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Intelligent Smoke Sensing and Exhaust Fan Activation Via IoT

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Abstract: The Intelligent Smoke Sensing and Exhaust Fan Activation via IoT aims to enhance indoor safety by detecting smoke and automatically responding. This system uses an Arduino UNO along with an MQ-2 sensor to constantly keep track of smoke levels in the air. When the smoke exceeds a certain limit, it automatically turns on an exhaust fan and a buzzer to clear the smoke and alert nearby people. Once the air quality goes back to normal, both the fan and buzzer turn off, helping to save energy. The setup is affordable, energy-efficient, and runs on its own without needing manual control. It's also compatible with IoT platforms, making it a flexible and scalable option for smart homes, labs, and industrial settings.

Index Terms - Internet of Things, smoke sensing, air quality monitoring, automation, smart home, energy efficiency, alert system.

I. Introduction

Indoor spaces like homes, labs, and industrial areas are often at risk of smoke-related hazards caused by things like cooking, chemical reactions, or electrical issues. Traditional ventilation systems usually need to be turned on manually or are left running constantly, which can either slow down the response to smoke or lead to unnecessary energy use. To address this challenge, the "Intelligent Smoke Sensing and Exhaust Fan Activation Via IoT" project introduces an automated solution for real-time smoke detection and response.

This system employs an Arduino UNO microcontroller integrated with an MQ-2 or MQ-135 smoke sensor to continuously monitor air quality. When smoke levels rise beyond a predefined threshold, the system automatically activates an exhaust fan to clear the air and a buzzer to alert nearby individuals. Once the air quality returns to normal, the system turns off both devices to conserve energy.

Designed to function without manual intervention, this IoT- based project not only enhances indoor safety but also supports energy efficiency. Thanks to its affordability and scalability, this system is a great fit for smart homes, schools, and industrial settings where embedded systems are used for monitoring and automation.

The smoke sensing and exhaust fan activation setup offers a practical and user-friendly way to improve indoor air quality and safety. It's designed to be simple and fully automatic, meaning it doesn't need any manual input to function, making it accessible even to users with minimal technical skills. Once installed, it keeps an eye on the air quality in real time, and when it detects an increase in smoke levels, it immediately activates the exhaust fan and buzzer to respond to the situation.

Built around the Arduino UNO and commonly available sensors like the MQ-2, the hardware is easy to assemble and maintain. Its compact design, plug-and-play setup, and low cost make it ideal for use in homes, classrooms, labs, and small industrial environment. Because the system runs on its own and doesn't require much user intervention, it aligns well with smart automation goals and puts user convenience at the forefront.

II. PROBLEM STATEMENT OF THE STUDY

Many homes, laboratories, and factories still rely on exhaust fans that must either be turned on manually or kept running continuously. This approach causes delays in emergencies when quick action is needed, and it also wastes electricity when the fan runs unnecessarily. Since these systems are not equipped with smart smoke detection or automatic control, they fail to maintain air quality effectively and increase the risks of health issues and fire hazards. Therefore, there is a strong need for a smarter, automated solution that can detect smoke in real time, operate efficiently, and make these environments both safer and more energy-efficient.

III. OBJECTIVES OF THE STUDY

The following objectives framed for the present study.

1) To detect smoke in enclosed spaces using sensors.
2) To automatically turn on the exhaust fan when smoke is detected.
3) To alert people nearby using a buzzer when smoke is present.
4) To turn off the fan and buzzer when the smoke clears.
5) To reduce the need for manual control, especially in emergencies.
6) To build a low-cost and easy-to-use system.
7) To allow future upgrades like mobile control or IoT integration.

IV. PROPOSED SYSTEM AND METHODOLOGY

The proposed system improves on traditional smoke detection by using a microcontroller-based setup with built-in IoT capabilities for real-time detection and automated response. At the heart of this system is an Arduino UNO, which is connected to an MQ-2 smoke sensor, a buzzer for sound alerts, and an exhaust fan that's operated through a relay module.

The system works by constantly monitoring the air for smoke. If the sensor detects that smoke levels go above a set threshold, the Arduino turns on the exhaust fan to clear the air and activates the buzzer to alert anyone nearby. Once the smoke level drops back to normal, the system automatically shuts off the fan and buzzer, helping to save energy and reset itself for the next incident.

This design offers quick response times, energy efficiency, and fully automatic operation, removing the need for manual control. The hardware setup is simple and easy to build, making it ideal for scaling or upgrading. It's also designed in a modular way, which means it can be expanded in the future to support IoT features like remote monitoring or data tracking.

Because of its simplicity, reliability, and smart functionality, this system is well-suited for use in smart homes, classrooms, laboratories, and small industrial settings. The following tables (Table 1 and Table 2) will list the hardware and software components used, along with their specific roles in the system.

TABLE 1. SOFTWARE REQUIREMENTS

Software	**Specification**
Operating System	Windows 11 or above
Programming Language	Embedded C
IDE	Arduino IDE
Optional Platform	Mobile App / IoT Dashboard (via Bluetooth or cloud)

TABLE 2. HARDWARE COMPONENTS

Component	Specification/ Details
Arduino UNO	ATmega328P, 14 I/O pins, 6 Analog inputs, 16 MHz clock
MQ-2/MQ-135 Sensor	Detects smoke, methane, LPG, CO, alcohol, etc
Exhaust Fan	5V/12V DC exhaust fan, connected via relay
Relay Module	5V Single-channel relay to control exhaust fan
Buzzer	Piezo buzzer for audible alerts
Bluetooth Module	HC-05/HC-06 for wireless mobile alerts (optional)
Jumper Wires	Used to connect circuit components
Breadboard	For circuit prototyping
Power Supply	5V via USB or external battery for Arduino board

V. SYSTEM DESIGN AND IMPLEMENTATION

The system is built around an Arduino UNO, which acts as the main controller. It's connected to a smoke sensor, a buzzer, a relay, and an exhaust fan, as shown in Figure 1. When the smoke sensor such as the MQ-2 detects smoke, it sends a signal to the Arduino. The Arduino then processes this input and automatically turns on both the exhaust fan and the buzzer using its digital pins and the relay. This setup helps remove harmful gases from the area while immediately alerting people nearby.

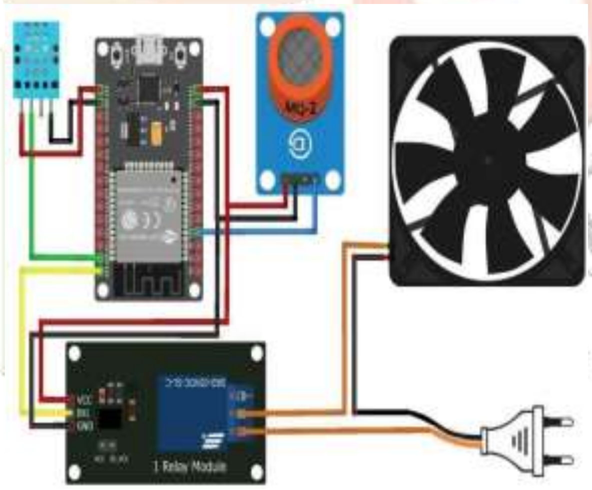

Fig 1. Circuit Diagram

The system follows a straightforward and efficient data flow, as shown in Figure 2. When the sensor detects smoke, it sends an Analog signal to the Arduino. The Arduino checks this value, and if it's higher than the set threshold, it activates the exhaust fan and buzzer. Once the smoke level goes back down below the threshold, the Arduino automatically switches off both devices to save energy. The circuit is built using jumper wires and a breadboard for easy prototyping, with power supplied either through USB or a battery.

On the software side, the code is written in Embedded C and uploaded to the Arduino using the Arduino IDE. The program continuously reads data from the smoke sensor and makes real-time decisions about whether to turn the fan and buzzer on or off. The system is designed to be lightweight and reliable, capable of running continuously without interruptions. For added functionality, optional features like Bluetooth-based mobile alerts or IoT integration can be included. To ensure everything works properly, the system is tested in multiple phases—unit testing, integration testing, system testing, and user acceptance testing—making sure it performs well in real-world conditions.

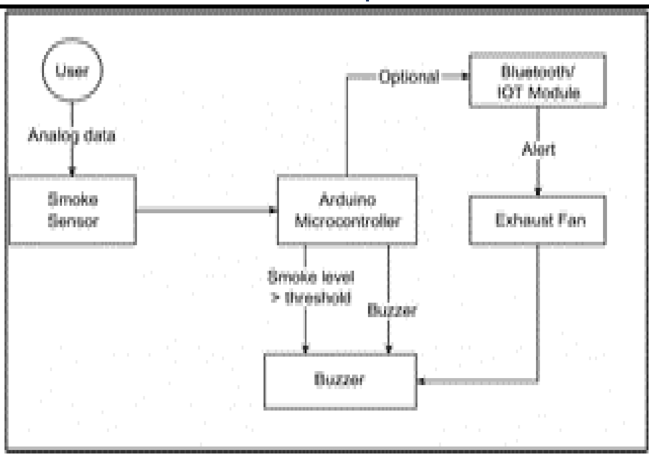

Fig 2. Dataflow Diagram

The data flow in the intelligent smoke detection and exhaust system starts with the MQ-2 smoke sensor, which constantly monitors the air for any signs of smoke. It sends an analog signal to the Arduino UNO, which then checks whether the smoke level crosses a predefined threshold. If it does, the Arduino sends digital signals to turn on the exhaust fan and buzzer, helping to quickly clear the smoke and alert nearby individuals. At the same time, the sensor readings are displayed on the serial monitor for real-time tracking. Once the smoke level drops back below the threshold, the Arduino automatically turns off the fan and buzzer, completing a smooth and energy-efficient response cycle.

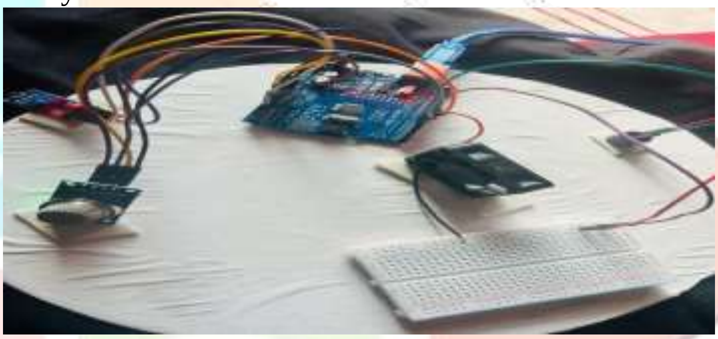

Fig. 3. Circuit Connection

Figure 3 shows how the components from Figure 1 are connected in the circuit. The system is built around an Arduino UNO, which serves as the main controller. The MQ-2 smoke sensor is connected to the analog pin A0 of the Arduino to continuously monitor smoke levels. A relay module is attached to digital pin D9 and controls the exhaust fan based on the sensor's readings. Similarly, a buzzer is connected to digital pin D8 to give an audio alert whenever smoke is detected.

All the components are wired together using jumper wires on a breadboard, which makes the circuit easy to test and modify. The system gets its power either from a USB cable or an external adapter. This simple and clean layout not only makes it easy to understand and debug but also allows for future expansion, like adding more sensors or integrating IoT features.

VI. RESULTS

The intelligent smoke detection and exhaust fan activation system worked effectively and consistently during implementation and testing. It accurately detected different levels of smoke and responded quickly by turning on the exhaust fan and buzzer. The detailed test cases are shown in Table 3.

Throughout extensive testing—including stress tests and full system checks—the system performed reliably. All components behaved as expected without any failures. It was also energy-efficient and highly responsive, with no false alarms recorded. The setup was easy to use, thanks to its simple interface and automated operation, making it well-suited for places like homes, classrooms, and small laboratories.

Overall, the results confirmed that the system is dependable for real-time air quality monitoring and smart, automated smoke control.

TABLE 3. TEST CASES

Test Case ID	Test Scenario	Input	Expected Output	Result
TC01	Smoke is detected	Smoke sensor > threshold	Fan turns ON, Buzzer sounds	Pass
TC02	No smoke is present	Smoke sensor < threshold	Fan and Buzzer remain OFF	Pass
TC03	Smoke clears after detection	Smoke level returns normal	Fan and Buzzer turn OFF	Pass
TC04	System response time	Smoke introduced	Response within 1–2 seconds	Pass
TC05	Relay operation	Arduino sends HIGH signal	Relay switches ON and activates fan	Pass
TC06	Sensor malfunction (simulate by disconnecting)	Sensor not connected	System shows no response or default OFF state	Pass
TC07	Fan works manually (for hardware test)	Direct connection to power	Fan should turn ON	Pass
TC08	Arduino code upload and execution	Upload via Arduino IDE	Code compiles successfully and runs without error	Pass
TC09 (Optional)	Bluetooth alert to mobile	Smoke detected	Mobile receives alert message (if feature is implemented)	Pass

VII. CONCLUSION AND FUTURE SCOPE

The intelligent smoke detection and exhaust fan activation system effectively fulfils its goal of providing a timely response to indoor smoke levels, ensuring safety through automated ventilation and alerts. The project demonstrates how simple and cost-effective components, such as the MQ-2 sensor and Arduino UNO, can be utilized to build a reliable and efficient smoke monitoring setup. The system's ability to autonomously control outputs like fans and buzzers based on real-time sensor data makes it highly practical for home, educational, and laboratory environments.

For future enhancements, the system can be upgraded with wireless communication modules such as Wi-Fi or Bluetooth to support remote notifications and real-time mobile alerts. Additional features like temperature or gas sensors could be integrated to expand its scope to multi-parameter environmental monitoring. Furthermore, cloud connectivity and mobile app integration could provide users with historical data analysis and remote-control capabilities, making the system more adaptive and in smart homes and industrial safety infrastructures.

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