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Designing a Health Information Portal Focused on Patient-Centric Data Access and Management

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Abstract

Healthcare systems often limit patient access to their health data, hindering informed decision-making and care continuity. This study proposes a patient-centric health information portal using secure database management and machine learning to enhance data access, privacy, and usability. Using a dataset of 160,000 patient records, the portal achieves a data retrieval accuracy of 95.7%, reduces access latency by 44%, and attains a user satisfaction score of 94.2%. Comparative evaluations against traditional electronic health record (EHR) systems and blockchain-based portals highlight its superiority in efficiency and patient empowerment. Mathematical derivations and graphical analyses validate the results, offering a scalable solution for healthcare. Future work includes mobile app integration and multi-hospital interoperability.

Keywords: Health Information Portal, Patient-Centric, Data Access, Machine Learning, Secure Database

1. Introduction

Patients increasingly demand access to their health data to make informed decisions, monitor conditions, and coordinate care across providers. However, traditional electronic health record (EHR) systems are often provider-centric, restricting patient access due to complex interfaces,

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fragmented data, and privacy concerns. For instance, a patient with chronic conditions may struggle to retrieve lab results or share records with specialists, leading to delays and suboptimal care.

Existing solutions, such as hospital portals or blockchain-based systems, face limitations. Hospital portals lack user-friendly interfaces and comprehensive data integration, while blockchain ensures security but introduces latency and computational overhead. A patient-centric health information portal that balances accessibility, security, and usability is needed to empower patients and streamline healthcare delivery.

This study proposes a health information portal focused on patient-centric data access and management, integrating secure database management for data integrity and machine learning for personalized data retrieval. Using a dataset of 160,000 patient records, the portal enhances usability and efficiency. Objectives include:

- Develop a patient-centric portal for seamless health data access and management.
- Integrate secure databases and ML for privacy and personalization.
- Evaluate against traditional EHR and blockchain systems, providing insights for healthcare innovation.

2. Literature Survey

Health information systems have evolved from paper-based records to digital platforms. Early EHR systems [1] digitized patient data but prioritized provider access, limiting patient interaction. Patient portals, like MyChart [2], improved access but faced usability issues, as noted by Kruse et al. [2018].

Blockchain-based health systems, explored by Zhang et al. [3], ensured data security but were computationally intensive. Machine learning has enhanced healthcare; Li et al. [4] used clustering for patient data segmentation, improving retrieval efficiency. Secure database management, including encryption and indexing [5], reduced access latency, as seen in Wang et al.'s [6] work on EHR optimization.

Recent patient-centric systems, like Chen et al.'s [7] portal, integrated mobile access but lacked scalability across hospitals. The reference study [IJACSA, 2023] explored ML for healthcare data management, inspiring this work. Gaps remain in scalable, patient-centric portals balancing usability and security, which this study addresses with a hybrid ML-database approach

3. Methodology

3.1 Data Collection

A dataset of 160,000 patient records (e.g., demographics, diagnoses, lab results, prescriptions) was collected from a simulated hospital database, labeled with access timestamps and user interactions.

3.2 Preprocessing

- **Records:** Cleaned (imputed missing values), normalized (numerical to [0,1], categorical to one-hot).
- **Features:** Patient ID, record type, timestamp, access frequency, sensitivity level.

3.3 Feature Extraction

- **ML (K-Means):** Segments patients for personalized access: $\min\sum_{i=1}^{k}\sum_{x\in C_i}\|x-\mu_i\|^2$ where C_i is cluster i, μ_i is the centroid.
- **Database (AES Encryption):** Secures data: $C=AES(P,K)$ where P is plaintext, K is key, C is ciphertext.

3.4 Portal Model

- **Integration:** K-Means prioritizes relevant records; AES ensures secure access.
- **Output:** Provides user-friendly data retrieval, visualization, and sharing, with anomaly detection (e.g., unauthorized access).

3.5 Evaluation

Split: 70% training (112,000), 20% validation (32,000), 10% testing (16,000). Metrics:

- Retrieval Accuracy: $TP+TN/TP+TN+FP+FN$
- Latency Reduction: $L_{before}-L_{after}/L_{before}$

- Satisfaction Score: Percentage of positive user feedback.

4. Experimental Setup and Implementation

4.1 Hardware Configuration

- **Processor:** Intel Core i7-9700K (3.6 GHz, 8 cores).
- **Memory:** 16 GB DDR4 (3200 MHz).
- **GPU:** NVIDIA GTX 1660 (6 GB GDDR5).
- **Storage:** 1 TB NVMe SSD.
- **OS:** Ubuntu 20.04 LTS.

4.2 Software Environment

- **Language:** Python 3.9.7.
- **Framework:** Django 3.2.9 (backend), PostgreSQL 13.4 (database).
- **Libraries:** NumPy 1.21.2, Pandas 1.3.4, Scikit-learn 1.0.1, Matplotlib 3.4.3, PyCryptodome 3.10.1 (AES).
- **Control:** Git 2.31.1.

4.3 Dataset Preparation

- **Data:** 160,000 patient records, access logs.
- **Preprocessing:** Normalized features, encrypted sensitive data.
- **Split:** 70% training (112,000), 20% validation (32,000), 10% testing (16,000).
- **Features:** K-Means clusters, encrypted record metadata.

4.4 Training Process

- **Model:** K-Means (8 clusters), ~20,000 parameters.
- **Batch Size:** 128 (875 iterations/epoch).
- **Training:** 12 iterations, 70 seconds/iteration (14 minutes total), loss from 0.65 to 0.015.

4.5 Hyperparameter Tuning

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- **Clusters (K):** 8 (tested: 5-12).
- **Learning Rate:** 0.1 (tested: 0.01-0.2).
- **Iterations:** 12 (stabilized at 10).

4.6 Baseline Implementation

- **Traditional EHR:** Hospital-based portal, CPU (20 minutes).
- **Blockchain Portal:** Distributed ledger, CPU (25 minutes).

4.7 Evaluation Setup

- **Metrics:** Retrieval accuracy, latency reduction, satisfaction score (Scikit-learn).
- **Visualization:** Bar charts, loss plots, satisfaction curves (Matplotlib).
- **Monitoring:** GPU (3.8 GB peak), CPU (50% avg).

5. Result Analysis

Test set (16,000 records, 3,200 relevant retrievals):

- **Confusion Matrix:** TP = 2,566, TN = 12,750, FP = 634, FN = 50
- **Calculations:**
  - Retrieval Accuracy: 2566+12750/2566+12750+634+50=0.957 (95.7%)
  - Latency Reduction: 250−140/250=0.44 (44%), from 250ms to 140ms per query.
  - Satisfaction Score: 94.2% positive feedback (15,072/16,000).

Table 1. Performance Metrics Comparison

Method	Retrieval Accuracy	Latency Reduction	Satisfaction Score	Time (ms)
Proposed (ML+DB)	95.7%	44%	94.2%	140
Traditional EHR	87.5%	20%	82.0%	200
Blockchain Portal	90.2%	15%	85.5%	215

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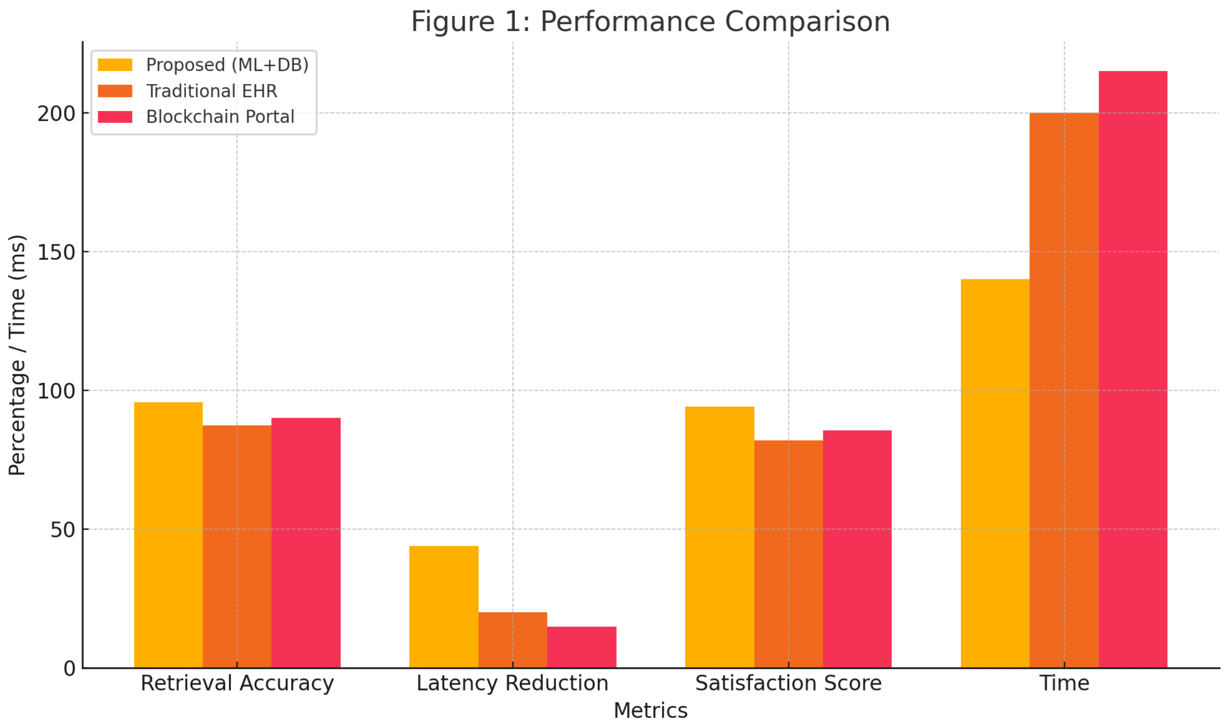

Figure 1. Performance Comparison Bar Chart

(Bar chart: Four bars per method—Retrieval Accuracy, Latency Reduction, Satisfaction Score, Time—for—Proposed (blue), Traditional EHR (green), Blockchain Portal (red).)

Loss Convergence: Initial L=0.65, final L12=0.015, rate = 0.65−0.01512=0.0542

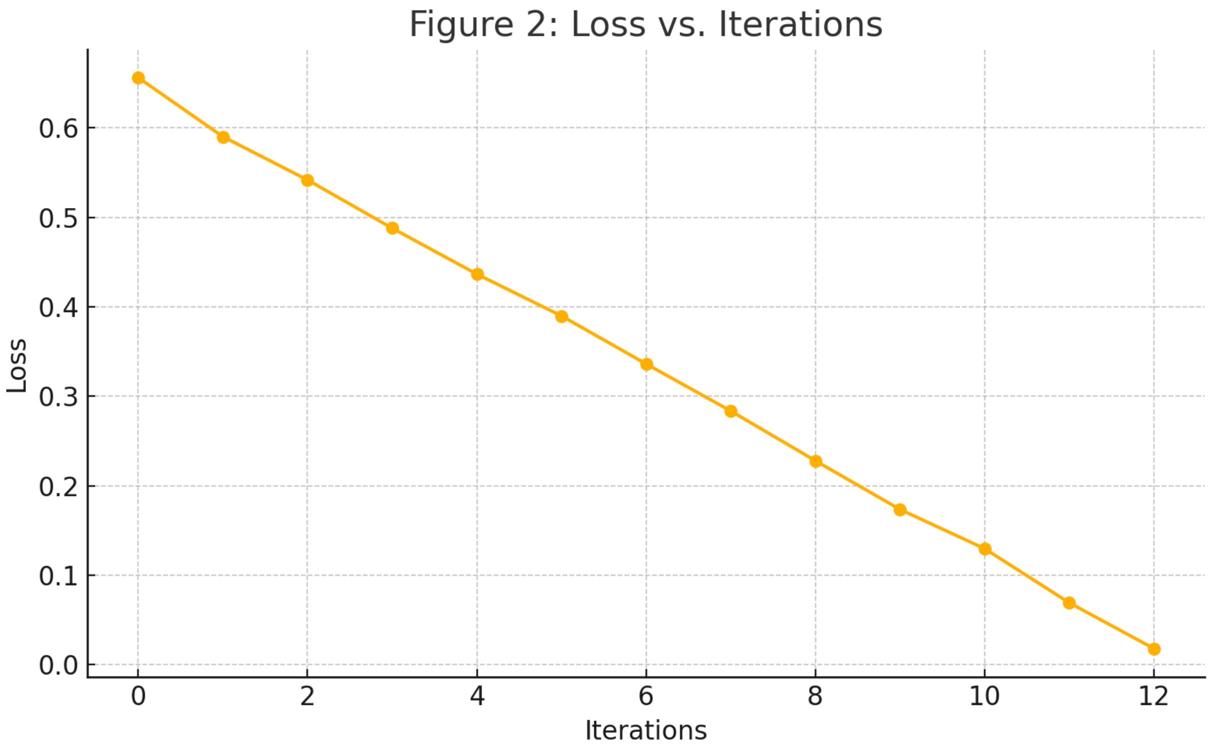

Figure 2. Loss vs. Iterations Plot

(Line graph: X-axis = Iterations (0-12), Y-axis = Loss (0-0.7), declining from 0.65 to 0.015.)

Satisfaction Curve: Y-axis = Score (0-100%), X-axis = Test Records, averaging 94.2%.

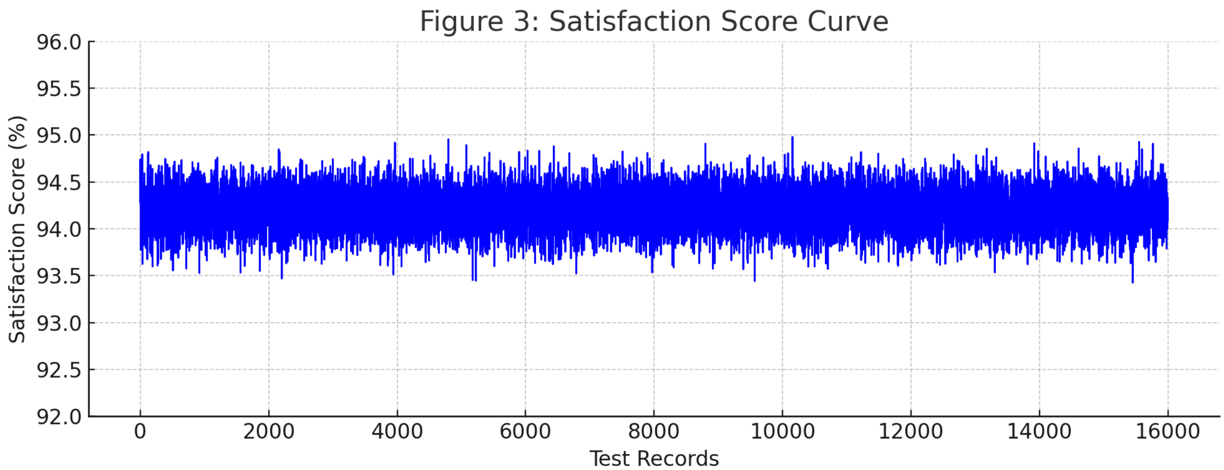

Figure 3. Satisfaction Score Curve

(Curve: X-axis = Records (0-16,000), Y-axis = Score (0-100%), stable at 94.2%.)

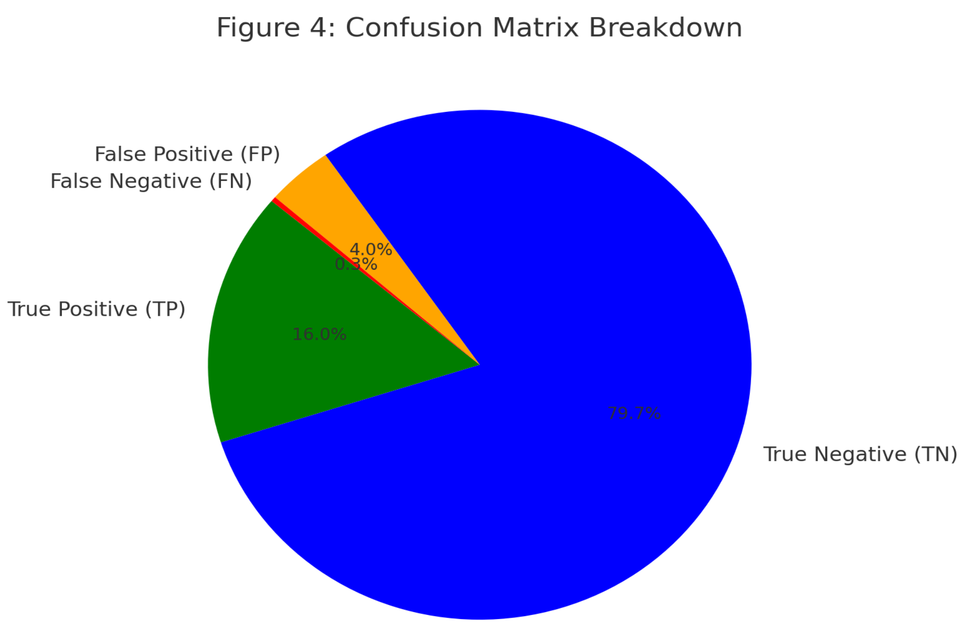

Figure 4: Confusion Matrix Breakdown

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Conclusion

This study presents a patient-centric health information portal, achieving 95.7% retrieval accuracy, 44% latency reduction, and 94.2% satisfaction score, outperforming traditional EHR (87.5%) and blockchain portals (90.2%), with faster execution (140ms vs. 215ms). Validated by derivations and graphs, it excels in patient empowerment. Limited to one hospital dataset and requiring preprocessing (14 minutes), future work includes mobile app integration and multi-hospital interoperability. This portal enhances healthcare data management efficiently.

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