RV INSTITUTE OF TECHNOLOGY AND MANAGEMENT®

BIOLOGY FOR ENGINEERS

ASSIGNMENT - 2

TOPIC: REPORT ON FINGERPRINT SENSOR MANAGEMENT SYSTEM WITH SERVOMOTOR INTEGRATION

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INTRODUCTION:

OVERVIEW:

This report presents the design and implementation of a fingerprint sensor management system integrated with a servo motor. The system allows for three primary functions: enrolling fingerprints, verifying fingerprints, and deleting fingerprints. Upon successful verification of a fingerprint, a servo motor is activated to perform a mechanical action, demonstrating the potential application of fingerprint recognition in security systems.

OBJECTIVES:

The primary objectives of this project are to design a system that can enroll, verify, and delete fingerprints using the Adafruit Fingerprint Sensor. Additionally, the system will integrate a servo motor that responds to successful fingerprint verification. A user-friendly interface will be provided through serial communication, allowing users to select different operation modes easily.

2. SYSTEM COMPONENTS

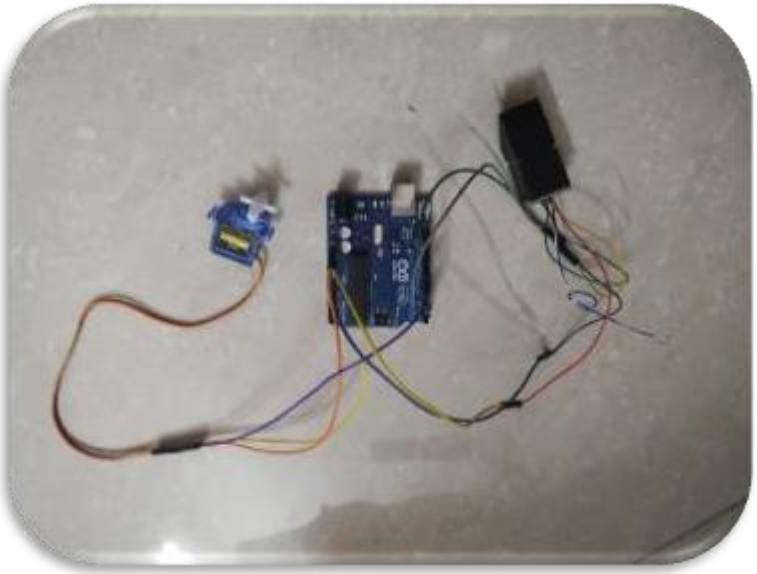
The hardware components for this project include the Adafruit Fingerprint Sensor, which is a capacitive fingerprint sensor module used for capturing and processing fingerprint images. The Servo Motor (SG90) is a small servomotor that demonstrates an action triggered by fingerprint verification. The Arduino Microcontroller serves as the central

processing unit, interfacing with both the fingerprint sensor and the servo motor to coordinate their functions.

THE SOFTWARE COMPONENTS:

For this project include the Arduino IDE, which is the development environment used for writing and uploading code to the Arduino microcontroller. The Adafruit Fingerprint Library simplifies the process of interfacing with the fingerprint sensor, while the Servo Library facilitates the control of servo motors. These libraries and tools work together to ensure smooth operation and interaction between the system's hardware components.

CIRCUIT DESIGN:



PIN CONNECTIONS

FINGERPRINT SENSOR

- TX to Arduino Pin 2 (or Serial1 TX on Mega)
- RX to Arduino Pin 3 (or Serial1 RX on Mega)
- VCC to 5V
- GND to GND

SERVO MOTOR

- Signal to Arduino Pin 9
- VCC to 5V

4. SOFTWARE IMPLEMENTATION:

INTIALIZATION AND SETUP

The `setup()` function initializes serial communication and the fingerprint sensor, verifies the sensor's password, and sets the initial position of the servo motor.

ENROLL FINGERPRINT FUNCTION

The `enrollFingerprint()` function guides the user through enrolling a new fingerprint. It captures two images of the fingerprint, converts them into a model, and stores this model in the sensor’s memory.

VERIFY FINGERPRINT FUNCTION

The `verifyFingerprint()` function continuously checks for a fingerprint on the sensor. If a match is found, the system activates the servo motor to perform a predefined action.

DELETE FINGERPRINT FUNCTION

The `deleteFingerprint()` function allows the user to remove a specific fingerprint from the sensor’s memory. It matches the fingerprint with stored records and deletes it upon confirmation.

5. OPERATION MODES

ENROLLMENT MODE

In this mode, the user can enroll a new fingerprint by entering an ID. The fingerprint is stored in the sensor’s memory under the provided ID.

VERIFICATION MODE

This mode is used to verify a fingerprint against stored records. Upon successful verification, the servo motor is activated.

DELETION MODE

The user can delete a stored fingerprint by entering the corresponding ID or by placing the finger on the sensor. The fingerprint is then removed from the memory.

6. PROGRAM FOR THE FINGERPRINT SENSOR:

```
#include <Adafruit_Fingerprint.h>

#include <Servo.h>

#if (defined(__AVR__) || defined(ESP8266)) && !defined(__AVR_ATmega2560__)

SoftwareSerial mySerial(2, 3);

#else

#define mySerial Serial1
```

```
#endif

Adafruit_Fingerprint finger = Adafruit_Fingerprint(&mySerial);
Servo myServo;
const int servoPin = 9;
uint8_t id;

void setup() {
  Serial.begin(9600);
  while (!Serial);
  delay(100);
  Serial.println("\n\nFingerprint Sensor Management");

  // Initialize 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); }
  }

  myServo.attach(servoPin);  // Attaches the servo on pin 9 to the servo object
  myServo.write(0);  // Initialize servo position
}

void loop() {
  Serial.println("Select mode: (e)nroll, (v)erify, (d)elete");
```

```
  while (!Serial.available());
  char mode = Serial.read();

  // Clear any remaining characters in the buffer (like newline)
  while (Serial.available()) {
    Serial.read();
  }

  switch (tolower(mode)) {
    case 'e':
      enrollFingerprint();
      break;
    case 'v':
      verifyFingerprint();
      break;
    case 'd':
      deleteFingerprint();
      break;
    default:
      Serial.println("Invalid mode! Please select (e), (v), or (d).");
  }
}

void enrollFingerprint() {
  Serial.println("Enrolling fingerprint...");
  Serial.println("Please type in the ID # (from 1 to 127) you want to save this finger as...");
  id = readnumber();
  if (id == 0) {
     return;
  }
```

```
  Serial.print("Enrolling ID #");
  Serial.println(id);

  while (!getFingerprintEnroll());
}

uint8_t getFingerprintEnroll() {
  int p = -1;
  Serial.print("Waiting for valid finger to enroll as #"); Serial.println(id);
  while (p != FINGERPRINT_OK) {
    p = finger.getImage();
    switch (p) {
      case FINGERPRINT_OK:
        Serial.println("Image taken");
        break;
      case FINGERPRINT_NOFINGER:
        Serial.println("No finger detected");
        break;
      case FINGERPRINT_PACKETRECIEVEERR:
        Serial.println("Communication error");
        break;
      case FINGERPRINT_IMAGEFAIL:
        Serial.println("Imaging error");
        break;
      default:
        Serial.println("Unknown error");
        break;
    }
  }
```

```
p = finger.image2Tz(1);
if (p != FINGERPRINT_OK) {
  Serial.println("Error in converting image");
  return p;
}

Serial.println("Remove finger");
delay(2000);
p = 0;
while (p != FINGERPRINT_NOFINGER) {
  p = finger.getImage();
}
Serial.print("ID "); Serial.println(id);
Serial.println("Place same finger again");
p = -1;
while (p != FINGERPRINT_OK) {
  p = finger.getImage();
  switch (p) {
    case FINGERPRINT_OK:
      Serial.println("Image taken");
      break;
    case FINGERPRINT_NOFINGER:
      Serial.println("No finger detected");
      break;
    case FINGERPRINT_PACKETRECIEVEERR:
      Serial.println("Communication error");
      break;
    case FINGERPRINT_IMAGEFAIL:
      Serial.println("Imaging error");
      break;
```

```
    default:
      Serial.println("Unknown error");
      break;
  }
}

p = finger.image2Tz(2);
if (p != FINGERPRINT_OK) {
  Serial.println("Error in converting image");
  return p;
}

p = finger.createModel();
if (p == FINGERPRINT_OK) {
  Serial.println("Prints matched!");
} else if (p == FINGERPRINT_PACKETRECIEVEERR) {
  Serial.println("Communication error");
  return p;
} else if (p == FINGERPRINT_ENROLLMISMATCH) {
  Serial.println("Fingerprints did not match");
  return p;
} else {
  Serial.println("Unknown error");
  return p;
}

p = finger.storeModel(id);
if (p == FINGERPRINT_OK) {
  Serial.println("Stored!");
} else if (p == FINGERPRINT_PACKETRECIEVEERR) {
```

```
    Serial.println("Communication error");
    return p;
  } else if (p == FINGERPRINT_BADLOCATION) {
    Serial.println("Could not store in that location");
    return p;
  } else if (p == FINGERPRINT_FLASHERR) {
    Serial.println("Error writing to flash");
    return p;
  } else {
    Serial.println("Unknown error");
    return p;
  }

  return true;
}

void verifyFingerprint() {
  Serial.println("Verifying fingerprint...");
  Serial.println("Place your finger on the sensor");

  while (true) {  // Continuous loop
    uint8_t p = finger.getImage();
    if (p != FINGERPRINT_OK) {
      switch (p) {
        case FINGERPRINT_NOFINGER:
          Serial.println("Waiting for finger...");
          break;
        case FINGERPRINT_PACKETRECIEVEERR:
          Serial.println("Communication error");
          break;
```

```
    case FINGERPRINT_IMAGEFAIL:
      Serial.println("Imaging error");
      break;
    default:
      Serial.println("Unknown error");
      break;
  }
  delay(1000);  // Wait a second before trying again
  continue;  // Skip the rest of the loop and start over
}

// If we get here, we've successfully captured an image
p = finger.image2Tz();
if (p != FINGERPRINT_OK) {
  Serial.println("Failed to convert image.");
  continue;
}

p = finger.fingerFastSearch();
if (p == FINGERPRINT_OK) {
  Serial.print("Found ID #"); Serial.print(finger.fingerID);
  Serial.print(" with confidence of "); Serial.println(finger.confidence);

  // Fingerprint verified, activate servo
  Serial.println("Fingerprint verified! Activating servo.");
  myServo.write(90);  // Turn servo to 90 degrees
  delay(1000);  // Keep servo activated for 1 second
  myServo.write(0);  // Return servo to initial position
} else if (p == FINGERPRINT_NOTFOUND) {
  Serial.println("Fingerprint not recognized.");
```

```
    } else {
      Serial.println("Error in fingerprint search.");
    }
    Serial.println("Verify another? (y/n)");
    while (!Serial.available());
    char response = Serial.read();
    if (response != 'y' && response != 'Y') {
      break;  // Exit the verification loop
    }
    Serial.println("Place your finger on the sensor");
  }

  Serial.println("Exiting verification mode.");
}

void deleteFingerprint() {
  Serial.println("Delete Fingerprint");
  Serial.println("Place finger to delete on the sensor");

  while (true) {
    uint8_t p = finger.getImage();
    if (p != FINGERPRINT_OK) {
      switch (p) {
        case FINGERPRINT_NOFINGER:
          Serial.println("Waiting for finger...");
          break;
        case FINGERPRINT_PACKETRECIEVEERR:
          Serial.println("Communication error");
          break;
        case FINGERPRINT_IMAGEFAIL:
```

```
      Serial.println("Imaging error");
      break;
    default:
      Serial.println("Unknown error");
      break;
  }
  delay(1000);
  continue;
}

p = finger.image2Tz();
if (p != FINGERPRINT_OK) {
  Serial.println("Failed to convert image");
  return;
}

p = finger.fingerFastSearch();
if (p != FINGERPRINT_OK) {
  Serial.println("Finger not found in database.");
  return;
}

// Found a match!
Serial.print("Found ID #"); Serial.print(finger.fingerID);
Serial.print(" with confidence of "); Serial.println(finger.confidence);

Serial.print("Deleting ID #"); Serial.println(finger.fingerID);

p = finger.deleteModel(finger.fingerID);
```

```
    if (p == FINGERPRINT_OK) {
      Serial.println("Deleted!");
    } else if (p == FINGERPRINT_PACKETRECIEVEERR) {
      Serial.println("Communication error");
    } else if (p == FINGERPRINT_BADLOCATION) {
      Serial.println("Could not delete in that location");
    } else if (p == FINGERPRINT_FLASHERR) {
      Serial.println("Error writing to flash");
    } else {
      Serial.print("Unknown error: 0x"); Serial.println(p, HEX);
    }

    return;
  }
}

uint8_t readnumber(void) {
  uint8_t num = 0;

  while (num == 0) {
    while (!Serial.available());
    num = Serial.parseInt();
  }
  return num;
}
```

7. TESTING AND RESULTS

TEST SCENARIOS

- Scenario 1: Enroll a new fingerprint and verify it successfully.
- Scenario 2: Attempt to verify a non-enrolled fingerprint.

- Scenario 3: Delete an enrolled fingerprint and verify the deletion by trying to authenticate the same finger.

OBSERVATIONS

The fingerprint sensor was able to enroll and verify fingerprints accurately in most cases. The servo motor responded promptly to successful verifications. The system effectively prevented unauthorized access by denying non-enrolled fingerprints.

PERFORMANCE ANALYSIS

- **SPEED**: The system responded within 1-2 seconds for enrollment and verification.

- **ACCURACY**: The fingerprint sensor demonstrated high accuracy with minimal false rejections.

- **RELIABILITY**: The system was reliable in various lighting conditions and for different users.

8. CONCLUSION

SUMMARY

The fingerprint sensor management system successfully demonstrated the integration of biometric authentication with mechanical action. The system effectively enrolled, verified, and deleted fingerprints, with the servo motor acting as a visual indicator of successful verification.

FUTURE ENHANCEMENTS

- Multi-fingerprint Enrollment: Enhancing the system to enroll multiple fingerprints for the same ID.

- Remote Management: Implementing remote fingerprint management via wireless communication.

- Additional Security Features: Adding features like PIN verification or two-factor authentication.

9. REFERENCES

- Adafruit Fingerprint Sensor Datasheet

- Arduino Servo Library Documentation

- Arduino IDE Official Site