Blockchain and AI-Powered Healthcare Management System

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***Abstract*— The proposed Blockchain and AI Powered Healthcare Management System is a lightweight, end-to-end decentralized platform designed to enhance trust, security, and intelligence in healthcare data processing. It integrates blockchain-based medical record storage with advanced artificial intelligence to enable secure data access, patient-controlled authorization, and identity verification through a React frontend connected via MetaMask and Web3. Smart contracts implemented in Solidity ensure immutable record handling, access control, and auditability, while AI models trained on medical datasets provide automated disease prediction, report analysis, and clinical decision support. By leveraging decentralized storage and blockchain validation instead of traditional databases, the system preserves data ownership, reduces centralized dependency, and improves medical decision-making through automated diagnosis support, serving as a comprehensive technical reference for blockchain-integrated and AI-driven healthcare systems.**

***Index Terms*— Web3 Integration, Decentralised Storage, Clinical Decision Support, Blockchain, Healthcare Record Management, Smart Contracts, AI-Based Diagnosis, Machine Learning, Medical Automation, React, MetaMask, Interoperability, and Prototype Architecture.**

I. INTRODUCTION

Blockchain technology has evolved from its origins in cryptocurrency into a scalable and secure distributed infrastructure capable of transforming data-centric industries. At the same time, Artificial Intelligence (AI) has demonstrated powerful capabilities in automating medical analysis, supporting evidence-based decision-making, and extracting insights from clinical data. Despite these advancements, the healthcare sector continues to face major challenges, including fragmented record systems, lack of interoperability, limited patient control, and increasing cybersecurity risks associated with centralized electronic health record (EHR) systems.

To address these challenges, this work proposes a decentralized Blockchain and AI Powered Healthcare Management System designed to securely manage medical records, automate authorization, and enhance clinical decision-making. The system integrates a React-based frontend with blockchain technologies such as MetaMask and Web3 to enable secure identity verification and fine-grained access control. A Solidity-based smart contract ensures data integrity and permissioned access using an immutable ledger, while an AI module analyzes medical reports, predicts disease trends, and generates clinical decision support to assist healthcare professionals.

The primary objective of this system is to serve as a functional prototype that demonstrates the effective integration of decentralized storage, smart contracts, and machine intelligence for next-generation healthcare solutions. By minimizing external dependencies and maintaining full operational capability, the platform enables repeatable experimentation, reliable performance evaluation, and future scalability. Through real-time access control, tamper-proof data handling, and automated medical analysis, the system provides a practical reference model for researchers and developers exploring secure, intelligent, and patient-centric healthcare ecosystems, while laying the foundation for real-world deployment and further technological enhancements.

II. METHODOLOGY

A. System Overview

The Blockchain and AI Powered Healthcare Management System is a decentralized platform designed to securely manage, share, and analyze medical data while preserving patient ownership and privacy. The system consists of a React-based frontend integrated with Web3 technologies for secure user authentication and interaction with the blockchain network. Smart contracts implemented in Solidity manage access control, consent enforcement, and audit logging using an immutable ledger. Medical records are stored using decentralized or hybrid storage mechanisms, with cryptographic hash references maintained on-chain to ensure data integrity. An integrated AI module processes uploaded medical reports and clinical data to generate diagnostic insights, disease predictions, and decision-support outputs, enabling secure, transparent, and intelligent healthcare data management.

B. System Architecture

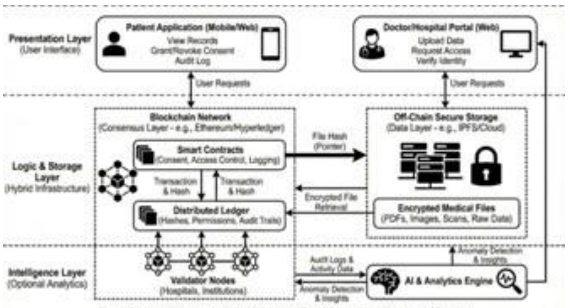

Fig. 1. Proposed Blockchain-Based Healthcare Data Management System Architecture

Figure 1 illustrates the overall architecture of the Blockchain and AI Powered Healthcare Management System, showing how its components interact to ensure secure medical data management and intelligent processing. Patients, doctors, and insurers access the system through a decentralized web application where they authenticate using blockchain-based identity verification before uploading, viewing, or sharing medical records. The React-based frontend integrates with Web3 libraries to communicate securely with the blockchain through user wallets. Uploaded medical data, including reports, prescriptions, and diagnostic images, is processed by the backend AI layer using machine learning and natural language processing techniques to extract meaningful insights, generate summaries, and support predictive analysis. Medical files are stored using decentralized or hybrid storage mechanisms, while cryptographic hash values are recorded on the blockchain to ensure data integrity and prevent unauthorized modification. Smart contracts manage role-based access control, consent enforcement, and transaction logging, ensuring that only authorized entities can interact with specific data. All critical operations, such as authentication, access requests, and permission updates, are permanently recorded on the blockchain network, providing transparency and auditability. The final outputs, including verified medical records, transaction histories, and AI-generated insights, are securely displayed through the user interface for authorized users.

C. Data Collection and Preprocessing

The data used in the Blockchain and AI Powered Healthcare Management System is collected from user-uploaded medical records, including clinical reports, prescriptions, laboratory results, and diagnostic documents. These records are obtained through the decentralized frontend after secure blockchain-based authentication and user consent. During preprocessing, raw medical data is cleaned to remove inconsistencies, noise, and redundant information, while sensitive identifiers are protected through anonymization techniques. Text-based records undergo natural language processing steps such as tokenization, normalization, and feature extraction, whereas structured data is standardized for compatibility with machine learning models. All processed data is validated before AI analysis, with cryptographic hash generation ensuring data integrity and traceability across the blockchain network.

D. Image Segmentation

Image segmentation is employed to extract clinically relevant regions from medical images such as X-rays, CT scans, MRI images, and scanned diagnostic reports. Before segmentation, images undergo preprocessing steps including noise reduction, contrast enhancement, and normalization to improve visual quality and segmentation accuracy. Machine learning and deep learning–based segmentation techniques are then applied to identify anatomical structures, abnormalities, or regions of interest by separating foreground medical features from background noise.

The segmented outputs enable more precise and reliable feature extraction by isolating clinically significant regions from irrelevant background information, thereby improving the accuracy and performance of downstream diagnostic and predictive models. By focusing analysis on welldefined anatomical structures and abnormal regions, the system enhances the quality of medical insights generated by machine learning algorithms. To ensure reliability and security, the segmentation results are associated with cryptographic hash values and securely recorded through the blockchain layer. This mechanism preserves data integrity, prevents unauthorized modification, and enables end-to-end traceability of medical images and their analytical outcomes within the healthcare management system.

E. Feature Extraction and Selection

Feature extraction transforms preprocessed medical data into structured representations suitable for machine learning analysis. In the proposed system, relevant features are derived from clinical text, medical images, and structured health records using natural language processing, image analysis, and statistical techniques. Text-based features include medical terms, symptoms, and contextual indicators extracted through tokenization and embedding methods, while image-based features capture anatomical structures, texture patterns, and abnormal regions identified during image segmentation. These extracted features provide a compact and informative representation of medical data for downstream diagnostic and predictive modeling.

Feature selection is applied to identify the most relevant and discriminative features while eliminating redundant or irrelevant information. By reducing feature dimensionality, the system improves computational efficiency, minimizes overfitting, and enhances model generalization. Techniques such as correlation analysis, statistical ranking, and model-based selection are used to retain features that contribute most significantly to diagnostic accuracy. This selective process ensures efficient AI-driven analysis while maintaining reliable and interpretable clinical decision support within the healthcare management system..

F. Models Workflow

The model workflow begins with secure user authentication through a blockchain-enabled wallet, after which patients upload medical data such as reports, images, or prescriptions via the decentralized frontend. The uploaded data undergoes preprocessing, including noise removal, normalization, and anonymization, followed by image segmentation or text parsing depending on the data type. Relevant features are then extracted and selected to form structured inputs for machine learning models. Throughout this process, cryptographic hash values are generated and recorded on the blockchain to ensure dataintegrity and traceability.

In the subsequent stage, the processed features are fed into trained machine learning and deep learning models for diagnostic analysis and prediction. The models generate outputs such as disease probability scores, clinical summaries, and risk assessments, which are validated and securely stored or referenced through smart contracts. Authorized healthcare professionals can access these results through role-based permissions enforced by the blockchain. This end-to-end workflow ensures secure data handling, transparent access control, and reliable AI-driven clinical decision support within the healthcare management system..

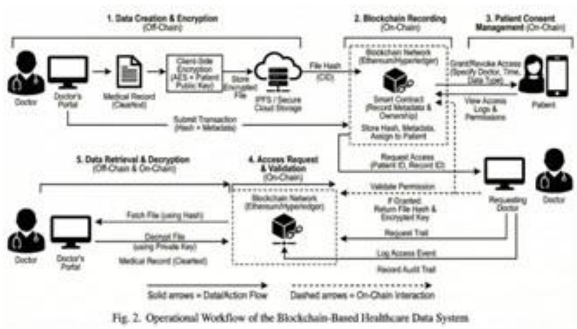

Fig.2.The end-to-end workflow of the Blockchain and AI Powered Healthcare Management System.

This diagram illustrates the end-to-end workflow of the Blockchain and AI Powered Healthcare Management System, highlighting the secure flow of medical data and intelligent processing stages. The workflow begins with blockchain-based user authentication, followed by the upload of medical records through the decentralized frontend. The data is preprocessed and analyzed by the AI module to generate diagnostic insights, while cryptographic hashes are stored on the blockchain to ensure data integrity and immutability. Smart contracts enforce role-based access control and consent management, allowing only authorized entities to access the records. Finally, verified medical data, transaction histories, and AI-generated results are presented to authorized users, ensuring transparency, security, and efficient healthcare decision support.

G. Model Evaluation

Model evaluation is conducted to assess the accuracy, reliability, and robustness of the machine learning models used in the healthcare management system. The trained models are evaluated using standard performance metrics such as accuracy, precision, recall, F1-score, and area under the ROC curve, depending on the diagnostic task. Validation is performed on unseen test data to measure generalization performance and reduce overfitting. Additionally, consistency checks are applied to ensure stable outputs across different data samples. The evaluation results help refine model parameters and ensure that AI-generated predictions provide reliable clinical decision support within the blockchain-integrated healthcare framework..

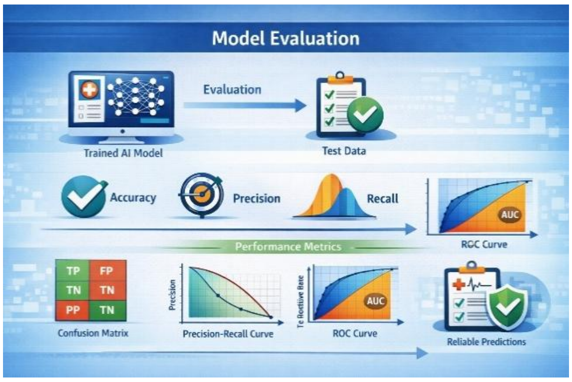

Fig. 3 The figure presents the model evaluation workflow, highlighting the use of test data and performance metrics such as accuracy, precision, recall, and AUC-ROC to assess prediction reliability.

III. MATH

The proposed system evaluates the performance of the trained machine learning model using standard classification metrics derived from the confusion matrix. Let the evaluation dataset consist of labeled samples used to assess the predictive capability of the model.

Let:

- TP denote the number of true positive predictions
- TN denote the number of true negative predictions
- FP denote the number of false positive predictions
- FN denote the number of false negative predictions

The accuracy of the model, which measures overall correctness, is defined as:

$$Accuracy = (TP + TN) / (TP + TN + FP + FN)$$

$$Precision = TP / (TP + FP)$$

$$Recall = TP / (TP + FN)$$

The performance of the proposed model is evaluated using standard classification metrics derived from the confusion matrix. Accuracy measures the overall correctness of predictions, precision indicates the reliability of positive classifications, and recall reflects the model's ability to identify relevant cases. These metrics collectively provide an effective assessment of the model's diagnostic reliability and predictive performance within the healthcare managementsystem.

The model performance is assessed using basic classification metrics to evaluate prediction accuracy and reliability. These measures help determine the effectiveness of the system in generating consistent and trustworthy diagnostic outcomes.

IV. RESULTS

Fig. 3. Dashboard view of the Blockchain and AI Powered Healthcare Management System.

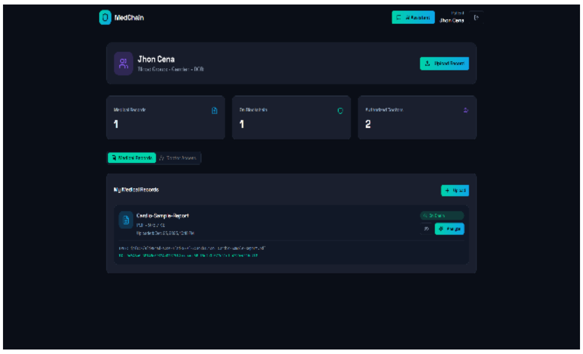

Fig. 4. User interface for the doctor dashboard in the proposed system.

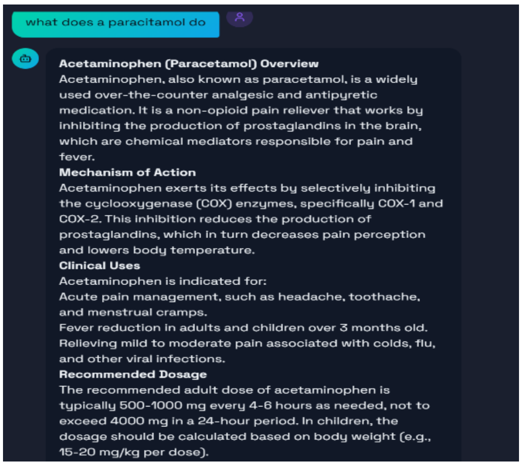

Fig. 5. User interface for the AI assistant in the proposed system.

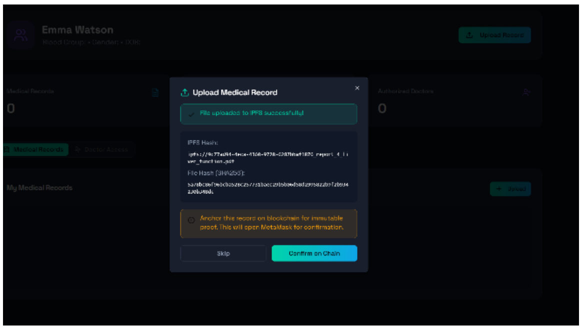

Fig. 6. User interface for media upload in the proposed system.

V. CONCLUSION

The Blockchain and AI Powered Healthcare Management System presented in this work demonstrates an effective integration of decentralized blockchain infrastructure with artificial intelligence to securely manage and analyze medical data. The system ensures data integrity, transparency, and patient-controlled access through smart contracts and immutable ledger storage, while the AI module enhances clinical workflows by providing automated diagnostic predictions and decision-support insights. The successful implementation validates the feasibility of combining blockchain security with AI-driven healthcare intelligence in a unified framework.

Although developed as a prototype, the proposed system establishes a strong foundation for future advancements in intelligent healthcare platforms. It can be extended to support large-scale deployment through consortium or Layer-2 blockchain networks, integration with IoT-based health monitoring devices, and adoption of advanced deep learning models for improved diagnostic accuracy. Overall, the system offers a scalable, secure, and patient-centric reference model for next-generation healthcare data management and automation.

VI. ACKNOWLEDGMENT

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