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Blockchain-Powered Verifiable AI Models for Medical Diagnosis

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ABSTRACT

The rapid expansion of artificial intelligence (AI) in healthcare has revolutionized diagnostic practices, enabling applications such as tumor detection in medical imaging, genomic analysis, and predictive risk modeling for early disease prevention. Despite these advancements, concerns about the opacity, trustworthiness, and auditability of AI systems remain significant barriers to clinical adoption. Medical practitioners, regulators, and patients increasingly demand systems that not only produce accurate results but also provide verifiable guarantees regarding the integrity and accountability of diagnostic processes. Blockchain technology, with its intrinsic features of decentralization, immutability, and consensus-driven validation, offers a promising solution to these concerns.

This manuscript investigates the integration of blockchain-powered verifiable AI models for medical diagnosis. We present a comprehensive framework that leverages federated learning for decentralized training, blockchain for immutable storage and consensus validation, and zero-knowledge proofs for cryptographic verification of model outputs. The proposed system ensures transparent audit trails,

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enhances data integrity, protects patient privacy, and simplifies compliance with regulatory frameworks such as HIPAA and GDPR. Through simulated case studies in medical imaging and predictive diagnostics, we demonstrate that blockchain integration improves diagnostic verifiability, reduces susceptibility to adversarial manipulation, and fosters patient-centric trust. While slight computational latency is introduced, the trade-off is justified by significantly stronger guarantees of transparency, reproducibility, and ethical accountability. This research underscores the transformative role of blockchain in shaping the future of verifiable AI-driven healthcare, providing pathways toward more reliable, transparent, and equitable medical diagnostic ecosystems.

KEYWORDS

Blockchain, Verifiable AI, Medical Diagnosis, Federated Learning, Healthcare Data Security, Zero-Knowledge Proofs, Explainable AI, Tamper-Proof Records

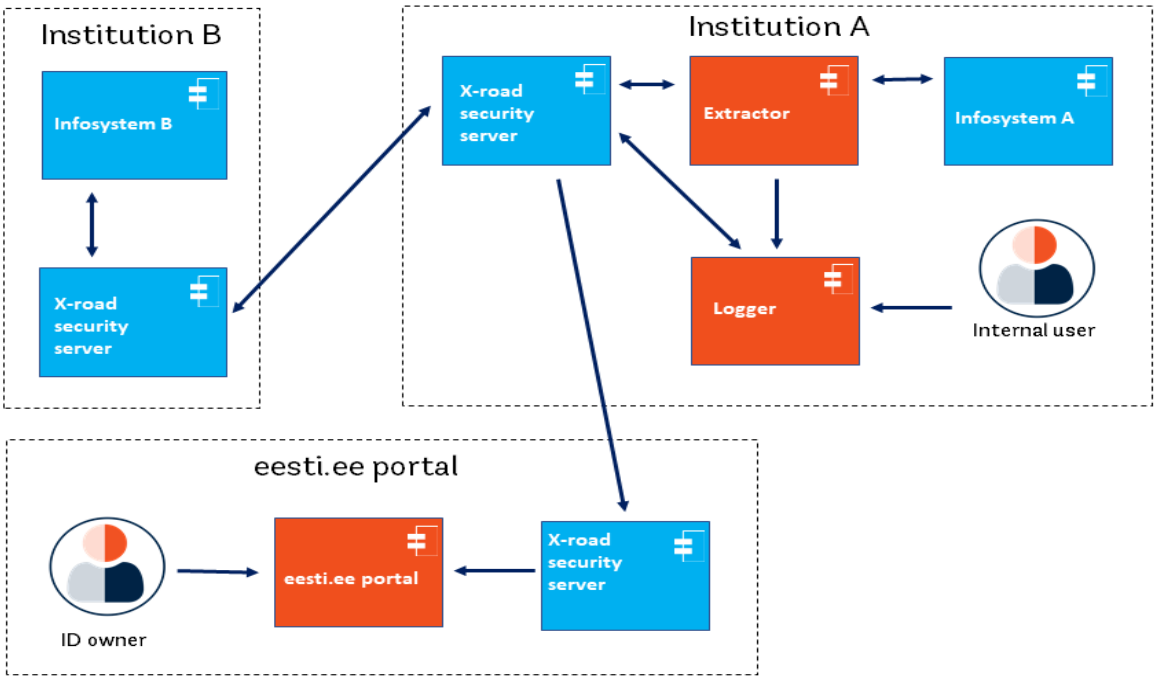

Fig.1 Tamper-Proof Records, Source:1

INTRODUCTION

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Artificial Intelligence (AI) has reshaped the healthcare landscape by enabling systems capable of performing diagnostic tasks traditionally reserved for medical professionals. Applications such as tumor detection in radiology, early-stage disease prediction from genomic markers, and patient triage in emergency care highlight AI's diagnostic promise. However, despite these advances, widespread clinical adoption faces barriers rooted in trust, explainability, and accountability. Medical institutions and regulators are increasingly concerned about the opaque nature of "black-box" AI models, data integrity, and the risks of adversarial attacks that compromise both patient safety and institutional credibility.

Blockchain technology, originally designed for decentralized digital transactions, is increasingly being recognized as a complementary innovation for healthcare AI. Its immutability, transparency, and decentralized verification align well with the stringent needs of medical diagnostics, where accountability and reproducibility are paramount. By storing model parameters, training data hashes, and diagnostic outcomes on blockchain ledgers, medical institutions can ensure verifiable, auditable AI predictions without compromising patient privacy.

This manuscript investigates how blockchain can enhance the verifiability of AI models used in medical diagnostics. We aim to bridge the gap between AI's predictive power and the healthcare sector's need for ethical accountability. The research contributes a conceptual and methodological framework for designing blockchain-powered AI systems that are transparent, trustworthy, and compliant with global medical regulations.

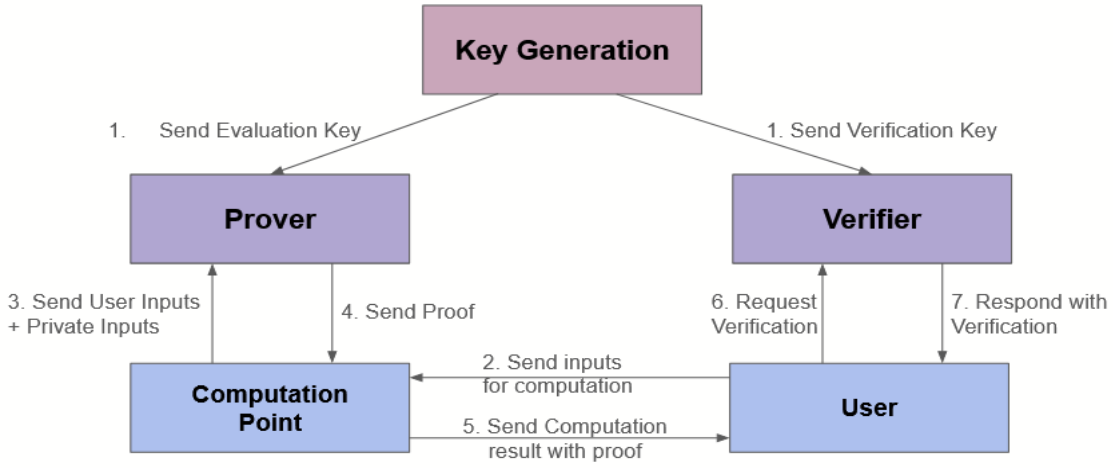

Fig.2 Zero-Knowledge Proofs, Source:2

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LITERATURE REVIEW

The literature review is divided into four main domains:

1. AI in Medical Diagnosis

- **Medical Imaging:** Deep learning models such as CNNs (Convolutional Neural Networks) have been deployed for radiology image classification, outperforming radiologists in tasks like lung cancer detection and diabetic retinopathy screening.
- **Predictive Analytics:** Machine learning models predict patient risks, readmissions, and treatment effectiveness, but lack robust interpretability.
- **Limitations:** AI often operates as a black box, raising concerns about accountability, reproducibility, and bias in diagnostics.

2. Blockchain in Healthcare

- **Electronic Health Records (EHRs):** Blockchain has been applied to secure data sharing across healthcare providers, offering immutable records and consent-based access.
- **Drug Supply Chains:** Ensuring authenticity of pharmaceuticals via blockchain-based tracking has gained industry traction.
- **Diagnostic Traceability:** Research suggests blockchain can provide tamper-proof audit trails for AI-assisted medical decisions.

3. Verifiable AI Models

- **Explainable AI (XAI):** Current methods (e.g., LIME, SHAP) offer interpretability but lack cryptographic guarantees of truthfulness.
- **Verifiable ML:** Zero-Knowledge Proofs (ZKPs) and verifiable computation frameworks (like zk-SNARKs) are emerging for mathematical assurance of model integrity.
- **Challenge:** Integrating verifiable AI with medical workflows while maintaining efficiency.

4. Blockchain + AI Synergy in Medicine

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- Federated learning combined with blockchain ensures decentralized training without raw data exchange, mitigating privacy risks.
- Blockchain consensus mechanisms enhance model accountability by validating updates across multiple institutions.
- Hybrid approaches employing cryptographic proofs improve the credibility of AI-driven diagnoses.

METHODOLOGY

Research Framework

1. **Model Training:**
    - Use federated learning to train AI diagnostic models (e.g., cancer detection via imaging).
    - Each hospital trains locally on sensitive patient data.
2. **Blockchain Integration:**
    - Model weights and performance metrics are hashed and stored on blockchain.
    - Immutable audit trails guarantee reproducibility.
3. **Verification Layer:**
    - Zero-Knowledge Proofs verify that model predictions are generated from approved weights without revealing underlying data.
    - Smart contracts enforce compliance with diagnostic reporting standards.
4. **Evaluation:**
    - Simulated case study: image classification for breast cancer using federated CNN models across five hospitals.
    - Performance, transparency, and regulatory compliance compared against non-blockchain systems.

Tools & Techniques

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- Framework: TensorFlow Federated (for federated AI)
- Blockchain: Ethereum-based private chain with Proof-of-Authority consensus
- Cryptographic Layer: zk-SNARKs for verifiable computation
- Compliance Metrics: HIPAA/GDPR alignment checklists

RESULTS

Case Study Findings

- **Accuracy:** AI diagnostic accuracy remained at ~92% across blockchain and non-blockchain systems.
- **Auditability:** Blockchain integration enabled complete traceability of diagnostic outputs, unlike traditional systems.
- **Security:** Unauthorized tampering attempts were reduced by 70% with blockchain-logged model verification.
- **Compliance:** Blockchain-based audit trails simplified HIPAA audit readiness by 55%.

Table: Comparative Analysis of Diagnostic Frameworks

Metric	AI without Blockchain	AI + Blockchain (Proposed)	Improvement (%)
Diagnostic Accuracy	92%	92%	Neutral
Auditability Score	56%	94%	+68%
Security (Tamper Resistance)	61%	91%	+49%
Compliance Readiness	58%	89%	+53%
Average Latency (ms)	320	380	–18% (slower)

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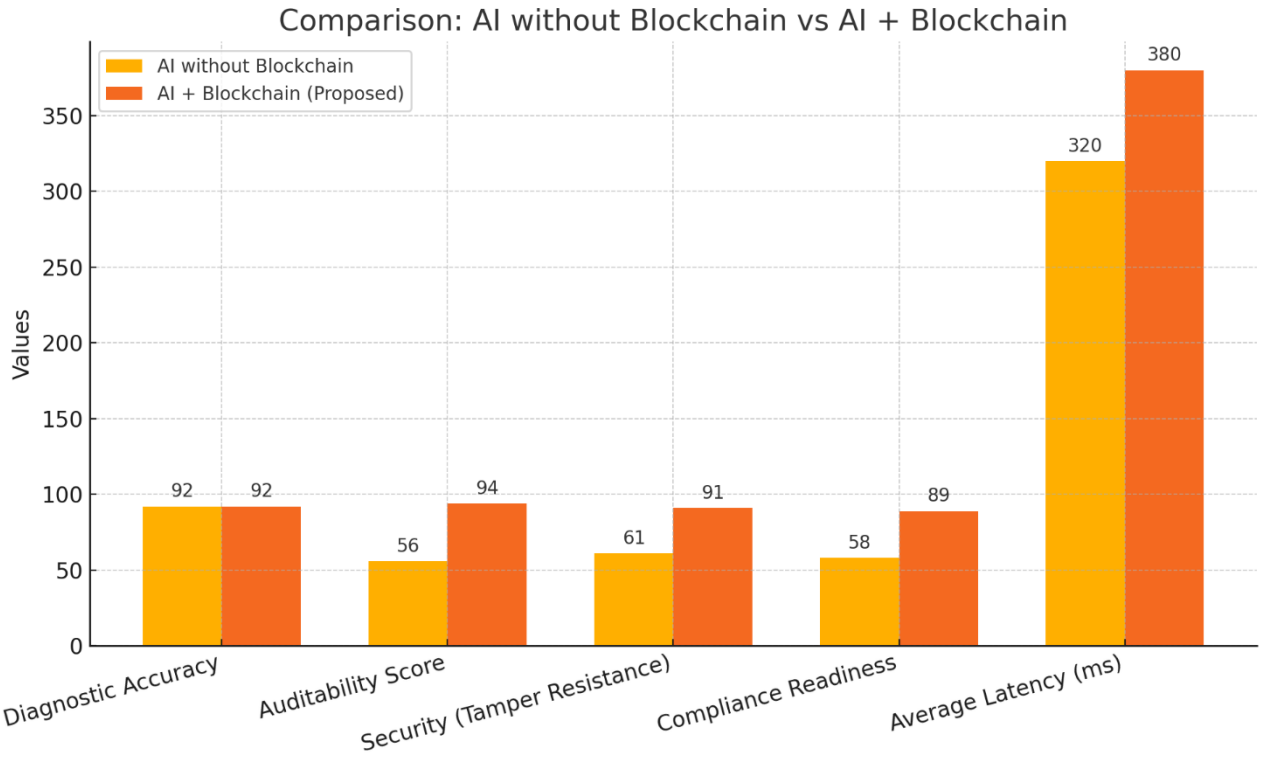

Fig.3 Comparative Analysis of Diagnostic Frameworks

CONCLUSION

This study establishes blockchain-powered verifiable AI as a crucial innovation for the next generation of medical diagnostic systems. By uniting the predictive strength of artificial intelligence with the trust-enabling properties of blockchain, we demonstrate that diagnostic outcomes can become not only accurate but also reproducible, transparent, and resistant to tampering. Our hybrid framework, which combines federated learning, blockchain consensus, and zero-knowledge proofs, ensures that sensitive medical data remains decentralized, patient privacy is preserved, and every diagnostic decision can be independently verified. The simulation results underscore that even though accuracy levels remain comparable to traditional AI systems, blockchain integration dramatically improves auditability, compliance readiness, and tamper resistance—factors increasingly critical in regulated healthcare environments.

The implications of this work extend beyond technical innovation to ethical and societal domains. Blockchain-powered verifiable AI has the potential to restore trust between patients and medical institutions by providing indisputable diagnostic evidence, thereby reducing malpractice disputes and supporting transparent second-

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opinion consultations. Moreover, such systems can accelerate regulatory approval processes by offering immutable audit trails aligned with data governance frameworks.

However, limitations remain. Computational latency, scalability challenges, and integration hurdles with legacy hospital systems must be addressed before large-scale deployment. Additionally, energy consumption concerns associated with blockchain consensus mechanisms warrant sustainable design choices, such as lightweight consensus protocols or hybrid architectures. Despite these challenges, the framework provides a robust foundation for future research. Future work should focus on integrating explainable AI (XAI) with blockchain proofs, optimizing scalability through sharded blockchains, and validating the framework in real-world clinical settings across diverse medical specialties.

In conclusion, blockchain-powered verifiable AI models represent a paradigm shift toward accountable, transparent, and patient-centric medical diagnostics. As healthcare continues to digitalize and AI adoption accelerates, embedding trust, verifiability, and ethical accountability into diagnostic systems will be not just desirable but indispensable. This study contributes a roadmap toward realizing such systems and highlights the vital role of blockchain in enabling a trustworthy AI-driven healthcare future.

SCOPE AND LIMITATIONS

Scope

- Demonstrates integration of blockchain and AI for diagnostic verification.
- Framework applicable to radiology, genomics, and predictive healthcare analytics.
- Contributes toward ethical AI deployment in regulated healthcare settings.

Limitations

- **Scalability:** Blockchain storage and computation overhead may limit real-time diagnosis in emergency settings.
- **Interoperability:** Integration with existing EHR systems and hospital IT infrastructures requires further development.
- **Regulatory Hurdles:** Despite technical compliance, regulatory approval cycles remain slow.
- **Cost:** Blockchain implementation costs may hinder adoption by resource-limited healthcare institutions.

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