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Fire Shield: Smart Fire Detection and Automatic Suppression System for Agricultural Fields

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***Abstract*— Agricultural fires pose a significant threat to crop production, leading to severe economic losses for farmers. Early detection and rapid response are critical for minimizing damage. This study presents Fire Shield, a smart fire detection and automatic suppression system designed for agricultural fields. The system integrates a NodeMCU ESP8266 microcontroller, MQ-2 gas sensor, and DHT11 temperature sensor to continuously monitor the environmental conditions. Upon detecting abnormal smoke levels and temperature, the system activates multiple responses, including an alarm, LCD warning display, and automatic sprinkler activation using a relay module. The sprinkler system suppresses fire at an early stage, preventing its spread. The proposed system is cost-effective, reliable, and suitable for rural agricultural applications, providing both detection and real-time fire control capabilities.**

Keywords*— Fire detection, Smart agriculture, IoT, NodeMCU ESP8266, MQ-2 sensor, DHT11, Sprinkler system, Relay module.

I. INTRODUCTION

Agriculture is essential for food production and economic stability in India. However, agricultural fields are highly vulnerable to fire hazards caused by dry weather, electrical faults, machinery sparks and human activities. Fires spread rapidly in fields due to the presence of dry crops, resulting in large-scale destruction.

Traditional fire detection methods rely on manual monitoring, which is inefficient in large agricultural areas. With advancements in embedded systems and IoT, automated fire detection systems can significantly improve response time and reduce losses.

The Fire Shield system is designed to detect fires at an early stage and automatically activate a sprinkler system to control them, ensuring enhanced protection for crops.

II. PROBLEM STATEMENT

Farmers face several challenges related to fire outbreaks:

- Lack of real-time monitoring systems
- Delayed detection of fire
- Rapid spread of fire across fields
- High economic losses

There is a need for a system that not only detects fire but also responds immediately to suppress it.

A. Objectives

The objectives of this study are as follows:

- To design a low-cost fire detection system
- To integrate multiple sensors for accurate detection
- To provide instant alerts to farmers
- To automatically activate a sprinkler system using a relay

To minimize crop damage through early intervention.

B. System Architecture

The Fire Shield system comprises the following components:

- Microcontroller (NodeMCU ESP8266)
- MQ-2 smoke sensor
- DHT11 temperature sensor
- 16×2 LCD display
- Relay module
- Sprinkler system
- Buzzer alarm

C. Hardware Components

- NodeMCU ESP8266: Controls the entire system and processes sensor data
- MQ-2 Gas Sensor: Detects smoke and combustible gases
- DHT11 Sensor: Measures temperature changes
- 16×2 LCD Display: Displays warning messages
- Relay Module: Switches the sprinkler system ON/OFF
- Sprinkler System: Sprays water to control fire
- Buzzer: Provides audible alert

III. METHODOLOGY

Monitoring: Sensors continuously collect environmental data from the field.
Data Processing: The NodeMCU compares sensor readings with predefined threshold values.
Fire Detection: A fire condition is identified when smoke levels rise and the temperature exceeds safe thresholds.
Response Mechanism: Upon detecting abnormal sensor values, the system initiates a multi-response mechanism, including alert generation and automatic fire suppression.

A. Working Principle

- Sensors continuously monitor field conditions
- Data is sent to the NodeMCU
- The system checks for abnormal smoke and temperature levels
- When fire conditions are detected, the system performs a sequence of actions including activating an alarm, displaying a warning message, and triggering a relay module to start the sprinkler system for fire suppression
- Water is sprayed to suppress fire

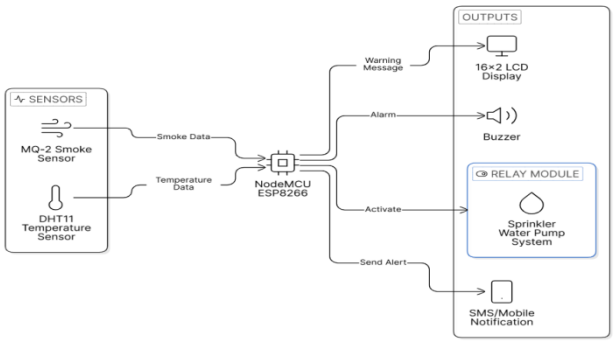

Fig 1: Smart Fire Detection and Alert System using NodeMCU ESP8266

IV. ALGORITHM

1. Start system
2. Initialize sensors
3. Read MQ-2 sensor value
4. Read DHT11 temperature value
5. Compare values with threshold
6. If fire detected:

- Activate buzzer
- Display warning
- Trigger relay
- Turn ON sprinkler

7.Repeat continuously.

A. Advantages

- Early fire detection
- Automatic fire suppression
- Low-cost implementation
- Real-time monitoring
- Reduced crop loss
- Easy installation

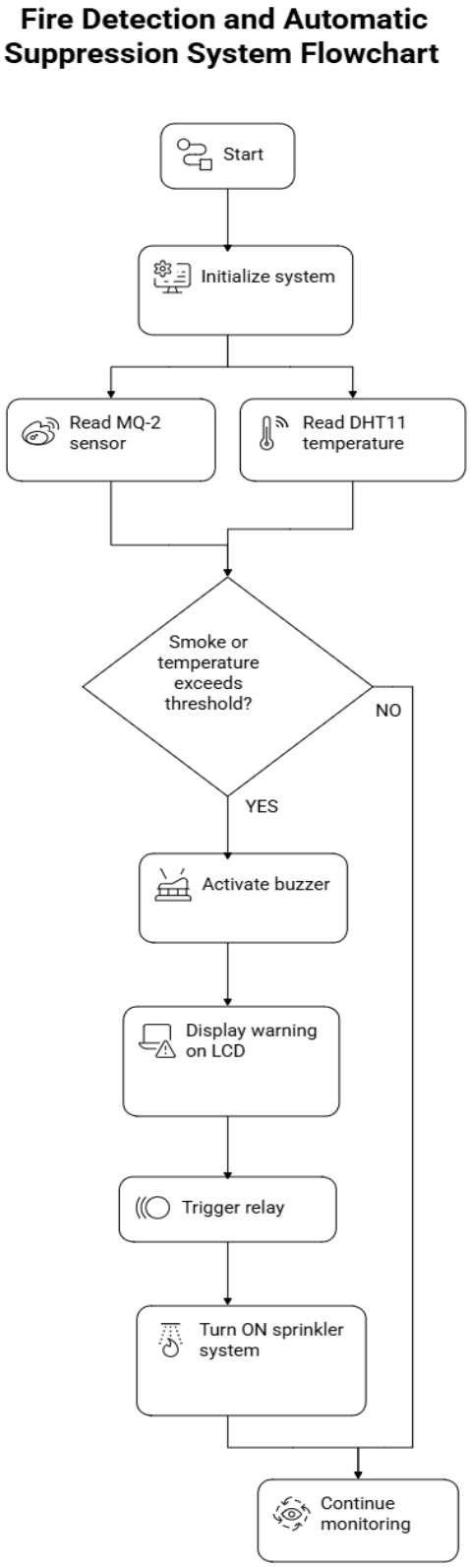

Fig 2: Fire Detection and automatic suppression system flowchart

B. Applications

- Agricultural farms
- Forest fire monitoring
- Warehouses
- Greenhouses
- Rural safety systems

*C. **Future Scope***

- Mobile app integration
- IoT cloud monitoring
- Solar-powered system
- AI-based fire prediction
- GPS tracking of fire location

V. Conclusion

The Fire Shield system provides an efficient solution for detecting and suppressing fires in agricultural fields. By combining sensor-based detection with an automatic sprinkler system, the system ensures early intervention and minimizes the damage. The use of affordable components such as NodeMCU, MQ-2, and DHT11 makes it suitable for widespread adoption in rural areas. This system can significantly improve agricultural safety and protect farmers from fire-related loss.

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