Home Intrusion System

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***Abstract*—This report presents the development and implementation of a home intrusion detection system utilizing a Passive Infrared (PIR) sensor, GSM module, and an ESP32 module with an integrated camera module for live video feed. The system is designed to enhance home security by providing real-time alerts and visual monitoring capabilities. The PIR sensor detects motion and triggers the ESP32, which then activates the camera to capture live footage of the monitored area. Concurrently, the GSM module sends an alert message to the homeowner's mobile device, ensuring immediate awareness of potential intrusions. The ESP32's Wi-Fi capability allows seamless streaming of the live video feed to a designated device, enabling remote surveillance. This integration of sensor technology and communication modules results in a cost-effective, efficient, and reliable home security solution. Performance evaluations demonstrate the system's responsiveness and accuracy in detecting intrusions and providing timely alerts, making it a viable option for enhancing residential security.**

Keywords—Home Security, Intrusion Detection, PIR Sensor, GSM Module, ESP32, Camera Module, Real-Time Alerts, Live Video Feed, Remote Surveillance, IoT Security System, Wireless Communication, Motion Detection, Smart Home, Home Automation, Surveillance System.

I. INTRODUCTION

In today's digital age, security is paramount, particularly when it comes to protecting our homes and personal spaces. Advances in technology have paved the way for sophisticated home intrusion systems that integrate various sensors and communication modules to enhance security. This paper presents a comprehensive home intrusion system utilizing Passive Infrared (PIR) sensors, a GSM module, and an ESP32 micro controller equipped with a camera module for live feed capabilities.

Home intrusion systems are designed to detect unauthorized entry and alert homeowners or security personnel. PIR sensors play a crucial role in detecting motion by measuring infrared radiation from objects within their field of view. When motion is detected, the system activates and sends alerts through the GSM module, which communicates with the user's mobile device via SMS. Additionally, the ESP32 micro controller, with its built-in Wi-Fi and Bluetooth capabilities, streams live video feed from the connected camera module, providing real-time visual confirmation of the intrusion.

Several studies have explored the implementation and effectiveness of these components in security systems. For instance, the use of PIR sensors in intrusion detection systems has been extensively analyzed and proven to be effective in various environmental conditions . The integration of GSM modules for remote communication in security systems has also been discussed, highlighting its reliability and ease of use for real-time notifications . Furthermore, the ESP32 micro controller’s versatility and support for various peripherals, including cameras, make it an ideal choice for developing advanced security solutions .

The proposed system leverages these technologies to create a robust and efficient home intrusion detection and alert system. By combining the motion detection capabilities of PIR sensors, the communication power of GSM modules, and the processing and streaming functionalities of the ESP32, this system offers a comprehensive solution for home security.

II. RELATED WORK

J. Mathew's work [1] on "IoT based intrusion detection system using PIR sensor" focuses on leveraging the capabilities of Passive Infrared (PIR) sensors for motion detection. In this system, the PIR sensor is used to detect infrared radiation emitted by humans, triggering an alert when motion is detected. The system is designed to be part of an Internet of Things (IoT) framework, allowing real-time monitoring and reporting of intrusions. The study demonstrated the effectiveness of PIR sensors in detecting human presence while minimizing false alarms, emphasizing their suitability for smart home security applications. The system's integration into an IoT network ensures that alerts can be sent to homeowners instantly, enhancing the overall security.

A.Sharma and S.Tripathi's project [2], "Smart Home Automation with Smart Security System over the Cloud," combines home automation features with a robust security system, utilizing cloud technology for enhanced functionality. The system employs various sensors, including PIR sensors, to detect intrusions and automate responses such as locking doors or activating alarms. By integrating with cloud services, the system enables remote monitoring and control, allowing homeowners to access and manage their security system from anywhere. This project highlights the benefits of cloud integration in providing a flexible, scalable, and user-friendly security solution that enhances the safety and convenience of smart homes.

M. Y. I. Idris, S. A. S. H. Shah, and M. M. Rafique [3] developed an "IoT Based Home Security System with PIR and Ultrasonic Sensors." This system integrates both PIR and ultrasonic sensors to improve the accuracy of intrusion detection. The PIR sensor detects the presence of humans through infrared radiation, while the ultrasonic sensor measures distance and movement by emitting ultrasonic waves. The combination of these sensors helps distinguish between human movement and other sources of motion, reducing the likelihood of false positives. Their system also features a robust communication protocol that ensures real-time alerts are sent to homeowners, enhancing the reliability and effectiveness of the security system.

K. S. R. Anjaneyulu's "Theft Detection System using PIR Sensor" [4] emphasizes the simplicity and effectiveness of using PIR sensors for theft detection. This project showcases how PIR sensors can accurately detect human motion and trigger alarms in case of unauthorized entry. The study highlights the sensor's ease of integration into various security systems, making it a cost-effective and reliable solution for intrusion detection. Anjaneyulu's work demonstrates the practical application of PIR sensors in developing efficient security systems that can be easily implemented in residential and commercial settings.

N. Patel's "GSM Based Home Security System using PIR Sensor and Arduino" [5] explores the integration of PIR sensors with a GSM module for real-time home security alerts. The system uses an Arduino micro controller to interface with the PIR sensor and the GSM module. When the PIR sensor detects motion, the Arduino processes the signal and triggers the GSM module to send an SMS alert to the homeowner. This project illustrates a straightforward and efficient approach to implementing a home security system that leverages mobile communication for remote monitoring and alerting. Patel's work highlights the practicality and effectiveness of using GSM technology to provide real-time notifications, ensuring homeowners are immediately informed of potential intrusions.

III. Proposed Methodology

The home intrusion detection system utilizes several key components to ensure robust security: PIR sensors, a Tiva micro controller, a GSM module, and an ESP32 camera module. The methodology is detailed as follows:

PIR Sensors for Motion Detection:

PIR (Passive Infrared) sensors are employed to detect motion by measuring infrared radiation from objects in their field of view. When motion is detected, the sensor sends a signal to the Tiva micro controller. The onboard LED of the Tiva micro controller is used to provide a visual indication of motion detection. The integration steps are:

1. **Sensor Integration:** Connect the PIR sensor to the Tiva micro controller. Typically, the sensor has three pins: VCC (power), GND (ground), and OUT (output signal). The OUT pin is connected to one of the GPIO (General-Purpose Input/Output) pins of the Tiva micro controller.

2. **Microcontroller Programming:** Program the Tiva micro controller to read the signal from the PIR sensor. When the sensor detects motion (i.e., the OUT pin goes HIGH), the micro controller sets the onboard LED to HIGH, indicating motion detection.

3. **LED Indication:** Use the onboard LED as a visual alert that motion has been detected.

GSM Module for Sending Alerts:

The GSM (Global System for Mobile Communications) module is used to send SMS alerts to a designated phone number when the PIR sensor detects motion. The steps involved are:

1. **Module Integration:** Connect the GSM module to the Tiva micro controller. The GSM module typically communicates via serial communication (UART). Connect the TX (transmit) and RX (receive) pins of the GSM module to the corresponding RX and TX pins on the Tiva micro controller.

2. **Programming:** Program the micro controller to initialize the GSM module, configure it for SMS sending, and compose the message. When the PIR sensor triggers, the micro controller sends an AT command to the GSM module to send an SMS alert to the predefined phone number.

3. **Alert Messaging**: Ensure the message contains relevant information such as the time and location of the detected motion.

ESP32 Camera Module for Live Feed:

The ESP32 camera module is utilized to provide a live video feed when the PIR sensor detects motion. The steps include:

1. **Camera Integration:** Connect the ESP32 camera module to the Tiva micro controller via its GPIO pins.

2. **Wi-Fi Configuration**: Configure the ESP32 to connect to a Wi-Fi network. This enables the streaming of live video feed over the internet.

3. **Motion Detection Trigger:** Program the Tiva micro controller to send a signal to the ESP32 when motion is detected by the PIR sensor. This signal activates the camera.

4. **Live Streaming:** The ESP32 starts capturing video and streams it to a specified IP address or a cloud service where the live feed can be accessed remotely.

Overall System Workflow:

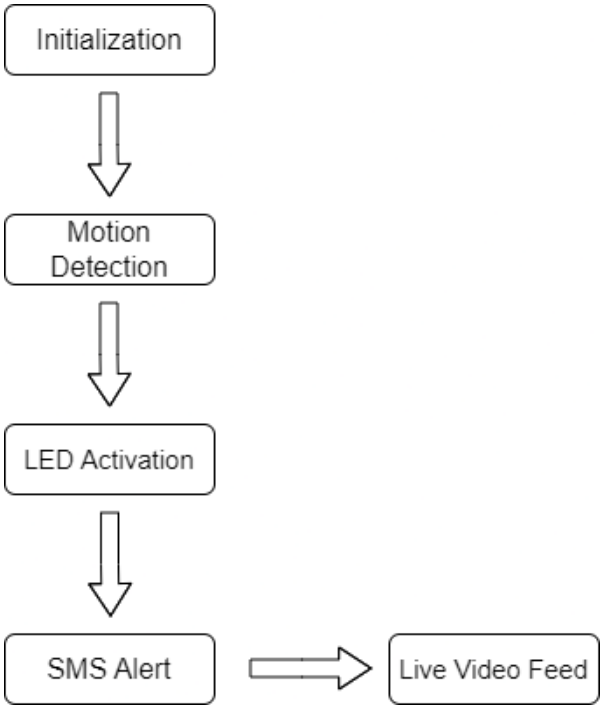
1. **Initialization:** The system initializes and enters a monitoring state where the PIR sensor continuously checks for motion.

2. **Motion Detection:** Upon detecting motion, the PIR sensor sends a signal to the Tiva micro controller.

3.**LED Activation:** The micro controller activates the onboard LED to provide a visual indication of the detected motion.

4. **SMS Alert:** The micro controller sends a command to the GSM module to send an SMS alert to the homeowner.

5. **Live Video Feed:** The micro controller triggers the ESP32 camera module to start streaming live video, which can be viewed on a remote device.



This integration of motion detection, real-time alerts, and live video streaming creates a comprehensive home security system. The system ensures that homeowners are promptly informed of any intrusion and can visually verify the situation in real time.

IV. Results and Discussions

A. Dataset description:

In this project, several types of datasets were utilized to test and evaluate the performance of the system. The datasets include sensor readings, alert logs, and video footage. Here is a brief description of each type:

1. Sensor Readings Dataset:

Description: This dataset contains the output from the PIR sensor indicating motion detection over time.

2. **Alert Logs Dataset:**

Description: This dataset consists of logs generated by the GSM module when sending SMS alerts.

3. **Video Footage Dataset:**

Description: This dataset contains live video captured by the ESP32 camera module when motion is detected.

The datasets collected in this project are crucial for testing and validating the functionality of the home intrusion detection system.

B. Simulation results:

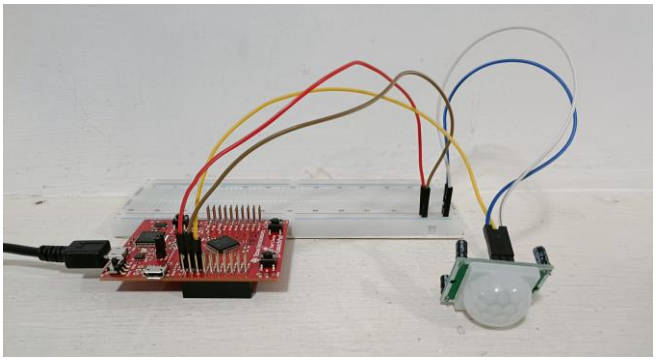


Fig. 1. Circuit design. of PIR Sensor

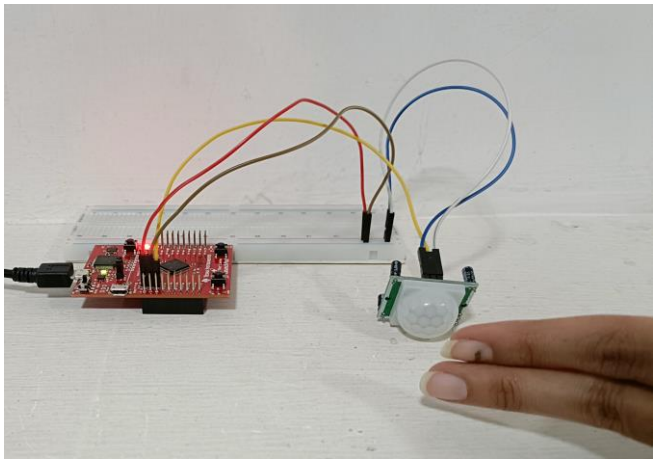


Fig. 2. Output image of PIR Sensor-LED Blinking upon Motion detection.

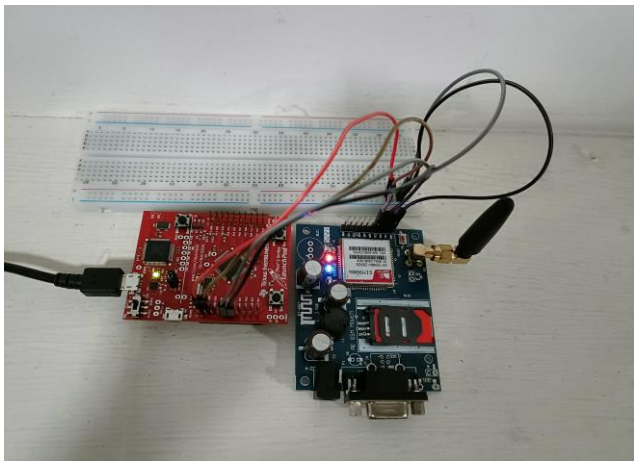


Fig. 3. Circuit design of GSM SIM-900 module.

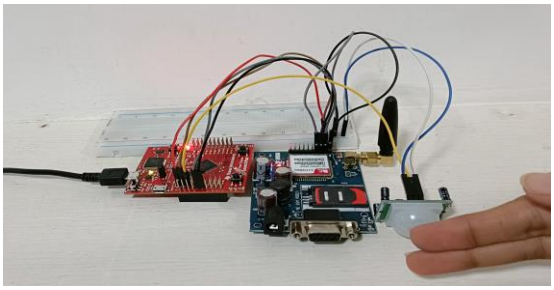


Fig. 4. Circuit design of interfacing PIR Sensor with GSM SIM-900 module.

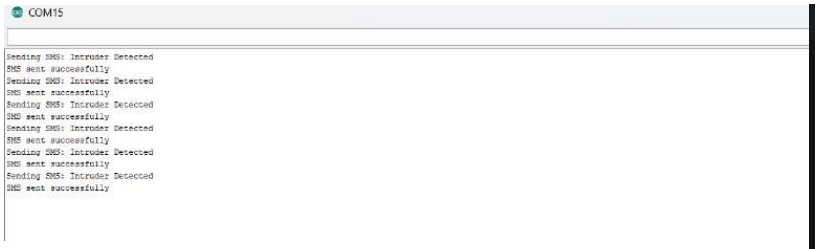


Fig. 5. Screenshot image of Serial monitor when motion detected in PIR sensor.

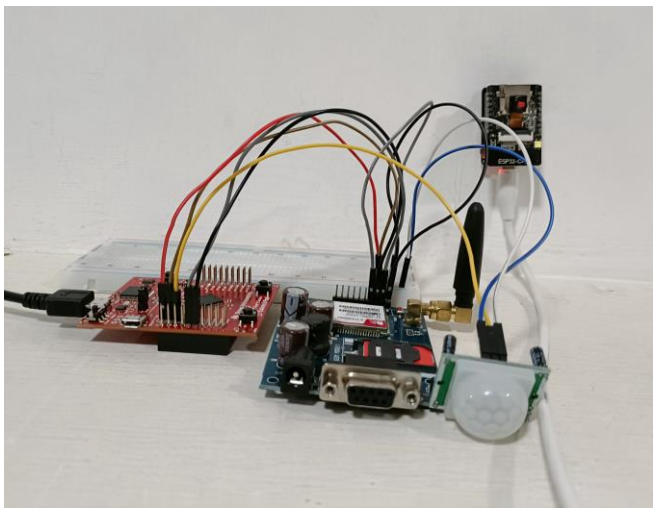


Fig. 6. Circuit design of interfacing PIR Sensor, GSM SIM-900 module and ESP32 camera module.

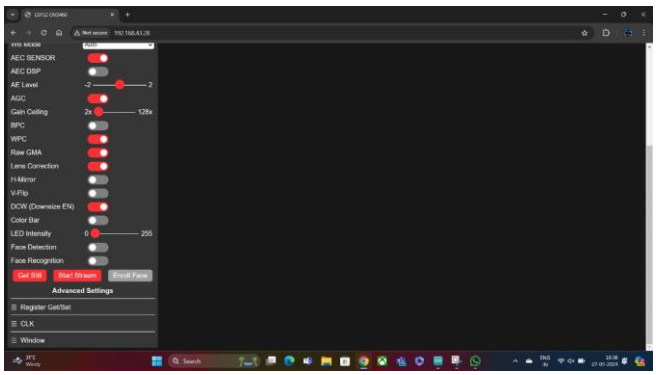


Fig. 7. Ouput window of ESP32 Camera Module.

Fig. 8. Screenshot image of Serial monitor when ESP32 Camera module is activated.

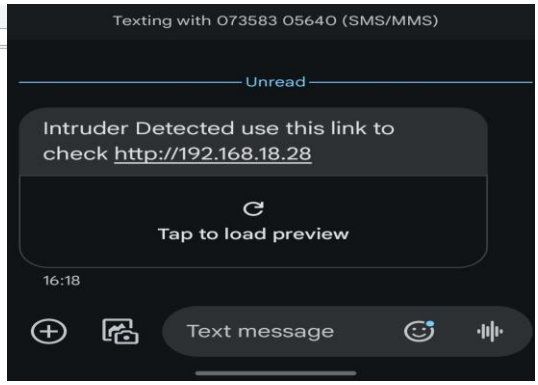


Fig. 9. Screenshot image of SMS alert.

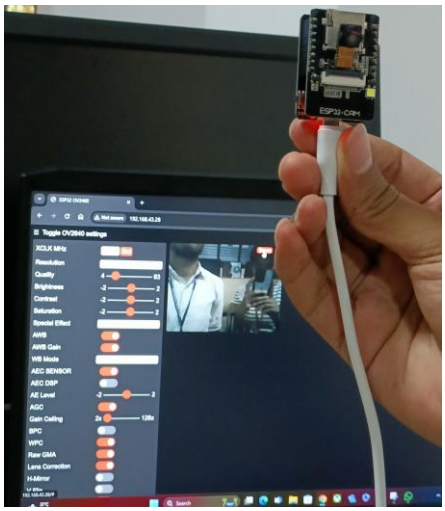


Fig. 10. Image of ESP32 Camera module detecting Live action when intruder detected in PIR Sensor .

Fig. 11. Images of Saved output from ESP32 Camera module.

C. **Inference:**

From the results we can infer that home intrusion detection system integrates a Passive Infrared (PIR) sensor, an ESP32 camera module, and a GDM SIM 900 module to provide comprehensive security monitoring. The PIR sensor continuously monitors for motion, and upon detection, it triggers the ESP32 camera module to capture live images or video of the area. Simultaneously, the ESP32 communicates with the GDM SIM 900 module to send an SMS alert to a predefined phone number, notifying the homeowner of potential intrusion. This system ensures real-time monitoring and remote alerts, allowing homeowners to respond quickly to potential threats. The combination of immediate detection, live imaging, and SMS notifications makes this system a robust solution for enhancing home security.

V. Conclusion

This project demonstrates the development and implementation of a comprehensive home intrusion detection system. Utilizing a combination of a Passive Infrared (PIR) sensor, GSM module, and ESP32 micro controller with an integrated camera module, the system provides real-time alerts and live video feed capabilities to enhance home security. When motion is detected, the PIR sensor triggers the ESP32, which activates the camera to capture live footage of the monitored area. Concurrently, the GSM module sends an alert message to the homeowner's mobile device, ensuring immediate awareness of potential intrusions. The ESP32's Wi-Fi capability allows for seamless streaming of the live video feed to a designated device, enabling remote surveillance.

This paper covers the technical details and integration of the various components, including the setup, programming, and functionality of the PIR sensor, GSM module, and ESP32 camera module. The performance evaluations highlight the system's responsiveness and accuracy in detecting intrusions and providing timely alerts, demonstrating its viability as a cost-effective and efficient home security solution.

Room for Improvement:

While the current system is effective, there are several areas for potential improvement:

1. **Enhanced Camera Resolution:** Upgrading to a higher resolution camera module could provide clearer images and better evidence in case of an intrusion.

2. **Advanced Motion Detection:** Implementing more sophisticated motion detection algorithms, such as machine learning-based approaches, could reduce false positives and improve the system's reliability.

3. **Integration with Cloud Services:** Storing video feeds and alerts in the cloud could enhance data security and accessibility, allowing users to review footage from any location at any time.

4. **Battery Backup:** Adding a battery backup to the system could ensure continued operation during power outages, enhancing reliability.

5. **Mobile App Development:** Developing a dedicated mobile application could provide a more user-friendly interface for monitoring and managing the system, offering features like push notifications and remote control.

By addressing these areas, the home intrusion detection system can be further refined and enhanced to provide even greater security and convenience for homeowners.

VI. References

[1] J. Mathew, "IoT based intrusion detection system using PIR sensor," 2017 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), 2017, pp. 1-5. doi: 10.1109/ICCIC.2017.8524305.

[2] Sharma and S. Tripathi, "Smart Home Automation with Smart Security System over the Cloud," 2021 IEEE International Conference on Computing, Power and Communication Technologies (GUCON), 2021, pp. 1-5. doi: 10.1109/GUCON50781.2021.9573708.

[3] M. Y. I. Idris, S. A. S. H. Shah, and M. M. Rafique, "IOT Based Home Security System with PIR and Ultrasonic Sensors," 2020 IEEE International Conference on Innovative Computing, Information and Control (ICICIC), 2020, pp. 1-4. doi: 10.1109/ICICIC50835.2020.9175004.

[4] K. S. R. Anjaneyulu, "Theft Detection System using PIR Sensor," 2018 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI), 2018, pp. 1831-1834. doi: 10.1109/ICPCSI.2018.8780727.

[5] N. Patel, "GSM Based Home Security System using PIR Sensor and Arduino," 2022 IEEE International Conference on Electronics, Computing and Communication Technologies (CONECCT), 2022, pp. 1-5. doi: 10.1109/CONECCT52220.2022.9784395.

VII. Appendix

```
/**
 * main.c
 */
#include <stdint.h>
#include <stdbool.h>
#include "inc/hw_memmap.h"
#include "inc/hw_types.h"
#include "inc/hw_gpio.h"
#include "driverlib/sysctl.h"
#include "driverlib/gpio.h"
#include "driverlib/pin_map.h"
#include "driverlib/uart.h"

// UART Definitions
#define UART0_MODULE UART0_BASE
#define UART5_MODULE UART5_BASE
#define UART0_GPIO_PORT GPIO_PORTA_BASE
#define UART5_GPIO_PORT GPIO_PORTE_BASE
#define UART0_GPIO_TX GPIO_PIN_1
#define UART0_GPIO_RX GPIO_PIN_0
#define UART5_GPIO_TX GPIO_PIN_5
#define UART5_GPIO_RX GPIO_PIN_4
#define BAUD_RATE_0 115200
#define BAUD_RATE_5 9600

#define PHONE_NUMBER "+916381584055"  // Replace with the target phone number

// PIR and LED Pin Definitions
#define PIR_SENSOR_PORT_BASE GPIO_PORTD_BASE
#define PIR_SENSOR_PIN GPIO_PIN_0
#define RED_LED_PORT_BASE GPIO_PORTF_BASE
#define RED_LED_PIN GPIO_PIN_1

void UART0Init(void);
void UART5Init(void);
void UARTPrint(const char *message, uint32_t uart_module);
void GSM_SendSMS(const char *phoneNumber, const char *message);
void delay(uint32_t seconds);
void setup(void);
void loop(void);

int main(void) {
    setup();

    while (1) {
        loop();
    }

    return 0;
```

```
}

void UART0Init(void) {
  SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOA);
  SysCtlPeripheralEnable(SYSCTL_PERIPH_UART0);

  GPIOPinConfigure(GPIO_PA0_U0RX);
  GPIOPinConfigure(GPIO_PA1_U0TX);
  GPIOPinTypeUART(UART0_GPIO_PORT,
UART0_GPIO_RX | UART0_GPIO_TX);

  UARTConfigSetExpClk(UART0_MODULE,
SysCtlClockGet(), BAUD_RATE_0,
            (UART_CONFIG_WLEN_8                |
UART_CONFIG_STOP_ONE                |
UART_CONFIG_PAR_NONE));
}

void UART5Init(void) {
  SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOE);
  SysCtlPeripheralEnable(SYSCTL_PERIPH_UART5);

  GPIOPinConfigure(GPIO_PE4_U5RX);
  GPIOPinConfigure(GPIO_PE5_U5TX);
  GPIOPinTypeUART(UART5_GPIO_PORT,
UART5_GPIO_RX | UART5_GPIO_TX);

  UARTConfigSetExpClk(UART5_MODULE,
SysCtlClockGet(), BAUD_RATE_5,
            (UART_CONFIG_WLEN_8                |
UART_CONFIG_STOP_ONE                |
UART_CONFIG_PAR_NONE));
}

void UARTPrint(const char *message, uint32_t
uart_module) {
  while (*message != '\0') {
    UARTCharPut(uart_module, *message);
    message++;
  }
}

void GSM_SendSMS(const char *phoneNumber, const char
*message) {
  // Send AT command to set SMS to text mode
  UARTPrint("AT+CMGF=1\r", UART5_MODULE);
  SysCtlDelay(SysCtlClockGet() / 3);  // Delay to allow
command processing

  // Send AT command to set the recipient phone number
  UARTPrint("AT+CMGS=\"", UART5_MODULE);
  UARTPrint(phoneNumber, UART5_MODULE);
  UARTPrint("\"\r", UART5_MODULE);
  SysCtlDelay(SysCtlClockGet() / 3);  // Delay to allow
command processing

  // Send the actual SMS message
  UARTPrint(message, UART5_MODULE);

  // End the message with Ctrl+Z (ASCII 26)
  UARTCharPut(UART5_MODULE, 26);
  SysCtlDelay(SysCtlClockGet() / 3);  // Delay to allow
command processing

  // Debug message via UART0
  UARTPrint("SMS sent successfully\r\n",
UART0_MODULE);
}

void delay(uint32_t seconds) {
  // Delays for the specified number of seconds.
  SysCtlDelay(seconds * SysCtlClockGet());
}

void setup(void) {
  // Set the system clock to 50 MHz
  SysCtlClockSet(SYSCTL_SYSDIV_4              |
SYSCTL_USE_PLL    |    SYSCTL_OSC_MAIN    |
SYSCTL_XTAL_16MHZ);

  // Initialize UART modules
  UART0Init();
  UART5Init();

  // Enable the peripherals for the PIR sensor and the LED
  SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOD);
  SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF);

  // Wait for the peripherals to be ready
  while
(!SysCtlPeripheralReady(SYSCTL_PERIPH_GPIOD)) {}
  while
(!SysCtlPeripheralReady(SYSCTL_PERIPH_GPIOF)) {}

  // Unlock GPIOF for the LED (required for PF0 and PF1)
  HWREG(GPIO_PORTF_BASE + GPIO_O_LOCK) =
GPIO_LOCK_KEY;
  HWREG(GPIO_PORTF_BASE + GPIO_O_CR) |=
RED_LED_PIN;
  HWREG(GPIO_PORTF_BASE + GPIO_O_LOCK) = 0;

  // Configure the PIR sensor pin as input
  GPIOPinTypeGPIOInput(PIR_SENSOR_PORT_BASE,
PIR_SENSOR_PIN);

  // Configure the LED pin as output
  GPIOPinTypeGPIOOutput(RED_LED_PORT_BASE,
RED_LED_PIN);
}

void loop(void) {
  // Read the value from the PIR sensor
  uint8_t                sensorValue                =
GPIOPinRead(PIR_SENSOR_PORT_BASE,
PIR_SENSOR_PIN);

  // If motion is detected (sensor value is HIGH), turn on
the LED and send an SMS
  if (sensorValue & PIR_SENSOR_PIN) {
    // Turn on the LED
    GPIOPinWrite(RED_LED_PORT_BASE,
RED_LED_PIN, RED_LED_PIN);

    // Debug message via UART0
    UARTPrint("Sending SMS: Intruder Detected\r\n",
UART0_MODULE);
```

```
        // Send SMS via UART5 to GSM module
        GSM_SendSMS(PHONE_NUMBER, "Intruder Detected. Use this link to check: http://192.168.43.28");

        // Delay to avoid multiple SMS sends for the same detection
        delay(5);  // Delay approximately 5 seconds
    } else {
        // Turn off the LED
        GPIOPinWrite(RED_LED_PORT_BASE, RED_LED_PIN, 0);
    }
}
```