IOT-BASED SMART FIRE DETECTION AND AUTOMATIC SUPPRESSION SYSTEM FOR AGRICULTURAL FIELDS

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ABSTRACT
Uncontrolled fire incidents in agricultural fields present a serious threat to human life, livestock, crops, and property, particularly in rural regions where monitoring systems are limited and response times are often delayed. Conventional fire management practices rely on manual observation, which is inefficient in large or remote agricultural areas and may result in late detection of fire hazards. This work presents the design and development of an IoT-based smart fire detection and automatic suppression system tailored for agricultural fields. The system integrates flame and temperature sensors for fire detection along with motion and object detection sensors to identify the presence of humans or animals. When a hazardous condition is detected, the system generates an immediate alert through an alarm and activates a water sprinkler mechanism to control the fire. In addition, IoT-based communication enables remote monitoring and timely notification to the farmer. The proposed system is implemented using a low-cost microcontroller platform and open-source software tools, making it suitable for small and marginal farmers. The approach emphasizes early detection, automated response, and improved safety.

Keywords: *IoT, Fire Detection, Smart Agriculture, Automatic Suppression, Embedded Systems, Agricultural Safety*

INTRODUCTION

Agriculture remains a key contributor to economic development and food security, especially in countries where a large portion of the population depends on farming activities. In many agricultural practices, controlled field burning is used for clearing crop residues, preparing land, and managing pests. Although this method is widely practiced due to its simplicity and low operational cost, it introduces significant safety risks when not properly supervised. Fire incidents in agricultural fields can escalate rapidly due to the presence of dry vegetation and environmental factors such as high temperature and wind. These conditions can lead to the uncontrolled spread of fire, resulting in damage to crops, loss of livestock, and potential harm
to human life. In rural areas, where access to emergency services may be limited, timely detection and response to fire incidents become even more critical. Traditional fire monitoring methods rely mainly on human observation, which is not always reliable or efficient, particularly in large agricultural fields. Recent advancements in sensing and communication technologies have enabled the development of systems that support real-time monitoring and automated decision-making. The Internet of Things (IoT) allows multiple devices to be interconnected, enabling continuous data collection and remote access to information. In this context, integrating IoT with fire detection systems provides an opportunity to enhance safety in agricultural fields. This work proposes a system that detects fire, identifies the presence of humans or animals, and activates a suppression mechanism automatically. The proposed system aims to provide a practical and cost-effective solution for improving fire safety in agriculture

LITERATURE SURVEY

Fire incidents in agricultural fields can case substantial damage to crops and property due to delayed the fire detection and response.

IoT-based Smart Fire Detection and Automatic Suppression for Agriculture:

the application of IOT technologies in fire detection within agricultural fields IoT sensors such as temperature, smoke, and flame sensors and water sprinkles are used to monitor environmental conditions, detect early to of fires ,and in agricultural field buzzer provides to a fire signal of farmer and send real-time text message to farmers for timely intervention, significantly reducing fire-related damages and losses.

IOT System for Fire Monitoring:

IOT, especially those based on microcontroller like Arduino, MQ2, Smoke Sensors are frequently utilized in fire detection system. These systems collect data from sensors, process it, and commucate the results over wireless networks (Wi-Fi, Loka, etc). They serve as the hack
bone of real-time monitoring systems in agricultural settings, with low-cost and low-power consumption being key advantages

Fig: ARDUINO

Fig:MQ2

Traditional Fire Detection System:

Traditional fire detection systems primarily rely on smoke detectors, heat sensors, and flame sensors to identify the presence of fire. Flame sensors detect infrared or ultraviolet radiation emitted by fire.These system have been widely used in agricultural for early fire detection, protecting crops, infrastructure and machinery from fire hazards

Fig: FLAME SENSORS

5 Volt Relay module:

The relay module is used to control high-power devices such as water pumps or sprinkler valves. It allows the microcontroller to safely control the operation of the sprinkler system without direct electrical connection and safe switching of high-voltage components. It acts as a bridge to 5V signals from microcontrollers.

Fig: 5V RELAY

Buzzer:

In the agricultural field the fire accidents can spread rapidly due to dry crops, high wind and high temperatures. The buzzer alarm provides immediate audible alerts to the farmers when fire condition in the agricultural field. The buzzer serves as a warning signal, then the farmer take immediate action before the fire spreads. Audible alerts are especially useful in rural environments where visual notifications may not be effective

Fig: BUZZER

RESULT AND DISCUSSION

RESULT:

The system was designed to monitor agricultural fields for the presence of fire or unusual temperature spikes that could indicate a fire. The following components were implemented:

Key results of the project include:

Sensors:

- Temperature Sensor: The temperature sensor constantly monitors environmental conditions. A threshold value of 60°C was chosen as the trigger for the detection
- Smoke Sensor: The smoke sensor detects the presence of smoke, which is another indicator of a potential fire.
- Motion Sensor: Motion sensor typically uses a PIR(passive infrared) sensor. It is connected to a microcontroller and it detects human moment, triggering real-time alerts.
- Automatic Water Spray Sensor: It uses the soil moisture sensor and temperature/humidity sensor and also it can used by a microcontroller.

Alert System:

- The system sends alerts via SMS to designated users, ensuring that they are notified even if they are not actively monitoring the dashboard.

Real- Time Monitoring:

The flask application displays real time of sensor data, helping users track temperature and smoke lev

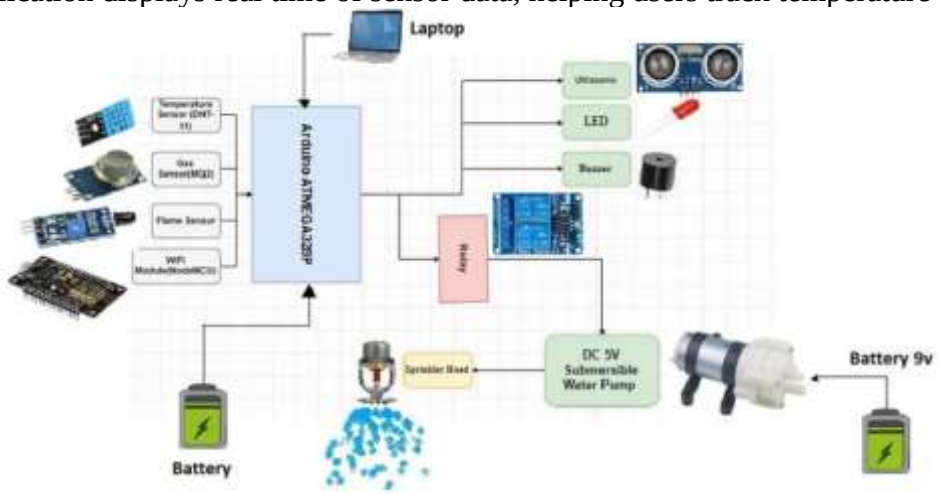

Fig: BLUE PRINT OF IOT-BASED SMART FIRE DETECTION AND AUTOMATIC SUPPRESSION SYSTEM FOR AGRICULTURAL FIELDS

Discussion:

The project demonstrates the feasibility of using IOT- enabled system for early fire detection in agriculture, which can greatly improve response times and prevent a huge amount of damage. Some of the key observations and challenges during the development of the system.

Network and Data Transmission:

- The use of SMS for data transmission ensured that the system could handle a large volume of sensor data in real- time.
- However, during field testing in areas with poor connectivity, delay in data transmission was noted, which affected the timeliness of alerts.

Energy/Power:

- Power consumption was a key consideration, particularly when deploying sensors in remote agricultural areas where power source may be limited.

User Interface:

- The web application's interface was user- friendly. But further improvements can be made for accessibility, such as mobile development for farmers who may not the desktop devices.
- The system's ability to send notifications via SMS or email provide value, especially in areas with limited internet access.

CONCLUSION

This work presented the design and implementation of an IoT-based smart fire detection and automatic suppression system intended for agricultural fields. The proposed approach addresses a practical and often overlooked safety issue associated with field burning practices, particularly in rural environments where monitoring is limited and response time is critical. By integrating multiple sensing mechanisms

with automated control and communication features, the system provides a comprehensive solution for early detection and rapid response to fire-related hazards.

The use of flame and temperature sensors enables timely identification of fire conditions, while the inclusion of motion and object detection enhances safety by accounting for the presence of humans and animals in the field. The automatic activation of the sprinkler system reduces dependence on manual intervention and helps in controlling the spread of fire at an early stage. In addition, the incorporation of IoT-based communication supports remote monitoring and ensures that farmers are informed in real time, even when they are not physically present at the site.

One of the key strengths of the proposed system is its emphasis on practicality and accessibility. By utilizing low-cost hardware components and open-source software tools, the system is designed to be affordable and suitable for small and marginal farmers. This makes it a viable solution for real-world deployment in agricultural settings, where cost and ease of use are important considerations.

The results indicate that the system can improve fire detection reliability, reduce response time, and enhance overall safety in agricultural operations. Although the current implementation provides an effective foundation, further improvements can be explored in future work. These may include the integration of solar power for uninterrupted operation, the use of advanced sensor fusion techniques to improve detection accuracy, and the development of mobile-based interfaces for enhanced user interaction.

In conclusion, the proposed system demonstrates how the integration of IoT and embedded technologies can be applied to address real-world challenges in agriculture. By improving safety, reducing risk, and supporting automated response, the system contributes to the advancement of smart farming practices and offers a practical step toward safer and more sustainable agricultural environments.

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