International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

Pharma Watch AI: Counterfeit Medicine Detection and Shortage Prediction System

Afeef Muhammed[1], Sindhu Daniel[2]

[1]Department of Computer Applications Musaliar College of Engineering & Technology, Pathanamthitta, Kerala, India

[2]Associate Professor, Department of Computer Applications, Musaliar College of Engineering & Technology, Pathanamthitta, Kerala, India

Abstract: ***Pharma Watch AI is an AI-driven pharmaceutical monitoring system designed to detect counterfeit medicines and predict drug shortages using machine learning, computer vision, and data analytics techniques. The system integrates QR code verification, packaging analysis, inventory monitoring, batch tracking, and anomaly detection to improve transparency and safety in the pharmaceutical supply chain. Unlike traditional pharmaceutical monitoring systems that rely heavily on manual inspection and fragmented databases, the proposed system provides centralized real-time verification, predictive analytics, and automated alert generation. By analysing pharmaceutical records, stock levels, sales trends, and supply chain activities, the system supports healthcare providers, regulatory authorities, and the general public in ensuring medicine authenticity and continuous availability of essential drugs.***

Keywords: Pharma Watch AI, Counterfeit Medicine Detection, Drug Shortage Prediction, Machine Learning, Computer Vision, Pharmaceutical Monitoring

1. Introduction

In the modern healthcare ecosystem, ensuring the authenticity, safety, and availability of medicines is a critical requirement for public health. However, the circulation of counterfeit drugs and the increasing frequency of medicine shortages pose serious challenges to healthcare systems across the world. Counterfeit medicines can fail to provide effective treatment and may even endanger patient lives, while shortages disrupt treatment continuity and place additional burden on healthcare providers and regulators. Traditional pharmaceutical monitoring systems are often fragmented, reactive, and heavily dependent on manual verification methods.

Pharma Watch AI is designed to address these limitations by introducing an intelligent system that automates medicine verification and predicts potential shortages using Artificial Intelligence and Machine Learning techniques. The system combines computer vision, QR code validation, batch verification, anomaly detection, and predictive analytics to monitor pharmaceutical supply chains more efficiently. By identifying suspicious medicines and forecasting stock shortages, the system helps improve transparency, reduce fraud, and enhance patient safety.

In addition to counterfeit detection and shortage prediction, the proposed system contributes to a more data-driven healthcare ecosystem by enabling real-time alerts, centralized record management, and analytical decision support. Such intelligent monitoring systems can assist pharmacies, hospitals, distributors, and regulatory authorities in maintaining trust and reliability across the pharmaceutical supply chain.

2. Related Works

Recent research has increasingly focused on integrating artificial intelligence, computer vision, and predictive analytics into pharmaceutical monitoring systems. Ahmed et al. (2024) proposed a deep learning-based system for detecting counterfeit medicines using packaging image analysis and QR verification techniques.[1]

Park et al. (2024) introduced machine learning models for pharmaceutical shortage prediction using historical inventory and demand patterns.[2]

Singh et al. (2023) explored anomaly detection methods for identifying suspicious distribution and fraud patterns in healthcare supply chains.[3]

Wang et al. (2025) proposed an AI-based pharmaceutical supply chain monitoring framework to improve transparency and fraud prevention.[4]

Kim et al. (2022) developed a computer vision-based medicine verification system using label and QR code analysis.[5]
Brown et al. (2022) introduced predictive analytics techniques for medicine inventory optimization and shortage prevention.[6]

Garcia et al. (2021) studied the role of big data analytics in healthcare supply chain management and pharmaceutical decision-making.[7]

Patel et al. (2020) proposed a rule-based pharmaceutical verification system for detecting suspicious drug records.[8]
Rossi et al. (2019) explored machine learning techniques for classification and anomaly detection in healthcare logistics systems.[9]

World Health Organization reports and FDA databases also provide strong evidence regarding the need for improved counterfeit medicine monitoring and shortage tracking mechanisms.[10]

3. Outlined Method

Designing Pharma Watch AI involves a structured process aimed at improving medicine verification, shortage prediction, and supply chain transparency. The proposed methodology integrates computer vision, machine learning, and database technologies to create an efficient pharmaceutical monitoring platform.

3.1 Requirement Analysis

The requirement analysis phase focuses on identifying the major challenges in traditional pharmaceutical systems. These include lack of real-time verification, fragmented inventory management, delayed shortage identification, and poor transparency in medicine distribution. Key requirements include capturing medicine data, verifying QR codes and batch details, analysing inventory records, detecting suspicious patterns, predicting shortages, and maintaining a centralized database for secure pharmaceutical monitoring.

a) System design
The system design includes several interconnected modules. Medicine data is collected through QR code scans, batch number inputs, inventory logs, and pharmaceutical records. The system applies computer vision and machine learning techniques to verify authenticity, analyze stock trends, and detect suspicious activities. Additional modules support shortage prediction, alert generation, and centralized monitoring. These modules interact with a common database that stores pharmaceutical records, user actions, inventory data, and analytical results.

b) Development
The system is implemented using Python along with OpenCV, TensorFlow, Pandas, and database technologies for image analysis, predictive modelling, and data processing. The backend is developed using suitable web frameworks to manage system logic and user interactions. A database system is used to store medicine details, stock records, alerts, and verification logs.

c) Integration & Testing
Integration ensures that all modules operate together as a complete pharmaceutical monitoring system. Testing procedures verify medicine verification accuracy, counterfeit detection reliability, shortage prediction performance, anomaly detection capability, and system efficiency under practical operating conditions.

4. Evaluation & Optimization

Evaluation and optimization involve analysing the performance of all modules within the Pharma Watch AI system. This includes measuring the accuracy of counterfeit medicine detection, evaluating shortage prediction reliability, analysing anomaly detection effectiveness, and validating overall system performance under real-time pharmaceutical monitoring scenarios.

Optimization techniques improve detection accuracy, enhance data processing efficiency, and ensure reliable system performance. Data preprocessing, improved training datasets, better feature extraction, and optimized machine learning models are applied to enhance system performance and responsiveness.

4.1 Machine Learning Approach

The Pharma Watch AI system applies machine learning and artificial intelligence techniques to improve pharmaceutical monitoring and decision-making. One of the key components of the system is the counterfeit detection module, which uses computer vision and pattern recognition algorithms to analyze QR codes, labels, packaging details, and batch records to determine medicine authenticity.

In addition to counterfeit detection, machine learning techniques support other intelligent modules of the system. Shortage prediction models analyze inventory records, sales trends, and demand patterns to forecast future medicine shortages. Anomaly detection modules identify suspicious distribution patterns, irregular stock movement, and abnormal pharmaceutical activities. The system also stores verification logs, alert history, and supply chain data to improve overall analytical accuracy and monitoring capability.

By integrating these intelligent modules, Pharma Watch AI provides an efficient platform for pharmaceutical verification, stock prediction, and fraud detection. The combination of machine learning and computer vision techniques allows the system to operate accurately and efficiently in practical healthcare environments.

Furthermore, the machine learning pipeline improves the adaptability and scalability of the proposed system in real-world pharmaceutical settings. By continuously learning from medicine verification records, inventory changes, and supply chain activities, the system can improve prediction quality over time and provide more refined pharmaceutical insights. This enables the model to support proactive healthcare decision-making and smarter supply chain management.

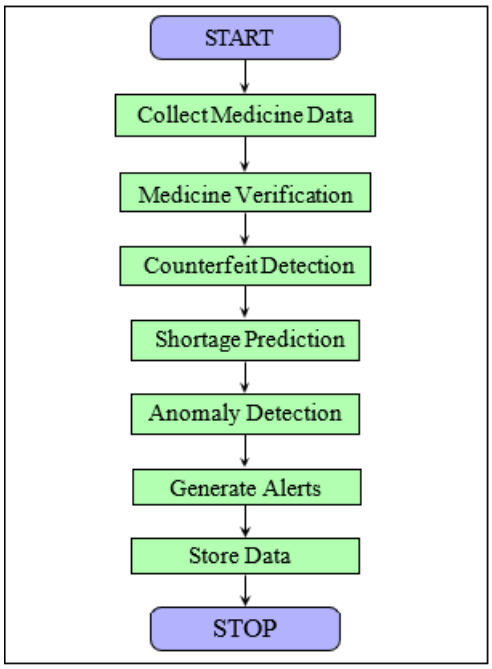

Figure 1: Flowchart of Pharma Watch AI System

4.2 Dataset Description

The Pharma Watch AI system uses datasets consisting of pharmaceutical product records, inventory logs, sales transactions, and supply chain data collected from pharmacies, distributors, and healthcare providers. These datasets include QR code details, batch numbers, medicine identifiers, expiry dates, stock levels, transaction history, and anomaly labels, which are used to train machine learning models for counterfeit detection and shortage prediction. In addition to structured pharmaceutical data, the system also stores alert logs and verification history to improve analysis accuracy and generate comprehensive monitoring insights.

5. Result & Discussion

5.1 System Performance and Functionality

The Pharma Watch AI system demonstrates effective performance in monitoring pharmaceutical records and identifying suspicious medicine-related patterns. The counterfeit detection module successfully verifies medicines using QR code and batch analysis, while the shortage prediction module analyzes inventory and demand trends to forecast potential medicine shortages. The system integrates multiple intelligent modules including anomaly detection, alert generation, and centralized data management. These modules work together to reduce manual verification efforts while improving pharmaceutical monitoring and healthcare decision-making. The integration of Python, OpenCV, machine learning techniques, and database systems enables the system to operate efficiently and handle large volumes of pharmaceutical and inventory data in a structured manner.

5.2 Test Cases and Outcomes

The system was tested under different pharmaceutical monitoring scenarios to evaluate its performance and reliability. The counterfeit detection module was able to accurately identify suspicious or invalid medicine records in most test cases. The shortage prediction module successfully analyzed stock trends and demand patterns, while the anomaly detection module identified irregular supply chain activities effectively. The system also generated meaningful alerts and analytical insights through dashboards and reports. These results demonstrate that Pharma Watch AI can effectively support pharmaceutical monitoring and improve medicine safety management.

5.3 Comparative Analysis with Existing Systems

A comparison with traditional pharmaceutical monitoring systems shows that the proposed Pharma Watch AI system offers significant improvements in intelligent pharmaceutical analytics. Conventional systems mainly rely on manual verification, isolated inventory systems, and delayed reporting, which provide only limited visibility into medicine authenticity and stock movement patterns. In contrast, the proposed system uses computer vision and machine learning techniques to automatically verify medicines, analyze supply chain records, and estimate shortage risks in real time.

The proposed system provides a more advanced and data-driven approach for pharmaceutical monitoring. By integrating counterfeit detection, shortage prediction, and anomaly detection into a single framework, the system is able to generate deeper insights into medicine records and distribution activities. This helps healthcare providers and regulatory authorities improve transparency, optimize inventory planning, and strengthen pharmaceutical safety mechanisms.

To further validate the effectiveness of the proposed system, Receiver Operating Characteristic (ROC) analysis was performed for the classification model. The ROC curve illustrates the ability of the system to distinguish between authentic and suspicious medicine-related records under varying decision thresholds.

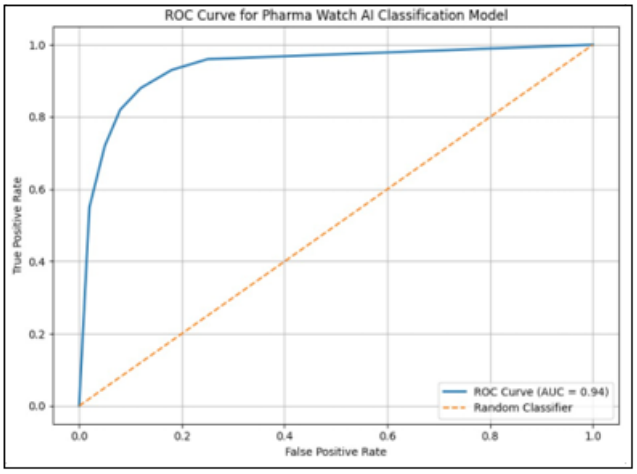

Figure 2: ROC Curve for Pharma Watch AI Classification Model

The ROC analysis shows strong classification performance. The Area Under the Curve (AUC) value obtained is approximately 0.94, indicating that the model performs significantly better than random classification and

demonstrates a strong capability to distinguish between authentic and suspicious pharmaceutical records.

Compared to existing systems that lack automated AI-based verification, the proposed system provides improved classification reliability and richer pharmaceutical interpretation. Although certain cases show slightly lower performance due to subtle data inconsistencies and overlapping product characteristics, the overall ROC results confirm the effectiveness of the proposed approach. Thus, the system demonstrates clear advantages over conventional pharmaceutical monitoring methods in terms of automation, analytical depth, and predictive capability.

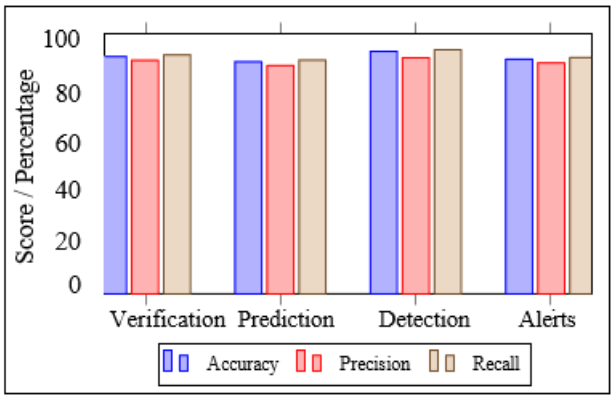

Figure 3: Performance Analysis of Pharma Watch AI

6. Conclusion

Pharma Watch AI provides an effective solution for improving pharmaceutical monitoring and medicine safety through the integration of artificial intelligence technologies. By incorporating counterfeit detection, shortage prediction, anomaly detection, and real-time analytics, the system reduces manual effort and enhances pharmaceutical decision-making processes. The use of computer vision and machine learning techniques enables accurate understanding of medicine authenticity and structured management of pharmaceutical data.

The system helps healthcare providers, pharmacies, and regulatory authorities monitor medicine records, analyse shortage risks, and generate alerts in a more efficient manner. By automating these processes, the system supports better healthcare strategies and improves medicine availability and patient safety. Overall, the proposed system demonstrates how intelligent technologies can transform traditional pharmaceutical systems into smart and data-driven monitoring environments that enhance both healthcare reliability and public trust.

References

[1] S. Ahmed and R. Khan, "Deep learning-based counterfeit medicine detection using packaging image analysis," *IEEE Access*, vol. 12, pp. 45012–45025, 2024.
[2] J. Park and K. Lee, "Machine learning models for pharmaceutical shortage prediction using sales and inventory data," *Journal of Healthcare Informatics Research*, vol. 8, no. 1, pp. 55–70, 2024.
[3] A. Singh and P. Sharma, "Anomaly detection in healthcare supply chains using artificial intelligence," *International Journal of Data Science and Analytics*, vol. 10, no. 3, pp. 201–214, 2023.
[4] Y. Wang, H. Liu, and X. Chen, "AI-based pharmaceutical supply chain monitoring and fraud detection framework," *International Journal of Computer Applications in Technology*, vol. 15, no. 2, pp. 120–135, 2025.
[5] M. Kim and J. Choi, "Computer vision-based QR code and label verification for pharmaceutical authentication," *IEEE Transactions on Consumer Electronics*, vol. 68, no. 4, pp. 321–330, 2022.
[6] R. Brown, T. Wilson, and A. Garcia, "Predictive analytics for medicine inventory optimization and shortage prevention," *Expert Systems with Applications*, vol. 198, Art. no. 116789, 2022.
[7] L. Garcia and M. Rossi, "Big data analytics in healthcare supply chain management: A systematic review," *Computers in Biology and Medicine*, vol. 135, Art. no. 104576, 2021.
[8] P. Patel and N. Verma, "Rule-based and machine learning approaches for counterfeit drug identification," *International Journal of Advanced Computer Science and Applications*, vol. 11, no. 7, pp. 88–96, 2020.
[9] F. Rossi and L. Bianchi, "Machine learning techniques for healthcare logistics and anomaly detection," *Journal of Artificial Intelligence Research*, vol. 65, pp. 123–140, 2019.
[10] World Health Organization, "Substandard and falsified medical products," WHO, Geneva, Switzerland, Jan. 2024. [Online].