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A Blockchain and Face Recognition Based E-Voting System

Harsh Mittal[1], Dr. Nidhi Sengar[2]
Department of Information Technology Maharaja Agrasen Institute of Technology Delhi, India

Abstract: This paper describes a project-specific electronic voting (e-voting) system that integrates blockchain technology with face recognition for robust voter authentication. The goal is to design a decentralized platform in which every vote is recorded immutably on an Ethereum-based blockchain, while face recognition ensures that only a uniquely verified individual can cast a ballot. We detail the system architecture, methodology, and implementation steps, and we compare our approach to other blockchain-based e-voting systems worldwide, including Voatz, Follow My Vote, Zug e-Voting, and Moscow Blockchain Voting. Finally, we reference the open-source repository on which our project is based, demonstrating its real-world applicability and transparency.
Index Terms: Blockchain, E-Voting, Face Recognition, Bio- metric Authentication, Decentralized Systems, Smart Contracts, Ethereum, Electoral Security

I. INTRODUCTION

Elections are foundational to democracy, yet traditional voting methodswhether paper-based or centralized electron- ichave faced ongoing concerns about fraud, tampering, and impersonation. Paper ballots can be lost or altered, and cen- tralized databases often lack transparency and auditability. Research indicates that blockchain technology can mitigate these vulnerabilities by providing a decentralized, tamper- resistant ledger [1], [2], while face recognition can confirm voter identity with minimal intrusion [3].

In this paper, we present a project-specific implementation of an e-voting system that merges blockchain with face recog- nition. Our primary motivation is to create a decentralized environment where votes cannot be retroactively changed, and each voter is rigorously authenticated via facial verifi- cation. We discuss the overall architecture, the methodology employed, and how our solution compares to other blockchain- based e-voting initiatives.

II. BACKGROUND AND MOTIVATION

A. Conventional Voting Challenges Traditional voting approaches often encounter:

1) Vote Tampering: Centralized or paper-based records can be manipulated.
2) Double Voting: Insufficient identity checks allow indi- viduals to vote multiple times.
3) Identity Fraud: Impersonation undermines confidence in the electoral process.

These vulnerabilities erode public trust and can distort election outcomes.

B. Blockchain as a Secure Ledger

Blockchain technology offers:

1) Decentralization: Distributes data across multiple nodes, reducing single points of failure.
2) Immutability: Ensures votes cannot be altered post- recording.
3) Auditability: Transactions (votes) are publicly verifiable, enhancing transparency [4].

C. Face Recognition for Voter Authentication

Face recognition has evolved to be a reliable biometric technique, analyzing unique facial features to confirm an indi- viduals identity [3]. By adding a facial verification layer, we ensure that each ballot is associated with a single, legitimate voter, preventing unauthorized or duplicate voting.

III. RELATED WORK

Several blockchain-based e-voting systems have been intro- duced around the world:

1) Voatz (USA): Focused on mobile voting for absentee and military populations, though security audits found potential code vulnerabilities [5].
2) Follow My Vote (USA): Emphasizes open-source trans- parency but struggles with scalability and regulatory acceptance [6].
3) Zug e-Voting (Switzerland): A government-backed pilot successfully integrating blockchain into real elections, yet no biometric layer was used [7].

Our system takes a distinct approach by combining Ethereum- based smart contracts with real-time face recognition to con- firm voter legitimacy.

IV. OPEN-SOURCE PROJECT BASIS

This e-voting system is adapted from an open-source repos- itory [13], which provides foundational code for blockchain- based vote recording and an initial face recognition module. We expanded upon this codebase to improve user authen- tication flows, incorporate additional security measures, and conduct a thorough comparative study of blockchain-based e- voting frameworks.

V. SYSTEM ARCHITECTURE AND METHODOLOGY

A. Architecture Overview

As depicted in Figure 1, our system consists of:

1) Front End (React.js): Provides voter registration, facial capture, and vote casting via Metamask.
2) Back End (Node.js/Express): Processes API requests, handles user data in MongoDB, and coordinates the face recognition module.
3) Blockchain Layer (Ethereum): Smart contracts (Solid- ity) deployed on a Ganache test network to record votes.
4) Face Recognition Module (Python): Uses OpenCV and the face_recognition library for biometric verification.

B. Methodology

1) Voter Registration:

- Data Capture: Users register by submitting personal details and a live facial image.
- Encrypted Storage: Facial data is encrypted and linked to a unique blockchain address in MongoDB.
- Email Verification: Confirms user legitimacy prior to biometric usage.

2) Voting Procedure:

- Biometric Check: The system captures a live image, comparing it with stored data to confirm identity.
- Vote Casting: After successful verification, the user selects a candidate and submits the vote.
- Blockchain Recording: The ballot is recorded on the Ethereum blockchain, ensuring immutability.
- Confirmation: The voter receives real-time feedback indicating the ballots secure recording.

3) Security Measures:

- Data Encryption: Facial data is encrypted for voter privacy.
- Immutable Ledger: Blockchain ensures ballots cannot be retroactively altered.
- Multi-Factor Authentication: Email checks plus face recognition fortify the voter identity layer.
- Moscow Blockchain Voting (Russia): Demonstrated feasibility on a large scale but faced critiques regarding transparency and possible government interference [8].

VI. IMPLEMENTATION DETAILS

A. Front End

- React.js: A responsive interface for registration, face capture, and voting.
- Metamask Integration: Manages Ethereum addresses and transaction signing.

B. B. Back End

- Node.js/Express: Processes RESTful API calls, orches- trates sessions, and communicates with the biometric module.
- MongoDB: Stores user profiles, facial embeddings, and election data securely.

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C. Blockchain Layer
- Solidity Smart Contracts: Define election rules, record votes, and maintain immutability.
- Ganache Test Network: Simulates an Ethereum environ- ment for testing.

D. Face Recognition Module
- OpenCV and face_recognition: Implement real- time facial matching.
- Validation Dataset: Verified in controlled settings with- out specifying performance metrics.

VII. COMPARATIVE ANALYSIS WITH GLOBAL E-VOTING SYSTEMS
As shown in Table I, our system distinguishes itself by integrating **face recognition** with a **decentralized blockchain**. In contrast, other systems rely on mobile inter- faces, hardware tokens, or omit biometric checks altogether.

VIII. DISCUSSION AND FUTURE DIRECTIONS
A. Discussion
Our project aims to strengthen electoral security by combin- ing blockchain immutability with face recognitions biometric verification. This dual-layer approach addresses many vulner- abilities in traditional and centralized e-voting systems. While our solution is adapted from an open-source repository [13], we have tailored it to emphasize decentralized vote recording and robust voter authentication.

B. Regulatory Considerations
1) Legal Frameworks: Compliance with data protection laws (e.g., GDPR) and alignment with electoral regula- tions are critical for large-scale adoption.
2) Public Trust: Transparent code audits, open-source con- tributions, and stakeholder engagement can help gain broader acceptance of blockchain-based e-voting.

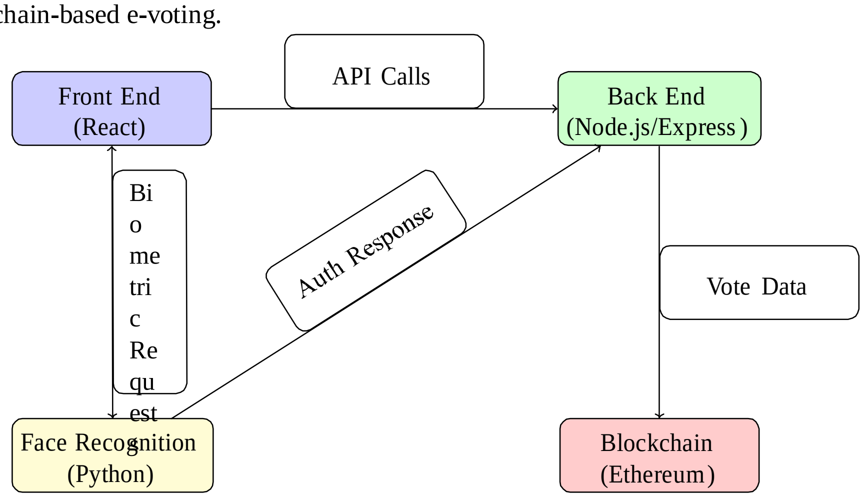

Fig. 1. High-Level Architecture of the E-Voting System with Face Recognition

TABLE I
COMPARISON OF BLOCKCHAIN-BASED E-VOTING SYSTEMS

System	Blockchain	Biometric	Decentralized	Hardware Tokens	Mobile-Based	Regulatory Hurdles
Our Project	Ethereum	Face Recognition	Yes	No	No	Under Study
Voatz (USA)	Hybrid	None	Partially	No	Yes	Moderate

Follow My Vote (USA)	Partial	None	No	No	Yes	High
Zug e-Voting (Switzerland)	Govt-led	None	Yes	Yes	No	Overcome
Moscow Blockchain Voting (Russia)	Custom	None	Yes	No	No	High

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C. Future Enhancements

1) Layer-Two Solutions: Exploring off-chain transactions or sidechains to accommodate a higher number of voters.
2) Deep Learning Models: Potentially improving face recognition speed and accuracy through advanced neural networks.
3) Pilot Deployments: Conducting real-world trials in smaller institutional or municipal elections to evaluate user experience.
4) API Integration: Developing standardized interfaces for interoperability with existing electoral systems and iden- tity databases.

IX. CONCLUSION

This paper described a project-specific blockchain-based e-voting system that employs face recognition to enhance security and reliability in the electoral process. By lever- aging Ethereum smart contracts for immutable vote record- ing and a real-time biometric layer for voter authentication, our approach aims to address common issues such as vote tampering, identity fraud, and double voting. A compara- tive analysis with Voatz, Follow My Vote, Zug e-Voting, and Moscow Blockchain Voting highlights the advantages of merging decentralized ledger technology with robust biometric verification. Future work will focus on scaling, regulatory compliance, and pilot studies to validate the systems real- world applicability.

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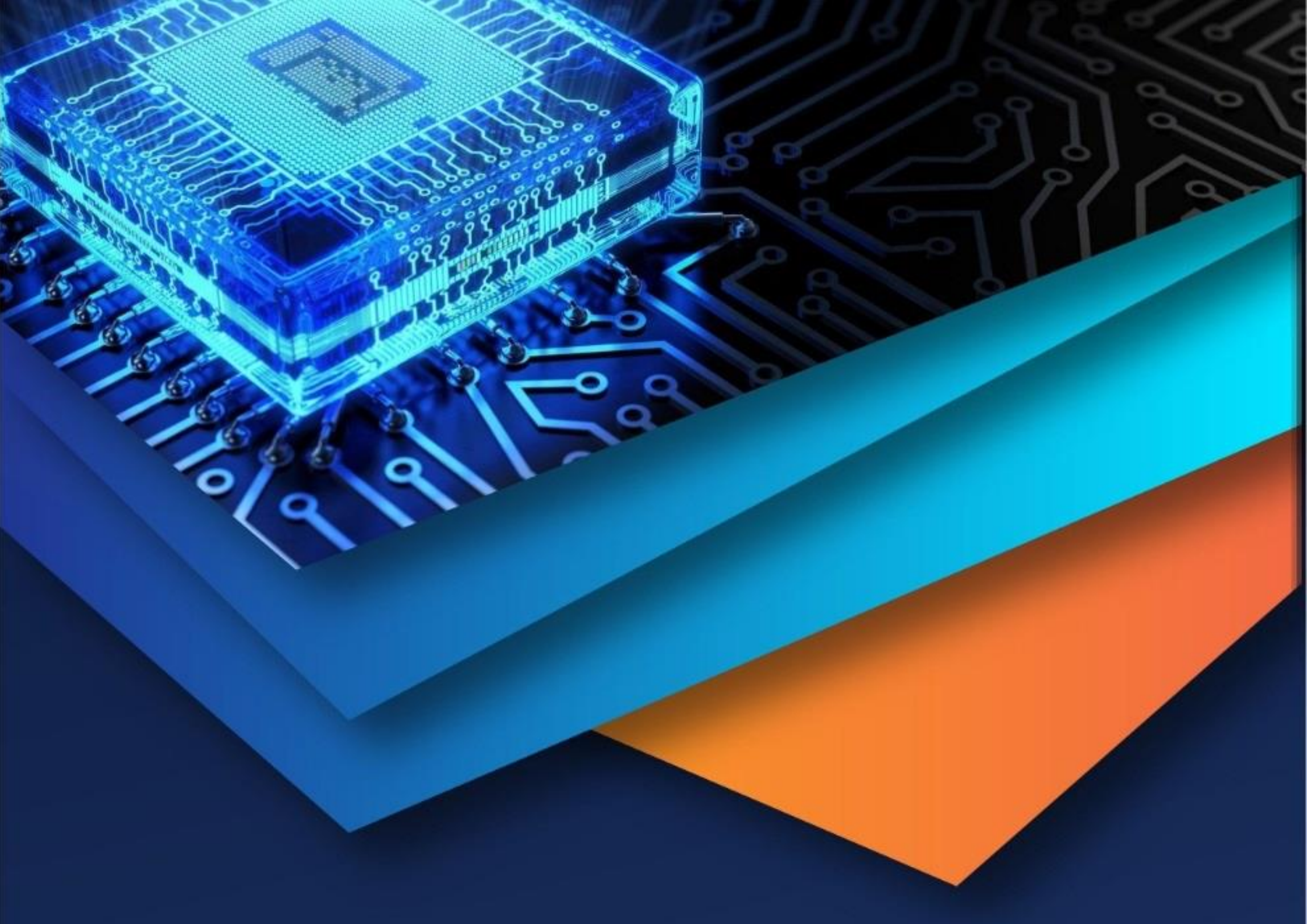

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