Smart Motion Sentinel 1.0

An IoT-Based Intrusion Detection and Monitoring System

India Space Lab – Summer Internship Program 2025

Submitted by: **Samarth Trivedi**
Department of Embedded Systems & IoT

CERTIFICATE

This is to certify that the report titled **“Smart Motion Sentinel 1.0: An IoT-Based Intrusion Detection and Monitoring System”**, submitted by **Samarth Trivedi**, is a bona fide record of the project work carried out during the **India Space Lab – Summer Internship Program 2025**.

The project has been carried out under our guidance and supervision, and it is certified that this work has not been submitted anywhere else for any academic or professional purpose.

Director
India Space Lab

Place: Delhi **Date:** ______________

Contents

Abstract

Smart Motion Sentinel 1.0 is a lightweight intrusion detection system based on the ESP32 microcontroller. Using a PIR sensor to detect motion and peripherals such as a buzzer, LED, and OLED display, the system can notify and log intrusion events in real-time. Developed as part of the India Space Lab internship program, the project showcases practical applications of embedded IoT systems in secure and critical environments.

1 Introduction

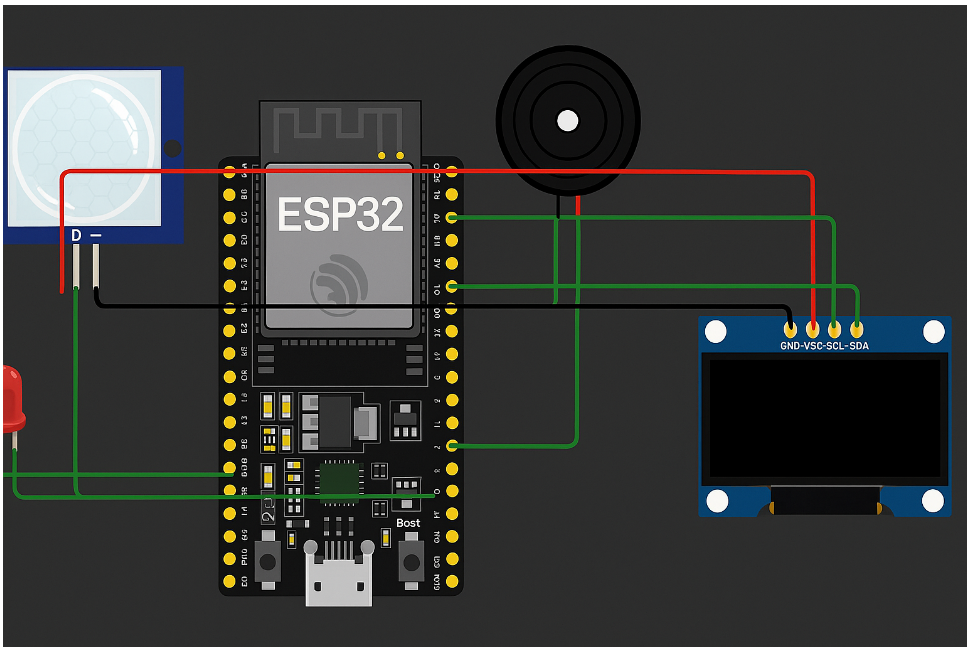
Security systems are increasingly integrating Internet of Things (IoT) technologies to provide real-time, automated surveillance and alerts. The need for efficient, responsive, and lightweight intrusion detection systems is paramount, especially in high-security environments such as research labs, data centers, and cleanrooms.

This project addresses this challenge by implementing a cost-effective and compact motion-sensing module using the ESP32 microcontroller. It demonstrates how embedded systems can be leveraged to build reliable smart security solutions using basic components and minimal computational resources.

2 Hardware Components

Component	**Description**
ESP32 DevKit V4	Wi-Fi enabled microcontroller used as the main controller
PIR Motion Sensor	Detects human presence via infrared radiation
SSD1306 OLED Display	128x64 I2C display for system status and motion count
Active Buzzer	Generates alert sound on intrusion
Red LED	Visual signal during motion detection
Breadboard and Wires	For circuit assembly and prototyping

3 Working Principle



The PIR sensor monitors infrared movement. Upon detection, it triggers:

- A red LED for visual alert
- A buzzer for audible alert
- The OLED display shows "Motion Detected!" and increments the motion count
- Serial output logs the event in real-time

When no motion is detected, the system reverts to the "Area Secure" state and updates both OLED and serial logs accordingly.

4 ESP32 Pin Mapping

Component	Function	ESP32 Pin
PIR Sensor	OUT	GPIO 13
PIR Sensor	VCC	3.3V
PIR Sensor	GND	GND
Buzzer	Positive (+)	GPIO 4
Buzzer	Ground	GND
LED	Anode	GPIO 2
LED	Cathode	GND
OLED VCC	Power	3.3V
OLED GND	Ground	GND
OLED SDA	I2C Data	GPIO 21
OLED SCL	I2C Clock	GPIO 22

5 Libraries Used

- Adafruit GFX Library
- Adafruit SSD1306 Library
- Wire (I2C)

6 Arduino Source Code

```
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 64
#define OLED_RESET -1

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET
   );

#define PIR_PIN     13
#define LED_PIN     2
#define BUZZER_PIN  4

int motionCount = 0;
bool motionPreviouslyDetected = false;

```

```
void setup() {
  pinMode(PIR_PIN, INPUT);
  pinMode(LED_PIN, OUTPUT);
  pinMode(BUZZER_PIN, OUTPUT);
  Serial.begin(115200);

  if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
    Serial.println("OLED␣initialization␣failed");
    while (true);
  }

  display.clearDisplay();
  display.setTextSize(1);
  display.setTextColor(WHITE);
  display.setCursor(0, 0);
  display.println("Smart␣Motion␣Sentinel");
  display.display();
  delay(1500);
  display.clearDisplay();
}

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

  if (motion == HIGH) {
    if (!motionPreviouslyDetected) {
      motionCount++;
      Serial.print("Motion␣Detected!␣Count:␣");
      Serial.println(motionCount);
      motionPreviouslyDetected = true;
    }

    digitalWrite(LED_PIN, HIGH);
    digitalWrite(BUZZER_PIN, HIGH);
    showStatus("Motion␣Detected", motionCount);
  } else {
    if (motionPreviouslyDetected) {
      Serial.println("Motion␣ended.");
    }

    digitalWrite(LED_PIN, LOW);
    digitalWrite(BUZZER_PIN, LOW);
    showStatus("No␣Motion", motionCount);
    motionPreviouslyDetected = false;
  }

  delay(200);
}

void showStatus(String status, int count) {
  display.clearDisplay();
  display.setCursor(0, 0);
  display.setTextSize(1);
  display.println("Smart␣Motion␣Sentinel");
  display.setCursor(0, 20);
  display.print("Status:␣");
  display.println(status);
  display.setCursor(0, 40);
  display.print("Count:␣");
  display.println(count);
  display.display();
}
```

Listing 1: Smart Motion Sentinel Arduino Code

7 Wokwi JSON Circuit Configuration

```
{
  "version": 1,
  "author": "Samarth␣Trivedi",
  "editor": "wokwi",
  "parts": [
    { "type": "board-esp32-devkit-c-v4", "id": "esp", "top": 0, "left":
        0, "attrs": {} },
    { "type": "wokwi-pir-motion-sensor", "id": "pir1", "top": -15.2, "
       left": -103.38, "attrs": {} },
    { "type": "wokwi-led", "id": "led1", "top": 102, "left": -111.4, "
       attrs": { "color": "red" } },
    { "type": "wokwi-buzzer", "id": "bz1", "top": -36, "left": 117, "
       attrs": { "volume": "0.1" } },
    { "type": "board-ssd1306", "id": "oled1", "top": 89.54, "left":
       201.83, "attrs": { "i2cAddress": "0x3c" } }
  ],
  "connections": [ ... ]
}
```

Listing 2: Wokwi Configuration

8 Results and Observations

The system was tested using a Wokwi virtual simulator as well as on a physical breadboard prototype. The OLED display correctly showed status changes between “Motion

Detected" and "No Motion" with each detection event.

Serial monitor logs confirmed motion events with real-time counts. The buzzer and LED responded promptly to trigger events. Overall, the project performed as intended under normal indoor lighting conditions.

9 Conclusion

This project demonstrates the successful development of a compact, real-time motion detection system. With its integration of sensory, visual, and auditory interfaces, it offers practical applications in high-security environments such as space labs, data centers, and smart infrastructure.

10 Acknowledgments and Real-World Relevance

I am sincerely thankful to the India Space Lab for providing this opportunity to gain hands-on experience with embedded systems and IoT technologies. Through this internship, I significantly deepened my understanding of real-world system integration.

Applications:

- Smart Homes
- Hospital Security Systems
- Automatic Lighting Systems
- Airport Surveillance
- Cleanrooms and Research Labs

References

- ESP32 Datasheet - Espressif
- Adafruit OLED Display Guide
- Wokwi Simulator Platform