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An Autonomous Institute Affiliated to Savitribai Phule Pune University
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Department of Computer Engineering

Embedded Systems and Internet of Things

"Motion-Based Security Alert System using Arduino"

SUBMITTED TO THE DEPARTMENT OF COMPUTER ENGINEERING

AISSMS IOIT

T. Y. BTech Engineering

SUBMITTED BY

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CERTIFICATE

This is to certify that the project report

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is a bonafide student of this institute and the work has been carried out by him/her under the supervision of **Mr. Sugat Pawar** and it is approved for the partial fulfillment of the Department of Computer Engineering AISSMS IOIT.

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CHATPER 1: ABSTRACT

The project outlines the realization of a Security Alert System using a microcontroller (Arduino Uno), that will detect unauthorized motion and create a real-time alert. The system employs a PIR (Passive Infared) movement sensor to verify the presence of a human. It uses an ultrasonic sensor to measure the distance of the detected object, and once motion is detected, it activates a piezo buzzer to generate an alert sound, in addition to displaying the distance of the intruder on a 16x2 LCD screen.

The primary purpose of the security alert system is to provide a cost-effective and efficient standalone security system, and offer additional security features, which can be used in homes, classrooms, labs, and hostels. This security solution is different from typical surveillance systems, as it does not involve any internet connection and/or a smartphone App. The Security Alert System was designed simply and designed for reliability. This buzzer sound will vary with the distance of the detected object, and offer and intuitive psychological indication of threat.

As detailed in this project, to implement a Security Alert System we successfully integrated various sensors, output devices and used an Arduino microcontroller to demonstrate this educational experience. It provides a great example of implementing embedded systems. The security alert system can be further expanded and integrated to incorporate features like password protection, GSM alerts, or IoT-based remote monitoring.

1.1 CONTEXT

The demand for practical and affordable solutions for security applications is rapidly evolving in today's environment. Property theft, unauthorized access, and safety violations are causing significant anxieties, especially in residential, educational, and institutional settings. Seeking effective methods for real-time alerts that detect this activity and respond, is in high demand.Most conventional security applications rely on advanced surveillance systems, internet connectivity, and costly services from a third-party. In small scenarios such as a classroom, student housing, the entrance of a home or laboratory, this is not practical.

This project seeks to provide a standalone motion-based Security Alert System in a low-cost, easily accessible manner using components such as Arduino Uno, PIR motion sensor, ultrasonic sensor, buzzer, and LCD display. The system will detect motion and measure distance of an object, while providing visual and audible alerts, all without the use of a network.Due to the simplicity of the design, educational applications can be accomplished and utilized to teach users about the practical and hands-on experiences of working with embedded systems in budget-friendly environments. The project provided a good indication of how basic sensors and programming of a microcontroller could be used to create an effective security system solution.

1.2 PROBLEM STATEMENT

"Traditional security systems are often costly, complex, and require internet connectivity. Small institutions and homes need a simple, low-cost alternative for motion detection and alerting. There is a lack of standalone systems that provide real-time alerts based on proximity. This project solves that by developing an Arduino-based motion detection and alert system."

1.3 OBJECTIVE

- To create a security alert system dependent on motion with a focus on using Arduino Uno.
- To implement a PIR sensor capable of detecting human motion in a secured area.
- To implement an ultrasonic sensor capable of detecting distance of the identified object.
- To use a buzzer alarm to signal alerts based on motion and distance.
- To use a 16x2 LCD Screen to display alerts and distance when asked.
- To provide a cost effective, stand-alone tool for an unknown security solution.
- To provide a solution that does not require internet, phone applications or surveillance.
- To provide stronger empirical working knowledge of embedded systems and sensor integration.

CHAPTER 2: DESCRIPTION

2.1 PROJECT INTRODUCTION:

Security has become a significant issue in our world, not only concerning homes and offices but also in educational institutions such as schools, colleges, laboratories, and hostels. As safety needs rise, so does the need for efficient and cost-effective security systems. Nonetheless, most of the conventional systems—such as CCTV surveillance or IoT-enabled alarm systems—are either too costly, require internet availability, or require complicated installations and maintenance.

This project attempts to tackle this problem by introducing an economical, standalone Security Alert System, built with an Arduino Uno microcontroller. The Security Alert System integrates the aspects of two main sensors: a PIR (Passive Infrared) motion sensor that detects human movement, alongside an ultrasonic sensor that estimates the distance of the object when the motion has been perceived. After the distance calculation, the system activates a piezo buzzer as an audible alert and provides this distance measure to a 16x2 LCD screen in real-time.

The project illustrates how to successfully integrate a range of sensors with Arduino to enable systems to detect intrusions and measure proximity while being able to respond almost instantaneously and does not rely on a mobile device or effective network. This is excellent for budget-conscious and simple solutions in classrooms, hostels, exam halls, and personal spaces.

In addition, the premise of this project encourages true hands-on learning of embedded systems for students in order to experience how a microcontroller can transform sensor, and ultimately, output device data to real-life applications. Lastly, the modularization of the project would allow for future enhancement to the system such as keypad authenication, SMS texting based on a GSM module, or even integration with cloud services through IoT.

2.2 PURPOSE AND SCOPE

The main goal of this project is to create and develop a cheap and fully standalone Security Alert System using an Arduino Uno microcontroller. The objective of the system is to detect human motion and provide an alert in real-time using a buzzer and visual display, allowing for a prompt response to unauthorized entry in secured areas.To achieve this, the project uses a PIR (Passive Infrared) motion sensor to detect motion and an ultrasonic sensor to measure distance to the intruder. When motion is detected, a piezo buzzer will sound an alert, and the distance detected will display on a 16x2 LCD screen. The system works independently, without the need of an internet connection, mobile app, or another monitoring device.

The scope of the system is intended for use within college classrooms, laboratories, hostels, homes, and small offices, where a full-fledged surveillance system would not apply, or is not feasible. The naive and modular design, also provides a basis for upgrading in the future, such as with GSM-based alerts, keypad passwords, or IoT monitoring, etc.; allowing for a larger application potential when used in future designs.

2.3 SOFTWARE REQUIREMENTS

S.No.	Software	Purpose / Description
1	Arduino IDE	Writing, compiling, and uploading code to the Arduino Uno board
2	LiquidCrystal Library	Used to control the 16x2 LCD display in 4-bit mode
3	Windows/Mac/Linux OS	Operating system to run the Arduino IDE
4	USB Driver for Arduino	Communication between Arduino Uno and PC via USB cable
5	Serial Monitor (IDE Tool)	To monitor sensor output and debug system in real-time

2.4 HARDWARE REQUIREMENT

Components Overview & Wiring

1. Arduino Uno Board

- **Power**: The Arduino Uno operates on 5V supplied either via USB or a 9V battery.
- **Voltage Flow**: The Arduino regulates the incoming 5V power, providing the required voltage to the connected components.

2. PIR Motion Sensor

- **Pinout**:
  - **VCC** (Power): Connect to 5V pin on the Arduino.
  - **GND** (Ground): Connect to the GND pin on the Arduino.
  - **OUT** (Output): Connect to a digital pin on the Arduino (e.g., **D2**).
- **How It Works**:
  - The PIR sensor detects motion by sensing infrared radiation.
  - When a body or object moves within its detection range, it outputs a HIGH signal (5V) to the Arduino, which can then trigger other actions like turning on the buzzer or LEDs.
- **Voltage Flow**:
  - The PIR sensor is powered by the 5V pin from the Arduino.
  - When motion is detected, the **OUT pin** sends a HIGH signal (5V) to the connected digital input pin (e.g., **D2**) on the Arduino.

3. Ultrasonic Sensor (HC-SR04)

- **Pinout**:
  - **VCC**: Connect to the 5V pin on the Arduino.
  - **GND**: Connect to the GND pin on the Arduino.
  - **TRIG** (Trigger): Connect to a digital pin on the Arduino (e.g., **D7**).
  - **ECHO** (Echo): Connect to another digital pin on the Arduino (e.g., **D6**).
- **How It Works**:
  - The **TRIG** pin sends a pulse (HIGH) to the ultrasonic sensor to emit a sound wave.
  - The sensor sends back a pulse through the **ECHO** pin that the Arduino measures to calculate the distance based on the time it takes for the pulse to return.

- **Voltage Flow**:
  - The sensor is powered by the 5V pin from the Arduino.
  - When the **TRIG** pin is set HIGH, the sensor emits a pulse, and the Arduino measures the pulse duration on the **ECHO** pin, using this information to calculate distance.

4. Piezo Buzzer

- **Pinout**:
  - **VCC**: Connect to the 5V pin on the Arduino.
  - **GND**: Connect to the GND pin on the Arduino.
  - **Signal Pin**: Connect to a digital pin on the Arduino (e.g., **D8**).
- **How It Works**:
  - When the Arduino receives a HIGH signal from the PIR sensor or ultrasonic sensor (depending on the motion and proximity), it activates the **Signal Pin** connected to the buzzer.
  - The buzzer emits a sound when powered.
- **Voltage Flow**:
  - The buzzer receives 5V from the Arduino when activated.
  - The **Signal Pin** sends the HIGH signal (5V) to trigger the buzzer.

5. LEDs (Red and Green)

- **Pinout**:
  - **Anode (positive)**: Connect to digital pins (e.g., **D3** for red and **D4** for green).
  - **Cathode (negative)**: Connect to **GND** through a **220Ω resistor**.
- **How It Works**:
  - The red LED lights up when the system detects motion or when proximity is within a certain range (using the ultrasonic sensor).
  - The green LED could be used to indicate the system is idle or in standby mode.
- **Voltage Flow**:
  - The Arduino sends a **HIGH** signal (5V) to the anode of the LED.
  - The current flows through the LED (lighting it up) and then through the resistor to **GND**.
  - The resistor limits the current to avoid damaging the LED.

6. LCD Display (16x2 or 20x4 LCD with I2C Interface)

- **Pinout**:
  - **VCC**: Connect to the 5V pin on the Arduino.
  - **GND**: Connect to the GND pin on the Arduino.
  - **SDA (Data Line)**: Connect to the **A4** pin on the Arduino.
  - **SCL (Clock Line)**: Connect to the **A5** pin on the Arduino.
- **How It Works**:
  - When motion is detected, the Arduino sends a signal to the LCD to display a message like "Intruder Detected!"
  - The **SDA** and **SCL** pins are used for communication between the Arduino and the LCD via I2C protocol.
- **Voltage Flow**:
  - The LCD receives 5V from the Arduino.
  - The data transfer between the Arduino and the LCD happens over the **SDA** and **SCL** pins using I2C communication.

Voltage Flow Explanation

1. **Power Supply**: The Arduino Uno is powered by either the **USB cable (5V)** or a **9V battery**. The 5V pin provides regulated voltage to all connected components.
2. **PIR Motion Sensor**: When motion is detected, the **OUT** pin outputs a HIGH signal (5V) to the Arduino, which triggers actions like turning on the buzzer or LEDs.
3. **Ultrasonic Sensor**: The **TRIG** pin sends a pulse to the sensor. The sensor measures the time taken for the pulse to return and sends a corresponding signal to the **ECHO** pin, which the Arduino uses to calculate the distance.
4. **Buzzer & LEDs**: When triggered by the motion or distance detection, the Arduino sends a HIGH signal (5V) to the **Signal Pin** of the buzzer or to the anodes of the LEDs, completing the circuit and activating the components.
5. **LCD Display**: The display receives 5V power from the Arduino and communicates via I2C protocol using the **SDA** and **SCL** lines.

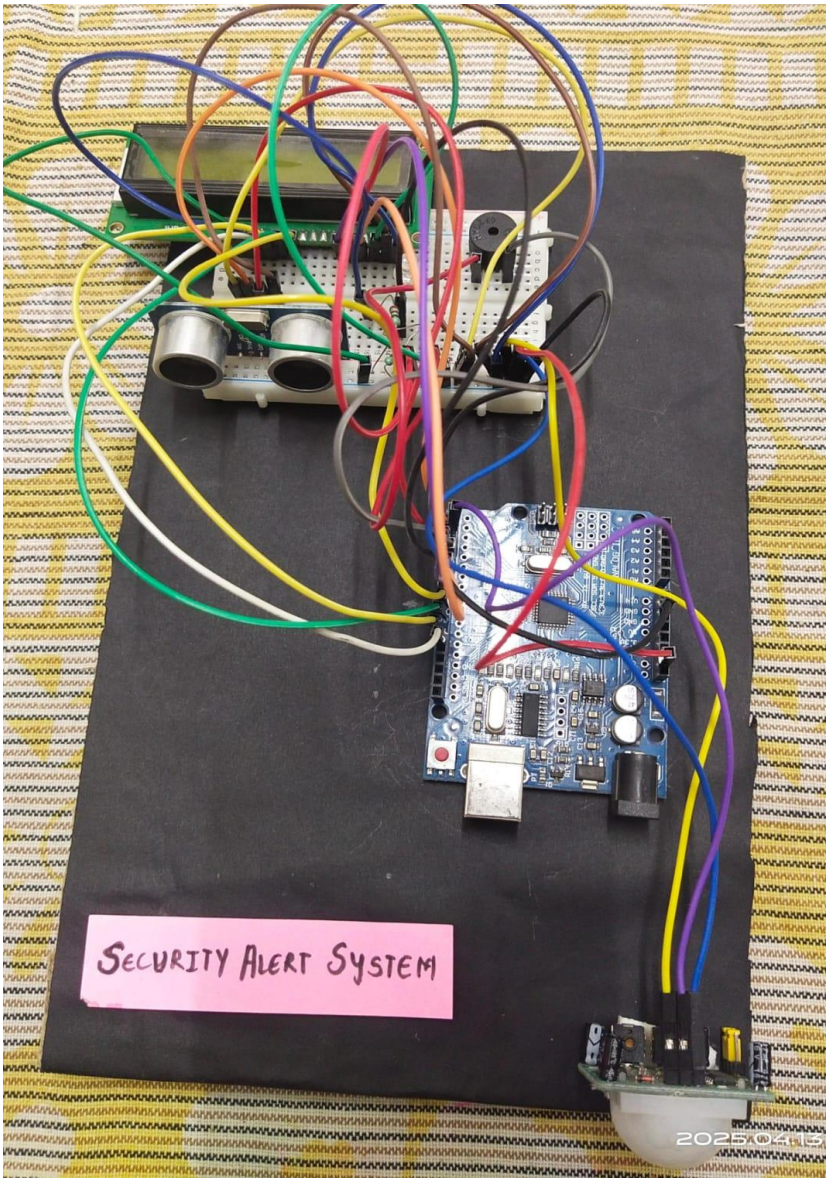
2.5 Code Snippets

```
#include <LiquidCrystal.h>

// LCD pin setup: RS, E, D4, D5, D6, D7
LiquidCrystal lcd(7, 8, 9, 10, 11, 12);

// Pin Definitions
const int pirPin = 2;          // PIR sensor output
const int trigPin = 3;         // Ultrasonic TRIG
const int echoPin = 4;         // Ultrasonic ECHO
const int buzzerPin = 5;       // Buzzer
const int ledPin = 6;          // LED (optional)

// Variables
long duration;
int distance;

void setup() {
  pinMode(pirPin, INPUT);
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(buzzerPin, OUTPUT);
  pinMode(ledPin, OUTPUT);

  lcd.begin(16, 2);               // Initialize LCD 16x2
  lcd.print("System Armed");      // Show startup message
  delay(2000);
  lcd.clear();
}

void loop() {
  int motion = digitalRead(pirPin);

  if (motion == HIGH) {
    // Motion Detected!
    digitalWrite(ledPin, HIGH);

    // Trigger Ultrasonic Pulse
    digitalWrite(trigPin, LOW);
    delayMicroseconds(2);
    digitalWrite(trigPin, HIGH);
    delayMicroseconds(10);
    digitalWrite(trigPin, LOW);

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

    // Show alert on LCD
    lcd.clear();
    lcd.setCursor(0, 0);
```

```
void loop() {
  if (motion == HIGH) {
    lcd.print("INTRUDER ALERT!");
    lcd.setCursor(0, 1);
    lcd.print("Dist: ");
    lcd.print(distance);
    lcd.print(" cm");

    // Buzzer logic
    if (distance < 50) {
      tone(buzzerPin, 1000);  // Louder/continuous
    } else {
      tone(buzzerPin, 500);   // Softer
    }

    delay(3000); // Stay active for 3 seconds

    noTone(buzzerPin);
    digitalWrite(ledPin, LOW);
    lcd.clear();
    lcd.print("System Idle...");
    delay(1000);
  } else {
    // No Motion
    digitalWrite(ledPin, LOW);
    noTone(buzzerPin);
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("System Idle...");
    delay(1000);
  }
}
```

CHAPTER 3: DIAGRAMS

3.1 HARDWARE COMPONENTS



3.2 DIAGRAMS

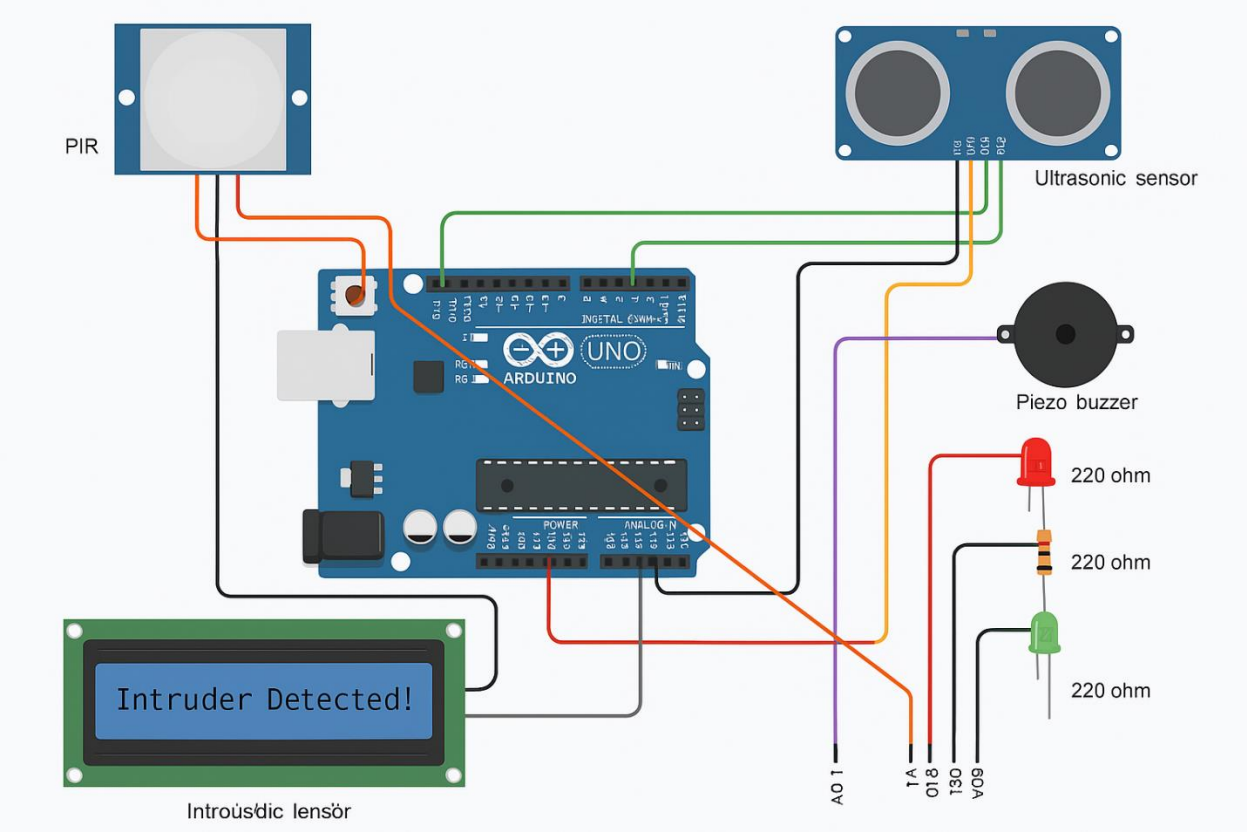


Fig. 1. Circuit Diagram

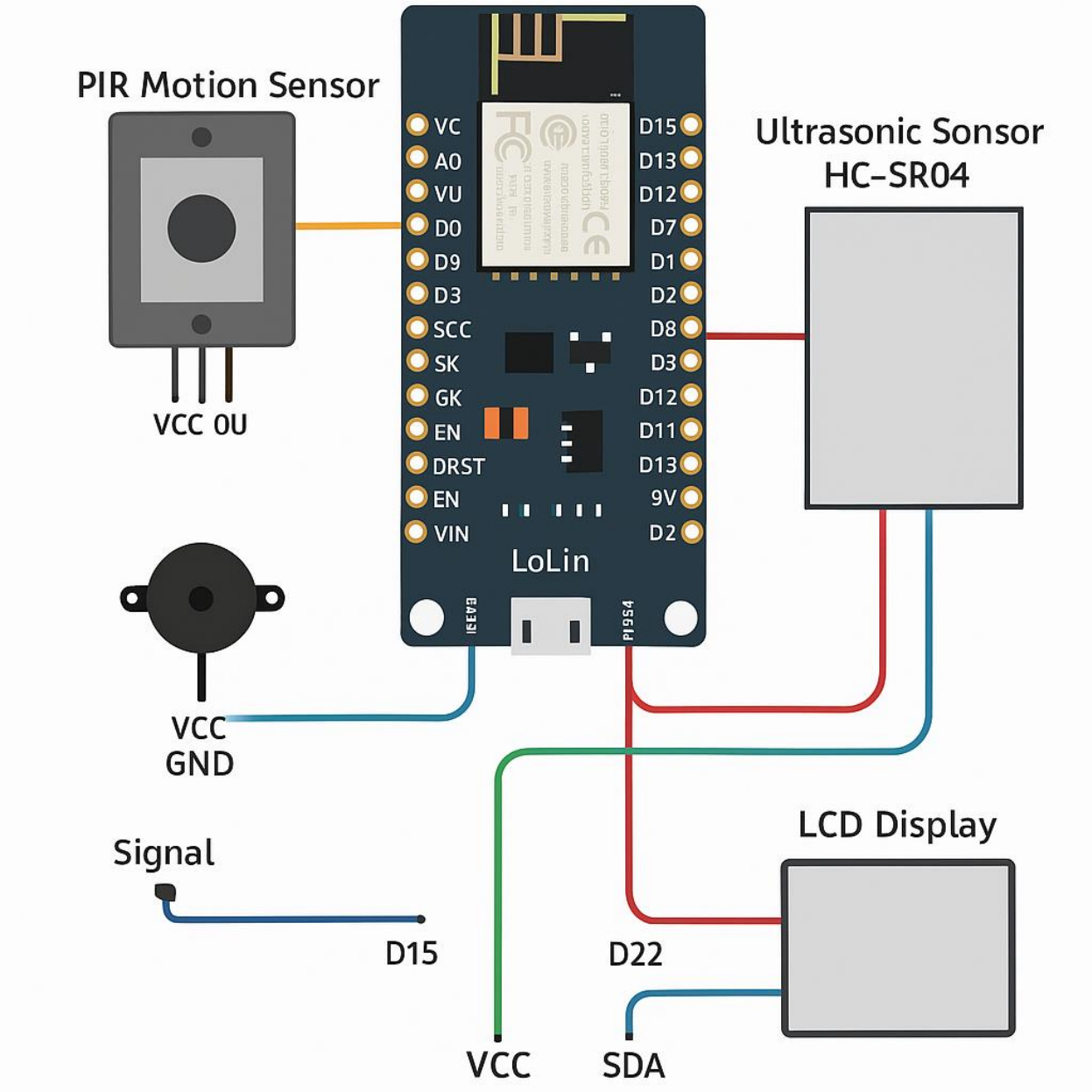


Fig. 2. Pin Diagram

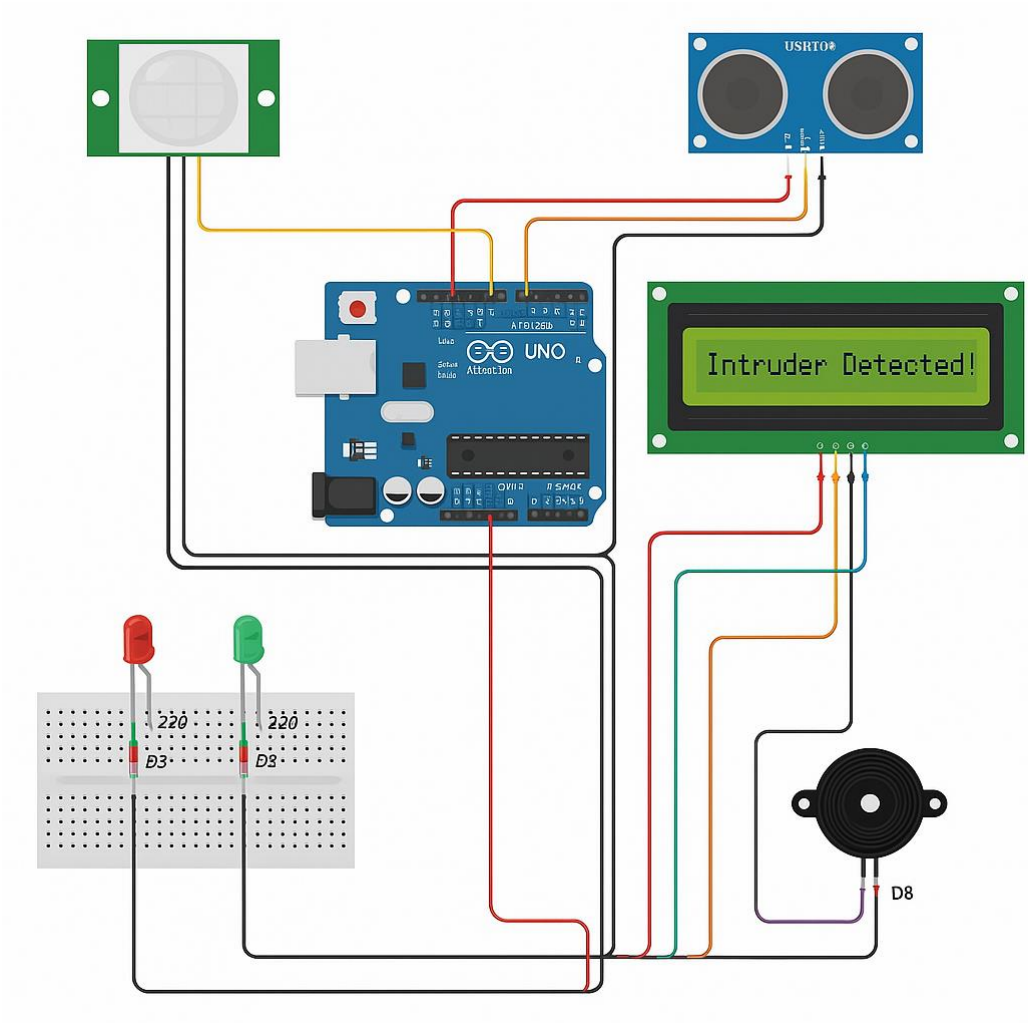


Fig. 3. Workflow Diagram

CHAPTER 4: ADVANTAGES

1. **Real-Time Monitoring:**
   Instantly detects motion and distance of an intruder, ensuring quick alerts.
2. **Cost-Effective:**
   Uses affordable components (PIR, Ultrasonic, Buzzer, LEDs, etc.), making it ideal for small-scale or DIY setups.
3. **Low Power Consumption:**
   Sensors and microcontroller consume minimal power, increasing efficiency.
4. **Customizable Alert System:**
   You can easily modify the alert type (sound, light, message) based on the distance or motion intensity.
5. **Non-Contact Detection:**
   The system can sense motion and distance without physical contact, making it suitable for hygiene-sensitive areas.
6. **Easy to Upgrade:**
   Can be extended with IoT modules (e.g., ESP8266 or NodeMCU) to send SMS/Email alerts.
7. **Silent Monitoring in Idle Mode:**
   The system remains silent until motion is detected, reducing unnecessary power and noise.

CHAPTER 5: APPLICATION

- **Home Security Systems:**
Detect unauthorized movement around doors, windows, or hallways.

- **Office or Warehouse Monitoring:**
Secure restricted zones from unauthorized personnel.

- **Bank Locker Rooms or Vaults:**
Early intrusion detection to trigger security protocols.

- **ATM Booths:**
Detect presence outside working hours and notify security.

- **Parking Area Intrusion Monitoring:**
Detect unauthorized entry into private garages or driveways.

- **Schools/Colleges:**
Use in labs, libraries, or restricted zones after working hours.

- **Smart Door Alert System:**
Alert when someone approaches your smart door or gate.

- **Animal Movement Detection in Farms:**
Detect animal entry or movement in restricted areas at night.

CHAPTER 6: CONCLUSION

The Security Alert System created in this project successfully integrates multiple sensors and electronic components to detect motion, measure proximity, and respond with audio-visual alerts.

To determine if there is movement in the coverage area, the system utilizes a passive infrared (PIR) motion sensor. After movement is detected, the system then uses an ultrasonic sensor to measure the distance from the sensor to the object (i.e. intruder). This adds intelligence to the system because it can evaluate how close the object or human is. The heart of the system is based on an Arduino Uno (or NodeMCU) to process the sensors and control output components like the piezo buzzer, LED(s), and optionally an LCD display. The piezo buzzer produces an alert sound, which may use intensity to vary the alert based on distance from the intrusion. Red and/or green LED(s) may give a visual cue for intrusion. This induces reliability of the system, but also improves human reaction time in case threats are real.

This project showcases the practical use of embedded platforms, and sensor technologies in real-world security applications. Here, the use of embedded systems presents a cost-effective, power-efficient, and convenient expansion of any solution that protects personal, commercial, or institutional property. By the addition of IoT (such as Wi-Fi/GSM modules) the system could even be upgraded to send alerts remotely and better situate itself to a smart home/industrial surveillance system.

Overall, this project demonstrates that it is an ideal solution for some environments requiring real time intrusion detection, representing the clear advantages of simple electronics equipped with intelligent logic to create a great security system.

CHAPTER 7: REFERENCES

Links

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