Arduino Based Authenticated Voting Machine (AVM) using RFID and Fingerprint for the Student Elections

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Abstract. The guiding principles of democracy are free elections. Through elections, people reaffirm their voice, their beliefs, and select someone whose ideas support them most. Voters will elect their representatives via elections. The purpose of the elections is not only to decide the outcome but also to give the winners credence, also for those voters who did not bother to vote for them. The need to hold free, equal, and secret elections is emphasized here. It involves the supervision of elections by free, accountable, impartial and autonomous electoral bodies. As the phrase is 'today teens, tomorrow's citizens,' the student community needs the process of elections to be involved, trained, and acquainted with. Under this respect, the institutions of higher education hold elections in the form of general elections to the Office of the student councils. By this student will receive first-hand information about filing nomination, scrutiny of papers, withdrawing, canvassing, addressing, and most importantly voting. The use of technology in voting will make it easier, more effective, and less prone to breaches of security. Technology will boost and speed up the safety of all votes and make the counting and automated verification much more effective.

The design of an advanced voting system is a difficult task as many main requirements have to be met. The secrecy of a poll should be maintained. No proof of which candidate gets particular voting shall be provided by the voting system. The authors implemented the Authenticated Voting Machine in the College elections in this paper to ease the process and improve transparency. The concept is still in its infancy and requires more research to keep it stable and theoretically strong. To ensure protection, the model uses radiofrequency and fingerprint recognition.

1. Introduction

Elections are an important feature of the democratic arrangement. To make the students understand the concepts of democratic structure and to inculcate leadership quality elections are conducted in schools and higher education institutions. Students’ Council is the largest student body in an educational institution. It is through Students’ Council students voice their opinions and express their grievances about the system. Technology has brought drastic changes in almost every field; the election process is not an exception to this. People rely on technology to make their work easy, fast, and accurate. Conventional paper ballot based voting system is simple but it is not transparent and error-free [1]. To overcome the limitations of conventional paper-based ballots Authenticated Voting System (AVM) is introduced. It uses two levels of authentication namely Radio Frequency Identification (RFID) and
During the time of the admission process, the biometric of every student is recorded and stored along with other necessary documents. Once the admission process is complete RFID-based identity cards are issued to every student. This ID card is the first identity proof for the election. The student who possesses a valid ID card can only participate in the election process. During the election process, the student places the RFID card on the card reader. To ensure that the card belongs to the same student who possesses it, the second level of authentication is used. In the second level biometric of the student is accepted using a fingerprint scanner available on the voting machine. This fingerprint is compared to that of the one stored in the database. If both the fingerprints match then only the student is permitted to vote. The necessary details are stored in the college database and the votes are stored in the voting machine itself [2] [3-5].

The voting system under discussion works for a maximum of three candidates for a single post. If there are more posts then a separate voting machine is to be used for each post. To speed up the voting process when there are more thousands of students, the entire college is logically divided into several blocks and the number of AVM units required is equal to the number of blocks, and each of the blocks contains a booth-level operator (BLO). Fingerprint data of students will be retrieved for the college database. To do so, Internet connectivity preferably Wi-Fi is needed [6]. This paper outlines specifications for pre-implementation, system architecture, modular decomposition, user interfaces, device operation and potential for development.

2. Pre-requisite

The organization must fulfill the following two conditions to enforce the AVM for voting in an educational system.

- Full student records like biometrics such as fingerprints must be stored in the institution's central database.
- Every student is issued with RFID Student Identification Cards.

3. System Design

The key components of the Automated Voting Machine presented in this paper are the two-one AVM unit and another User Interface (UI). AVM consists of IoT-component such as an Arduino Mega Board, Fingerprint Scanner, RFID Reader, WiFi Interface, Buzzer, mini LCD Monitor, and momentary push buttons integrated using breadboard and programming using Python programming language. The UI component is used for the configuration of the AVM device, by providing the initial values and commands needed. The designed AVM units are kept under the supervision of Booth Level Officer in election counters throughout the election process. The device must operate independently and interact via the wireless network with the central database to authenticate voters. Students visit one of the counters and exercise their voting rights [7-9]. The system design of the AVM unit is detailed in Figure 1 below.

ARDUINO MEGA 2560 R3 based on the Tmega2560 micro-controller is the brain of the AVM. All other integrated devices are controlled by this controller. The board has 14 digital input/output, 16 analog input, and 4 Universal Asynchronous Receiver/Transmitter pins. Also, it is integrated with 16MHZ crystal oscillator, DC power jack, USB connection, In-Circuit Serial Programming header, 8KB SRAM 4KB EEPROM, and 256KB Flash Memory. 9V AC-DC Power Supply Adapter is used to power the board and the circuit is made using a breadboard [10].
4. Module Design

4.1. RFID module
Every RFID tag is unique and stores a student's details. Such information regarding the RFID tag is already stored in this reader. To identify the voter, the system is using a contactless communication MFRC522RFID reader/writer module. This highly integrated RFID transmission module communicates at 13.56MHZ and uses a serial peripheral interface to communicate with the microcontroller [11-12].

4.2. Fingerprint module
R307 Fingerprint Module consists of optical fingerprint sensors, a fast DSP processor, a high-performance algorithm for aligning fingerprints, high-capacity FLASH fingerprints, and other composition of hardware and software, stability, simple layout, fingerprint entry, image processing, fingerprint matching, searching for and storage template and other functions. It is used to detect and verification of fingerprints. The fingerprint of the voter is already stored in the database which is matched at the time of voting using this module. High powered DSP chip is used for detection and verification by connecting it to the microcontroller with TTL serial. It sends data packets of fingerprints for detection. As every person has a unique finger image, a secured method is used for authentication of the voter at a low cost. The fingerprint processing unit has two functions: fingerprint enrolment and matching. The user can configure and store fingerprints in 1:1 or 1: N mode for the person and which is used at the voting period for identification of a person with multiple fingerprints also. In 1:1, comparison, this module compares the live finger to a specific template stored in the file, while in 1: N searching and matching, the module can consider a full image library for matching fingers. This process will ultimately end in failure or success [13-15]. The figure of the working AVM System given in Figure. 2.
4.3. WIFI module
To establish communication between the EVM and external data sources, the ESP8266 WiFi module is used. It allows microcontrollers to connect to a Wi-Fi network and to make simple, Haye-style TCP/IP connections. This system on a chip (SoC) module is commonly developed and used for IoT embedded applications. A set of AT commands are needed by microcontrollers to communicate with this ESP8266 module [16].

4.4. Switch module
The switch module includes an LCD crystal display, a Buzzer, and buttons. In this case, LCD is used to show messages. The vote is cast individually by the voters. The 12C liquid crystal display consists of four connections, which are GND, VCC, SDA, and SLC. It is capable of displaying 16 characters per row in two lines. This LCD screen bridges the gap between user and Arduino by showing the appropriate programmed message such as when to show id card, when to place finger, what is the status etc. When the authentication completes the system will allow the voter to cast his/her vote by pressing one of the three candidate buttons. If LED blinks once, the message of the successful vote will be displayed on the same LCD. Momentary mini pushbuttons are used as control buttons and to make candidate selection. The piezoelectric buzzer is used to add additional functionality. This is a small 2-pin structure that is used to generate audible warnings when the LCD shows the ballot message or some finger is identified incorrectly [17-18].
5. Interface Design

Figure 3 is providing the user interface structure of the AVM system. It contains only two main modules namely Election Commission (EC) and Student. EC has the right to create a BLO and add candidates for the election. It contains two main modules namely EC and BLO. EC has two sub-modules one to manage BLOs and another to manage students. EC can add, delete, or update the records of BLOs. In manage students, sub-module EC can view the details of students and view the results of the election process. As the data related to students is retrieved from the college database EC has no right to manipulate student records. BLOs module has two sub-modules manage council posts and manage candidates. All information related to the election process is posted by BLO using add post sub-module. Some of the posts include the last date of filing the nomination, last date for withdrawal of nomination, etc. are posted by BLO using add post module. BLO has the right to delete a post also. The process of filing and withdrawing of nominations is managed by the manage candidate sub-module.
Figure 4. Home Screen

Figure 5. View BLO

Figure 5 shows the GUI used by BLOs to add individual candidates. When the system is ready for the voting processes it displays the relevant message on the LCD on the AVM. Students are expected to swipe their respective RFID cards. Once this authentication is done, students are asked to keep their fingerprints on the fingerprint reader. The input thus obtained is matched to the corresponding data of student retrieved from the college database. If any discrepancies the student is not allowed to vote. Once the student passes the second level of authentication, he/she is permitted to vote. Upon the completion of the election process, the EC can view the result [20].

Figure 6. Add Candidate

6. Functioning of the AVM System
This program is specifically intended for elections to the Education Institutions Council of Students. The system assumes that student information including fingerprints is registered in the database and that each student is issued with RFID identification cards. In general, the students are the voters here. One of the limitations of this system is the need for a separate AVM for a post. This means that an
AVM machine is used for the election to a specific position of the Council of Students. The steps from the nomination of the candidate to announce the result in the electoral process is shown in Figure. 7.

Figure 7. Flow of election process

- The election process begins with a formal notifying by the election commission of the College, followed by a nomination of the corresponding block officers for each position.
- Candidate interested to contest for a particular post approach corresponding BLO and file the nomination. BLO in turn upload details to the system.
- The applicant can, by a certain last date for the cause, withdraw the application if he/she decides it.
- Upon the expiry of the last date, the BLO upload candidate names to AVM and reset the machine counters.
- On the day of the election, the BLO install AVM in a voting counter and activates the voting process.
- Students visit the voting counter and volunteer himself to exercise his franchise.
- After preliminary verification, the BLO enable the voting process.
- Students show their RFID ID card to the RFID reader which will read student roll no and sends to the microcontroller.
- The data so read is verified by checking with the student database. If verified to false student need to retry.
- The second level of authentication process being if verified ok.
- Now the student places his previously introduced finger on the Fingerprint scanner.
- Which read fingerprint image, process it and sends to the system.
The system verifies it by comparing the image just read in the student database
If not authenticated, the process gets aborted.
If verified ok, the voting buttons will be enabled so that he can make a choice
Now the students press any one button against the candidate name. With this voting is done
The machine gets locked automatically.
Finally to view the result the BLO press RESULT button which shows the result stating which candidate received how many votes [21-23].

Figure 8. Messages displayed in the process of voting

7. Conclusion & Future Work
In this paper, the authors presented an intelligent and secure authenticated voting system based on Arduino flat-form IoT technology for college elections. To ensure the security of the voter and preserve the sanctity of the method, a two-layer security scheme is introduced. We assume this method is useful in conducting fair and open Student Council elections for schools. Although the system produces the expected performance and efficiency, it is not 100% perfect. Some limitations of the system have been found. The system is supporting only three candidates at a time as it has only three voting switches. This can be addressed in our future work. Further, the system enables the election to only one post at a time. We can design the system such that it can be used to conduct elections to any number of posts at the time. One more point is that Arduino mega board has limited memory. In our future work, we are planning to use Raspberry Pi based board of the AVM. The devices built into this project can be updated, and the data can be stored in the cloud server and automated voting to speed up the voting process. As the system is in its infancy, more work is necessary to make it versatile and more adaptable. It is in beta; we will present a device that is upgraded, error-free, stable, and scalable in our future work.

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