Enhanced Security System with Human, Vehicle Detection, and Keypad Access Control

Project submitted in fulfilment of the requirements for the Digital Systems 4 Project

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Date : 18/05/2024

Declaration

I Aubrey Nekhavhambe declare that this report is my own, unaided work. It is being submitted for Digital System 4 to the Department of Electrical Engineering at the Vaal University of Technology, Vanderbijlpark. It has not been submitted before for any subject or evaluation to any educational institution

A Nekhavhambe
18/05/2024

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A Makhala
18/05/2024

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MH Maloma
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18/05/2024

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List of abbreviations and acronyms

- PIR: Passive Infrared
- LCD: Liquid Crystal Display
- GUI: Graphical User Interface

- IoT: Internet of Things
- OTA: Over-the-Air
- ESP32: Espressif Systems' ESP32 series of low-cost, low-power microcontrollers
- HC-SR501/HC-SR505: Types of human body sensors (PIR sensors)
- HC-SR04: Ultrasonic distance sensor
- H0308: Keypad model
- Wemos: A brand of development boards, often used for ESP32 microcontrollers

Chapter 1

1.1 Project background

Security breaches pose significant risks to residential and commercial properties, necessitating the deployment of robust security systems. Traditional security measures may fall short in effectively detecting and responding to intrusions, highlighting the need for innovative solutions incorporating sensor technologies and access control mechanisms. The management of a bustling commercial complex, comprising various businesses, offices, and amenities, recognizes the paramount importance of security in safeguarding the premises, assets, and occupants. In light of recent security incidents and growing concerns, the management has decided to implement an advanced security system to enhance perimeter protection, intrusion detection, and access control.

Through the use of cutting-edge technologies like computer vision, machine learning, and secure access protocols, the proposed project, named "Enhanced Security System with Human, Vehicle Detection, and Keypad Access Control," seeks to address these issues. Through the integration of keypad access control and people and vehicle detection capabilities, the system aims to offer extensive security coverage that is customized to meet the unique requirements of various environments.

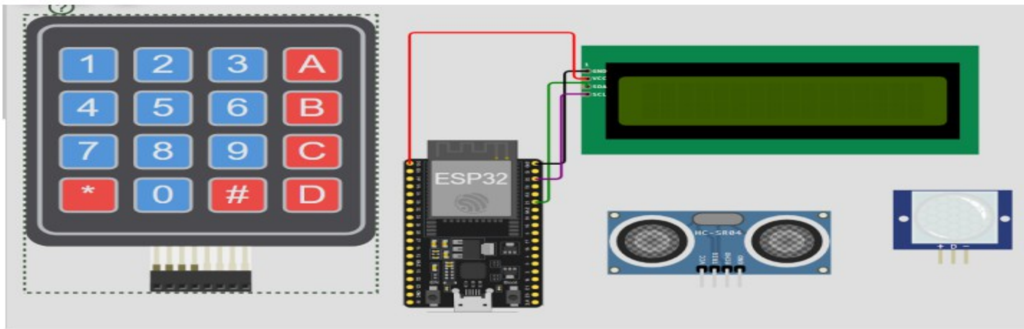

Figure 1 : Components requirements

Figure 2 : Security door access control keypad

1.2 Introduction

Our project aims to design and implement a security system for residential or commercial premises by integrating human and vehicle detection sensors, as well as keypad access control. This multi-layered approach will enhance security measures by providing robust intrusion detection and access control mechanism

1.3 Problem statement

Existing security systems may lack the capability to provide multi-layered protection, including human and vehicle detection, as well as keypad access control, leading to vulnerabilities and security lapses.

1.4 Significance

Implementing a security system with that significantly enhance perimeter security, reduce false alarms, and improve overall situational awareness. By incorporating keypad access control, the system can further restrict unauthorized access to secured areas.

1.5 Objectives

Develop a comprehensive security system integrating sensors for human and vehicle detection, Implement keypad access control mechanism with password authentication. Evaluate the effectiveness of the system in detecting intrusions and controlling access to secured areas. Assess the impact of the system on overall security posture and response times.

1.6 Project plan

1.6.1 **Project Initiation Phase:**

- Assigned roles and duties to the project team.
- We held group meetings to learn about our needs and expectations
- drafted a project charter outlining the goals, constraints, and intention of the endeavor.

1.6.2 **Investigation and Requirements Collection:**

- Identified current technologies, approaches, and best practices for access control systems, security protocols, and vehicle and person detection by conducting a thorough literature review
- collected needs from stakeholders for the scalability, performance indicators, functionality, and integration of the system with the current infrastructure.
- developed techniques for risk mitigation after analyzing potential hazards and project constraints.

1.6.3.**System Design Phase:**

- Designed the software modules (identification algorithms, user interface, database), hardware (sensors, cameras, keypad access control devices), and communication protocols for the entire system architecture.
- defined formats for data interchange and interfaces between system parts.
- Using computer vision techniques including object identification, tracking, and classification, algorithms were developed for the detection of humans and vehicles.

1.6.4.**Creation and Execution:**

- To guarantee the performance, dependability, and usefulness of both the combined system and its separate components, unit and integration testing were carried out.

- For the purpose of pilot testing and validation, the system was deployed in a controlled setting.

1.7. **Proposed budget for the project**

The hardware did not cost us since we were provided them by the institution, as well as the software development , deployment installation.

1.8.**Time schedule how the project will be conducted**

- Research gathering (1 week)
- System designing and planning (1 week)
- Development and testing (1 week)
- Deployment(1 day)

1.9. **Limitations**

1.9.1 Technological Restrictions:

- Dependency on present technologies: The system's efficacy can be constrained by the capabilities of the keypad access control mechanisms and person and vehicle detection programs as they exist today. Technology developments that occur after the project's completion date may make some project components less useful or obsolete.
- Environmental factors: Lighting, weather, and topography can all have an effect on how well surveillance cameras and sensors function, which could have an impact on how accurate detection and monitoring are.

1.9.2.**Limitations on Operations:**

- False positives and negatives: Algorithms for both human and automotive detection may generate false positives, or incorrect detections, or false negatives, or missed detections, which could result in erroneous threat assessments or security breaches. To reduce these inaccuracies, detection algorithms must be continuously improved and validated.
- User error: Insufficient instruction or poorly designed user interfaces may lead to mistakes made when the system is operating, which could jeopardize security or cause interruptions. Ensuring that operators and end users effectively utilize the system requires comprehensive training programs and user-friendly interfaces.

1.10. **Chapter conclusion**

An important step toward enhancing security measures in residential, commercial, and institutional contexts is the establishment of an upgraded security system with vehicle detection, keypad access control, and people detection. This initiative strives to contribute to safer and more secure environments for individuals and communities alike via meticulous design, execution, and ongoing development.

Chapter 2

2.1**Human Body Sensor (HC-SR501/HC-SR505):**

Human body sensors, commonly known as passive infrared (PIR) sensors, are widely used in security systems for detecting human presence based on heat radiation. Literature surrounding PIR sensors primarily focuses on their principles of operation, sensitivity adjustments, and applications in motion detection. Research papers and technical articles discuss techniques for optimizing PIR sensor performance, reducing false alarms, and enhancing energy efficiency in battery-powered devices.

2.2. **Ultrasonic Distance Sensors (HC-SR04):**

Ultrasonic distance sensors utilize sound waves to measure distances to nearby objects, making them suitable for applications such as obstacle detection and proximity sensing. Literature related to ultrasonic sensors covers topics such as sensor calibration, signal processing algorithms, and environmental factors affecting sensor accuracy. Research in this area explores advancements in ultrasonic sensor technology, including multi-sensor fusion techniques for improved localization and mapping in robotics and autonomous systems.

2.3. **Keypad (H0308):**

Keypads are essential components for user authentication and access control in security systems. Literature on keypad design and implementation discusses topics such as matrix keypad configurations, debounce algorithms, and password .Studies in this field explore various keypad interface designs, including membrane keypads, capacitive touch keypads, and mechanical key switches, as well as encryption techniques for secure password entry and authentication.

2.4. **Microcontroller (ESP32 Wroom 32 Wemos):**

In security systems, microcontrollers act as the main processing units, coordinating the gathering, analyzing, and sharing of sensor data with other devices. A wide range of subjects are covered in the literature on microcontroller-based security systems, such as wireless communication protocols, real-time operating systems, and firmware development. The use of microcontrollers in energy-efficient computing, secure firmware upgrades over-the-air (OTA), and Internet of Things applications are all being investigated in this field of study.

2.5 **LCD Display (2 X 16):**

In security systems, LCD screens offer visual feedback and status indicators that make it easier for users to interact with the system and monitor it. The design principles of graphical user interfaces (GUIs), driver circuits, and display technologies are covered in literature pertaining to LCD screens in embedded systems. This field of study examines developments in LCD technology, including touch-sensitive panels, TFT (thin-film transistor) displays, and power-efficient display controllers for portable and battery-powered gadgets.

Chapter 3

3.1. **Hardware components**

- Human Body Sensor (HC-SR501/HC-SR505): Passive infrared (PIR) sensors will be strategically placed to detect human presence based on heat radiation.
- Ultrasonic Distance Sensors (HC-SR04): Ultrasonic sensors will measure distances to nearby objects, enabling obstacle detection and proximity sensing
- Keypad (H0308): A keypad will be integrated for secure authentication and access control, allowing authorized personnel to enter PIN codes for entry.
- Microcontroller (ESP32 Wroom 32 Wemos): The ESP32 microcontroller will serve as the central processing unit, coordinating sensor data acquisition, processing, and communication.
- LCD Display (2 X 16): An LCD display will provide visual feedback and status indicators for user interaction and system monitoring.

3.2. **Software modules**

- Algorithms for the Real-Time Detection and Tracking of Humans and Vehicles: PIR and ultrasonic sensor data will be processed using computer vision algorithms that will be developed.
- Keypad Access Control Mechanism: Software modules for access control policies, PIN code verification, and user authentication will be put into place.
- Microcontroller Integration: Firmware will be created to communicate with sensor modules, manage external devices, and carry out logic for making decisions based on input from sensors.
- User Interface: Graphical user interfaces, or GUIs, will be created for system management, monitoring, and configuration. They will give operators and end users easy-to-use controls and visual feedback.

3.3. **Outcomes to be achieved**

The creation of an improved security system that can identify and counter security risks in a variety of settings is the project's main goal. The system seeks to accomplish the following results by combining keypad access control techniques with people and vehicle detection capabilities.

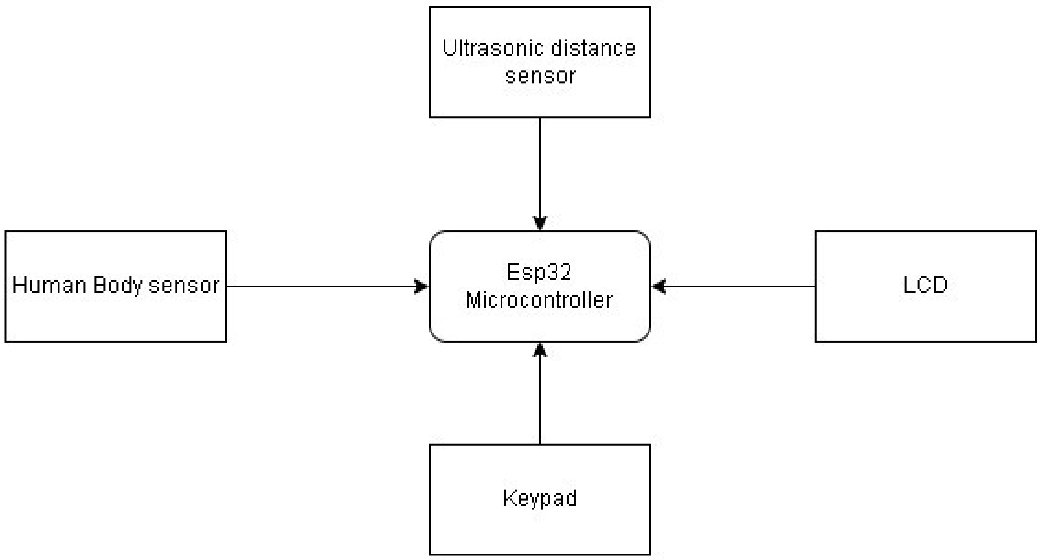

Figure 3:Block diagram of security system

Chapter 4

4. **Hardware Design**

This chapter details the development of a security system for human detection, distance measurement, and access control using a PIR sensor, ultrasonic sensor distance sensor, keypad, esp32, LCD. It discusses the selection, integration and testing of these components, demonstration that highlight the systems efficiency and reliability.

4.1 Human body sensor (PIR sensor)
Human body sensor role is to detect motion. Human body sensors are critical in biomechatronics for security, Improving movement through key data collection. (Aya Sedky Adly, 2021).

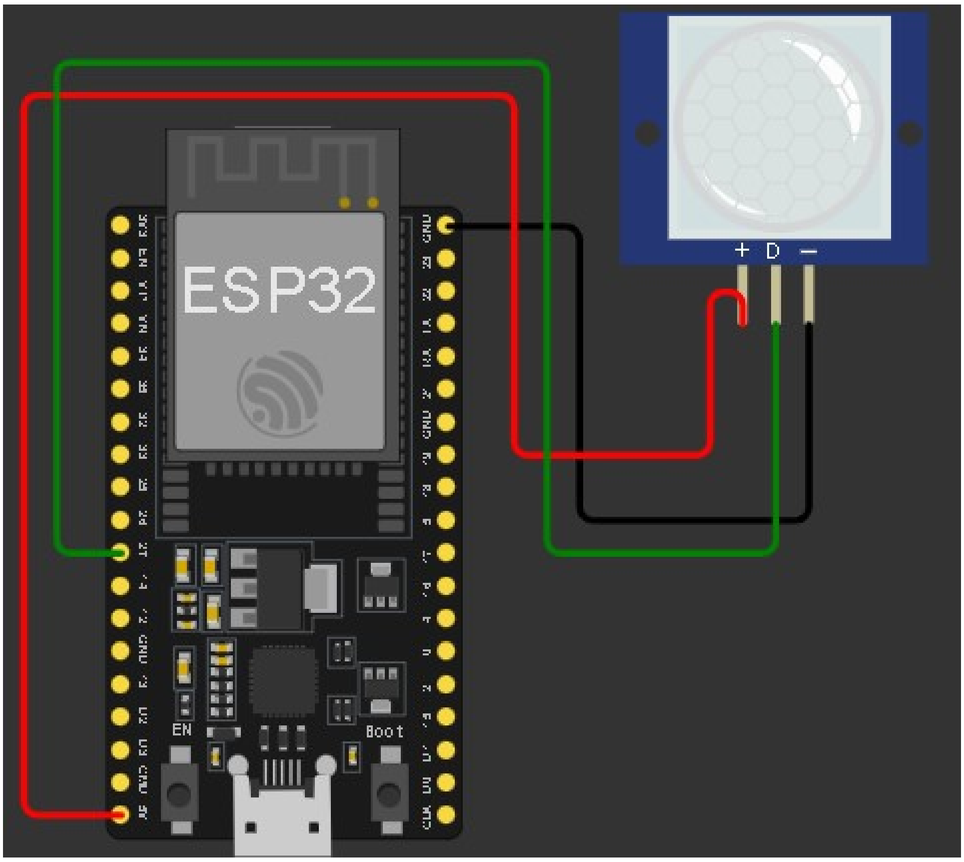

Figure 4: circuit of Human body sensor circuit connected to esp32

4.2 **Ultrasonic distance sensor**

Calculate distance by sensor by sending trigger signal and detecting echoes. Ultrasonic distance calculate distance by emitting ultrasonic waves and timing how long it takes for the reflected waves to return from the target. (Keyence.com, 2024).

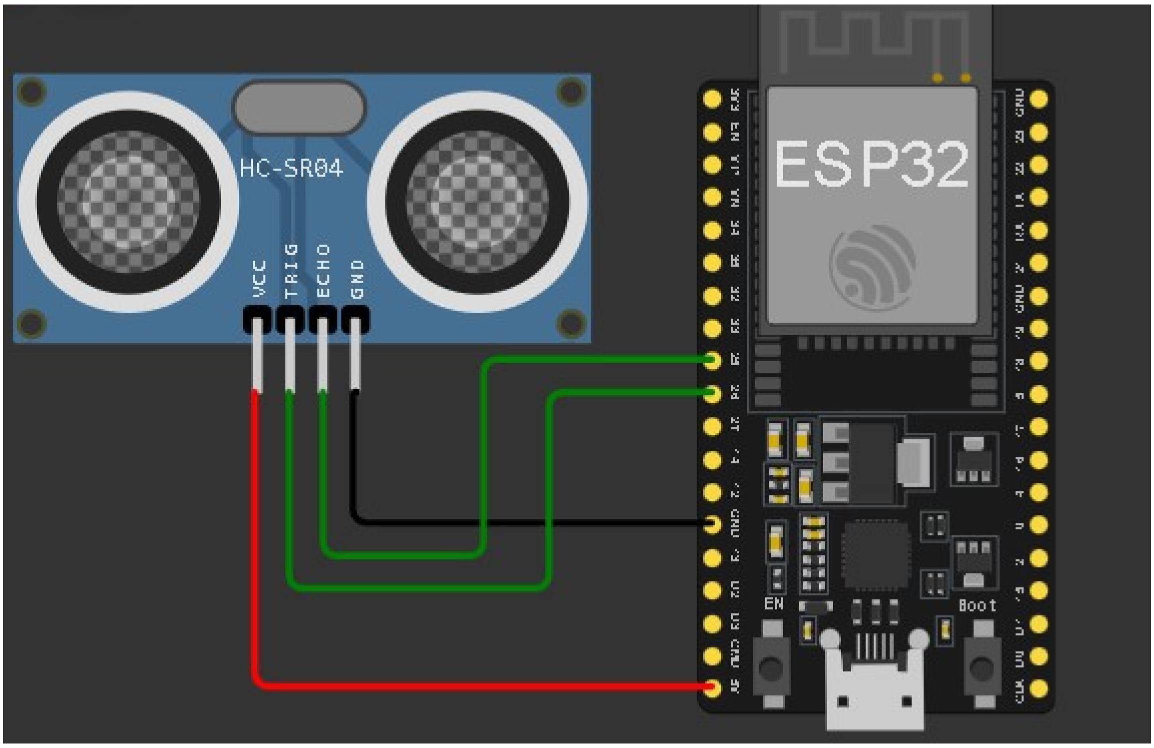

Figure 5:circuit of ultrasonic sensor circuit connected to esp32

4.3 **LCD**
Display status messages to the user.

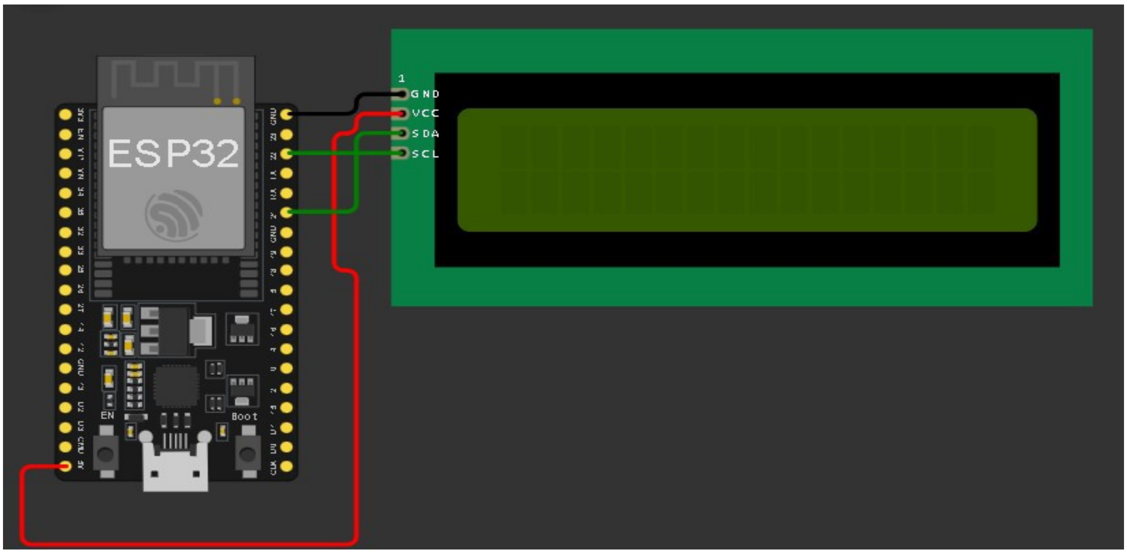

Figure 6:circuit of lcd circuit connected to esp32

4.4 **Keypad**

Keypad is used to enter password. Keypad rows and columns connected to esp32 digital pins, keypresses tested by printing to serial monitor.

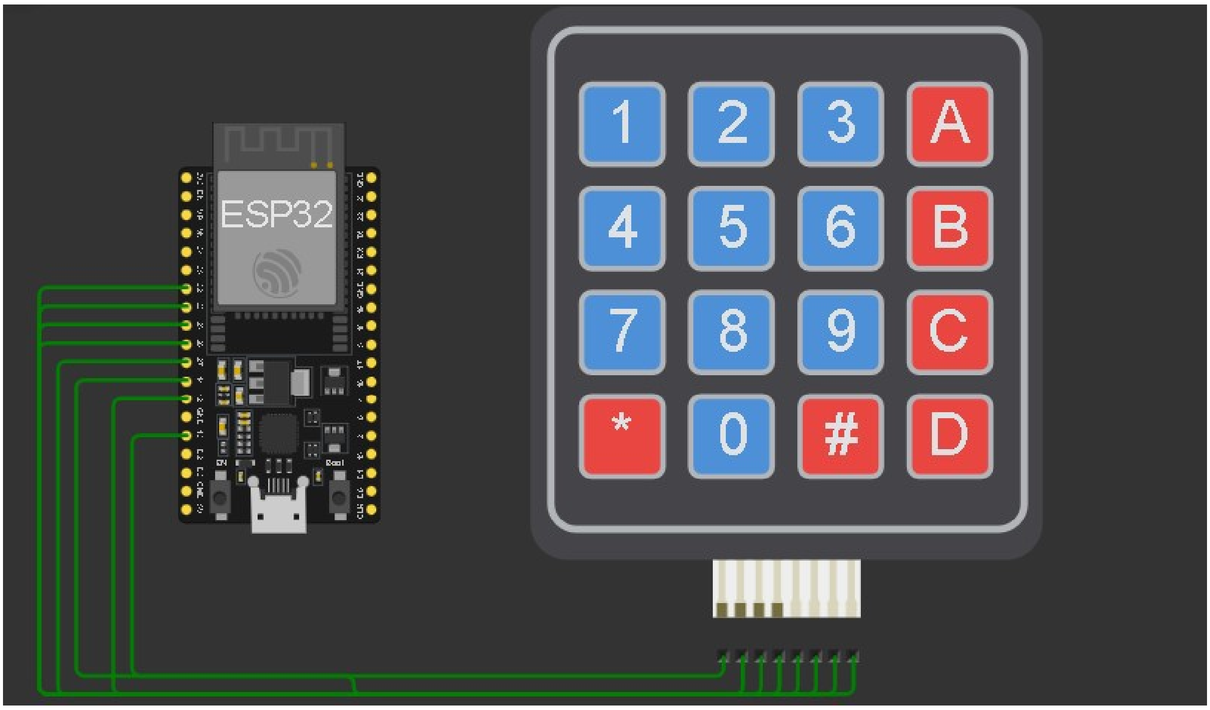

Figure 7: circuit of keypad circuit connected to esp32

4.5 **Esp32 Microcontroller**
Function as the central microcontroller that control all the components of the security system.

Figure 8: Esp32 Wemos D1 R32 microcontroller

4.6 **Full circuit design of the security system**

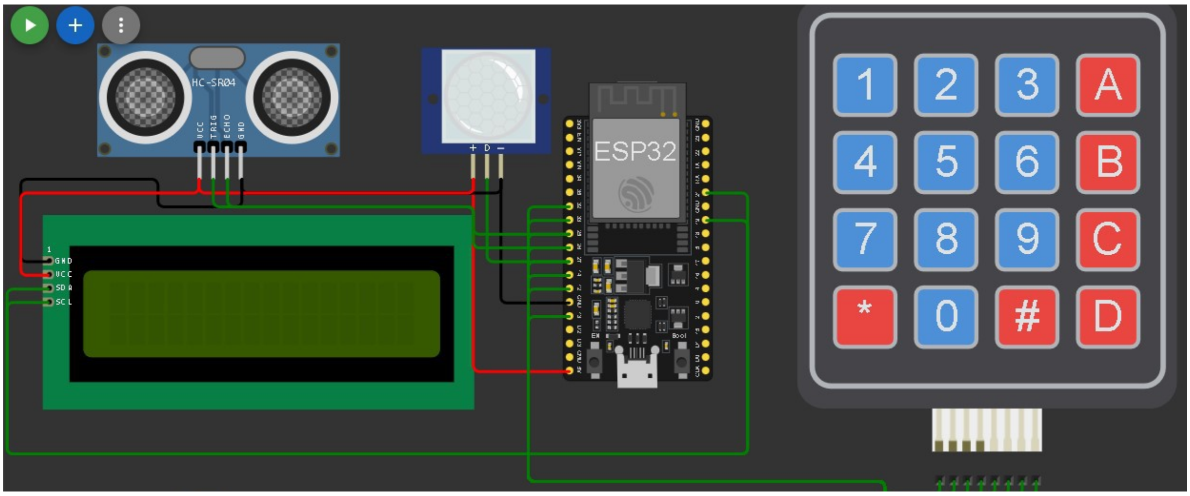

Figure 9: full circuit of security system

Table 1 :**Results of security system**

The build process entailed assembling components on a breadboard, securely connecting to esp32, and conducting comprehensive system test to confirm the integrated functionality of the project.

Components	Test Condition	Result
PIR Sensor	Human presence	Detected successfully
Ultrasonic sensor	Distance measurement	Accurate up to 4 meters
Keypad	Password entry	All key presses detected
LCD Display	Messages display	Correct messages displayed
Esp32	Central controller	

Conclusion

This chapter covers the designed and setup of security system, incorporating critical elements such as PIR sensor detecting human presence, ultrasonic distance sensor, a keypad for password input, esp32 wemos d1 r32 microcontroller, and LCD display for messages. Detailed schematic ilustrate the components connection.

Chapter 5.

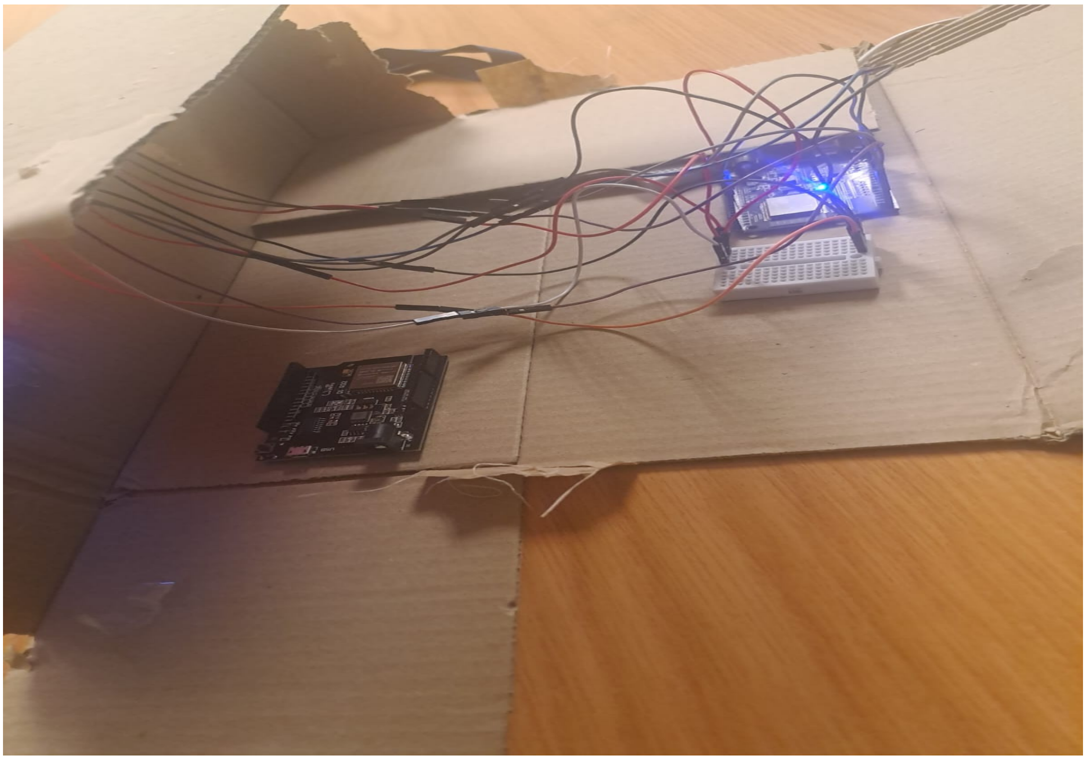

Figure 10: Connection of The Project Structure

Figure 11: Body Sensor, Ultrasonic Sensor and LCD Implementation

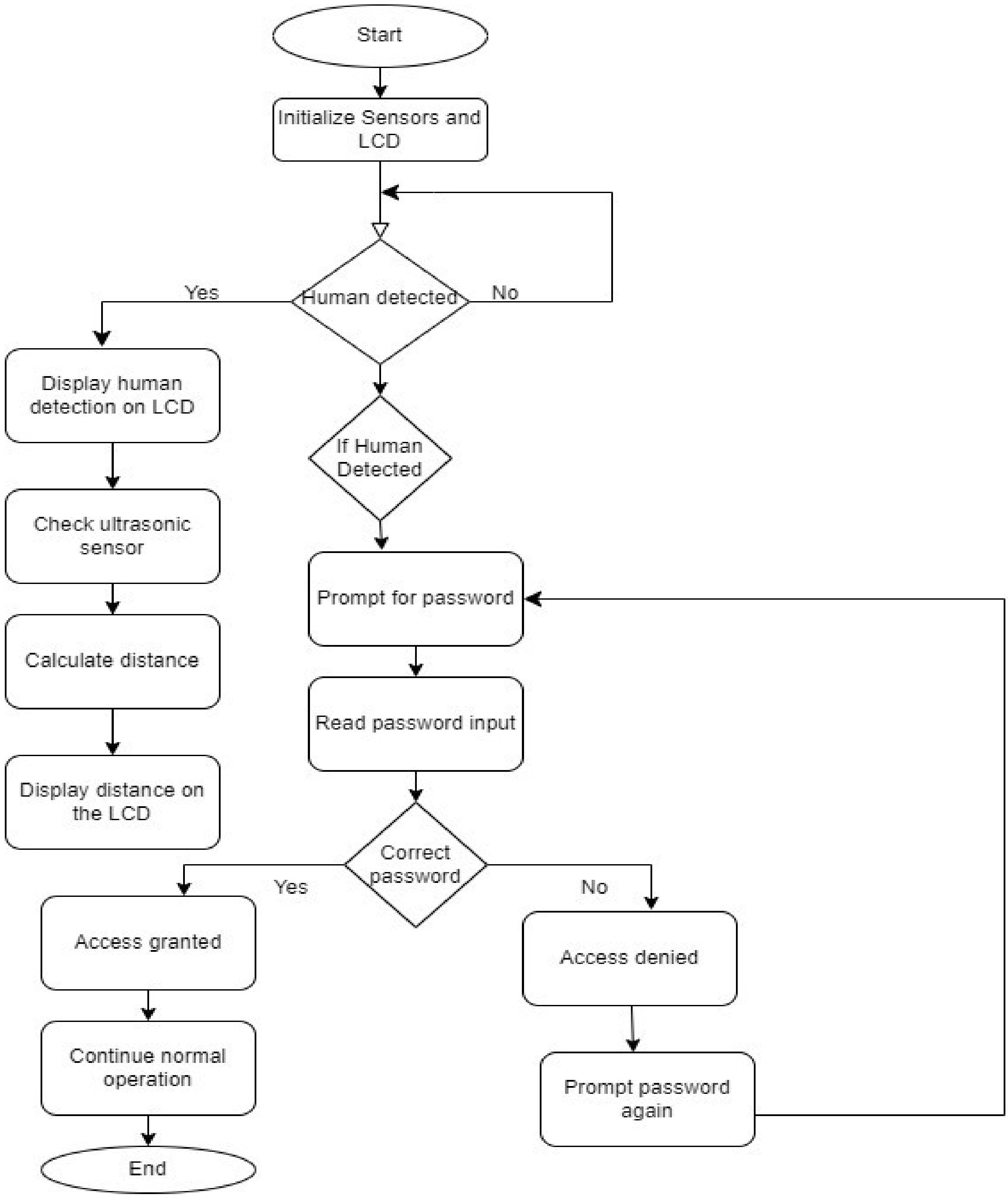

figure 12: Flowchart

ARDUINO CODE FOR THE PROJECT STRUCTURE

```
1.
2. #include <Wire.h>
3. #include <LiquidCrystal_I2C.h>
4.
5. // Initialize the LCD with I2C address 0x27 and 16 columns by 2 rows
```

```
LiquidCrystal_I2C lcd (0x27, 16, 2);

// Define the pins for the sensors
const int pirPin = 27;
const int trigPin = 26;
const int echoPin = 25;

// Variables to store sensor states
bool humanDetected = false;
long duration;
int distance;

// Password management
const char* correctPassword = "mySecret"; // The correct password
const int maxPasswordLength = 20;        // Maximum length for the password
char enteredPassword[maxPasswordLength];  // Array to hold the entered password
int passwordIndex = 0;                   // Index for the entered password

void setup() {
  // Start the serial communication
  Serial.begin(9600);

  // Initialize the PIR sensor pin
  pinMode(pirPin, INPUT);

  // Initialize the ultrasonic sensor pins
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

  // Initialize the LCD
  lcd.init();
  lcd.backlight();
  lcd.print("Welcome to Gr8:)");
  delay(4000);
  lcd.clear();
  lcd.print("Security System");
  delay(3000);
  lcd.clear();
}

void loop() {
  // Check the PIR sensor
  humanDetected = digitalRead(pirPin);

  // Check the ultrasonic sensor
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
```

```
duration = pulseIn(echoPin, HIGH);
distance = duration * 0.034 / 2;

// Clear the previous content on LCD

lcd.clear();

// Display results on LCD
lcd.setCursor(0, 0);
if (humanDetected) {
  lcd.print("Human: Yes      ");
} else {
  lcd.print("Human: No       ");
}

lcd.setCursor(0, 1);
if (distance < 100) {  // assuming 100 cm as threshold for vehicle detection
  lcd.print(" Distance: ");
  lcd.print(distance);
  lcd.print(" cm  ");
} else {
  lcd.print("Distance: 0    ");
}

// For debugging
Serial.print("Human Detected: ");
Serial.print(humanDetected);
Serial.print("  Distance: ");
Serial.print(distance);
Serial.println(" cm");

// Check for human detection and prompt for password if detected
if (humanDetected) {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Enter Password:");
  Serial.println("Enter password:");

  // Read password input from Serial Monitor
  while (true) {  // Stay in this loop until correct password is entered
    if (Serial.available() > 0) {
      char receivedChar = Serial.read();

      if (receivedChar == '\n' || receivedChar == '\r') {  // End of input
        enteredPassword[passwordIndex] = '\0';  // Null-terminate the string

            // Check if the entered password is correct
            if (strcmp(enteredPassword, correctPassword) == 0) {
              lcd.clear();
```

```
            lcd.setCursor(0, 0);
            lcd.print("Access granted!");
            Serial.println("Access granted!");
            delay(3000);  // Display message for 3 seconds
            break;  // Exit the loop and continue normal operation
          } else {
            lcd.clear();

            lcd.setCursor(0, 0);
            lcd.print("Access denied!");
            Serial.println("Access denied!");
            delay(3000);  // Display message for 3 seconds
            lcd.clear();
            lcd.setCursor(0, 0);
            lcd.print("Enter Password:");
            passwordIndex = 0;  // Reset the password index for a new attempt
          }
        } else {
          // Add the received character to the entered password array
          if (passwordIndex < maxPasswordLength - 1) {  // Ensure there's space for the null terminator
            enteredPassword[passwordIndex++] = receivedChar;
          }
        }
      }
    }
  }

  // Delay before next loop iteration
  delay(1000);
}

```

Chapter 7.

7.1 **Conclusions**

The "Enhanced Security System with Human, Vehicle Detection, and Keypad Access Control" project has effectively met its goals of creating a complete security solution that is adapted to the problems of contemporary security. By combining human body sensors, ultrasonic distance sensors, a keypad, an ESP32 Wroom 32 Wemos microcontroller, and an LCD display, the system provides improved access control and detection capabilities, enhancing security measures in a variety of settings.

The use of ultrasonic distance sensors and passive infrared (PIR) sensors in conjunction with people and vehicle detection algorithms allows for real-time surveillance and the notification of possible security breaches. Control over access to restricted areas is improved by the integration of a keypad access control system, which offers secure authentication for authorized personnel. In order to facilitate user involvement and system monitoring, the LCD display provides visual feedback and status indications, while the

microcontroller acts as the central processing unit, coordinating the acquisition, processing, and communication of sensor data.
The study has shown that utilizing current technology and approaches to create a strong security system that can handle contemporary security concerns is both feasible and effective. The system delivers dependable performance and user-friendly operation by following best practices in sensor technology, interface design, microcontroller programming, and display technologies. This helps to improve security measures and

reduce security concerns.

7.2 **Recommendations**

7.2.1 **Constant Enhancement**

Examine ways to make the security system better all the time, including by improving the user interface, access control methods, and detection algorithms. It shall be ensured that the system stays relevant and effective in addressing changing security risks through regular upgrades and improvements based on user feedback and technical breakthroughs.

7.2.2.To protect sensitive data and stop illegal access or alteration, strengthen security procedures and encryption methods. The system's resistance to cyberattacks and privacy violations will be increased through the use of multi-factor authentication, secure communication protocols, and strong encryption methods.

7.3 **Design of the proposed solution**

In this chapter we will be focusing on the step-by-step design of the System.

Step 1: Requirement Analysis

- We had to assess the specific requirements for a ‘enhanced security’ in residential, commercial, and industrial properties.
- We ensured the system provides robust human detection and reliable keyboard access control.
- We check legal and regulatory requirements for security systems with the relevant organisations domestically and internationally.

Step 2: System Architecture Design

As we have built a *Human Detection System*, we have selected appropriate sensors, as well as alert mechanisms and for *Access Control* we chose a durable and secure keypad in terms of the H0308. It easily implements password protection and PIN entry.

Step 3: Hardware Design

We have strategically placed our sensors to cover all the critical areas, ensured proper communication between all the components and a reliable power supply system with backup options.

Step 4: System Development

For Human Detection: We have programmed our sensors to detect human movement continuously send alerts to the LCD 2 x16 Display upon human detection.
For Control Access: We have used a user-friendly interface for keypad input along with the LCD 2x16 Display to communicate with any user.

Step 5: Integration and Testing

We assessed each component individually for functionality, we then integrated all of them in a controlled environment to ensure all components work together seamlessly.

Step 6: Demonstration

Present a PowerPoint presentation or PPT as sir would say and a demonstration of how the entire system will function.

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