Automatic Electronic Voting System

By

Huma Hashmi

CUI/FA19-EEE-047/ATD

Rana Ali Ahmar

CUI/FA19-BCE-033/ATD

Hamza Ahmed

CUI/FA19-BCE-031/ATD

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By

Huma Hashmi

CUI/FA19-EEE-047/ATD

Rana Ali Ahmar

CUI/FA19-BCE-033/ATD

Hamza Ahmed

CUI/FA19-BCE-031/ATD

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Name	Registration Number
Huma Hashmi	CUI/FA19-EEE-047/ATD
Rana Ali Ahmar	CUI/FA19-BCE-033/ATD
Hamza Ahmed	CUI/FA19-BCE-031/ATD

Supervisor

Dr. Zahid Jehangiri

Associate Professor, Electrical and Computer Engineering

Abbottabad Campus

COMSATS University Islamabad (CUI)

Abbottabad Campus

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Final Approval

This thesis titled

Automatic Electronic Voting System

By

Huma Hashmi

CUI/FA19-EEE-047/ATD

Rana Ali Ahmar

CUI/FA19-BCE-033/ATD

Hamza Ahmed

CUI/FA19-BCE-031/ATD

Has been approved

For the COMSATS University Islamabad, Abbottabad Campus

Supervisor:_____

Dr, Zahid Jehangiri, Associate Professor
Department of Electrical and Computer Engineering Engineering/CUI,
Abbottabad Campus

HOD: _____

Dr. Owais, Professor
Department of Electrical and Computer Engineering, CUI, Abbottabad Campus

Declaration

We, Huma Hashmi (CUI/FA19-EEE-047/ATD), Rana Ali Ahmar (CUI/FA19-BCE-033/ATD), and Hamza Ahmed (CUI/FA19-BCE-031/ATD), hereby declare that we have produced the work presented in this thesis, during the scheduled period of study. We also declare that we have not taken any material from any source except referred to wherever due that amount of plagiarism is within acceptable range. If a violation of HEC rules on research has occurred in this thesis, we shall be liable to punishable action under the plagiarism rules of the HEC.

Date: July 2023

Signature of the student:

_____

Huma Hashmi
CUI/FA19-EEE-047/ATD

_____

Rana Ali Ahmar
CUI/FA19-BCE-033/ATD

_____

Hamza Ahmed
CUI/FA19-BCE-031/ATD

Certificate

It is certified that Huma Hashmi (CUI/FA19-EEE-047/ATD), Rana Ali Ahmar (CUI/FA19-BCE-033/ATD), and Hamza Ahmed (CUI/FA19-BCE-031/ATD) have carried out all the work related to this report under my supervision at the Department of Electrical and Computer engineering, COMSATS University Islamabad, Abbottabad Campus and the work fulfills the requirement for award of BS degree.

Date: July 2023

Supervisor:

_____

Dr. Zahid Jehangiri
Associate Professor
Department of Electrical and Computer Engineering

Head of Department:

_____

Dr. Owais
Professor
Department of Electrical and Computer Engineering

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Huma Hashmi FA19-EEE-047
Rana Ali Ahmar FA19-BCE-033
Hamza Ahmed FA19-BCE-031

ABSTRACT

Automatic Electronic Voting System

Electoral fraud is common in countries that have weak rule of law. The most severe and frequently happening illegal activity while conducting elections is rigging. It is an electoral fraud and interference with the election process, which is prevalent in many countries. Voting is a very difficult and time taking process. Many countries wish to avoid conducting elections manually. However, free and fair elections conductions is always a question mark. An electronic voting machine is a system, which is designed keeping in view the flaws in the current electoral system of a country. Through this, a voter could vote easily through a face print. In previous systems, in countries like Pakistan, the NADRA office prints sheets of voters for different territories and establishes polling stations therein. Also, the election commission office has to hire a substantial staff to conduct the voting procedures. However, this process is expensive and consumes so much time along with the waste of many resources. Keeping in mind the aforementioned facts, this project aims to develop an Automatic Electronic Voting System (AEVS) that works in real-time with high accuracy and reliability. The proposed project comprises of various interconnected steps. First, the camera captures the image of the face of voter and the system checks for the verification of the user. Later, an efficient machine learning algorithm will detect and verify the face pattern of the person. On successful verification, he/she will cast his/her vote by simply pressing the button. In final stage, the votes cast for the candidate are displayed on the LCD screen. To perform this intelligent task, a python program will be loaded into the Raspberry-pi.

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ABBREVIATIONS

IT	Information Technology
FPTP	First Past The Post
E-Voting	Electronic Voting
AEVS	Automatic Electronic Voting System
ID	Identification
EVM	Electronic Voting Machine
ECP	Election Commission of Pakistan
NADRA	National Database and Registration Authority
LED	Light Emitting Diode
LCD	Liquid Crystal Display
RAM	Random Access Memory
HDMI	High Definition Multimedia Interface
DC	Direct Current
IoT	Internet of Things
ARM	Advanced RISC Machine
DSI	Display Serial Interface
SoC	System on Chip
ECC	Error Correcting Code
LAN	Local Area Network
TTL serial	Transistor- Transistor Logic serial
RX	Receiver
TX	Transmitter
UART	Universal Asynchronous Receiver- Transmitter
ID	Identity document
I/O	Input Output
NCC	Nearest Center Classifier
LDA	Linear Discriminant Analysis
N	No. of Images
CER	Classification Error Rate

Chapter 1

Introduction

1.1 Overview

Development of technology is one of the sensational development in 21st century. With the rapid growth of technology, technology has become vitally important in people's daily lives and people's life style has been changed and blended together with technology.

Technology, including the IT industry, in Pakistan has enormous potential for growth. But some hiccups, especially a lack of funds and encouragement for product development, have deterred start-ups from moving forward with disruptive innovations or technologies.

1.1.1 Electoral System in Pakistan

Evolution is the key to progress. Pakistan needs to explore a better system that can deal with advanced issues. Changes are needed in the electoral system to keep up with the world and deal with immediate problems. In general, there are two basic electoral systems to elect the members of the legislative council. The most used worldwide including Pakistan is "First Past the Post (FPTP)", while the other is "Proportional Representation" which is implemented in some of the developed countries. However, there are some defects in the current system. In the current system, two big parties make government mostly. Most parties do not tend to make enough seats due to the fewer number of candidates elected promoting the "two or few" parties system.

1.2 Problem Statement

Electronic voting systems are rapidly imbricating traditional paper-based voting. The current electoral ballot system consists of factors that make rigging in the whole electoral process such as counting of votes, fake voters and involvement of outside sources and also other problems like time consumption, cost budget problems etc. So the purpose of this project is to investigate how to model an authentic reliable and upright E-voting system so that a voter is submitted a vote in secure manner while maintaining the time, verification, budget and also the security of the entire system.

1.3 Objective

This project aims to design an Automatic Electronic Voting System (AEVS), which will identify a voter by going through face recognition before casting a vote. Specific objectives of the proposed AEVS are as follows.

- We aim to develop a user friendly and state-of-the-art voting mechanism using the concepts of biometrics, computer vision, and machine learning. The proposed AEVS will be implemented using Raspberry-pi and will detect and identify the face print pattern in real-time with high accuracy.
- We aim to propose an accurate, reliable, robust, and automated electronic voting system that can work in real-time. During the operation of the AEVS, all the data will be saved in the database of the voting system. After the closing of the voting time, the voting results will be generated automatically without delay.
- We are optimistic that this will save a lot of time. The main aim of our project is to ensure maximum transparency. We believe that such system will enable voting staff to efficiently perform their duties.

1.4 Benefits of the Project

We are optimistic that our proposed AEVS has the following potential advantages.

- It will ensure transparency during electoral processes. No one will be able to change the voting results. The proposed system will be free of any types of errors. Moreover, if any person argues, he/she can be provided the print receipt of the casted vote.
- Our proposed project will overcome the expense of voting and save time for the nation. It will be a reliable system. We believe that it will be environmentally friendly as it will require no ballot papers, which are used in conventional voting systems. Moreover, it will be a flexible system that can be upgraded easily. Furthermore, it will require very limited resources and can be used in remote places, where electricity is not available.

We are hopeful that our proposed project will be handy to facilitate security agencies and will resist illegal voting activities. This project also aims to solve rigging by giving obscure ID to each person through its Face print, which is unique to every individual.

1.5 Word Breakdown Structure

A Work Breakdown Structure sets a project's scope by breaking down the overall mission into cohesive sets. Given below is the Work Break down Structure of our proposed project:

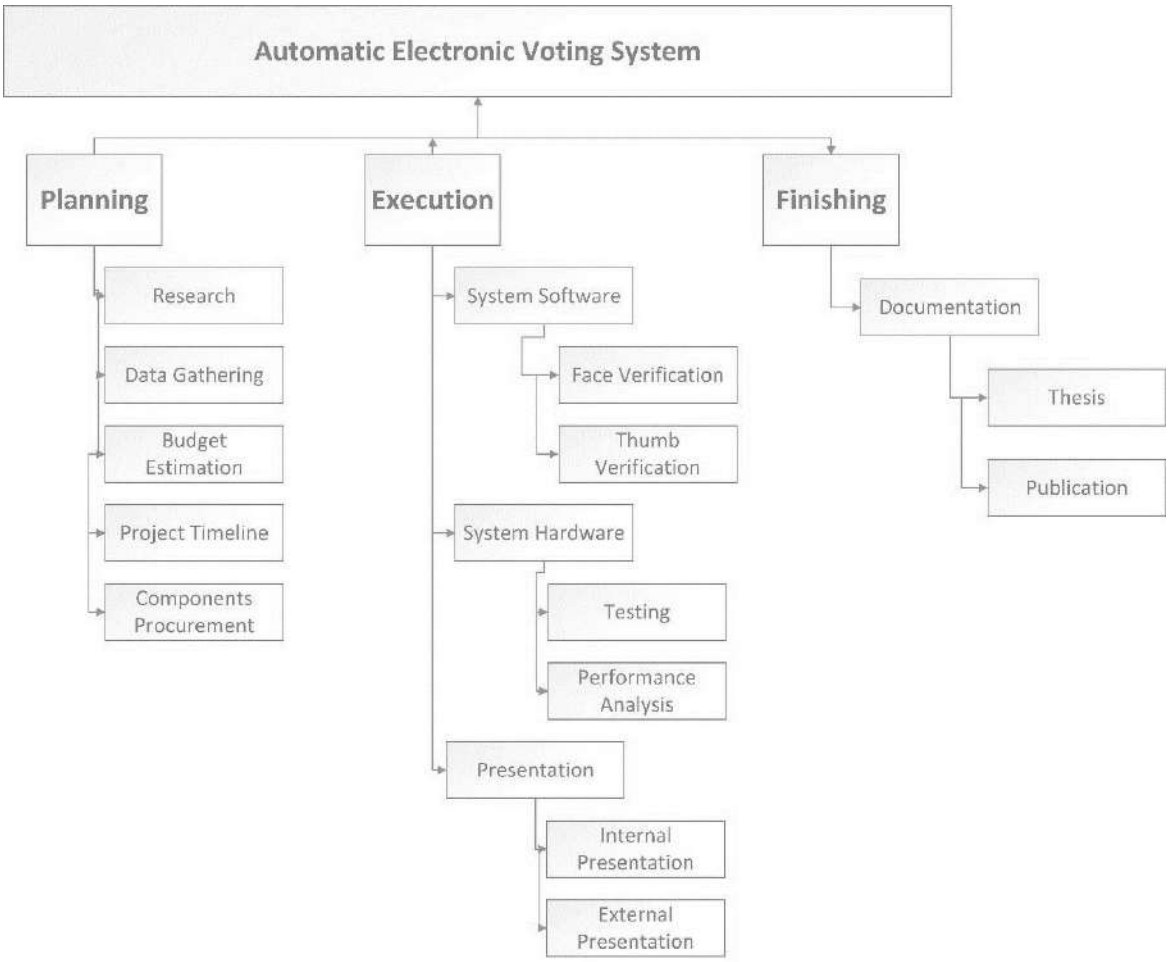

Figure 1.1: Project Work Breakdown Structure.

Chapter 2

Literature Review

2.1 Overview

The literature review covers the theories and researches done on many types of E-Voting Systems. This chapter will cover the problems in the existing system of voting system around the world and different biometric techniques involved in E-Voting system.

2.2 Biometric Techniques

This research paper proposed two voting environments one is offline E-voting system using face recognition and thumbprint with embedded security.

There are different biometric techniques for verification process in E-voting. Each of these techniques are briefed below:

2.2.1 Fingerprint Recognition

The fingerprint recognition is conventionally used biometric technique, used for identity, verification purpose.

Levels of Fingerprint Recognition

There are three levels of Fingerprint Recognition:

- **Level 1:** At the first level, fingerprint recognition will image the fingerprint as a whole and not highlighting the specifics of the print.
- **Level2:** In this level, Features of the fingerprint are extracted by gathering the minutiae points of the fingerprints.
- **Level3:** This includes the shapes and images of the associated which is the difficult to achieve.

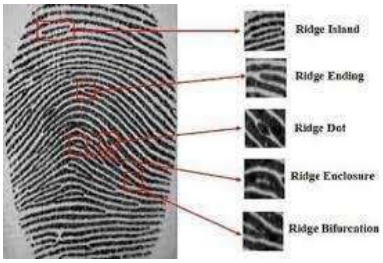

Figure 2.1: Fingerprint parts.

2.2.2 Face Recognition

Face recognition is one of the kinds of biometric techniques that uses face for verification and identification depicting face features and storing the data as a face print.

How does it work?

This technique identifies 80 nodal points of a human face. Nodal points are the endpoints measuring the variables of the face i.e. length of the nose, the shape of the cheekbone and the jaw, depth of the eye socket etc.

Step 1: Face Detection

In this step, the camera detects and locate the image of face whether alone or in a group of people.

Step 2: Face Analysis

Secondly, the camera captures the image and performs analysis on it. It reads the geometry of face like the space between eyes, depth of the eye socket, shape of cheekbone and jaw, length of nose etc. These are the features that distinguish one face from other faces.

Step 3: Converting the image into data

Thirdly, On the basis of a person's facial features, the face is converted into digital information that is, it is turned into mathematical formulas known as face print. Just like every individual has a unique fingerprint, every person possesses a unique face print.

Step 4: Finding a match

Your face print is then compared against a database of other known faces. If your face print matches an image in a facial recognition database, then a determination is made.

2.2.3 Voice Recognition

Voice Recognition is to define a person in term of his/her unique voice print.

Types of Voice Recognition

There are three broad categories of voice recognition:

- **Text Dependent**

  The system is trained to recognize predetermined voice passphrases by the speaker;

- **Text Independent**

  It doesn't require predetermined passphrases. The subject of the analysis is conversational speech.

How does it work?

It works by scanning the speech and establishing a match with the desired voice fingerprint. The speech recognition software breaks the speech down into bits it can interpret, converts it into a digital format, and analyzes the pieces of content.

It then makes determinations based on previous data and common speech patterns, making hypotheses about what the user is saying. After determining what the user most likely said, the smart device can offer back the best possible response.

2.2.4 Retinal Recognition

Retinal Recognition is the unique biometric technique of scanning retina and citing the image with the retinal features containing 400 unique data points for examination.

- **Drawbacks**
  1. The technique is considered expensive and difficult to operate.
  2. The infrared light used to illuminate the blood vessels is considered to be uncomfortable to withstand.
- **How does it work?**

  This technique uses infrared light to illuminate the blood vessel pattern of the retina and this light is absorbed much faster by the blood vessels. During the process, camera captures the reflected light for investigation and extract unique retinal features.
- **The Retina Recognition Process**

  This procedure is categorized into three steps:

  1. **Image Acquisition**

     In this step, the image of the retina is captured and is then cited with the database by first converting the image into digital format. This step is considered to be complicated.

2. **Retinal Matching**
   This is the verification step in which the imaging of the retina is verified, to find the exact match within the database. Here, blood vessel patterns of the retina plays a major role for the verification process.
3. **Representation**
   In this third and final stage, the retinal features are presented as an enrollment template.

2.2.5 Categories of Biometric Recognition

Typically, there are two categories of Biometric Recognition, given by:

- **Biometric Identification**
  It is also referred to as one-to-many comparison in which comparison is carried against the biometric database in order to establish an identity for an unknown individual. In this system, the biometric software will have to search the entire biometric database [6].

- **Biometric Verification**
  It is also known as one to one comparison in which captured biometric is compared with the specific template stored in the biometric database. In this system, some sort of identification like an ID card, password, or username is provided to match the biometric like a fingerprint with the fingerprints associated with the provided user ID [6].

2.4 Current EVM in Pakistan

Pakistan developed EVMs mainly for the purpose of reducing rigging. But ECP raised some objections over EVM in September. They showed concerns about low voter turnout, misuse of state authority, election fraud like rigging, ballot stuffing, dishonest staff, lack of ballot secrecy, lack of security during rest and transportation.

In this system, there are two modules i.e. Voter Verification module and Ballot module.

- In the Voter Verification module, verification of voters is carried out by placing thumb on EVMs identification module, connected to NADRA's database. If the

voter is verified, green light flashes and ID card information is captured and the voter is allowed to cast their vote.

Drawback

1. In this unit, no identity verification is available for presiding officer.
2. Face recognition is not available for double verification.
3. If the voter thumb pattern is not available or is vanished, no solution is provided for this case.

- In the Ballot casting unit, there are two units i.e. Control unit which is controlled by the presiding officer and Ballot unit where voters cast their after verification process. From the control unit, the presiding officer provides the access to the voter to choose the candidate. The balloting units are place behind to ensure voters' privacy. The units are not wirelessly connected to ensure data security. Multiple ballot units can be interconnected depending on the number of candidates and constituencies. For paper audit trial, a printer is fixed within the ballot unit. When the voter pushes the button to cast their vote, a paper prints out with the information. For the double verification, this paper is then dropped into the ballot box. After the completion of election, the presiding officer locks the election process and displays the result.

  This whole system is similar to EVM introduced in India but with a slight change of paper audit trial which is present in Pakistani EVMs.

2.5 Dimensionality Reduction and its Technique

2.5.1- Dimensionality Reduction

The performance of Machine Learning algorithm depends on the number of input variables. In case of large number of dimensions residing in the feature space, it results in a large volume of space. Suppose we have dimensions on a feature space and points located on the space. In case of large volume of space, the points on the space may represent only

a tiny, non-reprehensive sample, resulting in the imbalance having negative affect on the machine learning algorithm.

To reduce this imbalance and the negative effects, we must perform dimensionality reduction. Dimensionality Reduction means reducing dimensions of features. It reduces number of features.

Advantages:

- Features will be reduced and as a result we will have less complexity.
- Less storage space will be required as there will be fewer data.
- Less Computation time.
- Algorithms train faster.
- Removes noise and redundant features.

2.5.2- Linear Discriminant Analysis:

Dimensionality Reduction can be achieved using various techniques. Linear Discriminant Analysis is one of them. For feature extraction, Ada boost is integrated with LDA.

LDA is one of the most popular reduction algorithm which is able to discover a linear combination of input features in a lower dimensional space while maximizing class separation.

- **Class Separation:**

  In class separation, classes are kept as far as possible, maintaining minimum separation between the data points within each class. The better the separation of classes, the easier to draw decision boundaries between the classes to separate groups of data points.

LDA is used with classification data sets having class labels. It can also be used as a binary (multi-class) classification along with dimensionality reduction algorithm. Class labels are required for LDA when used for dimensionality reduction.

2.6 Project Flow

Our proposed project flow will be:

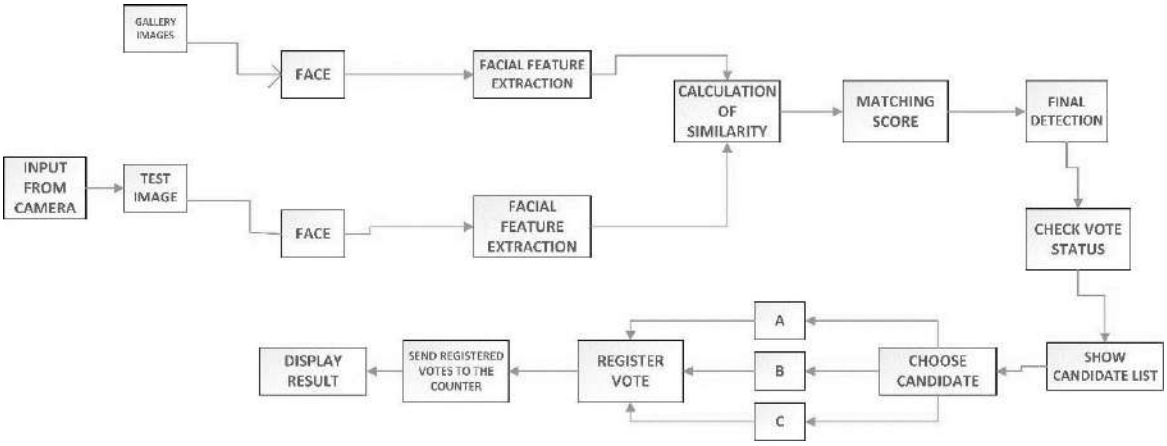

Figure 2.2: System Flowchart

The system will comprise of the following interconnected modules.

Step-1: Image Acquisition

The first step in expert systems involves the acquisition of the face image. In our work, the face image will be acquired through an image reader that will be embedded in Raspberry-pi. Our initial study reveals that Raspberry-pi module V2 contains 8 Mega-pixels camera, which is sufficient for our system development.

Step-2: Object Detection

In the proposed project, object detection will be studied and investigated in the context of face. To accurately detect the face, a robust methodology will be explored, such as deep learning and machine learning methods [1]. Ultimately, face region will be located by automatically drawing a rectangle around the face pattern. For face verification purpose, only space inside the rectangle will be analyzed to extract and identify features to conclude its identity.

Step-3: Features Extraction

Features are the visual cues that will be used for face verification. In our work, face features will be extracted through an automatic classification error driven mechanism that will be deployed in verification stage [2]. The extracted features will be measurable with

high sensitivity. The extracted features will also have high correlation with face features, which is high probability of true positive response. Furthermore, the extracted features will have high specificity, which is high probability of true negative response. We will explore state-of-the-art feature extractors, for instance [3] that will effectively help to detect human face.

Step-4: Verification

In the proposed project, face verification will be studied and investigated based on the outcomes of the Step-2 and Step 3, as described above. To verify, a feature comparison and recognition module will be deployed at the end [3]. In recent times, large numbers of published works have appeared in literatures that focus on various recognition tasks [4]. Moreover, the computation time is a crucial factor during the algorithm development. However, in our proposed project, we will apply a boosted and modified version of state-of-the-art method for the verification task [5]. We believe that the proposed verification scheme will be able to perform recognition task in higher dimension space that will result in robustness and improved accuracy. The feature classification module at the end will produce a score that will indicate the status of human face, which is either verified or unverified. After a face is verified, the user is allowed to proceed to cast the votes.

Step-5: Registration

Based on the output of Step-4, and before casting vote, we have to store face prints of voters by setting a specific number in the template, which in turn is stored in the database.

Step-6: Final stage of voting

This step contains following important interconnected phases.

- **Voting status:** This is the process to check whether the voter has casted voted more than once or not. If yes, then he/she is not allowed to vote and it is indicated by the RED LED, otherwise, the voter can cast his/her vote.

- **Choosing the Candidate:** In this process, the voter chooses his/her preferred candidate by pushing one of the three push buttons.

- **Registration of votes:** After choosing the candidate, his/her vote is registered by pressing the push button “enroll”.
- **Displaying the number of Votes:** As shown in Figure 2.2, that after the process of polling, the last stage is to display the net votes of candidates by pressing the push button “net votes”. By doing this, number of votes of each candidate is displayed on the LCD Display. The whole procedure will be controlled by using Python Language.

Chapter 3
Proposed Methodology

3.1- Overview

As our project is both, software and hardware based, in this chapter, an overview of hardware and software designs will be given.

3.2- System Hardware

In this section, block diagram of hardware along with the specifications of hardware components will be briefly explained.

3.2.1 – Block Diagram

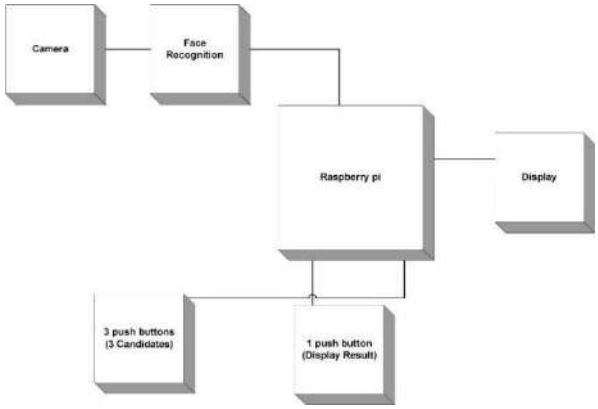

Figure 3.1: Block Diagram of Hardware of EVM.

3.2.2 – List of Hardware Components

Sr. no.	Components
1	Raspberry pi 4 Model B 4 GB RAM
2	5MP Raspberry Pi Camera Module
3	Raspberry pi DC Power Supply 5V 3A
4	Jumper Wires Male to Male
5	Jumper Wires Male to Female
6	Class 10 SanDisk 32GB Ultra Micro SD card
7	Push buttons
8	Casing box
9	7 inch HDMI Capacitive Touch LCD Screen for Raspberry pi

Table 3.1: Hardware Components

- **Raspberry pi**

Raspberry pi acts as a mini computer, connecting the peripherals like mouse, key board, display with it and you get yourself a PC at low cost. Raspberry pi foundation UK laid the foundation of the raspberry pi.

Raspberry Pi is popularly used for real time Image/Video Processing, IoT based applications and Robotics applications.

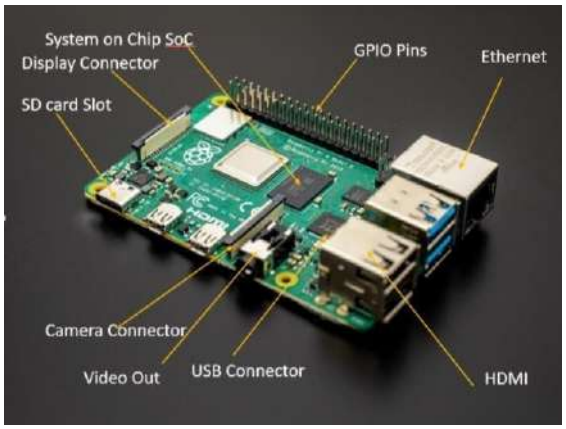

Figure 3.2: Raspberry pi components

- **How Does Raspberry Pi Work?**

Raspberry pi is a programmable device operating on 5V DC Voltage. It acts as an minicomputer but without any peripherals like keyboard, mouse, display. Raspberry pi comes with the SD card slot which is the main storage device for the raspberry pi. Raspberry pi supports Linux, Qtonpi, ARM, and Mac operating. Only one operating system can be used and needs to be written on the SD card. The raspberry pi supports maximum 64 GB SD card. Before Starting Raspberry pi, you will need to connect keyboard, display and mouse. Raspberry supports three O/Ps like DSI video, composite video and HDMI video. SD card is the most important specification of the raspberry pi as it stores all the documents, programs and operating system.

- **Features of Raspberry Pi**

The features embedded on the Raspberry pi board are listed above along with their brief description:

1. **Central Processing Unit (CPU)**

   Raspberry pi possesses CPU just like computer and it uses ARMM11 series as its processor on its board.

2. **HDMI Port**

   Raspberry pi consists of HDMI port allowing the raspberry pi to connect with the HDTV and have video option for the output.

3. **Graphic Processing Unit**

   GPU is also embedded on the board and its purpose is to hasten the speed of the image calculation.

4. **Memory**

   Random Access Memory is the core part of the processing system. The modern Raspberry pi has a memory of 256 GB.

5. **Ethernet Port**

   The Ethernet port provides wired internet access to the minicomputer as without it web surfing, software updates, etc. cannot be performed.

6. **SD Card Slot**

   Raspberry pi comes with an SD card embedded in the board. It is the most significant feature of the Raspberry pi as it contains all the documents, software, etc.

7. **General Purpose Input and Output Pins (GPIO)**

   These are upward-projecting clusters of pins. These are really sensitive and should be handled with care as they are essential parts of the Raspberry pi and are used to interact with the electronic circuits controlling them.

8. **LEDs**

   These diodes are used to indicate the current status of the raspberry pi, covering:

   1. **PWR (Red):** This indicates the power status of the raspberry pi. When the unit is ON, Red light is shown and when the unit turns OFF or is disconnected from the power source, the Red light turns off.
   2. **ACT (Green):** It indicates any SD card activity.
   3. **LNK (Orange):** This flashes to indicate the connectivity of Ethernet.

4. **100 (Orange):** This light comes on during an Ethernet connection when the data speed reaches 100Mbps**.**
5. **FDX (Orange):** This light comes on during Ethernet connectivity, indicating that the connectivity is full-duplex.

9. **USB Ports**

Universal Service Bus (USB) is the core part of the Raspberry pi. Through this port, the keyboard, mouse, display, etc. are connected to the Raspberry pi.

10. **Power Source**

Raspberry pi operates on the 5V DC voltage. Raspberry pi uses a 5V micro USB power cable.

- **Specifications of Raspberry Pi 4 Model B**

We are using Raspberry pi 4 Model B in our project. It's the latest product in the raspberry pi range offering increase in the processor speed, multimedia performance, memory and connectivity compare to other previous models of raspberry pi.

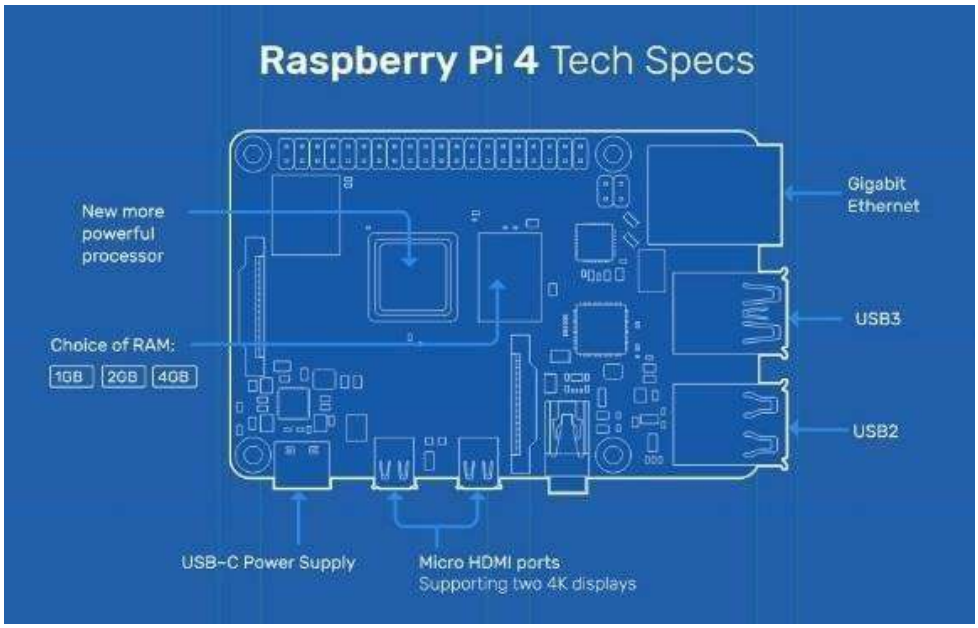

Figure 3.3: Raspberry pi 4 Model B Main Components.

- **Specifications**

Processor	Quad Core, 64-bit SoC
Memory	8-GB with on-die ECC
Connectivity	2.4 GHz and 5GHz wireless LAN, Bluetooth 5.0, BLE Gigabit Ethernet 2X USB 2.0 ports and 2x USB 3.0 ports
GPIO	Standard 40-pin GPIO header
Video and Sound	2 × micro HDMI ports (up to 4K60p supported) 2-lane MIPI DSI display port 2-lane MIPI CSI camera port 4-pole stereo audio and composite video port
SD card support	Micro SD card slot for loading operating system and data storage
Input power	5V DC via USB-C connector (minimum 3A1) 5V DC via GPIO header (minimum 3A1) Power over Ethernet (PoE)–enabled (requires separate PoE HAT)

Table 3.2: Specifications of Raspberry Pi 4 Model B

- **Schematic Diagram**

The schematic diagram of Raspberry pi 4 model B consists of the following major components:

1) Microcontroller Unit (MCU):

The Raspberry Pi 4 Model B's primary processing unit is known as the microcontroller unit (MCU). It is an ARM Cortex-A72 quad-core Broadcom BCM2711 CPU, with a maximum clock speed of 1.5 GHz. The main part in charge of carrying out computations and instructions is the CPU.

2) Random Access Memory (RAM):

The board offers a variety of RAM configurations, commonly beginning with 2GB, 4GB, and 8GB variations. RAM is used to store information temporarily so that the CPU can access it fast.

3) Multiple USB ports:

This includes two USB 3.0 ports and four USB 2.0 ports, are available on the Raspberry Pi 4 Model B. You may connect a variety of USB devices to these ports, including keyboards, mouse, external hard drives, etc.

4) Gigabit Ethernet Port:

This port connects the Raspberry Pi to a local network through a wired Ethernet connection, allowing for high-speed data transmission and internet access.

5) The HDMI connector:

It allows you to connect the Raspberry Pi to an external display, such as a monitor or television.

6) The USB-C Power Port:

It is where you connect the power source to power the Raspberry Pi.

7) The Camera Serial Interface (CSI) connection:

It allows you to connect a Raspberry Pi Camera Module to capture photographs and movies.

8) Display Serial Interface (DSI) connection:

The Display Serial Interface (DSI) connection connects the Raspberry Pi to a suitable display module.

9) GPIO Pins:

GPIO pins are utilized for interacting with various external components and sensors. The Raspberry Pi 4 Model B normally contains 40 GPIO pins that may be configured to do various activities dependent on the needs of your project.

10) MicroSD Card Slot:

The Raspberry Pi 4 Model B's primary storage media is a micro SD card, on which the operating system and user data are kept.

11) Audio/Video Jack:

This is a 3.5mm audio and video port that allows you to connect audio and video output to external devices such as speakers or televisions.

12) Wireless Connectivity:

The Raspberry Pi 4 Model B contains built-in dual-band Wi-Fi and Bluetooth, allowing for wireless network connectivity and Bluetooth device communication.

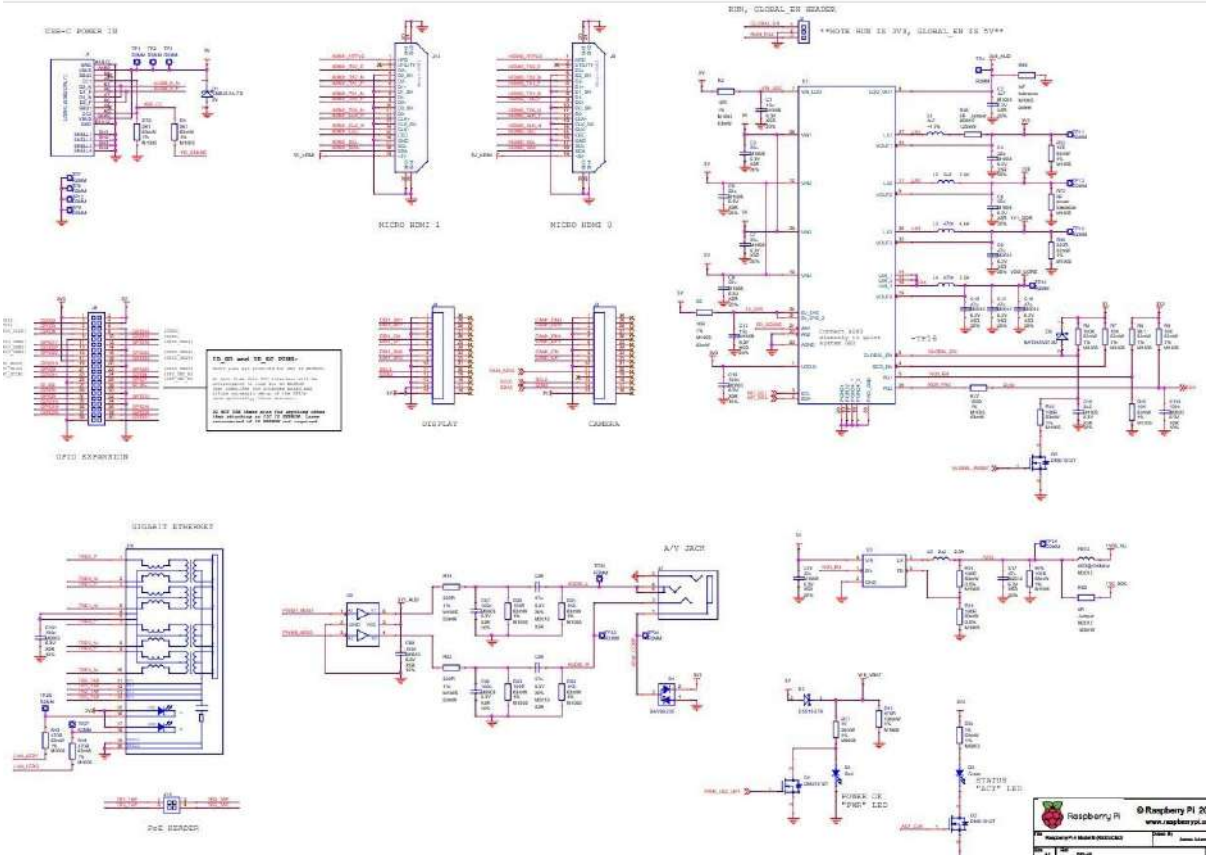

Figure 3.4: Schematic Diagram of Raspberry pi 4 Model B.

- **Power Source**

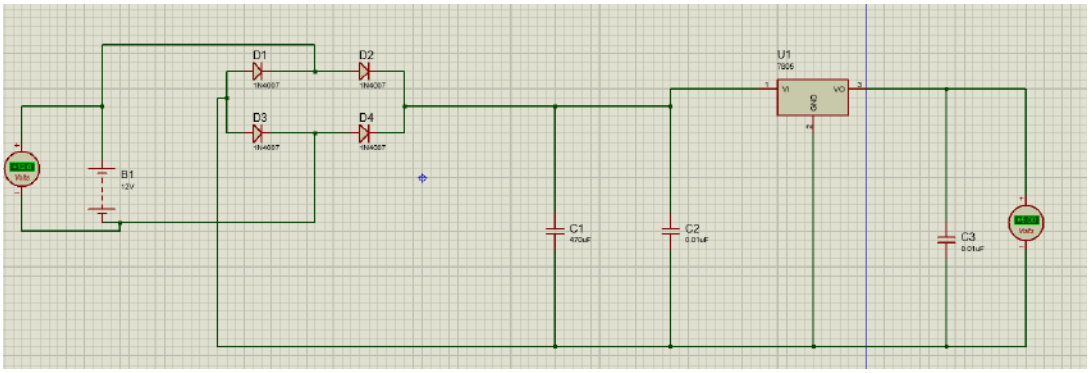

Figure 3.5: 5V power supply design for Raspberry pi.

To guarantee steady operation, the Raspberry Pi 4 Model B requires a 5V DC power supply with a recommended current capacity of at least 3A (3000mA), especially when utilizing power-hungry peripherals. Here are three popular ways to generate 5V power:

1) USB Power Adapter:

Using a USB power adapter with a micro USB or USB-C connection is one of the simplest methods to power a Raspberry Pi. Check that the adaptor can produce at least 5V and 3A. Many smartphone chargers and power banks satisfy these specifications.

2) Power Supply Module:

A dedicated power supply module may be used to convert AC mains voltage to a reliable 5V DC output.

3) Buck Converter:

A buck converter is a high-efficiency DC-DC converter that can reduce a greater voltage (e.g., 12V) to the 5V required by the Raspberry Pi. They are available as independent modules, and the output voltage may be accurately adjusted to 5V.

While other components like fingerprint module, ESP8266 Wi-Fi module, Display operate at different voltage levels like 3.3 V. For this purpose, a voltage regulator is designed.

The design shown in Fig 3.5 is the design of the power supply provided to the raspberry pi.

Operation:

The heart of this design is IC LM7805. A 220V input and 50 Hz frequency is taken from a supply that enters the LM 7805 voltage regulator IC. Residual noise in the voltage is removed by the capacitor of value $470\mu F$. The LM 7805 produces a constant 5V DC output. The transformer's main function is to step down (lower the amplitude) or step up (increase the amplitude) the signal to produce the desired DC level required at the output of the supply.

- **Voltage Converter**

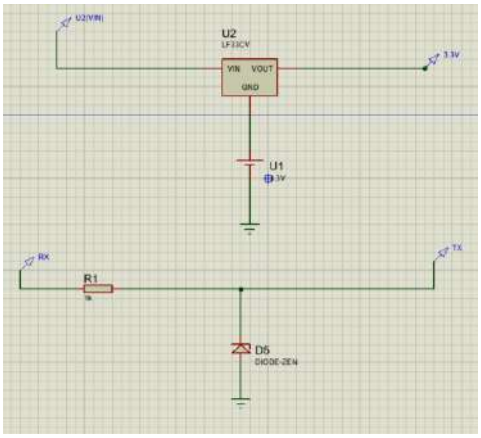

Figure 3.6: Voltage Regulator

When 5V voltage is supplied, it damages components like fingerprint module, display. For this we have designed a voltage regulator regulating 5V to 3.3 V which is them then supplied to these components. It converts TX and RX of from Arduino from 5V to 3.3 V and TX and RX of the ESP8266 Wifi module and UART fingerprint reader from 3.3V to 5V.

- **LCD**

LCD is a flat panel display involving liquid crystals in its operation. LCDs have replaced old technologies, Light-Emitting Diode, and gas plasma displays. LCDs are much thinner than Cathode Ray Tube (CRT). Unlike, LED and gas plasma displays, LCDs consume less power as they work on the principle of blocking light instead of emitting it.

TFT LCD Touch Screen Display

TFT, Thin-film Transistor LCD display is the type of LCD that involves an individual transistor to drive each pixel for faster response time. It uses thin film transistor technology to improve contrast and addressability.

Figure 3.7: TFT LCD Display.

Technical Specifications

LCD Type	TFT
Size	3.5 inches
Resolution	320 x 480 Pixels
Interface	SPI
Display Controller	XPT2046
Touch Type	Resistive
Backlight	LED
Aspect Ratio	8:5
Colors	65536
Supports	Camera, Mouse and Keyboard

Table 3.3: Technical Specifications of TFT LCD Display.

Connecting Raspberry pi with TFT LCD Display

For connection with Raspberry pi, LCD consists of female headers which are connected with the male header pins. Align the pins and press the LCD on top of the Raspberry pi. The main purpose of these pins is to develop the SPI communication between the LCD and the raspberry pi and also to provide power to the LCD through 5V and 3.3V pins of the raspberry pi. There are 26 pins in total.

Pin Configuration

Pin no.	Symbols	Description
1, 17	3.3 V	3.3 V power input
2, 4	5V	5V power input
3, 5, 7, 8, 10, 12, 13, 15,16	NC	No connection- used for support
6, 9, 14, 20, 25	GND	Ground
11	TP_IRQ	Active low interrupt pin for touchscreen
18	LCD_RS	Register select pin of the Display controller
19	LCD_SI	SPI data input for the LCD display
21	TP_SO	SPI data output from the LCD display
22	RST	Reset
23	LCD_SCK	Clock sync pin of SPI communication
24	LCD_CS	Chip select pin of SPI LCD
26	TP_CS	Chip select pin of SPI touchscreen

Table 3.4: Pin Configuration of TFT LCD Display.

3.3- System Software

Our proposed system comprises two parts, i.e. Addition of Fingerprints and faceprints in the database and the Polling process.

- **Addition of Faceprints in the Database**

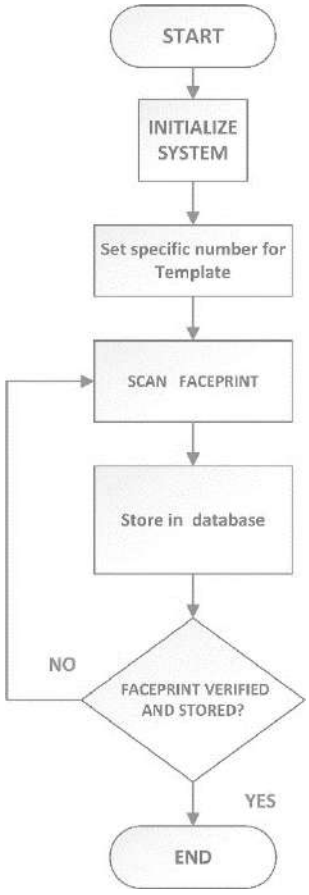

Figure 3.8- System Software Flowchart For Database.

The first step of the system is to register the face prints in the database in order to give access to the voters to cast their votes. The face prints are scanned first and then stored in the specific template allotted with a specific number. Once registered, it is then verified in the run time. The face prints of the voter are verified with the prints stored in the database. Once verified, the voter is then given access to the polling process.

- **The Polling process**

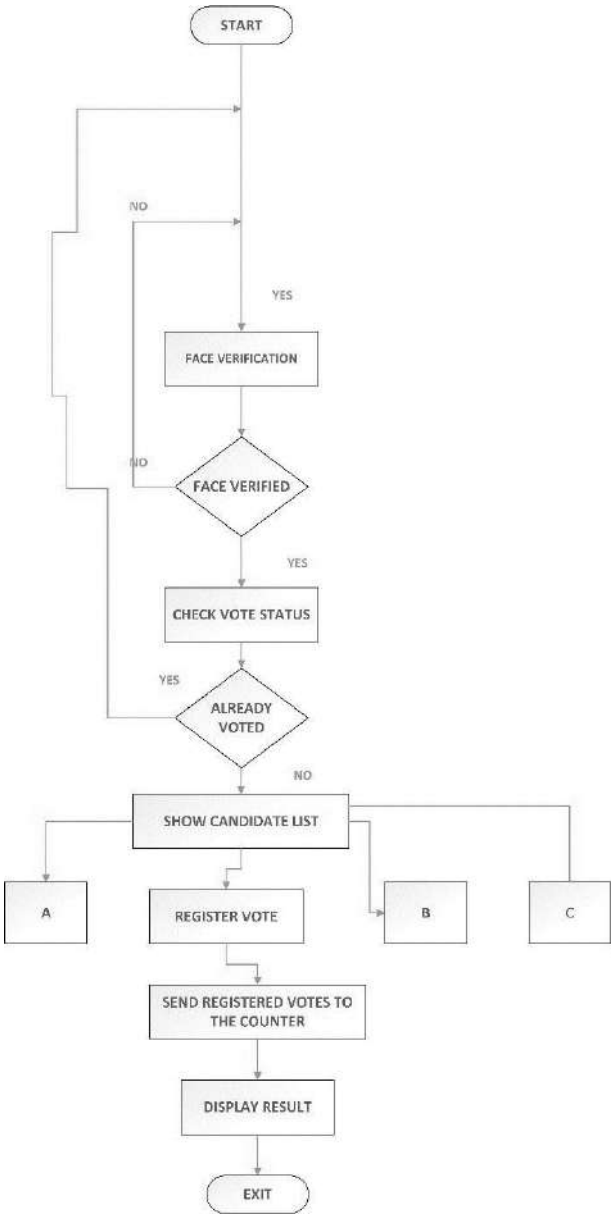

Figure 3.9- The Polling Process.

When the voter has passed the verification process successfully, the next process is the polling process. In this process, first, it is checked whether the voter casted vote more than once or not. If yes, then the voter access is denied for further process. If not, he/ she is provided with the candidate list which is displayed on an LCD display. The voter chooses his/her preferred candidate. These votes are then registered and sent to the counter where

these votes are counted. After the completion of the polling process, these votes are displayed on the LCD display.

3.4- Face Recognition:

We used standard Linear Discriminant Analysis (LDA)-based facial recognition systems. The ensemble-based method is based on a new technique known as "boosting." However, it is often assumed that boosting-type learning principles are unsuitable for a powerful and stable learner like LDA. The most prominent FR methodology are the so-called appearance-based approaches, which include the three most well-known FR methods, namely Eigenfaces [9], Fisherfaces [10], and Bayes Matching [11]. The appearance-based approaches generally operate directly on appearance images of face objects and process them as two-dimensional (2-D) holistic patterns to avoid difficulties associated with three-dimensional (3-D) modeling and shape or landmark detection [12].

3.4.1 – AdaBoost:

AdaBoost works by repeatedly applying a given weak learner to a weighted version of the training set in a series of rounds, and then linearly merging the weak classifiers generated in each round into a single strong classifier. The most intriguing aspect of AdaBoost is its astonishing ability to decrease over fitting and classification generalization error even when the sample size grows huge.

AdaBoost was first designed to help with binary classification jobs. AdaBoost.M1 and AdaBoost.M2 are two of its multiclass extensions [7]. The simplest straightforward generalization is AdaBoost.M1. However, if the classification error rate (CER) of the weak classifier created in any iterative phase is $\geq 50\%$, the method stops. According to research, this constraint frequently causes the operation to be terminated prematurely, resulting in poor categorization capabilities [14] [15]. To circumvent the issue, AdaBoost.M2 seeks to minimize a more complex error metric known as "pseudo loss," rather than the standard CER.

3.4.2 – Interaction between the Learner and the Booster:

To boost a learner, we must first establish a strong link between the learner and the boosting framework. This is accomplished in AdaBoost by modifying the "sample distribution," which is a measure of how difficult it is to categorise an example.

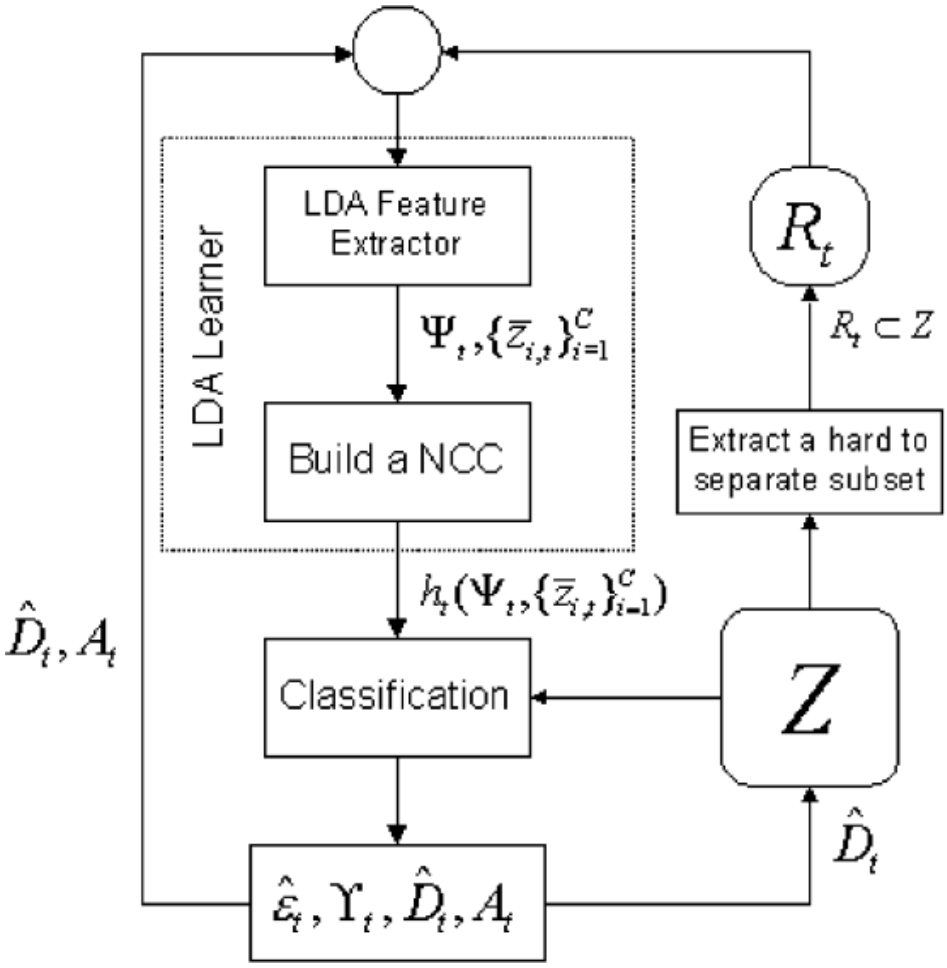

Figure 3.10: Flow chart of the cross-validation mechanism

The flow chart is based on one iteration, and the NCC denotes the nearest center classifier. Only a subset of the complete training set Z,$R_t \subset Z$ is utilised to train the LDA-style learner with the mechanism in place. In each cycle, the subset R_t is constructed by selecting the r≤ L hardest-to-classify samples per class depending on current values of $D_t(z_{ij})$.

3.4.3 – Pseudo code:

Input: A training set $\mathcal{Z}_t$ with C classes: $\mathcal{Z}_t = \{\mathcal{Z}_{i,t}\}_{i=1}^{C}$, each class contains $\mathcal{Z}_{i,t} = \{\mathbf{z}_{ij}\}_{j=1}^{L_i}$ face images, where $\mathbf{z}_{ij} \in \mathbb{R}^J$.

Output: A M-dimensional LDA subspace spanned by Ψ_t, a $M \times J$ matrix with $M \ll J$, and the class centers $\{\bar{\mathbf{z}}_{i,t}\}_{i=1}^{C}$.

Algorithm:

Step 1. Re-write $\hat{\mathbf{S}}_{b,t}$ of Eq.3: $\hat{\mathbf{S}}_{b,t} = \mathbf{W}_b\mathbf{W}_b^T$, where $\mathbf{W}_b = [\phi_1, \cdots, \phi_c]$.

Step 2. Find the eigenvectors of $\mathbf{W}_b^T\mathbf{W}_b$ with non-zero eigenvalues, and denote them as $\mathbf{E}_m = [\mathbf{e}_1, \ldots, \mathbf{e}_m]$, $m \leq C - 1$.

Step 3. Calculate the first m most significant eigenvectors ($\mathbf{V}$) of $\hat{\mathbf{S}}_{b,t}$ and their corresponding eigenvalues (Λ_b) by $\mathbf{V} = \mathbf{W}_b\mathbf{E}_m$ and $\Lambda_b = \mathbf{V}^T\hat{\mathbf{S}}_{b,t}\mathbf{V}$.

Step 4. Let $\mathbf{U} = \mathbf{V}\Lambda_b^{-1/2}$. Find eigenvectors of $\mathbf{U}^T(\hat{\mathbf{S}}_{b,t} + \hat{\mathbf{S}}_{w,t})\mathbf{U}$, $\mathbf{P}$, where $\hat{\mathbf{S}}_{w,t}$ is defined in Eq.4.

Step 5. Choose the $M(\leq m)$ eigenvectors in $\mathbf{P}$ with the smallest eigenvalues. Let $\mathbf{P}_M$ and Λ_w be the chosen eigenvectors and their corresponding eigenvalues respectively.

Step 6. Return $\Psi_t = \mathbf{U}\mathbf{P}_M\Lambda_w^{-1/2}$ and $\{\bar{\mathbf{z}}_{i,t}\}_{i=1}^{C}$.

Chapter 4

Simulation and Hardware Results

4.1- Overview

In this chapter, we will discuss the software and hardware results of the system.

4.2- Software Results

In this section, simulation results regarding face and thumb verification will be discussed.

4.2.1- Simulation Result

	Gallery Image 256×256 pixels	Probe Images						Verification Result						Execution time (Sec)
		Pose-I −15°	Pose-II −25°	Pose-III: Frontal no occlusion	Pose-III: Frontal occlusion	Pose-IV +25°	Pose-V +15°	Pose -I	Pose -II:	Pose-III: Frontal no occlusion	Pose-III Frontal occlusion	Pose-IV	Pose-V	
LDA								✓	×	✓	×	×	✓	5.1738
								✓	×	✓	✓	×	✓	5.1738
								✓	×	✓	×	×	✓	5.1738
LDA								✓	×	✓	✓	×	✓	5.1738
								✓	×	✓	×	×	✓	5.1738
								✓	×	✓	×	×	×	5.1738
								✓	×	✓	✓	×	✓	5.1738
								✓	×	✓	×	×	✓	5.1738
								✓	×	✓	×	×	✓	5.1738

Figure 4.1: Face Verification through LDA algorithm.

- **Face Detection**

For Face detection, we have used LDA based learner. As mentioned earlier, LDA is used for dimensionality reduction for which class labels are used.

Input Image	Detected Face
	
	

Table 4.1: Face Detection

4.2.2-Diagonal Values Matching

We carried out a matching test using MATLAB software. It can be seen from the figures below that as the diagonal values match, it means that the test image matches the image stored in the database.

Match threshold:

It is a variable value between 0 and 1 that controls which photos the algorithm considers to be a possible match. Any match score over the match threshold is considered a prospective match, but any match score below the match threshold is not considered a potential match.

Let S will be a NxN matrix, with each element S(i, j) representing the similarity score between picture i and image j. The higher the similarity score, the closer the two photos are thought to be.

In this context, diagonal values refer to items of the type S(i, j), where i might vary from 1 to N. These elements describe an image's similarity score with itself, which is always the highest similarity score it can get because it is comparing with itself.

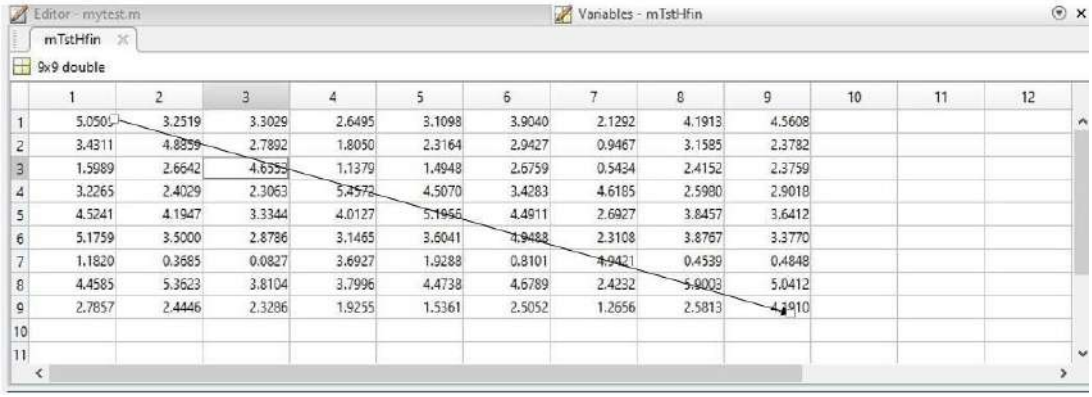

Figure 4.2: Diagonal Values of Matrix 1

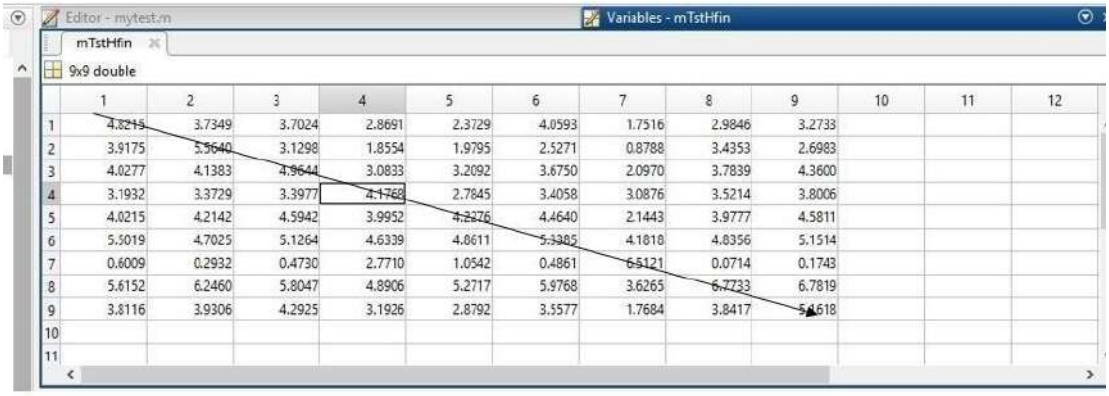

Figure 4.3: Diagonal Values of Matrix 2

4.2.3-Accuracy and Loss of Face Recognition

In this test, we checked for accuracy and loss percentage of face recognition. As a result, we achieved maximum accuracy with less loss percentage. The following are the figures:

Accuracy	Loss
0.8970	0.4446
0.9333	0.3589

Table 4.2: Accuracy and Loss

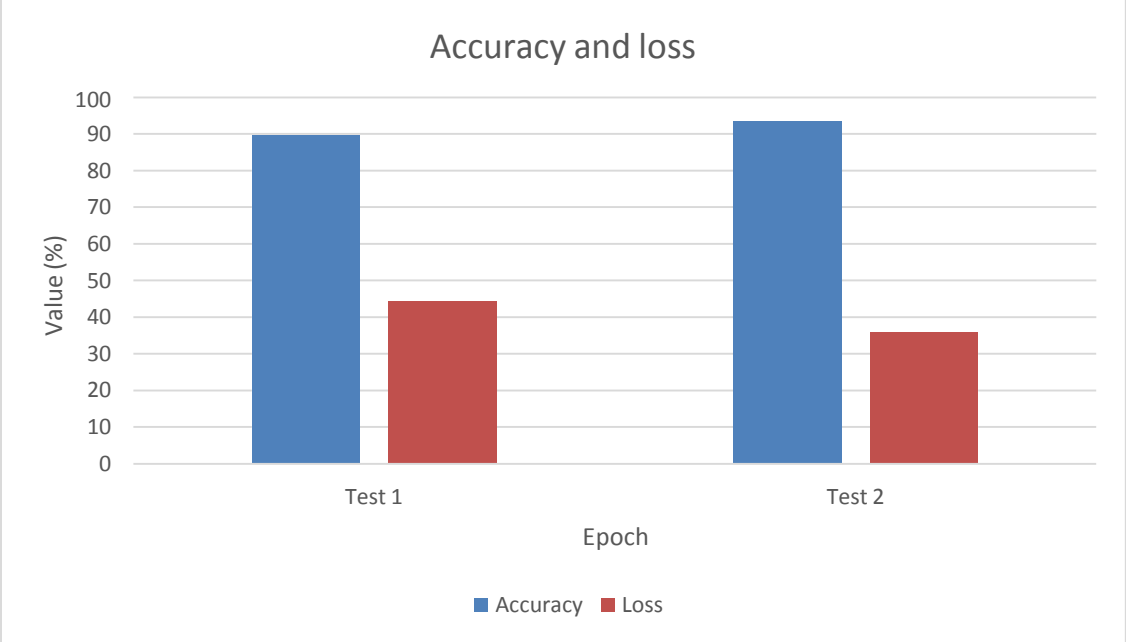

Figure 4.4: Graph Accuracy and Loss

Epoch:

An epoch is considered to be completed when a dataset goes through an algorithm. As a result, in machine learning, Epoch refers to the full transit of training data through the algorithm. It is a hyper parameter that governs the training process for the machine learning model.

Loss:

The term "loss" refers to the loss value over the training data at the end of each epoch. The optimization process is attempting to minimize this with the training, thus the lower the better.

Accuracy:

The term "accuracy" refers to the ratio of correct predictions to total predictions in the training data. The greater the number, the better. This is generally inversely connected to the loss, however, it is not always the case.

Relationship between Epoch and Accuracy:

The number of epochs is a critical hyper parameter to get right since it affects both the accuracy and computing efficiency of the training process. If the number of epochs is too low, the model may fail to understand the underlying patterns in the data, leading to under fitting. A large epoch size does not necessarily improve accuracy. All of the training data in a neural network had been utilized to modify the models' parameters after one epoch. Epoch sizes can improve precision up to a point, after which the model tends to over fit the data.

4.2.4-: System Execution Time

The execution of EVM can vary depending on several factors such as the number of voters, the complexity of the ballot and the processing power of the machine.

Time for Training Model	Face Recognition Time	Time taken by Voter
10 minutes	5.1738 seconds	30 seconds

Table 4.3: System Execution Time

4.3- Hardware

The hardware setup consists of a camera, LCD Screen, and Buttons, all three integrated with the Raspberry Pi 4 model B. There are 4 buttons, Blue button for Candidate 1, a Red button for Candidate 2, a White for the camera and Green for displaying results. When pressing white button, the camera is activated and it captures the picture of the voter along with the data of the voter is displayed i.e. name and ID card number. If the voter is matched with the database then he/she is allowed to cast vote. The system also checks whether the voter has casted vote before or not. In case if the voter has already casted, the system will not allow the voter to cast vote. The votes of each candidate are sent to the counter that

counts the vote of each candidate. In case of power failure, the data is saved in the fie with tags/labelsing the operation.

4.3.1-: Hardware Result:

As in the depicted in the hardware result given above, the system verifies whether the voter has casted vote more than once or not. As the voter's information is added, the system does not allow the voter to cast his vote as the person has already casted his vote.

Figure 4.5: Hardware setup.

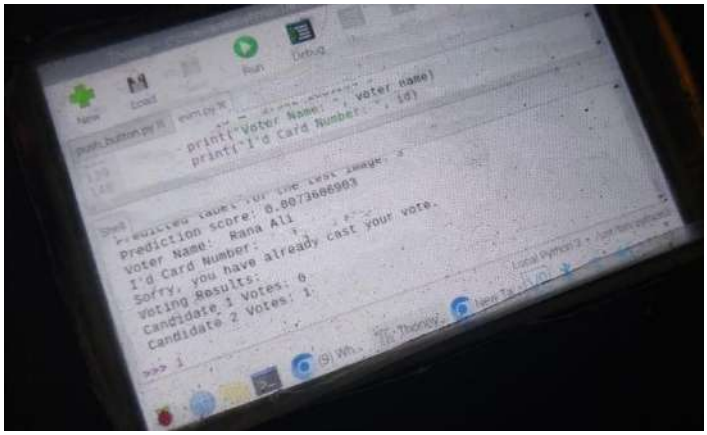

Figure 4.6: Hardware Result.

Voting Steps:

Users having registered face images are entitled to vote after successfully registering their face prints. The voting procedure is managed according to code. If the voter authentication is successful, the LCD panel will provide instructions on how to vote. In this initiative, two candidates are intended to gather the voted votes. By pushing buttons, the user may choose between candidates 1 and 2. These buttons are linked to the Raspberry Pi's I/O pins The total number of votes cast is incremented and saved in memory.

1) **Capture Picture at the Run Time:**

In this step, the system captures the picture of the voter and displays his/her name and ID card number after the verification process.

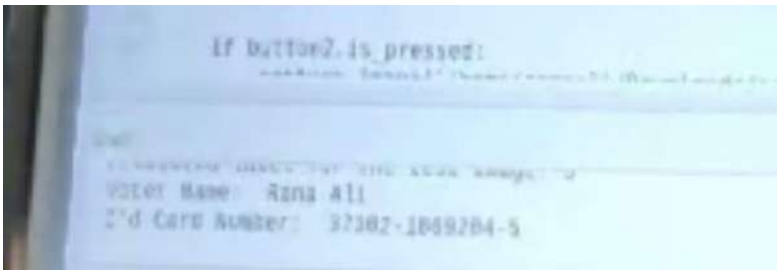

Figure 4.7: Capturing picture at the run time.

2) **System performing double verification:**

The system first verifies the person at the run time as mentioned above in step 1. After that, the system verifies whether the voter has casted his/her vote more than once or not. If the voter has casted his / her vote already, the system denies the access to voter.

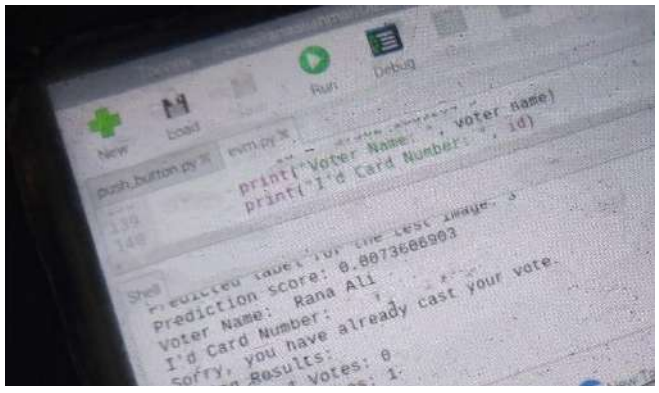

Figure 4.8: Verification of double vote by a single voter.

3) The system allowing voters to cast votes:

In this step, after the verification process, the system allows the voter to cast his/her vote. If the voter has not cast his vote before, then the system allows access to voter to cast vote.

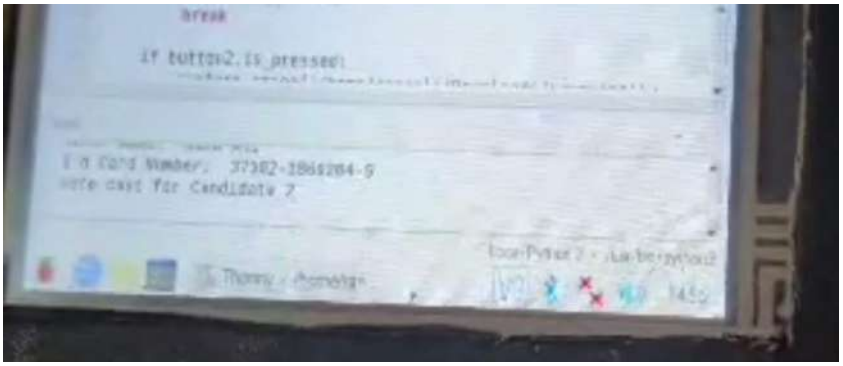

Figure 4.9: Casting vote.

4) Display result:

After the polling process, the presiding officer pushes the button to display the total casted votes of each candidate.

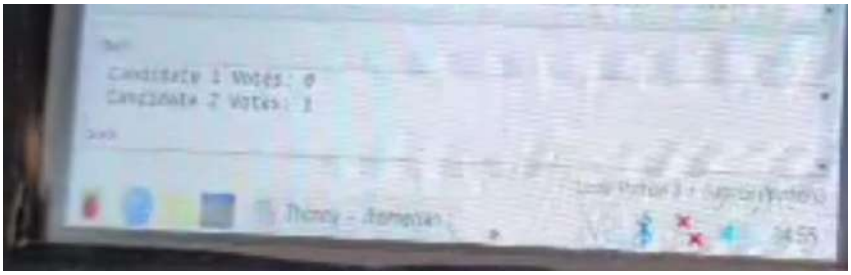

Figure 4.10: Display results.

Chapter 5

System Analysis

5.1- Overview

The last section is divided into three sections. We individually show the project's conclusion, points of interest, applications, and future enhancements.

5.2- Advantages

• It ensures transparency.

• It is more ecologically friendly since there is no need for voting papers, and it takes 35 seconds to cast a vote.

• Results are displayed in real-time.

• The technology employed is cutting-edge.

5.3- Points of Interest

In this system, our points of interest are:

- High Accuracy Rate and low loss rate
- Double Verification process (Facial and Multiple Vote)
- Less Time-consuming system as the system takes 35 seconds for the whole procedure.

5.4- Application

- Additionally, it is used to survey attendees during annual shareholder meetings.
- It might be utilized in many locations without access to electricity because the devices are powered by a basic 5 Volt battery.
- It might also be used to participate in administration frameworks in various organizations and institutions.
- A gathering of persons conducting research on various media rivalries, etc

5.5- Cost Analysis

Sr. no.	Components	Cost
1	Raspberry pi 4 Model B 4 GB RAM	**Rs. 30,000**
2	5MP Raspberry Pi Camera Module	**Rs. 800**
4	Raspberry pi DC Power Supply 5V 3A	**Rs. 800**
5	Jumper Wires Male to Male	**Rs 200**
6	Jumper Wires Male to Female	**Rs. 200**
8	Class 10 SanDisk 32GB Ultra Micro SD card	**Rs.1400**
9	Push buttons	**Rs. 150**
10	Casing box	**Rs. 4000**
11	7 inch HDMI Capacitive Touch LCD Screen for Raspberry pi	**Rs. 10,780**
	Total Estimated Cost	**Rs. 48330**

Table 5.1: Cost Analysis

Chapter 6

Conclusion

6.1- Overview

The last section is divided into three sections. We individually show the project's conclusion, points of interest, applications, and future enhancements.

6.2- Conclusion

This paper covers the Electronic Voting Machine as a whole, which is the core of our project. We have attempted to replace the paper balloting mechanism in voting with an electronic voting machine. With the aid of different verification, the security of our system is upheld to some extent, enabling the election commission to organize the election in a secure manner and provide results that are completely transparent.

To summarize, the prototype device was able to successfully enroll voters' face prints in memory, verify voters' status (registration and multiple voting), match the new face print input with the saved face print template, authorize the voter to vote, and generate results. To summarize, the device is an excellent alternative to other time-consuming election methods, particularly the ballot paper voting system.

According to the overall analysis, our system is superior to the present one and has been improved. Manual paper balloting system.

6.3- Future Enhancement

- In future versions of AEVM, thumb recognition can also be included with the facial recognition process ensuring maximum transparency. In the future, verification/recognition can be carried out using Retinal Recognition.
- The database can be created in an encrypted form.
- Although the prototype created for this project seeks to assist secure and quick voting procedure, the same device may be used for numerous other things with little hardware modification, such as face print based access control, attendance, billing, etc.
- Many voting machines can then be linked to a host server over a secure LAN. This will allow data to be stored in real time on a host server located in a secure area.

References

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