JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Biometric Voting Machine: A Review

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Abstract: This research introduces an innovative approach to enhance election security by incorporating fingerprint sensors and face recognition technology into an electronic voting system. Traditional voting methods, such as paper ballots and Electronic Voting Machines (EVMs), are vulnerable to misuse, emphasizing the need for a more robust and reliable system. In the proposed system, voters' fingerprints are captured and stored in a database during registration, preventing multiple registrations by the same individual. On election day, voters authenticate their identity by scanning their fingerprints, which are then compared with the stored database. This process, combined with a unique identifier, significantly reduces the risk of duplicate registrations and ensures a high success rate in the voting process. Additionally, voters can cast their ballots remotely using their unique identifier, authentication responses, and a token key provided through a dedicated election web module. The successful implementation of this system at the University of Ibadan demonstrates its effectiveness in eliminating electoral fraud and enhancing overall election security. The paper also highlights additional features incorporated into the proposed system, surpassing the functionality of existing systems.

Index Terms- AS608 Optical Fingerprint Sensor, Infrared Face Identification Camera, Online Database

I. INTRODUCTION

This study suggests integrating face recognition, iris recognition, and fingerprint-based authentication techniques to enhance the existing voting system's identity verification process. By incorporating these features, the system not only assists in identifying unauthorized individuals but also facilitates tracking and addressing issues such as fraud, forgery, and tailgating during the voting process. This multifaceted approach significantly improves security within voting premises and polling stations.

To implement face and iris recognition, custom Haar-cascade classifiers are trained, and a prototype is developed using Raspberry Pi 3. The face recognition classifiers are trained across different operating systems. Upon voters' arrival, their fingerprints undergo verification for authentication. Successful authentication triggers the display of their respective constituency details. Subsequently, voters can cast their votes for a preferred political party or candidate by entering the displayed serial number. The entered serial number is recorded in a text file and saved. The voting functionality remains inactive until the next voter arrives to cast their vote.

II. SMART BIOMETRIC VOTING MACHINE

Biometric voting machines represent a significant advancement in election technology. By utilizing sophisticated fingerprint, face, or iris recognition, these machines ensure robust voter authentication and enhance overall security measures. Beyond simplifying the verification process and enabling real-time monitoring, they also promote inclusivity by making voting accessible to a diverse population. State-of-the-art encryption techniques protect sensitive voter data, while audit trails enhance transparency and accountability. Their adherence to established standards reinforces public trust, affirming the fairness, reliability, and integrity of electoral outcomes. In essence, biometric voting machines herald a new era of democratic excellence.

III. LITERATURE REVIEW

Mr. Sharathchandra's [1] research introduces an IoT-based fingerprint voting system as a robust solution to prevent election rigging. This system seamlessly integrates biometric fingerprints canning and embedded systems technology, ensuring a secure and efficient voting process. During voter registration, individuals provide their fingerprints, which are then scanned and compared to stored images during elections for authentication as shown in the figure1. The incorporation of Wi-Fi connectivity facilitates the seamless transmission of voting information to a central web server, enhancing both efficiency and transparency in the electoral process.

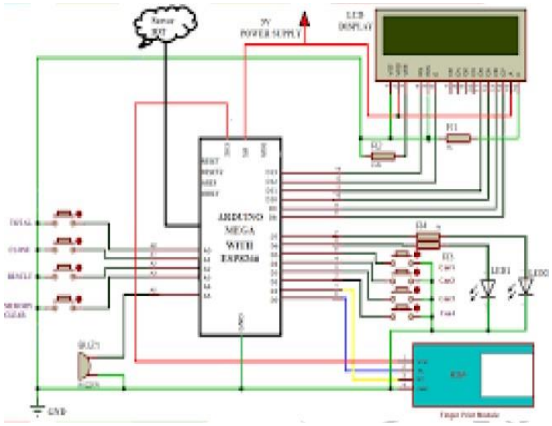

Figure 1: Circuit diagram of Arduino Uno

Nandan Gowda S H's [2] work focuses on a smart voting system that leverages face recognition technology to enable remote voting for Indian citizens. The system shown in figure 2 maintains a high level of biometric security by storing voter details in a server database. Key components, including Arduino Uno, LCD display, RFID technology, and a power supply unit, contribute to an integrated solution. Beyond enhancing security, this system addresses challenges such as proxy voting and missing identity, presenting a comprehensive approach to modernizing voting infrastructure.

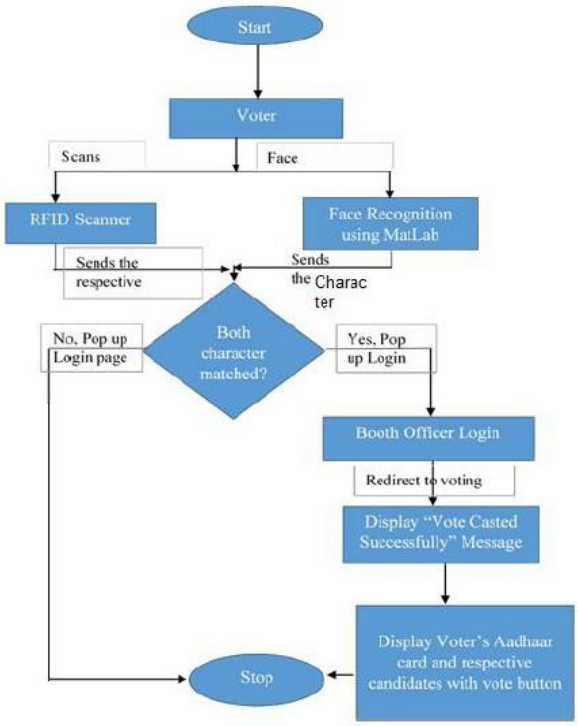

Figure 2: Flowchart for the proposed system

The smart voting system proposed by Mrs. Sakshi and Heena Kousar [3] integrates facial recognition technology with machine learning to enhance accuracy, security, and speed. By employing facial recognition algorithms trained using deep learning techniques, along with additional security measures like biometric data, real-time monitoring, and OTP verification, the system effectively prevents voter fraud. Their meticulous methodology, including dataset creation and a two-step verification process, demonstrates a holistic approach to ensuring the reliability and security of the voting process.

Sudeepthi Komatineni's [4] research focuses on a secured e-voting system that utilizes two-factor biometric authentication, incorporating both facial and fingerprint recognition. The Eigen-face-based facial recognition algorithm shown in figure 3 employs PCA for image transformation, while minutiae-based fingerprint recognition serves as the second factor.

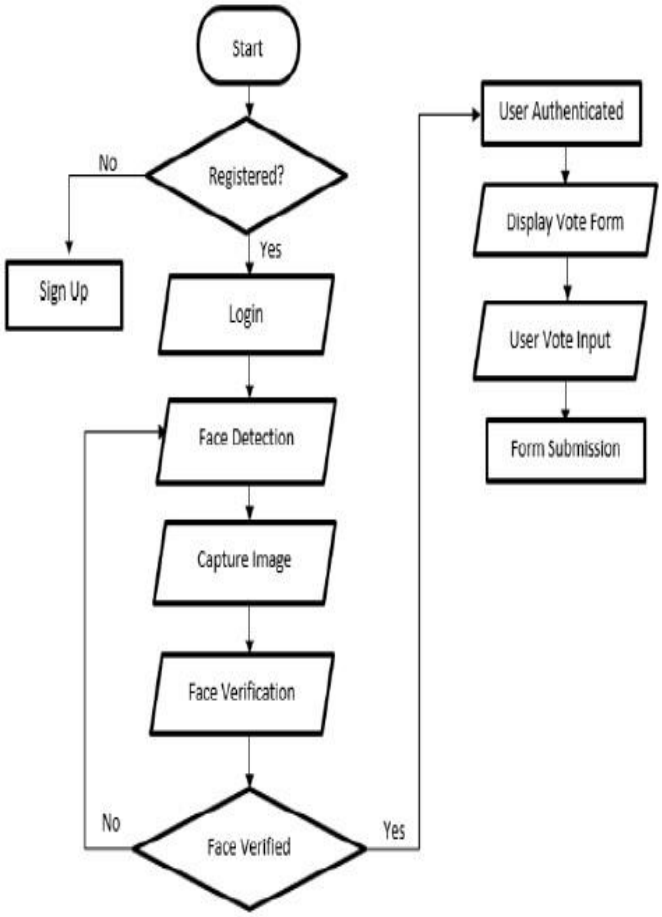

Figure 3: Block diagram of Eigen facial recognition algorithm

This robust and user-friendly biometric authentication process involves a two-step verification during polling, addressing challenges associated with traditional voting methods.

M G Gurubasavanna's [5] work centers around designing and implementing a smart electronic voting kiosk using Raspberry Pi. The system incorporates multi-layer security through face, iris, and fingerprint recognition. Its goal is to address low voter turnout by allowing voters to cast their ballots from any constituency. Components such as Raspberry Pi 3, a fingerprint sensor, and a Pi camera contribute to a portable and efficient voting experience. The paper highlights attributes like cost-effectiveness, low power consumption, and prevention of voting fraud as essential features of the proposed system.

Zakiah Mohdyusoff's [6] presentation on "Fingerprint Biometric Voting Machine using Internet of Things" delves into creating an electronic voting system that addresses the limitations of traditional voting methods. By integrating biometric authentication and IoT technology, this system aims to enhance security, efficiency, and accuracy in elections. The proposed solution employs an Arduino Uno microcontroller and fingerprint-based authentication to ensure that only registered voters can cast their ballots. Real-time monitoring and data transmission via IoT contribute to more accurate vote counting. The document emphasizes the significance of secure and fair elections, with biometrics playing a crucial role. It also advocates for a more reliable and scalable approach compared to current electronic voting systems. The methodology provides detailed information about the system's design, components, and functionality, while the results and discussion section explores potential scenarios and outcomes. In conclusion, the presentation suggests implementing this system at the national level to enhance electoral integrity.

Jinhui Liu's [7] research focuses on a publicly verifiable E-voting system that combines biometrics, cryptography, zero-knowledge proofs, and machine learning. The goal is to overcome the limitations of traditional paper ballots by ensuring verifiability, privacy, security, and intelligence in the election process.

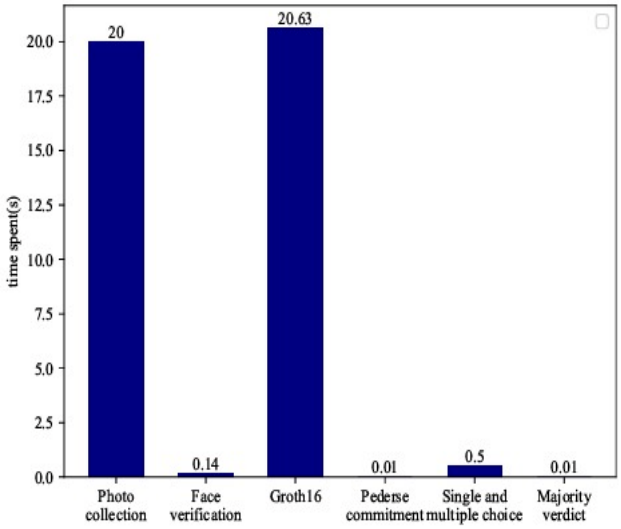

Figure 4: Time cost of our construction.

The system handles a large number of candidates and complex voting methods using commitment schemes, zk-SNARKs, and machine learning. Key entities involved include voters, tellers, the organization, and the bulletin board. Facial recognition based on convolutional neural networks is used for voter identity verification. Security analysis confirms privacy, hidden counting, and verifiability, highlighting advantages in terms of privacy protection, verifiability, resistance to coercion. The time for identification and authentication of user is shown in figure 4. Overall, the system provides a secure, private, and efficient E-voting solution, supported by performance evaluations.

Dr. Abhay A Deshpande [8] has introduced a Smart Voting System that leverages biometrics (specifically fingerprint and facial recognition) to address challenges in the Indian election process. This innovative system ensures secure, efficient, and accessible voting, particularly for absentee voters. By utilizing biometric authentication, the system effectively reduces instances of duplicate votes and enhances overall security. The system employs advanced image processing techniques, including the Haar Cascade Algorithm for face detection and minutiae-based matching for fingerprint recognition. These methods play a crucial role in authenticating voters. Additionally, the system streamlines the vote counting process, relying on Arduino microcontrollers and power source modules. Experimental results have demonstrated successful recognition and verification. Dr. Deshpande also suggests potential enhancements, such as integrating Aadhar card verification and developing mobile applications. Ultimately, the Smart Voting System aims to uphold democratic principles by ensuring accessibility, security, and efficiency in the electoral process.

Debojyoti Ghosh [9] conducted a thorough review of fingerprint-based electronic voting machines (EVMs), with a primary focus on enhancing voting security. The comprehensive literature survey explored various aspects, including biometrics, integration with the Aadhar database, GSM alert systems, and online e-voting. The study delved into technologies such as RFID, iris recognition, finger vein sensing, and the utilization of Android OS platforms. The proposed systems aim to enhance accuracy, transparency, and prevent illegal voting. The document provides an overview of the working principle, potential advantages, and disadvantages, with a strong emphasis on the role of fingerprint matching and biometric authentication. It incorporates insights from various academic works and proposals related to fingerprint-based EVMs.

On the other hand, Aman Jatain's [10] presentation focuses on designing an advanced voting system that leverages biometrics for efficiency, speed, and safety. The system integrates fingerprint and iris scanning for authentication, collecting and securely storing Aadhaar card details, fingerprints, and iris images in a database. The methodology ensures accuracy and reliability in voting results, covering processes such as voter registration, ID verification, machine setup, and voter authentication through scanning. The document includes a visual flow diagram illustrating the registration, verification, and voting process. Notably, the presentation highlights security issues in Indian electronic voting machines and proposes a secure biometric-enabled voting system aimed at achieving optimal and unbiased results. By addressing current security concerns, this proposed system contributes to the integrity of electronic voting machines.

P. Vimala's [11] work outlines the development of a biometric voting machine using a fingerprint scanner and Arduino. In this system, voters enroll their fingerprints, which are centrally stored in the Arduino. During voting, if a fingerprint matches the stored data, the individual can cast their vote, and the candidate's name is displayed on an LCD screen as shown in figure 5. The primary goals of this system are to simplify voting, reduce polling time, and ensure accurate counting. The essential components include a fingerprint sensor, Arduino Uno, LCD, connecting wires, and resistors. The introduction covers biometrics, while the literature survey explores related research areas, including blockchain and cryptographic methods in voting systems. The overarching objective is to design a secure system that addresses existing limitations.

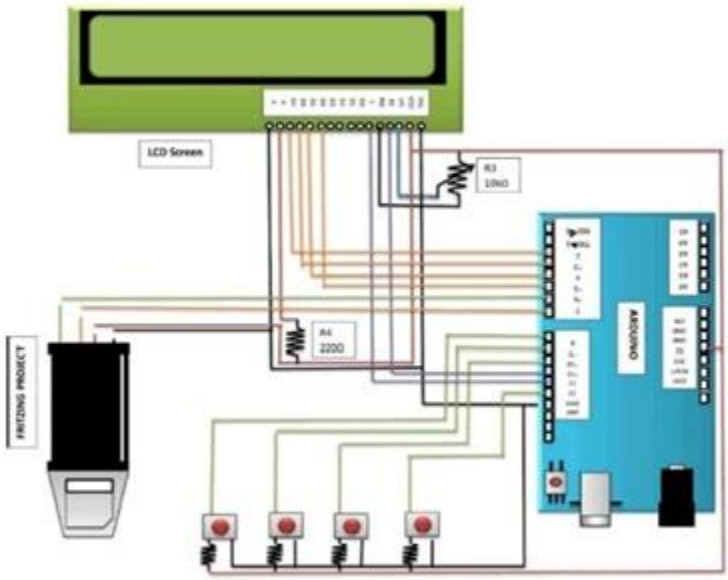

Figure 5: Circuit diagram of Arduino Nano

Shrushti Sankhe [14] discusses a Biometric Voting System (BVS) designed for secure electronic voting, leveraging fingerprint authentication and online modules. The BVS aims to address issues inherent in traditional voting systems, with a strong emphasis on reliability, security, and accessibility. The document outlines the methodology, advantages, disadvantages, and future scope of the BVS. It also reviews related literature, highlighting the potential of biometric technology. Notably, the BVS is designed with a fault-tolerant approach, and plans for multi-biometric expansion are emphasized as shown in figure 6. The document concludes by acknowledging contributors and providing relevant references.

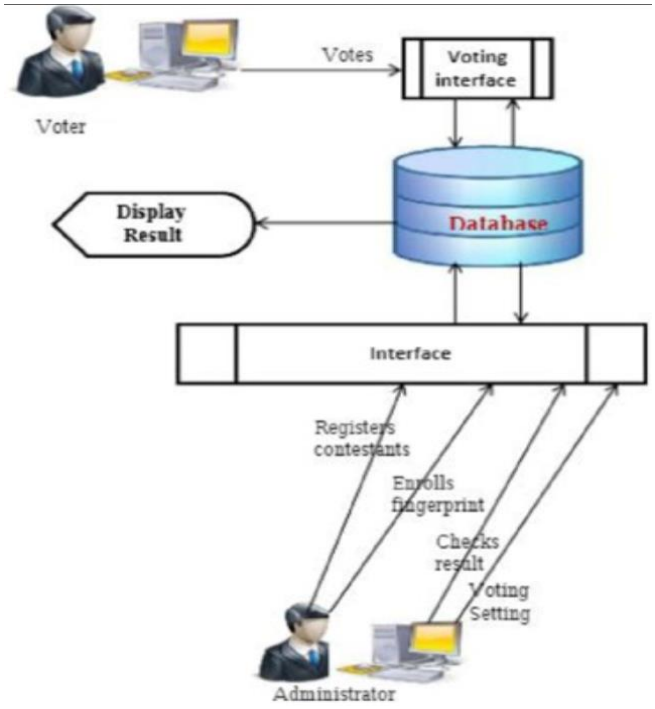

Figure 6 : System Architecture for the BVS System

G. Nithya [12] discusses a fingerprint-based electronic voting machine (EVM) that utilizes Arduino to enhance voting security. This EVM incorporates fingerprint verification, storing voter details in a database and allowing only authenticated voters to cast their votes. The hardware components include Arduino Uno, fingerprint module, LCD, keypad, ESP8266 WiFi module, and a DC motor for access control. The schematic diagram of EVM is show in figure 7. The work emphasizes the project's significance by detailing hardware components, working principles, schematic diagrams, and implementation results. It concludes by discussing potential enhancements, such as memory expansion and retina scanning, underscoring the EVM's crucial role in ensuring fair and secure elections.

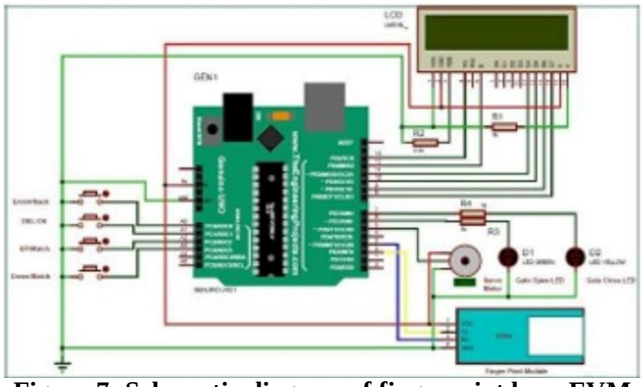

Figure 7: Schematic diagram of fingerprint base EVM

Parag Narendra Achaliya [13] conducted a review of a Biometric Voting System that utilizes fingerprint sensors for authentication, with the primary goal of preventing malpractices. In this system, if a voter's fingerprint doesn't match the database, the system alerts the authorities. Voting results are centrally stored, and statistics are generated on an admin portal for quick access. The document not only reviews existing voting systems but also introduces the proposed Biometric Voting System, emphasizing its high level of security. It provides detailed insights into the stages of implementation, stressing the importance of a legal framework. The conclusion highlights the effectiveness of fingerprint recognition and acknowledges the guide and department for their support.

A study by A. Ganesh [15] proposes a "Biometric Voting System Using Arduino Uno and LabVIEW" to enhance India's voting process. The system focuses on security and efficiency, utilizing biometric identifiers, GSM, and Wi-Fi modules. Arduino Uno and LabVIEW serve as the programming platform. The research includes a literature survey, highlighting related works and software requirements. Implementation involves circuit connections, LabVIEW-Arduino code, and real-time database usage. The system sends alerts and displays election results. The conclusion emphasizes the potential impact of this system on fair elections and suggests future enhancements.

Vakiti Mounika's [16] work focuses on implementing a secure electronic voting system with embedded security. Biometric authentication is a key feature, addressing challenges in e-voting. This paper discusses methods like iris recognition, fingerprint sensing, finger vein sensing (for offline e-voting), and facial recognition (for online e-voting). One-time passwords enhance online voter authentication. The proposed system covers user registration, biometric enrollment, and authentication. It prioritizes security, privacy, and accuracy. Detailed flow diagrams and screenshots are included. The work advocates for electronic voting systems' advantages over traditional methods, urging further improvements in usability, security, and privacy. References to relevant studies enhance the credibility of the proposed system.

Abeesh A I's Finger Print-based Voting System [17] A research team at KLE in Belgaum, India developed a voting system with the goal of enhancing the voting process through biometric fingerprint devices for identity verification. In this system, physical IDs are no longer necessary; instead, voters have their fingerprints scanned at the polling booth. The system then verifies their identity by comparing it with pre-stored data. Successful matches allow individuals to cast their votes using push buttons, with relevant messages displayed on an LCD screen. The document provides a detailed overview of the system's components, working process, and advantages, including cost-effectiveness, low power consumption, and prevention of invalid voting. Despite some sensitivity issues with the fingerprint module and the need for user enrollment, the system offers a secure and reliable method for voter identification, contributing to the integrity of democratic elections.

Mahboob Karim's Biometric Electronic Voting System [18] proposes an innovative Biometric Electronic Voting System aimed at enhancing the voting process in Bangladesh. The system addresses transparency and efficiency issues inherent in the existing manual voting system. Leveraging biometric authentication, this framework automates the voting process, overcoming limitations associated with traditional Electronic Voting Machines (EVMs). During voter registration, detailed information and fingerprints are collected for enhanced security. Fingerprint authentication ensures accuracy during voting. Notably, the system promptly notifies authorities of any irregularities, promoting transparency. The research document discusses global initiatives related to biometric EVMs, outlines future improvement plans, and provides insights into a successful prototype developed using Arduino Mega and fingerprint modules. In conclusion, the proposed Biometric Electronic Voting System holds immense potential to revolutionize elections in Bangladesh, aligning with democratic values. While acknowledging prototype limitations, the authors plan future enhancements to further increase its effectiveness.

G. Saranya's [19] document delves into the development of a Smart Electronic Voting Machine. This innovative system integrates technologies such as the ARM7 microcontroller**,** fingerprint sensor**,** and RFID to enhance the security and accuracy of the voting process. Unlike traditional methods, this machine offers superior reliability. It tackles challenges related to manual voter identification by incorporating fingerprint verification and RFID technology. Additionally, GSM technology is used for sending verification messages to voters' parents. The hardware implementation details the ARM7 microcontroller's features and outlines the voter verification process algorithm. Overall, the Smart Electronic Voting Machine represents a significant advancement in electronic voting technology, addressing issues like multiple voting and ensuring vote validity. The references cited in the document reflect thorough research and the application of established principles in its development.

IV. COMPARISON TABLE

Paper No.	Advantage	Remarks
1	Enhanced Authentication and Fraud Prevention	IoT-based fingerprint system for higher voter authentication, minimizing fraudulent voting.
2	Remote Voting and Comprehensive Modernization	Smart voting with face recognition technology enabling remote voting and modernizing infrastructure.
3	Accuracy, Security, and Speed	Biometric system with facial recognition and machine learning for enhanced accuracy and security.
4	Two-Factor Biometric Authentication	Secured e-voting with facial and fingerprint recognition as two-factor authentication.
5	Multi-Layer Security and Portability	Electronic voting kiosk using Raspberry Pi with multi-layer security for increased voter turnout.
11	Simplified Voting and Accuracy	Biometric voting machine simplifying the process and ensuring accurate counting.
12	Enhanced Voting Security	Fingerprint-based EVM with Arduino ensuring only authenticated voters can cast their votes.
13	Central Storage and Alerts	Biometric Voting System with fingerprint sensors, alerting authorities on mismatches.
14	Secure Electronic Voting	BVS designed for secure electronic voting with fingerprint authentication and online modules.
15	Security and Efficiency	Biometric Voting System using Arduino Uno and LabVIEW for secure and efficient voting.

V. CONCLUSION

In conclusion, biometric and face recognition systems represent a significant leap in security and authentication technology. By leveraging unique physiological or behavioral traits, these systems enhance access control, identity verification, and privacy protection. Their widespread adoption across various domains, including law enforcement, banking, and personal devices, underscores their effectiveness. However, challenges remain, such as ensuring accuracy, addressing biases, and safeguarding against spoofing attempts. As research and development continue, the future holds promising advancements in biometrics and face recognition, shaping a more secure and convenient digital landscape.

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VII. ACKNOWLEDMENT

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