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Full Length Article

Advanced Electronic Voting Machine Using Fingerprint Sensor And Arduino
Phase-I

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ABSTRACT

The rapid growth of electronic system has increased the need for secure, transparent, and reliable voting systems. This paper presents the design and implementation of an advanced Electronic Voting Machine (EVM) integrated with a fingerprint sensor and Arduino microcontroller to enhance and improve election security and eliminate wrong voting practices. The proposed (suggested) system uses biometric authentication to uniquely identify voters, assuring that only authorized individuals are allowed to cast a vote. The fingerprint sensor captures and verifies voter fingerprints against a pre-stored database, preventing false representation and multiple voting procedures. The Arduino platform acts as the central control unit, managing voter verification, vote recording, and system operations efficiently with minimal hardware complexity and low power consuming. Also, making the system suitable for large-scale deployment in both urban and rural areas. The projected EVM decreases human interference, and minimizes operational faults, also improves voter sureness in the election procedure. The results prove that the fingerprint-based voting system offers the high reliability, fast verification, and strong safety, and making it up-to-date self-governing elections. This project plays a vibrant role in refining the election process by minimizing human mistakes, and giving quick and precise vote counts. The system certifies that each voter can give or cast only one vote and all that data is safely recorded or stored for final process or we can say results process. Identity verification is secure and distinctive thus which may implement in mechanical device to realize high secure election. The Electronic Voting Machine using Arduino Uno demonstrates how embedded systems can contribute efficiency and transparent elections in both small-scale and large-scale applications and develop secure voting system.

I. INTRODUCTION

The honesty, transparency, and security of election processes are essential supports of any self-governing system [1][2]. Old-style voting process, plus paper ballots and conventional Electronic Voting Machines (EVMs), have meaningfully improved the speed, efficiency of the elections; but, it still face challenges such as voter impersonation, multiple voting, unauthorized access, and dependence on physical identity confirmation [3][4]. With the quick progress of embedded systems and biometric skills, there is a increasing need to integrate more safe and consistent authentication instruments into a voting system [5][6]. An advanced Electronic Voting Machine (EVM) using a fingerprint sensor and Arduino microcontroller presents an advanced and new ideas solution to these challenges by combining the biometric proof with automatic vote recording [7][8]. This combination improves election safety by safeguarding that only authenticated voters can give their vote, thus reduce fraud and improve public trust in the election process [9].The planned system uses a fingerprint sensor module for biometric confirmation and an Arduino microcontroller (MC) is the central processing unit, to manage the all operations of the voting system. Fingerprints is a unique, to each different person and remains consistent throughout a person's lifetime, it makes them as a highly reliable way for individuality verification. At the time of the voting procedure, the voter foremost records their fingerprint in the system databases. On election day, the fingerprint module takes the voter's fingerprint and compare and matches it with the stored data, to verify authenticity. Once it is verified, the Arduino device allows the voting interface, and also allowing the voter to choose their chosen applicant with a help of push buttons or a digital display unit. The structure records and keeps the vote safely and stops, avoids the matching and marking it as the authenticated voter as "voted" in the database.

II. LITERATURE SURVEY

The literature survey shows that many researchers have proposed biometric-based electronic voting systems to improve election security. Most systems use fingerprint authentication with microcontrollers such as Arduino to verify voters before allowing them to cast their vote.

Authors	Year	Title of paper	Method/ Technology used	Contribution	Advantages	Limitations
P. Bhargavi, A. Pavan Kumar, K. Chaitanya et al. [4]	2024	Design and Implementation of a Secure Electronic Voting System using Fingerprint Identification and Real-Time SMS Notification	Arduino microcontroller, fingerprint module, GSM module, LCD	Proposed a secure voting system where fingerprint authentication verifies voters and SMS notifications provide real-time voting updates.	Provides secure voter authentication using fingerprint verification and gives real-time SMS notifications which improves transparency.	Requires GSM network for sending SMS and increases system cost due to additional modules.
Amitesh Yadu, Omprakash Chandrakar [27]	2024	A Smart Voting System Combining Fingerprint and Facial Recognition for Enhanced Security	Fingerprint scanner, webcam, microcontroller	Introduced a dual biometric system using fingerprint and face recognition to reduce fake voting and improve voter identification.	Uses both fingerprint and facial recognition which increases accuracy and reduces fake voting.	Dual biometric system increases complexity and requires higher processing power and cost.
Zakiah Mohd Yusoff et al. [3]	2023	Fingerprint Biometric Voting Machine Using Internet of Things	Arduino Uno, fingerprint sensor, IoT cloud system	Developed an IoT-based voting system that verifies voters using fingerprints and stores results digitally in the cloud.	IoT based system allows digital storage of voting results and remote monitoring.	Dependence on internet connection may create security risks and network issues.
P. Nethaji Venkata Sai et al. [21]	2023	Arduino Based Electronic Voting Machine	Arduino, fingerprint reader, LCD, push buttons	Proposed a biometric voting system where the voter's fingerprint is verified before allowing vote casting.	Fingerprint verification ensures that only authorized voters can cast their votes, improving election security.	System may fail if fingerprint sensor does not properly read the fingerprint.
M. Satyanarayana, Rajiv pranam et al. [22]	2023	Biometric-Based Electronic Voting System	Fingerprint authentication, database storage	Designed a fingerprint-based EVM to ensure only registered voters can vote and receive confirmation messages.	Ensures that only registered voter can vote and provide confirmation messages for successful voting.	Requires secure database and management and may face privacy concerns regarding biometric data storage.

Suraj H.P. et al. [5]	2022	Arduino Based Smart and Remote Voting System with Dual Biometric Authentication	Arduino, fingerprint recognition, face recognition	Proposed remote voting with dual biometric verification to increase election security and reliability.	Dual biometric authentication improves reliability and reduces chances of duplicate voting.	Requires additional hardware such as camera and fingerprint module which increases system cost.
p. Vimala, n. Khadhar basha et al. [23]	2022	Biometric Voting Machine Based on Fingerprint Scanner and Arduino	Arduino controller, fingerprint scanner, LCD	Developed a biometric voting machine where voters are verified through stored fingerprint templates before voting.	Simple biometric authentication using Arduino and fingerprint scanner makes the system easy to implement.	Limited storage capacity for fingerprint templates and may not support large scale elections.
Tuerxun waili, Amir Nurlman Mohd Zaid [1]	2020	Advanced Voting System Using Fingerprint	Fingerprint biometric system, microcontroller	Proposed a secure voting system using fingerprint identification to reduce duplication and ensure voter authenticity.	Fingerprint identification helps prevent duplicate voting and improves voter authenticity.	Biometric system may face issues if fingerprints are damaged or not properly captured.
Marwa Adeed al-Jawaherry [24]	2019	Arduino Based Electronic Voting Machine	Arduino Mega, fingerprint sensor, TFT LCD	Designed an EVM with fingerprint verification and stored vote results in flash memory for secure counting.	Secure vote storage in flash memory improves safety of voting results and ensures proper vote counting.	Requires additional memory hardware and may have limited scalability for large elections.

Some recent studies also integrate additional technologies like GSM notifications, IoT, and facial recognition to further enhance security and transparency in the voting process.

Challenges in Existing Voting System

In many democratic nations, elections are directed using a voting system where residents select their governments through polling [17]. However, the currently used voting systems are not completely profitable or reliable [3][4]. Manual verification procedures are still required, so that it increases the overall time and resources needed to conduct the elections [18]. In the current voting process, separate ballot and control units are used, to choose candidates and polling officials allow voting access [19]. This old method is vulnerable to unlawful voting, including the possibility of votes being cast by invalid voters [7]. Also, the present voting device is highly sensitive to security threats such as sendup and interfering. These problems can lead to unfair election results, eventually affecting public trust and resulting in eligible residents losing their voting rights. Hence, there is a strong need for a secure, and automated voting system that reduces human interference and improve election integrity [6].

System explanation Suggested IoT Integrated Voting System

The automatic voting systems is developed before some years ago [3][25][26]. The prevailing systems have alone been approved in some growth obtained countries. That too, not all the countries develop together. As a result of the protection has not been totally preserved. We have a tendency to captive onto automation in the main to consider security, however, the prevailing systems didn't guarantee [17][20]. In the existing system, the voter selects a candidate using the ballot unit, while the polling officer controls the voting process through the

control unit [19]. Despite this arrangement, invalid voters may still cast votes, making the system susceptible to security breaches. As a result, such weaknesses may lead to incorrect election results and rejection of voting rights to genuine voters [4].The proposed (suggested) system introduces a biometric-based electronic voting machine that uses fingerprint authentication to enhance security and accuracy [7][10]. In this system, biometric data of eligible voters is collected and stored securely in a database during the registration phase [13]. Once a voter's fingerprint is enrolled, the individual becomes authorized to participate in the election.During the day of voting, the voter places their finger on the fingerprint sensor. The system compares the scanned fingerprint with the stored data to verify authenticity [14]. If the fingerprint matches the data, and it is correct the voter is allowed to give a vote for the selected candidate [15]. The LCD screen shows the voting procedure and helps guide the voter through voting process [11].The proposed mechanical device technique is consisting of fingerprint sensor it is use to scan voter's finger for enrolment and identification. voters finger has to match with database that is already kept. Results should be given to computers to verify it and authenticate it. For the staffing unit, the sensor scans a voters data double to make identity and to be secure. The image is extracted with the position and direction of finger alignment are available in database. If the fingerprint matches with database and required details it will allow to vote, first thing is to store the fingerprint value in database and is named as enrolment using this information it will cast their votes. Identification is for identify the given fingerprint supported the information that is already kept. If the fingerprint matches it'll enable you to vote otherwise it'll print as invalid or shows wrong person fingerprint. Verification is to verify whether it is eligible for voting or not. One to one matching is used during this process. Finally, voters cast their vote and it'll be kept. The elements are used in project are Arduino, Fingerprint sensor, universal synchronous receiver and transmitter (UART), personal computer and these are the main components used in the proposed system [8][10][16].

METHODOLOGY

HARDWARE COMPONENTS

Arduino uno:

It is used as main controller in this project. It controls all the operations of voting machine. It works like the "mind" of the entire machine. All the mechanisms such as the fingerprint sensor, LCD display, and buttons are connected to it. It is a microcontroller board based on the ATmega328P. It has digital and analog input/output pins that allow it to communicate it with different devices. It is easy to program using the Arduino IDE software. In this project, it controls the authentication process, stores vote counts, and manages the overall operation of the electronic voting machine in a simple and reliable manner.This device receives input from fingerprint sensor and processes the data.it also control the LCD displays, LEDs, push buttons, and buzzer. Arduino is used because it is suitable for small projects. Figure 1 shows Arduino uno which is used as main element in the project.

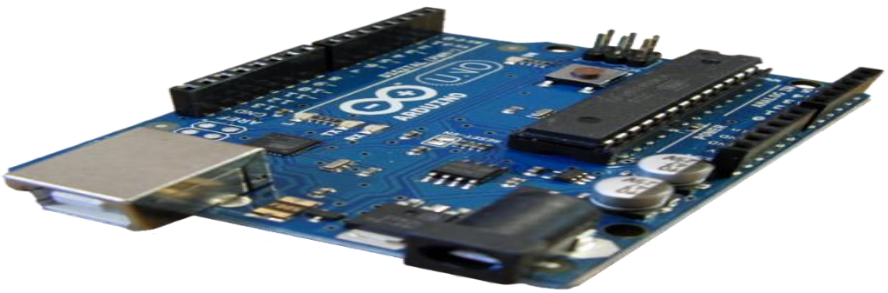

Figure 1: Arduino uno

Liquid crystal oscillator - LCD:

LCD display (16*2) is used to show messages and instructions to voter. The lcd is used to help the user understand the present status of system. It displays messages such as: Place finger, access granted, access denied, successfully voted and so on. It provide simple interface between machine and user. It makes the system more friendly and flexible and also easy to operate.The LCD is used to display messages and instructions to the voter. It acts as the communication medium between the system and the use. In this project, a 16x2 LCD is commonly used, which means it can display 16 characters in two lines. It helps the voter understand each step of the voting clearly. By providing proper guidance, the LCD makes the system accessible even for first-time users.

The figure 2 shows liquid crystal oscillator.

Figure 2: LCD display.

Fingerprint Module:

It is electronic device that is use full for storing, scanning and recognizing the fingerprint. It is basically used for security and safety purposes. A fingerprint module works like a digital guard. It helps in checking whether an individuals fingerprint matches the already saved data in the memory or not. If it matches, it will give access or if not matches it will decline. Fingerprint is a glass surface where a person can place their fingers. It captures the image. Inside the module fingerprint image is processed and then it will be converted into digital data. It stores the authorized users data. It works like first we need to place the finger on the sensor then, it captures the image, after that it will checks the unique patterns then compares it with stored data and finally if it will match the data then it will grant or give permission for voting. It will identify people correctly, takes only 2 seconds.

The figure 3 shows fingerprint sensor.

Figure 3: fingerprint sensor

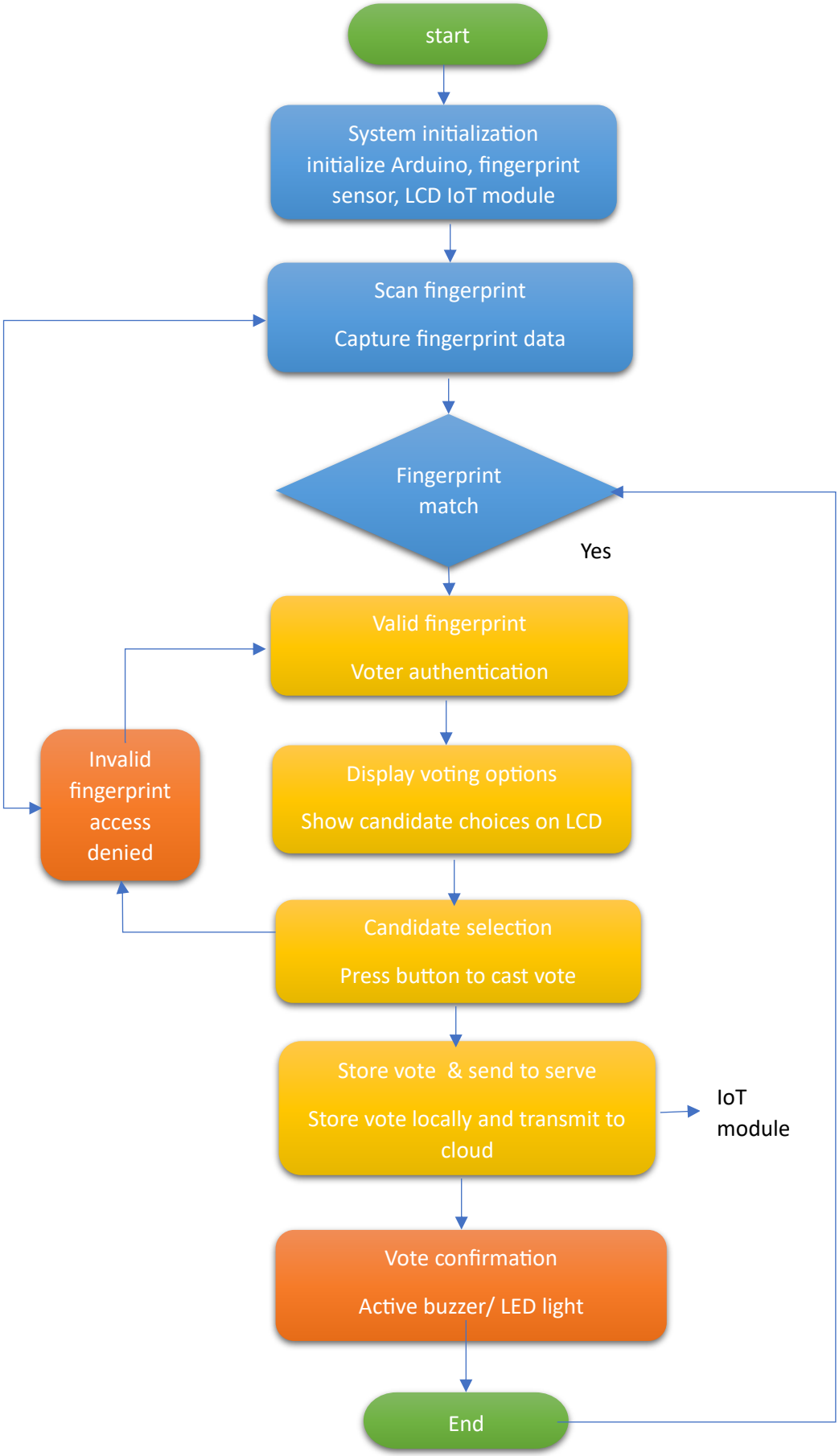
start
System initialization
initialize Arduino, fingerprint sensor, LCD IoT module
Scan fingerprint
Capture fingerprint data
Fingerprint match
Yes
Valid fingerprint
Voter authentication
Invalid fingerprint access denied
Display voting options
Show candidate choices on LCD
Candidate selection
Press button to cast vote
Store vote & send to serve
Store vote locally and transmit to cloud
IoT module
Vote confirmation
Active buzzer/ LED light
End

Figure 4: flow chart of IoT enabled fingerprint electronic voting system

SOFTWARE COMPONENTS:

Arduino IDE:

The whole determination of the "Arduino IDE software " is to allow for easy and fast response. the skill to merely attach to show and be ready to display messages in minutes rather than taking hours, simply surprisingly powerful and convenient once you have a concept in your head and just need to visualize if it works. When you want additional management and are literally thinking on changing your epitome into a true product, then yes, you would like to urge at heart into the microcontroller and obtain eliminate all the surplus fat, trim the circuit to simply the clean bones, optimize the code and build them simply graspable etc. For prototyping, the Arduino platform provides you loads of pre-wiring and free code libraries that may allow you to consider testing your plan rather than payment some time building supporting electronic equipment or writing plenty of low-level code.Since the beginning of the Arduino, it's not a microcontroller any longer however a scheme and setting that is ported to completely different architectures. Arduino ide software is easy to use and access. it is simple and efficient.

COMPARISON OF ALGORITHMS:

Algorithm type	**description**	**Suitability for Arduino uno EVM**	**Performance metrics (Approx)**
Minutiae-based matching	Extracts and compares unique local features of a fingerprint, such as ridge endings and bifurcations.	Highly suitable. It requires less memory and it is faster than other methods, making it ideal for the Arduino, limited resources.	Accuracy ~ 99.25% (when combined with correlation features in advanced studies), very low memory usage (in KB), and fast processing time.
Correlation based matching.	Superimposes two fingerprint images and calculate the correlation between corresponding pixels.	Less suitable. It is computationally intensive and requires significantly processing power and memory (in MB) to store and compare full images, which strains the Arduino uno capabilities.	Slower processing time, high memory usage.
Pattern based (image based) matching	Compares general patterns, size, type and orientation of the aligned fingerprint images.	Less suitable, like correlation based it requires more memory and processing power for image alignment and comparison than is typically available on the Arduino uno.	Slower processing time, high memory usage.

Extraction Algorithm:

Correct image representation of a fingerprint image is vital and important for dependable automatic print ID. before removing details structures, the captured image undergoes numerous preprocessing stages, together with image enhancement, noise reduction, edge reconstruction, and feature study. These steps expand and improve image clarity and ensure that the take out details points are precise and suitable for additional matching processes.

Matching Algorithm:

The algorithm notices and checks similarity between two fingerprints that were created using feature extraction method.This algorithm compares the position and unique features of each fingerprint structure to see if they match.

Algorithm Steps:

Step 1: Start
Step 2: Scan voter's fingerprint
Step 3: Enrolled and stored
Step 4: Check voter's fingerprint matches
Step 5: Authorized voter, cast the vote
Step 6: Press a button from candidate list
Step 7: Candidate is selected
Step 8: The vote is successfully submitted
Step 9: The process ends.

CONCLUSION:

The advanced EVM developed using a fingerprint sensor and Arduino provides safe and secure voting system compare to old systems. By using biometric system, it helps us to cast vote securely. Also ensures that voter is identified before giving vote. It is a smarter way to conduct a vote. The system checks

the voter's fingerprint before allowing them to vote, because every fingerprint is unique for every person. The Arduino works as the main unit in the whole process. It connects all devices like lcd, fingerprint module and many more. It is easy to use and simple to understand. For those who are using it first time they can use it easily without any problem.it is not very expensive, people can afford it.Overall, this project demonstrates that the combining technology of biometric and embedded systems can progress election security. This system can be further improved in the future by adding features such as online result transmission, voter database management, and cloud storage. Therefore, this advanced EVM can play a significant role in building a fair, trustworthy election process.

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