

# Trusty Record - Decentralized Medical Record Management System using Blockchain and Artificial Intelligence

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**Abstract-** Increasing demand for secure, accessible, and patient-controlled healthcare data systems has exposed the limitations of traditional centralized electronic health record (EHR) platforms. These systems often suffer from data breaches, limited interoperability, and a lack of transparency, leaving patients with minimal control over their personal medical information. This paper presents TrustyRecord, a decentralized medical record management system that leverages blockchain technology and artificial intelligence (AI) to overcome these challenges. Ethereum-based smart contracts are used to manage access control, ensuring transparency and immutability, while Interplanetary File System (IPFS) enables tamper-proof, distributed storage of sensitive medical data. Additionally, a machine learning model trained on real-world clinical data performs predictive analysis, providing patients with early warnings of heart risk based on extracted health indicators. The system integrates Optical Character Recognition (OCR) technology to process unstructured medical files and convert them into structured data for analysis. TrustyRecord offers a secure, scalable, and intelligent approach to health data management, enhancing both patient empowerment and proactive healthcare delivery.

**Keywords—** Blockchain, Artificial Intelligence, Electronic Health Records, Smart Contracts, Decentralized Storage, Predictive Healthcare, IPFS, OCR, Ethereum, Patient Data Privacy

## I. INTRODUCTION

The rapid evolution of the healthcare environment has intensified the need for secure, efficient, and patient-centric medical record management systems. Traditional methods, such as paper-based records and electronic health records, are increasingly vulnerable to cyberattacks and face challenges related to data sharing inefficiencies. Addressing these issues, the TrustyRecord system proposes an innovative decentralized solution that leverages blockchain technology and artificial intelligence.

The primary aim of this research is to develop a decentralized and secure medical record management system leveraging blockchain technology, alongside an AI component that predicts potential future health outcomes

from a patient's medical records. To achieve this, the study investigates current medical record systems and identifies limitations in terms of security, accessibility, and interoperability. The system incorporates blockchain-based encryption and access control mechanisms to enhance privacy and data ownership. Furthermore, an artificial intelligence model is developed to analyse patient data and provide predictive insights into possible health risks. The usability and effectiveness of the application are evaluated through user interactions with both patients and healthcare professionals.

This system provides a secure platform where patients can manage and share their medical records with authorized healthcare providers. The integration of blockchain ensures data immutability and transparency, while smart contracts facilitate automated and secure access controls. Additionally, AI-powered predictive analytics enable early detection of health risks, such as heart disease, based on uploaded medical reports and health indicators.

The development of TrustyRecord involves various modern technologies, including Ethereum smart contracts, IPFS for decentralized storage, OCR for automated data extraction, and a user-friendly web interface built with React.js. The system is designed to modernize health data management, improve interoperability, and empower patients with full control over their medical information, ultimately contributing to a more secure, accessible, and efficient healthcare ecosystem.

## II. LITERATURE REVIEW

The integration of blockchain and artificial intelligence (AI) in healthcare has emerged as a solution to long-standing challenges in medical record management. Traditional Electronic Health Record (EHR) systems, often centralized, suffer from data breaches, limited interoperability, and restricted patient control over personal health information. Studies have shown that centralized systems are more vulnerable to unauthorized access and cyberattacks, resulting in a lack of trust and data privacy concerns among users [1],[2].

Blockchain offers a tamper-proof, transparent architecture that ensures data immutability and decentralized access control. By allowing patients to own and share their medical records securely, blockchain shifts the power from institutions to individuals. According to Kaur et al. [3], decentralized record-keeping enhances auditability and reduces fraudulent activity. Furthermore, storing metadata (such as content identifiers) on-chain while keeping actual data in decentralized file systems like IPFS optimizes performance and cost-efficiency.

On the AI front, machine learning models have revolutionized healthcare by enabling predictive analytics for chronic diseases such as heart disease and diabetes. AI models, when trained with clinical datasets, can identify at-risk patients with high accuracy and provide timely, personalized insights [4],[5]. This reduces the dependency on manual diagnostics and enables proactive care. Rong et al. [6] emphasize that integrating AI into health systems improves early diagnosis and decision-making, especially in resource-limited settings.

Several commercial and academic systems have attempted to address individual parts of this problem. MedRec: M uses blockchain for secure document exchange but lacks predictive capabilities. Epic Systems offers centralized EHR management but limits patient ownership. Ada Health provides AI-based symptom analysis but does not integrate decentralized storage or access control [7],[8],[9]. This highlights a clear gap: the need for a unified platform that combines secure, decentralized storage with intelligent, real-time health predictions.

TrustyRecord aims to bridge this gap by leveraging Ethereum smart contracts for access control, IPFS for decentralized storage, and AI for disease prediction, providing a secure, patient-centric, and intelligent medical record management system.

Even though many systems have been developed for electronic health record management, they still have issues with data security, patient access control, and a lack of an AI prediction system. The reason is that most of these systems are centralized. So, these systems are more prone to cyberattacks. Even though they use blockchain, they mostly do not use it effectively. This creates a gap for a system that provides secure, decentralized storage with AI technology for Predictive analysis. The following **Error! Reference source not found.** Show the difference between the current systems and the proposed system.

TABLE III. RESEARCH GAP

Features	Existing Systems			Proposed system
	Medrec: M	Epic Systems	Ada Health	
Decentralized	Yes	No	No	Yes
Predictive AI	No	Limited	Yes	Yes
Interoperability	Limited	Yes	No	Yes

Expense	Free	Expensive	Subscription	Cost effective
Record Ownership	Patients	Healthcare Providers	Shared	Patients

### III. METHODOLOGY

This research adopts an Agile development methodology due to the evolving requirements and complex integration of decentralized systems and artificial intelligence. The iterative nature of Agile allowed for flexible planning, regular feedback, and continuous improvement across development sprints.

#### A. System Architecture

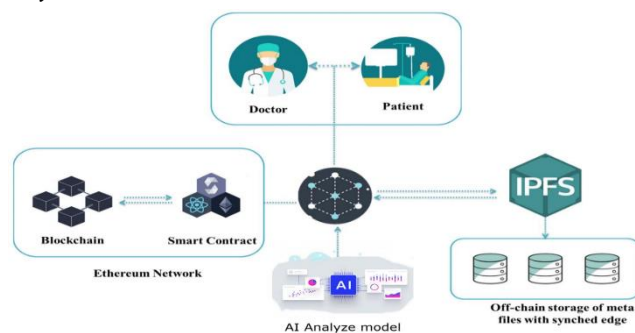


Fig. 1. System Architecture

The system architecture integrates three main components: the frontend web interface, the backend AI engine, and the blockchain access control layer. The frontend, built with React.js, enables user interaction for uploading records, granting permissions, and receiving AI predictions. The backend, powered by Python and Flask, manages Optical Character Recognition (OCR) and predictive analysis. Blockchain integration uses Ethereum smart contracts to handle decentralized access control and record tracking.

#### B. Decentralized Storage and Access Control

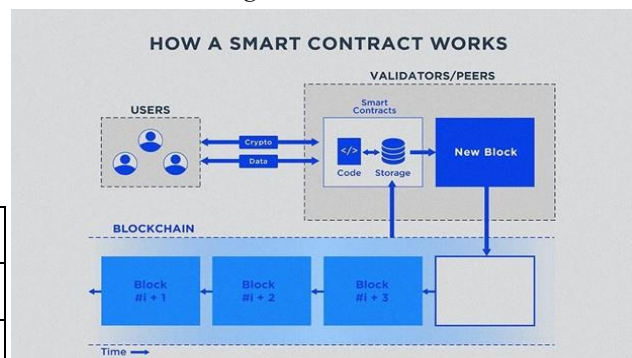


Fig. 2. Blockchain Access Control Mechanism

Medical records uploaded by users are encrypted and stored on the Interplanetary File System (IPFS). Each file is assigned a unique Content Identifier (CID), which is stored on the Ethereum blockchain via smart contracts. These contracts manage role-based permissions, allowing patients to grant and revoke access to doctors. MetaMask is used to sign transactions securely within the browser, ensuring that control remains fully with the user.

### C. Smart Contract Implementation

Smart contracts are written in Solidity and deployed locally using Ganache for development and Truffle for migration. The contracts handle CID registration, permission granting, and access revocation. Every transaction is logged immutably on the blockchain to maintain a verifiable audit trail of record activity. Only users with a valid wallet address and authorization can access the records.

### D. OCR and Feature Extraction

OCR is implemented using Tesseract and PyMuPDF to extract structured data (e.g., cholesterol, glucose, age) from uploaded PDFs or images. A custom mapping logic uses regular expressions and keyword matching to identify relevant health metrics, which are then pre-processed for the AI model.

### E. AI Model for Predictive Analysis

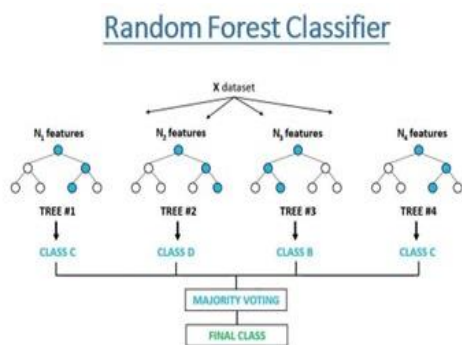


Fig. 3. Random Forest Classifier

The system uses a Random Forest Classifier trained on the Framingham Heart Study dataset to predict the risk of heart disease within the next ten years. The model processes inputs such as cholesterol levels, blood pressure, smoking habits, and glucose readings. The AI engine returns a risk classification (low, moderate, or high) in real-time, providing instant feedback to users.

### F. Technology stack

- **Frontend:** React.js, Web3.js, MetaMask

- **Backend:** Python, Flask, Tesseract OCR, Scikit-learn
- **Blockchain:** Ethereum, Solidity, IPFS, Truffle, Ganache
- **AI Model:** Random Forest with performance-tuned hyperparameters

This modular architecture ensures a scalable, secure, and user-centric medical record system that combines privacy-preserving blockchain access with intelligent health forecasting.

## IV. SYSTEM DESIGN AND IMPLEMENTATION

The implementation of the TrustyRecord system combines decentralized blockchain storage, AI-driven predictive analysis, and a user-friendly web interface. The frontend is developed using React.js, enabling patients and doctors to interact with the system, including functionalities such as uploading medical records, viewing AI predictions, and managing access rights. Web3.js is used to interface with the Ethereum blockchain, and MetaMask facilitates secure transaction signing directly from the browser.

The backend is implemented in Python using the Flask framework to handle server-side processing for OCR and AI analysis. Uploaded medical documents, either in PDF or image formats, are processed using PyMuPDF and Tesseract OCR to extract structured health data such as glucose levels, cholesterol, age, and gender. A rule-based mapping engine ensures accurate extraction of medical features, which are then passed to a trained Random Forest Classifier.

For storage, encrypted files are uploaded to the Interplanetary File System (IPFS), a peer-to-peer decentralized storage protocol. The resulting Content Identifier (CID) is stored on the Ethereum blockchain through smart contracts written in Solidity. These contracts control access permissions, allowing patients to grant or revoke access to doctors. Ganache is used for local blockchain simulation, while Truffle manages smart contract compilation and deployment.

The Random Forest Classifier is trained on the Framingham Heart Study dataset and fine-tuned using Scikit-learn. It classifies patients into low, moderate, or high-risk categories for heart disease within the next ten years. The AI model processes input either automatically from OCR or manually via form fields, and predictions are returned in real-time. This tightly integrated architecture ensures secure data storage, verifiable access control, and immediate health insights, making TrustyRecord a robust solution for decentralized medical record management.

## V. RESULTS AND EVALUATION

### A. Prediction Performance of the AI Model

The effectiveness of the AI component within TrustyRecord was evaluated using a Random Forest

classifier trained using the Framingham Heart Study dataset. The target variable was the 10-year risk of coronary heart disease. Records with missing values were excluded during the preprocessing stage. The dataset was pre-processed to remove missing values and then split into 80% training and 20% validation subsets.

To address class imbalance, balanced class weights were applied during model training. The model's evaluation metrics on the validation set are summarized in the Table IV. These results indicate strong predictive performance, with a particularly high recall value, which is critical for minimizing false negatives in medical diagnosis applications.

TABLE IV. AI EVALUATION MATRICS

Metric	Value
Accuracy	88.53%
Precision	87.31%
Recall	89.19%
F1-Score	88.24%
ROC-AUC	0.9563

Fig. 4 Illustrates the confusion matrix of the trained classifier, highlighting its performance in distinguishing between patients at risk and not at risk of coronary heart disease.

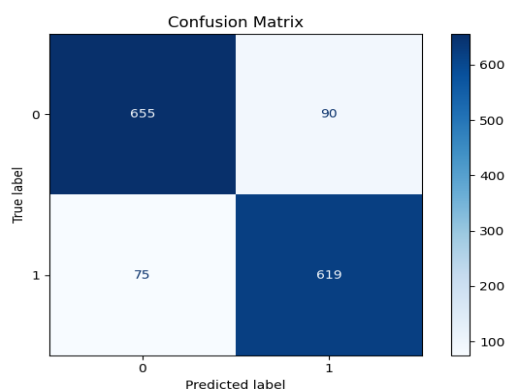


Fig. 4. Confusion matrix

The model achieved a high ROC-AUC score of 0.9563, indicating strong discriminative capability between positive and negative classes. The corresponding ROC curve is presented in

Fig. 5.

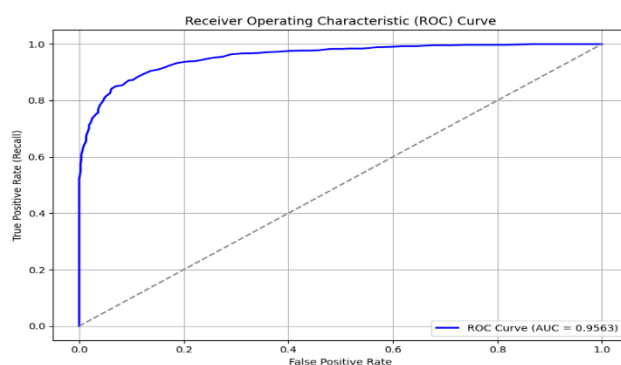


Fig. 5. ROC curve

### B. Blockchain Evaluation

To evaluate the blockchain component, smart contracts were deployed and tested on Ganache, a local Ethereum test network. Performance metrics are summarized in Table V. Demonstrate low gas costs and latency, with 100% success in access control. These results indicate that the blockchain layer is efficient in a controlled environment. Scalability and performance on public networks remain areas for future investigation.

TABLE V. BLOCKCHAIN PERFORMANCE MATRICS

Metric	Value
Average Gas Cost (record upload)	43700 gas
Average Gas Cost (access grant)	39200 gas
Transaction latency(avg)	3 seconds
Contract Deployment Time	6 seconds
Access Control Logic Success Rate	100%

### C. Usability Evaluation

Due to the system not being hosted online, usability testing was conducted in person. Two doctors and nineteen patients were surveyed via a structured Google Form to assess system usability, performance, and trust.

Doctor feedback was fully positive. Both participants rated usability as high (4 or 5), found the interface intuitive and fast, and confirmed ease in viewing records. Both described the design as clear; one expressed full trust in data privacy, the other partial.

Patient responses showed similar trends. Over 68% rated usability positively (scores 4 or 5), with the rest indicating a neutral experience (score 3). Only 15.8% reported any issues. Regarding data safety, 84.2% felt their information was secure, with a few expressing uncertainties.

Trust in decentralized storage (IPFS) was generally strong. 63.2% were fully confident, while others showed partial trust. Most users (78.3%) are comfortable uploading medical records. Additionally, 94.7% found it easy to upload and view records. The same percentage considered

the AI predictions helpful. Overall, 89.5% would recommend the system.

These results collectively indicate that the system achieved a high level of usability, performance satisfaction, and user trust among both doctors and patients.

## VI. CONCLUSION AND FUTURE WORK

### A. Conclusion

TrustyRecord addresses key limitations of current Electronic Health Record (EHR) systems through its novel decentralized design, using blockchain and AI. It uses Ethereum smart contracts and IPFS for secure medical data storage and patient-controlled access, eliminating central points of failure and reducing data breach risks. All record access permissions are immutably logged in the blockchain, ensuring that transparency and accountability are often absent in traditional systems. The integrated AI feature proactively assesses heart disease risk in real-time, supporting early detection and care.

TrustyRecord was built using tools like React.js, Flask, Solidity, and Tesseract OCR, and improved step by step using the Agile method. Tests showed that people found the system easy to use, even if they didn't have technical skills. This project shows how blockchain and AI can work together to create safer, more user-friendly digital health systems.

### B. Future Work

While the current version of TrustyRecord is functional and has passed internal validation, several areas remain open for future development and research:

- **Multi-disease Prediction Models:** Extend the AI engine to support predictive analysis for additional conditions such as diabetes, stroke risk, or liver disease using larger and more diverse datasets.
- **Real-World Deployment:** Deploy the system on a public Ethereum testnet or mainnet to assess transaction costs, latency, and smart contract performance under live conditions.
- **Mobile Application:** Develop a lightweight mobile app for Android and iOS to enhance accessibility for patients in low-resource settings or remote areas.

By evolving TrustyRecord beyond its current scope, the project has the potential to become a foundational tool in the emerging era of decentralized digital health infrastructure. Ecosystems.

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