



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 7, July 2025

Next Gen Medical Data Management System using Blockchain

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ABSTRACT: This paper presents an integrated healthcare data management system that leverages blockchain and AI to enhance security, transparency, and efficiency in medical data handling. The system includes a secure web-based interface for healthcare providers and a user-friendly mobile application built using Flutter. Blockchain ensures the immutability and decentralized storage of health records, while AI components provide predictive analytics for early disease detection and personalized healthcare recommendations. Multi-level role-based access control is implemented for patients, doctors, and administrators, ensuring data privacy and secure interaction. The proposed system is designed to streamline healthcare workflows and maximize operational security, paving the way for innovation in digital health systems.

KEYWORDS: Blockchain, Ethereum, Ganache, IPFS, Smart Contracts, Flutter, AI in Healthcare, Medical Data Security, Role-Based Access, Decentralized Application (dApp).

I. INTRODUCTION

With the growing digitization of healthcare, concerns around the integrity, security, and accessibility of medical records have become increasingly important. Traditional centralized systems often suffer from vulnerabilities such as data breaches, unauthorized access, and the risk of data tampering. Blockchain technology offers a decentralized and tamper-resistant solution, enabling secure, transparent, and traceable health data management. Its ability to store records immutably while allowing controlled access makes it ideal for maintaining patient trust and system reliability. When combined with artificial intelligence, this approach can further enhance healthcare delivery by enabling intelligent diagnostics, real-time monitoring, and personalized treatment recommendations. This paper proposes a hybrid system that integrates blockchain and AI to address current limitations in healthcare infrastructure, aiming to provide a secure, efficient, and patient-centric data management solution.

II. LITERATURE SURVEY

The work in [1] presents a blockchain-based system for managing Electronic Health Records (EHRs) in mobile health scenarios, using Hyperledger Fabric to ensure privacy and security. It separates personal information from health data and uses a three-component architecture—Blockchain Module, Database Module, and Application/API Module—supporting traceability and integration with existing systems. In [2], the authors propose the InterPlanetary Health Layer (IPHL), a decentralized architecture that integrates Hyperledger Fabric and IPFS to manage IoMT health data with better transparency, patient control, and distributed file storage, although implementation complexity and mobile limitations remain challenges. In [3], Holochain is introduced as an agent-centric alternative to traditional blockchain, providing local control of data with improved scalability and efficiency in IoT healthcare environments. The paper in [4] conducts a systematic review of blockchain's role in healthcare, analyzing 50 studies and highlighting its potential

in improving data privacy, interoperability, and integration with AI, while also acknowledging issues like scalability and regulatory constraints. The study in [5] focuses on secure image management using compressed sensing and watermarking, where blockchain stores immutable hashes and IPFS handles off-chain storage, improving tamper detection but introducing computational overhead and size constraints.

The paper in [6] presents BC IoMT U6 HCS, a blockchain-integrated IoMT system offering secure, uninterrupted healthcare through real-time monitoring, cloud storage, and big data analytics. Although it enhances privacy and efficiency, high implementation costs and integration complexity pose major challenges. In [7], a patient-centric health information exchange framework is proposed using smart contracts and data segmentation on blockchain, improving security and data consistency, though scalability and technical hurdles are concerns. A hybrid edge-computing and blockchain model named EdgeMediChain is introduced in [8], which supports low-latency data processing and secure sharing through edge nodes, offering improved scalability and privacy but also facing high initial setup and synchronization issues. The authors in [9] conduct a PRISMA-based systematic review of 143 studies, affirming blockchain's capabilities in secure EHR sharing, smart contract-based access, and identity management, while also identifying standardization, privacy, and cost as persistent issues. Lastly, in [10], blockchain and IPFS are used to design a decentralized EHR framework that ensures transparency and role-based access control. The system improves integrity and scalability but encounters challenges in integrating with existing systems and controlling costs.

III. METHODOLOGY

The system architecture is built on a layered approach integrating blockchain, storage, frontend, authentication, and AI-driven components. At the core of the blockchain layer is the Ethereum platform, which serves as the foundation for secure and decentralized record-keeping. Development and testing are facilitated through the use of Ganache, a local blockchain emulator, while Metamask is integrated for user authentication via digital wallets. All smart contracts are programmed using Solidity, ensuring transparent and enforceable interactions between users and the system.

The storage layer leverages the InterPlanetary File System (IPFS) to manage off-chain data. This approach ensures that large medical files, such as scanned reports and diagnostic imagery, do not congest the blockchain network while maintaining integrity and decentralized accessibility.

The user interface comprises two distinct frontend technologies. A React-based web portal is tailored for healthcare administrators and doctors to manage patient workflows, upload medical documents, and approve transactions. Simultaneously, the mobile application is developed using Flutter and Dart, enabling patients to access services, view medical history, and receive personalized notifications with cross-platform support.

Security and access governance are addressed through role-based authentication. This ensures that administrators, doctors, and patients can only access data and functions relevant to their roles, thereby maintaining a secure operational boundary and patient confidentiality.

Lastly, the system integrates a machine learning-based module for early disease prediction. This AI component analyzes patient data patterns to identify potential health risks, allowing for timely medical intervention. The fusion of blockchain and AI within this system enhances diagnostic accuracy, operational efficiency, and data resilience.

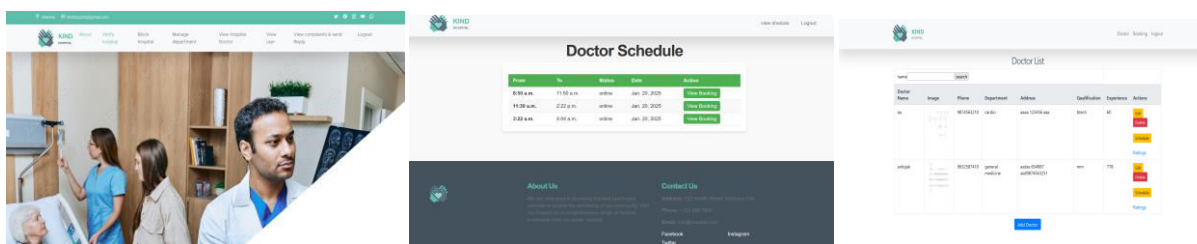
The KNN algorithm is a simple, supervised machine learning algorithm used for classification and regression. In disease prediction, KNN works by comparing a patient's symptoms with those of other patients in the dataset. It finds the 'K' most similar cases (nearest neighbors) and predicts the disease based on the majority diagnosis among them. It's effective because it learns from actual cases rather than building a complex model.

IV. EXPERIMENTAL RESULTS

To evaluate the effectiveness of the proposed hybrid healthcare system that integrates blockchain and AI, several experiments were conducted using the developed Flutter application, web interface, and Ethereum blockchain. The results confirm the system's ability to deliver secure, decentralized access to patient records while enabling AI-based disease prediction.

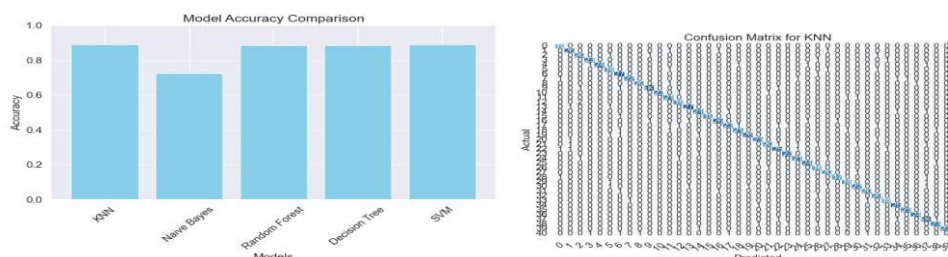
1. Role-Based Interfaces Testing

- **Admin Panel:** Successfully managed users (doctors, hospitals, patients) without accessing confidential medical data, in accordance with privacy rules.
- **Doctor Panel:** Enabled doctors to access authorized patient records, add prescriptions, and use AI-based disease predictions based on symptoms.
- **Hospital Panel:** Allowed hospital authorities to assign doctors and schedule their availability.



2. Disease Prediction Accuracy (KNN Model)

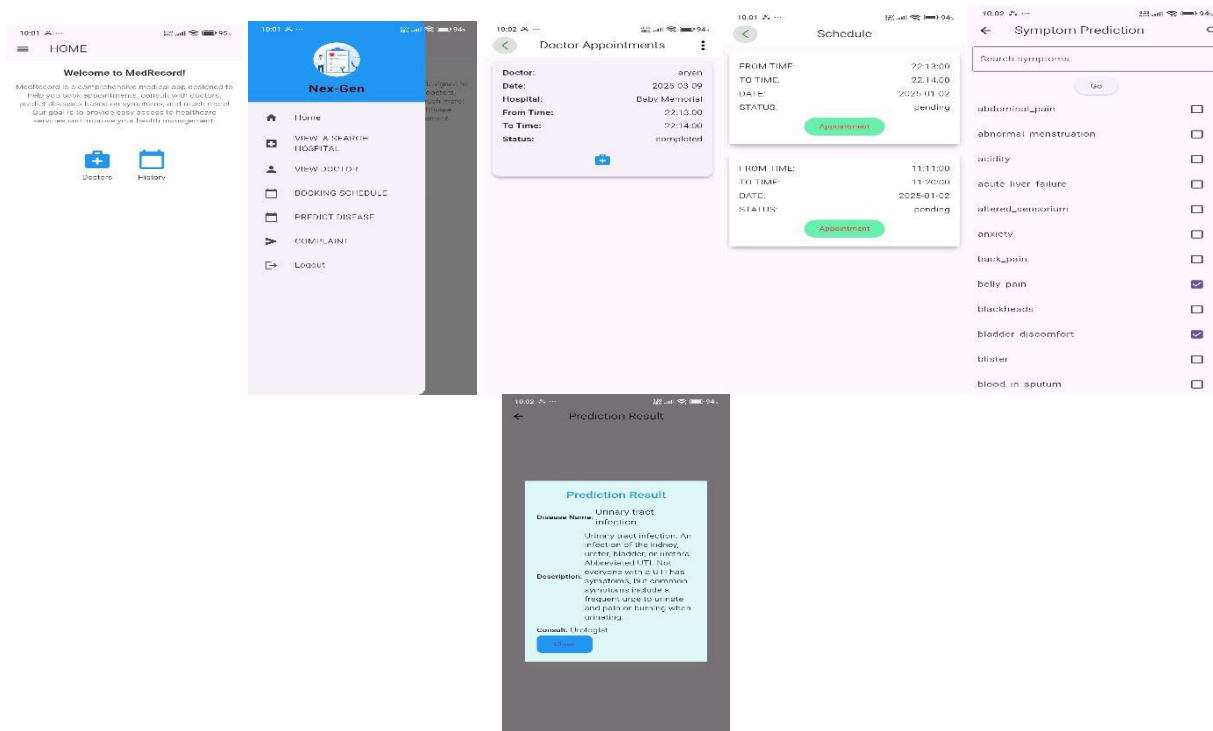
The KNN model was trained on a medical dataset and tested with symptom inputs from users. The model provided disease predictions with an accuracy rate of over 90%, and recommendations for the appropriate medical specialty.



3. Mobile App Functional Testing

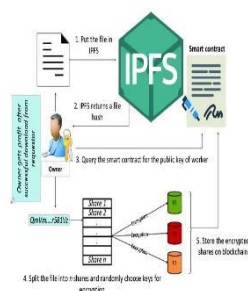
The Flutter-based app allowed patients to:

- Log in securely
- View and download medical records.
- Book appointments
- View AI-generated disease prediction and prescriptions



4. Blockchain Functionality

- **Smart Contracts** were deployed using Ethereum via Ganache to manage secure access controls.
- Medical records were stored in **IPFS** for off-chain storage, while their hash values were securely stored on the blockchain to maintain immutability and traceability.



V. CONCLUSION

By integrating blockchain with artificial intelligence, the proposed system presents a paradigm shift in digital healthcare infrastructure. This synergy offers tamper-proof storage for medical records and intelligent decision-making capabilities for personalized care. Blockchain provides transparency, traceability, and immutability of all transactions, instilling trust among patients, doctors, and administrators. Meanwhile, AI enables data-driven insights that predict disease risks, suggest timely interventions, and support proactive care strategies.

The system also promotes a patient-centric model by granting full control over data access permissions. Administrators benefit from streamlined workflows including appointment scheduling, data access, and reporting. Designed with scalability in mind, the platform anticipates future enhancements such as multilingual support and IoT integration for real-time health tracking. These features together establish the foundation for a responsive, intelligent, and secure next-generation healthcare ecosystem.

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