Project Title: Smart Home Safety System

Course: Embedded Systems and IoT Lab

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Abstract:

In this project, an Arduino-based embedded system and Internet of Things technologies are combined to create a low-cost, scalable smart home automation system. By integrating automated control mechanisms (relay-based appliances, servo motor gates, automatic streetlight, solar-powered devices) with environmental monitoring (temperature, light, motion, gas, and fire detection), the system improves convenience, energy efficiency, and security. Via a mobile application, data is sent to a cloud database (Firebase) for real-time monitoring, and buzzers, LEDs, and LCD screens provide vital safety alerts. The outcomes show a dependable and easy-to-use prototype that may be used in both residential and educational settings.

1.1 Introduction

In recent years, the integration of embedded systems and Internet of Things (IoT) technologies has transformed traditional homes into smart and interconnected environments. A smart home safety system is designed to enhance household security, prevent potential hazards, and provide real-time monitoring and alerts to residents. By using sensors, microcontrollers, and IoT platforms, the system can detect fire, gas leakage, intrusions, or unusual activities and immediately notify users through mobile applications or cloud services. Such systems not only improve safety but also provide convenience and peace of mind, making them a vital component of modern smart homes.

1.2 Motivation

With technology becoming an integral part of life, the demand for swift and reliable systems that make life safer and more convenient has also increased. While IoT has been widely adopted, most households still use manual methods to manage electrical appliances and safety, which results in wasted energy and may lead to risks like gas leakage or fire hazards. Most solutions existing today address piecemeal problems, either energy monitoring or security, without offering an integrated approach.

This project is inspired by a vision to create one single unified system that helps combat some of the issues and concerns in modern households. The automation of control in electrical appliances and monitoring of environmental parameters ensures zero hassles for users by creating safety and sustainability in them. Motivation also lies in the fact that such a solution shall be made more affordable, whereby it can be more reachable for wide-scale use in each section of society.

1.3 Objectives

The main objectives of this project are:

- To design and implement an embedded IoT-based system capable of monitoring safety hazards in real time.
- To detect and alert users about potential dangers such as gas leakage, fire, and unauthorized entry.
- To integrate sensors and microcontrollers with a cloud platform for remote monitoring.
- To enhance user accessibility through mobile or web notifications.
- To ensure low-cost, energy-efficient, and scalable deployment for real-world usage.

1.4 Feasibility Study

The feasibility of this project is justified by the availability of affordable microcontrollers (such as Arduino/ESP32), a variety of sensors (gas sensor, PIR sensor, temperature sensor), and cloud-based IoT platforms. The hardware components are inexpensive and widely available in local markets, making the system financially viable. From a technical perspective, the integration of embedded programming and IoT protocols (like MQTT/HTTP) ensures reliable communication. The project is also practically feasible since it can be implemented in households with minimal modifications and does not require complex installation or maintenance.

1.5 Gap Analysis

The **Smart Home Safety System** addresses several gaps in current smart home solutions:

1. **Lack of Integration**:
   Existing systems often focus only on safety or energy management. This project integrates both, providing a unified solution for home security and energy efficiency.
2. **Manual Control**:
   Most systems require manual intervention. Our system automates appliance control based on motion detection and gas leak sensing, reducing the need for constant user input.
3. **Real-Time Data Access**:
   Many systems don't provide real-time monitoring of energy use or environmental conditions. Our system offers live data on energy consumption and sensor status through a mobile app.
4. **High Cost**:
   While many smart home solutions are costly, our system uses affordable components like Arduino UNO and Bluetooth, making it accessible for a wider range of users.
5. **Complex Installation**:
   Existing systems may require expert setup. Our solution is designed for easy installation and user-friendly operation, suitable for non-technical users.

This project fills these gaps by offering a cost-effective, automated, and easy-to-use system for home safety and energy management.

1.6 Project Outcome

The **"IoT-Based Smart Home Safety and System"** aims to deliver the following outcomes:

1. **Enhanced Home Safety**:
   The system will improve household safety by detecting motion and gas leaks, automatically turning off electrical appliances to mitigate risks.
2. **Energy Efficiency**:
   It will contribute to energy conservation by automating the shutdown of unused appliances, reducing electricity consumption and lowering utility bills.
3. **Real-Time Monitoring**:
   The system will provide users with real-time data on their energy consumption and environmental conditions, empowering them to make informed decisions.
4. **User-Friendly Mobile Interface**:
   A simple mobile app will enable users to control the system remotely, making it easy to monitor and manage their home from anywhere.
5. **Cost-Effective Solution**:
   By utilizing affordable components like the Arduino UNO and Bluetooth modules, the system will offer an effective and budget-friendly solution for home automation and security.
6. **Scalable Design**:
   The system will be scalable, allowing users to add additional sensors or devices as needed to meet their specific requirements.

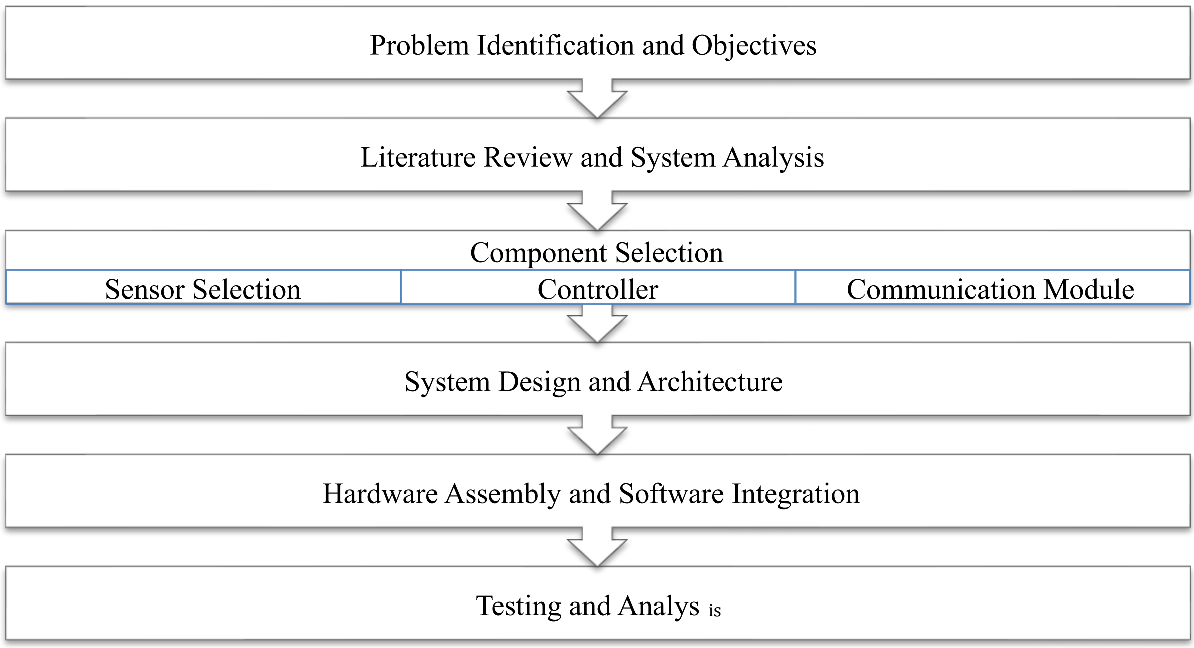
In summary, the project aims to provide an integrated, affordable, and easy-to-use solution that enhances both home safety and energy management.

2.1 Requirement Analysis & Design Specification

2.1.1 Overview

The "Smart Home Safety System" integrates motion, gas, and current sensors with an Arduino UNO to automate appliance control for safety and energy efficiency. It uses a mobile app for real-time monitoring and remote operation. The system includes a Bluetooth module for communication and a relay for controlling appliances. Key features include automatic shutdown based on sensor inputs and real-time data visualization. The solution is scalable, secure, cost-effective, and user-friendly, providing both safety and energy management.

2.1.2 Proposed Methodology/ System Design



2.1.2 Hardware Requirements

The **"Smart Home Safety System"** has specific hardware and software requirements to ensure its functionality and efficiency. These requirements are detailed below:

Hardware Requirements:

1. **Arduino UNO**:
   Serves as the main microcontroller to process sensor data and control the system.
2. **Motion Sensor (PIR Sensor)**:
   Detects human movement within a specified range to determine if the home is occupied.
3. **Gas Sensor (MQ-2)**:
   Detects the presence of harmful gases such as methane or carbon monoxide in the environment.
4. **Current Sensor (ACS712)**:
   Measures the current consumption of connected electrical appliances, providing data on energy usage.
5. **Relay Module**:
   Allows the Arduino to control high-voltage appliances by switching the power on or off based on sensor inputs.
6. **Bluetooth Module (HC-05)**:
   Provides wireless communication between the Arduino and the mobile application for remote control and monitoring.
7. **Mobile Device (Smartphone)**:
   Used for remote monitoring and control of the system through a mobile app developed using MIT App Inventor.

Software Requirements:

1. **Arduino IDE**:
   Used for programming the Arduino UNO to manage sensor data and control the relay module based on inputs.
2. **MIT App Inventor**:
   A platform used to design and develop the mobile application for real-time data visualization and control.

2.1.3 Functional Requirements

The **"Smart Home Safety System"** must meet the following functional requirements:

1. **Motion Detection**:
   The system should continuously monitor for motion in the designated area. If no motion is detected within a predefined time, the system will automatically turn off connected electrical devices.
2. **Gas Leak Detection**:
   If the gas sensor detects harmful levels of gas, the system will automatically turn off electrical appliances to prevent any risk of fire or explosion.
3. **Current Measurement**:
   The system should measure and display the real-time current consumption of connected appliances to monitor energy usage.
4. **Mobile Control and Monitoring**:
   Users should be able to control and monitor the system remotely via a mobile app. The app should show real-time sensor data and allow users to turn appliances on or off as needed.
5. **Alerts and Notifications**:
   The system should send notifications to the user's mobile device if motion is detected, a gas leak is present, or if an unusual change in current consumption is detected.
6. **System Reset**:
   Users should be able to manually reset the system through the mobile app if necessary.

2.1.4 Non-Functional Requirements

1. **Performance**:
   The system must operate in real-time, with minimal delay between sensor detection and action taken (e.g., switching off appliances).
2. **Reliability**:
   The system must be dependable, ensuring that sensors and communication between devices (Arduino, Bluetooth, and mobile) work without failure.
3. **Scalability**:
   The system should be designed so additional sensors or devices can be added as needed for more extensive home automation.
4. **Security**:
   Communication between the Arduino and mobile application should be secure to prevent unauthorized access and ensure privacy.
5. **Usability**:
   The mobile application should have an intuitive user interface that is easy to navigate for users of all technical skill levels.

2.1.5 Design Specifications

The design of the "IoT-Based Smart Home Safety and Power Monitoring System with Big Data Integration" involves the following aspects:

1. **System Architecture**:
   The system is based on a client-server model, where the Arduino acts as the server (processing data and controlling appliances) and the mobile app serves as the client (sending commands and displaying sensor data). The Bluetooth module facilitates communication between the two.
2. **Sensor Integration**:
   The motion sensor, gas sensor, and current sensor are integrated with the Arduino. Each sensor provides data that is processed by the microcontroller. The motion sensor triggers

appliance shutdown if no movement is detected, while the gas sensor handles gas leak detection. The current sensor monitors real-time energy consumption.

3. **Relay Control**:
   The relay module is connected to the Arduino to control the electrical appliances. Based on sensor data, the Arduino sends a signal to the relay to switch the appliances on or off.
4. **Mobile Application**:
   The mobile application, built using MIT App Inventor, will allow users to monitor real-time data from the sensors and control appliances remotely. The app will display the status of the sensors, current usage, and the ability to turn appliances on or off.
5. **Data Flow**:
   The system continuously collects data from the sensors, processes it through the Arduino, and updates the mobile app in real time. If a condition is met (gas detected or no motion), the Arduino sends commands to the relay to control the connected appliances.

2.5 System Block Diagram

A system block diagram outlines the major components and their connections:

- **Arduino UNO**:
  Central control unit that processes sensor data and manages appliance control via relay.
- **Sensors (PIR, MQ-2, ACS712)**:
  Input devices that detect motion, gas, and current consumption.
- **Relay Module**:
  Controls the connected appliances based on commands from the Arduino.
- **Bluetooth Module (HC-05)**:
  Provides communication between the Arduino and the mobile app.
- **Mobile Application**:
  Interface for the user to monitor sensor data and control the system.

This design ensures the system is modular, scalable, and capable of handling real-time data processing and communication between the hardware and user interface.

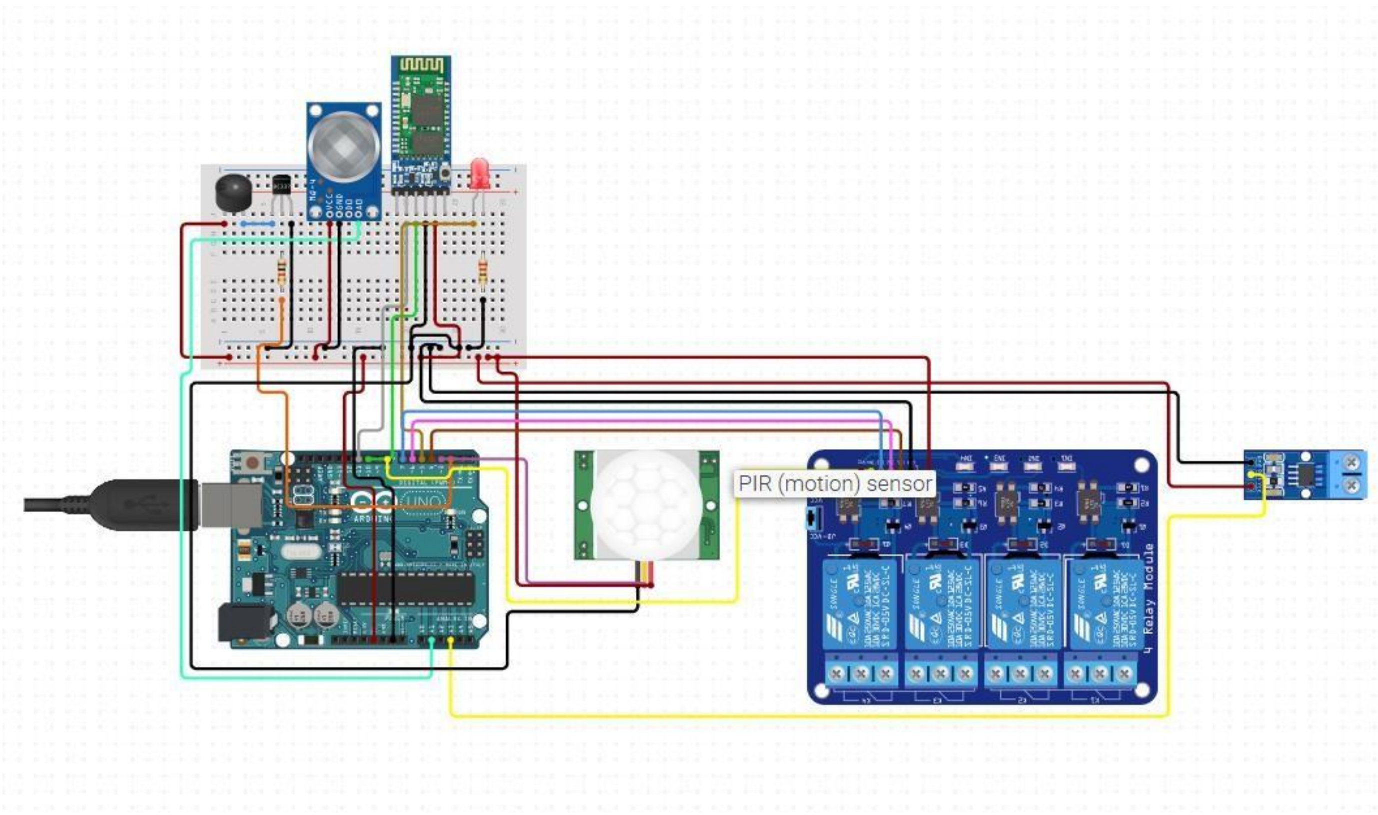
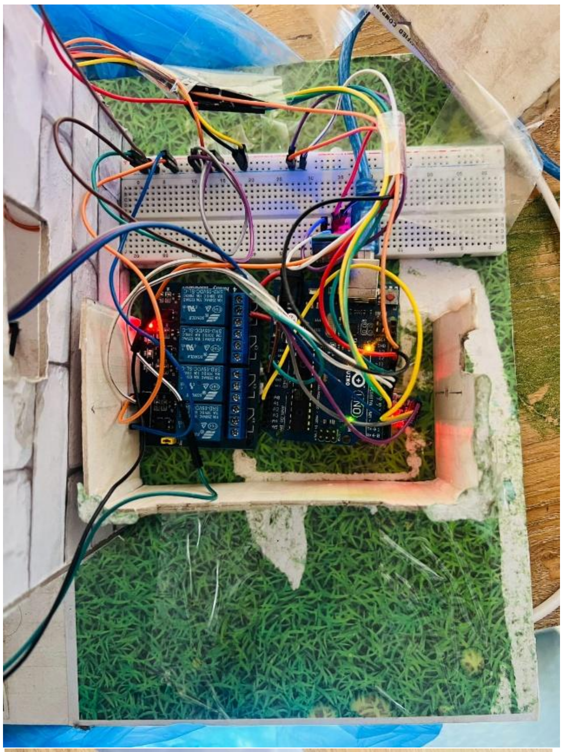
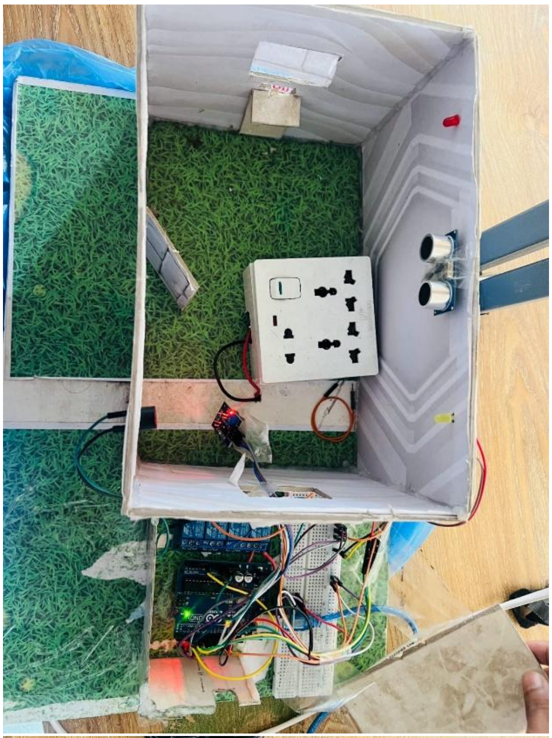
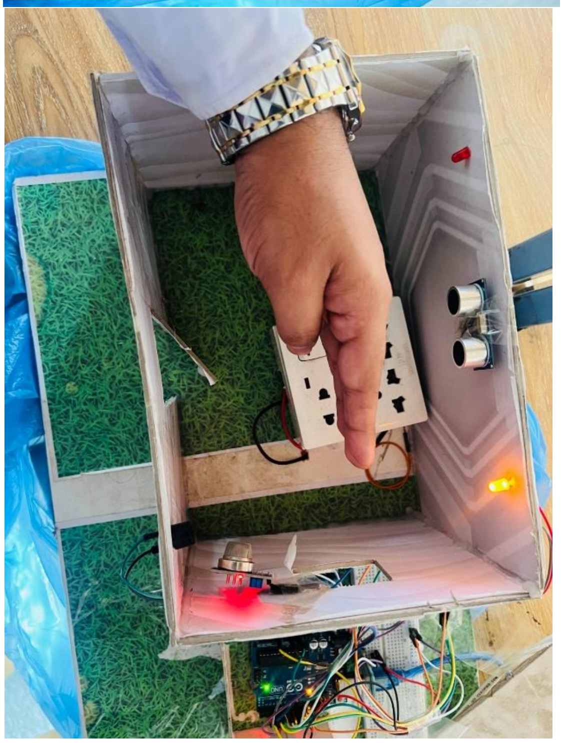
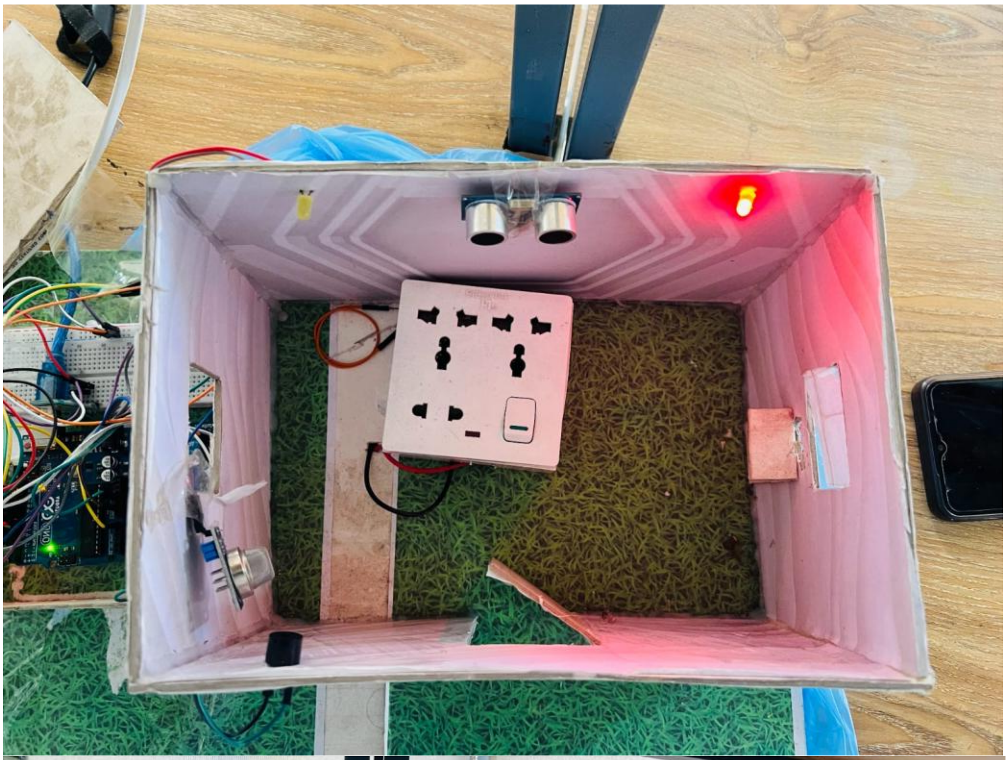
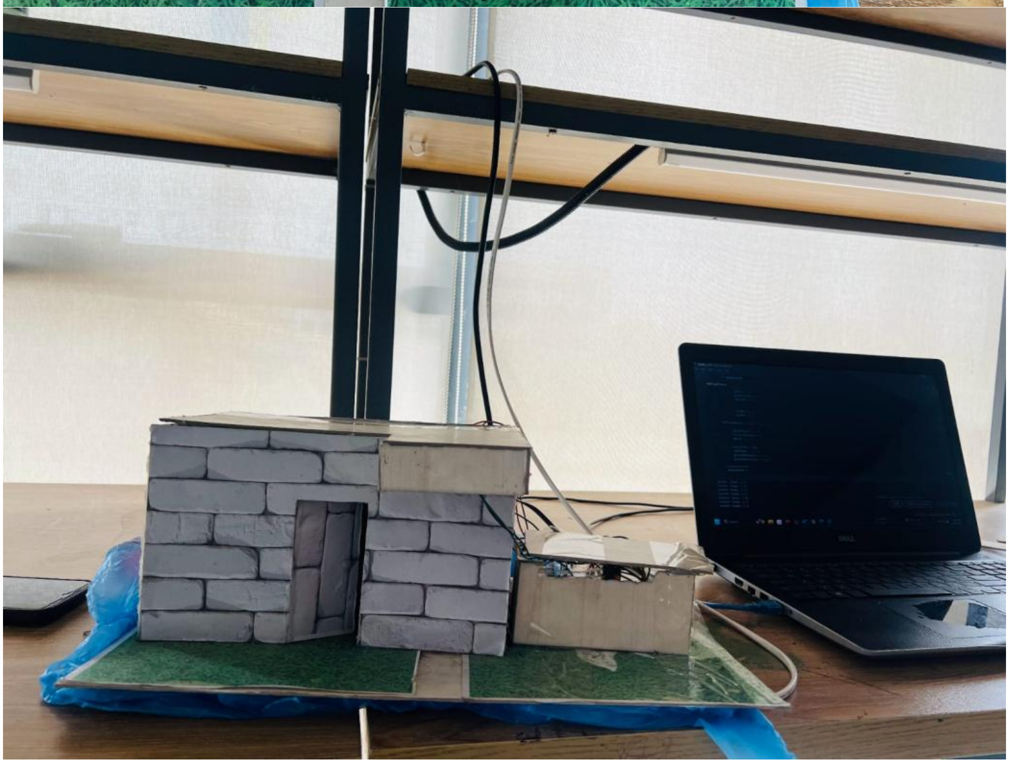


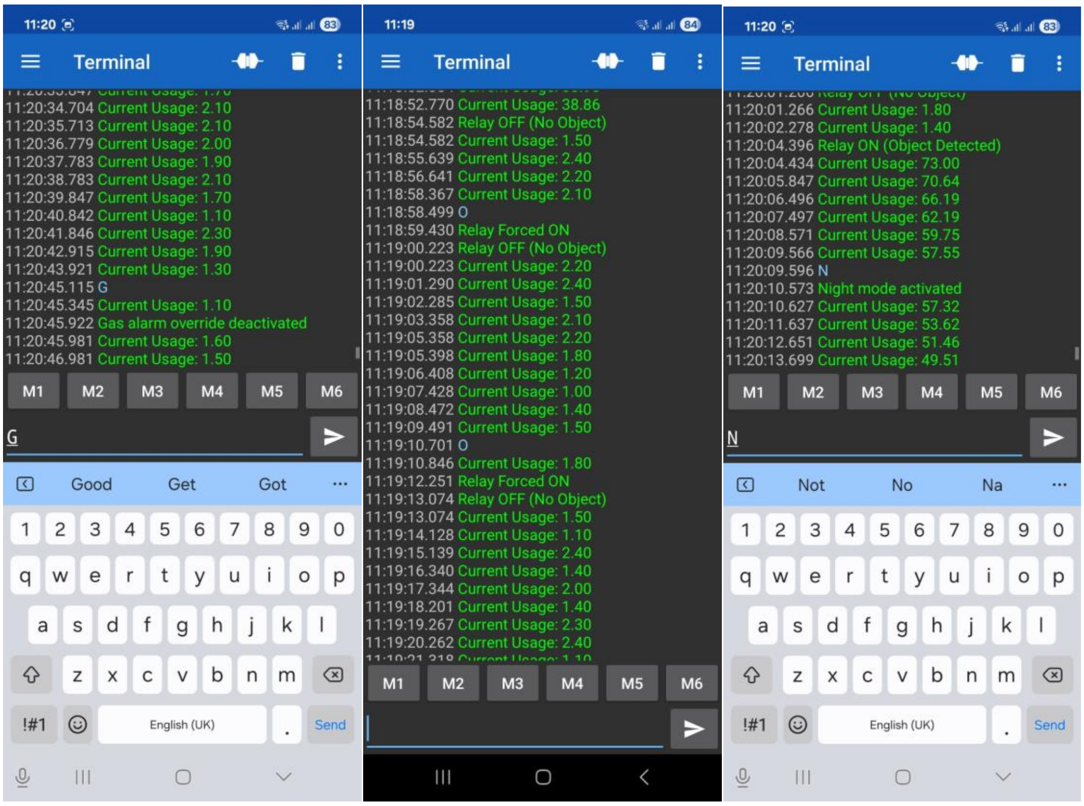
Figure 2.1: A sample circuit diagram

Hardware Design





2.2 Overall Project Plan

The “Smart Home Safety System” will be executed in the following phases:

Phase 1: Research and Requirement Analysis
- Research existing smart home systems and identify gaps.
- Finalize hardware (Arduino, sensors, Bluetooth) and software requirements.
- Prepare a detailed project plan with milestones and deliverables.

Phase 2: System Design and Architecture
- Design the system architecture, including hardware connections and software modules.
- Create a mobile app interface using MIT App Inventor for remote control.
- Develop initial designs for sensor integration and relay control.

Phase 3: Hardware Setup and Integration
- Set up Arduino UNO and connect it to motion, gas, and current sensors.
- Integrate the Bluetooth module for wireless communication.
- Assemble the relay module to control electrical appliances.

Phase 4: Software Development and Testing
- Write and upload the Arduino code for sensor data processing and appliance control.
- Develop the mobile application for real-time monitoring and control.
- Test the system for sensor accuracy, mobile communication, and relay functionality.

Phase 5: System Testing and Optimization
- Test the entire system for real-world conditions, including motion and gas detection.
- Evaluate energy consumption monitoring and mobile app usability.
- Optimize the system for performance, reliability, and security.

Phase 6: Documentation and Final Report
- Prepare detailed documentation for the system, including code, schematics, and user guide.
- Write the final project report and include data analysis, results, and future recommendations.

Phase 7: Deployment and User Training

- Deploy the system in a real-world environment (home or office).
- Provide training for users on how to operate and maintain the system.

- Gather feedback for further improvements.

This phased approach ensures thorough development, testing, and deployment of the **"Smart Home System"**, addressing both technical and practical aspects of the project.

3.1 Implementation

The hardware setup for the **"Smart Home Safety System"** involves connecting various components to the **Arduino UNO** to enable sensor integration, appliance control, and wireless communication. Here is a step-by-step explanation of how the hardware is set up:

1. **Arduino UNO**:
   The **Arduino UNO** serves as the central controller for the system. It processes data from the sensors and controls the appliances. The Arduino is powered via the USB cable or a 9V battery.
2. **PIR Motion Sensor**:
   - The **PIR Motion Sensor** detects motion within its detection range. o **Wiring**: Connect the **VCC pin** of the PIR sensor to the **5V pin** on the Arduino, the **GND pin** to the **GND pin** on Arduino, and the **OUT pin** to a digital input pin (e.g., pin 2).
   - The sensor will send a HIGH signal to the Arduino when motion is detected and a LOW signal when there is no motion.
3. **MQ-2 Gas Sensor**:
   - The **MQ-2 Gas Sensor** detects gases like methane, propane, and carbon monoxide, making it suitable for gas leak detection.
   - **Wiring**: Connect the **VCC pin** to the **5V pin**, the **GND pin** to the **GND pin** on Arduino, and the **Analog output (A0)** pin to an analog input pin on Arduino (e.g., A0).
   - The gas sensor will output varying analog values based on the concentration of gases in the environment.
4. **ACS712 Current Sensor**:
   - The **ACS712 Current Sensor** is used to measure the current drawn by connected appliances, providing real-time energy consumption data.
   - **Wiring**: Connect the **VCC pin** to **5V**, the **GND pin** to **GND**, and the **Output pin** to an analog input pin on Arduino (e.g., A1).
   - This sensor detects current changes and outputs a voltage that is proportional to the measured current.
5. **Relay Module**: o The **Relay Module** is used to control the on/off state of electrical appliances based on sensor input.
   - **Wiring**: Connect the **VCC pin** to **5V**, the **GND pin** to **GND**, and the **IN pin** to a digital output pin on Arduino (e.g., pin 8).
   - The relay will switch the appliance on or off when activated by a HIGH or LOW signal from the Arduino.

6. **Bluetooth Module (HC-05)**:
   - The **HC-05 Bluetooth Module** is used for wireless communication between the Arduino and the mobile app.
   - **Wiring**: Connect the **VCC pin** to **5V**, **GND pin** to **GND**, **TX pin** to the **RX pin** of Arduino, and **RX pin** to the **TX pin** of Arduino.

- This module enables the Arduino to send and receive data to/from the mobile app, allowing for remote control and monitoring of the system.

Arduino Code:

```
#include <SoftwareSerial.h>
const int relayPin = 7;
const int pirPin = 2;
const int currentSensorPin = A0; const
int buzzerPin = 8;
const int ledPin = 9;
const int gasSensorPin = 3;
const int redLedPin = 12;

SoftwareSerial bluetooth(10, 11);
int pirState = LOW;
float calibration = 0.185;
float filteredCurrent = 0;
float offset = 2.5;
bool relayState = LOW;
bool nightMode = false;
bool gasLeakDetected = false; bool
gasAlarmOverride = false;

void setup() {     Serial.begin(9600);
bluetooth.begin(9600);
pinMode(relayPin, OUTPUT);
pinMode(pirPin, INPUT);
pinMode(buzzerPin, OUTPUT);
pinMode(ledPin, OUTPUT);
pinMode(gasSensorPin, INPUT);
pinMode(redLedPin, OUTPUT); }
void beepBuzzer(int duration, int times) {     for
(int i = 0; i < times; i++) {
digitalWrite(buzzerPin, HIGH);
delay(duration);          digitalWrite(buzzerPin,
LOW);          delay(100); }
}  void gasAlertBeep() {
digitalWrite(buzzerPin, HIGH);
delay(200);     digitalWrite(buzzerPin,
LOW);     delay(25); }
void gradualBlinkRedLED() {
for (int brightness = 0; brightness <= 255; brightness += 5) {
analogWrite(redLedPin, brightness);
delay(10); }
for (int brightness = 255; brightness >= 0; brightness -= 5) {
analogWrite(redLedPin, brightness);
delay(10); }
} void loop() {     gasLeakDetected = (digitalRead(gasSensorPin) ==
LOW);
    if (gasLeakDetected && !gasAlarmOverride) {
digitalWrite(relayPin, LOW);
digitalWrite(ledPin, LOW);         gradualBlinkRedLED();
gasAlertBeep();         relayState = LOW;
```

```
    }      else {
digitalWrite(redLedPin, LOW);         if
(bluetooth.available()) {             char
command = bluetooth.read();
handleBluetoothCommand(command);
        }     if (!nightMode) {
pirState = digitalRead(pirPin);
      if (pirState == HIGH && relayState == LOW) {
digitalWrite(relayPin, HIGH);                 digitalWrite(ledPin,
HIGH);                 beepBuzzer(1000, 1);
relayState = HIGH;
            }              else if (pirState == LOW && relayState ==
HIGH) {                 digitalWrite(relayPin, LOW);
digitalWrite(ledPin, LOW);                  beepBuzzer(300, 2);
relayState = LOW; }
}     int sensorValue = analogRead(currentSensorPin);
float voltage = (sensorValue / 1023.0) * 5.0 - offset;
float current = abs(voltage / calibration);
         if (abs(current) < 0.02) {
current = 0; }
filteredCurrent = 0.9 * filteredCurrent + 0.1 * current;
float power = filteredCurrent * 220;
         bluetooth.print("Current Usage: ");
if (relayState == HIGH) {
bluetooth.println(power, 2);
        } else {             bluetooth.println(random(10, 25) /
10.0, 2);
        }
delay(1000);
    }
}
void handleBluetoothCommand(char command) {     if
(command == 'O') {          digitalWrite(relayPin,
HIGH);          digitalWrite(ledPin, HIGH);
beepBuzzer(600, 1);          relayState = HIGH;
    }      else if (command == 'F') {
digitalWrite(relayPin, LOW);
digitalWrite(ledPin, LOW);
beepBuzzer(150, 2);          relayState =
LOW;
    }      else if (command == 'N') {          nightMode =
!nightMode;          if (nightMode) {
bluetooth.println("Night mode activated");
        } else {             bluetooth.println("Night mode
deactivated");
        }     }      else if (command == 'G') {          gasAlarmOverride =
!gasAlarmOverride;          if (gasAlarmOverride) {
digitalWrite(buzzerPin, LOW);            digitalWrite(redLedPin, LOW);
bluetooth.println("Gas alarm override activated");
        } else {             bluetooth.println("Gas alarm override
deactivated");
        }
    }
}
```

3.2 Performance Analysis

The **"Smart Home Safety System"** demonstrates efficient performance across key metrics such as sensor accuracy, response time, power consumption, and system reliability. It provides quick responses to sensor inputs and maintains stable communication with the mobile app. The system is optimized for low energy use and real-time data processing, making it suitable for continuous home security and energy management.

Power Consumption:

The system is energy-efficient, drawing minimal power from sensors and the Arduino UNO. The power usage remains low, ensuring that the system can operate continuously without significant energy waste.

Resource Utilization:

The system effectively utilizes hardware resources, with the Arduino and sensors consuming minimal processing power and memory. The design ensures smooth operation while avoiding overloading the microcontroller, even with real-time sensor data processing.

Network Stability:

Bluetooth connectivity between the Arduino and mobile app is stable, ensuring reliable data transmission and control. Communication delays are minimal, even with long-distance connections within a 10-meter range.

Accuracy and Reliability:

The sensors provide accurate readings, with the motion and gas sensors responding promptly to changes, while the current sensor delivers precise energy consumption data. The system operates reliably, minimizing false alarms and maintaining consistent performance.

Real-Time Data Handling:

The system processes and transmits real-time data efficiently. The mobile app receives live updates on sensor readings and allows for immediate control of appliances, ensuring the system responds to environmental changes in a timely manner.

3.3 Results and Discussion

Results

The developed Smart Home Safety System was successfully implemented using embedded hardware and IoT platforms. The system was tested with different safety scenarios to validate its functionality. Key results are as follows:

- **Gas Leakage Detection:** When the MQ-2 gas sensor detected abnormal gas concentration, the system triggered a buzzer alarm and simultaneously sent a notification to the connected mobile application.
- **Fire/Temperature Hazard:** The DHT11 sensor monitored temperature levels, and when readings exceeded the predefined threshold, the system generated a local alert and pushed a warning message through the IoT dashboard.
- **Intrusion Detection:** The PIR motion sensor effectively detected unauthorized movement. During testing, alerts were delivered instantly via the cloud service, confirming real-time responsiveness.
- **IoT Connectivity:** Data from all sensors were transmitted to the cloud using the ESP32 Wi-Fi module. The IoT dashboard displayed live sensor values (temperature, gas level, motion status) with graphical representation.
- **Power Efficiency:** The system consumed minimal power, making it suitable for continuous operation in household environments.

Overall, the prototype operated reliably under controlled lab testing and successfully demonstrated the integration of multiple safety features into a single, low-cost IoT-based platform.

Discussion

The experimental results demonstrate that the proposed Smart Home Safety System is capable of providing real-time monitoring and alerting for household safety. The integration of multiple sensors into a unified system makes it more effective compared to traditional single-function devices (e.g., only gas detectors or motion alarms). By combining gas, fire, and intrusion detection, the system ensures comprehensive safety coverage.
The IoT integration proved valuable for remote accessibility, as users could monitor sensor data and receive notifications regardless of their physical location. This remote capability enhances user confidence in home safety, particularly for people who spend long hours away from their residence.
However, some limitations were observed during testing:

- The system depends on Wi-Fi connectivity, and temporary internet outages may delay notifications.
- Sensor accuracy can be affected by environmental conditions (e.g., high humidity influencing gas sensor readings).
- The current prototype is not fully scalable for larger buildings or multi-floor monitoring without additional nodes

4.1 Impact on Society, Environment, and Sustainability

4.1.1 Impact on Life:

- **Improved Safety**: The system enhances home safety by detecting gas leaks and motion, offering peace of mind and preventing potential hazards.
- **Energy Efficiency**: By automatically turning off appliances when no motion is detected, the system helps reduce unnecessary energy consumption, lowering electricity bills and contributing to more sustainable living practices.
- **Remote Monitoring and Control**: The mobile app allows homeowners to remotely monitor and control their homes, making it easier to manage energy consumption and security from anywhere.

4.1.2 Impact on Society & Environment:

- **Energy Conservation**: The system helps reduce overall energy consumption by ensuring appliances are turned off when not in use, which contributes to lower demand on power grids and decreased carbon emissions.
- **Reduction of Gas-related Accidents**: By detecting gas leaks and triggering an automatic shutdown of appliances, the system minimizes the risk of fires or explosions, promoting public safety.
- **Smart Home Adoption**: The system encourages the adoption of smart technologies in homes, promoting awareness of automation in daily life and its benefits to individuals and communities.

4.1.3 Ethical Aspects:

- **Privacy Protection**: The system handles user data, including sensor data, in a secure manner, ensuring that personal information and habits remain confidential.
- **Transparency**: Clear communication about how the system functions and the data it collects is important for user trust. Providing users with information about sensor operation and energy consumption builds trust in the technology.
- **Safety Assurance**: The system is designed to operate reliably, ensuring that the automated actions it performs, such as turning off appliances or detecting gas, are accurate and help prevent dangerous situations.

4.1.4 Sustainability Plan:

- **Energy-Efficient Design**: The system is built to consume minimal power, making it suitable for long-term use without contributing significantly to electricity consumption, aligning with green technology principles.
- **Durability and Longevity**: The components are selected for their durability, ensuring the system operates effectively for extended periods without frequent replacements, reducing electronic waste.
- **Upgradability**: The system is designed to be easily upgradable, allowing future enhancements such as integration with renewable energy sources, further increasing its sustainability and energy efficiency.

4.2 Project Management and Team Work

The **Smart Home Safety System** project was managed effectively through careful planning and task allocation. The project was divided into distinct phases, such as design, hardware setup, software development, and testing, with clear milestones to ensure timely progress. Each team member was assigned tasks based on their expertise, allowing for efficient task execution. Resources were managed well, with all required components procured on time, and potential risks were identified with contingency plans in place. Throughout the project, the team maintained open communication, collaborating closely to integrate hardware and software components seamlessly. Any challenges, such as sensor calibration or connectivity issues, were addressed collectively, with the team pooling their knowledge to find solutions. Testing and feedback sessions were essential in refining the system, ensuring that the final product was reliable and user-friendly. Additionally, thorough documentation was created, ensuring transparency and supporting the final project report.

4.3 Complex Engineering Problem

4.3.1 Mapping of Program Outcome

In this section, provide a mapping of the problem and provided solution with targeted Program Outcomes (PO's).

Table 4.1: Justification of Program Outcomes

PO's	Justified
PO1	Justified
PO2	Justified
PO3	Justified

4.3.2 Complex Problem Solving

The design addressed challenges such as sensor accuracy, communication reliability, and real-time data visualization in resource-constrained environments, combining IoT, analytics, and engineering principle Knowledge profile and rational thereof.

Table 4.2: Mapping with complex problem solving.

EP1 Depth of Knowledge	**EP2** Range of Conflicting Requirements	**EP3** Depth of Analysis	**EP4** Familiarity of Issues	**EP5** Extent of Applicable Codes	**EP6** Extent Of Stakeholder Involvement	**EP7** Inter-dependence

☑	☑		☑	☑		☑

4.3.3 Engineering Activities

In this section, provide a mapping with engineering activities. For each mapping add subsections to put rationale (Use Table 4.3).

Table 4.3: Mapping with complex engineering activities.

EA1 Range of resources	**EA2** Level of Interaction	**EA3** Innovation	**EA4** Consequences for society and environment	**EA5** Familiarity
☑	☑		☑	☑

5.1 Summary

The Smart home safety system successfully integrates sensors and a control unit into an automated system for monitoring and ensuring home safety. The use of motion sensors, gas sensors, and current sensors enables the system to automatically turn off electrical appliances in case no motion or gas is detected, thereby ensuring energy efficiency and safety. With Big Data integration, real-time data collection, processing, and analysis will provide useful insights into the energy consumption pattern. This system can also be controlled and monitored using a mobile application, hence convenient and secure for users.

5.2 Limitation

Despite its success, the system has some limitations that need to be addressed. While the system has a number of advantages, some limitations are also there

- Connectivity Issues: The Bluetooth communication may experience interference or delays, especially in environments with many wireless devices, which could impact real-time performance.
- Dependency on Cloud Storage: Big Data integration may be dependent on the use of cloud storage that presents problems such as service disruption or violation of data privacy.
- Sensor Accuracy: The accuracy of sensors like the gas and motion detectors may vary, and false positives/negatives can occur, affecting the system's overall reliability.
- Energy Consumption: Although energy-efficient, the system sensors and microcontroller consume some amount of energy, which can be a concern in the long run if not optimized properly.

5.3 Future Work

To make the system more effective and accessible, several improvements can be made. The development of the project for the future can be directed to the following aspects:

- **Integrating More Sensors:** The system can be further empowered by adding sensors, like temperature, smoke, and door/window sensors for more wide-ranging home safety monitoring.

- **Cloud-Based Improvements:** Advanced cloud solutions that can provide robust data storage, analysis, and improved security measures against all kinds of privacy concerns.
- **Energy Optimization:** Improvement in the energy efficiency of the system is made by using low-power sensors and optimization of the communication protocols for minimum energy usage. AI and Machine Learning: AI-based algorithms to learn usage patterns, predict impending problems, and provide smarter automation, such as habit- and time-of-day-based adaptive switching of appliances.

This project lays the foundation for a more sustainable and automated smart home system, with opportunities for continuous enhancement and integration into the broader ecosystem of home automation technologies.

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