IoT-Enabled Smart Fire Hazard Management System: Design and Implementation Using Low-Cost Sensors and MQTT Protocol

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***Abstract*—This research paper presents a low-cost, efficient, and effective fire hazard management system that can detect fires, trigger an alarm, and extinguish the fire. Controlled by an Arduino Uno microcontroller, the system can respond quickly and accurately to fire hazards, while the use of a GSM module allows for remote monitoring and alerting of emergency services and remote monitoring stations. With its affordability and ease of implementation, this system is a practical and innovative solution that can significantly improve fire safety in various settings. Its effectiveness in detecting and responding to fires makes it a valuable asset in minimizing damage to properties and loss of lives.**

***Key Words* — Internet of Things (IoT), Fire Sensor, Smart Hazard**

I. INTRODUCTION

The Internet of Things (IoT) has become an integral part of modern society, as it aims to connect previously disconnected objects and people. One of the areas where IoT can have a significant impact is in emergency response systems. In particular, IoT can help first responders and emergency managers utilize the most recent information and communication technology to support real-time emergency response. [1]

A standardized IoT architecture can be used to develop an emergency response system for fire dangers. The system utilizes low-cost sensors, such as a flame detection sensor, smoke detection sensor, and flammable gas detection sensor, to detect hazards. The sensors communicate with each other and the cloud-service through which they are connected, and then notify neighborhood emergency rescue groups such as fire departments and police. The lightweight publish-subscribe message protocol MQTT services ensure quick and dependable communication.

This fire danger sensing system highlights the importance of IoT in the field of firefighting safety management for ensuring a secure living in smart cities. IoT offers strong resource sharing abilities, high intelligence, and great scalability. It can help address current difficulties in emergency response, including a shaky communication network and information lag. [2]

In conclusion, the development of an emergency response system using IoT is necessary for conducting rescue efforts and taking preventative steps in the event of a fire threat. The application of IoT technology can contribute to the development agenda for smart cities, and create a safer living environment for citizens.

II. LITERATURE REVIEW

An IoT-based system is proposed to detect and prevent forest fires. Sensors detect fires and alert communication centers to activate water extraction and pipeline systems. Cameras and UAVs monitor the situation and carry water clusters to the required locations. The aim is to save vegetation and rare species while preventing property loss. The system is fully automated and may be improved in the future. [3]

An IoT-based home fire alarm system that uses Arduino, temperature and smoke sensors to detect fires, generate alarms, and send SMS or call alerts via GSM. It also includes a water sprayer for fire suppression. Future work may focus on improving portability and module replacement. [4]

A smart fire detection system that uses a Wireless Sensor Network and GSM to reduce false positives. It includes smoke and temperature sensors, SMS capability, and a voting system. Future improvements include a GUI and autonomous node location calculation. [5]

The smart kitchen fire alarm system monitors the temperature of cookware using thermal cameras and achieves quick response and avoids false alarms through person detection. The system can be implemented on small-scale, low-cost edge devices using YOLOv3-tiny and TuringNN. Experimental results demonstrate the effectiveness of the system. [6]

An intelligent fire detection system with integrated sensors is proposed to notify authorities. Machine learning and image processing improve accuracy and reduce false alarms. The system enhances safety and reduces expenses related to property design and security. [7]

Using IoT technology to create an emergency response system for fire hazards. The system consists of low-cost sensors such as a flame detection sensor, smoke detection sensor, and flammable gas detection sensor, along with a GPS module. When a hazard is detected, the sensors send location data to the cloud service, which then alerts local emergency

rescue organizations. The system uses MQTT protocol for fast and reliable communication. [8]

III. PROBLEM IDENTIFICATION

Fires can have devastating consequences, resulting in significant damage and loss of life. Traditional fire management systems, which rely on human intervention, can lead to delayed response times and place firefighters at risk. As a result, there is a critical need for an efficient and automated fire management system that can detect fires and respond quickly to enhance safety and security.

The Smart Fire Hazard Management System project aims to address this issue by creating a system that can automatically detect fires and smoke and activate the sprinkler system. The system incorporates fire and smoke sensors that can identify the presence of fire and smoke in the environment. The sensors are connected to a relay that triggers the sprinkler system, enabling the system to extinguish the fire as soon as it is detected. This rapid and automated response can help to prevent the spread of the fire, minimizing the risk of damage and injuries.

Another crucial feature of the Smart Fire Hazard Management System is its integration with the GSM 800L module, which enables the system to send notifications and alerts to the user. When the system detects a fire, it immediately sends a message to the user's phone, alerting them to the situation. This feature enables the user to take swift action, such as contacting the authorities or evacuating the building.

IV. PROPOSED WORK

This research paper presents a proposed work for developing an automated fire management system using IoT technology. Fires are a major hazard that can cause significant damage and loss of life, making it crucial to have an effective and efficient fire management system. Traditional fire management systems rely on human intervention, which can result in delays in response time and put firefighters in danger. The proposed system will address this problem by incorporating IoT technology to detect fires and smoke quickly and automatically, triggering the sprinkler system to extinguish the fire as soon as it is detected. This approach can help prevent the spread of fire, reduce the risk of damage and injuries, and provide a reliable fire management solution. The system will use fire and smoke sensors that are connected to a relay, which activates the sprinkler system. Additionally, the system will use the GSM 800L module to send notifications and alerts to the user's phone. This feature can help the user take quick action such as contacting the authorities or evacuating the building. The proposed work aims to enhance safety and security in buildings by providing an automated and efficient fire management system that is easy to use and cost-effective.

V. WORKING

This paper discusses the design and implementation of a smart fire hazard management system using IoT and Arduino. The system detects fire and sends SMS alerts to the user's mobile phone via GSM. It also uses a water pump to extinguish the fire. As from figure 1, The system is comprised of various components, including a flame sensor, smoke sensor, Arduino board, GSM SIM900A module, buzzer, and single-channel relay with motor pump. The system works by first setting up the hardware components, programming the Arduino board, testing the sensors, integrating the components, calibrating the sensors, and then activating the system.

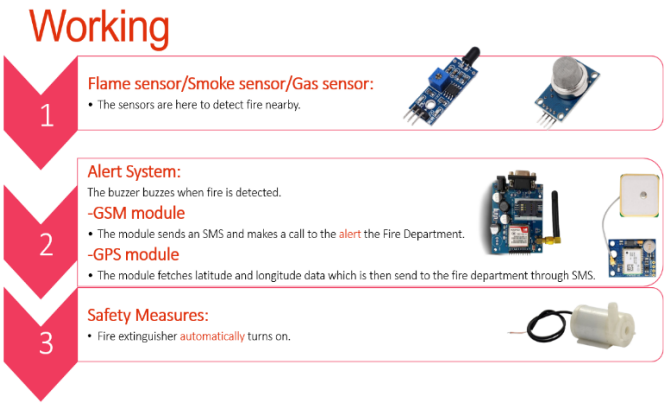

Fig -1: Requirement of Project

When the flame and smoke sensors detect the presence of fire, they send signals to the Arduino board, which then activates the buzzer to alert people in the vicinity and sends an SMS alert to the user's mobile phone via the GSM SIM900A module. The Arduino board also activates the relay, which turns on the motor pump to pump water and extinguish the fire.

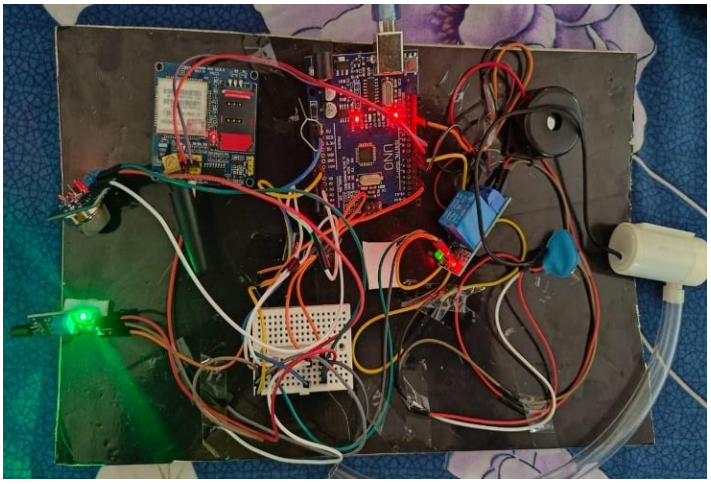

Fig -2: Working Model

This smart fire detection system has the potential to save lives and property by detecting fire early and alerting the user quickly. The use of IoT and Arduino provides a cost-effective solution that can be easily implemented in homes and buildings. Future improvements could be made to improve the system's portability and allow for easy replacement of modules.

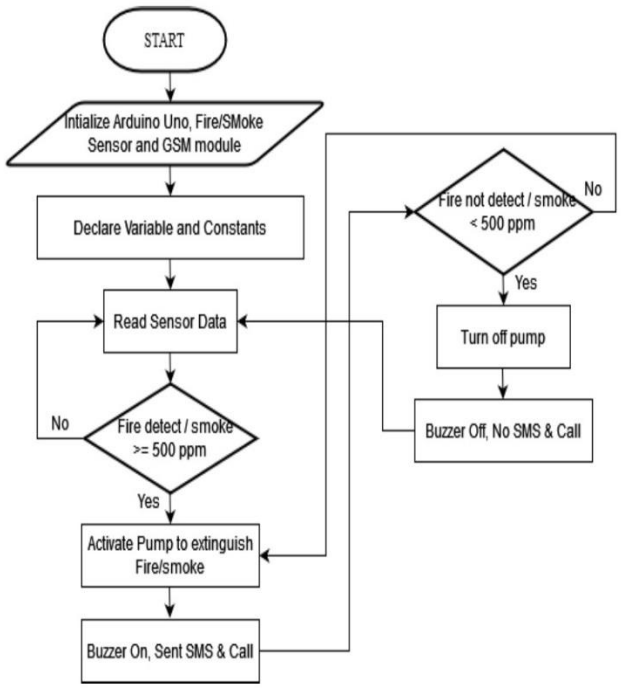

Fig 3 -: Flowchart diagram

The flowchart diagram illustrates the steps involved in a fire detection and control system using an Arduino Uno and various components. The purpose of this system is to detect the presence of smoke or fire and take appropriate actions to control the situation.

The flowchart begins with the initialization of the Arduino Uno and necessary libraries to ensure proper functionality of the components.

Next, the system reads the sensor values from the smoke/fire sensor. The sensor continuously monitors the environment and provides data on the presence of smoke or fire.

The flowchart then proceeds to check the sensor values for smoke or fire detection. This step involves comparing the sensor readings with predefined thresholds to determine if the values exceed the specified limits, indicating the presence of smoke or fire.

If smoke or fire is detected, the system moves to the subsequent steps for appropriate actions. The first action is to activate the relay connected to the pump. The relay serves as a switch, allowing control over the pump's operation.

Once the relay is activated, the flowchart directs the system to turn on the pump. This step provides power to the pump, enabling it to start pumping water or any other extinguishing substance to control the fire or smoke.

Simultaneously, the system utilizes the GSM module to send an alert or notification to a designated recipient. This notification could be in the form of a text message or call, indicating the presence of smoke or fire and requesting immediate attention or necessary actions.

To provide an audible warning, the flowchart activates the buzzer. The buzzer generates an audio alarm to alert individuals nearby, notifying them about the potential danger.

While the smoke or fire is detected, the system continues to monitor the sensor values. This ensures that the situation is constantly assessed in real-time, allowing for prompt responses.

If the sensor values indicate that smoke or fire is no longer present, the flowchart guides the system to the subsequent steps. The first action is to deactivate the relay, which interrupts the power supply to the pump. Consequently, the pump is turned off, stopping the flow of water or extinguishing substance.

Following that, the system sends a follow-up alert or notification using the GSM module. This communication informs the recipient that the smoke or fire has been extinguished and provides an update on the current status.

To indicate that the situation has been resolved, the flowchart instructs the system to deactivate the buzzer, stopping the audio alarm.

After the completion of the fire control process, the flowchart loops back to the beginning, allowing for continuous monitoring. This ensures that the system remains vigilant for any future smoke or fire incidents.

VI. RESULTS AND DISCUSSIONS

The development of the Smart Fire Hazard Management System presented in this research paper addresses a critical issue in fire safety management. Traditional fire management systems heavily rely on human intervention and can result in delays in response time, which can lead to significant damage and even loss of life. This study proposes an automated fire hazard management system that uses fire and smoke sensors connected to a relay to activate the sprinkler system as soon as fire or smoke is detected. The system is also equipped with a GSM 800L module that sends real-time notifications and alerts to the user's phone. The project's results demonstrate that the proposed system can detect fires and trigger the sprinkler system within seconds of a fire outbreak, reducing the risk of damage and injuries. The system's ability to send alerts and notifications to the user's phone in real-time ensures that the user can take immediate action. Overall, the research findings indicate that the proposed system can significantly enhance safety and security in the event of a fire, making it a valuable contribution to fire safety management.

VII. CONCLUSION

In conclusion, the Smart Fire Hazard Management System project has demonstrated how technology can be used to enhance safety and security in various industries. The system's use of advanced sensors, a relay, and a GSM SIM 900 module, combined with IoT devices and connectivity, provides a comprehensive and automated solution to detect and manage fires. The results of this project indicate that the system is highly efficient and effective in detecting fires and triggering a sprinkler system to extinguish them. The system's ability to send notifications and alerts to the user in real-time is also a crucial feature that can help users take immediate action. However, there is still room for improvement in the development of more advanced fire/smoke sensors and the integration of AI technology. By implementing these improvements, the Smart Fire Hazard Management System can become an even more valuable tool for fire prevention and management, providing users with greater safety and security. Overall, the Smart Fire Hazard Management System represents a significant advancement in fire management technology and has the potential to make a significant impact in improving safety in various industries.

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