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SMART VOTING SYSTEM THROUGH FINGERPRINT RECOGNITION

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***Abstract*—**In modern democracies, ensuring secure, transparent, and tamper-proof voting systems is a critical challenge. Traditional voting methods are often vulnerable to issues such as voter impersonation, duplicate voting, and manual errors. This paper proposes a Smart Voting System based on fingerprint recognition to enhance the integrity and efficiency of the electoral process. The system uses biometric authentication, specifically fingerprint recognition, to uniquely identify each voter. During registration, voters' fingerprints are captured and securely stored in a database. On election day, the system verifies the voter's identity by matching the live fingerprint with the stored data. Once authenticated, the voter is allowed to cast their vote electronically, ensuring that each individual can vote only once.

I. INTRODUCTION

The Smart Voting System uses Aadhar cards with face and fingerprint scans as personalized keys for secure voting. This minimizes fraud, ensuring each vote is genuine. It's like having a special lock for every vote, making the process fair and transparent. Linking Aadhar with biometrics enhances reliability, building confidence in the system. This system acts as a safeguard, preventing identity fraud and promoting secure elections. It fosters trust, making sure each vote is real and counts, upholding the principles of fairness in governance. Though the secure voting system that uses facial and fingerprint recognition. This online voting uses image processing to detect voters faces by HAAR Cascade Algorithm. Face and fingerprint image features are exacted and compared with the database. The system proposed in the present paper, shall serve with a set of innovative advantages namely, and reduced rigging and fake/invalid votes, ease of carrying the machine, faster and most accurate voting process**.**

The existing voting system confronts significant challenges, including issues of voter duplication, fraudulent activities, prolonged queues at polling stations, and the potential for unauthorized voting from different locations. These challenges compromise the integrity and reliability of the democratic process. To address these issues, a fundamental overhaul is proposed: transitioning from conventional voter IDs to Aadhar cards, which incorporate biometric features such as fingerprints for unique identification. This shift aims to enhance the security of the voting process by minimizing the risks associated with duplicate and fake votes. Aadhar-based identification ensures a more precise verification of voters' identities, contributing to a more secure electoral system.Beyond the security aspect, the proposed solution targets operational inefficiencies in the voting process. The introduction of Aadhar-based identification not only strengthens security but also streamlines the voting process, eliminating the need for extensive queues at polling stations. This not only enhances the overall efficiency of the electoral system but also facilitates greater

II.LITERATURE REVIEW

Although there are many research works on online/smart voting systems, here in this chapter we have critically analysed and summarized several research works and projects, which are more recent and relevant and similar to project. This literature survey will logically explain the system.

1. **Smart Online Voting System:** Ganesh Prabhu S, et al. system approach [1] to voting systems by leveraging face recognition technology to develop a secure internet voting system. The paper proposes an advanced voting system addressing traditional limitations through online/offline options, face recognition, and OTP authentication. Eliminating the need for election officers and

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paper ballots, it enables location-independent voting with real-time result viewing. Emphasizing efficiency and security, the authors advocate for a more accessible democratic process. Published in 2017, it signifies a significant contribution to voting technology discourse and potential future advancements.

2. **Biometric Based Secured Remote Electronic Voting System:** Samarth Agarwal, et al. system approach [2] presents the development of system to address issues such as rigging and fake voting in elections .The paper introduces an electronic voting system using a fingerprint sensor, Arduino, and matrix keypad for secure elections. It verifies voter identities, preventing duplicates. Featuring a comprehensive literature review, methodology, and real-life case studies, it recommends national-level implementation. The paper contributes to biometric-based electronic voting systems' understanding and development, offering a detailed overview of Arduino and fingerprint sensor integration.

3. **A Secured Biometric Voting System Using RFID Linked with the Aadhar Database:** P.M. Benson Mansingh, et al. approach [3] a system to develop a secured biometric voting system by integrating RFID technology with the Aadhar database.

The project addresses voting system limitations by advocating a biometric-based approach using RFID tags, fingerprint scanning, IoT, and future integration of face and IRIS technology. It aims to enhance security, efficiency, and

accuracy in voting, potentially revolutionizing the process. The paper demonstrates a deep understanding of biometric recognition advancements.

4. **Online Smart Voting System Using Biometrics Based Facial and Fingerprint Detection on Image Processing and CNN**: Chandra Keerthi Pothina, et al. approach [4] presents an innovative online smart voting system that leverages biometrics-based facial and fingerprint detection for secure and convenient voting. This web-based voting system employs image processing and Convolutional Neural Networks for precise face and fingerprint recognition, reducing duplicate votes globally. Aimed at improving efficiency and accessibility, it addresses limitations in India's voting system. The methodology involves capturing and comparing facial and fingerprint images, integrating Haar Cascade and Adaboost algorithms. The article discusses potential improvements and references related studies, emphasizing enhanced security, efficiency, and accessibility.

5. **Fingerprint Based Secured Voting:** Khadija Hasta, et al. presents [5] a Fingerprint Based Biometric Voting Machine using Arduino, which employs SHA-1 encryption to safeguard data and a fingerprint-based voting system to ensure secure and accurate voting. The tested system proves effective and user-friendly, suggesting improvements with additional biometric features and advanced algorithms. It addresses online voting challenges through fingerprint authentication, a matching algorithm, and Captcha for security. Drawing on past research, it offers a secure and reliable online voting platform with biometric authentication, encryption, and security measures, promising a modernized voting process.

6. **Smart and Secure Voting System Using Biometrics :**A. BalaMurali, et al. approach [6] creates a comprehensive solution to address the challenges of the existing voting system in India. The proposed smart voting system integrates GSM, SMS, GPS, fingerprint, image scanners, LCD, EVM, and cloud-based databases for secure and efficient elections. Utilizing biometric verification, confirmation messages, and cryptographic techniques, it enhances security. The inclusion of GPS and cloud databases strengthens reliability. The paper concludes with results, future improvements, and references, presenting a promising solution for India's voting process.

III. OBJECTIVES

To create an application which performs the following functionalities

- Enhanced Security: Implement advanced biometric features, such as face and fingerprint scans, to strengthen voter identification and authentication.
- Integration with Aadhar Database: Integrate the voting system with the Aadhar database,

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leveraging its comprehensive and secure repository of citizen information.

- Streamlined Authentication: Simplify and streamline the voter authentication process using biometric data linked to Aadhar cards. This not only ensures accuracy but also facilitates a smooth and efficient voting experience for citizens.
- Tamper-Proof Voting: Develop a system that prevents tampering and manipulation of votes. By utilizing the Aadhar database as a secure foundation, the project seeks to eliminate vulnerabilities and provide a robust defense against any attempts to compromise the integrity of the voting process.
- Transparency and Trust: Foster transparency in the electoral process by utilizing advanced technology and the Aadhar database. The project aims to build trust among voters by providing a secure, transparent, and reliable platform for expressing their democratic rights.
- Minimize Errors: Reduce manual errors in voter identification.
- Scalable Solution: Adaptable to large-scale elections with multiple polling stations.
- User-Friendly: Simple interface for voters and polling officials.
- Data Security: Protect voter information with encryption and secure storage.
- Compliance: Align with electoral regulations and standards.

IV. PROPOSED SYSTEM

- Biometric Voter Verification: Voters register their fingerprint during enrollment; on voting day, a fingerprint scan authenticates identity before allowing a vote.
- Integration with EVM/Digital Ballot: After verification, voter proceeds to cast vote on Electronic Voting Machine (EVM) or digital terminal.

1. Voter Registration Module

- Capture fingerprint (high-resolution sensor) → Store encrypted template in secure DB linked to voter ID.

2. Authentication Station (Polling Booth)

- Fingerprint scanner → Real-time matching (1:N) against registered DB.
- Confirmation → Grant access to vote; flag mismatch → deny or manual check.

3. Voting Interface

- Secure UI on EVM/terminal → Record vote, generate VVPAT slip.

4. Backend System

- Encrypted DB, tamper-proof logs, audit trails.
- Admin panel for officials to monitor status, results.
- Fast Matching: Low-latency fingerprint algorithm (e.g., MINDTIA, Deep Learning-based).
- Security: Template encryption, multi-factor fallback (PIN/ID card).
- Redundancy: Backup power, offline mode for remote areas.
- Privacy: Data stored only for verification, deleted post-election audit.

1. Voter arrives → Scan fingerprint.
2. System verifies → Match found → Proceed to vote.
3. Vote cast → Confirmation receipt (VVPAT).
4. Log entry stored securely.

- False Rejects/Accepts: Use high-accuracy sensors, liveness detection.
- Hygiene: Contactless or sanitizable sensors.
- Data Protection: End-to-end encryption, compliance with data laws.

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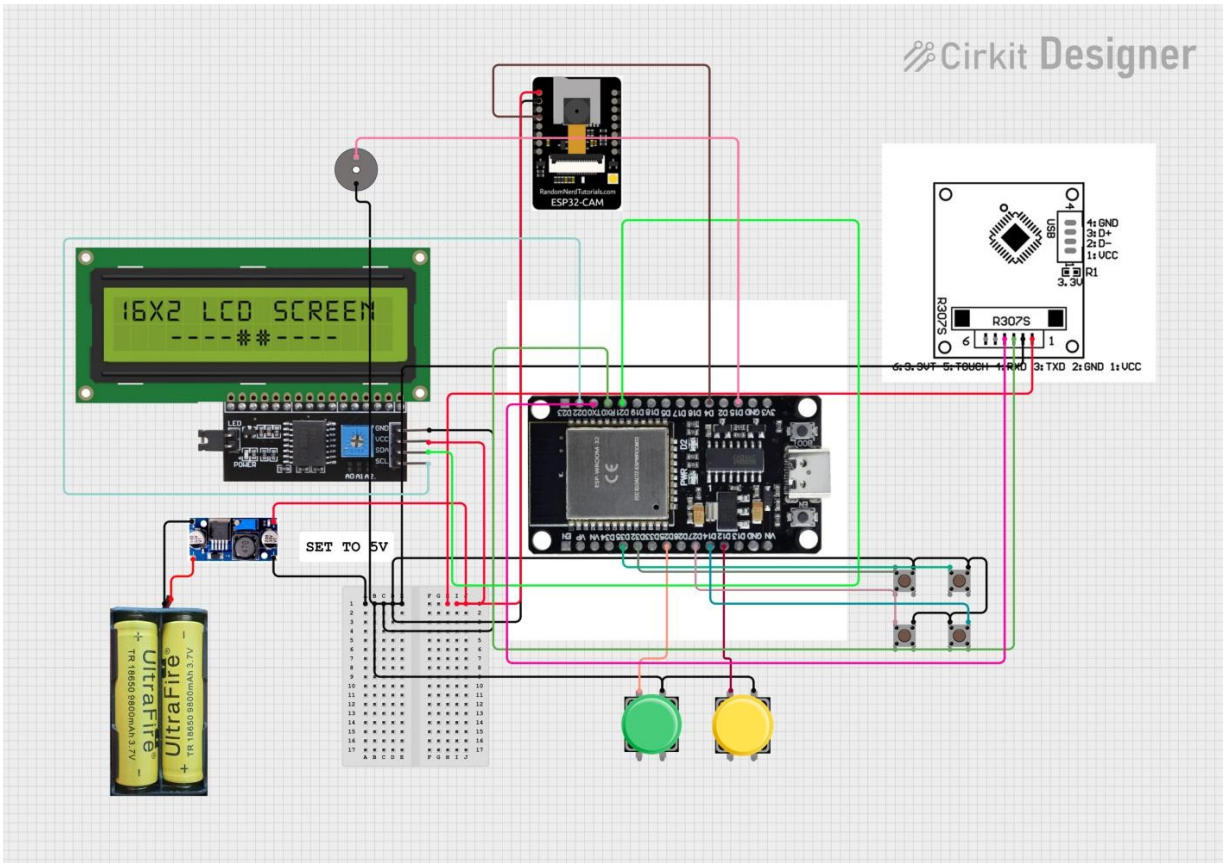
CIRCUIT DIAGRAM



ESP32 CODE:

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h> #include <Adafruit_Fingerprint.h> #include <HardwareSerial.h>
// LCD
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Fingerprint HardwareSerial mySerial(2);
Adafruit_Fingerprint finger = Adafruit_Fingerprint(&mySerial);

// Buttons
#define ENROLL_BTN 13
#define DELETE_BTN 25
#define CAND1 32
#define CAND2 33
#define CAND3 27
#define CAND4 14

// ESP32-CAM Trigger #define CAM_TRIGGER 4

#define LED_PIN 12
```

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```
#define BUZZER_PIN 15  // □ BUZZER #define MAX_USERS 4
bool voted[MAX_USERS + 1] = {false}; int votes[4] = {0};
// □ PARTY NAMES
String partyNames[4] = { "BJP",
"Congress", "TDP", "YSRCP"
};

uint8_t totalUsers = 0;

------// -DISPLAY  -----------
void displayMsg(String l1, String l2 = "") { lcd.clear();
lcd.setCursor(0, 0); lcd.print(l1); lcd.setCursor(0, 1); lcd.print(l2);
}

------// -SETUP  -----------
void setup() { Serial.begin(115200);

pinMode(ENROLL_BTN, INPUT_PULLUP); pinMode(DELETE_BTN, INPUT_PULLUP);

pinMode(CAND1, INPUT_PULLUP); pinMode(CAND2, INPUT_PULLUP); pinMode(CAND3,
INPUT_PULLUP); pinMode(CAND4, INPUT_PULLUP);

pinMode(CAM_TRIGGER, OUTPUT);
digitalWrite(CAM_TRIGGER, LOW); pinMode(LED_PIN, OUTPUT);
pinMode(BUZZER_PIN, OUTPUT);  // □
digitalWrite(BUZZER_PIN, LOW);

lcd.init(); lcd.backlight();
mySerial.begin(57600, SERIAL_8N1, 16, 17); finger.begin(57600);

if (!finger.verifyPassword()) { displayMsg("Sensor Error!"); while (1);
}

finger.getTemplateCount(); totalUsers = finger.templateCount;
displayMsg("Place Finger");
}

------// -LOOP  -----------
void loop() {

if (digitalRead(ENROLL_BTN) == LOW) { handleEnroll();
}

if (digitalRead(DELETE_BTN) == LOW) { handleDelete();
}

checkFingerprint();
}

------// -FINGER CHECK  -----------
```

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```
void checkFingerprint() {

int p = finger.getImage();
if (p != FINGERPRINT_OK) return;
if (finger.image2Tz() != FINGERPRINT_OK) return;

if (finger.fingerFastSearch() != FINGERPRINT_OK) { displayMsg("Access Denied");
delay(1500); displayMsg("Place Finger"); return;
}
int id = finger.fingerID; if (voted[id]) {
displayMsg("Already Voted");

// □ BUZZER ON digitalWrite(BUZZER_PIN, HIGH); delay(2000); digitalWrite(BUZZER_PIN,
LOW);
displayMsg("Place Finger");

return;
}

displayMsg("Verified ID:", String(id)); digitalWrite(LED_PIN, HIGH);
// Trigger Camera digitalWrite(CAM_TRIGGER, HIGH); delay(1000);
digitalWrite(CAM_TRIGGER, LOW);
delay(3000); selectCandidate(id); digitalWrite(LED_PIN, LOW);
displayMsg("Place Finger");
}

------// VOTING ----------
void selectCandidate(int id) { displayMsg("Select Candidate"); int selected = -1;
while (true) {
if (digitalRead(CAND1) == LOW) { selected = 0;
break;
}
if (digitalRead(CAND2) == LOW) { selected = 1;
break;
}
if (digitalRead(CAND3) == LOW) { selected = 2;
break;
}
if (digitalRead(CAND4) == LOW) { selected = 3;
break;
}
}

votes[selected]++; voted[id] = true;

displayMsg("Voted:", partyNames[selected]); delay(2000);

displayMsg("Vote Stored"); delay(1500);
}
```

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```
-----// ENROLL -----------
    void handleEnroll() { delay(300);
    if (totalUsers >= MAX_USERS) { displayMsg("Memory Full!"); delay(2000);
    displayMsg("Place Finger"); return;

    }

    enrollFingerprint(totalUsers + 1);

    finger.getTemplateCount(); totalUsers = finger.templateCount;
    displayMsg("Place Finger");
    }

-----// DELETE ----------
    void handleDelete() { delay(300);

    if (totalUsers == 0) { displayMsg("No Users"); delay(2000); displayMsg("Place Finger"); return;
    }

    finger.deleteModel(totalUsers); voted[totalUsers] = false; totalUsers--;
    displayMsg("Deleted"); delay(1500);
    displayMsg("Place Finger");
    }

-----// ENROLL FUNCTION -----------
    void enrollFingerprint(uint8_t id) {

    displayMsg("Enroll ID:", String(id)); delay(1500);

    while (finger.getImage() != FINGERPRINT_OK); finger.image2Tz(1);
    displayMsg("Remove Finger"); delay(2000);

    while (finger.getImage() != FINGERPRINT_NOFINGER); displayMsg("Place Again");
    while (finger.getImage() != FINGERPRINT_OK); finger.image2Tz(2);
    if (finger.createModel() == FINGERPRINT_OK) { finger.storeModel(id);
    displayMsg("Stored!");
    } else { displayMsg("Error");
    }

    delay(2000);
    }

    ESP32 CAM CODE:
    #include "esp_camera.h" #include <WiFi.h>
    #include <ESP_Mail_Client.h>
    // WIFI
-----#define WIFI_SSID "IOT"
    #define WIFI_PASSWORD "12345678"

-----// EMAIL-----
```

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```
#define SMTP_HOST "smtp.gmail.com" #define SMTP_PORT 465

#define AUTHOR_EMAIL "iothub15@gmail.com"
#define AUTHOR_PASSWORD "ccwyqbpevbaabxll" // remove spaces #define
RECIPIENT_EMAIL "dwijender15@gmail.com"
-----// PINS -----
#define TRIGGER_PIN 13
#define FLASH_LED_PIN 4  // Flash LED SMTPSession smtp;
// --------- CAMERA CONFIG ----------
void setupCamera() { camera_config_t config;
config.ledc_channel = LEDC_CHANNEL_0; config.ledc_timer = LEDC_TIMER_0;
config.pin_d0 = 5;
config.pin_d1 = 18;
config.pin_d2 = 19;
config.pin_d3 = 21;
config.pin_d4 = 36;
config.pin_d5 = 39;
config.pin_d6 = 34;
config.pin_d7 = 35;
config.pin_xclk = 0;
config.pin_pclk = 22;
config.pin_vsync = 25;
config.pin_href = 23;

config.pin_sccb_sda = 26;
config.pin_sccb_scl = 27;

config.pin_pwdn = 32;
config.pin_reset = -1;
config.xclk_freq_hz = 20000000; config.pixel_format = PIXFORMAT_JPEG;

config.frame_size = FRAMESIZE_VGA; config.jpeg_quality = 12;
config.fb_count = 2;  // □ IMPORTANT
if (esp_camera_init(&config) != ESP_OK) { Serial.println("Camera init failed");
while (1);
}
}

// --------- CAPTURE + SEND ----------

void captureAndSend() { Serial.println("Capturing...");
// □ FLASH ON digitalWrite(FLASH_LED_PIN, HIGH); delay(400);

// □ CLEAR OLD FRAMES (MOST IMPORTANT FIX)
for (int i = 0; i < 4; i++) {
camera_fb_t *fb_temp = esp_camera_fb_get(); if (fb_temp) esp_camera_fb_return(fb_temp);
delay(50);
}

// □ CAPTURE NEW FRAME
```

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```
camera_fb_t *fb = esp_camera_fb_get();

// □ FLASH OFF digitalWrite(FLASH_LED_PIN, LOW);
if (!fb) {
Serial.println("Capture Failed"); return;
}

Serial.println("Captured Fresh Image"); sendEmail(fb);
esp_camera_fb_return(fb);
}

// --------- SEND EMAIL ----------
void sendEmail(camera_fb_t *fb) { SMTP_Message message;
message.sender.name = "Voting System"; message.sender.email = AUTHOR_EMAIL;
message.subject = "Voter Image Captured"; message.addRecipient("Admin",
RECIPIENT_EMAIL);

// Attachment SMTP_Attachment att; att.descr.filename = "voter.jpg"; att.descr.mime =
"image/jpeg"; att.blob.data = fb->buf; att.blob.size = fb->len;
att.descr.transfer_encoding = Content_Transfer_Encoding::enc_base64; message.addAttachment(att);
ESP_Mail_Session session;

session.server.host_name = SMTP_HOST; session.server.port = SMTP_PORT; session.login.email
= AUTHOR_EMAIL; session.login.password = AUTHOR_PASSWORD;

if (!smtp.connect(&session)) { Serial.println("SMTP Failed"); return;
}

if (!MailClient.sendMail(&smtp, &message)) { Serial.println("Send Failed: " + smtp.errorReason());
} else {
Serial.println("Email Sent Successfully!");
}
smtp.closeSession();
}

-----// SETUP-----
void setup() { Serial.begin(115200);

pinMode(TRIGGER_PIN, INPUT); pinMode(FLASH_LED_PIN, OUTPUT);
digitalWrite(FLASH_LED_PIN, LOW);
// WiFi
WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
Serial.print("Connecting WiFi");

while (WiFi.status() != WL_CONNECTED) { delay(500);
Serial.print(".");
}

Serial.println("\nWiFi Connected");
setupCamera();
```

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```
}

-----// LOOP-----
void loop() {

if (digitalRead(TRIGGER_PIN) == HIGH) { Serial.println("Trigger Received!"); captureAndSend();
delay(7000); // prevent multiple triggers
}
}
```

CONCLUSIONS

The Smart Voting System through Fingerprint Recognition offers a robust solution to enhance electoral integrity, security, and efficiency. By leveraging biometric technology, it ensures accurate voter identification, prevents fraud, and streamlines the voting process. The system's scalability and user-friendly interface make it suitable for large-scale elections, boosting voter trust and confidence. With secure data handling and audit trails, it sets a new standard for transparent and reliable voting systems.

The Smart Voting Machine represents a significant advancement in electoral technology, addressing the critical challenges of traditional voting systems. By incorporating RFID, fingerprint authentication, and real-time database updates, the system ensures secure, efficient, and transparent elections. Its scalability and adaptability further position it as a future-proof solution capable of modernizing electoral processes globally. This innovative approach not only enhances the integrity of elections but also fosters greater trust and participation in democratic practices

FUTURE SCOPE

1. Multi-modal Biometrics: Integrate face/iris recognition for enhanced security.
2. Mobile Voting: Enable secure remote voting via mobile apps.
3. Blockchain Integration: Store votes immutably for transparency.
4. AI Analytics: Real-time monitoring for faster results and fraud detection.
5. IoT Connectivity: Smart polling booths with automated voter check-ins.
6. Global Standards: Align with international electoral security norms.
7. Voter Accessibility: Voice/fingerprint-based voting for differently-abled voters.
8. Cloud-Based Infrastructure: Scalable, cost-effective data storage and processing.
9. Real-time Results: Instant vote counting and analytics.
10. Enhanced Security Measures: Anti-spoofing tech and biometric encryption.

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