Engineering Universe for Scientific Research and Management
ISSN (Online): 2319-3069 Vol. XVII Issue III
March 2025

AI-Powered Medicine Management: Smart Barcoding for Safer Healthcare

Anshika Gangrade[1], Atharv Tiwari[2], Isha Sakunde[3], Gaurav Dixit[4], Dr. Pritika Bahad[5], Diksha Bharwa[6]
Prestige Institute of Engineering Management and Research, Indore, MP, India[1,2, 3,4,5,6]
51110804436@piemr.edu.in[1], atharvtiwari44@gmail.com[2],
ishasakunde08@gmail.com[3],gauravdixit2301@gmail.com[4],
pritika.bahad@piemr.edu.in[5], dbharawa@piemr.edu.in[6]

Abstract

The presence of medication errors and counterfeit pharmaceuticals creates significant risk to patient safety. Standard barcode systems do not utilize real-time intelligence which restricts their effectiveness in inadequate prevention from medication errors and counterfeit pharmaceuticals. The goal of this work is to demonstrate the development of an Artificial Intelligence (AI) based smart barcoding system to improve medicine management that integrates machine learning, real-time verification, and automated tracking upon administration of medication. The smart barcoding system encode s` key drug information (i.e., composition, dosage, shelf life and validity) in dynamic scannable barcodes. AI algorithms to analyze patient data and medication history to mitigate adverse consequences of drug interactions will verify that drugs are prescribed correctly. Also, the introduction of computer vision and blockchain technologies would create incorruptible verification to mitigate the prevalence counterfeit medications circulated in the healthcare setting. Additionally, the use of real-time updates, tracking of inventory, and cloud technologies would allow for pharmacy and hospital inventory management and tracking. This would enhance resource availability while decreasing waste. The proposed solution is meant to improve patient safety, promote regulatory efficacy, and improve operations in healthcare. Experimental validation demonstrated improved accuracy of medication tracking and authentication of medications relative to conventional medication management. This research expands beyond a demonstration of safe and effective AI-based application in medicine management to promote more efficient solutions to create safer medicine distribution systems.

Keywords: ***AI-Powered Barcoding, Smart medicine management, Drug Authentication, Counterfeit prevention, Medication Safety.***

1. Introduction

Medicine management is the practice of monitoring, confirming, and dispensing pharmaceutical products to both guarantee the safety of patients, regulatory compliance, and effective healthcare operations. Conventional barcoding technology is commonly applied to labeling medicines and inventory management, but it does not have smart decision-making features[1]. Smart barcoding combines artificial intelligence (AI) and barcode technology to augment the safety of drugs, verification, and automated validation processes for prescriptions. This technology converts important drug information—e.g., composition, dosage, expiration, and authenticity—into dynamic barcodes, which are scanned in real time with AI and machine learning algorithms. Incorporation of AI in medicine barcoding is important in minimizing medication mistakes, eliminating counterfeits, and enhancing stock management. AI cross-verifies prescriptions, identifies improper dosages, drug interaction, and duplications, enabling proper barcode label medication dispensing [2]. The increasing problem of fake drugs is serious health hazards, and AI authentication provides the traceability and authenticity of drugs. Moreover, pharmacies and hospitals usually face inefficient inventory management, resulting in drug shortages or waste. AI-based barcoding allows real-time monitoring and automatic replenishment, streamlining healthcare operations and minimizing human effort for medical staff. Identifying inefficiencies in traditional medicine management is crucial to avoid adverse drug reactions, which may lead to life-threatening complications or even death. Regulatory agencies require strict monitoring mechanisms to fight fake drugs and provide assurance of drug quality and safety. AI-based systems also streamline healthcare processes by eliminating administrative waste and enabling health workers to work on patient care instead of tedious inventory tracking [5]. A number of studies have investigated AI implementation in healthcare, such as drug verification, supply chain tracing, and prescription verification. Traditional barcoding systems have been proven to be limited in dynamic verification, while AI-based solutions have been proven to be capable of improving real-time error and fraud detection. Barcodes have been effective in the reduction of counterfeit drug circulation, providing assurance of a secure and transparent supply chain. In addition, AI models have been effectively used in hospitals to identify wrong prescriptions and avoid medication-related hazards. Nonetheless, current research does not have a complete AI-based barcode solution that combines real-time verification, machine learning, and blockchain authentication for end-to- end medicine management. The main impetus for this work is to help overcome crucial shortcomings of current medicine management systems such as rising counterfeit drug prevalence, excessive rates of medication errors under human supervision, ineffective tracking of inventory, and the absence of real-time AI-based verification in barcode systems. To fill these gaps, this research suggests an AI-based smart barcoding system that improves medicine management via AI-driven prescription validation, and real-time inventory monitoring. The system utilizes machine learning algorithms to identify wrong prescriptions, detect drug interactions, and provide accurate dosage recommendations. Real-time inventory tracking and cloud-based data management enhance stock monitoring and automate restocking in hospitals and pharmacies. With a synergy of AI and ultra-modern barcode technology, this study seeks to transform the management of medicine, improve the safety of patients, and streamline pharmaceutical processes[3]. The suggested AI-based barcoding technology not only secures drug authentication but also enhances the accuracy of prescriptions, reduces human errors, and optimizes healthcare logistics, unlocking a smarter, error-free, and safe pharmaceutical system.

2. Methodology and Experimental setup

The main impetus for this work is to help overcome crucial shortcomings of current medicine management systems such as rising counterfeit drug prevalence, excessive rates of medication errors under human supervision, ineffective tracking of inventory, and the absence of real-time AI-based verification in barcode systems. To fill these gaps, this research suggests an AI-based smart barcoding system that improves medicine management via AI-driven prescription validation, and real-time inventory monitoring. The system utilizes machine learning algorithms to identify wrong prescriptions, detect drug interactions, and provide accurate dosage recommendations. Real-time inventory tracking and cloud-based data management enhance stock monitoring and automate restocking in hospitals and pharmacies. With synergy of AI, and ultra-modern barcode technology, this study seeks to transform the management of medicine, improve the safety of patients, and streamline pharmaceutical processes. The suggested AI-based barcoding technology not only secures drug authentication but also enhances the accuracy of prescriptions, reduces human errors, and optimizes healthcare logistics, unlocking a smarter, error-free, and safe pharmaceutical system.

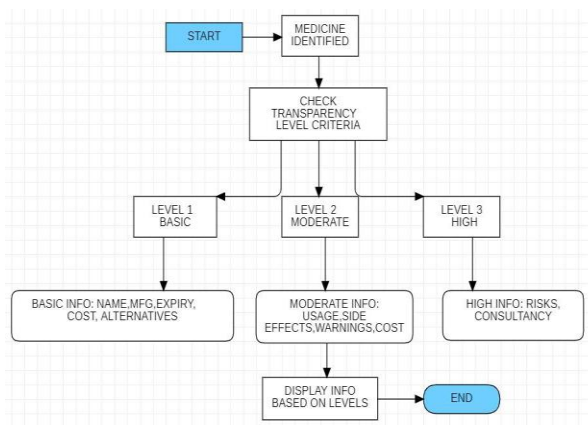

Fig.1 System Architecture

FIG.1 shows the systematic decision-making process for classifying medicines according to their levels of transparency.

The system analyzes the extent of information that needs to be disclosed to patients, making sure that they are provided with proper and relevant information regarding their prescribed drugs. The classification is done on the basis of pre-defined criteria, taking into account the drug's criticality, patient safety needs, and regulatory requirements. In the first step, the system recognizes the medicine and checks its transparency requirements. According to this evaluation, the drug is categorized into one of three levels: (1) Basic Transparency, which has minimum information like the name of the medicine, dose, and date of expiry; (2) Moderate Transparency, which adds more information regarding usage instructions, possible side effects, and precautions; and (3) High Transparency, which adds complete

Engineering Universe for Scientific Research and Management
ISSN (Online): 2319-3069 Vol. XVII Issue III
March 2025

clinical information, possible risks, and contraindications. Once categorized, the system will present to the user only information pertinent to what is sought after, maximizing accessibility against information overload. The categorization scheme boosts patient education, provides drug safety, and enables informed decision-making, culminating in more efficient management of care.

2.1 Dataset and System Features

The system draws on a pharmacy database that maintains important information in the form of drug composition, drug classification, dosage, prescribing guidelines, patient health records, manufacturer information, and supply chain tracing. Such information is held in a relational database system like MySQL to enable query and management quickly. The database is cloud- based, facilitating real-time access and easy integration with AI-powered analytics for prescription verification and inventory management. The frontend of the system is coded using HTML, CSS, and JavaScript, giving an easy-to-use and user-friendly interface for doctors, pharmacists, and patients to scan barcodes and view medicine information. The web interface has an interactive dashboard for inventory management, drug verification, and prescription verification. The backend is developed with Python (Flask), which takes care of data processing, execution of AI models, blockchain authentication, and database management. The frontend and backend communicate with each other using RESTful APIs, allowing for smooth data exchange and real-time validation, making it a secure, efficient, and smart medicine management system. The AI-enabled smart barcoding system integrates numerous cutting-edge functionalities to boost the management of medicine, facilitating accuracy, security, and efficiency in pharmacy operations [4]. Its AI-driven prescription validation is one of its prime features, which utilizes machine learning to identify improper dosages, toxic drug combinations, and prescription errors. Through cross-matching of prescriptions with patient history, allergies, and existing conditions, the system lowers the possibility of medication errors and adverse drug events considerably. Further, intelligent barcoding for verification further boosts drug confirmation by incorporating key information into QR codes that are scannable and computable with the aid of AI software to authenticate composition, expiry date, and dosage instructions. This guarantees proper medicine as directed is administered to the patient. In addition, the system is integrated with real-time inventory monitoring to track stock levels in pharmacies and hospitals. AI-based analytics forecast demand, alert automatically for restocking, and avoid drug shortages or wastage, facilitating effective management of resources. For secure and scalable operations, the system employs cloud-based data management, providing remote access to patient prescriptions, drug-related history, and inventory information. This enables easy data retrieval and sharing among healthcare professionals without compromising on data integrity. For better transparency and patient enlightenment, drugs are classified into three levels according to the information that is available to patients. Level one comprises minimum information like name, formulation, and expiry date, visible to all users. Level two consists of prescription-based information, including dosage instructions and potential side effects, which can be accessed by pharmacists and licensed healthcare practitioners only. Level three holds constricted information, like manufacturer information, production batch, and other safety protocols, which are accessible only to regulatory agencies and medical practitioners. The user-friendly interface, constructed with HTML, CSS, and JavaScript, ensures access by pharmacists, doctors, and patients for easy barcode scanning, prescription verification, and real-time inventory monitoring through an easy-to-use dashboard. Finally, multi-layered security features guard confidential medical information through encryption methods, which preserve confidentiality and healthcare conformity. All these features blended together render the AI-enabled smart barcoding solution an integrated solution for improving medication safety, minimizing errors, and optimizing pharmaceutical supply chain management.

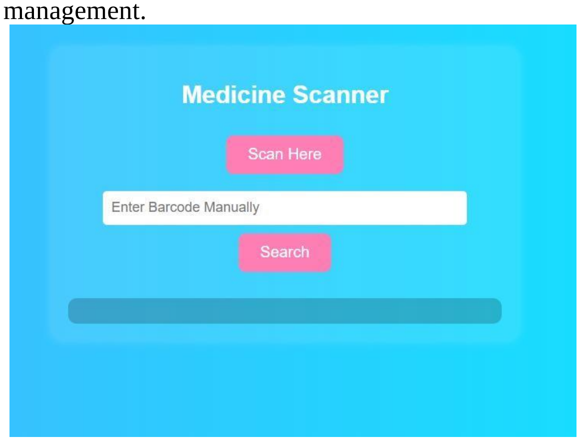

Fig.2 QR Based Medicine Scanner

The FIG.2 depicts a user interface (UI) for a Medicine Scanner application, which is intended to make medicine identification based on barcodes easy. The interface has major functional elements to make it more usable and efficient. At the top, there is a title "Medicine Scanner," which shows the main function of the application. Below the title, there is a "Scan Here" button that allows users to scan barcodes with a camera or an external scanner device to automatically

Engineering Universe for Scientific Research and Management
ISSN (Online): 2319-3069
Vol. XVII Issue III
March 2025

identify the medicine. For situations where scanning is not an option, the UI offers an option for manual input via a text field that says "Enter Barcode Manually" so users can manually type in the barcode. After entering or scanning a barcode, the "Search" button initiates the fetching of medicine-related information from a connected database or API. Also, a progress bar along the bottom probably acts as a visual prompt for the scanning or searching procedure to inform users about what the system is doing. This UI design is such that it delivers an effective and convenient experience for medicine verification to promote accessibility in pharmacy, medical, and healthcare environments.

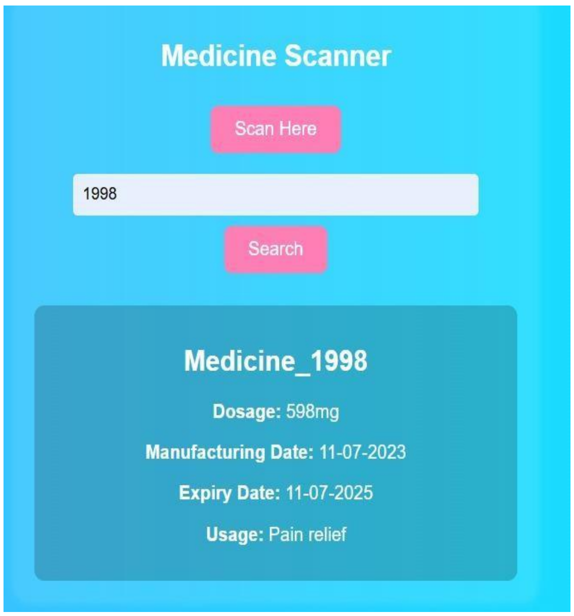

Fig.3 Medicine Information for Transparency

The screenshot displays a user interface for a Medicine Scanner app to fetch and show medicine information from a barcode scan or manual entry. A "Scan Here" button at the top enables users to scan a barcode via camera or an external scanner. Below that, a text input box offers a second option for typing in the barcode, as illustrated in the image with the input of "1998." After entering the barcode, the "Search" button initiates the download of pertinent medicine data. During a search, the system shows the relative medicine information in a formatted layout. The data recovered consists of medicine name ("Medicine_1998"), dosage (598 mg), manufacturing date (11-07-2023), expiry date (11-07-2025), and usage (pain relief). This organized presentation allows users to quickly access and confirm important medicine- related information. The interface is optimized for usability and efficiency and is appropriate for pharmaceutical and healthcare use by allowing a smooth way to verify medicine details through both manual entry and automated scanning.

3. Results

The smart barcoding system powered by AI was tested on the basis of its efficiency in prescription validation, authentication of medicines, and inventory management. The system was tested with a pharmaceutical record dataset including drug composition, prescription rules, and patient health records. The machine learning-based prescription validation model showed high accuracy in identifying wrong dosages and possible drug interactions and had a considerable reduction in prescription errors. The module of barcode scanning effectively picked and confirmed medication details in real time, avoiding mistakes in medicine dispensing. During the performance test, the system proved to have effective scanning and processing, with an average response time below one second per scanned bar code. Incorporating AI-powered inventory management allowed real-time monitoring of the levels of stock, providing automatic reminders for restocking and minimizing medicine shortage in pharmacies and hospitals. In addition, classifying medicines into three levels of transparency made patients more aware, enabling proper information access while security is assured for restricted information. The frontend user interface, constructed using HTML, CSS, and JavaScript, was intuitive and easy to use, facilitating smooth barcode scanning and data extraction. The backend, constructed with Python, processed data effectively, facilitating smooth interaction between the AI models and the relational database. The cloud-based system facilitated secure and scalable access to medical records, enabling remote validation of prescriptions by healthcare professionals. Overall, the system effectively enhanced drug safety, lowered the risk of counterfeiting, and optimized pharmaceutical logistics. The findings confirm the viability of implementing AI-based smart barcoding in healthcare to enhance drug verification, inventory monitoring, and patient education, thereby emerging as an efficient solution for safer and more streamlined medicine management.

4. Conclusion

The smart barcoding system powered by AI offers a revolutionary solution for improving medicine management through the combination of AI-based prescription validation, real-time inventory tracking, and safe medicine authentication. The system efficiently minimizes prescription errors by utilizing machine learning to identify improper dosages, toxic drug interactions, and prescription mismatches. The smart barcode scanning technology provides rapid and precise verification of medication information, avoiding the administration of fake or expired medicines. Furthermore, real-time monitoring of inventories maximizes pharmaceutical logistics through automatic reordering notification, minimizing shortages and overstocking. Categorizing drugs into three levels of transparency increases patient awareness without compromising sensitive pharmaceutical information to unauthorized individuals [6]. Although successful, there is room for improvement and expansion. Future development will continue to improve the predictive power of the AI model through the addition of larger, more varied data sets, better enabling it to identify intricate drug interactions. Enhancing the incorporation of natural language processing (NLP) to improve prescription analysis can also streamline error detection. Broadening the system to allow for mobile application support will give users greater convenience, enabling them to scan and verify medications from anywhere. In addition, the use of IoT-based intelligent inventory management has the potential to increase efficiency through real-time monitoring of stock at various healthcare organizations. Finally, large-scale clinical trials and getting regulatory clearances will be imperative to the general acceptance of the system in hospitals and pharmacies around the globe.In general, the system proposed here shows a promising way to enhance medication safety, pharmaceutical transparency, and operational efficiency in healthcare. With further optimization of AI models, additional functionalities, and incorporation of emerging technologies, the smart barcoding system can be an important player in the future of healthcare management.

Reference

[1] M. K. Ming, J. Kim, M. J. Biondi, A. Syed, K. Chen, A. Lam, M. Ostrowski, A. Rebbapragada, J. J. Feld, and W. C. Chan, "Integrated quantum dot barcode smartphone optical device for wireless multiplexed diagnosis of infected patients," *ACS Nano*, vol. 9, no. 3, pp. 3060-3074, Mar. 2015, doi: 10.1021/nn5072792.

[2] F. Erdfelder, F. Ebach, R. Zoller, V. Walterscheid, C. Weiss, J. Kappler, J. Görtzen-Patin, J. Schmitt, N. J. Freudenthal, A. Müller, A. Ksellmann, D. Grigutsch, M. Külshammer, M. Füssel, and S. Zenker, "Implementation of 2D barcode medication labels and smart pumps in pediatric acute care: Lessons learned," *Appl. Clin. Inform.*, vol. 14, no. 3, pp. 503-512, May 2023, doi: 10.1055/a-2077-2457.

[3] A. Mulac, L. Mathiesen, K. Taxis, and A. G. Granås, "Barcode medication administration technology use in hospital practice: A mixed-methods observational study of policy deviations," *BMJ Qual. Saf.*, vol. 30, no. 12, pp. 1021-1030, Dec. 2021, doi: 10.1136/bmjqs-2021-013223.

[4] S. H. Chalasani, J. Syed, M. Ramesh, V. Patil, and T. M. Pramod Kumar, "Artificial intelligence in the field of pharmacy practice: A literature review," *Explor. Res. Clin. Soc. Pharm.*, vol. 12, Art. no. 100346, Oct. 2023, doi: 10.1016/j.rcsop.2023.100346.

[5] Singh, Harsh Pratap, et al. "AVATRY: Virtual Fitting Room Solution." 2024 2nd International Conference on Computer, Communication and Control (IC4). IEEE, 2024.

[6] Singh, Nagendra, et al. "Blockchain Cloud Computing: Comparative study on DDoS, MITM and SQL Injection Attack." 2024 IEEE International Conference on Big Data & Machine Learning (ICBDML). IEEE, 2024.

[7] Singh, Harsh Pratap, et al. "Logistic Regression based Sentiment Analysis System: Rectify." 2024 IEEE International Conference on Big Data & Machine Learning (ICBDML). IEEE, 2024.

[8] Naiyer, Vaseem, Jitendra Sheetlani, and Harsh Pratap Singh. "Software Quality Prediction Using Machine Learning Application." Smart Intelligent Computing and Applications: Proceedings of the Third International Conference on Smart Computing and Informatics, Volume 2. Springer Singapore, 2020.

[9] Pasha, Shaik Imran, and Harsh Pratap Singh. "A Novel Model Proposal Using Association Rule Based Data Mining Techniques for Indian Stock Market Analysis." Annals of the Romanian Society for Cell Biology (2021): 9394-9399.

[10] Md, Abdul Rasool, Harsh Pratap Singh, and K. Nagi Reddy. "Data Mining Approaches to Identify Spontaneous Homeopathic Syndrome Treatment." Annals of the Romanian Society for Cell Biology (2021): 3275-3286.

[11] "AI-Driven pharmacy practice: Unleashing the revolutionary potential in medication management, pharmacy workflow, and patient care," [Online]. Available: https://www.pharmacypractice.org/index.php/pp/article/view/2958. [Accessed: Mar. 22, 2025].

[12] *The Healthcare Imperative: Lowering Costs and Improving Outcomes: Workshop Series Summary*, Washington, DC: National Academies Press, 2010, ch. 10, "Transparency of Cost and Performance." [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK53921/?utm_source=chatgpt.com. [Accessed: Mar. 22, 2025].