Clean Air Sentinel

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***Abstract*—Fire hazards pose a significant threat to human lives and properly, necessitating efficient smoke detection and exhaustion systems. The most recent advances in smoke detectors have been motivated to make them smarter. Smoke can be detected either optically (photoelectric) or by physical process (ionization). This project presents an automated smoke exhaustion system designed for multi-level buildings using an Arduino-based control mechanism. The system employs an MQ-2 smoke sensor to detect smoke levels and activate fans based on predefined logic. When smoke is detected, the servo motor and relay operate to ensure efficient smoke exhaustion, with the fan activation hierarchy adjusting according to the floor where smoke is detected. Additionally, a GSM module (SIM900A) is integrated for real time alerts, enhancing emergency response. The proposed system improves indoor air quality, minimizes fire risks, and ensures rapid smoke exhaustion, making it suitable for residential and commercial buildings.**

***Index Terms*—Smoke detection, Exhaustion, Multi-level building, Real time alerts through GSM Modules.**

I. INTRODUCTION

Fire accidents are a serious risk to human life and infrastructure, and they usually result in catastrophic outcomes. Smoke inhalation is among the leading causes of death in fire accidents, and this highlights the importance of effective smoke detection and exhaustion systems. Traditional fire alarm systems are based on smoke detection and warning systems but do not have an automated system for exhausting smoke from the area of occurrence. This can result in higher risks of suffocation and delayed safe evacuation.

Recent developments in automation and embedded system technologies have made it possible to create intelligent fire safety solutions. Yet, most current ventilation and smoke exhaustion systems are either manually operated or have limited capability to respond dynamically to the presence of smoke. In multi-story buildings, smoke can travel fast, and hence it is crucial to have a system that works strategically depending on the floor where smoke is sensed.

This paper introduces an automated smoke exhaustion system that senses smoke in multi-level structures and turns on fans accordingly. The system has been simulated to test its practicality in the real world prior to hardware development. The major components are the MQ-2 smoke sensor, which senses smoke concentration and sends an output voltage signal to the Arduino Uno microcontroller. According to pre-defined conditions, the Arduino switches on a relay module to drive servo motors and fans to facilitate effective smoke exhaustion. The operation of the fans is hierarchical.

A GSM module (SIM900A) is also incorporated to provide real-time alerts upon detection of smoke, enabling prompt response and preventive measures. The suggested system improves building safety through timely smoke exhaustion, reduces health risks, and enhances air circulation.

A. Problem Statement

Cities are often confronted with fire outbreaks, which are major risks to human life and property. The major hurdles in response to Fire emergencies are:

a) Delayed Response Time:
- Dense Traffic makes it Difficult for the movement of the fire brigade.
- Emergency calls are delayed due to fear or failure of early detection.
- Limited Fire Fighting equipment delays action

b) Increased Damage and Health Risks
- Fast buildup of smoke leads to asphyxiation and impaired visibility.
- Delayed ventilation increases fire Propagation and damage to property.

c) No immediate Exhaustion of Smoke:
- Current systems mainly address fire alarms and not so much smoke elimination.

- Lack of automatic ventilation aggravates inbuilding air quality prior to fire department arrival.

B. Need For a Proactive Solution

To overcome these issues, there should be an automated smoke exhaust system that can detect smoke, and start exhaust fans, and alert emergency responders in real time. The system would prevent smoke exposure, increase occupant safety, and enhance response effectiveness during the firefighter's arrival.

C. Goal

The objective of this paper is to design and simulate an automatic smoke exhaustion system that reacts to fire hazards effectively. The study revolves around implementing an affordable method through readily available components and experimenting its performance in the form of real-time simulations. The remainder of the paper discusses the system architecture, working process, simulation outcomes and future improvement possibilities.

II. LITERATURE SURVEY

1. The Effectiveness of Exhaust Fan Rotation with Microcontroller for indoor CO2 Gas Concentration Control System, 2023 - (Sri Hartanto, SRI and Tri Ongko Priyono, TOP and Triono):

This study aims to create a device for the regulation of CO2 gas concentration in indoor settings, especially from cigarette smoke. The system involves an MQ-2 sensor for measuring CO2 levels and an Arduino Uno microcontroller for data processing and operating an exhaust fan for ventilation. A simulation experiment was performed inside a 15 cm × 20 cm × 15 cm room with two ventilation holes of 3.5 cm in diameter. The findings show that the exhaust fan is able to control CO_2 levels, keeping concentrations at below 350 ppm, which means improved air quality.

2. Smoke Detection Alert System via Mobile Application – (Wan Hazimah Wan Ismail, Herny Ramadhani Mohd Husny, Norhaiza Ya Abdullah):

This project suggests a smart home security system that employs a smoke sensor to identify possible fire risks and informs user through SMS and an Alarm. Controlled by an Android mobile application, the system enables authorized users to turn it on or off remotely. Developed on an Arduino Uno, the system focuses on early smoke detection to safeguard lives, properly, and the environment.

3. Study of smoke prevention and exhaust system for high rise buidings – (Xiao Kunhua)

The article focuses on the underrated role of smoke prevention and exhaust systems in fire protection. It points out defects in existing system design, inspection, and maintenance, particularly in high-rise buildings. A novel approach to determining smoke exhaust flow rate is presented. Results emphasize the effect of weather wind outdoors and the necessity to upgrade the system.

4. Smart Automated smoke Detected Exhaust Fan

Safety is a primary concern in residential and commercial building design in order to secure against loss of life and loss of property. Fire is an essential component of safety considerations. This project thus aims to develop an arduino based smoke detector fan that will constantly observe the presence of a substantial amount of smoke and turn on a fan to pull out a smoke to contain the situation.

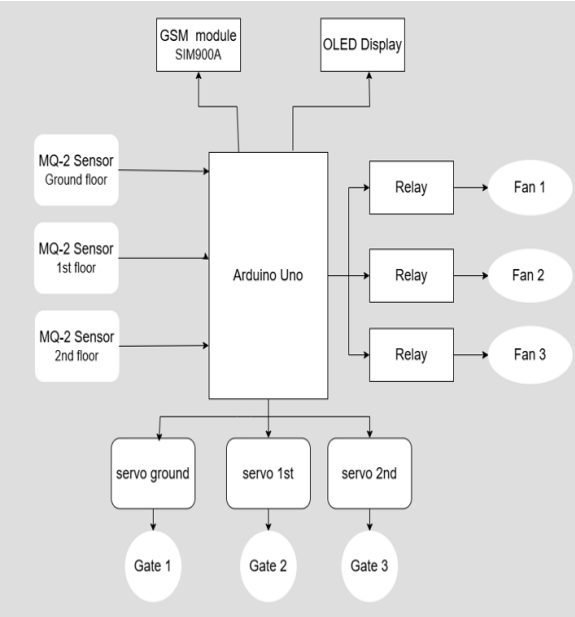
5. Integrated Reasearch on smoke control for n unnderground mall fire, based on smoke barrier and mechhanical smoke exhaust system - (Jinzhang Jia, Xiuyuan Tian):

This research examines smoke spread in an underground mall fire employing both smoke barriers as well as a mechanical exhaust system. Simulations examined the influence of barrier sagging height and spacing and vent size, number, and arrangement on smoke control. A 1 m high smoke barrier with 5 m spacing successfully controlled high-temperature smoke. Raising the barrier height to 1.2 m presented no worthwhile gain. Best exhaust performance was achieved with 12 vents in double-row arrangement. A perfect system has a 1 m/5 m smoke barrier with 12 double-row vents for efficient and cost-effective smoke control.

III. SYSTEM ARCHITECTURE OVERVIEW

The smoke exhaust system is implemented with a hierarchical response system for multi-story buildings. The Arduino Uno is a processing unit, reading input from MQ-2 smoke sensors and managing the relay module, servo motors, fans, and GSM module

accordingly. Furthermore, an OLED display gives real-time status updates.



IV. FLOW OF THE CIRCUIT

- Smoke Detection (MQ-2 Sensors)

There are three MQ-2 sensors (each on a different floor) that constantly check the air quality and provide analog signals to the Arduino.
When smoke concentrations cross the set threshold (500), an emergency response is initiated by the system.

- Arduino Processing & Decision Making

Reads analog values from MQ-2 sensors.
Checks which floor is infected and turns components on accordingly:

- If smoke on Ground Floor → All fans ON.
- If smoke detected on 1st Floor → Only 1st and 2nd-floor fans ON.
- If smoke detected on 2nd Floor → Only 2nd-floor fan ON.

- Servo Motor Operation

The servo motor (it's used for the door which opens for fan to exhaust the smoke on the whole floor) rotates 90° when smoke is detected to enable airflow.
It goes back to 0° when there is no smoke detected.

- Relay & Fan Activation

The relay module regulates the normal exhaust fans depending on the location of smoke.
It toggles ON/OFF the fans based on hierarchical logic.

- OLED Display for Real-Time Status

The OLED display indicates messages regarding smoke detection, detailing which floor is suffered by smoke.
It gives real-time feedback to the users.

- GSM Module for Emergency Alerts

The SIM900A GSM module triggers an SMS alert to the owner and fire brigade when smoke is detected.
It also automatically calls to alert emergency responders.

- Loop & Reset Mechanism

The system periodically checks sensor values every 5 seconds and if there is no smoke, the fans switch OFF, servo motors reset, and the display updates accordingly.

A. Components

- Arduino Uno board (Circuit Controller)
- Mq-2 Smoke Sensors
- Servo motors
- Relays
- Exhaust Fan
- OLED Display
- GSM Module

B. Components Specification

- Arduino Uno

i) The main microcontroller that handles sensor data and manages the system.
ii) Reads input from the MQ-2 smoke sensors and activates the relay, servo motor, OLED display, and GSM module based on predefined logic

- MQ-2 Smoke Sensor

i) Detects smoke, LPG, CO, and other gases in the environment.
ii) Provides an analog voltage signal to the Arduino, triggering smoke Exhaustion measures when the threshold is exceeded.

- Servomotor (SG-90)

i) Applied for the control of ventilation dampers or flaps to help exhaust smoke.

ii) Rotates 90° to enable airflow if smoke is present and resets to 0° when it is cleared.

- Relay (Active Low)

i) Serves as an electrical switch to switch ON/OFF the exhaust fans according to Arduino signals.

ii) Provides isolation between Arduino low-voltage signals and high-power fans.

- Exhaust Fan

i) It removes smoke when received signal from the affected area, by creating an airflow.

ii) In this project, fans operate in a hierarchical manner based on which floor detects smoke.

- OLED Display

i) Displays real time messages about the condition of floors regarding smoke and system status.

ii) Helps users identify which floor is affected and whether the system is functioning properly.

- GSM Module (SIM900A)

i) Sends SMS alerts and make emergency calls to notify building owners and fire departments.

ii) Ensures quick response time by providing fire alerts with the location.

C. Simulation Setup and Circuit design of Logic

The system was simulated using WOKWI software.

The circuit diagram, as shown in Fig.1, represents the interconnections of the MQ-2 (Potentiometers), Arduino Uno, Relay Module, Servo Motor, GSM module, and exhaust fans.

The logic consists :

- Case1: When smoke is detected on the ground floor the servomotor of the ground floor will rotate opening the gate covering the fan of the ground floor, and the fans of all floor will turn On to exhaust the smoke from the ground floor level to the uppermost (2nd floor).
- Case2: When smoke is detected on the 1st floor the servomotor of the first floor will activate, which open the gate covering the fan of 1st floor, and the fans of 1st and 2nd floor will be turned On only, as they are sucking the smoke so there is no need for fan of ground floor to be turned On.
- Case3: When smoke is detected on the 2nd floor the servo motor of the 2nd floor will activate, that is opening the gate covering the fan of 2nd floor, and fan of 2nd floor will be turned On only.
- Case4: When smoke is detected on the both ground and 2nd floor the servo motor of the ground and 2nd floor will activate, that is opening the gates of ground and 2nd floor, and fans of all the floor will be turned On. Here gate of 1st floor will be closed for blocking the smoke entering the 1st floor while exhausting.
- Case5: When Smoke is detected on all the floors the servo motor of all floors will be activated, opening all gates and activating all fans.

V. CONCLUSION

This paper introduced an automated smoke exhaustion system to enhance fire safety within multi-level structures. The system incorporates an MQ-2 smoke sensor for real-time monitoring, an Arduino Uno microcontroller for making decisions, and exhaust fans operated by relays and servo motors for efficient smoke exhaust. The GSM module (SIM900A) promotes quick response through instant notification to building occupants and firefighting teams. The simulation showed that the system responds dynamically upon smoke detection to turn on fans depending on the floor affected to avoid smoke piling up and minimizing suffocation hazards. In contrast to traditional fire alarm systems that only give warnings, this system provides an active ventilation system that greatly enhances evacuation conditions. The hierarchical fan activation strategy guarantees that smoke is evacuated effectively without spreading to other floors, thus making it a viable solution for high-rise buildings and enclosed areas.

Although the simulation results confirm the efficiency of the system, more can be improved. Future directions involve integrating more sensors, including temperature sensors for measuring fire intensity, improving fan efficiency through AI-based control algorithms, and using IoT-based cloud monitoring for real-time visualization. Additionally, hardware implementation in real-world settings will be an important step toward large-scale deployment.

This study underscores the significance of automated smoke exhaustion as a principal aspect of fire safety, providing an affordable and scalable solution to prevent fire dangers and provide occupant protection prior to the arrival of emergency personnel.

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