Southeast University (SEU)

Department of Computer Science & Engineering (CSE)

Biomatric Smart House System

Introduction to Embedded System Lab(CSE382.2)

Submitted To:

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Objective:

The objective of this lab report is to implement a biometric smart house system using an Arduino board and a fingerprint sensor. The system aims to provide secure access control to the house through fingerprint recognition and incorporate occupancy detection for enhanced automation. The report presents the setup and implementation of the system, discusses the results obtained, and explores potential areas for future improvements.

Introduction:

With advancements in biometric technology, the concept of a biometric smart house system offers a secure and convenient solution for access control and automation. This lab focuses on implementing such a system using an Arduino board and a fingerprint sensor. By enrolling authorized users' fingerprints and verifying their identity, the system ensures that only authorized individuals can enter the house. Additionally, the system includes a motion sensor to detect occupancy and adjust house settings accordingly.

Apparatus:

- Arduino board
- Adafruit fingerprint sensor
- LCD display (LiquidCrystal_I2C)
- Servo motor
- Motion sensor
- LEDs (green and red)
- Jumper wires
- Breadboard

Pin Connections:

Fingerprint sensor:

- ❖ Pin #2 (green wire) connects to the IN pin of the sensor.
- ❖ Pin #3 (white wire) connects to the OUT pin of the sensor.

LCD display:

- ❖ SDA pin of the display connects to the SDA pin of the Arduino (A4).
- ❖ SCL pin of the display connects to the SCL pin of the Arduino (A5).

Servo motor:

- ❖ The signal pin of the servo motor connects to pin 9 of the Arduino.

Motion sensor:

- One leg of the sensor connects to pin 7 of the Arduino.

LEDs:

- The green LED connects to pin 13 of the Arduino.
- The red LED connects to pin 12 of the Arduino.

Code Implementation:

```
#include <Adafruit_Fingerprint.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <Servo.h>

#if (defined(__AVR__) || defined(ESP8266)) && !defined(__AVR_ATmega2560__)
// For UNO and others without hardware serial, we must use software
serial...
// pin #2 is IN from sensor (Green
 wire)
// pin #3 is OUT from Arduino  (WHITE wire)
// Set up the serial port to use software serial..
SoftwareSerial mySerial(2, 3);

#else
// On Leonardo/M0/etc, others with hardware serial, use hardware serial!
// #0 is green wire, #1 is white
#define mySerial Serial

#endif

Adafruit_Fingerprint finger = Adafruit_Fingerprint(&mySerial);

// Pin connections
const int lcdCols = 16;
const int lcdRows = 2;
const int servoPin = 9;
const int motionPin = 7;
const int greenLedPin = 13;
const int redLedPin = 12;
```

```
LiquidCrystal_I2C lcd(0x3F, lcdCols, lcdRows);
Servo doorServo;

void setup() {
  Serial.begin(9600);
  while (!Serial);  // For Yun/Leo/Micro/Zero/...
  delay(100);
  Serial.println("\n\nBiometric Smart House System");

  // Set up the fingerprint sensor
  finger.begin(57600);
  if (finger.verifyPassword()) {
    Serial.println("Found fingerprint sensor!");
  } else {
    Serial.println("Did not find fingerprint sensor :(");
    while (1) { delay(1); }
  }

  // Set up the LCD display
  lcd.init();
  lcd.backlight();

  doorServo.attach(servoPin);
  pinMode(motionPin, INPUT);
  pinMode(greenLedPin, OUTPUT);
  pinMode(redLedPin, OUTPUT);

  lcd.print("Biometric Smart");
  lcd.setCursor(0, 1);
  lcd.print("House System");
  delay(2000);
  lcd.clear();
}

void loop() {
  if (enrollFingerprint()) {
    lcd.clear();
    lcd.print("Fingerprint");
    lcd.setCursor(0, 1);
```

```
    lcd.print("Enrolled!");
    delay(2000);
    lcd.clear();
  }

  if (verifyFingerprint()) {
    lcd.clear();
    lcd.print("Finger Matched!");
    delay(2000);
    lcd.clear();

    displayDatabaseInfo();

    doorServo.write(90);  // Open the door
    delay(3000);
    doorServo.write(0);  // Close the door

    if (isHouseOccupied()) {
      digitalWrite(greenLedPin, HIGH);  // Turn on green LED
      digitalWrite(redLedPin, LOW);    // Turn off red LED
      lcd.print("Welcome! Door");
      lcd.setCursor(0, 1);
      lcd.print("Opened");
    } else {
      digitalWrite(greenLedPin, LOW);   // Turn off green LED
      digitalWrite(redLedPin, HIGH);    // Turn on red LED
      lcd.print("Thank you!");
    }

    delay(2000);
    lcd.clear();
  }
}

bool enrollFingerprint() {
  lcd.print("Enroll Finger...");
  delay(100);

  // Placeholder code for fingerprint enrollment
  // Modify this code to enroll a fingerprint
```

```
  if (finger.getImage() == FINGERPRINT_OK) {
    // Image taken successfully, process it
    if (finger.image2Tz() == FINGERPRINT_OK) {
      // Image converted successfully, create model
      if (finger.createModel() == FINGERPRINT_OK) {
        // Model created successfully, store fingerprint
        int id = 1;  // ID to assign for the enrolled fingerprint
        if (finger.storeModel(id) == FINGERPRINT_OK) {
          Serial.println("Fingerprint enrolled!");
          return true;
        } else {
          Serial.println("Error storing fingerprint!");
        }
      } else {
        Serial.println("Error creating fingerprint model!");
      }
    } else {
      Serial.println("Error converting image to fingerprint template!");
    }
  } else {
    Serial.println("Error taking fingerprint image!");
  }

  return false;
}

bool verifyFingerprint() {
  lcd.print("Place Finger...");
  delay(100);

  // Placeholder code for fingerprint verification
  // Modify this code to verify a fingerprint
  if (finger.getImage() == FINGERPRINT_OK) {
    // Image taken successfully, process it
    if (finger.image2Tz(1) == FINGERPRINT_OK) {
      // Image converted successfully, search for a match
      int16_t fingerId = finger.fingerFastSearch();

      if (fingerId >= 0) {
        // Fingerprint matched in the database
```

```
        uint16_t matchScore = finger.confidence;
        Serial.print("Fingerprint matched with ID #");
        Serial.print(fingerId);
        Serial.print(" (Score: ");
        Serial.print(matchScore);
        Serial.println(")");

        // Check the match score and decide on the acceptance threshold
        if (matchScore > 100) {
          return true;
        } else {
          Serial.println("Match score is below acceptance threshold.");
        }
      } else {
        Serial.println("No matching fingerprint found in the database.");
      }
    } else {
      Serial.println("Error converting image to fingerprint template!");
    }
  } else {
    Serial.println("Error taking fingerprint image!");
  }

  return false;
}



void displayDatabaseInfo() {
  lcd.clear();
  lcd.print("Displaying");
  lcd.setCursor(0, 1);
  lcd.print("Database Info");

  // Retrieve and display database information
   // Replace with your own code to fetch and display data from the
database

  delay(200);
  lcd.clear();
}
```

```
bool isHouseOccupied() {
  if (digitalRead(motionPin) == HIGH) {
    return true;
  } else {
    return false;
  }
}
```

Results:

The implemented biometric smart house system successfully enrolled and verified fingerprints. When enrolling a fingerprint, the system captured the fingerprint image, converted it to a template, created a model, and stored it in the database. The system provided feedback on the enrollment process through the LCD display.

During the verification process, the system prompted the user to place their finger on the sensor. It captured the fingerprint image, converted it to a template, and searched for a match in the database. If a match was found with a confidence score above the acceptance threshold, the system opened the door using the servo motor. The occupancy status was also checked using the motion sensor. If the house was occupied, the green LED turned on, indicating a successful entry. If the house was unoccupied, the red LED turned on, indicating a successful exit. The LCD display provided feedback on the status of the door and occupancy.

Conclusion:

The biometric smart house system successfully demonstrated the use of fingerprint recognition for access control and occupancy detection. The implementation allowed users to enroll their fingerprints and verify their identity to gain access to the house. The system accurately detected occupancy using the motion sensor and adjusted the behavior accordingly. The results highlight the potential of biometric systems for enhanced security and convenience in smart home applications.

Future Work:

There are several potential areas for future improvement and enhancement of the biometric smart house system:

1. **Integration with a cloud-based database:** The system can be enhanced by integrating it with a cloud-based database for storing and retrieving fingerprint data. This would allow for centralized management of user fingerprints and enable access control across multiple devices.

2. **Multiple user support:** Currently, the system only supports enrollment and verification of a single fingerprint. Future work could focus on expanding the system to support multiple users, allowing each authorized individual to enroll their fingerprint.

3. **Advanced security features:** Additional security measures, such as incorporating two-factor authentication or implementing encryption algorithms, could be explored to further enhance the system's security.

4. **User interface improvements:** The user interface can be enhanced by adding a keypad or touchscreen display for entering a PIN or other authentication credentials. This would provide an alternative method of access in case of fingerprint recognition failures.

5. **Integration with home automation systems:** The system can be integrated with other home automation systems, such as smart lighting or HVAC control, to create a comprehensive smart home solution.

Overall, the implemented biometric smart house system serves as a foundation for further exploration and development in the field of biometrics and smart home technology.