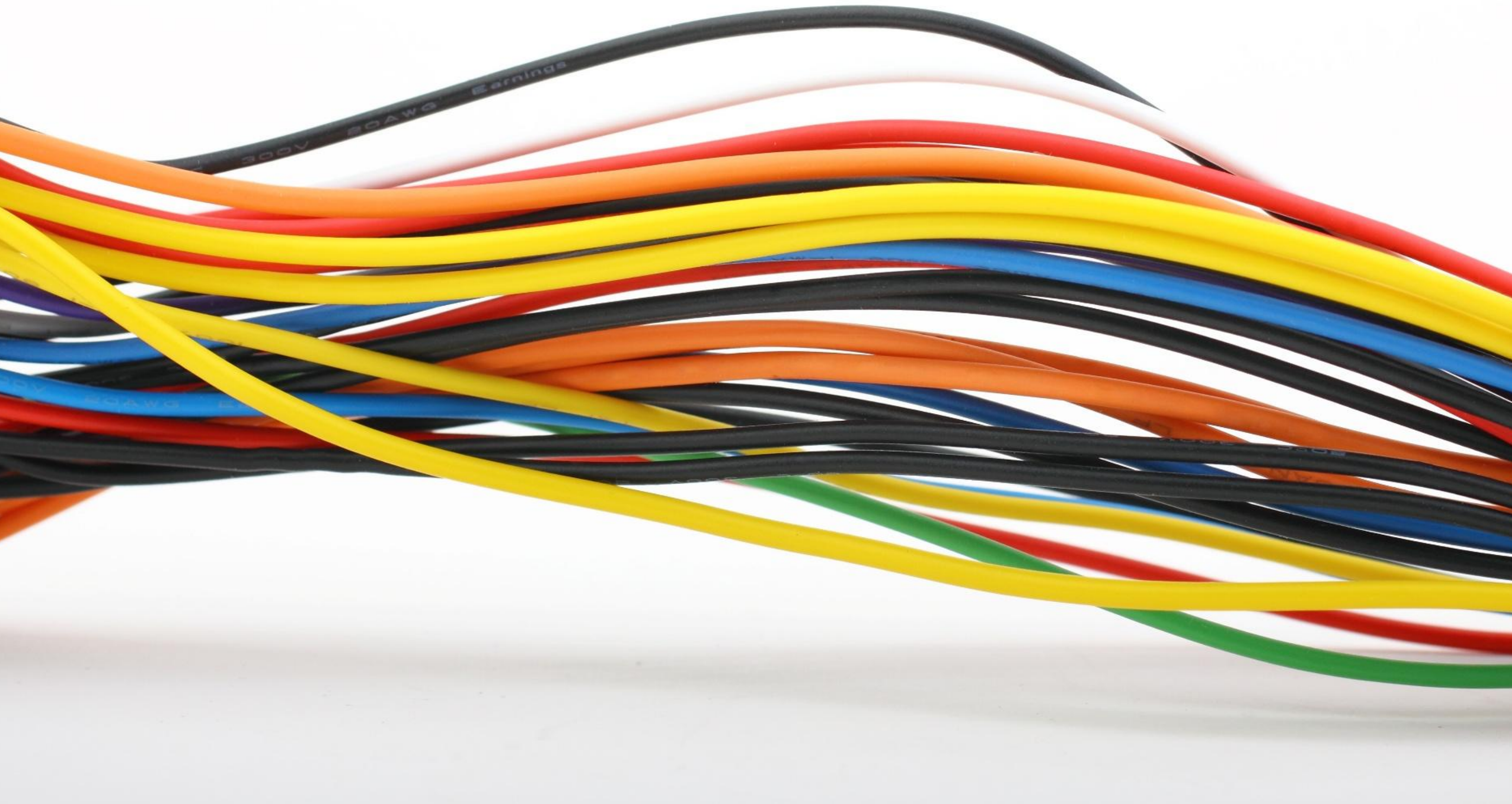
EMBEDDED SYSTEMS HARDWARE
ECE202
Dr. Rohit Singh



HOME SECURITY SYSTEM

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Abstract

This project presents the design and implementation of a cost-effective, reliable, and user-friendly home security system that leverages Passive Infrared (PIR) sensors and a laptop camera to enhance safety. The system is designed to detect unauthorized motion and provide instant alerts, ensuring real-time monitoring and prompt action.
The PIR sensors detect motion within a predefined range, triggering the laptop camera to capture images of the detected activity. Thus, every motion is captured using PIR sensors and a camera.

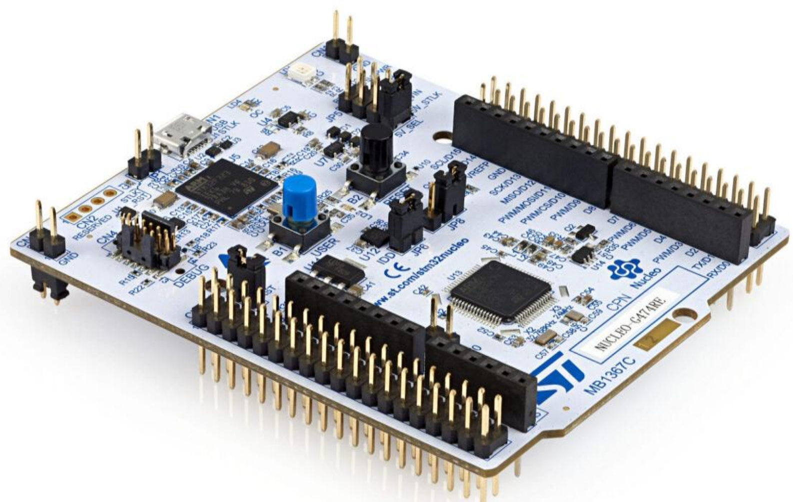
Hardware and software required

HARDWARE	SOFTWARE
Stm 32	STM32 IDE
Buzzer	Python
PIR Sensor	
Laptop camera	
Breadboard and wires	

Parts used

1) STM32 MICROCONTROLLER

The STM32 microcontroller series, developed by STMicroelectronics, is a robust and versatile solution for embedded systems. Renowned for its high performance, low power consumption, and extensive peripheral options, the STM32 microcontroller is widely utilized in diverse applications, including IoT and home automation projects.



Here are some key specifications of the STM 32 Microcontroller:

Specification	Details
Processor Core	ARM Cortex-M0, M3, M4, or M7
Clock Speed	Up to 72 MHz
Flash Memory	16 KB – 512 KB
RAM	2 KB – 80 KB
Operating Voltage	2.0 V – 3.6 V
Power Consumption	Typically < 200 mA (varies with application)

Interfaces	UART, SPI, I²C, USB, CAN, Ethernet, SDIO, ADC, DAC, DMA, RTC, etc.
Operating Temperature	–40 °C to +85 °C (typical) –40 °C to +105 °C (extended variants)

2) BUZZER

A buzzer is an electronic signaling device that produces sound when activated. It is commonly used for audio alerts, notifications, or alarms in various applications. Buzzers operate by converting electrical energy into sound through mechanical or piezoelectric mechanisms.

<u>Key Features:</u>

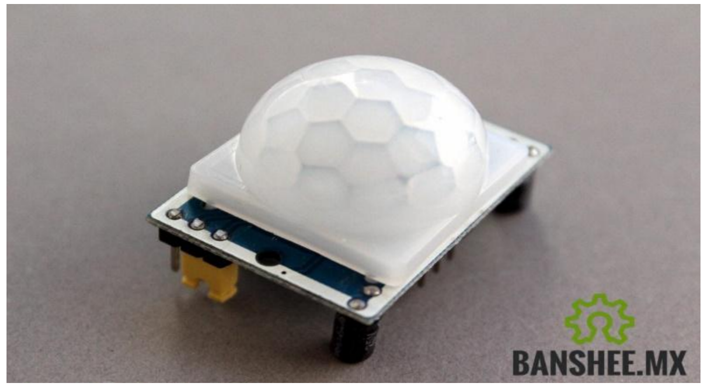
- Compact Size: Easily integrated into electronic systems.
- Low Power Consumption: Suitable for battery-operated devices.
- Durable: Designed for long-term use.

<u>Common Applications:</u>

- Alarm systems
- Timers and reminders
- Notification systems in electronics
- Indicators in appliances (like microwaves and washing machines)

3) PIR SENSOR

A Passive Infrared (PIR) sensor is a motion-detection device that detects infrared radiation (heat energy) emitted by living beings, such as humans and animals. PIR sensors are widely used in security systems, automation, and energy-saving applications due to their reliability and cost-effectiveness.



<u>Key Features:</u>

- Passive Operation: It does not emit radiation but detects the natural IR radiation from objects.
- Energy Efficient: Low power consumption, making it ideal for battery-powered devices.
- Adjustable Sensitivity and Range: Can be tuned for specific applications.
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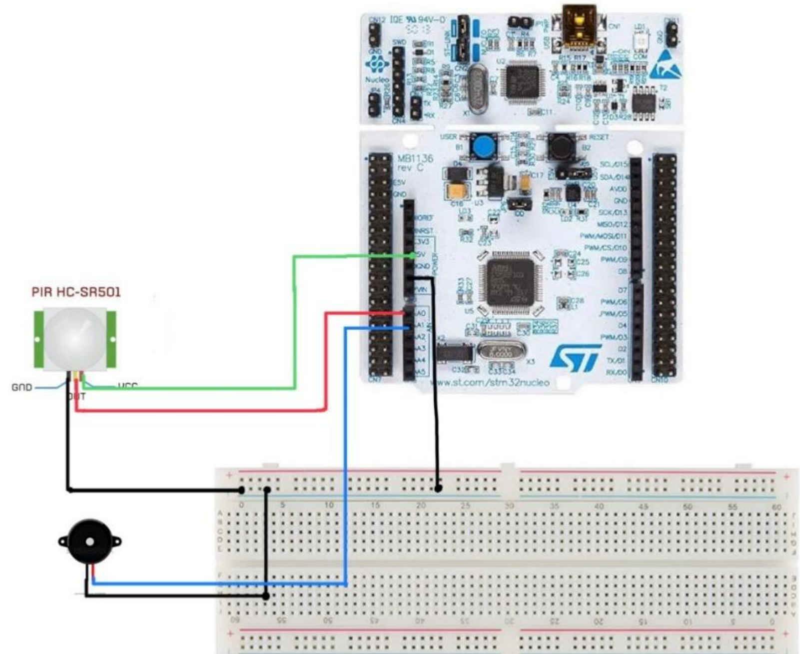
<u>Applications:</u>

- Home Security: Detecting unauthorized motion to trigger alarms or cameras.
- Lighting Automation: Turning lights on/off based on occupancy.
- Industrial Automation: Monitoring movement in warehouses or production lines.
- Smart Devices: Used in IoT systems for presence detection.

CIRCUIT DIAGRAM



PYTHON CODE

```python
import cv2
import serial
import time
cap = cv2.VideoCapture(0)  # camera intilization
previous_frame = None
while True:
    ret, frame = cap.read()
    if not ret:
        break
    gray_frame = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)  # converting frame to grayscale
    gray_frame = cv2.GaussianBlur(gray_frame, (21, 21), 0)
    if previous_frame is None:  # comparing with the initial frame
        previous_frame = gray_frame
        continue
```

```python
    frame_delta = cv2.absdiff(previous_frame, gray_frame)
    thresh_frame = cv2.threshold(frame_delta, 25, 255, cv2.THRESH_BINARY)[1]
    thresh_frame = cv2.dilate(thresh_frame, None, iterations=2)

    contours, _ = cv2.findContours(thresh_frame.copy(), cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)
 #movement detection


    motion_detected = False  # initially
    for contour in contours:
        if cv2.contourArea(contour) < 100:  # Ignore small movements
            continue
        motion_detected = True  # motion is detected
        (x, y, w, h) = cv2.boundingRect(contour)
        cv2.rectangle(frame, (x, y), (x + w, y + h), (0, 255, 0), 2)
    if motion_detected:  # if motion is detected it saves the images
        timestamp = time.time()
        image_name = f"motion_{int(timestamp)}.jpg"
        cv2.imwrite(image_name, frame)

    cv2.imshow("Frame", frame)
    previous_frame = gray_frame
    if cv2.waitKey(1) & 0xFF == ord('q'):  # to exit press q
        break
cap.release()
cv2.destroyAllWindows()
```

STM32 CODE

```c
int main(void)
{
  HAL_Init();
  SystemClock_Config();

  MX_GPIO_Init();
  while (1)
  {
    if (HAL_GPIO_ReadPin(GPIOA, GPIO_PIN_0) == GPIO_PIN_SET) {
      // Motion detected
      HAL_GPIO_WritePin(GPIOA, GPIO_PIN_1, GPIO_PIN_SET);  // Turn on buzzer
      HAL_Delay(20);  // Buzzer sound duration
      HAL_GPIO_WritePin(GPIOA, GPIO_PIN_1, GPIO_PIN_RESET); // Turn off buzzer
    } else {
      // No motion detected, buzzer off
      HAL_GPIO_WritePin(GPIOA, GPIO_PIN_1, GPIO_PIN_RESET);
    }
  }
}
```

ADVANTAGES & BENEFITS

- **Improved Safety**: The home security system enhances safety by detecting motion and alerting users with a buzzer sound. Additionally, the laptop camera captures images of suspicious activities, ensuring better monitoring.

- **Real-Time Monitoring**: With the integration of a laptop camera, the system provides real-time surveillance, helping homeowners stay aware of any movements in their surroundings.

- **Cost-Effective Solution**: Using affordable components like the STM32 microcontroller, PIR sensor, and buzzer, the project delivers an efficient and economical security solution without requiring advanced equipment.

- **Energy Efficiency**: The system operates only when motion is detected, reducing energy consumption compared to always-on surveillance systems.

- **User-Friendly Setup**: Simple hardware like a breadboard, connecting wires, and commonly available sensors ensures the system is easy to assemble and maintain.

- **Scalability and Customization**: The project can be expanded to include additional features, such as remote monitoring, smartphone alerts, or integration with other IoT-based systems, to adapt to user-specific needs.

- **Emergency Response Enhancement**: The system facilitates a quick response to potential security breaches or emergencies by providing instant alerts through the buzzer and real-time image capture.

USES

- **Home Security:**
  The project is an affordable and efficient home security system that detects unauthorized movement and captures evidence through images for future reference.

- **Workplace Monitoring:**
  It can be used in offices or warehouses to monitor restricted areas, ensuring security by detecting intrusions during off-hours.

- **Animal Monitoring:**
  Useful in monitoring animal movements in farms or gardens to prevent trespassing by stray animals or alert owners about a specific activity.

- **Elderly Care:**
  The system can assist in monitoring the movements of elderly individuals in homes or care centers, providing alerts if unexpected inactivity or movements occur, and ensuring their safety.

POTENTIAL ENHANCEMENTS

- **Integration with IoT Platforms**: Enhance the project by connecting it to an IoT platform. This would allow users to monitor motion events and access captured images remotely through a smartphone or web application.
- **Advanced Camera Features**: Implement features like video recording or live streaming through the laptop camera, providing real-time monitoring and capturing images during motion events.
- **Multi-Sensor Integration**: Add more sensors, such as ultrasonic or microwave motion sensors, to improve detection accuracy and reduce false alarms caused by environmental factors.
- **Cloud-Based Data Storage and Analysis**: Store captured images in a secure cloud storage system. Incorporate data analytics tools to provide insights, such as the frequency and time of motion detection events, enabling pattern recognition for enhanced surveillance.

DIFFICULTY ENCOUNTERED

While developing the **Home Security System**, we faced a challenge with the PIR sensor during the initial stages. The main issue was understanding how the sensor worked and correctly configuring its pin connections with the STM32 microcontroller. Misinterpreting the PIR sensor's datasheet led to incorrect wiring, causing the sensor to either not detect motion or produce false triggers. Additionally, the sensor's sensitivity and signal stability needed to be more consistent, further delaying progress. After multiple failed attempts and troubleshooting, we identified the correct configuration and stabilized the system. This was the only significant issue faced during the project.

SOLUTION

To resolve the issue, we referred to the PIR sensor's datasheet and tutorials to understand its VCC, GND, and OUT pin configuration. The VCC pin was connected to the 5V power supply, GND to the STM32 ground, and the OUT pin to a GPIO configured as input. We tested the connections and verified the output to ensure proper functionality. To prevent such issues in the future, we recommend studying datasheets in detail, testing individual components before integration, and providing secure and correct wiring.

ACKNOWLEDGEMENT

We sincerely thank **Dr. Rohit Singh** for allowing us to undertake the **Home Security System** project. This project has been an invaluable learning experience, allowing us to apply theoretical concepts to practical challenges and gain deeper insights into embedded systems and security technologies.

The hands-on work with the STM32 microcontroller, PIR sensors, buzzer, and camera has strengthened our technical knowledge and problem-solving abilities. This project also enhanced our skills in teamwork, critical thinking, and system integration, all of which are vital for real-world applications.

We are deeply grateful for this opportunity, as it has contributed to our academic growth and prepared us for future endeavors in electronics and automation. Your guidance and support have been instrumental in making this project a success, and we sincerely appreciate the mentorship provided throughout this journey.