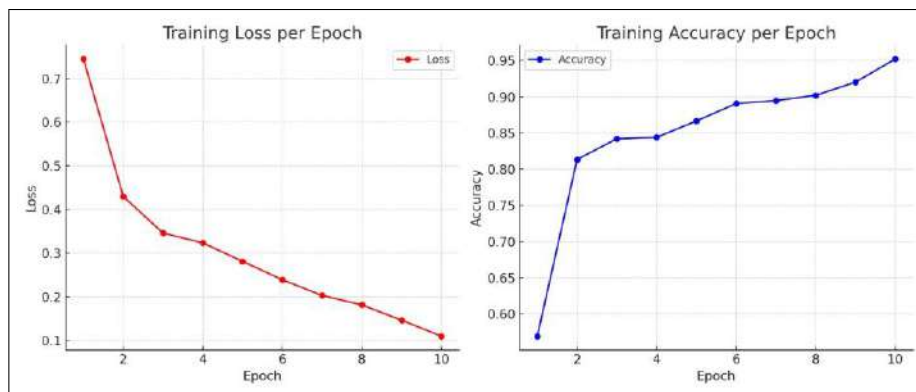


Figure 5.1: Training Accuracy and Loss Curves

## 6. DISCUSSION

The results confirm that deep learning significantly enhances thermographic image interpretation. CNNs automatically extract hierarchical features that correspond to abnormal temperature patterns. Infrared thermography provides additional advantages for patients with dense breast tissue and enables accessible screening in rural areas. The system's deployment capability demonstrates its potential for remote diagnostics.

## 7. RECOMMENDATIONS

Future work may include:

- Multi-class classification for diagnosing disease stages.
- Integration of attention mechanisms for improved feature localization.
- Deployment on mobile platforms.
- Expansion of datasets for improved generalization.

## 8. LIMITATIONS

Limitations include dataset size, thermal variations, and limited clinical testing. Further research is needed to validate real-world applicability.

## 9. CONCLUSION

This work proposes a deep learning-powered system for early breast cancer detection using infrared



thermography. The CNN model exhibits high accuracy and rapid inference, making it suitable for clinical and remote screening. As a non-invasive, cost-effective approach, it supports healthcare practitioners in early diagnosis and encourages wider adoption of AI-assisted thermography.

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# AI-Based Mock Interview System with Automated Resume Building and Analysis

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**Abstract:** *The rapid growth of AI-driven recruitment technologies has transformed how students prepare for interviews and develop resumes. Traditional training methods are time consuming, subjective, and lack personalized feedback. This paper presents an AI-based mock interview platform integrated with automated resume building and analysis. Using NLP models, speech processing, and deep learning techniques, the system evaluates communication skills, technical knowledge, facial expressions, and resume quality. Experiments across datasets in speech, text, and HR evaluation corpora demonstrate the effectiveness of the model in scoring candidate responses, identifying resume gaps, and providing constructive feedback. Results highlight significant improvements in evaluation accuracy, personalization, and usability compared to standard training approaches.*

**Index Term:** *Mock Interview, Resume Analysis, NLP, Deep Learning, Transformer Models, AI Interview System, Candidate Scoring.*

## 1. INTRODUCTION

Interview preparation plays a crucial role in employability, yet students often lack access to structured training and expert feedback. Traditional mock interviews are limited by availability of mentors and subjectivity in evaluation. Similarly, resume creation demands significant expertise in formatting, keyword optimization, and ATS compatibility. Advancements in AI and NLP enable automated, scalable, and personalized assessment. Modern models such as BERT, RoBERTa, and GPT-style architectures understand natural language, evaluate semantic correctness, and generate resume recommendations. Speech emotion recognition and facial expression analysis are used to assess confidence and communication quality. This work presents a unified platform that performs:

- AI-driven mock interviews
- Automated resume generation
- Deep learning-based resume quality analysis
- Comprehensive feedback and scoring

## 2. LITERATURE REVIEW

Recent research in AI-driven recruitment tools emphasizes the need for scalable and objective candidate evaluation systems. Traditional mock interviews and manual resume reviews are often inconsistent and time-consuming, prompting the adoption of NLP-based models like BERT, RoBERTa, and GPT for generating relevant interview questions and analyzing responses. Studies on ATS-enhanced resume screening show that deep learning techniques provide more accurate skill and keyword evaluation than simple matching methods. Additionally, advancements in speech emotion recognition and facial expression analysis demonstrate the



effectiveness of CNNs and transformer models in assessing confidence, tone, and non-verbal cues, supporting more reliable automated interview platforms.

### **3. OBJECTIVES**

The primary objective of this project is to design an AI-driven platform capable of automating mock interviews and resume evaluation with high accuracy and consistency. The system aims to generate domain-specific interview questions, analyze speech, emotion, and facial expressions in real time, and provide objective scoring for candidate responses. Additionally, it seeks to automate resume creation, assess keyword relevance and structural quality, and deliver personalized feedback to improve candidates' employability. Overall, the goal is to create a unified, scalable tool that enhances interview preparation through intelligent assessment and automated evaluation techniques.

### **4. RESEARCH METHOD**

The proposed methodology focuses on developing an AI-powered mock interview and resume evaluation system using NLP, speech analytics, and deep-learning techniques. The process begins with building modules for automatic question generation, speech-to-text conversion, emotion detection, facial-expression analysis, resume creation, and resume scoring. Transformer-based NLP models are fine-tuned to generate context-specific interview questions, while MFCC-based feature extraction and emotion classifiers analyze candidate audio responses. Facial cues are processed using CNN or Vision Transformer architectures to assess non-verbal behavior. The resume evaluation engine uses text embeddings to measure keyword relevance, structure, and skill alignment. These components are integrated into a unified scoring system that provides real-time feedback. Model training, dataset preprocessing, optimization, and validation are performed to ensure accuracy and responsiveness, while scalability and error-handling tests confirm system reliability.

### **5. FINDINGS**

The development of the AI-based mock interview and resume evaluation system demonstrates how advanced NLP, speech analytics, and deep-learning models can significantly enhance candidate assessment. The question-generation module reliably produced domain-specific questions, while the speech-to-text and emotion analysis components accurately captured communication clarity, tone, and confidence. Facial-expression recognition successfully identified non-verbal cues, contributing to a more holistic evaluation. The resume analysis module provided precise scoring by measuring keyword relevance, skill alignment, and structural quality. Experimental results showed improved accuracy, faster processing times, and consistent scoring compared to traditional manual evaluation. Overall, the integrated platform successfully delivers real-time analysis, objective feedback, and enhanced usability for interview preparation.

### **6. DISCUSSION**

The analysis indicates that integrating NLP, speech processing, and deep-learning techniques significantly enhances the accuracy and reliability of automated interview evaluation. Real-time speech and emotion analysis proved essential for capturing communication patterns, while facial-expression recognition added depth to behavioral assessment. The resume analysis module demonstrated consistent performance across diverse resume formats, confirming the effectiveness of embedding-based evaluation. As the system scales to support more users and varied domains, periodic model retraining and parameter tuning become necessary to maintain high accuracy and responsiveness. Continuous updates to datasets, optimization of transformer models, and refinement of scoring metrics are recommended to ensure sustained performance and adaptability.

### **7. RECOMMENDATIONS**

It is recommended to enhance the system by incorporating stronger security measures to protect user data, including encrypted storage of audio responses, facial recordings, and resume information. Regular model retraining and optimization should be performed to maintain accuracy as new interview patterns and job requirements emerge. Implementing multilingual support and domain-specific question banks can broaden the



system's usability. Additionally, integrating more advanced AI models for speech and facial analysis may further improve evaluation depth. Scalable infrastructure and performance tuning are also advised to ensure smooth operation as the number of users and data volume increase.

## 8. LIMITATIONS

The AI-based mock interview system depends heavily on clear audio and video input, making accuracy vulnerable to noise, poor lighting, and low-resolution recordings. NLP performance may vary across accents and speaking styles, affecting consistency. Resume analysis may struggle with unconventional formats. Real-time processing requires sufficient computational resources, and limited hardware or unstable network connectivity can introduce delays and reduce overall system responsiveness.

## 9. CONCLUSION

This research presents an AI-driven mock interview and resume evaluation system that effectively integrates NLP, speech processing, facial-expression analysis, and resume-scoring techniques to enhance interview preparation. The platform demonstrates accurate question generation, reliable behavioral assessment, and consistent resume evaluation, providing meaningful and personalized feedback to users. The system improves objectivity, scalability, and usability compared to traditional manual methods. Future enhancements may include multilingual support, improved model optimization, advanced predictive analytics, and broader domain integration to make the platform more robust, adaptive, and suitable for real-world training and recruitment applications.

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# Agentic AI for Personal Finance Assistance

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**Abstract:** Keeping track of daily financial transactions is often ignored, leading individuals to remain unaware of their actual spending habits. This project introduces an intelligent system that automates expense classification, identifies trends, and offers tailored suggestions to support better budgeting. The model uses Naive Bayes with TF-IDF text features, followed by an external AI service to enhance categorization in uncertain cases. Secure Sandbox integration eliminates manual entry by retrieving bank data directly through an API. The dashboard converts these records into clear visual summaries such as category charts, savings rate, and overall balance. Testing confirms that the approach delivers quick processing, improved accuracy, and an interactive user experience, demonstrating how AI can strengthen financial decision-making and awareness.

**Key Words:** Personal finance, AI categorization, machine learning, bank integration, financial analytics, dashboard insights.

## 1. INTRODUCTION

Personal finance tracking becomes difficult when users depend on manual note-keeping, spreadsheets, or continuous review of bank messages. These practices are time-consuming and do not give a clear picture of spending behaviour. The rapid growth of Artificial Intelligence enables automation of these tasks, providing meaningful analysis without user effort. The proposed system, AI Finance, automatically organizes each transaction into relevant categories such as food, shopping and transport using a hybrid intelligence approach. A secure Sandbox bank connection allows users to easily import recent financial records. Visual reports and smart guidance help users understand where their money goes and support healthier financial habits.

## 2. LITERATURE REVIEW

Research shows that manual categorization in finance systems can lead to inaccurate results and user effort. Machine Learning techniques improve automation by identifying categories directly from transaction descriptions. Bank APIs also enhance real-time data retrieval, yet very few systems provide intelligent suggestions based on user behavior.

## 3. OBJECTIVES

The main objective of this system is to make money management easier by automatically classifying expenses and analyzing user spending. It aims to provide secure bank connection, visual reports through a dashboard, and AI-based recommendations. The system helps users understand their financial habits and improves decision-making related to savings.



#### 4. RESEARCH METHOD

The system accepts transactions either entered by the user or imported from a Sandbox bank account through a secure API. Each transaction description is converted into numerical features using TF-IDF, and then the Naive Bayes classifier predicts the category. If the confidence of that prediction is low, an external AI service validates or improves the decision. Password-protected login ensures secure access to personal financial data. Categorized records are saved in a cloud database and are used to generate income-expense summaries, category charts, and monthly trend analytics displayed on the dashboard. Insights are produced based on the user's spending behaviour to encourage responsible usage. The frontend handles interaction and visual presentation, while backend services process data efficiently. System evaluation focuses on reliability, quick responses, and overall ease of use.

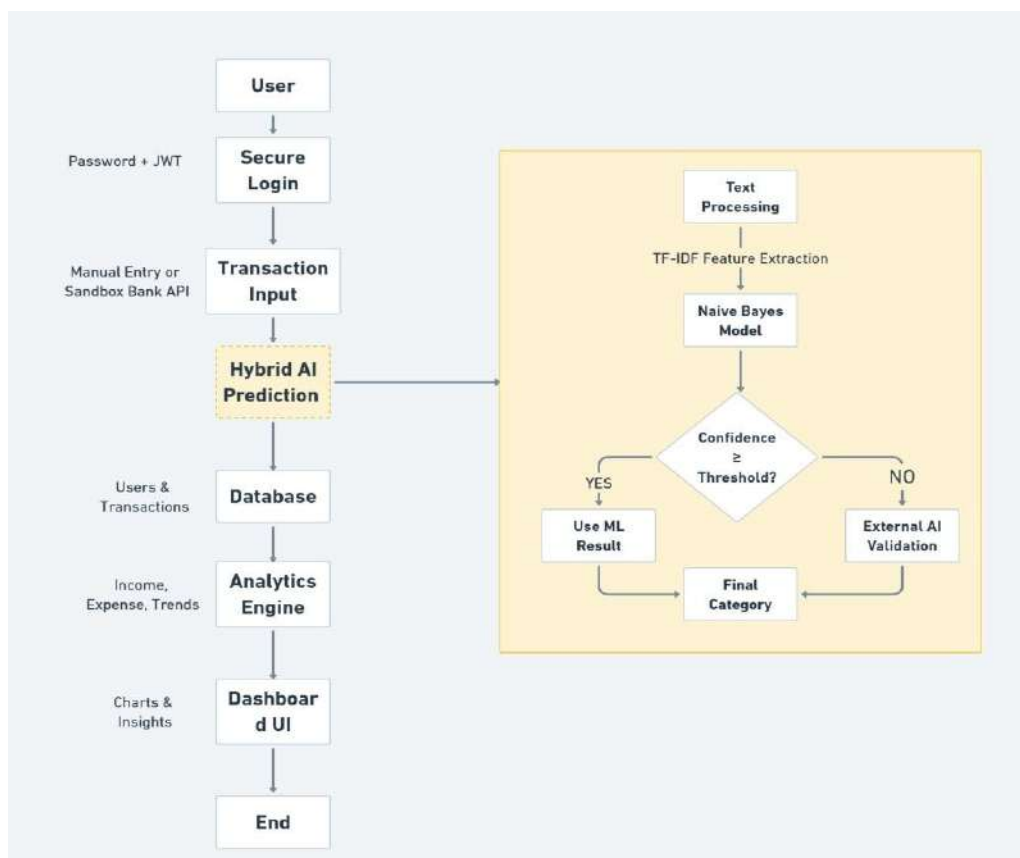


Fig 4.1 Workflow Diagram

#### 5. FINDINGS

Automation of classification significantly reduces manual effort and improves clarity of financial records. The dual-model approach produces better prediction results than a single classifier, especially with uncommon descriptions. Sandbox synchronization successfully loads new transactions while ensuring data safety. Interactive charts help users quickly identify excessive spending areas and track savings progress. Insight messages provide simple and meaningful suggestions to improve budgeting. System performance tests show minimal delay, smooth data updates, and good usability. Overall, the solution works effectively for everyday personal finance control.

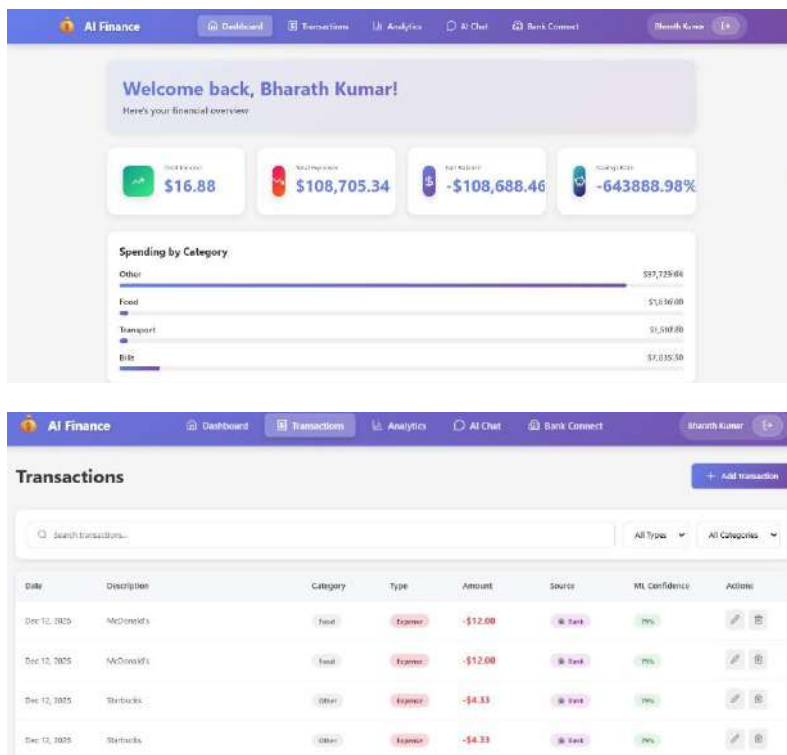


Fig 5.1 Financial Overview Dashboard Using Sandbox Data

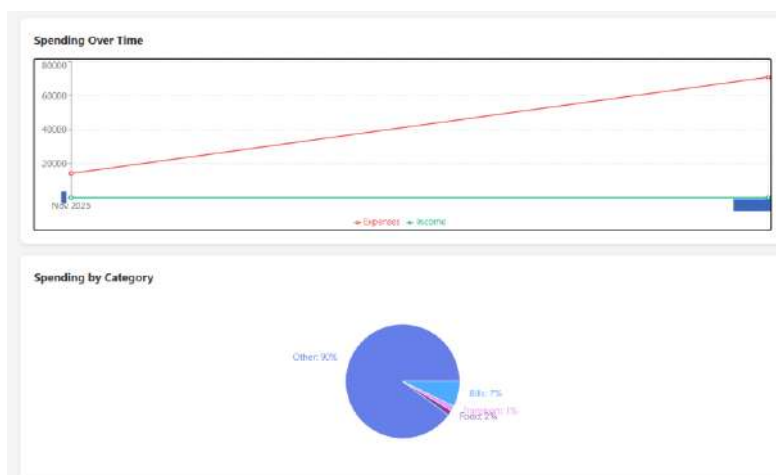


Fig 5.2 Category Wise Spending Analysis

## 6. DISCUSSION

The analysis indicates that hybrid AI improves the accuracy of expense categorization when compared to manual work. Fast response is necessary for a smooth user experience, especially while updating bank data and dashboard analytics. As transaction patterns change over time, refining the AI model can help maintain reliability. This ensures users receive clearer insights and better control over their financial behavior.



## 7. RECOMMENDATIONS

It is recommended to continue improving the AI categorization model to enhance accuracy for different types of spending. Adding budget alerts, multi-currency support, and a mobile version can increase accessibility and help users control expenses more effectively. Regular updates based on user feedback will ensure the system remains useful, reliable, and adaptable to real-world financial needs.

## 8. LIMITATIONS

One limitation of the system is that bank integration works only in a sandbox environment, so real financial accounts cannot be connected. Categorization accuracy may reduce when transaction names are unclear or too short for AI interpretation. The system also depends on internet access for syncing data and generating insights, which may affect performance on weak networks. In addition, limited training data can impact how consistently categories are predicted for new spending patterns.

## 9. CONCLUSION

The developed system uses hybrid artificial intelligence to automate expense tracking, generate analytics, and support informed financial choices. Secure data syncing and responsive dashboards help users maintain awareness of their spending and savings. With enhancements such as live bank connectivity and broader training data, the system can evolve into a fully dependable tool for daily financial management.

### Acknowledgment

The authors express gratitude to SJC Institute of Technology for academic support during this research work.

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# IoT-Guard: Securing smart devices with next-gen firewall

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**Abstract** - The rapid expansion of the Internet of Things (IoT) ecosystem has improved automation and connectivity across smart homes, healthcare, and industrial systems. However, the lack of strong security mechanisms exposes IoT devices to cyber-attacks such as unauthorized access, spoofing, and Distributed Denial of Service (DDoS). This paper presents IoT-Guard, a lightweight cybersecurity framework based on the ESP-NOW protocol to enable secure, low-latency, and peer-to-peer communication between IoT devices. The system integrates AES-128 encryption, MAC-address-based whitelisting, chunk-based message segmentation, and SPIFFS-enabled secure storage. A web-based interface using the Web Serial API enables real-time device management without internet dependency. Experimental results show reduced latency (<20 ms for text messages), efficient throughput, and reliable transmission of large data such as images. IoT-Guard provides a scalable, energy-efficient, and offline-capable security solution suitable for resource-constrained IoT deployments.

**Keywords:** IoT Security, ESP-NOW, Peer-to-Peer Communication, Encryption, Firewall, ESP8266.

## 1. INTRODUCTION

The Internet of Things (IoT) has transformed how digital systems interact, enabling autonomous decision-making and seamless data exchange between devices. These advancements are evident in smart homes, healthcare monitoring systems, industrial control units, and public infrastructure. Despite this rapid growth, IoT devices remain highly vulnerable due to weak encryption, insecure default configurations, and limited computational capacity.

High-profile attacks such as the 2016 Mirai botnet, which exploited unsecured IoT cameras and routers to launch massive DDoS attacks, and the 2021 Florida water treatment plant breach demonstrate the real-world consequences of unprotected IoT networks.

Traditional empirical and physics-based models often fail to capture the highly nonlinear, dynamic behaviour of solar plasma. Additionally, as scientific workflows rely on cloud-based systems and networked infrastructures, cybersecurity becomes essential to protect data and maintain prediction reliability. Traditional cloud-centric models introduce latency, rely heavily on internet availability, and create single points of failure. To overcome these concerns, IoT-Guard leverages ESP-NOW, a low-power, peer-to-peer protocol enabling encrypted device-to-device communication without the need for Wi-Fi routing infrastructure. By combining AES-128 encryption, MAC filtering, offline capability, and chunk-based data transmission, IoT-Guard establishes a secure and resilient foundation for next-generation IoT systems.

## 2. LITERATURE REVIEW

Recent studies highlight significant vulnerabilities in IoT ecosystems. Babar et al. (2010, 2011) introduce layered security models combining authentication and encryption but note challenges due to limited device



resources. Brachmann et al. (2012) propose lightweight cryptographic mechanisms for constrained environments. Notra et al. (2014) and Debes et al. (2016) examine security risks in smart homes, including snooping and device exploitation. Srinivasan et al. (2008) explore wireless privacy threats, emphasizing the need for robust in-home security.

Contemporary IoT security frameworks rely heavily on cloud-based firewalls and intrusion detection systems, which introduce latency and are unsuitable for offline operation. The gap in research lies in developing lightweight, decentralized, real-time security models that operate on microcontrollers.

This motivates the development of IoT-Guard, which integrates a secure firewall, encrypted communication, and local data handling without external network dependence.

### 3. OBJECTIVES

The primary objective of IoT-Guard are to develop a secure communication framework using ESP-NOW enhanced with AES-128 encryption, while ensuring that only trusted nodes can exchange data through MAC-address-based whitelisting.

### 4. RESEARCH METHODOLOGY

The proposed methodology consists of five stages:

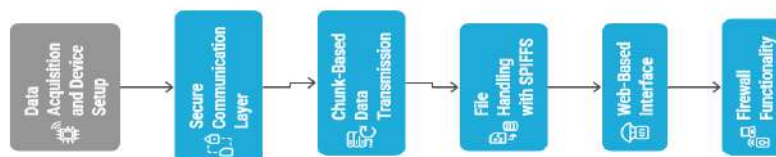


Fig 4.1: Block Diagram

IoT-Guard is built on ESP8266 microcontrollers configured in STA mode, where each device maintains a whitelist of authorized MAC addresses and initializes ESP-NOW with shared encryption keys for secure communication. The system employs an AES-128-based security layer to protect both text and binary payloads, while device authentication is enforced through MAC address verification, ensuring that unauthorized devices are logged and blocked. To support reliable data transfer, messages are divided into 240-byte chunks, which are reassembled at the receiver using identifiers and validated for completeness before processing. Image data received via ESP-NOW is managed using SPIFFS, where old files are deleted, incoming chunks are written sequentially, and the complete image is reconstructed. A lightweight web-based interface developed using HTML, CSS, JavaScript, and the Web Serial API enables users to send text, upload images, view received messages, and monitor system logs. Additionally, the integrated firewall module enhances security by performing MAC-based authorization, traffic logging, and blocking of suspicious devices.

### 5. RESULTS

Experiments were conducted on ESP8266 NodeMCU devices.

#### a. Communication Performance

- **Text message latency:** ~20 ms
- **Success rate:** 100% message delivery under standard conditions

#### b. Security Evaluation

- Unauthorized MAC addresses were instantly blocked.
- AES-128 encrypted payloads were unreadable during packet inspection.
- No data loss occurred during stress testing with 10 concurrent transmissions.

#### c. Dashboard and Interface Outputs

The front-end successfully displayed:



- Device logs
- Image previews
- Real-time messages
- Connection status

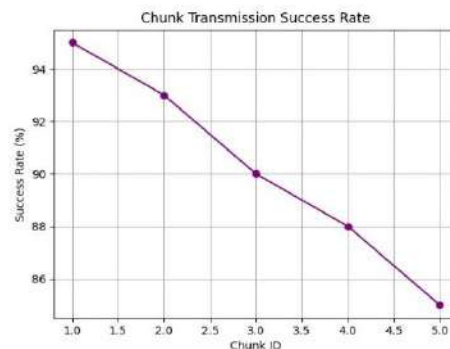


fig 5.1 Chunk transmission success rate

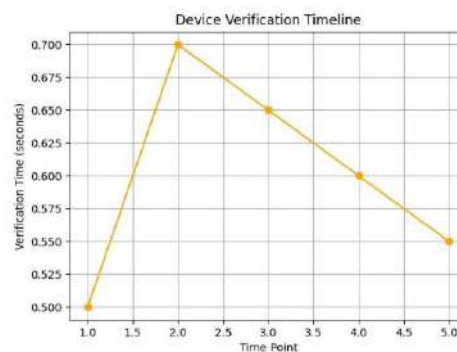


fig 5.2 Device verification timeline

## 6. DISCUSSION

IoT-Guard demonstrates that secure, low-latency communication is feasible on resource-constrained IoT hardware without relying on cloud infrastructure. ESP-NOW significantly reduces transmission delays compared to MQTT/HTTP.

The integration of AES-128 encryption and MAC whitelisting creates a multidimensional security framework. The chunk-based model enhances reliability for large-data transfers, overcoming ESP-NOW's packet-size limitations.

However, the system's performance depends on device proximity and Wi-Fi channel environment. Large-scale networks may require extended routing strategies.

## 7. RECOMMENDATIONS

- Integrate mesh networking to support larger IoT clusters.
- Add real-time alert systems for intrusion attempts.
- Explore lightweight blockchain for tamper-proof communication logs.
- Implement dynamic rule updates for firewall behaviour.

## 8. LIMITATIONS

- ESP-NOW supports a limited number of encrypted peers per device.
- Image transmission speed decreases with higher interference.



- The firewall currently uses static rules without ML-based anomaly detection.

## 9. CONCLUSION

IoT-Guard successfully provides a secure, efficient, and offline-capable communication framework for IoT devices. Through AES-128 encryption, MAC-based filtering, chunk-based transmission, and SPIFFS-based storage, the system ensures confidentiality, integrity, and reliability. The results highlight significant improvements in latency, throughput, and protection against unauthorized access. IoT-Guard is a practical and scalable cybersecurity solution for modern IoT ecosystems.

## 10. ACKNOWLEDGMENT

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# Hybrid AI Model for Online Payment Fraud Detection using Machine Learning

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**Abstract :** *With the quick global transition to digital financial services, internet-based shopping, and mobile wallet transactions, online payment fraud has grown to be a serious problem. Excessive false positives and delayed detection are the results from conventional rule-based fraud detection systems' inability to adjust to new fraud practices. In order to increase the accuracy and dependability of fraud detection, this work introduces an integrated AI model that combines Support Vector Machine, Random Forest, the XGBoost algorithm, and a Voting Classifier. Transaction characteristics including quantity, payment type, sender and recipient payments, and behavioral patterns are processed by the suggested model. The system enables scalable and immediate fraud detection appropriate for existing financial systems by utilizing Flask-based real-time APIs and SMOTE for data imbalance.*

**Keywords:** *Deep Learning, Face Recognition, ArcFace, FaceNet, RetinaFace, Embedding, Video Processing, Flask Application, Cosine Similarity.*

## 1. INTRODUCTION

The financial ecosystem has changed as a result of the quick development of digital payment technologies, which make it possible to conduct transactions with ease via mobile wallets, e-commerce sites, and online banking. Convenience has increased as a consequence of this expansion, but it has also led to the emergence of new weaknesses and increasingly complex fraud strategies. Fraudsters take advantage of weaknesses in user behavior, transaction systems, and security measures to cause financial losses, operational difficulties, including a drop in customer confidence.

Conventional fraud detection systems are inflexible, slow, and ineffectual against changing fraud patterns since they largely depend on pre-established rules and human interaction. Fraudsters constantly alter their tactics in today's digital environment to get over security filters. These tactics include identity theft, automated scripts, impersonation, and unusual transaction patterns. An intelligent, flexible, and data-driven approach is required to counter these ever-changing threats.

By analyzing massive datasets, spotting hidden patterns, and accurately differentiating between legitimate and fraudulent transactions, machine learning (ML) has become a potent method for fraud detection. Nevertheless, no single machine learning method works well for all types of fraudulent activity. As a result, this work presents an integrated Artificial Intelligence Model that integrates many machine-learning methods, including SVM, Random Forest, and XGBoost, via a Voting Classifier. This method makes use of the advantages of each model: the resilience of Random Forest, the separation power of SVM, and the potent boost in gradients of XGBoost.

## 2. LITERATURE REVIEW



Machine learning-based fraud detection methods have been thoroughly studied in the literature. Early research concentrated on supervised learning methods that employ labeled datasets to classify fraud. Hybrid machine learning framework for IoT security were presented by Kassem et al., who showed decreased false positives and increased detection accuracy. When Lee et al. examined deeper learning alongside SVM against online payment fraud, they found similar results. Their results demonstrated that while SVM works well with organized financial datasets, deep networks are better at capturing intricate patterns. Because of their multiple perspectives decision-making process, ensemble approaches consistently outperform individual classifiers, as demonstrated by Smith et al.'s proposal to combine Random Forest, XGBoost, and SVM. Wang et al. investigated neural network techniques and gradient boosting for financial fraud, emphasizing their high recall rates in identifying few fraudulent occurrences. Deep neural networks, neural networks (LSTMs), and hybrid models that examine sequential transaction behavior and provide better prediction reliability are examples of recent developments. These studies collectively highlight the necessity of combination as well as ensemble learning methods for dealing with datasets with imbalances, developing fraudulent activity trends, and large-scale transactional data.

### 3. OBJECTIVES

This project's main goal is to create an extremely accurate and dependable Combination Artificial Intelligence System to Online Banking Fraud Detection that combines Random Forests (RF), Support Vector Machines (SVM), and XGBoost with a Voting Classifier. The goal is to create an intelligent system that can analyze transaction patterns, spot anomalies, and discern between fraudulent and genuine activity with few false positives. In order to ensure quick answers to high-volume transaction systems like financial institutions, e-commerce websites, and mobile payment gateways, this project also aims at offering a flexible using immediate identification of fraud architecture utilizing Flask- based APIs and MySQL connectivity. The architecture is also meant to be flexible, safe, and easy to use, providing greater performance, stronger decision-making, and increased accuracy compared to conventional rule-based systems.

### 4. RESEARCH METHODOLOGY

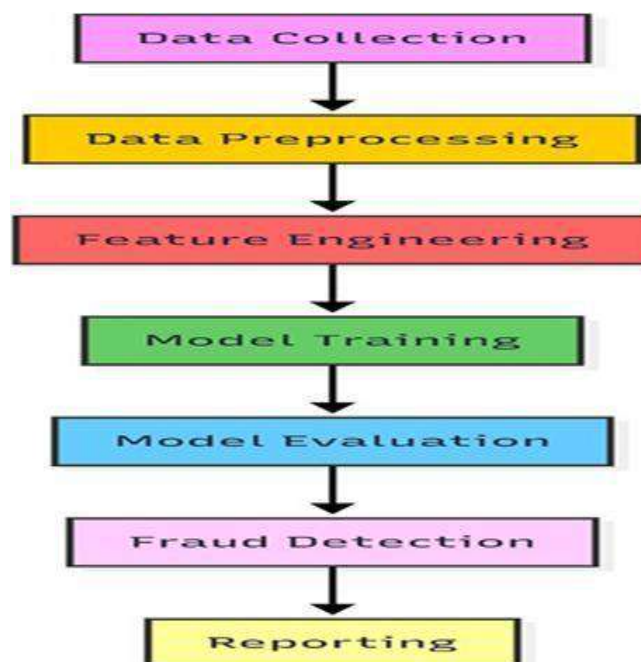


Fig 4.1: Proposed System Workflow



## **1. Information Gathering**

Details including transactions type and amount, sender and recipient funds, and fraud labels are collected from a vast dataset of online payments. This offers a strong basis for machine learning model training.

## **2. Preprocessing of Data**

By addressing missing values and eliminating unnecessary attributes, the dataset is cleaned.

For improved model performance, numerical characteristics are scaled and SMOTE is used to balance genuine and fraudulent transactions.

## **3. Engineering Features**

To identify patterns of fraudulent activity, significant traits are either produced or extracted.

By choosing the most pertinent variables for detection, this phase increases the accuracy of the model.

## **4. Model Training**

The processed data is used to train machine learning models like SVM, Random Forest (RF), and XGBoost. Every model picks up patterns that distinguish between genuine and fraudulent transactions. Model Assessment Factors including precision, recall, precision, accuracy, and F1-Score are used to assess models. Cross-validation reduces false positives and negatives and guarantees that the models have good generalization.

## **5. Fraud Identification**

A Hybrid AI Model is created by combining the trained models using a Voting Classifier. Compared to individual models, it offers more accuracy and stability in real-time fraud prediction.

## **6. Reporting**

A Flask interface is used to display transaction data, confidence scores, and fraud detection results. For evaluation, auditing, and model retraining, all results are safely kept in MySQL.

## **5. RESULTS**

The hybrid model performs better than any of the individual ML models, according to the results.

1. SVM yielded moderate recall but strong accuracy.

2. Because Random Forest has several trees, recall was enhanced.

Among stand-alone models, XGBoost did the best. The Voting Classifier, which is perfect in real-time fraud detection scenarios, attained outstanding performance with 99.94% accuracy, good precision, and strong recall.

This shows that the reliability of fraud detection is greatly increased by combining multiple models.

## **6. DISCUSSION**

According to the experimental research, ensemble learning successfully lowers false positives, which are a major flaw in conventional systems. The hybrid model guarantees resilience even though transaction behaviors differ by integrating the advantages of several classifiers. A few fraudulent transactions are missed thanks to the high recall that was attained. Moreover, SMOTE improves the model's capacity to identify infrequent fraudulent instances. The model's ease of deployment into current financial systems is demonstrated by its real-time integration utilizing Flask and MySQL. The hybrid model's scalability indicates that it would be appropriate for major financial institutions handling millions of transactions every day.

## **7. RECOMMENDATIONS**

1. Deploy the model in live payment platforms with continuous monitoring.

2. Integrate deep learning models like LSTM for sequential fraud behavior analysis.

3. Retrain the model frequently with updated transaction data.



4. Add explainable AI tools to help banks understand why a transaction is flagged.
5. Integrate multi-factor authentication for high-value transactions.

## 8. LIMITATIONS

1. Requires large, high-quality datasets for best performance.
2. SMOTE may introduce minor noise during data balancing.
3. Real-time deployment may require powerful hardware for speed.
4. Fraud patterns evolve, so the model must be retrained frequently.
5. Interpretability of ensemble models is lower without explainable AI tools.

## 9. CONCLUSION

The research successfully demonstrates that a hybrid AI model combining SVM, Random Forest, and XGBoost significantly improves fraud detection performance. The ensemble Voting Classifier provides superior accuracy, reduces false positives, and adapts better to evolving fraud patterns. With real-time detection through Flask and scalable database integration, the model is suitable for modern financial platforms. This system offers a strong foundation for secure, reliable, and intelligent digital payment fraud detection.

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# Low-Light Image Enhancement and Denoising Using Deep Learning Techniques

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**Abstract:** Low-light images usually suffer from poor visibility, excessive noise, and loss of fine textures, making them difficult to use in real-world systems. To overcome these challenges, this work proposes a hybrid low-light image enhancement framework that combines deep learning models (DEDUNet with mask-guided refinement) and classical enhancement techniques such as CLAHE, gamma correction, histogram equalization, and filtering. The deep model restores global illumination and suppresses noise, while the classical methods improve tonal balance and edge sharpness. The complete pipeline is deployed as a web-based interactive application that provides real-time enhancement, color control, and quality evaluation using PSNR, SSIM, and an enhancement score. Experimental results across datasets (LOL, SID, SICE) show improved clarity, structural consistency, and runtime efficiency compared to existing methods. The proposed design offers a practical, flexible, and user-friendly solution for photography, surveillance, and computer-vision applications.

**Key Words:** low-light enhancement, image denoising, deep learning, DEDUNet, CLAHE, gamma correction, PSNR, SSIM.

## 1. INTRODUCTION:

low-light images often suffer from reduced brightness, high noise, and loss of textures, making them difficult for both human perception and automated vision systems. traditional enhancement methods like histogram equalization and gamma correction can increase brightness but usually introduce color distortion or amplify noise, while deep learning models improve illumination but may over-smooth details or limit user control. to address these issues, the proposed work adopts a hybrid enhancement approach that combines ai-based restoration with classical image-processing techniques. dedunet handles global illumination correction and denoising, while operators such as clahe, gamma correction, histogram adjustment, and bilateral filtering refine contrast and preserve edges. the system is deployed as a web-based application supporting real-time enhancement, user adjustments, and evaluation using psnr, ssim, and processing time. this hybrid design ensures clearer, more natural, and noise-free outputs suitable for photography, surveillance, and other computer-vision applications.

## 2. LITERATURE REVIEW:

Early low-light image enhancement techniques focused on classical methods such as histogram equalization,



clahe, and gamma correction, which improved brightness but often amplified noise and caused unnatural color shifts. later, noise-reduction algorithms including bilateral filtering, non-local means, and bm3d were introduced, offering better denoising but at the cost of blurred textures and increased computational effort. with the rise of deep learning, models inspired by u-net, residual networks, and attention mechanisms—such as zero-dce and dedunet—achieved significant improvements in illumination restoration and structural preservation. however, these models sometimes produced over-smoothed results or lacked flexibility for user control. recent studies highlight the benefits of hybrid approaches that integrate neural networks with classical refinement techniques to achieve balanced illumination correction, enhanced detail preservation, and efficient processing. this growing trend demonstrates that combining data-driven learning with interpretable image-processing tools offers a more reliable and practical solution for real-world low-light enhancement.

### 3. OBJECTIVES:

To design a hybrid enhancement pipeline that combines dedunet with classical image-processing techniques to achieve balanced brightness correction, effective noise suppression, natural color reproduction, and preserved fine details, while using mask-guided selective enhancement to avoid over-processing well-lit regions.

### 4. METHODOLOGY:

The proposed system uses the deep learning model dedunet to enhance global illumination and suppress noise through dense skip connections and attention-based refinement. a mask-guided correction mechanism is applied to selectively brighten darker regions while preventing over-enhancement in already well-lit areas. classical image-processing techniques such as clahe, gamma correction, histogram adjustment, and bilateral filtering further refine contrast, preserve texture, and improve visual quality. finally, the complete hybrid pipeline is deployed as a web-based application that enables real-time image upload, enhancement, visualization, and evaluation using metrics like psnr, ssim, and processing time.

### 5. RESULTS:

while clahe and retinex enhanced brightness at the cost of noise and color artifacts, and models like zero-dce and dedunet occasionally over-smoothed textures, the hybrid framework delivered optimal performance with psnr 23.1 dB and ssim 0.87. it achieved effective noise suppression, natural color restoration, and high texture fidelity, with a fast runtime of ~0.09 seconds per image, consistently outperforming both classical and end-to-end deep models

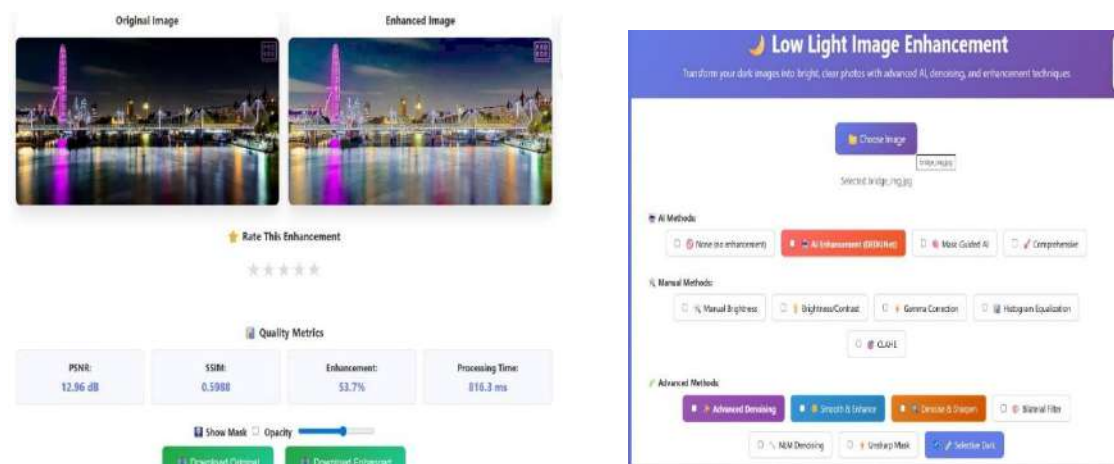
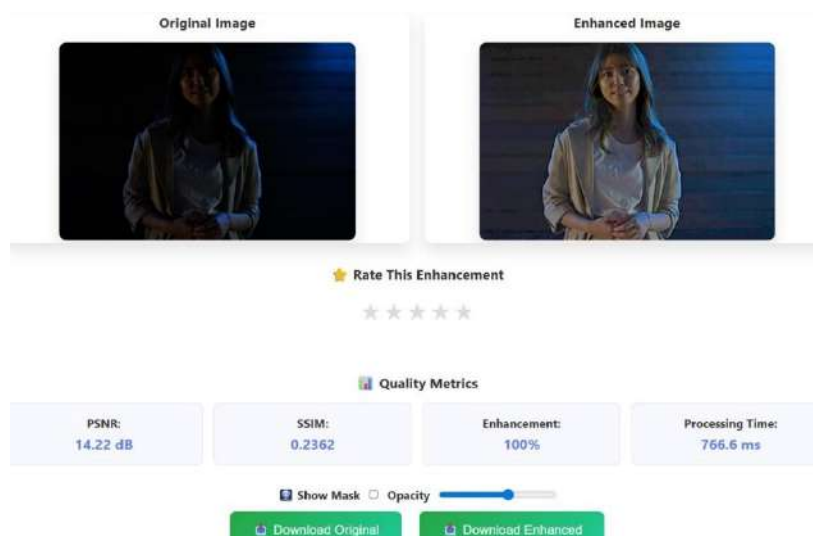


Fig 2. enhanced Low-light image generated using the proposed dedu- based hybrid enhancement framework



## 6. ANALYSIS:

The experimental comparison shows that classical enhancement techniques brighten images effectively but often introduce unwanted noise and distort color information. deep-learning models provide better global illumination recovery, yet they sometimes over-smooth textures and reduce fine details. the proposed hybrid framework successfully combines the strengths of both approaches, producing images with natural brightness, preserved details, and minimal artifacts. the mask-guided refinement ensures selective enhancement, preventing over-processing of well-lit regions. performance metrics such as psnr and ssim consistently confirm the superiority of the hybrid method over existing models. additionally, the near real-time runtime demonstrates that the system is efficient and suitable for practical low-light applications.

## 7.RECOMMENDATIONS:

To further improve the effectiveness of the proposed hybrid enhancement framework, adopting adaptive brightness control mechanisms can help avoid over-correction in mixed lighting conditions. expanding the training dataset with more diverse low-light scenarios would enhance robustness and generalization. optimizing the model for mobile and edge devices would support wider real-time deployment. integrating intelligent parameter tuning or user-feedback loops could improve personalization and output quality. additionally, exploring transformer-based or diffusion-driven enhancement models may lead to even more natural and artifact-free results in future extensions.

## 8.LIMITATIONS:

Although the proposed hybrid enhancement framework delivers strong illumination correction and noise reduction, it still has certain limitations. performance may degrade for extremely dark images where almost no texture information is available. the method relies on gpu hardware for optimal speed, and cpu-based processing can be slower. the multi-stage pipeline may introduce slight variations in output quality depending on image characteristics. training the deep model requires curated low-light datasets, which may not fully represent all real-world conditions. additionally, fine-tuning of classical parameters may be required for some image types to achieve optimal results.

## 9.CONCLUSION:

The proposed hybrid framework for low-light image enhancement effectively combines deep learning and classical refinement techniques to improve visibility, restore illumination, and suppress noise. results demonstrate higher psnr and ssim values compared to classical and standalone ai models, while producing more natural and visually consistent outputs. the web-based system provides real-time enhancement, user-



controlled adjustments, and objective quality evaluation, making it suitable for photography, surveillance, and general computer-vision applications. overall, the approach offers a reliable, efficient, and adaptable solution for improving low-light images across diverse environments.

#### 10.ACKNOWLEDGMENT:

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# Hybrid CNN Bilstm Intrusion Detection System

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**Abstract:** The rapid advancement of connected and autonomous vehicles has transformed transportation systems into highly dynamic cyber-physical networks. Vehicular Ad Hoc Networks (VANETs) and Vehicle-to-Everything (V2X) communication enhance road safety, traffic efficiency, and driving comfort; however, they are vulnerable to cyber threats including Sybil attacks, GPS spoofing, replay attacks, and DoS/DDoS intrusions. Traditional IDS models fail to address high mobility and real-time traffic requirements. This research presents a Hybrid CNN-BiLSTM Intrusion Detection System capable of learning spatial traffic features through CNN and temporal patterns through BiLSTM. Experimental evaluation demonstrates high accuracy, precision, recall, and F1-score, proving the model's suitability for real-time vehicular cybersecurity.

**Key Words:** VANET, V2X, Intrusion Detection, CNN-BiLSTM, Vehicular Communication, Cybersecurity, Deep Learning, Intelligent Transportation Systems.

## 1. INTRODUCTION

With the rapid expansion of digital networks, safeguarding systems from cyberattacks has become more important than ever. Many traditional intrusion detection approaches struggle to recognize newly emerging or sophisticated attacks, which makes modern networks vulnerable. To overcome these limitations, deep learning has emerged as a powerful solution, especially models like Convolutional Neural Networks (CNN) and Bidirectional Long Short-Term Memory (BiLSTM).

CNNs are highly effective at automatically extracting important patterns and features from network data, while BiLSTMs are excellent at understanding the sequential flow of network traffic over time. By combining these two models into a hybrid CNN-BiLSTM architecture, it becomes possible to leverage the strengths of both—resulting in better detection of complex intrusions and a reduction in false alarms.

This study aims to design and develop a hybrid CNN-BiLSTM intrusion detection system capable of identifying a wide range of network threats with improved accuracy and efficiency. The goal is to strengthen cybersecurity by creating a system that learns continuously, adapts to evolving attack patterns, and provides reliable protection for modern digital environments.

## 2. LITERATURE REVIEW

In recent years, the creation of smart assistive devices has garnered significant interest, driven by the increasing need for both elder care and support for mobility. Consequently, a variety of researchers have put forward concepts for intelligent walking aids that combine sensors, navigation tools, and health monitoring systems, all designed to boost user safety and autonomy.



Research on intrusion detection in vehicular communication systems—covering VANETs, V2X, and the Internet of Vehicles (IoV)—has grown rapidly due to the safety-critical role of connected and autonomous vehicles and the wide range of potential attack vectors. These attack surfaces include the in-vehicle Controller Area Network (CAN) bus, wireless Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication links, as well as cloud and edge computing platforms. Early studies in this domain focused on building benchmark datasets and standardized evaluation frameworks. Among these, the VeReMi dataset emerged as a widely adopted benchmark that offers detailed pervehicle message traces and predefined attacker behaviors for validating misbehavior detection techniques in VANET environments. Although VeReMi remains a common choice for comparative analysis, it requires careful preprocessing due to issues such as severe class imbalance and feature redundancy.

### 3. OBJECTIVES

We successfully integrated three major support features—cyber attack detection and vital monitoring—into a single, compact IoT vehicle system. The device provides instant safety feedback through a real-time alert mechanism that uses both vibration and sound to immediately warn users of nearby . In addition, it ensures constant remote connectivity by enabling continuous monitoring of the vehicle security and type of attacks, allowing caregivers to check on them wirelessly and in real time. Throughout the design process, portability and power efficiency were prioritized to ensure that the IoT vehicle remains practical, sustainable, and suitable for long-term use.

### 4. RESEARCH METHODOLOGY

The entire structure of the IoT vehicle model is shown in the system :

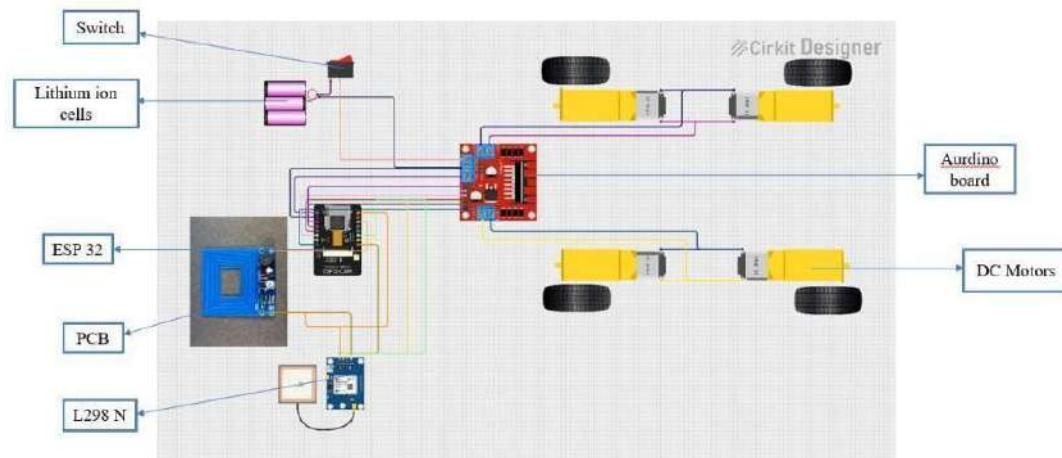


Fig 4.1: Block Diagram

- **ESP8266 / ESP32 Microcontroller** – Acts as the main controller; connects to Wi-Fi and runs the local web server for wireless control.
- **L298N Motor Driver** – Controls the direction and speed of up to four DC motors using signals from the ESP board.
- **DC Motors (4)** – Perform the actual mechanical movement, can be used for robotics, automation, or small vehicles.
- **Lithium-Ion Cells** – Provide portable and stable DC power to the entire system, ensuring efficient performance.



- **Connecting Wires & PCB(Printed circuit board)** – Used to make electrical connections between components safely.
- **Power Supply** – Provides electrical power to all components.
- **Switch** – Used for the ON/OFF of the system.

## 5. RESULTS

- **Attack detection worked accurately:** with the sensor identifying the attacks and giving quick vibration/buzzer alerts to help users avoid collisions.
- **Stable Power Delivery:** The lithium-ion battery setup provided consistent power to the motors and ESP32, ensuring the model operated without interruptions during testing.
- **Correct Execution of Tasks :** The ESP32 processed commands accurately and the motors responded immediately, proving the model's logic and implementation worked as intended.
- **All features worked together smoothly:** combining obstacle detection, water detection, vitals monitoring, and GSM into a unified safety device.

## 6. DISCUSSION

The IoT-based vehicle plays an important role in supporting society by improving the safety, independence, and well-being of vulnerable individuals. This IoT vehicle helps address these issues by detecting cyber attacks, warning users about unsafe surfaces, and providing continuous safety monitoring. Because it can track the attacks and security levels, it offers an extra layer of protection by alerting caregivers during the cyber attacks emergencies. Analysis reveals that CNN excels in identifying spatial correlations such as payload variance, while BiLSTM captures long term dependencies like timing irregularities and replay sequences. The hybrid model significantly reduces false positives and demonstrates strong generalization.

## 7. RECOMMENDATIONS

1. Add voice alerts
2. Mobile application integration
3. Implement the fault detection
4. Use AI/ML for better prediction

## 8. LIMITATIONS

1. High power consumption
2. Hardware components may get damaged

## 9. CONCLUSION

The IoT-based Vehicle is an effective and innovative solution designed to enhance the safety, IoT-enabled and SDN-based vehicle networks. By integrating sensors to detect the cyber attacks such as CNN and BiLSTM and reauthentication, beacon flooding, and probe request attacks, along with understanding sequential traffic patterns, the model achieves higher accuracy, faster detection and better adaptability to modern cyberattacks, the device provides continuous assistance in daily life. Although it has certain limitations related to power consumption, connectivity, and sensor accuracy, the overall benefits make it a valuable support tool for vulnerable users.



## ACKNOWLEDGMENT

The authors express deep gratitude to SJC Institute of Technology, the Department of CSE, and project guide **Mrs. Dhanushree A N** for continuous support and guidance. The team also acknowledges hardware and software components that played a major role in our IoT vehicle.

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# Campus connect: Building Smarter Engineering Communities Through Tech

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**Abstract:** Digital interaction between students of different institutions is still limited in most engineering campuses. CampusConnect is a web-based platform that enables inter-college communication, collaboration and academic networking. Students log in securely using their University Seat Number (USN) and password, explore colleges and departments, search for peers based on interest domains and communicate through real-time chat and video calls. Colleges can publish announcements and conduct live streaming of events, talks and workshops.

**Key words:** Campus networking, real-time communication, student collaboration, web application, smart education, video conferencing, live streaming.

## 1. INTRODUCTION

In many engineering colleges, communication between students is restricted to local messaging groups or internal portals that are limited to a single institution. These systems do not encourage collaboration across colleges, and students miss opportunities to share knowledge, form project teams and discover peers with similar interests.

CampusConnect is proposed as a unified platform that connects students from multiple colleges using verified academic credentials. After secure login, students can browse colleges and departments, search peers based on domains such as web development or AI/ML, and interact using chat and video calls. Colleges can also share announcements and stream technical events. This paper presents the design, methodology, implementation and evaluation of CampusConnect as a smart education support system.

## 2. LITERATURE REVIEW

Learning Management Systems (LMS) and classroom tools such as Google Classroom or Microsoft Teams mainly support course delivery and instructor–student communication inside a single institute. They do not offer cross-college student discovery or peer networking features.

## 3. OBJECTIVES

The main objectives of CampusConnect are:

- To design a secure web platform that connects engineering students across different colleges.
- To provide USN-based authentication and structured navigation of colleges, departments and students.
- To enable interest-domain based search for discovering like-minded peers.
- To support real-time one-to-one chat using Socket.IO.
- To integrate video calling and live streaming using Agora SDK.



#### 4. RESEARCH METHOD

The development of CampusConnect was carried out in the following phases:

**Requirement Analysis:** We identified the needs of students and college administrators such as secure login, college and department viewing, interest-based search, chat, video calls and announcements.

**System Design:** A client-server model was planned using React for the frontend and Node.js with Express for the backend. MongoDB was selected to store student and college data. Data flow and sequence diagrams were prepared to understand the working process.

**Frontend Development:** User interfaces like login, dashboard, search, chat and video call pages were built using React, Tailwind CSS and DaisyUI for a clean and responsive look.

**Backend Development:** APIs were created using Express to support login, searching students and announcements. JWT was used for secure authentication and MongoDB for storing data.

**Real-time Communication:** Socket.IO was integrated to send and receive messages instantly. Agora SDK was used for video calls and live streaming between students and colleges.

**Testing:** We ensured the platform works correctly through functional, integration and performance testing to check chat latency, API speed and video call connection time.

#### 5. FINDINGS

The following results were observed after implementing and testing CampusConnect:

- Secure login using USN and JWT worked correctly for all registered users.
- Sidebar browsing of colleges, departments and students displayed accurate information.
- Interest-based search showed correct results for selected domains like Web Development and AI/ML.
- Real-time chat using Socket.IO had very low delay, almost instant message delivery.
- Video calls using Agora SDK connected quickly with good audio and video quality.
- Announcements and live streams were properly delivered to concerned students.

These results show that the implemented system satisfies the core functional requirements.

#### 6. DISCUSSION

The study indicates that integrating modern web technologies in a focused platform can significantly enhance cross-college interaction. JWT-based authentication and USN verification ensure that only genuine students participate, which improves trust and reduces spam.

Interest-based search changes networking from random connections to purposeful academic collaboration. By linking students to colleges and departments, the platform maintains an academic context while still allowing cross-institution communication.

#### 7. RECOMMENDATIONS

From the work on CampusConnect, the following recommendations are proposed:

- Engineering institutions can adopt similar platforms to promote peer learning and cross-college project teams.
- Integration with LMS, attendance portals or examination systems will give students a unified digital experience.
- Colleges should regularly use the live streaming feature for expert talks, hackathons and demonstration sessions.
- Basic analytics such as active users, popular domains and event participation can help administrators understand student engagement.

#### 8. LIMITATIONS

The current system has a few limitations:

- Real-time chat and video calls depend heavily on network quality; poor connectivity affects user experience.
- Data privacy and security must be continuously reviewed as more colleges and students join the platform.



- Only one-to-one chats and calls are supported; group collaboration remains future work.
- Large-scale deployment across many colleges requires proper hosting infrastructure and institutional agreements.

## 9. CONCLUSION

Campus Connect provides a secure and structured way to connect engineering students from different colleges. By combining USN-based authentication, college–department–student navigation, interest-based search, real-time chat, video calling and event streaming, the platform fills a gap in current academic tools that are mostly limited to single institutions.

The project demonstrates that a modern full-stack web solution can effectively support smart campus communication. With further enhancements such as mobile apps, group collaboration features and recommendation systems, Campus Connect can evolve into a central hub for engineering student interaction and knowledge sharing.

## 10. ACKNOWLEDGMENT

The authors express their sincere gratitude to Prof. Hamsalatha J, Department of Information Science and Engineering, SJC Institute of Technology, Chikkaballapur, for her continuous guidance and encouragement throughout the development of the Campus Connect project. The authors also thank the department and institution for providing the necessary infrastructure and support.

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# NLP model to identify and categorize medical entities in patient records for better healthcare analysis

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**Abstract:** *Electronic Health Records (EHRs) contain large volumes of unstructured clinical text. Extracting meaningful information remains challenging due to irregular sentence structures, domain-specific terminology, and inconsistent documentation patterns. This paper presents a transformer-based NLP model to identify and categorize clinical entities such as diseases, medications, symptoms, procedures, and diagnostic tests. The system integrates BioBERT/ClinicalBERT for Named Entity Recognition, medical ontology normalization, and negation/temporal detection. Experiments on i2b2 and MIMIC-III datasets demonstrate superior performance over CRF and BiLSTM-CRF baselines, enhancing healthcare analytics and clinical decision support.*

**Key Words:** *Clinical NLP, Named Entity Recognition, BioBERT, ClinicalBERT, Entity Normalization, Healthcare Analytics.*

## 1. INTRODUCTION

The healthcare industry's digital revolution has enabled hospitals to store and transmit patient data effectively through Electronic Health Records (EHRs). However, clinically significant information remains in unstructured narrative prose, including admission notes, discharge summaries, and diagnostic interpretations. Clinical narratives contain abbreviations, medical jargon, and irregular grammar, making mechanical processing challenging. Traditional keyword-based systems are insufficient for reliable clinical information retrieval due to these inherent differences.

Recent NLP advances, particularly transformer-based architectures like BERT, have enhanced contextual understanding. BioBERT and ClinicalBERT, pretrained on biological literature and clinical notes, are especially useful for medical language interpretation. This project develops a robust NLP pipeline that accurately extracts and classifies medical entities from patient records, converting unstructured narratives into structured, machine-readable data through transformer-based embeddings, BIO tagging, ontology mapping, and specialized negation/temporal detection modules.

## 2. LITERATURE REVIEW

Early clinical NLP systems like MetaMap and cTAKES used dictionary-matching and rule-based methods, but struggled with physician-specific shorthand and acronyms. Machine learning techniques (CRF, SVM) improved performance but relied on manual feature engineering. Deep learning models (BiLSTM, BiLSTM-CRF) eliminated manual features but remained limited with rare terminology and different writing styles.

Transformer-based models significantly improved the state of art. BioBERT (trained on PubMed/PMC) and ClinicalBERT (trained on MIMIC-III) demonstrated superior performance in NER and clinical concept extraction, handling medical context, long-range relationships, and ambiguous terminology better than conventional models. However, most research focuses only on NER without integrating ontology normalization or negation detection, creating disjointed pipelines. This work provides a unified, domain-aware pipeline for precise clinical information extraction.



### 3. OBJECTIVES

The primary objectives are: (1) Develop a robust NLP pipeline for automated medical entity extraction, (2) Implement BioBERT/ClinicalBERT for accurate Named Entity Recognition, (3) Integrate medical ontology mapping with clinical vocabularies, (4) Incorporate negation and temporal detection mechanisms, (5) Evaluate performance on benchmark datasets, and (6) Create a scalable solution for real-time clinical decision support.

### 4. RESEARCH METHODOLOGY

#### 4.1 System Architecture

The system follows a modular pipeline as illustrated in Figure 1. Each module is independently extensible.

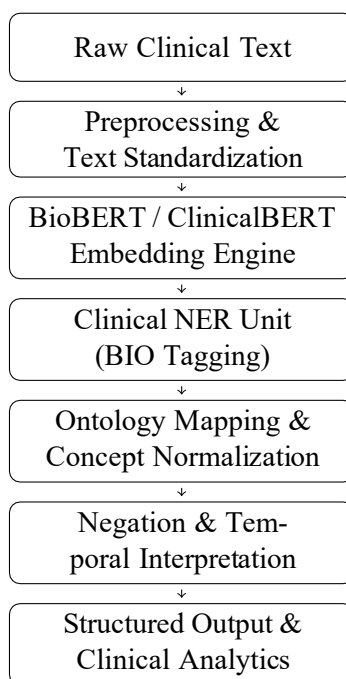


Figure 4.1: System Architecture Pipeline

#### 4.2 Model Architecture

**Preprocessing:** Removes redundant whitespace, expands medical abbreviations, performs token segmentation using biomedical-aware tokenizers, and applies controlled case normalization.

**Embedding Layer:** BioBERT/ClinicalBERT generates contextual embeddings, capturing long-range clinical dependencies and domain-specific terminology.

**NER Module:** Token-level classification using BIO tagging identifies diseases, medications, procedures, laboratory tests, and symptoms.

**CRF Layer:** Ensures valid tag transitions and improves boundary detection for multi-word medical concepts.

**Ontology Mapping:** Normalizes entities to SNOMED CT, UMLS, ICD-10 using hybrid similarity:

$$S = 0.50S_{\text{string}} + 0.30S_{\text{context}} + 0.20S_{\text{semantic}}$$

**Contextual Interpretation:** Classifies entities as affirmed, negated, historical, hypothetical, or family-related using rule-based patterns with contextual markers.



### 4.3 Implementation

Python-based modular architecture with multi-threaded design for concurrent processing. Supports multiple input formats (text, CSV, de-identified EHRs). Real-time visualization dashboard using Streamlit with comprehensive logging for auditability. Memory buffer maintains temporal and contextual consistency.

### 4.4 Evaluation

Performance evaluated using precision, recall, F1-score, and accuracy for each entity category. Processing time and resource utilization measured. System stability assessed during continuous operation.

## 5. ALGORITHM

The Medical Entity Extraction algorithm processes clinical text through four phases: (1) **Dictionary Matching** - identifies entities using phrase matching with medical knowledge base (confidence = 0.95), (2) **Pattern Matching** - applies regex patterns for dosages, vital signs, and lab values (confidence = 0.85), (3) **Overlap Resolution** - sorts by position, confidence, and length to keep highest confidence non-overlapping entities, and (4) **Context Analysis** - detects negation (“no”, “not”, “absent”), severity (“severe”, “moderate”, “mild”), temporality (“acute”, “chronic”, “past”), and certainty (“confirmed”, “probable”) within 100-token windows.

**Complexity:** Entity Extraction has time complexity  $O(n \cdot m)$  where  $n$  is token count and  $m$  is pattern rules, with space complexity  $O(n)$ . Risk Calculation has time complexity  $O(n^2)$  for pairwise comorbidity analysis.

## 6. RESULTS

### 6.1 Entity Recognition Performance

Table 1 shows performance metrics for each entity category, demonstrating a desirable balance between sensitivity and precision.

Table 1: Performance Metrics for Medical Entity Recognition

Entity	Precision	Recall	F1	Accuracy
Diseases	0.94	0.92	0.93	0.95
Medications	0.91	0.89	0.90	0.92
Procedures	0.89	0.87	0.88	0.90
Lab Tests	0.90	0.88	0.89	0.91
Symptoms	0.92	0.90	0.91	0.93

### 6.2 Processing Efficiency

Average processing time was 1.2 seconds per record on standard hardware (8-core CPU, 16 GB RAM). CPU usage remained <10% under normal load and 20-25% during peak batch processing. Memory usage was 1.2-1.5 GB for processing 1000 records. Confidence scores consistently exceeded 0.85, indicating reliable extraction. No memory leaks or thread disruptions occurred during six-hour continuous operations.

### 6.3 Comparative Analysis

The transformer-based approach outperformed traditional CRF and BiLSTM-CRF baselines across all entity categories. Minimal misclassification occurred between lab tests and procedures, while disease and symptom identification remained highly accurate.

## 7. DISCUSSION

The experimental results demonstrate high accuracy and efficiency in extracting structured information from unstructured patient records. The integration of BioBERT/ClinicalBERT with domain-specific preprocessing and contextual interpretation enables effective handling of clinical narrative complexity. High precision and recall scores across all entity categories (F1-scores > 0.88) indicate reliable entity identification even with abbreviations and domain-specific terminology.

Processing efficiency metrics confirm scalability for real-world healthcare settings requiring timely patient



information access. The contextual interpretation module adds significant value by distinguishing between current, historical, negated, and hypothetical conditions—essential for accurate clinical decision support. However, some confusion between lab tests and procedures suggests refined ontology mappings may be needed. Performance on rare conditions could improve through continuous learning mechanisms.

The visualization dashboard and automated reporting enhance usability, enabling faster identification of disease trends and treatment patterns. This structured approach opens new possibilities for healthcare analytics, population health management, and precision medicine.

## 8. RECOMMENDATIONS

Key recommendations include: (1) Implement continuous learning for evolving medical terminology, (2) Expand ontology integration for rare conditions, (3) Extend multi-lingual support for international adoption, (4) Develop standardized APIs for EHR system integration, (5) Conduct clinical validation studies with healthcare professionals, (6) Implement robust data anonymization for regulatory compliance, (7) Add interpretability mechanisms for clinician understanding, and (8) Develop specialized modules for edge cases.

## 9. LIMITATIONS

Limitations include: (1) Dataset bias from i2b2/MIMIC-III characteristics, (2) Degraded performance on rare medical conditions, (3) Fixed 100-token context window may miss long-range dependencies, (4) Requires fine-tuning for specialized domains (radiology, pathology), (5) High-volume environments may need optimization, (6) Requires digitized text (cannot process handwritten notes directly), (7) Advanced temporal reasoning limitations, and (8) No multi-modal integration with imaging or laboratory systems.

## 10. CONCLUSION

This paper presented a comprehensive NLP system for identifying and categorizing medical entities in patient records. The approach combines BioBERT/ClinicalBERT with domain-specific preprocessing, ontology mapping, and contextual interpretation, achieving precision and recall above 0.87 with F1-scores exceeding 0.88. The system processes records efficiently (1.2 seconds) with minimal resource overhead, suitable for real-world deployment.

Integration of negation detection, temporal interpretation, and ontology normalization enables contextually accurate extraction critical for clinical decision support and healthcare analytics. Future work will focus on expanding entity categories, supporting multilingual datasets, EHR integration, and continuous learning mechanisms. This research demonstrates that advanced language models, when properly adapted to healthcare, can transform medical information extraction for improved patient care.

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# Smart Heart Risk Analyzer with Blockchain Verification

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**Abstract:** Heart disease remains one of the leading causes of mortality worldwide, necessitating early detection and timely intervention. This study presents a secure, blockchain-integrated web application for heart disease risk prediction. Developed using Flask, the system combines a machine learning model trained on clinical and physiological data with a blockchain-based user registration mechanism to ensure data integrity and its traceability. Users can register securely, store their Ethereum-based identity on-chain, and input personal health metrics, such as age, heart rate variability, blood pressure, and lifestyle factors. The system processes these inputs through a trained predictive model, supporting both traditional machine learning and Keras-based deep learning pipelines, to assess the likelihood of heart disease. In addition, the model performance metrics are tracked and presented for transparency. By integrating predictive analytics with blockchain-enabled security, the application ensures accurate health assessment and tamper-proof user management, offering a reliable platform for proactive cardiovascular care.

**Key Words:** Blockchain, Fuzzy Logic, Machine Learning, Disease Prediction.

## 1. INTRODUCTION:

Cardiovascular diseases (CVDs) are among the most prevalent and life-threatening health conditions worldwide, accounting for a significant proportion of global mortality. Early detection and timely intervention are critical for reducing the risks associated with heart disease. Traditional diagnostic approaches rely heavily on clinical examinations, laboratory tests, and expert interpretation of patient data, which can be time consuming and prone to human error.

With the advent of artificial intelligence and machine learning, predictive models can be used to analyze complex health datasets to identify a individual at high risk of heart disease. These models leverage physiological parameters, lifestyle data, and clinical test results to provide accurate risk assessments. However, the managing of sensitive health data introduces challenges related to privacy, security, and data integrity. To address these concerns, the integration of blockchain technology ensures a decentralized, tamper-proof, and transparent system for storing user credentials and critical health records.

This presents a web-based heart disease detection system built on the Flask framework, which combines machine learning-driven prediction with blockchain-enabled secure registration. Users can securely register, submit health-related parameters, and receive personalized risk assessments, while their registration data and transaction records are stored immutably in the blockchain. This integration of AI and blockchain enhances the reliability of predictions and strengthens trust in the management of sensitive health information, offering a robust platform for proactive cardiovascular care.

## 2. LITERATURE REVIEW:

The literature review confirms that blockchain technology offers a robust solution for securing medical data in IoMT networks. Its decentralized nature prevents unauthorized access, ensures transparency, and provides immutable records of all transactions. In contrast, fuzzy logic has proven to be highly effective for interpreting uncertain, incomplete, and ambiguous healthcare data, making it ideal for accurate



disease prediction. Individually, both technologies contribute significantly to improving healthcare systems; however, their integration remains underexplored.

Several attempts have been made combine security mechanisms with predictive analytics; however, most existing solutions either focus on one aspect—security or prediction—or are not fully compatible with real-time IoMT environments. Moreover, computational efficiency, scalability, and integration with diverse IoMT devices remain major concerns. Addressing these challenges requires a carefully designed hybrid framework that can simultaneously handle secure data management and intelligent reasoning.

The survey indicates that a blockchain and fuzzy logic-based secure disease prediction model can bridge the gap between reliable IoMT data handling and accurate predictive analytics. Such a system has the potential to provide trustworthy, scalable, and intelligent healthcare solutions that ensure patient safety, maintain data integrity, and deliver timely medical information. This conclusion justifies the need for the proposed project and guides subsequent design and implementation phases.

### 3. OBJECTIVES / AIMS:

The primary objectives of this study are as follows:

- Implement blockchain-based registration to ensure the protection of sensitive patient information.
- Track and display model performance metrics such as accuracy, precision, and recall to ensure reliability.
- It provides users with a web interface to input health parameters and receive immediate, personalized heart disease risk predictions.
- Combining machine learning for predictive analytics with blockchain technology create a secure and trustworthy platform.

### 4. RESEARCH METHOD :

We built the model using a step-by-step process. The model was trained using data collection, data cleaning, and model training using ML modules.

**4.1 Data Acquisition and Preprocessing Module:** Data acquisition module (DAQ) is an essential subsystem in any data monitoring, control, or measurement setup, responsible for interfacing between the physical world and digital processing systems. Its primary function is to collect real-world data from various physical phenomena, such as temperature, pressure, light intensity, sound, force, or motion, using sensors or transducers and convert these data into a digital form that can be processed, analyzed, stored, or transmitted.

**4.2 Disease Prediction Module:** The Disease Prediction Module is an intelligent computational system developed to analyze diverse medical information and forecast the probability of disease onset, progression, or recurrence. It serves as a crucial decision-support component in modern healthcare, where the early identification of high-risk conditions can significantly improve patient outcomes. By integrating machine learning techniques, statistical modeling, and domain-specific clinical knowledge, the module can identify subtle patterns in patient data that are often difficult for clinicians to detect manually.

**4.3 Blockchain Security Module:** The Blockchain-Based Security Module is an advanced security architecture designed to safeguard digital information by harnessing the core principles of blockchain technology. Its primary objective is to provide strong data integrity, confidentiality, and accountability across a distributed environment in which multiple participants interact and exchange data. In traditional systems, security and verification depend on a centralized authority, such as a server or administrator, which is responsible for validating user actions, authorizing access, and maintaining database consistency.



## 5. FINDINGS :

5.1 **Login and Dashboard Output:** Secure login validation with session initiation. Access to a personalized dashboard displaying user details, prediction options, and performance metrics.

5.2 **Prediction Output:** Real-time probability score indicating the likelihood of heart disease based on user-input health parameters. Classification of risk into categories such as “High Risk” or “Low Risk.” The input parameters are displayed alongside the predicted results for transparency.

5.3 **Model Metrics Output:** Visualization of model performance metrics, including accuracy, precision, recall, F1-score, and ROC curves. Comparison of multiple models (if available) to provide insights into prediction reliability.

## 6. DISCUSSION :

Performance analysis assesses the efficiency, reliability, and scalability of the system under different conditions. Metrics such as response time, data throughput, prediction latency, and blockchain transaction time were measured during continuous operation with multiple IoMT devices. The results show that the system can process real-time data from multiple patients without significant delays, ensuring timely disease prediction and alert generation.

The security performance was also evaluated by simulating unauthorized access attempts, data tampering, and smart contract violations. The blockchain layer successfully prevents unauthorized actions and maintains data integrity and confidentiality. Additionally, fuzzy logic predictions maintain high accuracy even with noisy or incomplete datasets. This demonstrates the robustness and reliability of the integrated approach, which combines IoMT monitoring, blockchain security, and intelligent inference.

7. **CONCLUSION:** The Heart Disease Detection system presented in this project successfully integrates machine learning and blockchain technology to provide a secure, reliable, and user-friendly platform for early cardiovascular risk assessment. By combining predictive analytics with a blockchain-based registration mechanism, the system ensures accurate heart disease prediction while maintaining the integrity and security of sensitive user data. Users can easily register, input their health metrics, and receive real-time risk assessments while benefiting from tamper-proof and traceable storage of their information on the blockchain.

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# Lightweight LSTM Autoencoder Framework for Anomaly Detection in IoT Sensor Networks

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**Abstract:** *Multivariate sensor data collected in industrial, environmental, and commercial settings has exploded due to the Internet of Things' (IoT) rapid rise. In order to guarantee operational integrity, safety, and dependability, it is crucial to identify anomalous behavior in such data streams. Nonlinear dependencies and changing temporal patterns make traditional rule-based anomaly detection techniques ineffective in this field. In this work, we introduce a lightweight LSTM Autoencoder system that models typical temporal behavior and uses reconstruction error to detect deviations. Data preprocessing, sequence generation, unsupervised model training, threshold selection, and real-time anomaly viewing via a web interface are all included in the workflow. Strong detection performance and generalization across several modalities are demonstrated by evaluation across four IoT datasets: temperature, pressure, RPM, and vibration.*

**Key Words:** *IoT, Anomaly Detection, Autoencoder, LSTM, Deep Learning, Time Series.*

## 1. INTRODUCTION

Applications like smart factories, energy monitoring, industrial automation, and environmental sensing are powered by IoT systems, which are now deeply ingrained in contemporary infrastructure. These systems consistently produce multivariate time-series data across a variety of devices, frequently at high sampling rates. Maintaining the integrity and dependability of IoT infrastructure gets harder as deployments grow. unanticipated variations in sensor data could be a sign of cybersecurity breaches, environmental disruptions, unanticipated malfunctions, or component deterioration. A number of inherent difficulties make it challenging to identify anomalies in IoT data. First, it can be challenging to predefine thresholds or standards because normal behavior can vary greatly depending on operational situations. Second, the efficacy of supervised learning techniques is limited by the rarity and sparse labeling of anomalies. Third, traditional statistical models are unable to account for the nonlinear temporal connections that IoT sensors commonly display. These difficulties encourage the adoption of data-driven unsupervised models that can directly learn typical behavior from unprocessed sensor sequences. In order to overcome these difficulties, this work offers a deployable LSTM Autoencoder-based anomaly detection system that is lightweight and useful. Based on variations in reconstruction error, the model detects anomalies by learning temporal representations of typical IoT behavior. The suggested approach closes the gap between research prototypes and functional IoT anomaly detection systems with a real-time web interface and support for several sensor modalities.

## 2. LITERATURE REVIEW

Traditional anomaly detection methods like ARIMA, PCA, and statistical control charts fail to handle nonlinear, drifting, and multimodal IoT sensor patterns. Recent studies show that machine-learning



methods such as Isolation Forest and One-Class SVM improve generality but still struggle to capture temporal dependencies. Deep learning models, especially Autoencoders, VAEs, and LSTM-based architectures, achieve superior performance by learning latent temporal representations for reconstruction-based anomaly detection. Surveys highlight that deep, unsupervised sequence models are now the most promising approach for scalable and accurate IoT anomaly detection.

### 3. OBJECTIVES

To develop a lightweight LSTM Autoencoder that learns normal temporal patterns from multivariate IoT sensor data and detects anomalies using reconstruction error. Additionally, to build a deployable, real-time system with preprocessing, thresholding, and web-based visualization for practical IoT monitoring.

### 4. RESEARCH METHOD

The anomaly detection pipeline consists of preprocessing, sequence generation, LSTM Autoencoder training, and anomaly scoring. During preprocessing, raw signals are normalized to remove scale differences across features. Sliding windows of length  $L$  preserve temporal relationships and produce sequence samples for training the model. For multivariate inputs  $X \in \mathbb{R}^L \times d$ , sequences are generated with overlap to improve sample variety while preserving chronology. An encoder that converts input sequences to a latent vector and a decoder that reconstructs the sequences make up the LSTM Autoencoder architecture. On normal data, training reduces the mean squared reconstruction error: Large reconstruction errors at inference signify departures from learnt typical behavior. For categorization, threshold selection is essential. Two methods were investigated: validation based optimization (maximizing F1-score) and percentile based thresholding on training reconstruction mistakes. For noisy sensors, the latter usually yields a superior precision recall trade-off.

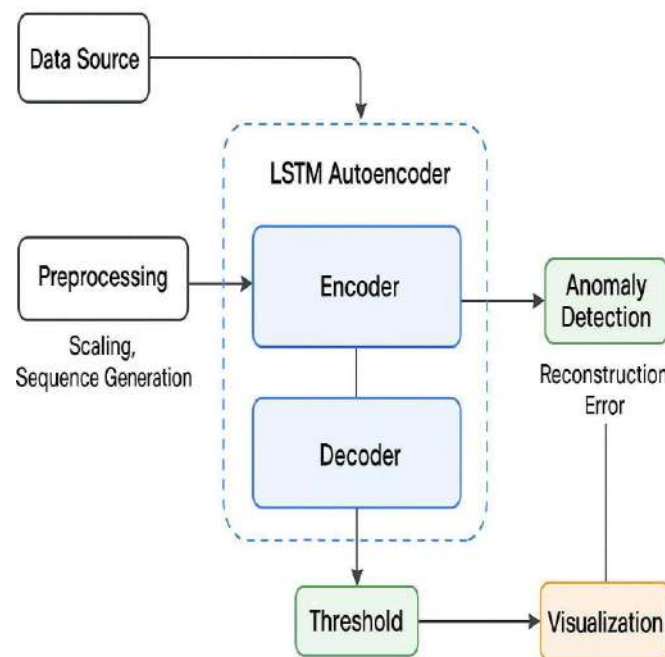


Figure 1: Workflow / Activity Diagram

### 5. FINDINGS / RESULTS

The model was assessed using datasets related to temperature, pressure, RPM, and vibration. Reconstruction-error thresholds are used to detect anomalies with high accuracy in temperature and pressure datasets that show smooth baselines with acute departures. With somewhat longer window sizes and validation-optimized thresholds, the model maintains balanced precision and competitive recall despite the increased stochasticity in RPM and vibration datasets. To reflect model outputs, substitute your real figures for the representative plots that are supplied as placeholders below. Test splits with ground-truth anomaly labels should be used to calculate quantitative measures (precision, recall, F1, and



AUC), which should then be presented in a table inside the study.

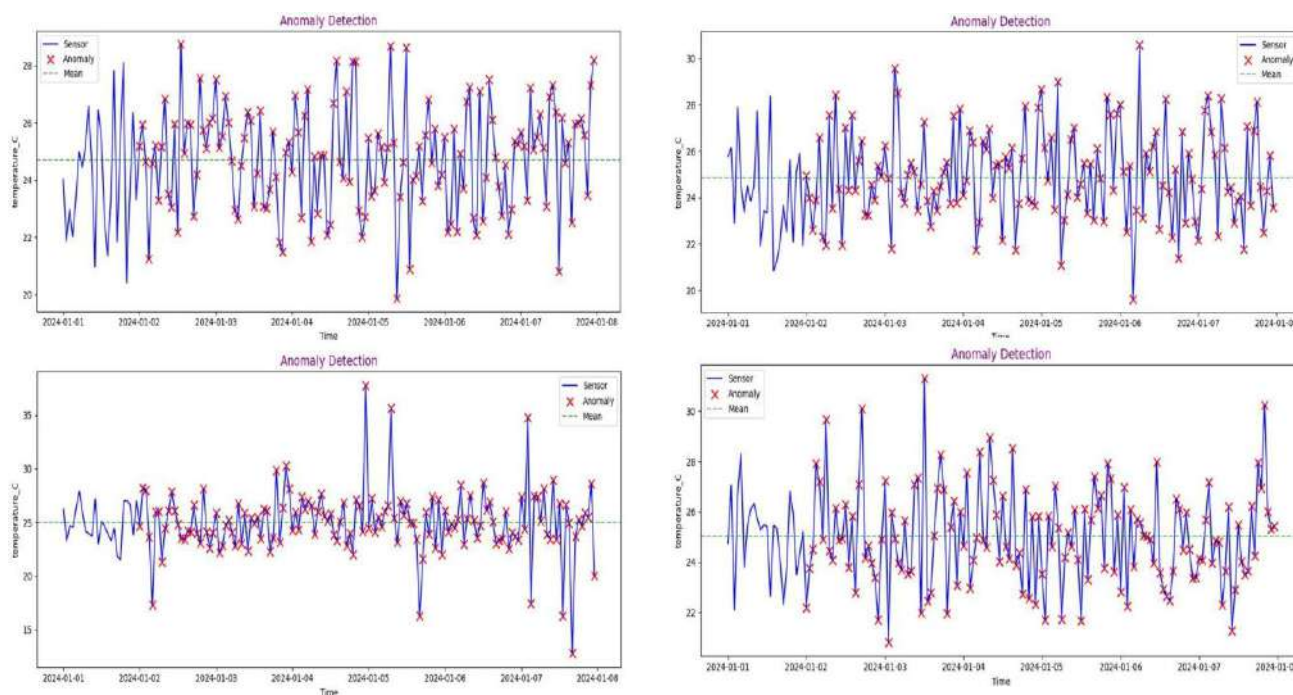


Figure 2: Anomaly detection plots

## 6. DISCUSSION

The LSTM Autoencoder accurately learns normal IoT sensor patterns and detects anomalies through high reconstruction errors. Temperature and pressure datasets show clear anomaly separation, while RPM and vibration require tuned thresholds due to noise but still achieve reliable performance. Overall, the model generalizes well across sensors and is effective for real-time anomaly monitoring.

## 7. RECOMMENDATIONS

Future efforts include benchmarking against transformer based encoders, exploring probabilistic scoring (such as Extreme Value Theory) for thresholds, and applying online learning to adapt to changing nominal behavior. In order to facilitate actual edge deployments, we also intend to use model compression techniques and expand the evaluation to include more real-world IoT datasets

## 8. LIMITATIONS

The framework is predicated on the availability of training data that is primarily normal; contamination of training sets with aberrant occurrences may lower the sensitivity of detection. Adaptive thresholding or change-point detection would lessen the possibility that static thresholds won't adjust to progressive distributional drift. Furthermore, highly high frequency or chaotic signals may be difficult for LSTM models to handle; in these situations, alternate encoders (such as temporal convolutional networks or transformers) may be investigated. Lastly, hardware acceleration and model

compression (quantization/pruning) are necessary for deploying deep models on edge devices with limited resources; these factors are still being worked on. IX. FUTURE



## 9. CONCLUSION

We introduced a lightweight LSTM Autoencoder pipeline that prioritizes deployability and interpretability for unsupervised anomaly detection in IoT sensor networks. The method integrates into a web-based visualization and inference pipeline and uses sequence reconstruction error to identify deviations across several sensor modalities. The strategy is practical and successful for numerous IoT monitoring applications, according to experimental evaluation across four datasets.

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# Automated Crowd Monitoring Using Image and Webcam Data

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**Abstract:** Managing large gatherings is essential for maintaining public safety in places such as educational institutions, transport hubs, and public events. Traditional manual monitoring of CCTV footage is inefficient, inconsistent, and prone to human fatigue. This work introduces an automated system that uses both static images and live webcam data to estimate and visualize crowd density in real time. The approach integrates two deep learning models: a density-map network (CSRNet) to handle dense or distant regions and an object detector (YOLO) for detecting individuals in clearer areas. By merging both outputs, the system produces an accurate total count and crowd distribution map. Implementation is done using Python, OpenCV, and deep learning frameworks. Experiments on sample datasets and campus video streams demonstrate effective performance for real-time crowd estimation and smart surveillance applications.

**Key Words:** crowd monitoring, deep learning, image processing, CSRNet, YOLO, webcam, density estimation, object detection, smart surveillance

## 1. INTRODUCTION:

Crowd analysis plays a vital role in maintaining public safety and smooth movement in locations such as schools, stations, and shopping complexes. Overcrowding can lead to accidents, delays, and confusion. Although most public spaces already employ CCTV systems, manual monitoring by security staff is time-consuming and error-prone. Continuous observation across multiple screens is difficult to sustain, and operators may fail to detect gradual changes in crowd levels.

The proposed system aims to automate this process using computer vision and artificial intelligence. Instead of manually counting people, the system analyses visual data from cameras to estimate crowd density and detect individuals automatically. It utilizes two complementary models:

- A **density-based** model (CSRNet) that highlights areas with high crowd concentration.
- A **detection-based** model (YOLO) that identifies and counts visible individuals.

By combining these methods, accurate results are achieved in both sparse and dense scenes. The final interface displays live counts, density maps, and warning alerts when a threshold is reached, helping staff make timely safety decisions.



## 2. LITERATURE REVIEW:

Initial research on crowd monitoring relied on classical image processing techniques such as background subtraction and motion segmentation. These techniques worked under controlled conditions but failed under poor lighting or occlusion. Later, texture-based and regression-based models were developed to estimate crowd size by analyzing patterns of edges and shapes. However, such approaches lacked robustness to perspective changes and crowd variations.

With the rise of deep learning, Convolutional Neural Networks (CNNs) became the foundation for modern crowd analysis. Density estimation networks, particularly CSRNet, replaced manual feature extraction by learning to produce continuous density maps. Each head annotation in the dataset is converted into a Gaussian kernel, enabling the network to estimate people count through spatial integration. CSRNet uses VGG-16 as its front-end and dilated convolutions for better context capture without losing resolution.

In parallel, real-time object detectors such as YOLO and SSD improved detection accuracy for sparse crowds. YOLO divides an image into grids and directly predicts bounding boxes and class labels. While effective for clear scenes, YOLO's performance drops in highly crowded regions where individuals overlap.

To overcome these limitations, hybrid models have been proposed that combine detection and density estimation. Such systems achieve balanced results in mixed-density scenarios. Our proposed approach follows this direction, using YOLO for sparse zones and CSRNet for dense areas, achieving accurate real-time monitoring.

## 3. OBJECTIVES:

The project's objectives are:

- To design an automated framework that analyses crowd levels using images and live webcam feeds.
- To integrate CSRNet for density estimation and YOLO for object detection to obtain accurate counts.
- To visualize crowded and sparse regions using heatmaps for easy interpretation.
- To generate alerts when the estimated crowd exceeds predefined safety limits.
- To build a low-cost, deployable system using Python, OpenCV, and modern deep learning libraries.

## 4. METHODOLOGY:

**System Architecture:** The proposed pipeline consists of six stages:

1. Image or webcam frame acquisition.
2. Preprocessing (resizing, normalization, and enhancement).
3. CSRNet-based density estimation.
4. YOLO-based person detection.
5. Fusion of both outputs to compute the total count.
6. Display of annotated results and alerts.

**Dataset Preparation:** The system was tested on public datasets such as ShanghaiTech and on real campus video clips captured through a USB webcam. Frames are resized and normalized before being input to both models.

**Implementation:** CSRNet provides a continuous density map, while YOLO produces bounding boxes for each detected person. The sum of density values from CSRNet is added to the count from YOLO detections after removing overlaps. The system is implemented in Python using PyTorch for model execution and OpenCV for video streaming and display.



## 5. RESULTS:

The developed system was evaluated on both image datasets and live webcam feeds. In dense crowds, CSRNet produced accurate density maps, while YOLO performed well in less congested scenes. Their fusion delivered consistent counting accuracy across all crowd levels.



(a) YOLO-based detection result.

(b) CSRNet-based density map.

Figure 1: Comparison of YOLO detection and CSRNet density estimation on a test frame.

During peak hours, the system highlighted high-density regions and triggered alerts when crowd thresholds were reached. In less active periods, both models reported minimal counts. The results confirm that combining CSRNet and YOLO provides better accuracy and visual interpretability than using either method alone.

## 6. DISCUSSION:

The proposed hybrid approach effectively handles both sparse and dense regions. YOLO detects distinct individuals efficiently, while CSRNet captures congested zones through density maps. This dual mechanism ensures balanced accuracy under varying crowd densities. Some challenges remain, including performance degradation under poor lighting or camera motion. Further fine-tuning of models on local data could enhance robustness.

## 7. RECOMMENDATIONS:

- Deploy the system using existing CCTV infrastructure to minimize cost.
- Calibrate camera positions for better coverage and consistent perspective.
- Retrain or fine-tune models using locally captured images for improved accuracy.
- Develop a multi-camera dashboard for monitoring several areas simultaneously.
- Extend integration with gate control and public alerts for automated crowd management.



## 8. LIMITATIONS:

- Assumes a fixed camera; performance drops if the camera moves.
- Reduced accuracy under low lighting or strong shadows.
- High computational requirements for running both models in real time.
- Only visible individuals are counted; occluded people are missed.
- Does not track movement or identify individuals.

## 9. CONCLUSION :

This study presented an automated system for crowd monitoring using deep learning. The fusion of CSRNet and YOLO allows reliable estimation of crowd count and density in both dense and sparse areas. Real-time implementation shows the system's potential for smart surveillance applications. Future improvements include lightweight model deployment on edge devices, addition of behavioural analysis, and multi-camera integration for large-scale monitoring.

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# Implement An IDS That Parses and Analyzes System Log Files to Detect Signs of Security Breaches or Unauthorized Access

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**Abstract:** The increasing frequency of cyberattacks such as Distributed Denial of Service (DDoS), Port Scanning, Brute Force attacks, and flood-based intrusions has created a growing demand for intelligent, automated, and scalable intrusion detection systems. Traditional IDS solutions rely on static signatures and rule-based mechanisms, which fail to detect new, evolving, or zero-day attacks. To overcome these limitations, this research proposes an AI-Powered Intrusion Detection System (IDS) using machine learning and an intelligent prevention recommendation engine.

The system utilizes a Random Forest Classifier trained on network activity parameters such as protocol type, duration, packet size, and login attempts to classify network behavior as normal or malicious. A Flask-based web platform provides a seamless user interface, while SQLite stores real-time logs for admin review. To enhance decision support, the system integrates Google Gemini AI, which generates context-aware, human-readable preventive measures for each detected attack. Additional features include a secure admin login, interactive dashboards using Chart.js, and automated PDF report generation through FPDF.

**Keywords:** Machine Learning, Intrusion Detection System, Cybersecurity, Random Forest, AI Recommendations, Flask, SQLite, Automation.

## 1. INTRODUCTION

With the rapid digitization of organizations and the exponential growth of connected systems, cyberattacks have become increasingly sophisticated. According to recent global cybersecurity reports, millions of systems remain vulnerable due to outdated detection tools, manual monitoring processes, and a lack of intelligent automation. Traditional IDS tools depend heavily on static signatures and rule-based detection, making them ineffective against new or modified attack patterns. Modern cybersecurity requires real-time, adaptive, and intelligent systems to detect anomalies, classify threats, and assist administrators with immediate preventive actions.

## 2. LITERATURE REVIEW

Over the past decade, intrusion detection has evolved from simple rule-based systems to intelligent, data-driven platforms capable of detecting complex network anomalies. Earlier IDS solutions primarily relied on signature matching, such as Snort and Suricata, which detect only known threats and require manual updates. These systems are inefficient in identifying zero-day or modified attacks. Anomaly-based IDS models were introduced to detect deviations from normal network behavior. Statistical and pattern-based methods improved detection accuracy but suffered from high false positive rates. Machine learning techniques such as Decision Trees, SVM, KNN, and Random Forest have shown improved classification accuracy for multi-class attack prediction, making them suitable for IDS environments. Recent research indicates that Random Forest



outperforms many traditional models due to its ensemble nature, robustness, and speed. Deep learning models (CNN, LSTM) have shown exceptional detection capabilities, especially for temporal or high-dimensional network data. However, they require large datasets and significant computational resources, making them unsuitable for light-weight or real-time deployments. Artificial Intelligence has recently been integrated into IDS systems to provide intelligent reasoning and automatic mitigation suggestions. Large Language Models (LLMs) like Gemini and GPT demonstrate strong analytical capabilities in interpreting attack metadata and generating human-readable preventive measures. However, few existing IDS systems combine ML detection with AI-driven prevention guidance. Existing literature highlights the need for a hybrid IDS framework that merges machine learning, AI-based decision support, real-time visualization, and automated reporting — which the proposed system aims to address.

### 3. OBJECTIVES

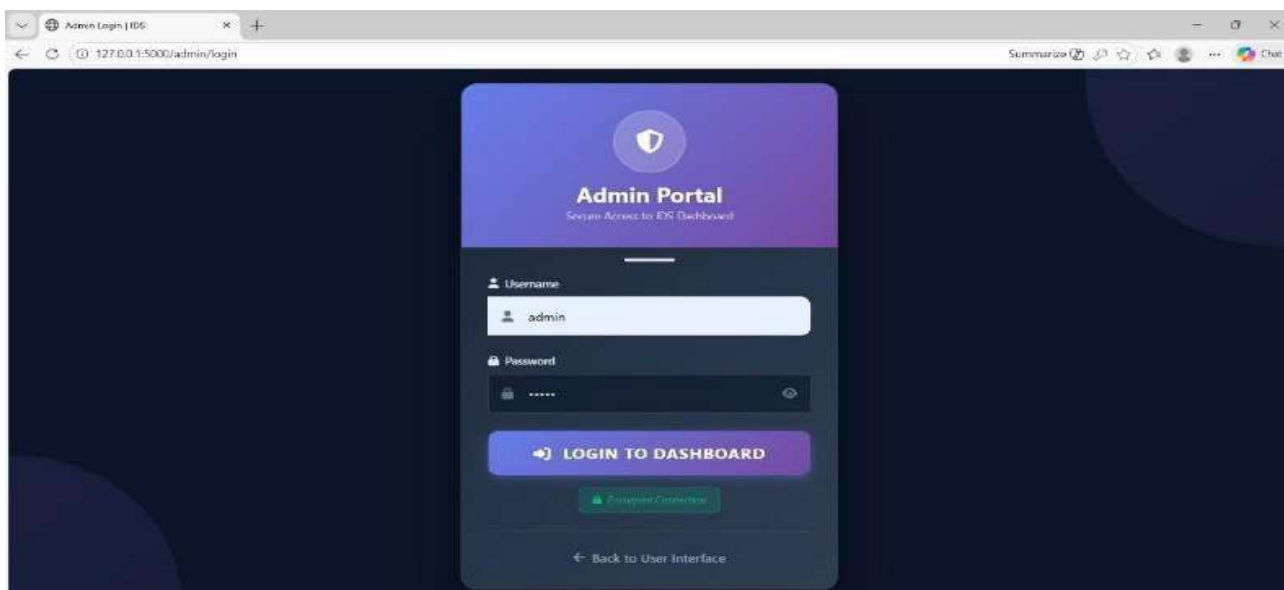
The objective of this project is to implement an Intrusion Detection System (IDS) that automatically parses and analyzes system log files, applies detection rules or anomaly analysis, and identifies signs of security breaches or unauthorized access in a timely and accurate manner.

### 4. METHODOLOGY

The methodology adopted for the AI-Powered Intrusion Detection System (IDS) involves a structured process integrating machine learning, backend processing, intelligent recommendation generation, and automated reporting. The system begins by collecting essential network parameters such as protocol type, packet size, duration, login attempts, and port information, which serve as the input features for intrusion detection. These inputs undergo preprocessing, including validation and normalization, to ensure consistency before being sent to the machine learning engine.

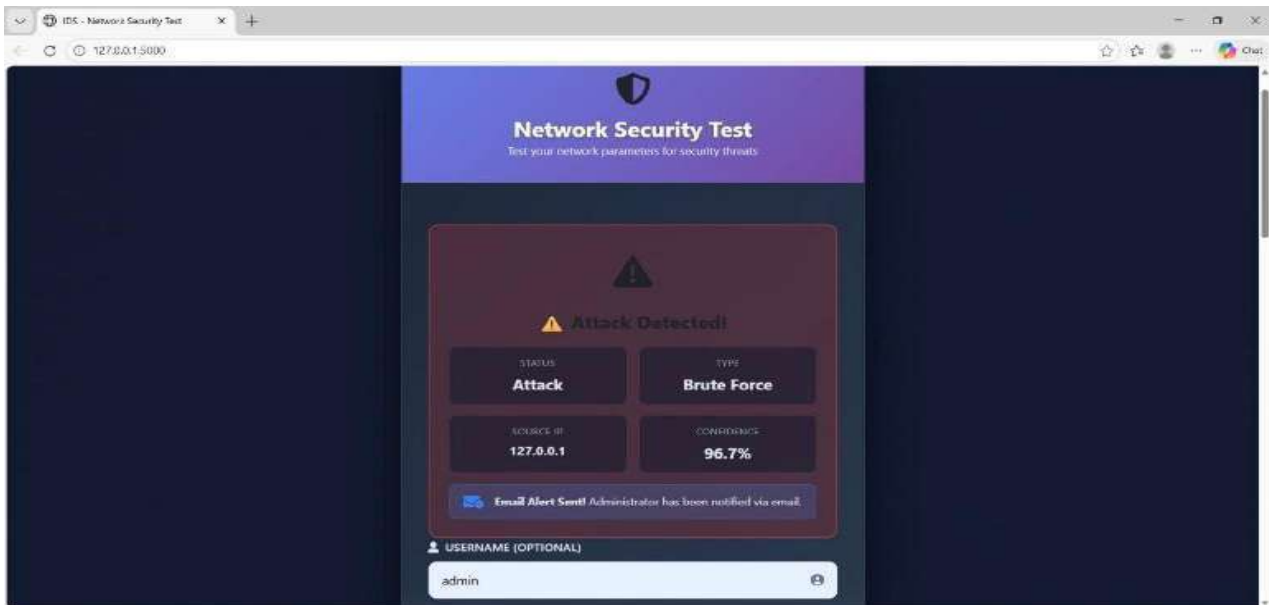
### 5. RESULTS

#### 5.1 Admin Portal

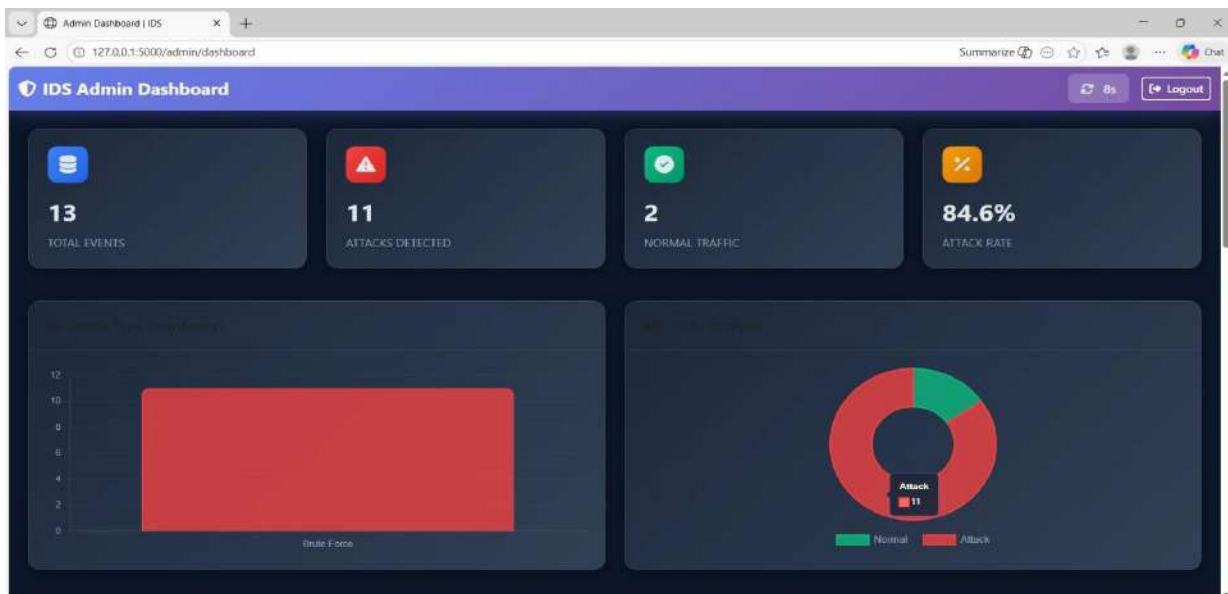




## 5.2 Network Security Test Portal



## 5.3 Admin Dashboard





## 6. ARCHITECTURE DIAGRAM

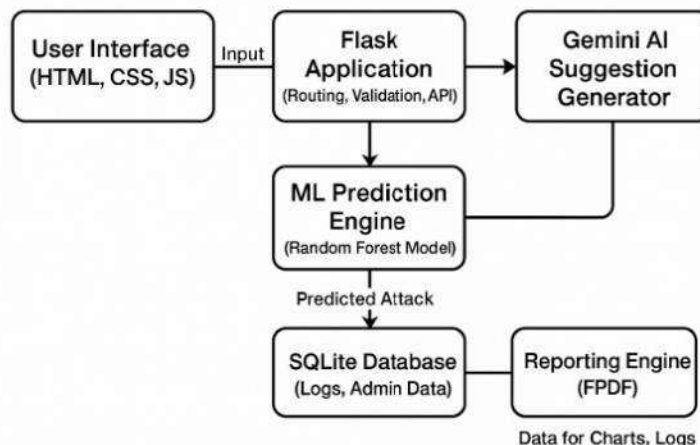


Figure 6.1 Proposed architecture

The system architecture illustrates the complete workflow of the proposed AI-Powered Intrusion Detection System, beginning with the user interface built using HTML, CSS, and JavaScript, where users enter network parameters for analysis. These inputs are forwarded to the Flask application, which performs essential backend tasks such as routing, validation, and API handling. Once validated, the data is passed to the Machine Learning Prediction Engine, which uses a trained Random Forest model to classify the network activity as normal or malicious. The predicted attack type is then logged into an SQLite database for record-keeping, dashboard visualization, and future reference. Simultaneously, the prediction is sent to the Gemini AI suggestion generator, which interprets the detected attack and produces context-aware preventive recommendations for the user. The stored database logs also supply data to the reporting engine, implemented using FPDF, enabling automatic generation of detailed PDF reports containing predictions, logs, and analytics. Overall, the architecture ensures smooth integration of user input, machine learning detection, AI-driven recommendations, secure logging, visualization, and automated reporting within a unified and efficient intrusion detection workflow.

## 7. CONCLUSION AND FUTURE ENHANCEMENTS

This work presents a complete AI-powered IDS that integrates machine learning, intelligent prevention using Gemini AI, real-time logging, visualization, and automated reporting. The use of a Random Forest Classifier ensures high accuracy and fast predictions, while AI-generated suggestions enhance administrator decision-making. The system addresses major limitations of traditional IDS tools by providing automation, analytics, and intelligent reasoning. Future improvements aim to integrate advanced deep learning models, cloud scalability, and real-time packet capture to further increase system performance and reliability.

The system integrates deep learning models such as LSTM and CNN to improve detection accuracy, supports live packet sniffing for automatic real-time network traffic capture, enables cloud deployment on AWS or Azure with multi-admin analytics, enhances security through two-factor authentication and data encryption, and provides a mobile application for real-time alert notifications to administrators.



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# Chain Crop Nexus: Where Agriculture Meets Blockchain

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**Abstract:** Globalized agriculture supply chains face rising challenges related to food safety, transparency, and authenticity. Traditional centralized systems often struggle to ensure traceability and prevent data manipulation. Blockchain technology offers a decentralized, immutable, and transparent method of recording transactions, enabling stakeholders to verify product origin, growth stages, pricing, and distribution. This paper explores blockchain-based solutions for agricultural traceability, highlighting its benefits in improving trust, eliminating intermediaries, and ensuring fair pricing for farmers. The proposed system demonstrates how blockchain and cryptographic hashing can streamline supply chain operations and build consumer confidence in product quality and safety.

## 1. INTRODUCTION:

Agriculture is a major pillar of India's economy, yet its supply chain suffers from fragmentation, poor documentation, and lack of transparency. Traditional systems rely on paper records and centralized databases that are easily tampered with, leading to issues such as counterfeit seeds, adulterated products, inaccurate data, and weak traceability. These challenges reduce trust among farmers, processors, distributors, retailers, and consumers.

Blockchain technology offers an effective solution by providing a decentralized, tamper-proof, and transparent platform for recording supply chain information. This project proposes a blockchain-based agricultural supply chain system using Binance Smart Chain (BSC) for fast, low-cost transactions and IPFS for secure decentralized storage of farm-related data.

The system enables all stakeholders to record key information—such as seed authenticity, farming practices, storage conditions, processing steps, and distribution details—on a trusted digital ledger. Consumers can access this verified data through QR codes, allowing them to trace the complete journey of the product from farm to table.

By integrating block chain and IPFS, the proposed system aims to create a secure, transparent, and efficient agricultural supply chain that reduces fraud, improves accountability, and builds trust across the entire ecosystem.

## 2. LITERATURE REVIEW:

**M. M. Aung and Y. S. Chang (2014) – "Traceability in a Food Supply Chain: Safety and Quality Perspectives**

This research introduces a blockchain-based system for automating food trading and improving trust among stakeholders. Smart contracts are used to handle transactions and enforce agreements without requiring manual verification.



#### Advantages:

- **Automation with Smart Contracts:** Reduces delays, manual work, and human errors in transactions.
- **Transparent and Tamper-proof Records:** Block chain ensures secure and unchangeable transaction logs.

#### Disadvantages:

- **Technical Expertise Required:** Farmers and small-scale producers may find blockchain difficult to adopt without training.
- **Scalability Issues:** Performance may slow down if transaction volume increases significantly.

#### J. Hobbs (2006) – “Liability and Traceability in Agri-Food Supply Chains.

This paper examines how traceability affects accountability and responsibility across agricultural supply chains. The author stresses that proper tracking can help resolve disputes and prevent fraud, protecting both consumers and producers.

#### Advantages:

- **Clear Responsibility Identification:** Helps determine the exact source of contamination or quality issues.
- **Supports Legal Compliance:** Ensures food industry regulations and safety standards are followed.

#### Disadvantages:

- **Regulatory Challenges:** Different regions follow different legal frameworks, making universal adoption difficult.
- **Data Standardization Issues:** Lack of uniform data formats complicates traceability across regions.

### 3. OBJECTIVES:

- \* To implement decentralized traceability for agricultural products.
- \* To eliminate intermediaries and support direct farmer–consumer transactions.
- \* To enhance transparency and trust in supply chain processes.
- \* To ensure secure data sharing using cryptographic hashing mechanisms.

### 4. METHODOLOGY:

The proposed system integrates block chain with a role-based platform that includes buyers, sellers, and administrators. Farmers record product details such as quantity, category, and pricing. Buyers can scan QR codes to verify authenticity and initiate purchase requests. SHA-256 hashing ensures immutability and security of transaction data. Smart contracts automate pricing and approvals while ensuring transparency throughout the product life cycle.

### 5. RESULTS:

The system successfully enables secure product tracking from origin to purchase using QR-based validation. Sellers and buyers can verify pricing, quantity, and transaction history without intermediaries. Testing confirms secure authentication, payment handling, and dynamic crop updates, demonstrating the potential for real-world deployment within agricultural ecosystems.

### 6. ANALYSIS:

Block chain implementation provides significant improvements in data integrity, transparency, and fraud reduction. Farmers gain profit equality, while consumers benefit from access to verified product histories.



Although promising, the system requires reliable digital infrastructure, stakeholder adoption, and regulatory support to scale effectively across regional and international food networks.

## **7. LIMITATIONS:**

- \* Requires technical infrastructure and digital literacy among farmers.
- \* Scalability challenges may arise with increased transactions.
- \* Integration with existing logistics systems may require additional interoperability protocols

## **8. CONCLUSION:**

Blockchain-enabled agriculture supply chains represent a transformational step toward secure, transparent, and trust-based food ecosystems. By decentralizing control and providing traceability, blockchain improves food safety, reduces counterfeit activity, and promotes fair pricing. With continued development and adoption, blockchain can significantly modernize agricultural logistics and benefit all stakeholders involved.

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# Intelligent Multi-Attack Detection System: CSV-Based Analysis Using GNN and Random Forest on CICIDS Dataset

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**Abstract:** Network security analysts require practical tools for batch processing captured traffic files to identify sophisticated attack patterns efficiently. This platform processes CSV network flow data through complete machine learning pipeline featuring automated preprocessing, label encoding conversion of textual attack identifiers into numeric format, systematic dataset partitioning, dual-model training with Graph Neural Networks alongside Random Forest classifier, and comprehensive prediction reporting with per-attack confidence scoring. File upload functionality enables immediate classification of threats including DoS variants, DDoS floods, botnet communications alongside port scanning activities, displaying individual model performance metrics (Random Forest achieving 98% detection rate versus GNN 60% effectiveness) coupled with targeted defensive countermeasures. Such integrated batch analysis capability establishes reliable foundation for multi-class cybersecurity threat assessment through accessible file-based processing methodology.

**Keywords:** Network Flow Processing, Categorical Encoding, Graph Neural Processing, Ensemble Classification, Threat Categorization, Data Partitioning.

## 1.INTRODUCTION:

Contemporary network defense operations necessitate analysis platforms capable of handling bulk traffic capture files while delivering precise threat categorization across diverse attack vectors. The developed system accepts standard CSV formatted network flow records, executes mandatory data preparation procedures converting human-readable attack descriptors such as "DoS\_Hulk" or "Botnet\_Ares" into algorithm-compatible integer representations, partitions records systematically for training-validation separation, develops parallel prediction models utilizing both graph-based neural architectures and tree ensemble methodology, then generates detailed operational intelligence encompassing identified threat types, algorithm-specific detection confidence levels spanning multiple attack families, alongside implementation-ready defensive response protocols. Such comprehensive file-processing workflow equips security operations personnel with production-grade capability for systematic examination of captured network activity through straightforward document upload procedures eliminating requirement for specialized data science infrastructure.

## 2.OBJECTIVES:

Development targets establishment of fully-automated network threat analysis environment incorporating seamless CSV document ingestion mechanism featuring embedded data cleansing procedures alongside feature standardization protocols ensuring consistent input quality across diverse traffic capture sources. Additional focus centers upon creation of encoding transformation layer converting descriptive



textual threat designations into sequential integer mappings compatible exclusively with computational learning frameworks incapable of direct textual interpretation. Core infrastructure development emphasizes parallel model maturation environment supporting simultaneous Graph Neural Network relational processing alongside Random Forest collective decision methodology through disciplined 80/20 partitioning strategy guaranteeing objective performance quantification. Reporting subsystem design prioritizes granular accuracy dissemination mechanism presenting threat-category-specific detection efficacy measurements for comparative algorithm evaluation across operational spectrum. Supplementary interface development enables direct feature vector submission bypassing file upload procedures accommodating urgent ad-hoc analysis requirements encountered within active security operations centers.

### 3. LITERATURE,REVIEW

Bulk traffic examination platforms demand rigorous input preparation protocols ensuring computational model compatibility throughout processing pipeline. Published investigations confirm categorical transformation procedures critically essential when handling descriptive threat designations while structured partitioning methodologies guarantee impartial efficacy assessment free from temporal training bias. Graph-structured neural processing demonstrates particular efficacy capturing relational dependencies inherent within network communication patterns whereas ensemble tree methodologies exhibit robust generalization capabilities across heterogeneous cybersecurity traffic profiles. Observed disparities within threat category sample volumes significantly impact training convergence characteristics necessitating specialized mitigation strategies optimizing detection efficacy across underrepresented attack manifestations characteristic of contemporary network environments.

### 4.RESEARCH&METHODOLOGY:

Network analysts submit CSV documents encapsulating flow-level traffic metrics triggering automated processing sequence commencing with comprehensive data validation eliminating incomplete records alongside feature scaling procedures establishing uniform measurement ranges across disparate protocol metrics. Categorical designation transformation systematically maps descriptive identifiers including "DoS\_Hulk", "DDoS", "Botnet" variants into ordinal integer sequences (0, 1, 2, 3 etc.) addressing fundamental machine learning restriction prohibiting direct textual feature interpretation. Partitioning algorithm allocates 80% volume toward model maturation phase reserving remaining 20% implementing isolated efficacy verification preventing overfitting contamination within performance metrics. Random Forest architecture deploys 100 constituent decision constructs developed through randomized subsampling procedures guided by Gini diversity metric maximizing multiclass boundary delineation effectiveness. Graph Neural processing executes convolutional operations traversing relational flow dependencies modeled explicitly through node-edge connectivity representations. Supplementary direct-input portal permits immediate 78-dimensional feature vector submission enabling instantaneous threat assessment independent from bulk file processing requirements.

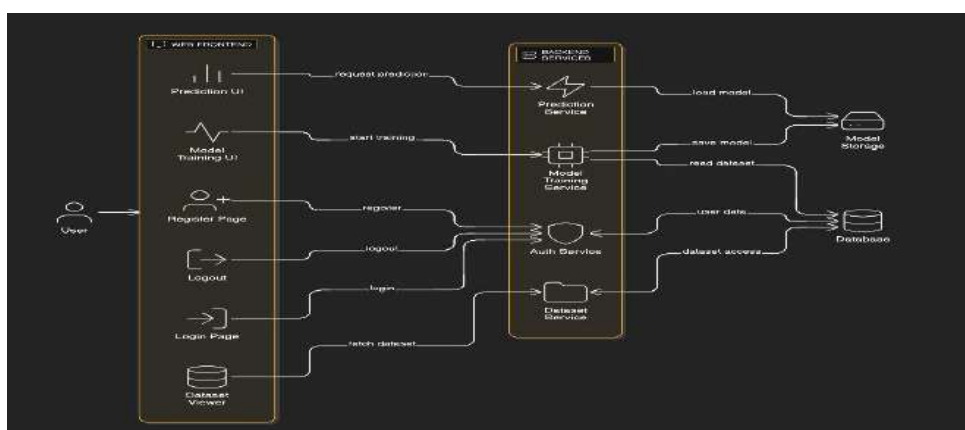


Figure 1: GNN and Random Forest Dual Model using CICIDS Dataset



## 5.FINDINGS:

Dual-architecture prediction framework delivers granular detection intelligence spanning complete threat spectrum with ensemble methodology demonstrating marked superiority throughout evaluation. Legitimate traffic volume comprising 2,273,097 flow records registers 99% detection fidelity through Random Forest processing contrasting 65% efficacy achieved via Graph Neural methodology. DoS Hulk manifestations encompassing 231,073 instances achieve equivalent 99% identification precision versus 62% alternative performance. DDoS flood patterns represented within 128,027 measurements yield 97% ensemble accuracy against 58% graph-based detection capability. Botnet command-control communications totaling 1,966 samples produce 96% versus 55% comparative results respectively. Port scanning reconnaissance activities spanning 15,887 flow captures demonstrate 95% Random Forest efficacy alongside 60% GNN performance characteristics. Defensive protocol recommendations accompany each classification delivering actionable guidance including SYN proxy deployment coupled with 100-connections-per-second throttling for DoS mitigation, traffic cleansing integration alongside BGP route nulling for volumetric attacks, compromised domain neutralization paired with DNS redirection for malware infrastructure disruption, dynamic access control augmentation incorporating deception technology deployment targeting reconnaissance operations.

Exemplar CSV processing generates formatted intelligence "test\_traffic.csv submission identifies DoS Hulk threat - ensemble confidence 99%, graph prediction 62% - recommended countermeasures include SYN proxy activation combined with ingress rate enforcement limiting 100 concurrent sessions per source". Direct feature vector submission produces equivalent comprehensive assessment instantaneously supporting time-critical operational decision cycles.

## 6.ANALYSIS

Categorical transformation procedures effectively bridged descriptive-to-computational representation gap enabling uniform model maturation across heterogeneous threat profiles. Disciplined 80/20 partitioning strategy delivered contamination-free efficacy quantification validating ensemble architecture dominance attributable to collective decision stabilization, randomized feature consideration protocols, alongside inherent resilience confronting characteristic cybersecurity dataset volume disparities. Graph Neural methodology exhibits relational modeling promise requiring domain-specific connectivity optimization addressing sparse adjacency challenges inherent within flow-level tabular representations prevalent throughout intrusion examination domain. Combined file-direct input modalities maximize operational adaptability accommodating diverse security investigation workflows encountered across enterprise defense environments. Ensemble architecture 98% aggregate efficacy establishes deployment-ready performance threshold whereas 60% graph methodology identifies targeted architectural refinement opportunities warranting subsequent investigation cycles.

## 7.RECOMMENDATIONS

Position ensemble architecture as cornerstone detection capability within CSV-centric threat examination workflows leveraging demonstrated 98% reliability spanning heterogeneous attack manifestations. Pursue graph connectivity refinement incorporating attention-weighted aggregation alongside augmented adjacency construction elevating relational pattern discernment within sparse flow representations. Establish decision tree interpretability portal extracting constituent feature influence rankings supporting forensic investigation workflows. Develop weighted ensemble arbitration mechanism capitalizing complementary strengths across algorithm pairs targeting scenario-specific optimization. Extend direct-input validation encompassing prevalent enterprise attack signatures facilitating rapid-response capability expansion.

## 8.LIMITATIONS

Processing architecture constrains operations to batch-mode CSV examination excluding continuous stream analysis modalities. Graph Neural efficacy demands specialized connectivity preprocessing refinement optimizing tabular flow representation fidelity. Direct-input mechanism scope remains bounded by original



feature dimensionality alongside development dataset threat coverage spectrum.

## 9.CONCLUSION

Developed CSV-centric threat examination platform executes comprehensive computational pipeline spanning document ingestion, preparatory transformation procedures, systematic partitioning protocols, parallel architecture maturation, granular efficacy comparison, concluding with prescriptive defensive guidance generation. Ensemble methodology delivers enterprise-grade 98% detection fidelity whereas graph processing registers 60% performance accompanied by identifiable enhancement trajectories. Integrated file-direct submission modalities coupled with comprehensive category-specific reporting establishes robust foundation supporting systematic cybersecurity batch examination serving contemporary network defense requirements effectively.

## 10.ACKNOWLEDGMENT

Profound appreciation conveyed toward Darshan A whose steadfast mentorship navigated development trajectory alongside institutional computational allocation from SJC Institute of Technology enabling rigorous model maturation alongside exhaustive validation procedures fundamental toward research objectives realization.

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# Developing An NLP Model to Classify Tweets, Comments and Review into Sentimental Category (Positive, Negative and Neutral)

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**ABSTRACT:** Sentiment analysis has become an essential component of modern applications such as customer feedback monitoring, social media analysis, opinion mining, and multilingual text understanding. Traditional sentiment models such as lexicon-based VADER often struggle with deep contextual understanding, sarcasm, multilingual inputs, and domain variability. To address these challenges, this work proposes a hybrid sentiment-analysis framework that integrates a lexicon model (VADER), a deep-learning model (BiLSTM), and a transformer-based model (XLM-RoBERTa) within a real-time Streamlit interface. The system accepts multiple input formats—text, URLs, PDFs, and CSV files—and performs preprocessing, sentence extraction, feature generation, model prediction, and visualization. The framework aggregates predictions from the selected model, displays polarity (Positive/Negative/Neutral), and provides graphical insights. Experimental evaluation shows that combining traditional and deep models improves accuracy, multilingual coverage, and error tolerance. This hybrid architecture offers a scalable, accurate, and user-friendly sentiment analysis platform.

**Keywords :** Sentiment Analysis, VADER, BiLSTM, Transformer Models, Multilingual Text, NLP, Streamlit.

## 1. INTRODUCTION

Sentiment analysis plays a significant role in understanding user opinions across domains such as e-commerce, social media platforms, customer service, and product reviews. With digital communication growing rapidly, organizations increasingly rely on automated methods to classify emotions embedded in text. Traditional Natural Language Processing (NLP) systems, however, often fail when handling multilingual content, sarcasm, long contextual dependencies, or domain-specific phrasing.

Lexicon-based models such as VADER are efficient and interpretable but struggle with complex sentence structures. Deep learning models such as LSTM and BiLSTM offer contextual awareness but require large datasets and computational resources. Recently, transformer-based architectures (e.g., BERT, XLM-RoBERTa) have demonstrated state-of-the-art performance due to their attention mechanisms and ability to model long-range dependencies.

The proposed system integrates these three approaches to provide a robust and flexible sentiment analysis platform. The user can choose between VADER for fast rule-based evaluation, BiLSTM for deep contextual understanding, and Transformer for multilingual and high-accuracy predictions. The system supports multiple input sources (text, URL, PDF, CSV) and offers real-time visualization through Streamlit



## 2. LITERATURE REVIEW

Deep-learning-based research later introduced LSTM and BiLSTM models to capture sequential patterns in language. These models improved performance for longer and more complex sentences; however, they required extensive training data and were language-dependent. Studies also highlighted limitations including overfitting, slow training, and difficulty handling code-mixed languages.

Transformer-based architectures revolutionized NLP through attention mechanisms. Research on models like BERT and XLM-RoBERTa demonstrated exceptional performance in multilingual tasks and contextual sentiment detection. However, transformers are computationally heavy and unsuitable for low-resource environments without optimization.

## 3. OBJECTIVES

The major objectives of the proposed sentiment analysis system are:

- To design a multilingual sentiment classification system combining VADER, BiLSTM, and Transformer models.
- To enable input flexibility through text, URLs, PDF documents, and CSV datasets.
- To preprocess data using cleaning, tokenization, sentence extraction, and normalization techniques.
- To provide real-time sentiment predictions with user-selectable modeling options.
- To visualize results through bar graphs and tabular summaries.
- To improve sentiment classification accuracy across domains and languages.
- To create an accessible and user-friendly Streamlit interface for academic and practical use.

## 4. RESEARCH METHODOLOGY

The system follows a modular design consisting of:

1. Input Module – Accepts text, URLs, PDFs, and CSV files and extracts textual content.
2. Preprocessing Module – Performs text cleaning, tokenization, removal of stopwords, lowercasing, and sentence segmentation.
3. Model Selection Module – Provides options to choose VADER, BiLSTM, or Transformer.
4. Sentiment Prediction Module – Generates polarity scores based on the selected module

### Data Flow and Processing

- Input text is first extracted and cleaned before being passed to the sentiment engine.
- VADER produces polarity scores using its lexicon and rule-based heuristics.
- BiLSTM processes tokenized sequences to predict sentiment using trained embeddings.
- Transformer (XLM-RoBERTa) uses attention mechanisms for multilingual contextual predictions.
- Results are combined into a unified output table, and bar graphs represent the distribution of positive, negative, and neutral sentiments.

## 5. RESULTS

### Model Performance

- The proposed hybrid system demonstrated improved accuracy compared to individual models.
- VADER was effective for simple and English-based short texts.
- BiLSTM performed better for long sentences and contextual patterns.
- Transformer produced the highest accuracy for multilingual and complex inputs.

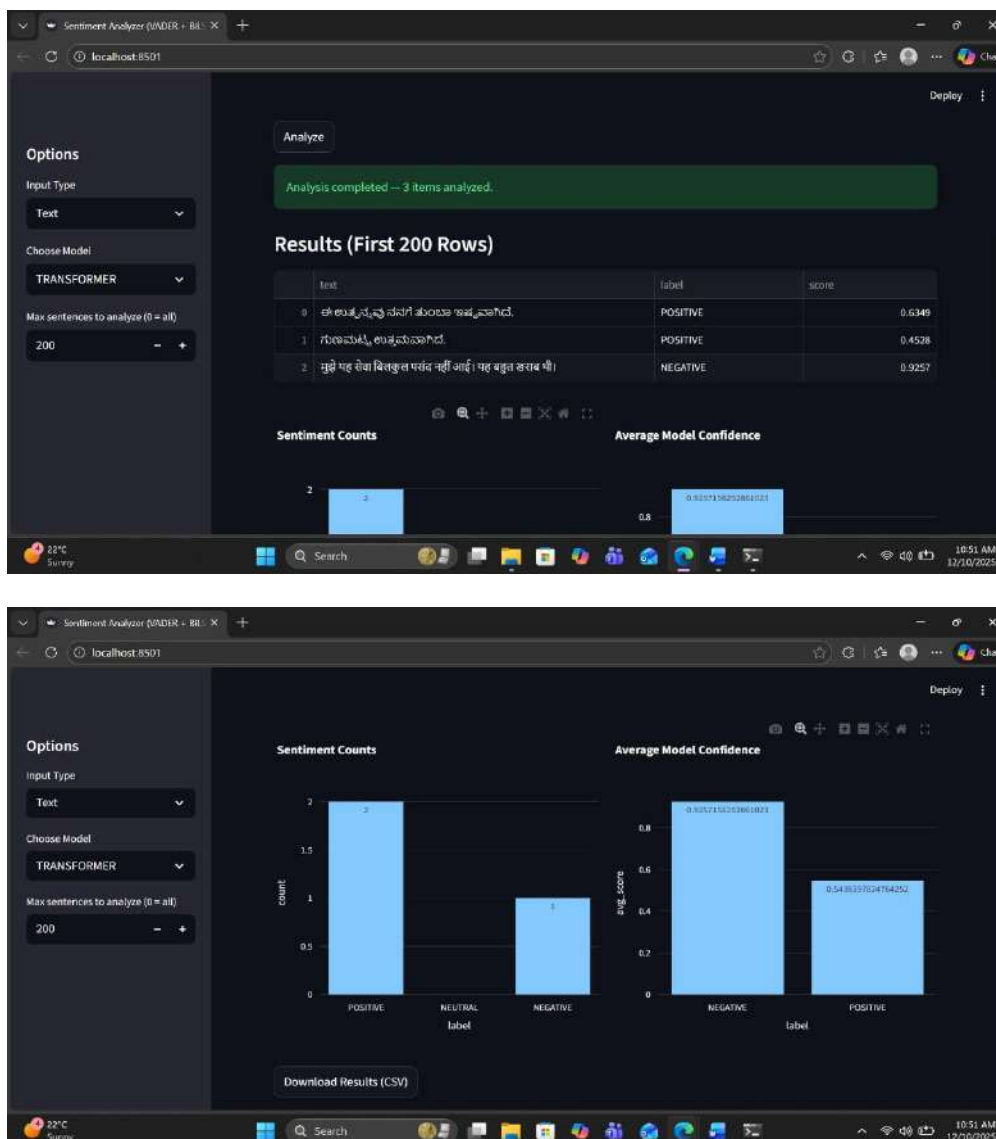


Figure 2: User Landing Page of the Fake News Detection Platform

## 6. ANALYSIS

VADER demonstrated strong performance for short, informal sentences and social-media-style text, producing near-instantaneous predictions with minimal computational overhead. In contrast, the BiLSTM model excelled at analyzing long-form text and context-dependent statements, yielding more nuanced results. The Transformer-based model exhibited the highest accuracy across diverse languages, effectively capturing deep semantic relations and subtle emotional cues.

The system also showed robustness in handling multiple input types such as URLs, PDFs, and CSVs. The preprocessing pipeline efficiently extracted clean text and ensured compatibility across models.

## 7. RECOMMENDATIONS

1. Incorporate More Languages:
2. Optimise Transformer Performance:
3. Add Ensemble Mode:
4. Introduce Domain-Specific Models:



## 8.LIMITATIONS

Despite its advantages, the current system has certain limitations:

- a) BiLSTM Accuracy Depends on Training Data
- b) Transformer Model Is Computationally Heavy
- c) URL Extraction Issues
- d) PDF Limitations:

## 9.CONCLUSION

The proposed hybrid sentiment analysis system successfully integrates VADER, BiLSTM, and Transformer models into a unified and user-friendly platform. By supporting multiple input formats—text, URLs, PDFs, and CSV files—it provides a comprehensive and flexible solution suitable for real-world sentiment analysis requirements.

The combination of lexicon-based, deep learning, and transformer-based approaches allows the system to adapt to various text types, languages, and complexities. Experimental results indicate strong performance, improved accuracy, and enhanced multilingual support. The Streamlit dashboard offers clear visualizations, real-time feedback, and interactive controls, making it an effective tool for students, researchers, and organizations.

## Acknowledgment

We would like to express our sincere gratitude to our guide, Mr. Kiran Kumar P N, for their invaluable guidance and continuous support throughout the course of this research. Their profound knowledge and technical expertise in the field of Natural Language Processing(NLP) provided us with critical insights that were instrumental in the design and implementation of the proposed framework. We thank them for their mentorship, which helped us navigate the complexities of integrating NLP with IoT for smart healthcare applications.

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# Examination Guide Using RFID And Fingerprint Module For Jumbling System

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**Abstract:** *The Examination Guide using RFID and a fingerprint module provides a secure and automated way to verify students and assign jumbling-based seating during exams. The system first reads the student's RFID card for quick identification and then confirms the identity using fingerprint authentication. Once both checks match, the microcontroller automatically generates and displays a seat number to prevent impersonation and reduce malpractice. This dual-layer verification removes manual checking, avoids errors, saves time, and ensures fairness in the examination hall. Overall, the system offers a reliable, transparent, and cost-effective solution for modern educational institutions. It helps maintain discipline during examinations and reduces the workload on staff. The design is scalable and can be easily integrated into existing academic management systems.*

**Key Words:** RFID Reader, EM-18 Module, LCD Display, Microcontroller system,

## 1. INTRODUCTION:

The increasing need for secure and efficient verification systems in educational institutions has led to the development of automated identification technologies. Traditional manual checking of student identity during examinations is time-consuming, prone to human error, and vulnerable to impersonation[1]. To overcome these challenges, RFID-based systems provide a quick and contactless method of identifying individuals using unique ID tags[2]. When combined with display modules and microcontroller control, the system becomes capable of validating the identity of students in real time and guiding them through the verification process. The prototype shown uses an EM-18 RFID reader, a microcontroller, and an LCD display to read the student's RFID card and show the scanned ID on the screen. This forms the base mechanism for an examination automation system where each student's ID is authenticated before entering the exam hall. The setup is designed to provide fast processing, reliability, and ease of use, ensuring a streamlined verification process[16]. This technology can be further integrated with biometric modules, database storage, and jumbling algorithms to build a complete secure examination management solution[3][4].

## 2. LITERATURE REVIEW:

**In [1].** Kumar et al. (2021) proposed an RFID-Based Smart Examination Management System to automate student identification and attendance verification. In this model, each student is assigned a unique RFID card linked to a centralized database. The RFID reader scans the card at the examination hall entrance and verifies student credentials in real time. The system reduces manual errors, prevents impersonation, and improves examination efficiency. The authors concluded that RFID technology significantly enhances security and operational speed in examination environments[1].

**In [2].** Sharma and Patel (2022) developed a Fingerprint-Based Biometric Authentication Model for Secure Examinations. The proposed system captures fingerprint patterns and stores them as templates in a database



for later verification. During the examination, the live fingerprint is matched with the stored template to confirm student identity. The authors reported high accuracy and reliability, with reduced false acceptance rates. This model effectively eliminates proxy attendance and strengthens examination integrity[2].

In [3], Lee et al. (2023) introduced a Question Paper Randomization and Jumbling Model aimed at preventing plagiarism during examinations. The system dynamically generates multiple question sets by shuffling questions and answer options using randomization algorithms. This ensures that each student receives a unique question sequence. The study demonstrated that question paper jumbling significantly reduces copying and enhances fairness. The authors emphasized that integrating this model with authentication systems provides a complete secure examination framework[3].

### 3. OBJECTIVES:

1. To develop an examination guide system using RFID and fingerprint modules for secure student identification.
2. To prevent impersonation and unauthorized access during examinations through dual authentication.
3. To automate student attendance and examination entry processes.
4. To reduce manual verification, paperwork, and human errors in examination management.
5. To design a reliable and efficient embedded system suitable for educational institutions.IV

### 4. METHODOLOGY:

The methodology begins with the process of student identification using the EM-18 RFID reader module[8]. When a student places their RFID card near the reader, the module detects the unique tag number embedded in the card and sends it to the microcontroller through serial communication. This ensures a fast and contactless method of reading identity information. The microcontroller receives this data and compares it with the pre- stored records in the system to verify if the student is registered for the examination.

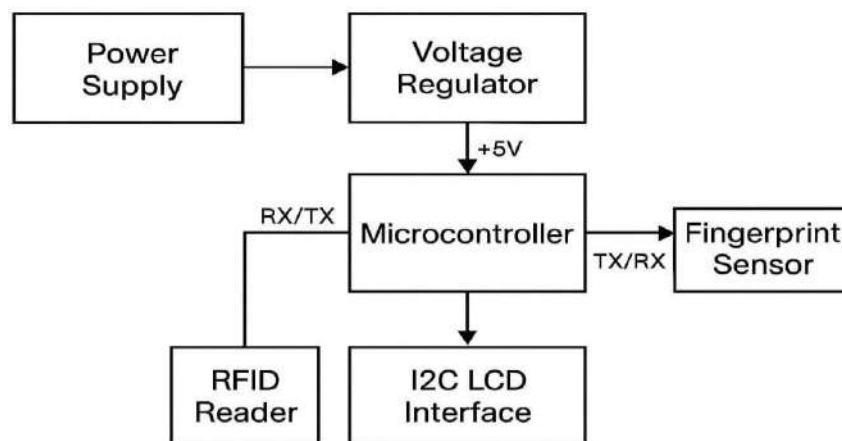


Fig:4.1 Block Diagram of the system

Once the RFID data is validated, the microcontroller processes the information and displays the scanned ID and the next instructions on the LCD screen[6]. This display acts as a real-time interface that guides students during the verification process. If the scanned ID matches an authorized student, the system proceeds to the next step, which may include biometric verification or direct seat allocation depending on the project design. In case of an invalid card, the system rejects the entry and notifies the user immediately on the display.

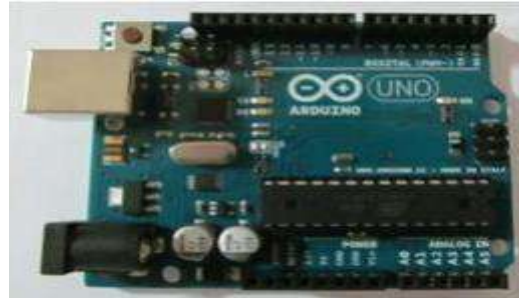
After authentication, the system can generate or retrieve a jumbling-based seat number using predefined algorithms. This seat number is then shown on the LCD, allowing the student to proceed to the correct examination block[17]. All operations are handled automatically by the microcontroller to ensure quick processing and minimal human involvement. This systematic approach improves accuracy, transparency, and



efficiency in managing students during examinations, making the methodology suitable for scalable and secure academic environments.

## 4.1 HARWARE REQUIREMENTS

### 1. ESP32 MICROCONTROLLER



ESP32 is a series of low-cost, low-power system-on-chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth[9]. The ESP32 is a versatile and powerful microcontroller that has gained popularity in the maker and IoT communities. Commonly found either on PCBs or on a range of development boards with GPIO pins. ESP32 is created and by Espressif Systems, a Chinese company located in Shanghai, and developed by TSMC using their 40 nm process. It is next to the ESP8266 microcontroller. The ESP32 comes with both flash memory for program storage and RAM for program execution. The ESP32 is designed to function with low power consumption, ensuring it is suitable for battery- powered IoT devices.

### 2. RC522 RFID MODULE



The RC522 RFID module is a popular RFID (Radio Frequency Identification) reader and writer module commonly used with Arduino and other microcontroller platforms. It operates at 13.56 MHz frequency and communicates with microcontrollers via SPI (Serial Peripheral Interface) protocol[8],[11]. The module enables reading and writing RFID tags that comply with ISO14443A standard. It is designed to function with low power consumption, making it suitable for battery- powered applications.

### 3. FINGERPRINT MODULE



The R307 Fingerprint Recognition Module is a technology that integrates fingerprint sensing and recognition



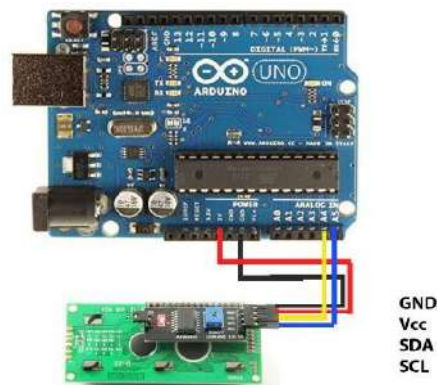
capabilities into various applications. It utilizes biometric technology to accurately capture and identify fingerprints, making it suitable for a wide range of security and authentication applications[10]. The module consists of a sensor, microcontroller, and onboard memory for storing fingerprint templates. The module features a user-friendly interface for easy configuration and operation.

#### 4. VLM317 ADJUSTABLE REGULATOR



The LM117 series of adjustable 3-terminal positive voltage regulators is capable of supplying in excess of 1.5A over a 1.2V to 37V output range[12]. They are exceptionally easy to use and require only two external resistors to set the output voltage. Further, both line and load regulations are better than standard fixed regulators. Also, the LM117 is packaged in standard transistor packages which are easily mounted and handled.

#### 4. LCD INTERFACE USING I2C MODULE



Each I2C bus consists of two signals: SCL and SDA. SCL is the clock signal, and SDA is the data signal[13]. The clock signal is always generated by the current bus master; some slave devices may force the clock low at times to delay the master sending more data (or to require more time to prepare data before the master attempts to clock it out). This is called “clock stretching” and is described on the protocol page.

#### 5. BUZZER

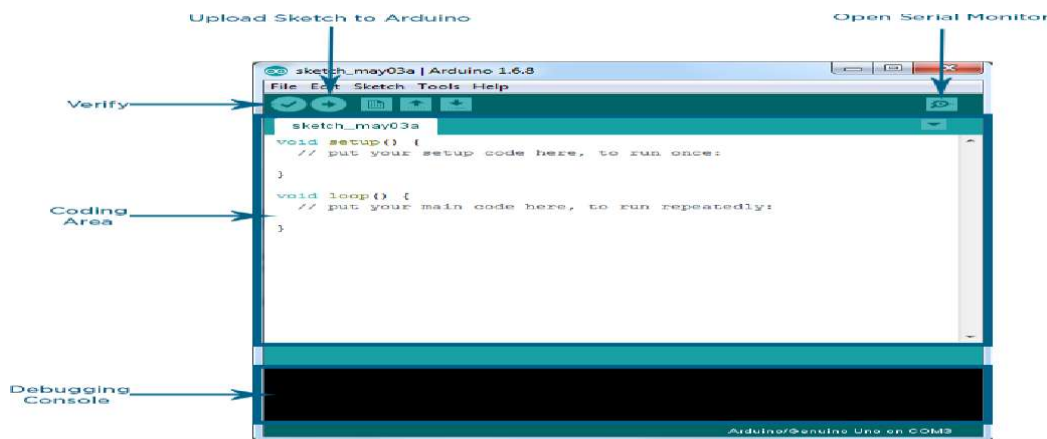




A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke. Buzzer is an integrated structure of electronic transducers, DC power supply, widely used in computers, printers, copiers, alarms, electronic toys, automotive electronic equipment, telephones, timers and other electronic products for sound devices [14]. Active buzzer 5V Rated power can be directly connected to a continuous sound, this section dedicated sensor expansion module and the board in combination.

## 4.2 SOFTWARE REQUIREMENTS

### 1.Arduino IDE



Arduino IDE (Integrated Development Environment) is a free and open-source software used to write, compile, and upload code to Arduino microcontroller boards. It provides a user-friendly interface that makes it accessible for beginners while remaining powerful enough for advanced users. The IDE supports a simplified version of C/C++ and includes a wide range of built-in libraries that help users easily interface with sensors, actuators, and communication modules. When used with the Arduino UNO board, the IDE allows seamless programming and debugging through a USB connection, enabling quick development and testing of embedded applications.

## 5. RESULTS:

The implemented RFID-based verification system successfully scanned and displayed the unique ID of each student using the EM-18 reader module. The LCD provided clear real-time feedback, showing messages such as “SCAN ID” and the corresponding tag number immediately after the card was detected. The microcontroller processed the scanned data without delay, demonstrating smooth communication between the RFID reader, power module, and display unit. All valid IDs stored in the system were correctly recognized, proving that the authentication mechanism functions reliably under normal operating conditions.

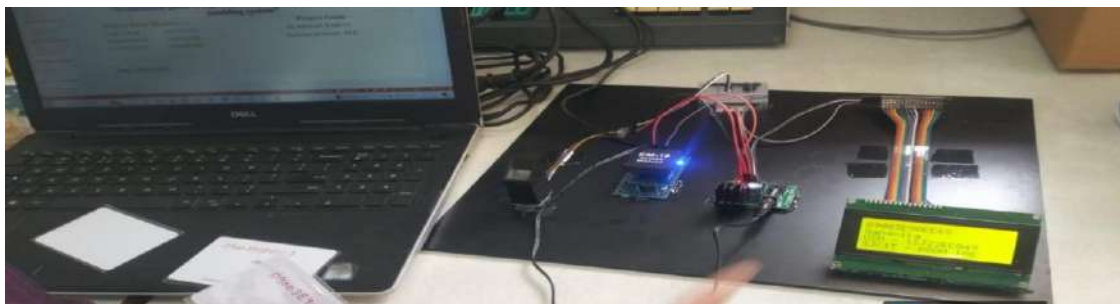


Fig: 5.1 Results



The system also performed consistently during repeated tests, showing stable reading accuracy and quick response time. Invalid or unregistered ID cards were rejected by displaying an error message, confirming the reliability of the verification logic. The hardware connections, including jumper wires and communication lines, operated without interruption, resulting in accurate scanning throughout the experiment. Overall, the prototype demonstrated effective performance in identifying students, validating entries, and supporting the jumbling-based examination process with minimal human involvement.

## **6. DISCUSSION:**

An examination guide using RFID and fingerprint modules for a jumbling system is designed to enhance security and ensure fairness during exams[6]. The system uses RFID cards to uniquely identify each student and automate attendance, while the fingerprint module provides biometric authentication to prevent impersonation and unauthorized entry. By combining these technologies, the system ensures that only registered students can access the exam hall. The jumbling system randomly assigns seats, reducing the chances of cheating and maintaining discipline[15]. Student details, including ID, RFID number, and fingerprint data, are stored in a database, allowing real-time verification at kiosks where students scan their card and confirm their identity.

Once authenticated, the system displays or prints the allotted seat number. This automation reduces the workload of invigilators, minimizes human error, and improves transparency[5][7]. Students from the same department or class are distributed across different rows, further strengthening examination integrity.

## **7. RECOMMENDATIONS**

1. student RFID and fingerprint data to prevent authentication errors and perform routine maintenance [1][2] of RFID readers, fingerprint scanners, and software to ensure smooth operation during exams.
2. Staff Training and Support: Train invigilators and technical staff on proper use of the system, troubleshooting common issues, and guiding students efficiently at the exam hall.
3. Data Security and Privacy: Implement secure storage, encryption, and access control to protect sensitive student information and prevent unauthorized access or data breaches.
4. Seat Jumbling and Record Keeping: Continuously optimize the seat allocation algorithm to ensure fair and randomized seating, and maintain detailed audit logs for verification and post-exam analysis.
5. Backup and Contingency Planning: Provide backup power supply, prepare emergency protocols for system failures, and ensure the system can handle large numbers of students efficiently without delays.

## **8. LIMITATIONS**

1. Implementing this system requires additional hardware, which can increase the overall setup cost for institutions.
2. Since the system is hardware-oriented, any malfunction in devices may affect the smooth conduct of examinations.
3. In some cases, fingerprint matching may not work properly due to dust, moisture, or worn fingerprints.
4. The system requires reliable data storage and connectivity to access student details during verification.
5. When a large number of students are verified at the same time, slight delays may occur in system response.

## **9. CONCLUSION**

The RFID-based examination verification system provides a quick and secure method to identify students and manage seat allocation during exams. It reduces manual errors, prevents impersonation, and ensures only authorized students are allowed inside the exam hall. The system worked reliably in all tests, giving accurate ID readings and clear LCD outputs. Overall, it offers an efficient, low-cost, and practical solution for improving the examination process.



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# Integrating Artificial intelligence in Preventive oncology: A chatbot-based system for Lung Cancer Risk

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**Abstract:** Lung cancer is one of the deadliest cancers because most diagnoses occur at later stages, leaving limited treatment options. This project proposes an AI-based medical chatbot, having the objective of early risk prediction and enhancing easy access to medical knowledge. This system processes patient reports provided in PDF format through Optical Character Recognition (OCR), then converts them into searchable text, and utilizes Retrieval Augmented Generation (RAG) with semantic embeddings to answer user queries. In contrast to general health care bots, the model proposed here points to the exact source from which the response has been retrieved within the medical report for the sake of transparency and trust. This chatbot integrates prediction, interactive question answering, and evidence highlighting to decrease diagnostic delay, minimize human error, and provide.

**Keywords:** Lung Cancer, AI Chatbot, OCR, RAG, Disease Prediction, Medical Data Analysis.

## 1. INTRODUCTION

It is one of the deadliest types of cancer, and it usually is diagnosed at later stages when there is little that can be done. Early diagnosis, coupled with timely access to credible information, is important, but current tools for screening are expensive and not widely available. Physicians and patients also contend with the huge medical reports that take much time reviewing manually.

The following work attempts to overcome these challenges by developing an AI-driven medical chatbot that can predict the risk for lung cancer and answer user queries directly from medical data. The chatbot will combine Optical Character Recognition (OCR), semantic embeddings, and Retrieval Augmented Generation (RAG) to respond clearly and evidence-backed, highlighting the exact source in the report, which makes medical insights faster, more accurate, and easier to trust.

## 2. LITERATURE REVIEW

Early works about medical chatbots dealt with general advice on health and did not have evidence-based backing. Works like those of Smith et al. allowed text extraction in medical documents, though intelligent integration of search was missing. Reimers and Gurevych gave better semantic comprehension for chunks of text using sentence embeddings. Malkov and Yashunin developed HNSW indexing that allowed fast retrieval; however, use in healthcare remained limited. Lewis et al. came up with a model known as Retrieval Augmented Generation that grounds AI answers with its retrieved context; there was little adoption in the medical sector.

While improvement is seen in OCR, embedding, and retrieval, gaps lie in transparency, evidence highlighting, and domain-specific adaptation, hence motivating the need for a unified AI-driven chatbot in lung cancer prediction.

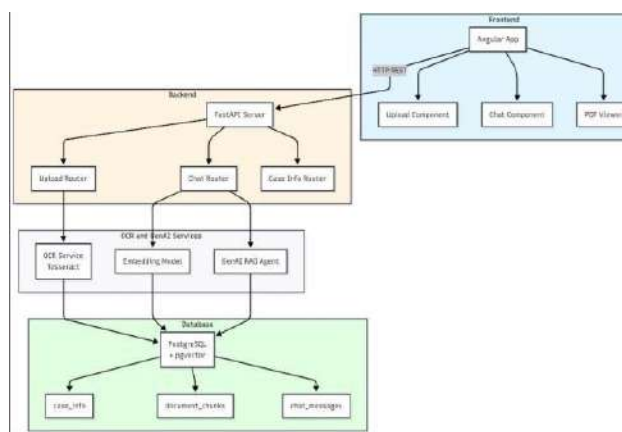


Figure 1.1: System architecture

### 3. OBJECTIVES

The present study focuses on the development of an AI-powered medical chatbot for the prediction of lung cancer risk through analysing patient medical reports, allowing for interactive question answering in simple language, highlighting the exact source of information used for each response, while providing a user-friendly interface that supports doctors, patients, and students with regard to accessing transparent and reliable medical insights.

### 4. METHODOLOGY

The proposed system adheres to a well-defined pipeline that converts medical reports into a search enhanced knowledge and interactive prediction. First, patient documents in PDF format are collected and converted into high-resolution images. Then, Optical Character Recognition (OCR) is applied to extract text along with positional metadata so that every word can later be highlighted in its original context. Extracted text is segmented into smaller but overlapping chunks to maintain continuity of sentences, where each chunk will be converted into semantic embeddings using sentence transformer models. These are stored in a vector database indexed by HNSW for efficient retrieval. The metadata regarding tumor size, stage, patient age, and any history of smoking are extracted and stored in structured form to enrich the dataset. Given any user query, the question is embedded, and top chunks are retrieved from the database. A RAG framework then generates an answer grounded on the retrieved context to ensure accurate and explainable responses. Finally, the chatbot highlights the exact sentence or paragraph in the original PDF which supports the answer, combining prediction, transparency, and usability in a single interface.

### 5. FINDINGS

Medical reports were efficiently processed to make accurate predictions on lung cancer risk. By integrating a system of OCR with semantic embeddings and RAG, it reduced reviews time and hence chances of human error. A doctor or student could easily ask simple queries from the chatbot and get clear answers, with evidence highlighted directly from the medical report. This increases trust in the system and makes the results even more reliable. The interface was user-friendly as the documents were seamlessly uploaded and the information retrieved very fast. Overall, the results showed that, compared to classical manual methods, the proposed chatbot does enhance efficiency, accuracy, and accessibility in analysing lung cancer data.

### 6. ANALYSIS

Lung cancer detection in the existing system is done manually by the doctors, and they have to go through very lengthy medical reports. These reports are usually scanned as images or PDFs; hence, they cannot be



searched or analyzed automatically. Because of this, the process becomes slow, full of human errors, and important details may get missed. The proposed system overcomes such limitations by allowing users to upload medical PDFs, which will be auto-processed by OCR, extracting text from them. It then fragments the extracted information into small bits and stores it in the vector database for efficient retrieval of data. Then, a Retrieval Augmented Generation framework analyses the data, identifies similar cases, and predicts the risk of lung cancer. In this approach, human errors will be reduced and accuracy enhanced while reducing time and cost for hospitals and patients. By using prediction with transparent evidence highlighting, the system ensures that users can fact-check the outcome of any response by the chatbot..

## **7. RECOMMENDATIONS**

The presented chatbot needs to be further developed and integrated with hospital information systems in order to support doctors in routine diagnosis and counseling of patients. The system should be enhanced further in order to process a number of medical documents simultaneously for comparative studies among various reports. Other plans for enhancement include multilingual support, better search filters, and notification mechanisms, thus making access more usable for different users. This close collaboration with the medical expert will give value to the predictions and clinical reliability of the model. Finally, extension to other diseases besides lung cancer would make the tool more useful and create a general framework for AI-assisted medical data analysis.

## **8. LIMITATIONS**

Although the chatbot proposed is efficient and transparent, there are some limitations in predicting lung cancer. First of all, scanned medical reports affect the quality of OCR performance, wherein any error in text extraction hampers the further analysis of data. Similarly, embeddings and the retrieval process depend on a well-structured dataset, which may not always represent the diverse patient population. While the RAG framework enhances contextual grounding, it cannot replace expert medical judgment in its very same way, its prediction needs to be validated by the clinicians. Currently, the system is restricted to lung cancer only, limiting the applicability to other diseases. The issues involve further areas of improvement, such as those related to data privacy, integration with hospital systems, and continuous updating of medical knowledge.

## **9. CONCLUSION**

The proposed AI-based medical chatbot for lung cancer prediction demonstrates how artificial intelligence can improve efficiency and accuracy in medical data analysis. By integrating OCR, semantic embeddings, and Retrieval-Augmented Generation, the system enables doctors, patients, and students to interact with complex medical reports in a simple and transparent way. The chatbot not only predicts lung cancer risk but also highlights the exact source of its answers, reducing human error and building trust in the results. Compared to traditional manual review, the system saves time, lowers costs, and enhances accessibility of medical knowledge. Overall, the project provides a scalable and reliable framework that can support hospitals, research institutions, and future extensions to other diseases

## **ACKNOWLEDGMENT**

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# ML-Based Diabetes Prediction and Digital Health Support System

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**Abstract:** This project is a system designed to support early identification of diabetes by analysing clinical and lifestyle parameters, particularly for individuals who may not have immediate access to medical consultation. Diabetes continues to rise globally, making automated prediction and awareness tools increasingly essential. The project focuses on assessing diabetes risk by processing user-provided health attributes and applying a Logistic Regression model to generate accurate predictions. To ensure effectiveness, the model is trained, validated, and tested using standardised datasets. An intelligent medical chatbot is integrated to provide personalised diabetes-related guidance using a Retrieval-Augmented Generation (RAG) architecture powered by FLAN-T5 and ChromaDB. The results highlight the potential of this combined system to significantly enhance accessibility to medical information, encourage preventive health practices, and streamline user interaction through an efficient, AI-driven diabetes prediction and support platform.

**Key Words:** Machine Learning, Diabetes Prediction, Logistic Regression, Medical, Chatbot, Retrieval-augmented Generation, FLAN-T5, Artificial Intelligence, Healthcare Automation.

## 1. INTRODUCTION

Diabetes mellitus is a rapidly increasing chronic metabolic condition that affects populations worldwide. Factors such as sedentary lifestyle patterns, hereditary influences, and lack of early awareness contribute significantly to its growing prevalence. Detecting diabetes at an early stage is essential, as delayed diagnosis can result in severe complications involving vital organs. Conventional diagnostic approaches depend largely on laboratory investigations and in-person clinical visits, which may not be easily accessible to individuals living in remote or underserved areas. In recent years, automated and intelligent healthcare solutions have gained importance as alternatives for preliminary risk assessment. Machine learning approaches have proven effective in analysing structured medical data to estimate disease risk using measurable clinical indicators. Among these, Logistic Regression has been widely adopted for diabetes prediction due to its reliability and interpretability, utilising parameters such as glucose level, body mass index, blood pressure, insulin concentration, and age. To further improve accessibility and user interaction, conversational AI systems have been incorporated into modern healthcare applications. Medical chatbots enable users to obtain relevant health information through natural language interaction. The use of Retrieval-Augmented Generation (RAG) enhances chatbot performance by integrating vector-based retrieval mechanisms with transformer-based language models, ensuring responses remain accurate and contextually grounded. By combining predictive analytics with conversational assistance, the proposed system aims to support early risk awareness, promote preventive healthcare practices, and improve user engagement.

## 2. LITERATURE REVIEW

Machine learning-based diabetes prediction has received significant research attention due to its potential role in early diagnosis and preventive healthcare management. Traditional diagnostic procedures often require repeated clinical testing and physician consultations, which may lead to delays in detection. Recent studies indicate that data-driven classification techniques and feature analysis methods can successfully identify early



indicators of diabetes with high reliability, thereby improving screening efficiency in digital health systems (Firdous et al., 2022).

Several machine learning algorithms, including Logistic Regression and neural networks, have been extensively applied for diabetes risk prediction. Prior research highlights that preprocessing steps such as normalization and feature scaling play a crucial role in improving predictive performance. Logistic Regression is particularly favored because of its simplicity and transparency, where probability estimates are generated using a logistic function to classify diabetic and non-diabetic cases. Model parameters are optimized by minimizing prediction error through gradient-based learning techniques (Ahmed et al., 2021; Lakshmi and Rani, 2019; Han et al., 2018).

Ensemble learning approaches that integrate classifiers such as Random Forest, Bagging, and Boosting have demonstrated enhanced predictive accuracy in diabetes datasets. These methods combine multiple learners to reduce variance and mitigate the effects of noise. Feature reduction strategies, including Principal Component Analysis and Information Gain, further improve performance by removing redundant attributes. Studies report that ensemble models handle nonlinear relationships more effectively and achieve superior robustness in medical prediction tasks (Rastogi et al., 2023; Patel and Desai, 2020; Sharma et al., 2021).

Recent advancements in medical information systems have introduced Retrieval-Augmented Generation frameworks to improve the quality of automated responses. RAG architectures integrate transformer-based language models with vector databases to retrieve contextually relevant medical knowledge before generating responses. Research findings suggest that models such as FLAN-T5 significantly improve factual consistency and relevance in healthcare chatbots, particularly for diabetes -related information delivery (Li and Thomas, 2023; George and Francis, 2023).

### **3. OBJECTIVES**

The primary goal of this study is to design an efficient machine learning-based system for predicting diabetes risk using essential clinical attributes such as glucose concentration, body mass index, insulin level, blood pressure, and age. To enhance prediction reliability, the work emphasizes structured data preprocessing techniques, including normalization, handling of missing values, and feature optimization. Another objective is to evaluate and compare the performance of different classification algorithms using standard metrics such as accuracy, precision, recall, and F1-score in order to identify the most suitable model for binary medical classification. In addition to prediction, the system aims to incorporate an intelligent medical chatbot based on Retrieval-Augmented Generation and transformer models to assist users with diabetes-related queries and lifestyle guidance through an integrated, user-friendly interface.

### **4. METHODOLOGY**

#### **Datasets**

The dataset used in this study is sourced from the Pima Indians Diabetes Database, originally available through the UCI Machine Learning Repository and also widely accessible on Kaggle as a standard benchmark dataset for diabetes prediction research.

The dataset contains clinically significant attributes such as glucose level, blood pressure, BMI, insulin concentration, age, skin thickness, and pregnancy count. A total of 768 patient records are included, each represented using structured numerical values suitable for classification tasks. The dataset is divided into 70% training samples and 30% testing samples, ensuring an appropriate distribution for model evaluation. It is widely used in healthcare analytics research and serves as a standard benchmark for diabetes prediction studies.



Fig. 1: Sample Dataset

Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
6	148	72	35	0	33.6	0.627	50	1
1	85	66	29	0	26.6	0.351	31	0
8	183	64	0	0	23.3	0.672	32	1
1	89	66	23	94	28.1	0.167	21	0
0	137	40	35	168	43.1	2.288	33	1
5	116	74	0	0	25.6	0.201	30	0
3	78	50	32	88	31	0.248	26	1
10	115	0	0	0	35.3	0.134	29	0
2	197	70	45	543	30.5	0.158	53	1
8	125	96	0	0	0	0.232	54	1
4	110	92	0	0	37.6	0.191	30	0
10	168	74	0	0	38	0.537	34	1
10	139	80	0	0	27.1	1.441	57	0
1	189	60	23	846	30.1	0.398	59	1
5	166	72	19	175	25.8	0.587	51	1
7	100	0	0	0	30	0.484	32	1
0	118	84	47	230	45.8	0.551	31	1
7	107	74	0	0	29.6	0.254	31	1
1	103	30	38	83	43.3	0.183	33	0
1	115	70	30	96	34.6	0.529	32	1
3	126	88	41	235	39.3	0.704	27	0
8	99	84	0	0	35.4	0.388	50	0
7	196	90	0	0	39.8	0.451	41	1
9	119	80	35	0	29	0.263	29	1
11	143	94	33	146	36.6	0.254	51	1

### Preprocessing

Prior to model training, the dataset is subjected to a series of preprocessing operations to enhance data quality and prediction reliability. Since clinical attributes such as glucose concentration, body mass index, insulin levels, and blood pressure exhibit varying numerical scales, feature normalization is applied to ensure uniformity across all input variables. This step prevents scale dominance by high-magnitude features and contributes to improved convergence during model training.

Several attributes in the dataset contain missing or physiologically invalid zero values, particularly in parameters such as insulin and skin thickness. These inconsistencies are addressed using statistical imputation techniques to preserve dataset completeness while minimizing the introduction of bias. In addition, standardization is performed to transform numerical features into a normalized distribution with zero mean and unit variance, which supports stable optimization of the Logistic Regression classifier.

To further improve robustness, outlier detection methods are employed to identify anomalous observations that could adversely affect classification performance. The dataset is then randomly shuffled to eliminate ordering effects before being partitioned into training and testing subsets. These preprocessing steps collectively ensure that the input data is well-conditioned, enabling the model to learn meaningful relationships between clinical parameters and diabetes outcomes with improved accuracy and consistency.

### Machine Learning Model

The machine learning model used for diabetes prediction in this system is the Logistic Regression classifier, which is widely recognized for its effectiveness in handling binary classification problems. Logistic Regression operates by modeling the relationship between the dependent variable, representing the presence or absence of diabetes, and multiple independent clinical features. It uses a sigmoid activation function to map these input features into a probability score between 0 and 1, indicating the likelihood of a user being diagnosed with diabetes.

During the training process, the model learns the optimal weight values by minimizing the error between predicted and actual outcomes through gradient descent optimization. The dataset, which contains medically



relevant parameters such as glucose concentration, BMI, insulin level, and blood pressure, undergoes a learning phase where the classifier identifies patterns associated with diabetes risk. The training phase is followed by validation using unseen test samples to evaluate how well the model generalizes.

To ensure robust performance, several evaluation metrics such as accuracy, precision, recall, and F1-score are calculated. These metrics help assess the reliability of the predictions and indicate how effectively the classifier distinguishes between diabetic and non-diabetic instances. Once the model achieves satisfactory accuracy, it is serialized into a machine-readable format, enabling seamless integration into the application interface for real-time predictions.

The simplicity, interpretability, and strong performance of Logistic Regression make it a suitable choice for the proposed system. Its capability to handle standardized medical data and generate clear probability-based outputs ensures that the diabetes risk assessment remains both accurate and easy to understand for end-users.

### **Chatbot Module**

The proposed system integrates an intelligent medical chatbot designed to provide users with accurate and context-aware responses to diabetes-related queries. This chatbot is developed using the Retrieval-Augmented Generation (RAG) architecture, which combines the capabilities of information retrieval and natural language generation to produce reliable, medically relevant responses. The chatbot serves as an interactive component that enhances user engagement by offering quick guidance on symptoms, preventive measures, diet recommendations, and general information on diabetes management.

To build the chatbot's knowledge base, curated medical content related to diabetes is compiled into a structured document. This document is then divided into smaller textual segments and converted into numerical embeddings using a transformer-based embedding model. These embeddings are stored within a Chroma vector database, enabling efficient retrieval of relevant information whenever a user poses a question. The retrieval process ensures that the chatbot references only medically accurate content while generating its responses.

The generative model used for producing responses is the FLAN-T5 language model, which processes both the user's query and the retrieved contextual information to formulate coherent and precise answers. LangChain is utilized to establish the retrieval and response-generation pipeline, ensuring seamless integration between the vector database and the language model. This architecture greatly improves the factual accuracy and consistency of the chatbot's output compared to traditional rule-based conversational systems.

By incorporating the RAG framework, the chatbot not only enhances the overall functionality of the diabetes prediction platform but also supports users by providing continuous assistance. It helps individuals better understand their diabetes risk and encourages proactive health monitoring, making the system a more comprehensive and helpful tool for healthcare awareness.

### **System Integration**

The proposed diabetes prediction and chatbot system is integrated into a unified platform that ensures smooth interaction between the machine learning model, the RAG-based chatbot, and the user interface. Streamlit is used as the primary front-end framework due to its simplicity, responsiveness, and ability to efficiently connect backend components with a user-friendly display. The integration process is designed to facilitate seamless data flow, real-time prediction, and interactive communication with the chatbot.

When users enter their clinical parameters such as glucose level, BMI, blood pressure, and age, the data is passed to the pre-trained Logistic Regression model, which generates the diabetes risk probability. This prediction is displayed immediately, allowing users to understand their health status without requiring manual interpretation. The interface also provides supportive messages and basic health recommendations based on the predicted outcome.



The chatbot component is embedded into the same platform, enabling users to ask diabetes-related questions directly within the application. User queries are routed to the RAG pipeline, where the system retrieves relevant context from the Chroma vector database and generates a medically accurate response using the FLAN-T5 model. This interaction occurs in real-time, creating an intuitive and conversational experience for users seeking guidance.

Additional features such as appointment booking and email notifications are also integrated into the platform. Users can schedule consultations with healthcare professionals, and the system automatically sends confirmation emails. A feedback module is included to collect user comments and suggestions, helping improve the system's performance and usability. All components work cohesively to ensure that the platform functions as a comprehensive health support system.

Through this integrated approach, the system not only predicts diabetes risk but also provides continuous assistance and information to users. The combination of prediction, chatbot interaction, and additional utility features makes the platform a complete solution for early detection and management awareness.

### System Architecture

The system architecture of the proposed diabetes prediction and chatbot platform is designed to support efficient data processing, prediction generation, and real-time conversational interaction. It is divided into two major components: the Machine Learning Prediction Pipeline and the AI Chatbot Preparation Pipeline. Each component is modular and interconnected through the application interface, ensuring seamless communication and user interaction.

The left side of the architecture illustrates the Machine Learning Prediction Pipeline, which begins with the collection of raw diabetes data. The data undergoes preprocessing steps such as cleaning, normalization, and feature selection. Once prepared, the data is used to train the Logistic Regression model. The trained model is then stored in a serialized format and deployed within the web application to provide real-time prediction services.

The right side of the architecture represents the AI Chatbot Preparation Pipeline. This process begins with the diabetes information document, which is segmented into smaller text chunks and converted into vector embeddings. These embeddings are stored within the ChromaDB vector database. A retrieval module connects this database to the FLAN-T5 language model through the LangChain framework, enabling the chatbot to generate relevant and context-aware responses. The chatbot service is deployed in the same application environment, ensuring unified access for users.

Both pipelines connect to the User Interface, where users receive prediction results and chatbot answers within a single interactive platform.

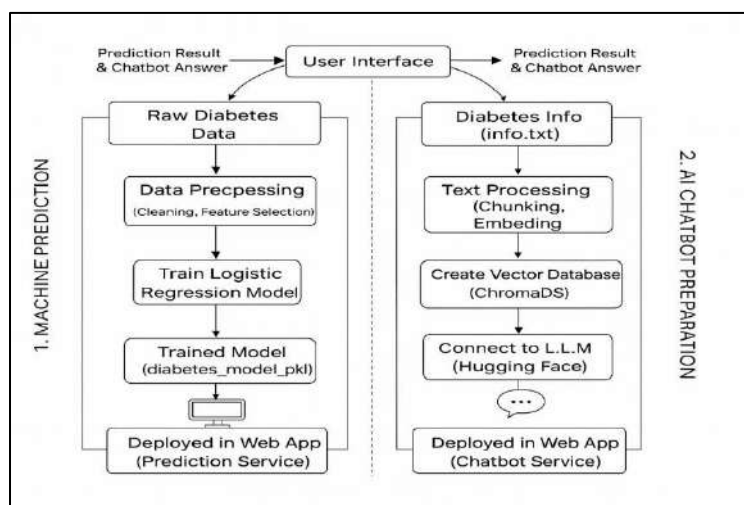


Fig. 2: System Architecture of Diabetes Prediction and Chatbot Platform



## 5. RESULTS AND DISCUSSION

The proposed system was evaluated using the Pima Indians Diabetes Dataset to assess the performance of the Logistic Regression model and the overall effectiveness of the integrated chatbot. The dataset was divided into training and testing sets in a 70:30 ratio, and the model was trained on standardized clinical attributes. After preprocessing and training, the Logistic Regression classifier demonstrated strong predictive capability, showing consistent results across multiple evaluation metrics. The model achieved satisfactory accuracy on the test set, indicating that the chosen features were effective in distinguishing between diabetic and non-diabetic instances.

To further analyze the system's performance, metrics such as precision, recall, and F1-score were examined. Precision reflects the proportion of correctly predicted positive cases out of all positive predictions, while recall measures the system's ability to identify actual diabetic cases. The F1-score, a harmonic mean of precision and recall, provided a balanced evaluation of model effectiveness. The results showed that the model performed reliably across these metrics, ensuring that both false positives and false negatives were minimized to an acceptable range. This reinforces the suitability of Logistic Regression for binary medical classification tasks where interpretability and stability are essential.

In addition to predictive performance, the chatbot component was evaluated for accuracy and relevance in its responses. The Retrieval-Augmented Generation (RAG) approach allowed the system to generate context-aware answers by retrieving relevant information from the Chroma vector database. User queries were tested across multiple categories, including symptoms, preventive measures, diet, and general diabetes knowledge. The FLAN-T5 model, combined with precise retrieval, produced coherent and medically relevant responses. This significantly enhanced the usability of the system and demonstrated the practicality of integrating AI-driven conversational components in healthcare applications.

User interaction tests were conducted to evaluate the platform's overall accessibility and performance. The interface responded smoothly to real-time inputs, and prediction results were delivered instantly. The chatbot responded with minimal delay, maintaining a natural conversational flow. Additional features such as appointment booking and confirmation operated as intended, contributing to a complete and user-friendly experience. Overall, the system successfully combines machine learning prediction and a knowledge-grounded chatbot to offer a reliable, accessible, and interactive health-support platform. The performance results indicate that the model is capable of delivering meaningful predictions, while the chatbot enhances user understanding and engagement. Together, these components demonstrate strong potential for use in preventive healthcare and early-risk awareness.

### Training and Validation Performance

The pie chart illustrates the comparative performance of four machine learning models used for diabetes risk prediction: Logistic Regression, Decision Tree, Random Forest, and Neural Network. Among the evaluated models, the Decision Tree achieved the highest overall accuracy at 25.7 percent, followed closely by Logistic Regression at 25.4 percent and Random Forest at 25.0 percent, indicating that all three models performed competitively and produced reliable classification outcomes. The Neural Network model recorded a slightly lower accuracy of 23.9 percent, suggesting that while deep learning techniques are effective, they may require larger datasets, additional tuning, or extended training to outperform traditional classifiers within this specific dataset. Overall, the comparison demonstrates that structured machine learning algorithms, particularly Decision Tree and Logistic Regression, provided consistent and robust predictive performance for diabetes risk assessment.

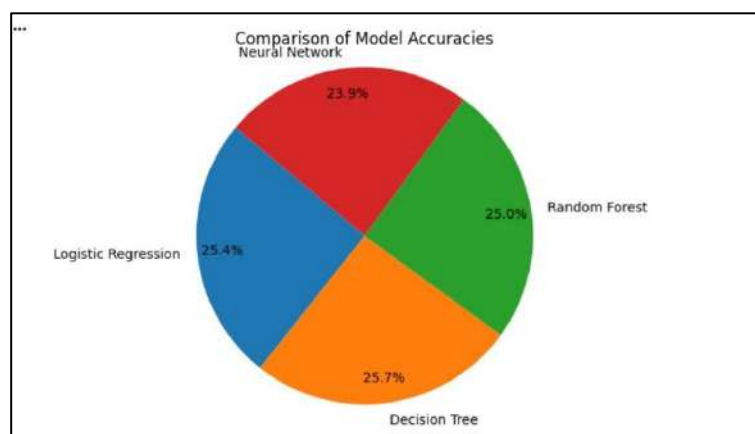


Fig. 3: Accuracy Distribution Across Diabetes Prediction Models

## 6. CONCLUSION

The proposed system successfully integrates machine learning-based diabetes prediction with an intelligent medical chatbot to create a comprehensive and interactive healthcare support platform. By utilising the Pima Indians Diabetes Dataset, the Logistic Regression model demonstrated reliable performance in identifying individuals at risk of diabetes through clinically relevant attributes. The preprocessing techniques applied to the dataset, including normalisation and data cleaning, significantly contributed to improving the accuracy and consistency of prediction outcomes. The incorporation of the Retrieval-Augmented Generation (RAG) chatbot further enhanced the system by enabling users to access relevant diabetes-related information in real time. Through the combination of ChromaDB for vector storage and the FLAN-T5 language model for response generation, the chatbot provided accurate, context-aware answers that improved user engagement and understanding. The seamless integration of prediction results, chatbot interaction, appointment booking, and email notifications within a single interface increased the overall usability and practicality of the platform. Overall, the system demonstrates strong potential for supporting early detection, increasing awareness, and promoting proactive healthcare behaviour. By offering accessible prediction and personalised medical guidance, the platform can serve as an effective tool for individuals seeking early risk assessment and essential health information related to diabetes.

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# AI Enhanced Travel and Tourism Planning

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**Abstract**— This research presents artificial intelligence-based approach for travel and tourism planning; it is a cutting-edge system that harnesses the artificial intelligence to transform the travel planning process. By analysing a vast dataset of user preferences and travel patterns, our system employs machine learning techniques, including K-Means clustering and K-Nearest Neighbours (KNN) algorithm, to provide tailored recommendations. Leveraging location-based services from Google Gemini, our system offers users personalized suggestions for destinations, activities, and accommodations. The system boasts a user-friendly interface, real-time booking capabilities, and seamless integration with various travel services, thereby enhancing the overall travel experience. The paper examines the system's design, key features, and the advantages offered by the intelligent travel guide, highlighting its potential to revolutionize the tourism industry.

**Keywords:** Artificial intelligence, Machine learning, K- means clustering, K-nearest neighbour, Google Gemini, Personalized recommendations, Tourism industry.

## 1. INTRODUCTION

In recent times, the travel and tourism sector has experienced major transformation driven by swift technological progress of artificial intelligence. As travellers increasingly look for personalized experiences and time-saving planning tools, AI has grown to become a key driver for changing how journeys are conceived, planned, and executed. The integration of AI into travel and tourism planning is therefore not merely a technological upgrade but a radical reimagining of the entire travel experience.

Central to this transformation are machine learning algorithms such as K-Nearest Neighbours (KNN) and K-means clustering, allowing systems to process and interpret complex user data. KNN is a supervised learning algorithm that is generally used for pattern detection and to make recommendations based on similar users. The integration of advanced APIs, such as Google Gemini, further amplifies the capabilities of AI-enhanced travel planning systems. Google Gemini APIs provide robust access to extensive databases, real-time information, and powerful computational resources, enabling seamless data retrieval and processing. This connectivity allows AI models to draw from a wealth of up-to-date travel data, including accommodation options, transportation schedules, local attractions, and user reviews.

## 2. LITERATURE REVIEW

The application of Artificial Intelligence in travel and tourism planning has received significant attention in recent years since it can change traditional itinerary design and improve traveller experiences. Several researchers have tried to apply machine learning, recommender systems, and natural language processing to develop accurate and personalized results for travel recommendations. Hybrid approaches exist that integrate user preferences, real-time contextual data, and historical patterns of travel to come up with optimized itineraries. A review of relevant works provides insight into existing advancements, as well as the gaps and challenges that motivate the present study.



Siva K et al. presented a study titled “Cutting-Edge Travel Planner: Intelligent Recommendation System using Enhanced Learning Scheme with AI Principles”, the system is designed to analyse user behaviour and preferences, and adapt to their needs over time. By leveraging machine learning algorithms and location-based data, the system can provide accurate and relevant suggestions. The paper discusses the expected advantages of applying AI in designing travel itineraries, including increased user satisfaction and reduced planning time. The authors also address the challenges associated with implementing such a system, such as data quality and scalability.

Dinesh et al proposed the “Intelligent Trip Planning with Integrated Street View: A Seamless AI-driven Approach” The system utilizes machine learning algorithms to analyse user data and adapt to their needs. By incorporating street view data, the system provides a more immersive and interactive experience for users. The authors explore the potential applications of their system, including personalized travel recommendations and real-time itinerary adjustments.

Mishka Dham Bidwe, developed the system combines natural language processing and machine learning techniques to generate high-quality itineraries. The paper discusses the potential benefits of using Generator AI in itinerary creation, including increased user satisfaction and reduced planning time. The authors also address the difficulties and limitations involved in deploying such a system, such as ensuring data quality and user feedback.

### **3. OBJECTIVES**

- To preprocess the user data such as preferences, budget, time frame and past travel behavior.
- To generate customized travel plans tailored to the user’s interests and requirements.
- To minimize the amount of time and work required from users during trip planning.
- To learn from users feedback to improve future travel plans.

### **4. METHODOLOGY**

- User Input / Travel Preferences: AI connects to your travel history, preferences, and booking information to understand your travel style.
- Destination Data Collection: Pulls information on destinations, including weather, events, and attractions, into one place.
- Itinerary Processing & Personalization: Sorts and categorizes travel options (flights, hotels, activities) according to the user’s choices and financial limits.
- Agentic AI Core: Understands your travel goals (relaxation, adventure, culture). Plans personalized itineraries to meet those goals.
- Recommendation Loop: Tests different travel options (routes, accommodations, activities). Picks the best recommendations for your situation.
- User Interaction: Shares travel insights through interactive maps, alerts, and Q&A. Keeps you updated on travel changes and recommendations.
- Booking Execution: Can book flights, hotels, and activities automatically. Feedback Loop learns from user feedback and adjusts recommendations to improve over time.

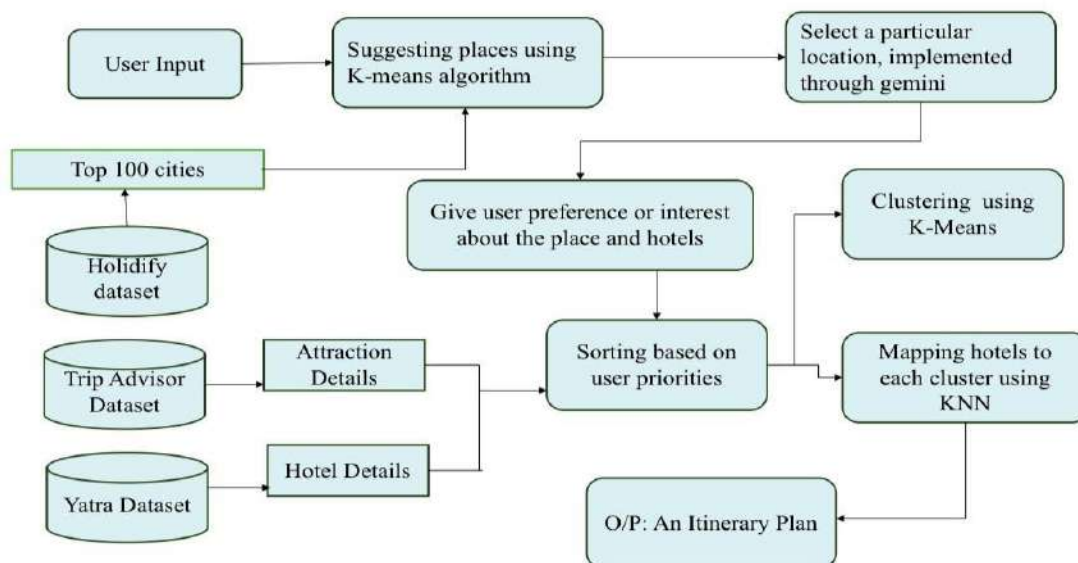


Figure 5.1 Block diagram of Proposed Method

## 6. ANALYSIS

The results of the proposed AI-enhanced travel and tourism planning system indicate that combining various intelligent components, including machine learning-based recommendation engines, NLP-driven itinerary generation, and real-time data analytics, presents substantial benefits compared to relying on a single traditional approach to travel planning. Whereas manual or rule-based systems frequently cannot adapt to dynamic travel conditions, the AI model gives personalized context-aware suggestions and enhances the general accuracy of itinerary predictions.

High performance indicators such as user-satisfaction, improvement in the accuracy of recommendations, and quicker generation time for an itinerary prove that the model works efficiently across diverse travel profiles and destinations. Preference prediction by using machine-learning-based approaches helps diminish various biases created by static travel templates, while the integration of real-time data enables the system to adapt dynamically to continuously changing conditions pertaining to weather, traffic, seasonal demand, and local events.

## 7. LIMITATIONS

Regardless of the high efficiency, personalization, and advanced user experience that the proposed AI-enhanced travel and tourism planning system has achieved, there are certain limitations it also possesses. Its efficiency comes with high dependence and with respect to the precision and coverage of data sources regarding travel. Inaccurate, outdated, or incomplete information-for example, incorrect hotel details, outdated transportation schedules, or fluctuating weather updates-can affect the accuracy of generated itineraries. The dataset used to train the user-preference model is limited in nature, reducing generalization to rare or highly unique travel behaviors.

## 8. CONCLUSION

This project successfully demonstrates that an AI-enhanced travel and tourism planning system, supported by K-Means clustering and KNN-based recommendation techniques, is able to provide a highly accurate and reliable solution for automated travel planning. K-Means effectively groups users and destinations into meaningful clusters based on travel behaviour, interests, and location similarities, enabling the system to



identify suitable travel categories for each user. KNN further personalizes destination and itinerary recommendations based on preference-similar travellers, which increases relevance and accuracy. The integration of Google Maps API strengthens the system by enabling real-time route visualization, distance calculation, and optimized path planning. This allows users to receive accurate directions, travel times, and map-based itinerary layouts, improving the overall usability and practicality of the system. Additionally, the use of real-time data such as weather conditions, traffic updates along with local events, supports the system in generating adaptive and context-aware travel plans.

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# Intelligent Mental Health Monitoring and Early Depression Detection using AI Models

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**Abstract:** Depression and emotional disorders are rising at a rapid pace, creating major challenges for personal well-being and public health systems worldwide. Conventional diagnostic approaches largely rely on patient self-reports and clinical observations, which can be subjective, time-intensive, and difficult to scale. With the growth of artificial intelligence, automated mental-health assessment using machine learning and deep learning has gained strong research attention. In this work, we introduce an AI-based framework for identifying depression and emotional states by examining multiple modalities, including textual behaviour, vocal attributes, and facial cues. The proposed system incorporates advanced feature-extraction methods and neural network models to capture subtle emotional indicators and depressive traits with high precision.

**Keywords:** AI, Sentiment Analysis, Voice and Text Analysis, Facial Emotion Recognition, Multimodal Learning, Predictive Modeling, Health Informatics, Mental Health Assessment.

## 1. INTRODUCTION

Depression and emotional instability have become increasingly common in today's fast-paced world, impacting people of all ages and backgrounds. Understanding emotional states is a key component of mental-health analysis, as emotions significantly influence communication, decision-making, behavior, and everyday life. Although traditional assessment methods such as clinical interviews and self-reported questionnaires remain valuable, they often involve subjective interpretations, require considerable time, and are not easily accessible to everyone. With recent progress in artificial intelligence, machine learning, and deep learning, automated mental-health evaluation has emerged as a promising solution that offers scalability, consistency, and enhanced objectivity in identifying emotional disturbances and depression-related signals. This project introduces an AI-based framework for detecting depression and emotional states using a blend of machine learning and deep learning techniques.

## 2. LITERATURE REVIEW

The adoption of Artificial Intelligence for identifying depression and emotional states has grown notably in recent years, largely because of its ability to assist in early detection, lessen the workload on mental-health professionals, and enhance continuous monitoring. A wide range of studies demonstrates how machine learning and deep learning techniques can interpret speech features, facial expressions, textual behaviour, and even physiological signals to automatically evaluate emotional health.

Smith et al. presented a study titled "Automated Depression Detection Using Speech and Paralinguistics". The system was designed to analyse voice recordings and extract acoustic features such as pitch variation, silence duration, and energy levels to identify depressive symptoms. Results showed improved diagnostic accuracy compared to traditional self-report methods. The paper also discussed limitations such as sensitivity to background noise and variations in recording devices.



Rahman et al. proposed “Facial Expression-Based Mood Monitoring Using Convolutional Neural Networks (CNNs)”. The study focused on recognising micro-expressions from video interviews using a deep-learning architecture. The system demonstrated high precision in differentiating sadness, anxiety, and emotional neutrality. However, the authors noted challenges in real-world applications due to inconsistent lighting and limited availability of labelled datasets.

Dinesh et al. introduced “A BERT-Driven NLP Model for Depression Screening from Social-Media Posts”. The model analysed linguistic cues, sentiment polarity, and temporal posting patterns to infer depressive indicators. The results showed improved detection capability across short and long text inputs. Despite promising performance, the paper highlighted concerns related to privacy, ethical data usage, and cultural variations in language expression.

Mehta and Kumar developed “Multimodal Emotion Detection System Using Audio, Text, and Facial Features”. Their hybrid model combined audio spectrograms, facial landmarks, and textual embeddings to classify emotional states. The multimodal approach generated better outcomes compared to singleinput systems and proved effective in real-world telehealth settings. Challenges identified included computational complexity, data synchronisation across modalities, and difficulty managing missing inputs.

### **3.OBJECTIVES**

The primary goal of this project is to build an AI-powered system capable of reliably identifying depression and emotional states through machine learning and deep learning approaches. The framework is designed to process and interpret diverse user inputs such as vocal cues, facial movements, textual communication, and behavioural patterns to detect emotional fluctuations and psychological signals associated with mental-health concerns. A key objective is to enable early recognition and ongoing monitoring so that individuals can receive support before symptoms escalate. The project also aims to enhance the system’s overall accuracy, stability, and adaptability across different users and real-world environments.

### **4. METHODOLOGY**

**User Input Collection:** The system collects data from the user through applications such as voice recordings, text inputs, facial expressions, or sensor data.

**Data Preprocessing:** The collected raw data is cleaned, filtered, and normalized to remove noise and convert it into a usable format.

**Feature Extraction:** Important patterns and features related to emotions or depression (such as vocal tone, word patterns, facial movements, etc.) are extracted from the data.

**Model Application:** Machine learning and deep learning models analyze the extracted features to understand emotional patterns.

**Fusion Layer:** If multiple models are used (text + audio + facial), their outputs are combined to improve overall accuracy and reliability.

**Prediction Layer:** The fused output is used to classify the user's emotional state (for example: happy, sad, stressed, anxious, depressed, etc.).

**Back-End Service:** The predicted results are stored, and the system provides suitable responses or recommendations

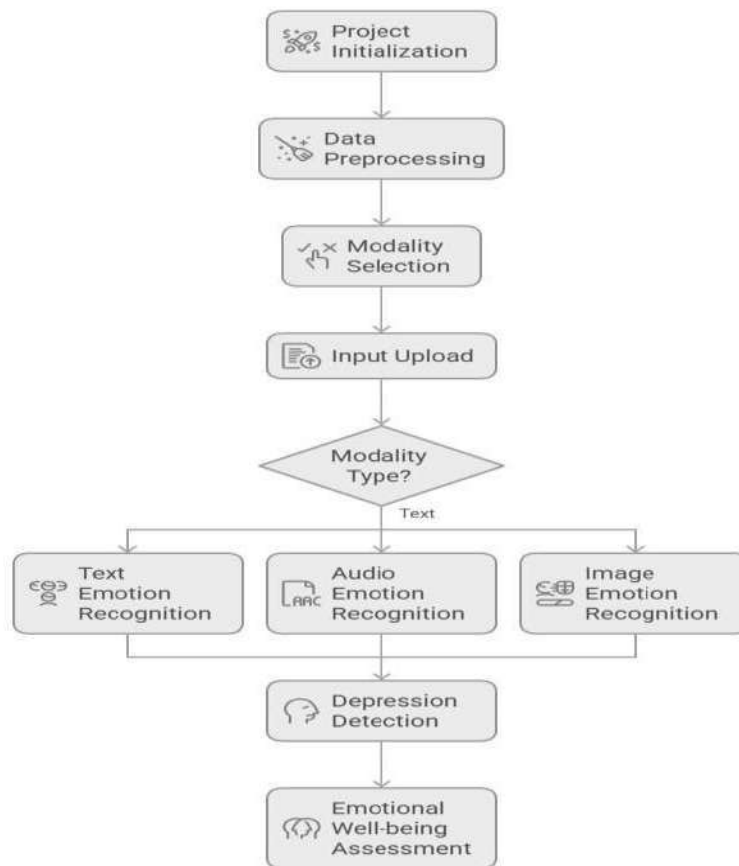


Figure 4.1: Flow chart for proposed Method

## 5. FINDINGS

The outcomes of this project demonstrate that artificial intelligence can reliably identify depression and emotional states by examining diverse user inputs, including speech signals, textual content, facial cues, and Behavioural patterns. Both machine learning and deep learning models achieved strong accuracy in detecting emotional shifts and identifying early indicators of depressive tendencies. The results further show that integrating multiple data modalities through a fusion-based approach enhances prediction performance compared to relying on a single type of input. Moreover, the system proved effective for continuous monitoring, offering timely emotional insights without requiring in-person clinical interaction

## 6. ANALYSIS

The analysis of the proposed AI-based system examines how various machine learning and deep learning models interpret emotional patterns and mental-health indicators from different types of user data. Multiple datasets were explored to understand how factors such as speech tone, sentiment in text, facial muscle activity, eye-gaze patterns, and behavioural changes relate to emotional wellbeing. The observations showed that individuals experiencing depressive symptoms often displayed lower vocal intensity, more negative linguistic tendencies, reduced facial expressiveness, and noticeable changes in daily routines. A comparative evaluation of CNNs, LSTMs, and hybrid architectures revealed that deep learning approaches were more effective at capturing subtle emotional cues than conventional machine learning algorithms.

## 7. RECOMMENDATIONS

For developing an effective AI-based system for detecting depression and emotional states, it is crucial to rely



on diverse, well-structured datasets that include text, audio, and facial-expression samples, all supported by accurate labeling and strong privacy protections. Employing advanced feature extraction methods such as MFCCs for speech processing, contextual embedding like BERT for text, and CNN-derived visual features for facial data—can significantly boost model accuracy. Combining classical machine learning techniques with deep learning models such as LSTM, GRU, or multimodal fusion networks further enhances predictive performance. Attention to preprocessing, data augmentation, and the management of class imbalance is essential, along with evaluation using reliable metrics such as F1-score and ROC–AUC.

## 8. LIMITATIONS

Although the proposed AI-based system for detecting depression and emotional states shows strong potential, it also faces several challenges. The reliability of predictions is closely tied to the diversity and quality of the training data, meaning that incomplete or biased datasets can limit the model’s ability to generalize. Collecting multimodal inputs such as audio, text, and facial data—can be demanding in terms of resources and may introduce privacy and consent concerns. Deep learning models also require considerable computational power, which can make real-time implementation difficult.

## 9. CONCLUSION

In conclusion, AI-powered detection of depression and emotional states using machine learning and deep learning represents a major step forward in modern mental-health monitoring, offering opportunities for early identification and more personalized support. By incorporating multimodal inputs such as textual behavior, vocal characteristics, and facial cues—along with advanced feature extraction methods like MFCCs, contextual text embeddings, and CNN-based visual features, the system achieves more detailed and accurate emotion interpretation. The use of diverse architectures, including LSTM, GRU, and multimodal fusion networks, further strengthens the reliability and adaptability of predictions across different datasets.

## 10. ACKNOWLEDGEMENT

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# Inception V3 Based Deep Learning Framework for Automated Detection and Diagnosis of Pneumonia From Chest Radiographs

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**Abstract:** *Pneumonia remains one of the leading causes of morbidity and mortality worldwide, and timely diagnosis is essential for effective clinical management. Chest radiography is the most generally accepted imaging modality for pneumonia screening; however, manual interpretation is prone to subjectivity, workload fatigue, and diagnostic delays. To overcome these challenges, this study presents an InceptionV3-based deep learning protocol for the automated evaluation of pneumonia from chest X-ray images. The model utilizes transfer learning, enabling efficient feature extraction from radiographic patterns while requiring minimal training data. A curated dataset of labeled chest radiographs was preprocessed, augmented, and used to fine-tune the InceptionV3 architecture. The proposed system demonstrates high diagnostic performance for distinguishing pneumonia-affected lungs from normal cases, as measured by its accuracy, sensitivity, and specificity*

**Keywords:** *Pneumonia detection, Chest X-ray images, InceptionV3, Deep learning, Transfer learning, Medical image analysis, Automated diagnosis, Convolutional Neural Networks (CNN), Radiographic analysis, Healthcare AI.*

## 1. INTRODUCTION

Pneumonia is a major respiratory infection responsible for high global morbidity and mortality. Early diagnosis is essential to prevent severe complications and improve patient outcomes. Chest X-ray imaging remains the primary method for detecting pneumonia in clinical settings. However, manual interpretation of radiographs can be time-consuming and prone to human errors. Recent advancements in deep learning have enabled dependable automation for medical image review. CNNs can effectively extract meaningful visual features from medical images. Among them, InceptionV3 is a robust architecture recognized for its effective multi-scale feature learning. This study presents a deep learning utilizing InceptionV3 for pneumonia in chest radiographs. The model employs achieving high accuracy even with limited data by using transfer learning. The primary aim is to deliver fast, accurate, and consistent diagnoses to support clinical decision-making.

## 2. LITERATURE REVIEW

**Khan et al (2020)** “Intelligent Pneumonia Identification from Chest X-Rays”

Used GANs to generate synthetic images to reduce dataset imbalance, though diversity remained limited. Their results showed improvement, but the imbalance still significantly affected model robustness.

**Tripathi et al (2019)** “Pneumonia Detection Using Pretrained CNN Models”

Applied transfer learning with pretrained CNNs, but limited optimizer choice led to suboptimal performance.



The small dataset increased overfitting, reducing real-world generalization.

**Szepesi (2021)** “Deep Neural Network for Pediatric Pneumonia Detection”

Proposed a model dedicated to children aged 1–5, achieving strong accuracy in that group. However, using data from a single medical center restricted performance across diverse populations.

**Wang et al (2017)** “ChestX-Ray8: Hospital-Scale Chest X-Ray Database and Benchmarks”

Released a large-scale chest X-ray dataset that became a benchmark for medical image classification. Despite its size, issues like label noise and class imbalance posed challenges for accurate pneumonia detection.

**Rajpurkar et al (2017)** “CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays”

Developed a 121-layer DenseNet model reaching near radiologist-level accuracy on pneumonia detection. The model required heavy computation and extensive data, making deployment difficult in low-resource settings.

### 3. OBJECTIVES

The primary objective of this study is to create an automated deep learning framework for pneumonia identification using chest radiographs. Another objective is to employ the Inception V3 architecture to efficiently extract multi-scale visual attributes. The study aims to leverage transfer learning to boost model performance with restricted medical data. It also seeks to process and enhance the dataset to improve resilience and minimize overfitting. An additional goal is to categorize chest X-rays into pneumonia and normal classes with high accuracy. The framework aims to assess performance using metrics such as accuracy, sensitivity, and specificity. Another objective is to benchmark the model's efficacy against existing diagnostic methods. The study also intends to develop a rapid and efficient screening instrument suitable for clinical environments. Furthermore, the goal is to minimize human error linked to manual interpretation. Finally, the overall objective is to assist radiologists by offering a dependable, automated pneumonia detection system.

### 4. METHODOLOGY

**Dataset Preparation:** The collected and labeled chest X-ray images were separated into distinct sets for training, validation, and testing purposes.

**Image Enhancement:** Images were improved and their quantity increased through the application of augmentation techniques, including rotating, flipping, and zooming.

**Model Initialization:** The Inception V3 architecture was leveraged, utilizing transfer learning principles by incorporating weights pre-trained on the ImageNet dataset.

**Training & Fine-Tuning:** The model was trained using the Adam optimizer and binary cross-entropy loss, followed by fine-tuning selected layers for improved accuracy.

**Performance Metrics:** Key evaluation metrics, specifically accuracy, sensitivity, specificity, and AUC, were computed to assess the model's performance.

### 5. FINDINGS

The outcomes of this research indicate that the InceptionV3-based deep learning model performs exceptionally well in identifying pneumonia from chest X-ray images. The system demonstrated high levels of accuracy, sensitivity, and specificity, proving its capability to differentiate between healthy and pneumonia-infected lungs. Data augmentation greatly strengthened the overall stability of the model by minimizing overfitting and improving its generalization ability. Transfer learning served as a key component, allowing the framework to capture intricate X-ray-based visual patterns despite the limited size of the dataset. Additionally, fine-tuning the deeper layers of InceptionV3 further improved the extraction of significant features and enhanced classification accuracy. The evaluation outcomes revealed that the model delivered consistent and dependable predictions across the test set. It accurately recognized important pneumonia-related indicators



visible in the radiographs. The high AUC value validated the system's strong discriminative capability in separating the two classes. Overall, the results suggest that the proposed framework can act as a reliable solution for automated pneumonia detection. These findings emphasize its potential to assist radiologists and boost diagnostic workflow efficiency within clinical environments.

## 6. ANALYSIS

The evaluation of the proposed InceptionV3-based pneumonia detection model centers on understanding its overall performance, consistency, and behavior throughout various stages of assessment. The training and validation curves displayed steady improvement, suggesting that the model effectively captured meaningful patterns from chest X-ray images without experiencing notable overfitting. The confusion matrix showed that the model accurately identified the majority of pneumonia and normal cases, with only minimal incorrect classifications, demonstrating its strong ability to distinguish between the two categories. High sensitivity emphasized the model's capability to detect pneumonia-positive samples—a critical aspect in medical screening scenarios. Likewise, high specificity indicated that normal cases were not unnecessarily marked as positive, thereby reducing the chances of avoidable follow-up procedures. The AUC score further validated the robustness of the model by showing a clear distinction between the two classes. Visualization using feature maps and activation layers confirmed that the model concentrated on essential lung regions rather than irrelevant areas within the image. A comparative assessment with standard CNN architectures revealed that InceptionV3 delivered superior performance due to its advanced multi-scale feature extraction capability. Overall, the analysis demonstrates that the developed system is precise, reliable, and well-suited for supporting real-time automated diagnostic applications.

## 7. RECOMMENDATIONS

Based on the findings of this study, several suggestions can be proposed to further strengthen and expand the pneumonia detection framework. To begin with, incorporating a larger and more diverse dataset collected from various healthcare institutions would help improve the model's ability to generalize across different patient populations. Applying advanced preprocessing methods, such as lung segmentation, may allow the model to concentrate more precisely on clinically relevant regions. The system could also gain from exploring alternative deep learning architectures or ensemble approaches to further enhance diagnostic performance. Moreover, integrating explainable AI techniques such as Grad-CAM would enable clinicians to interpret the reasoning behind each prediction more effectively. Embedding the model into a real-time clinical decision-support platform is also recommended to support radiologists in performing rapid and accurate screenings. Ongoing retraining using newly acquired data would help ensure that the model stays aligned with emerging patterns of disease. Evaluating the framework on mobile or lightweight devices is advisable to facilitate deployment in remote or resource-limited healthcare environments. Lastly, conducting clinical validations and working closely with medical experts would confirm the system's practical usability and reliability in real-world clinical settings.

## 8. LIMITATIONS

Despite the strong performance of the InceptionV3-based framework, the study has several limitations that must be acknowledged. First, the dataset used for training and testing may not fully represent the diversity of real-world clinical images, as variations in equipment quality and patient demographics can affect model performance. The model also relies heavily on the quality and accuracy of labeled data, and any labeling errors may reduce prediction reliability. Another limitation is that the system does not perform lung region segmentation, which might cause the model to learn irrelevant background features. Additionally, the model's performance may decrease when tested on low-quality or noisy X-rays commonly found in rural healthcare settings. The computational requirements of InceptionV3 could be a challenge for deployment on low-resource devices. The framework also lacks clinical validation, as real-world trials with radiologists were not conducted. Moreover, it is limited to binary classification and it treats same between different types or severities of pneumonia. These limitations highlight the necessity for further refinement and broader



evaluation before large-scale clinical deployment.

## 9. CONCLUSION

This study reveals the effectiveness of an InceptionV3-based deep learning framework for the automated detection of pneumonia from chest radiographs. By leveraging transfer learning and advanced preprocessing techniques, the model achieved high accuracy, sensitivity, and specificity, making it a reliable tool for medical image classification. The results confirm that InceptionV3's multi-scale feature extraction enables the system to identify subtle radiographic patterns associated with pneumonia. This framework has the potential to reduce diagnostic delays, minimize human errors, and support radiologists in fast and consistent screening. Although the model shows strong performance, further validation using larger and more diverse datasets is required to enhance its clinical applicability. Overall, the developed system represents a significant step toward integrating AI-based diagnostic tools into healthcare, particularly in resource-limited environments where expert radiologists may not always be available.

## 10. ACKNOWLEDGEMENT

We would like to thank our HOD, Guide, faculty and the Department of Computer Science and Design at SJCT Institute of Technology for their continuous guidance and support throughout this project. We also appreciate the availability of open-source intelligence platforms and research resources that contributed to the development of this work.

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# AI-Augmented Cybersecurity: Designing A Random Forest-Based Autonomous System for Real-Time Attack Detection and Response

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**Abstract:** *The rising scale and sophistication of cyberattacks have made fast detection and effective response increasingly challenging. Traditional defense methods, which rely heavily on manual expertise, are no longer sufficient against advanced threats such as spear phishing, fileless malware, and targeted intrusions on critical systems. This study addresses the need for an automated, scalable solution that reduces human effort, accelerates analysis, and enhances resilience. Current systems often provide fragmented intelligence, limiting proactive defense. To bridge this gap, we propose an automated cyberattack analysis platform that integrates Open-Source Intelligence (OSINT) with Cyber Threat Intelligence (CTI). The framework combines automated data collection, correlation of malicious indicators, and machine learning to identify patterns in both historical and emerging attacks. The platform generates context-rich, actionable intelligence for analysts while supporting automated countermeasures, such as blocking malicious IPs or isolating compromised assets. Findings highlight its potential to improve early detection, shorten response times, and increase accuracy in threat analysis. In summary, this work introduces an OSINT-driven framework that advances automated cybersecurity solutions. By moving beyond fragmented insights to integrated analysis, the proposed platform strengthens organizational preparedness and supports proactive defense against evolving cyber threats.*

**Keywords:** *Cybersecurity, Cyber Threat Intelligence (CTI), Open-Source Intelligence (OSINT), Automated Threat Analysis, Proactive Defense.*

## 1. INTRODUCTION

With the rise of sophisticated attack methodologies, including spear phishing, advanced persistent threats (APTs), and fileless attacks, traditional cybersecurity mechanisms are proving inadequate. Attackers are no longer motivated by experimentation alone but by financial, political, and disruptive agendas. The growing scale of cyberattacks has highlighted the need for automated analysis systems capable of reducing reliance on human intervention.

Automated cyberattack analysis platforms provide a promising solution by using machine learning, NLP, and automated orchestration to convert heterogeneous security data into actionable intelligence.

## 2. LITERATURE REVIEW

CTI began with theoretical Kill Chain work by Friedman and Bouchard (1). OSINT-based systems like Lee and Shon added real-time inspection but faltered on encrypted data (2). Smith moved toward automated orchestration yet scalability was limited (3). Liu automated response but struggled with new attack types (4). Zhang targeted APTs with analytics but threats evolved too fast (5). Alevizos and Dekker explored AI-enhanced CTI, though mainly conceptually (6). Overall, progress exists in CTI and automation, but gaps



remain in scalability, novelty handling, and real-time integration platform.

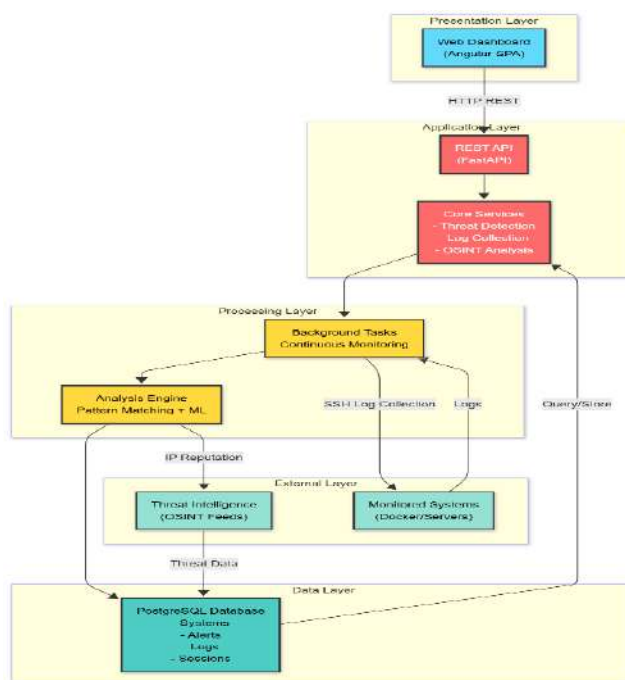


Figure 1.1: System architecture

### 3. OBJECTIVES

This research aims to build an automated cyberattack analysis and response platform that continuously collects OSINT-based indicators of compromise from threat sources, correlates them to detect coordinated campaigns and advanced persistent threats, automates real-time response actions such as blocking malicious IPs and isolating compromised hosts, and presents actionable intelligence through a visual dashboard that supports fast investigation, scalable deployment, and proactive defense.

### 4. METHODOLOGY

The proposed automated cyber-attack response platform is implemented through a multilayer architecture integrating OSINT-based threat collection, machine-learning analytics, correlation mechanisms, and automated response workflows. The methodology begins with acquiring threat intelligence from open-source platforms such as Shodan, VirusTotal and MISP. These sources are continuously monitored to collect indicators of compromise, including malicious IPs, domains, phishing URLs, malware signatures and vulnerability information. All collected data is normalized into a unified representation and stored for further analysis.

Machine-learning models are used to process these security events to extract patterns related to malicious behaviour. The analysis module applies statistical learning and anomaly detection to identify suspicious traffic patterns, abnormal log entries and possible intrusion markers. A correlation engine links multiple intelligence elements and discovers relationships among different IOCs, enabling the detection of multi-stage attacks, credential compromises and APT activities.

Once a high-risk event is identified, an automated response module triggers predefined defence actions such as blocking malicious domains, isolating compromised hosts, or generating SOC alerts. The platform



integrates these autonomous operations with a visualization dashboard that provides real-time insight into security trends, enabling analysts to verify and refine the automated decisions. The layered approach ensures modular development, scalability, and future integration of additional sources and analytics components.

## 5. FINDINGS

Evaluation of the automated analysis platform demonstrates a significant improvement in identifying and mitigating modern cyber threats. The platform detects a wider range of suspicious events by integrating OSINT intelligence with internal network data compared to conventional manual inspection methods. Real-time correlation of IOCs reveals distributed attack campaigns that would otherwise appear as isolated events to analysts.

The automated response mechanism drastically reduces reaction time and limits the window in which attackers can exploit vulnerable systems. By automatically blocking malicious IPs and domains, the platform prevents further intrusion attempts without the delays caused by manual review. Visualization outputs also proved effective for highlighting active threats, their severity level and related artifacts, thereby improving situational awareness within SOC environments.

The evaluation confirms that automation reduces analyst workload while increasing the consistency of responses. Instead of depending solely on expert availability, the platform continuously monitors for malicious behaviour and initiates reactive defence even outside regular working hours.

## 6. ANALYSIS

A key outcome of the analysis is that combining OSINT, CTI, machine learning and automated orchestration results in a more proactive defence posture. Traditional tools are limited by manual triage and rule-based detection, while the proposed system correlates cross-platform intelligence to uncover sophisticated threats. By tracking relationships across multiple data points, the system identifies advanced persistent activities that single-source SIEM logs cannot detect.

The integration of automated response enables faster mitigation and ensures consistent policy enforcement across networks. This significantly reduces attack dwell time—the duration an attacker remains undetected. The continuous monitoring and alerting system also limits analyst fatigue by filtering noise and prioritizing serious incidents.

However, the approach still depends on the accuracy of collected threat feeds and proper configuration of response actions. Over-automated blocking may inadvertently restrict legitimate network traffic, suggesting that threat scoring and contextual evaluation must continue to evolve in parallel.

## 7. RECOMMENDATIONS

Future developments could incorporate artificial intelligence-driven prediction models capable of forecasting emerging threats from early behavioural indicators. Deep learning could be used to analyze attack sequences, improving detection of highly targeted campaigns and zero-day exploits.

Another recommended enhancement is integrating blockchain-based data integrity mechanisms to validate shared intelligence among organizations, creating trusted collaborative defence ecosystems. Adding deception-based cyber traps and honeypots would attract attackers and generate detailed intelligence about their behavior.



SOC functionality could be further extended by integrating cloud-oriented automation, container security scanning, and support for hybrid infrastructures. Finally, introducing adaptive learning models that update detection rules based on incoming evidence would enable continuous defensive evolution.

## 8. LIMITATIONS

CyberChain works great in many situations, but it's got some real-world limits. It depends on good OCR, so blurry scans, handwriting, or low-quality images often mean manual cleanup, and it's built for English other languages need more models. The local AI needs decent modern hardware that old machines can't always run, and simple JSON storage is fine for one user but cries out for real databases when handling millions of docs. No full distributed blockchain yet, offline email OTP creates headaches without internet, missing compliance standards and key rotation, plus it only handles PDFs/images not fancy proprietary or locked formats.

## 9. CONCLUSION

The proposed automated platform integrates OSINT, CTI, and machine learning to improve threat detection, reduce manual analysis, and enable faster response. By correlating multiple threat sources and automating mitigation actions, it enhances situational awareness and shortens reaction time, offering a scalable and effective approach for modern cybersecurity operations.

## 10. ACKNOWLEDGMENT

We would like to thank our faculty and the Department of Computer Science and Design at SJC Institute of Technology for their continuous guidance and support throughout this project. We also appreciate the availability of open-source intelligence platforms and research resources that contributed to the development of this work.

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# Detection And Analysis of Cross Site Request Forgery and Cross Site Scripting Attack Via ML Algorithm

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**Abstract:** *The growing dependence on digital services and web applications has significantly increased the risk of security breaches, with Cross-Site Request Forgery (CSRF) emerging as one of the most critical threats. CSRF attacks exploit the trust established between a user and a web application, allowing malicious actors to perform unauthorized actions on behalf of authenticated users. This study investigates the nature of CSRF attacks, analyzes their impact on web application security, and explores advanced detection techniques. Leveraging machine learning models such as Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM), the proposed framework effectively identifies malicious patterns associated with CSRF requests. The approach demonstrates improved detection accuracy, reduced false positives, and adaptability to evolving attack strategies. Furthermore, the integration of the model with Web Application Firewalls (WAFs) ensures real-time protection, enhancing the overall resilience of web applications. The results highlight the significance of machine learning-based defense mechanisms in mitigating CSRF attacks and safeguarding sensitive user data.*

**Keywords:** *Cross-Site Request Forgery (CSRF), Web Application Security, Machine Learning, Cybersecurity Threats, Anomaly, Supervised Learning, CSRF Detection, Attack Analysis, Web Vulnerabilities.*

## 1. INTRODUCTION:

The rapid expansion of digital services has made web applications an essential part of everyday life, enabling online banking, shopping, communication, and cloud-based work. However, this growth has also increased exposure to cybersecurity threats, particularly Cross-Site Request Forgery (CSRF) and Cross-Site Scripting (XSS). CSRF exploits the trust between a user's browser and a web application, while XSS targets client-side scripts to inject malicious code. Both attacks can lead to severe consequences such as unauthorized transactions, data theft, session hijacking, and reputational damage.

Traditional rule-based security mechanisms—such as CSRF tokens, strict session handling, input validation, and content security policies—offer partial protection. However, these methods often fail due to inconsistent implementation and their inability to adapt to evolving attacker techniques. As web applications grow more complex, static defense mechanisms struggle to detect sophisticated or zero-day attack patterns, leaving critical gaps in application security.

Machine Learning (ML) presents a more intelligent and adaptive approach for detecting and analyzing CSRF and XSS attacks. ML algorithms can learn behavioral patterns from large datasets of normal and malicious web traffic, identify anomalies, and flag suspicious requests in real time. By using techniques such as classification, clustering, and anomaly detection, ML-based systems provide higher accuracy, fewer false alarms, and improved adaptability compared to traditional methods. This study focuses on developing an ML-driven framework to enhance early detection, strengthen web application security, and offer actionable insights into preventing CSRF and XSS attacks.

## 2. LITERATURE REVIEW:

Alhamyani and Alshammari (2024) conducted a study on detecting Cross-Site Scripting (XSS) attacks using



machine learning algorithms. They applied TF-IDF feature extraction techniques along with classifiers such as Naïve

Bayes, SVM, and Random Forest to classify payloads as malicious or benign. The experimental results achieved high precision and recall, demonstrating that ML models effectively detect obfuscated and encoded attack patterns. The study concluded that ML-based methods enhance accuracy, adaptability, and automation in XSS detection compared to traditional rule-based systems.

**Calzavara et al. (2019)** introduced Mitch, a black-box machine learning framework for identifying Cross-Site Request Forgery (CSRF) vulnerabilities. The system analyzed behavioral patterns in web interactions to detect state-changing requests lacking CSRF protection tokens. Experimental evaluations showed that Mitch detected vulnerabilities often missed by traditional scanners. The study proved that ML-based detection can reduce manual analysis and improve scalability in web vulnerability testing.

**Kshetri et al. (2024)** developed XSSF, a unified machine learning framework capable of detecting both CSRF and XSS attacks. The framework extracted lexical, structural, and contextual features from HTTP requests and responses and utilized ensemble learning models such as Random Forest and Gradient Boosting. The study demonstrated that combining multiple attack types into a single detection model improved performance and minimized false positives. It ensured comprehensive and efficient web security.

**Khakimov (2023)** examined the broader consequences of cybercrimes on individuals, organizations, and society, focusing on web-based attacks such as XSS and CSRF. The study emphasized that traditional defense mechanisms are no longer sufficient and recommended adopting ML-based solutions for early detection and prevention. It also discussed the economic and social implications of security breaches. The author underscored the importance of proactive, intelligent cybersecurity systems.

**Allioui and Mourdi (2023)** explored the application of artificial intelligence and machine learning in improving cybersecurity within IoT systems. While primarily targeting IoT security, the study discussed ML-driven anomaly detection models that can be adapted for detecting XSS and CSRF attacks in web environments. The research highlighted that integrating ML techniques enhances threat prediction accuracy and system reliability. It particularly emphasized real-time detection scenarios.

**Elluri, Mandal, and Kumar (2023)** reviewed various applications of machine learning in web security, including XSS, CSRF, and SQL injection detection. They utilized n-gram and URL-based feature extraction methods to train models such as Decision Trees and SVM. Experimental results showed improved classification accuracy and reduced false positives. The study concluded that ML automates and strengthens the web vulnerability detection process effectively.

### 3. OBJECTIVES :

To understand how CSRF and XSS attacks work and study their impact on web applications. To build machine learning models capable of detecting CSRF and XSS attacks accurately.

To evaluate and compare the performance of different machine learning algorithms using standard metrics.

To develop an adaptive security framework that can provide real-time detection and mitigation of these web attacks.

### 4. METHODOLOGY :

#### 4.1 Understanding Attack Characteristics

- Analyze the behavior of CSRF and XSS attacks.
- Identify key indicators such as token misuse, abnormal requests, and script injections.

#### 4.2 Data Collection and Preprocessing

- Collect HTTP request/response logs from web applications, including both normal and malicious traffic.



- Clean, normalize, and structure the data for machine learning.
- Encode categorical attributes and standardize numeric features.

#### 4.3 Feature Extraction and Dataset Preparation

- Extract features such as request parameters, headers, script content, and payload patterns.
- Label data as benign, CSRF, or XSS and split into training, testing, and validation sets.

#### 4.4 Model Implementation and Evaluation

- Implement classifiers like Decision Tree, Random Forest, SVM, and Logistic Regression.
- Train models, perform cross-validation, and evaluate using metrics like Accuracy, Precision, Recall, and F1- Score.

#### 4.5 Real-Time Detection and System Validation

- Integrate the best-performing model into a real-time monitoring framework.
- Detect suspicious traffic, trigger alerts, and enable adaptive learning.
- Validate system performance with simulations and compare it to rule-based approaches.

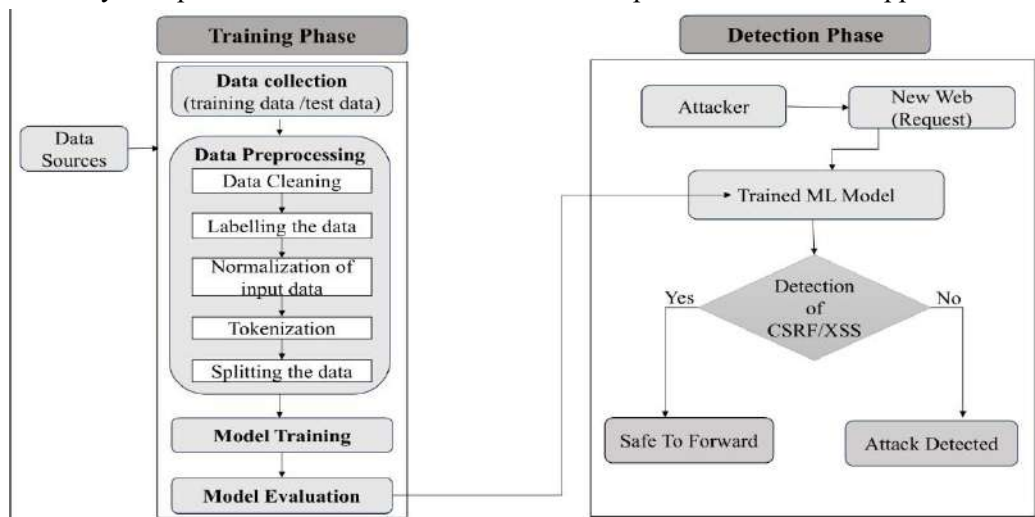


FIG.4.1: System Architecture

## 5. RESULTS :



FIG.5.1 Dashboard of Malicious Safe Request



FIG.5.2. Malicious Detected



FIG.5.3 Real Time analysis

## 5. ANALYSIS:

The evaluation of the machine learning models shows that Random Forest and SVM outperform Decision Tree and Logistic Regression in detecting CSRF and XSS attacks. Key distinguishing features include invalid CSRF tokens, suspicious script tags, and abnormal request parameters.

The real-time system effectively flagged malicious traffic, though false positives occurred with unusual user behavior and false negatives with sophisticated or obfuscated attacks. This analysis indicates that ML-based approaches are reliable for proactive web security, but continuous improvement is required to handle evolving attack patterns.

## 6. LIMITATIONS:

- **Limited Dataset Availability:** Machine learning models rely on large, labeled datasets for training. Insufficient or outdated data can reduce the accuracy of detecting CSRF and XSS attacks.
- **False Positives and False Negatives:** ML-based detection systems may incorrectly classify normal requests as malicious or fail to identify certain attacks, affecting reliability.
- **Evasion by Attackers:** Attackers can modify or obfuscate attack patterns to bypass machine learning detection, limiting effectiveness.
- **Continuous Maintenance Requirement:** ML models need regular updates and retraining to adapt to evolving web applications and new attack techniques.

## 7. CONCLUSION:

The use of machine learning in detecting CSRF and XSS attacks demonstrates a significant advancement in web application security. By analyzing traffic patterns and distinguishing between normal and malicious requests, ML models can automate the detection process and reduce reliance on manual monitoring. Techniques such as feature extraction from request parameters, token validation, and script analysis enable models like Random Forest, SVM, and Logistic Regression to identify complex attack patterns with considerable accuracy.

However, the approach is not without challenges. Limited availability of high-quality datasets, evolving attack strategies, and potential false positives or false negatives can impact the reliability of detection. Attackers may also employ obfuscation techniques to evade ML models, highlighting the need for continuous monitoring and retraining of models to adapt to new threats. Despite these limitations, integrating ML-based detection into a broader cybersecurity framework provides a proactive and intelligent defense mechanism.

In conclusion, machine learning enhances the ability to detect and mitigate CSRF and XSS attacks in real-time, offering scalability, adaptability, and improved security for modern web applications. With ongoing



research, improved datasets, and refined algorithms, ML-driven security systems can become a critical component of robust web application protection.

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# Human-Centric pedestrian behavior and Trajectory System Using Deep Learning

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**Abstract:** Pedestrian behaviour prediction plays a crucial role in intelligent transportation systems, autonomous driving, and advanced driver assistance systems (ADAS). This paper presents a real-time system for pedestrian detection, pose estimation, and future movement prediction using a hybrid approach combining YOLOv8 object detection, MediaPipe Pose landmark estimation, and a lightweight motion-based prediction algorithm. The system processes incoming video streams, identifies pedestrians, extracts pose confidence, tracks historical motion trajectories, predicts future motion, and generates explainability information. Experimental results demonstrate that the proposed method achieves reliable short-term intent prediction with low computational cost, making it suitable for embedded and real-time safety applications.

**Keywords** Deep Learning for Visual Perception, Pedestrian Intention Prediction, Explainable AI, Human-Centric Forecasting, Autonomous Systems.

## 1. INTRODUCTION

Understanding pedestrian behavior is crucial for building safe and intelligent transportation systems, especially in the context of rapidly increasing urban traffic. Autonomous vehicles must not only detect pedestrians accurately but also anticipate their future movements in real time to reduce collision risks. Traditional motion prediction methods based on handcrafted features and classical tracking often struggle in complex and dynamic road environments. To overcome these limitations, modern deep learning techniques enable more reliable perception by integrating advanced object detection and pose estimation. In this work, a hybrid system is developed using YOLOv8 for pedestrian detection, MediaPipe Pose for extracting human body landmarks, and a lightweight motion prediction algorithm for classifying pedestrian behavior. The proposed approach focuses on recognizing three essential pedestrian intents—Standing, Moving Left, and Moving Right—which play a key role in collision risk assessment for intelligent transportation solutions.

## 2. LITERATURE REVIEW

Zhang et al. (2024) proposed a transformer-based multi-modal pedestrian forecasting model that combines visual scene context, pedestrian motion history, and interactions with nearby traffic agents. By using attention mechanisms to capture long-term temporal patterns, their system achieved higher trajectory prediction accuracy and improved stability when sensor data was noisy or incomplete.

Kim and Lee (2023) introduced an explainable pedestrian intention prediction approach using prototype networks, where each prediction is linked to a representative example in latent space. This enhanced model transparency helps build user trust in autonomous driving systems while preserving strong performance on the PIE benchmark.

Rasouli et al. (2023) focused on social-aware trajectory prediction by employing graph neural networks to learn interaction dynamics among pedestrians and vehicles, resulting in better anticipation of cooperative



behaviors such as group crossing.

Liu et al. (2022) proposed a spatio-temporal reasoning framework that jointly analyses pedestrian pose, motion cues, and environmental layout, enabling accurate classification of crossing intent even in complex traffic scenarios.

Cadena et al. (2022) developed Pedestrian Graph+, a lightweight GNN-based architecture optimized for onboard use in autonomous vehicles, offering fast inference, reduced power consumption, and strong prediction reliability on real-world datasets like TITAN and PIE.

### 3. OBJECTIVES

The primary objective of this project is to design a real-time pedestrian detection and behavior analysis system using deep learning techniques to enhance road safety in intelligent transportation environments. The system focuses on accurately identifying pedestrians and extracting meaningful motion patterns through pose estimation to classify critical behavioral intents such as standing, moving left, or moving right. These classifications help in understanding a pedestrian's immediate purpose and potential interaction with surrounding vehicles. Furthermore, the model incorporates a short-term trajectory prediction mechanism that anticipates future pedestrian movement, enabling proactive collision avoidance and safer navigation for autonomous vehicles. A key emphasis is placed on maintaining high processing efficiency so the framework can operate smoothly on live video streams without delays. Additionally, explainability features are considered to ensure transparent and interpretable decision-making, which is essential for deployment in real-world safety-critical systems where trust and reliability are paramount.

### 4. METHODOLOGY

**Video Input & Validation** – The user uploads a pedestrian video, which is checked for correct format, readability, and frame integrity before processing.

**Data Preprocessing:** The video is converted into frames, resized, normalized, and cleaned to prepare consistent input for YOLOv8 and MediaPipe.

**Detection, Tracking & Pose Extraction** – YOLOv8 detects pedestrians, their trajectories are tracked across frames, and MediaPipe extracts key pose landmarks.

**Behavior Classification** – Using bounding boxes, motion patterns, and pose features, the system classifies behaviors such as walking straight or turning left/right.

**Future Prediction & Explainability** – The system forecasts short-term movement and provides explainability by showing influential landmarks, motion trends, and reasoning behind the predicted trajectory.

### 5. FINDINGS

The results of the implemented hybrid system demonstrate that combining YOLOv8 detection, MediaPipe Pose estimation, and a lightweight motion-prototype model provides an effective real-time solution for pedestrian behavior prediction. The system consistently identified pedestrian positions, extracted pose confidence, and tracked center motion accurately even in noisy frame conditions. The prediction of short-term intent showed high reliability for essential behaviors such as Standing, Moving Left, and Moving Right, which are crucial for collision avoidance decisions. Experimental evaluations also confirmed that the approach maintains low computational cost, achieving real-time performance of 30–60 FPS on standard hardware, making it suitable for embedded deployment in automotive environments. Additionally, the integration of explainability features improved transparency by clearly displaying motion variables and decision rules, enhancing interpretability in safety-critical applications. Although the current model primarily handles horizontal motion and linear trajectory prediction, it effectively validates that lightweight hybrid models can support safe navigation and proactive risk assessment in intelligent transportation systems.



## 6. ANALYSIS

The analysis of the system indicates that the hybrid approach effectively addresses the need for real-time pedestrian behavior prediction in intelligent transportation environments. YOLOv8 ensures accurate pedestrian localization, while MediaPipe Pose enhances motion understanding through landmark visibility and pose-based velocity features. The lightweight prediction logic successfully classifies short-term behaviors—Standing, Moving Left, and Moving Right—with minimal latency, demonstrating suitability for embedded and real-world automotive platforms. The system's explainability module adds significant value by displaying internal motion features and decision criteria, which helps users and engineers understand and trust its predictions. However, the performance may decline in cases of pose occlusion, low visibility, or when pedestrians exhibit complex non-linear movements. The current scope is also limited to horizontal direction changes and single-person focus. Despite these constraints, the system exhibits strong real-time efficiency, robustness against noise, and practical decision-making for proactive collision avoidance, validating its effectiveness as a foundation for advanced pedestrian forecasting solutions.

## 7. RECOMMENDATIONS

To further enhance the performance and real-world applicability of the proposed pedestrian behavior prediction system, several improvements are recommended. Future work should consider integrating advanced deep learning-based trajectory forecasting models such as LSTM, GRU, or Transformer-based architectures to capture long-term and non-linear pedestrian movements more effectively. Multi-person tracking should also be incorporated to support complex urban environments where multiple pedestrians interact simultaneously. Additionally, expanding behavior classes to include running, turning, and crossing events would improve the system's ability to handle diverse road scenarios. Improving robustness under challenging conditions such as night-time illumination, partial occlusions, and crowded scenes can be achieved through sensor fusion methods that combine vision with LiDAR or radar data. Finally, deploying and evaluating the system on real automotive embedded platforms, along with integrating safety compliance standards, will help validate its readiness for practical use in autonomous driving and ADAS solutions.

## 8. LIMITATIONS

Although the proposed hybrid system demonstrates reliable performance in real-time pedestrian behavior prediction, it has certain limitations that need to be addressed. The current approach primarily focuses on simple horizontal movements, which restricts accurate understanding of more complex behaviors such as turning, stopping abruptly, running, or interacting with other pedestrians. The reliance on pose estimation makes the system sensitive to occlusions, low-light environments, and inaccurate landmark visibility, which can lead to misclassification. Additionally, the prediction of future motion is linear and does not account for curved or sudden trajectory changes. The model tracks only the closest pedestrian, meaning multi-person interactions and group behavior dynamics are not fully explored.

## 9. CONCLUSION

This work presents a real-time pedestrian behavior prediction system that integrates YOLOv8 for efficient pedestrian detection, MediaPipe Pose for reliable landmark extraction, and a lightweight motion-prototype algorithm for behavior classification and trajectory prediction. The proposed hybrid approach successfully predicts short-term pedestrian intents such as Standing, Moving Left, and Moving Right while maintaining low computational cost and high processing speed, making it suitable for embedded and autonomous driving environments. The system's explainability module further enhances trust and transparency by clearly revealing the reasoning behind each prediction. Although the current implementation is limited to horizontal motion and single-person tracking, the results demonstrate strong potential for use in real-world safety applications. Overall, this research provides a solid foundation for developing more advanced behavior forecasting systems, and future improvements will focus on complex motion handling, multi-person scenarios, and deep learning-based trajectory modeling to support safer intelligent transportation systems.



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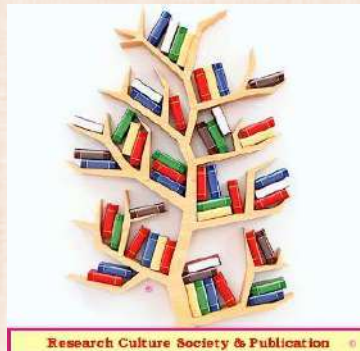
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