Smart Disaster Management System using STM32F401

Project Name: Smart Disaster Management System using STM32F401

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1. Abstract

The Smart Disaster Management System using STM32F401 is an integrated solution designed to detect and manage various types of hazards such as gas leaks, fires, and earthquakes in real-time. By utilizing a combination of sensors (MQ-2 gas sensor, flame sensor, and MPU6050 vibration sensor), the system enables comprehensive monitoring of different hazards, providing quick and reliable detection of potential disasters. This system employs the STM32F401 microcontroller as the central processing unit, while incorporating Bluetooth technology (via HC-05) to send real-time alerts to remote devices such as smartphones and PCs.

The core idea behind the project is to enhance public safety by detecting multiple hazards simultaneously, providing both local alerts through buzzers and LEDs, and remote alerts through Bluetooth. This report discusses the design, hardware setup, software implementation, and the results of testing the system in simulated disaster scenarios.

2. Introduction

Natural disasters such as fires, gas leaks, and earthquakes pose serious threats to human life and property. While many systems exist to detect these hazards, most traditional systems are designed to detect a single type of hazard, leaving people vulnerable when multiple hazards occur simultaneously. This limitation has driven the need for a more robust, integrated solution that can detect multiple hazards simultaneously and alert people in real-time.

This report details the development of the Smart Disaster Management System, a multi-hazard detection system based on the STM32F401 microcontroller. The system integrates sensors to detect gas leaks (via the MQ-2 sensor), flames (via a flame sensor), and earthquakes (via the MPU6050 vibration sensor). By combining these sensors, the system provides timely alerts to users through local and remote channels, enhancing safety and response times.

3. Problem Statement

Natural disasters, such as fires, gas leaks, and earthquakes, pose significant risks to life and property. Existing safety systems are usually designed to detect only one type of hazard, often leading to delayed responses in emergencies. The need for an integrated disaster management system that can simultaneously detect multiple hazards and provide real-time alerts is critical. This project addresses the need for a multi-hazard detection system capable of identifying gas leaks, fires, and earthquakes, ultimately reducing the response time and enhancing safety.

4. Motivation for Choosing This Project

The motivation behind this project arises from the limitations of existing single-purpose alarm systems. Many conventional safety systems can only detect one type of hazard, such as gas leaks or fire. However, there is no unified system capable of detecting multiple hazards at the same time. By developing this multi-hazard detection system, we aim to provide an efficient solution to ensure safety across a variety of disaster scenarios. Our system integrates multiple sensors, such as a gas sensor, flame sensor, and vibration sensor, allowing for comprehensive monitoring.

5.System Design

The system is designed to continuously monitor multiple hazards: gas leaks, fire, and earthquakes. The architecture is divided into three key components:

- **Sensor Unit**: This includes the MQ-2 gas sensor for gas leak detection, the flame sensor for detecting fire, and the MPU6050 vibration sensor for detecting earthquake-induced vibrations. These sensors feed data to the STM32F401 microcontroller.
- **Microcontroller (STM32F401)**: The STM32F401 microcontroller is the heart of the system, responsible for processing data from all sensors, comparing it to predefined thresholds, and triggering alerts when necessary.
- **Alert Mechanisms**: The system includes both **local alerts** (via buzzer and LEDs) and **remote alerts** (via Bluetooth communication with a smartphone or PC). The local alerts are triggered when a hazard is detected, while Bluetooth is used to send real-time notifications to remote devices.

6. Hardware Components

The hardware components used in this project are as follows:

- **STM32F401 Black Pill:** The central microcontroller that controls the entire system, processing inputs from all sensors and managing alerts.
- **MQ-2 Gas Sensor**: A sensor for detecting various gases, particularly methane, propane, and smoke, used to identify gas leaks.
- **Flame Sensor:** A digital sensor that detects the presence of fire by measuring infrared radiation.
- **MPU6050:** A vibration sensor that detects vibrations or shocks, used for earthquake detection.
- **HC-05 Bluetooth Module:** A Bluetooth communication module that transmits alerts to mobile phones or PCs.
- **Buzzer and LEDs:** Local alerting mechanisms for immediate visual and auditory feedback when a hazard is detected.

7. Implementation

The implementation of the Smart Disaster Management System involves the following steps:

1. **Sensor Data Acquisition:** The system continuously reads data from the gas, flame, and vibration sensors using the STM32F401 microcontroller.
2. **Normal Operation:** When the sensor values are within safe limits, the system operates normally without triggering any alarms.
3. **Hazard Detection:** If any sensor value exceeds a predefined threshold (for gas) or if an interrupt is triggered (e.g., from the flame sensor or MPU6050), the system recognizes a hazard.
4. **Alert Activation:** Upon detection of a hazard, the system activates local alerts through the buzzer and LEDs. It also sends a Bluetooth message to the connected mobile device or PC, informing the user of the hazard.

This system integrates multiple types of sensors to ensure a timely response to various hazards, enhancing overall safety.

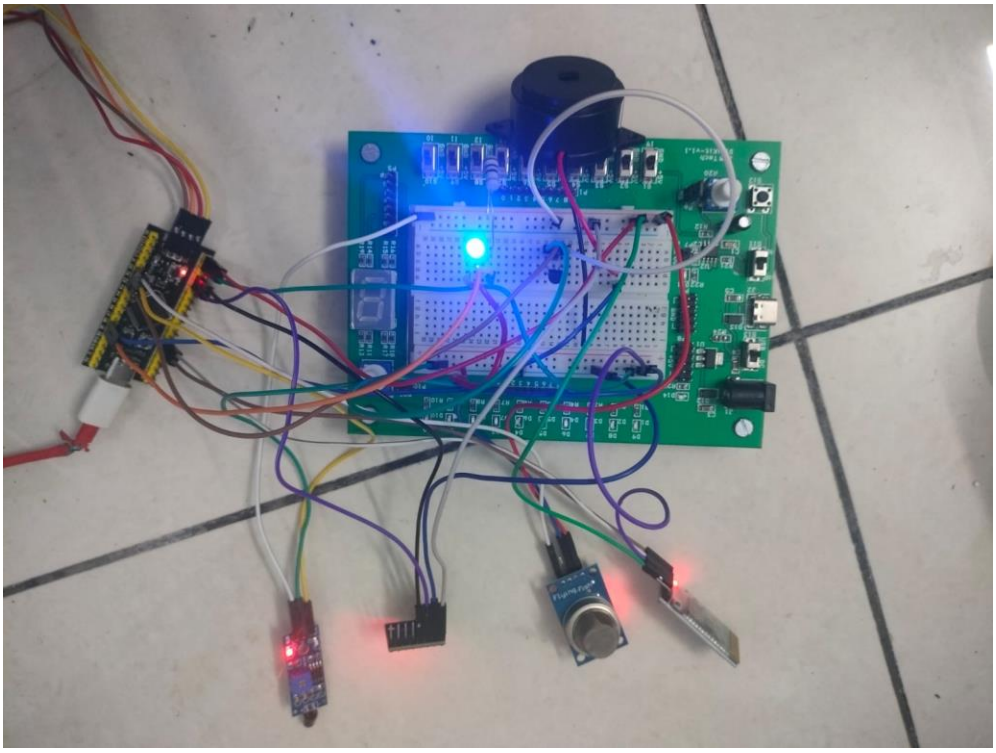
8. System Integration

System integration involved connecting the hardware components together and ensuring they work seamlessly with the software. The STM32F401 microcontroller interacts with all the sensors, processes the sensor data, and triggers alerts. Key steps in system integration include:

- Ensuring proper communication between the microcontroller and sensors (I^2C, ADC, GPIO).
- Programming the microcontroller to handle data from multiple sensors and trigger alerts based on hazard detection logic.
- Integrating the Bluetooth module for remote communication and real-time alerts.
- Testing the system to ensure accurate detection of gas, fire, and earthquake events, with proper feedback (local and remote).

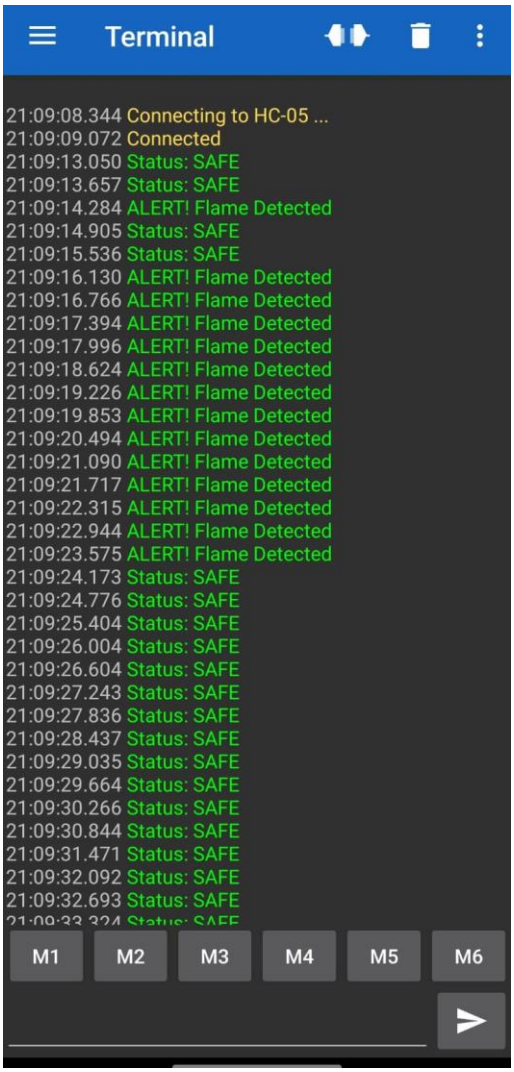
9. Prototype

The prototype of the system was built using the components listed in the hardware section. The sensors are connected to the STM32F401 Black Pill, which processes the input signals, evaluates them, and takes the necessary actions based on predefined conditions. The Bluetooth module (HC-05) enables communication with external devices, allowing real-time alerts to be sent to a smartphone or PC.



10. Bluetooth Module Output

The HC-05 Bluetooth module plays a crucial role in sending hazard alerts to mobile or PC. When a hazard is detected, the STM32F401 communicates with the HC-05 module to transmit a message containing the hazard type (e.g., 'ALERT! Flame Detected' or 'Gas Detected' or ‘Earthquake Detected’) and the corresponding sensor values (e.g., gas concentration or flame detection status or movement value). This allows users to remotely monitor the system and take necessary action.



11.Conclusion

The Smart Disaster Management System offers a comprehensive solution for real-time hazard detection, enabling faster responses to potential disasters. By integrating multiple sensors and Bluetooth communication, the system ensures that users are notified promptly, minimizing the risk of damage or loss of life. The project highlights the importance of having a multi-hazard detection system in place to ensure safety in both residential and industrial environments.

12.References

13. STM32F401 Reference Manual
14. MQ-2 Gas Sensor Datasheet
15. MPU6050 Accelerometer and Gyroscope Datasheet
16. HC-05 Bluetooth Module Datasheet
17. STM32CubeIDE Documentation