

Secure E-Voting System Using Facial Recognition and Blockchain

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Abstract

With the growing demand for secure and transparent digital voting, traditional electronic voting systems face challenges related to authentication, integrity, and trust. This paper presents a robust e-voting framework that integrates facial recognition, liveness detection, OTP-based verification, and blockchain technology. The system introduces a multi-layer authentication mechanism to ensure that only authorized users can participate in the voting process. To prevent spoofing attacks, real-time liveness detection is incorporated using facial landmark analysis. Votes are securely recorded as immutable transactions in a blockchain ledger, ensuring transparency and tamper resistance. The proposed system is implemented using Flask, React.js, and computer vision libraries, demonstrating improved security, reliability, and usability for modern digital voting applications.

Keywords: E-Voting, Facial Recognition, Blockchain, Live-ness Detection, Artificial Intelligence, Secure Authentication, Digital Voting

INTRODUCTION

Voting represents the primary mechanism through which individuals participate in collective decision-making processes within democratic frameworks. However, traditional voting mechanisms, including paper-based and electronic systems, often face challenges such as lack of transparency, susceptibility to fraud, and operational inefficiencies. With the advancement of digital technologies, there is a need to develop secure and scalable online voting systems that address these limitations.

To address these challenges, this work proposes a secure e-voting system that combines biometric authentication with blockchain-based vote storage. Facial recognition is used to verify voter identity, while liveness detection prevents spoofing attempts. Blockchain ensures that cast votes are immutable, traceable, and resistant to unauthorized modification [5], [6]. The proposed solution aims to provide a reliable and transparent online voting platform suitable for institutional and organizational elections.

PROBLEM STATEMENT

Traditional and centralized digital voting systems are vulnerable to impersonation, data manipulation, and insufficient transparency. Existing systems often rely on weak authentication methods such as

passwords or ID numbers, which are susceptible to misuse [8]. There is a need for a secure digital voting architecture that guarantees legitimate voter participation, one-person-one-vote enforcement, and tamper-resistant vote storage.

OBJECTIVES

The major objectives of the proposed system are:

- To develop a secure online voting platform with multi-factor authentication.
- To implement AI-based facial recognition for voter identity verification.
- To incorporate liveness detection to prevent spoofing attacks.
- To store votes securely using blockchain for immutability and transparency.
- To provide a user-friendly web interface for registration, authentication, and vote casting.

PROPOSED METHODOLOGY

The proposed framework consists of multiple interconnected modules designed to provide secure and efficient voting.

A. Voter Registration

Users register using voter ID, date of birth, and mobile number. OTP verification is used to validate the registered mobile number before account activation.

B. Facial Recognition Authentication

During registration, the user's face is captured using a webcam and stored securely. During login, the live image is compared against the registered face using AI-based facial verification techniques such as FaceNet [2].

C. Liveness Detection

To prevent spoofing through printed photographs or recorded videos, liveness detection is performed by tracking facial landmarks and requiring real-time head movements.

D. Vote Casting

After successful authentication, the voter is allowed to access the ballot interface and cast a vote for a selected candidate.

E. Blockchain-Based Vote Storage

Each vote in the proposed system is stored as a transaction within a blockchain structure, where every block contains a cryptographic hash of the previous block. This chaining mechanism ensures that any modification in stored data would break the entire chain, making tampering easily detectable and practically infeasible [5], [7].

SYSTEM ARCHITECTURE

The proposed system follows a modular architecture with the following components:

- Frontend layer for voter interaction
- Backend API server for logic execution
- Biometric verification module
- OTP authentication module
- SQLite database for voter data
- Blockchain ledger for secure vote storage

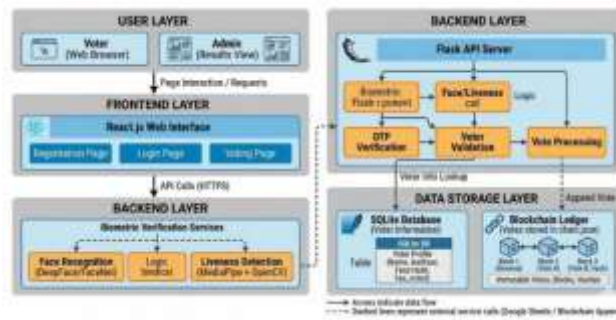


Fig. 1. Proposed Secure E-Voting System Architecture

IMPLEMENTATION DETAILS

The system is implemented using the following technologies:

- **Frontend:** React.js, HTML, CSS, JavaScript
- **Backend:** Python Flask
- **Database:** SQLite
- **AI/Computer Vision:** DeepFace, OpenCV, MediaPipe
- **Security Layer:** Blockchain ledger with hashing

ALGORITHMS USED

A. Facial Recognition

Facial embeddings are extracted from the registered and live images, and similarity matching is performed to verify identity.

B. Liveness Detection

MediaPipe-based landmark tracking is used to monitor face orientation and movement to confirm the presence of a live user.

C. Blockchain Hashing

Each block is linked to the previous block using cryptographic hashing, making the vote chain tamper-evident.

RESULTS AND DISCUSSION

The experimental evaluation of the system demonstrates that integrating facial recognition with liveness detection significantly reduces impersonation attempts. Additionally, the use of blockchain ensures that recorded votes remain immutable and verifiable, enhancing trust in the overall voting process [5], [12].

TABLE I
SYSTEM EVALUATION SUMMARY

Parameter	Observation
Authentication Accuracy	High
Spoofing Resistance	Effective
Vote Integrity	Secure
Transparency	Improved
Accessibility	High

ADVANTAGES OF THE PROPOSED SYSTEM

- Multi-layer authentication enhances security
- Prevention of impersonation using biometric verification
- Tamper-proof vote storage through blockchain
- Transparent and auditable system design
- Reduced dependency on physical infrastructure

LIMITATIONS

Despite its advantages, the system has certain limitations:

- Performance may depend on camera quality and lighting conditions
- Requires stable internet connectivity
- Raises concerns regarding biometric data privacy
- May face scalability challenges in large-scale deployments

FUTURE ENHANCEMENTS

Future improvements can include:

- Integration with distributed blockchain networks
- Deployment on cloud infrastructure for scalability
- Advanced anti-spoofing mechanisms
- End-to-end encryption for enhanced privacy
- Optimization for large-scale election environments

CONCLUSION

This paper presents a secure e-voting system that combines biometric authentication with blockchain technology to address critical challenges in digital voting. By integrating OTP verification, facial recognition, and liveness detection, the system ensures that only legitimate users can participate in the voting process. The use of blockchain guarantees transparency, immutability, and trust in vote storage. The proposed framework demonstrates a practical approach toward building secure and reliable online voting systems for modern applications.

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