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IoT-Based Fire Alarm Detection and Prevention System Using NodeMCU

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Abstract: This project presents an IoT-based fire alarm detection and prevention system utilizing a NodeMCU (ESP8266) microcontroller, fire sensor, alarming buzzer, and automated water sprinkler. Unlike conventional systems that only provide alerts, this system integrates fire suppression by automatically activating a water sprinkler upon fire detection. The NodeMCU continuously monitors sensor data and immediately triggers safety mechanisms, minimizing fire spread and potential damage. Additionally, IoT connectivity enables real-time remote monitoring and notifications, ensuring timely response even in the absence of on-site personnel.

Keywords: IoT, Fire Detection, NodeMCU, Fire Prevention, Automated Sprinkler, Remote Monitoring, ESP8266, Smart Safety System.

I. INTRODUCTION

Fire accidents pose a significant threat to life and property, making early detection and immediate response crucial in minimizing damage. Traditional fire detection systems primarily rely on sensors to detect smoke or temperature variations, triggering alarms to alert occupants. While these systems provide early warnings, they often lack automated fire suppression mechanisms, requiring manual intervention or external assistance, which may lead to delays in controlling the fire.

With advancements in the Internet of Things (IoT), smart fire detection systems have become more efficient, offering real-time monitoring and remote notifications. Existing IoT-based systems use microcontrollers such as Arduino or Raspberry Pi to detect fires and send alerts. However, these solutions mainly focus on warning users rather than actively suppressing the fire. This limitation highlights the need for a system that not only detects fire but also includes an integrated response mechanism to prevent its spread.

This project proposes an IoT-based fire alarm detection and prevention system using the NodeMCU (ESP8266) microcontroller, fire sensors, a buzzer, and an automated water sprinkler. The system

continuously monitors fire hazards, and upon detection, it triggers an alarm while simultaneously activating the sprinkler to mitigate the fire. Additionally, its IoT connectivity ensures that real-time alerts are sent to users or a central monitoring system, enabling swift action even when no one is present on-site. By integrating both fire detection and suppression, this system enhances safety and reduces the risk of extensive damage in residential and commercial environments.

II. EXISTING SYSTEM

The existing fire detection systems primarily utilize IoT and Arduino technologies for early fire detection. Studies by Muheden et al., Sarkar et al., and Ralevski and Stojkoska focus on IoT-based systems that effectively monitor fire hazards but typically provide only alerts without automated fire mitigation mechanisms like sprinklers. Similarly, Halim et al., Hyeong-Su et al., and Salam et al. have developed Arduino-based systems that use temperature and fire sensors to detect fires and trigger alarms or notifications. However, these systems lack active fire suppression components and rely on manual intervention or third-party solutions for fire control, which can lead to delayed responses during emergencies, potentially resulting in significant damage. This highlights a critical gap in current fire detection systems, emphasizing the need for integrated fire suppression capabilities.

III. PROPOSED SYSTEM

To overcome the limitations of existing fire detection systems, this project introduces an IoT-based fire alarm detection and prevention system that integrates both fire detection and automated suppression. The system is built using a NodeMCU (ESP8266) microcontroller, fire sensors, a buzzer for alerts, and an automated water sprinkler to control the fire.

When the fire sensor detects smoke or a sudden rise in temperature, the NodeMCU processes the data and immediately activates the buzzer to alert nearby occupants. Simultaneously, the system triggers the water sprinkler to release water over the affected area, helping to extinguish or contain the fire before it spreads.

Additionally, the IoT capabilities of the NodeMCU allow real-time monitoring and notifications via Wi-Fi. Users receive instant alerts on their mobile devices, ensuring they are informed even when they are not present at the location. This automated system reduces response time, minimizes fire-related damage, and enhances overall safety in residential and commercial spaces.

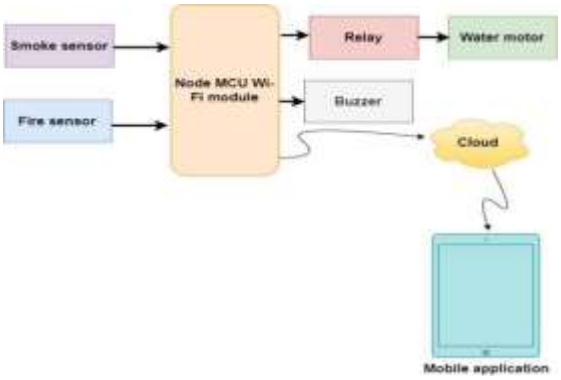

Fig.1. General Block diagram

The architecture of the IoT-based fire alarm detection and prevention system integrates multiple components to ensure efficient fire detection, alerting, and suppression. At the core of the system is the NodeMCU (ESP8266) microcontroller, which processes sensor data, controls alarms and sprinklers, and enables IoT

connectivity for remote monitoring. A fire sensor, such as a flame or smoke detector, continuously monitors the environment for fire hazards and sends real-time data to the NodeMCU. Upon detecting a fire, the system activates a buzzer to provide an audible alert, ensuring immediate awareness among occupants. Simultaneously, the NodeMCU triggers a relay module to activate an automated water sprinkler, which releases water over the affected area to suppress or contain the fire. The IoT connectivity allows the system to send real-time alerts and status updates to users via a cloud platform or mobile application, ensuring timely action even when they are off-site. The entire setup is powered by a reliable power source, with options for battery backup to maintain functionality during emergencies. This architecture ensures a rapid and automated response to fire incidents, minimizing damage and enhancing safety in residential and commercial spaces.

IV. Components used and description

1. NodeMCU

The ESP-12E module, which houses the ESP8266 chip with Tensilica Xtensa 32-bit LX106 RISC CPU, is included with the NodeMCU ESP8266 development board. This microprocessor runs at a configurable clock frequency of 80MHz to 160MHz and supports RTOS. To store information and applications, the NodeMCU features 4MB of Flash memory and 128 KB of RAM. It is perfect for Internet of Things applications because of its powerful processing capacity, built-in Wi-Fi and Bluetooth, and Deep Sleep Operating capabilities.

Fig.2. ESP8266 NodeMCU

2. Power Supply

The system requires a regulated power supply to ensure proper functioning of the Arduino Uno and other components. Typically, a 5V or 9V DC power source (such as an adapter or battery) is used to supply stable power to the microcontroller and connected modules.

3. Relay

The relay module is a key component in the IoT-based fire alarm detection and prevention system, responsible for controlling the activation of the water sprinkler. It acts as an electronic switch that is triggered by the NodeMCU (ESP8266) when a fire is detected. Once the fire sensor detects smoke or flames, the NodeMCU sends a signal to the relay, which then activates the water pump or solenoid valve connected to the sprinkler system. This ensures that water is released immediately over the affected area, helping to suppress or contain the fire. The relay module operates with low power and provides electrical isolation, making it a reliable interface between the microcontroller and high-power devices like pumps. Its automation eliminates the need for manual intervention, ensuring a

quick and efficient fire mitigation response.

Fig.3. Relay

4. **Buzzer**

A buzzer is used to provide audio feedback for system notifications. It sounds an alert when an order is placed, a payment is completed, or when a customer presses the waiter call button. This feature ensures staff members are immediately notified, reducing response time and enhancing service quality.

Fig.6. Buzzer

5. **MQ-2 Smoke Sensor**

A variety of gases, such as butane, propane, methane, hydrogen, and smoke, may be detected by the multipurpose MQ-2 Gas Sensor. It is made up of a sensitive substance that changes resistance in response to changes in gas concentrations in the air. The concentration of gases in the air may be measured by connecting this sensor to a microcontroller's analogue input.

Fig.8. MQ2

6. **Mobile Application**

The mobile application is an essential part of the IoT-based fire alarm detection and prevention system, enabling remote monitoring and real-time alerts. Through IoT connectivity, the NodeMCU (ESP8266) transmits fire sensor data to a cloud platform, which then sends notifications to the user's mobile device. The application provides real-time status updates on fire detection, system activity, and water sprinkler activation.

In case of a fire, users receive instant alerts, allowing them to take necessary actions even if they are not physically present. The app can also include additional features such as manual sprinkler activation, fire history logs, and integration with emergency services for quick response. This enhances fire safety by ensuring that users stay informed and can respond swiftly to potential fire hazards.

7. **Flame/Fire Sensor**

One tool for detecting the presence of a fire or other strong light source is a flame sensor. Although there are other approaches to implementing a flame sensor, this project uses an infrared radiation-sensitive sensor module.

A LM393 comparator chip is used by the module to produce a steady digital output signal. The driving capacity of this comparator is 15 mA. Numerous applications, such as fire alarms and other fire detection tools or projects, can make use of this flame detector sensor.

Fig.9. Flame sensor

8. water motor

The automated water sprinkler is a crucial component of the fire prevention system, designed to control and suppress fires immediately upon detection. When the fire sensor detects smoke or flames, the NodeMCU (ESP8266) processes the signal and triggers a relay module, which activates the sprinkler system. This mechanism ensures that water is released directly over the affected area, helping to extinguish or contain the fire before it spreads. Unlike traditional fire alarm systems that only provide alerts, this integrated sprinkler system offers an active fire suppression solution, reducing response time and minimizing potential damage. The automation of the sprinkler ensures a quick and efficient reaction, enhancing safety in residential and commercial spaces without requiring manual intervention.

Fig.10. servo motor

V. WORKING

The proposed system operates based on the following step-by-step process:

1. **Fire Sensor Monitoring:**
The fire sensor, such as a flame or smoke sensor, continuously scans the surrounding environment for any signs of fire hazards. It detects parameters like smoke concentration, flame intensity, or temperature changes to identify potential fire risks. This data is then sent to the NodeMCU (ESP8266) for further processing.
2. **Data Processing by NodeMCU:**
The NodeMCU (ESP8266) receives real-time sensor data and analyzes it against predefined threshold values. If the readings are within a safe range, the system continues normal monitoring. However, if the values exceed the set thresholds, indicating a fire, the system proceeds with necessary emergency actions.
3. **Fire Detection Decision:**
Once the sensor data crosses the fire detection threshold, the system confirms the presence of a fire. This decision-making process ensures accurate detection, reducing false alarms while ensuring a prompt response to actual fire incidents. The system then activates safety mechanisms to control the fire.

4. **Buzzer Activation:**
As soon as a fire is detected, the system triggers a buzzer to produce a loud alarm. This immediate audible alert warns occupants of potential danger, allowing them to evacuate or take necessary precautions. The buzzer continues to sound until the fire is controlled or the system is manually reset.
5. **Relay Module Activation:**
The NodeMCU sends an electrical signal to the relay module, which acts as a switch to control the operation of the water motor. This ensures that the fire suppression system is activated only when fire is detected, conserving water and energy while ensuring rapid response.
6. **Water Sprinkler Activation:**
Upon receiving a signal from the relay, the water motor is powered on, and the sprinkler system starts spraying water over the affected area. This automated response helps contain or extinguish the fire before it spreads further, significantly reducing property damage and enhancing safety.
7. **IoT-Based Notification:**
Simultaneously, the system sends real-time alerts to a cloud server, which forwards notifications to users via a mobile application. This feature allows users to monitor the fire situation remotely, ensuring they can take quick action even if they are away from the location.
8. **Continuous Monitoring & Reset:**
The system continuously monitors fire conditions even after activation. If the fire is successfully controlled and sensor readings return to normal, the system stops the sprinkler and resets itself for future fire detection. If fire persists, the alarm and notifications continue until intervention is made.

VI. RESULTS

The implementation of the IoT-based fire alarm detection and prevention system demonstrated effective real-time fire monitoring, alerting, and suppression. During testing, the fire sensor successfully detected smoke and flames within seconds, triggering the buzzer to alert occupants immediately. The NodeMCU (ESP8266) processed sensor data efficiently and activated the automated water sprinkler without delay, ensuring rapid suppression of fire. The system's IoT connectivity enabled real-time notifications to be sent to a mobile device, providing remote monitoring and control.

The integration of an automated sprinkler system significantly reduced response time compared to traditional fire alarm systems, which rely solely on manual intervention. Additionally, the system proved to be reliable under different environmental conditions, maintaining stable operation even during extended monitoring periods. The results highlight the effectiveness of the proposed system in enhancing fire safety, reducing potential damage, and providing real-time alerts for both on-site and remote users.

Fig.11. Implementation Result

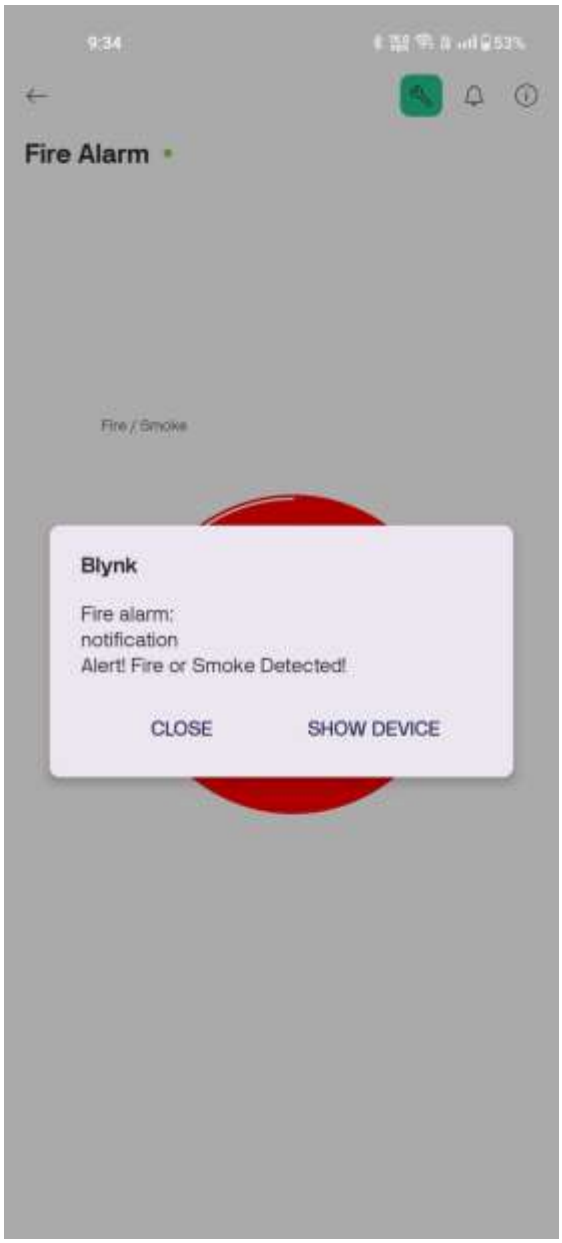

Fig.12. work status

VII. CONCLUSION

The IoT-based fire alarm detection and prevention system using NodeMCU (ESP8266) provides an efficient, automated solution for fire safety by integrating real-time fire detection, immediate alerts, and active suppression. Unlike traditional systems that only issue warnings, this system incorporates an automated water sprinkler to control fire at an early stage, reducing response time and potential damage. The IoT connectivity ensures remote monitoring, allowing users to receive instant alerts even when they are not present. Overall, the system enhances fire safety in residential and commercial spaces by offering a proactive and automated approach to fire prevention.

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