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Auditorium Power Control and Fire Detection System

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Abstract: *The Auditorium Power Control and Fire Detection System is a microcontroller-based project designed to automate power management and enhance safety within auditoriums and large halls. The system integrates sensors to monitor temperature and smoke levels in real-time, ensuring efficient energy use and quick detection of fire hazards. When abnormal conditions such as excessive heat or smoke are detected, the system automatically disconnects the power supply and triggers an alarm to alert occupants. Under normal conditions, it intelligently controls lighting and electrical loads to optimize energy consumption. This project combines automation, safety, and energy efficiency into a single platform using components such as Arduino, temperature and smoke sensors, relays, and buzzers. It demonstrates a cost-effective solution for modern auditorium management and can be further expanded with IoT-based remote monitoring and alert systems for improved reliability and response time.*

Keywords*:* Arduino, Temp. Sesensor, Relay, Buzzer etc

I. INTRODUCTION

A short circuit, an overheated electrical appliance, a lit cigarette, a burning splinter or just about any of these can trigger a fire and the presence of foam sofa sets, nylon settings and other flammable materials works as a catalyst and the poisonous gases and smoke is generated. So it hardly needs a few minutes to spread the fire and render persons helpless, even before they realize what is happening. The fire alarm system that is installed in our university is not so advanced and the systems that are currently available in the market have high initial cost as well as it requires more maintenance.

An Auditorium Power Control and Fire Detection System is an advanced automation and safety project designed to manage electrical power efficiently and ensure fire safety within large public spaces such as auditoriums, conference halls, and theaters. In such venues, multiple electrical devices like lighting, sound systems, air conditioning units, and projectors operate simultaneously, leading to high power consumption. Therefore, an automated system is essential for optimizing energy usage and maintaining safety standards.In modern auditoriums, managing electrical power efficiently and ensuring safety against fire hazards are two critical requirements. Manual control of lighting, fans, and other electrical systems often leads to energy wastage and delayed response in case of emergencies.

To overcome these issues, automation technology using Arduino can be employed to create a smart and reliable solution. The Auditorium Power Control and Fire Detection System using Arduino is designed to automatically control the electrical power supply and detect any signs of fire or smoke in the environment. It uses sensors such as temperature (LM35/DHT11) and smoke (MQ-2) to continuously monitor the surrounding conditions. When abnormal conditions are detected such as high temperature or smoke the Arduino immediately activates an alarm and cuts off the main power supply using relays, preventing potential damage or accidents.

This system not only enhances safety but also helps in reducing energy consumption by automating the control of electrical appliances based on need. It demonstrates how microcontroller-based automation can transform traditional systems into smart, responsive, and energy-efficient solutions suitable for public places like auditoriums, halls, and conference centers.

II. LITERATURE REVIEW

Issaka D et al. (2025) This research proposes an IoT-based fire detection and suppression system that enables real-time monitoring and automated response. Using an ATmega328p microcontroller, RF transceivers, flame and smoke sensors, and NodeMCU (ESP8266), the system detects fires with high accuracy through sensor fusion, reducing false alarms. Upon confirming a fire, it activates alarms and controls a jockey pump to release water via sprinklers, while transmitting data to a remote server for continuous supervision.

Rakshan S et al. (2025) This paper introduces a smart home safety system that integrates advanced sensors and automation to protect against disasters like fires and earthquakes. It continuously monitors environmental and seismic conditions, providing real-time alerts through sensors and a buzzer. A servo motor performs automatic actions such as closing windows or doors during emergencies. The system, programmed using Arduino IDE and embedded C, offers flexibility and customization to enhance home safety and emergency response.

Hossain MA et al. (2025) This project develops an IoT- and cloud-based centralized waste management system to improve waste collection efficiency and sustainability. Implemented at Pabna University of Science and Technology (PUST), it uses smart dustbins equipped with ultrasonic and gas sensors, a NodeMCU ESP8266, and servo motors for real-time monitoring of waste levels and odors. The system sends automated email alerts with location details, supports a mobile app to find nearby dustbins, and leverages cloud computing for data analysis and remote monitoring. Overall, it promotes cleanliness, hygiene, and eco-friendly waste management through automation and predictive analytics.

Burchan et al. (2019) The paper examines the potential use of fire extinguishing balls as part of a proposed system, where drone and remote-sensing technologies are utilized cooperatively as a supplement to traditional firefighting methods. The system consists of courtingunmanned aircraft system (UAS) to detect spot fires and monitor the risk of wildfire approaching a building via remote sensing, communication UAS to establish and extend the communication channel between scouting UAS and firefighting UAS, and a fire-fighting UAS. One has to be very skillful in controlling drones and also the system is very complex which makes the system unreliable.

Qin et al. (2018) Designed an intelligent smoke alarm system with wireless sensor network using ZigBee. The system consists of a smoke detection module, a wireless communication module, and intelligent identification and data visualization module. The disadvantage of his system is that it is very expensive and complex to design.

Izang et al. (2018) Designed An SMS Based Fire Alarm and Detection System. The system works when fire or gas is detected by the sensors, the Arduino will trigger the GSM module to send SMS, sound the alarm system and trigger the servo motor. The disadvantage of this system is that the servo motor works at an angle of 170 degrees and hence cannot reduce fire outbreak as compared to using a pump motor.

Jinan (2018) Designed and Implemented a Factory Security System that consist of a smoke sensor, a GSM (Global System for Mobile communication) module and a sound module. When the gas leakage is detected, an SMS will be sent to a number. The disadvantage of the system is that there is no device that can stop the gas leakage and hence, when there is fire outbreak the necessary deviceto extinguish the fire is not included in the system which may cost loss of properties.

Poonam et al. (2014) Designedan Intelligent Fire Extinguisher System. the features are intelligent fire detection and suppression, locate the position of fire origin, effective power control of electricity, reporting through an SMS or email and effective usage of water supply, among the sensors used is a gas sensor which detect any type of smoke, this can send a false alarm and hence not reliable.

III. BACKGROUND OF THIS PROJECT

Fire-Smoke Detection and Weather Data Collection

The main S&T result of WP3 is the development of algorithms and software for fire and smoke detection based on optical and IR cameras. The developed software enables early detection of fires in large open areas and can be used for the protection of forests and cultural heritage areas, as well as for the detection of fires in landfills, industrial areas (chemical fires, warehouses) and military training areas. Computer vision based flame detection Optical cameras and video-based algorithms provide an effective and low cost solution for the detection of flames at an early stage. However, video-based flame detection systems are affected by several limitations that challenge their performance such

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as the presence of sun reflections, car lights, bad lighting conditions, poor image quality, movements of fire-like coloured objects, etc. To overcome the aforementioned drawbacks, partners focused on improving existing algorithms and developing three new techniques for flame detection. The developed algorithms offer increased detection rates and lower false positive ratios compared to the literature. BILKENT developed a covariance matrix based fire detection method for video sequences. The algorithm divides the video into spatiotemporal blocks and uses covariance-based features extracted from these blocks to detect fire. Both the spatial and the temporal characteristics of flame coloured regions are exploited. Unlike other algorithms used for similar tasks, the proposed method does not use background subtraction, which means that it does not require a stationary camera for the detection of moving flame regions and can, therefore, be also used with moving cameras. This is an important advantage because fixed cameras may sway because of the wind or a PTZ camera can slowly pan an area of interest to detect fire.

CERTH's flame detection

Detected flame blobs are illustrated as coloured regions. CERTH developed a video based flame detection algorithm, which initially applies background subtraction and colour analysis to identify candidate flame regions on the video frames and subsequently distinguishes between fire and non-fire objects based on a set of five extracted features including colour probability, spatial variation, temporal variation (flickering), spatiotemporal variance and contour variability of candidate blob regions. Classification is based either on classifiers trained with fire and non-fire video frames or on a rule-based approach. Finally, SUPCOM developed a real-time flame detection system for video sequences captured by both fixed and moving (PTZ) cameras. First, moving objects are detected in each frame.
Then, a set of flame characteristics including colour, temporal intensity variance, spatial intensity variance, shape variation and shape complexity are extracted and classified as flame or non-flame using a set of fuzzy Context Independent Variable Behaviour (CIVB) classifiers.

Computer vision based smoke detection

Generally, the two video compression standards MJPEG and MPEG2 are commonly available in most cameras. They both involve a blockwise Discrete Cosine Transform (DCT). SUPCOM's first contribution for designing such smart camera functionality consists of exploiting the local fractal feature of smoke areas based on the DCT coefficients. The second novelty relies in refining the estimation of the fractal feature by considering larger blocks of coefficients to increase detection accuracy without Page 11 of 97 increasing the complexity. This technique could be very useful in low bit-rate transmission applications.

PIR sensor based fire detection

A flame detection algorithm developed by BILKENT utilizes pyro-electric infrared (PIR) sensors, with two versions: one for PCs and a standalone system using digital signal microprocessors. This system leverages differential PIR sensors, sensitive to sudden temperature changes, to analyze signals through Markov models related to flame flicker and human activities. Unlike conventional point smoke detectors, which rely on particle detection and are ineffective in large spaces, the PIR system monitors infrared light from flames, allowing for efficient fire detection in larger areas with high detection rates and low false alarms. Additionally, the system incorporates a flood detection sensor and includes software platforms for smoke and flame detection, both online and standalone, capable of real-time monitoring and integration with multiple cameras. Weather data for the system is sourced from local stations and national meteorological agencies. Furthermore, a novel wireless sensor network (WSN) has been developed for environmental monitoring and fire detection using affordable, long-lasting batteries.

Forset Fire detection using wireless sensor

In recent years, various forest fire detection systems have been developed, with video surveillance being the most common. These include visible-spectrum cameras (detecting smoke and flames), infrared thermal imaging (detecting heat), IR spectrometers (analyzing smoke gases), and LIDAR systems (measuring light backscatter from smoke). However, these methods often produce false alarms due to environmental factors like fog or dust.To improve accuracy

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and response time, modern systems use IoT-based sensors to monitor environmental conditions such as temperature, humidity, pressure, and gas concentrations (CO, CO_2) in real time. Sudden changes in these parameters can indicate potential fire risks or adverse weather conditions. The proposed system integrates IoT devices with secure communication, data encryption, and authentication protocols to ensure reliable and safe transmission of environmental data and alerts.

IV. EXISTING SYSTEM

In most traditional auditorium setups, power control and fire detection are managed independently and often manually, leading to inefficiencies in both energy management and safety response. The existing system generally relies on human operators to control electrical equipment and standalone fire alarms for safety, with very little integration or automation.

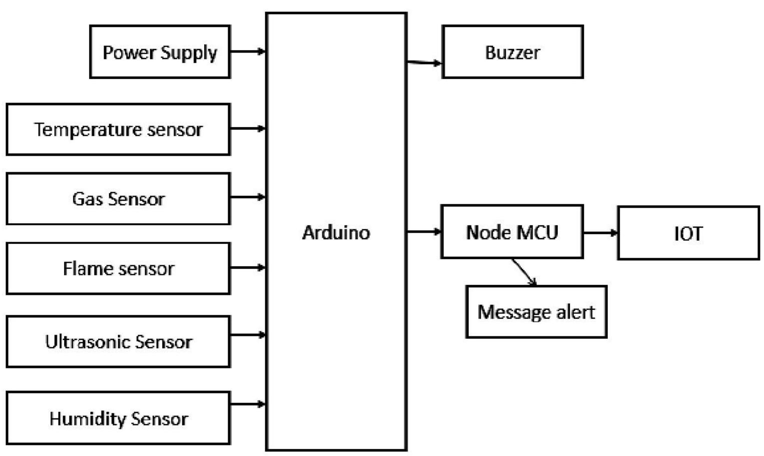
Limitations of Existing Fire Detection:

- Delayed response time due to human dependency.
- No automatic isolation of power to prevent electrical fires.
- Lack of integration with other systems (lighting, ventilation, alarms).
- No remote monitoring or alerting through SMS, app, or network.
- Difficult maintenance faults in detectors are often unnoticed until an inspection.

The existing system in auditoriums is inefficient, uncoordinated, and outdated. It depends heavily on human intervention for both power control and fire safety. This leads to unnecessary energy consumption, slower emergency response, and reduced overall safety. Hence, there is a clear need for an integrated, microcontroller-based power control and fire detection system that can automate operations, monitor in real-time, and respond immediately during emergencies to ensure both energy efficiency and occupant safety.

V. PROPOSED METHOD

The effectiveness and quick response in emergency management are crucial to reducing casualties. Real-time analysis of environmental conditions using IoT sensors which monitor temperature, humidity, pressure, and gases like CO and CO_2 can help detect or prevent disasters such as forest fires.



The proposed system continuously monitors these parameters and uploads data to the IoT cloud . When sensor readings exceed preset thresholds, it automatically sends an alert email to the user. Unlike existing systems that rely on robots for firefighting, this approach focuses on early detection and monitoring. Additionally, the system ensures secure communication between IoT devices, web services, and mobile platforms using data encryption, secure authentication, and block cipher algorithms for safe data transmission.

Each IoT device in the auditoriums fire detection system communicates wirelessly via 4G with a central web service that stores and processes data. These devices are Arduino-based and equipped with sensors to measure temperature, humidity, atmospheric pressure, and pollutant gases like CO and CO_2 (for air quality monitoring).
The system also provides Automatically manage and optimize electrical loads (lights, HVAC, AV equipment) to save energy, Detect fire early (smoke/heat/flame) and trigger automated safety actions (alarms, evacuation lights, power isolation), Provide manual override and remote monitoring/control, Log events for maintenance and safety audits.

Hardware

- Central controller: Arduino Mega / ESP32 / STM32 or small PLC (depends on scale)
- Smoke detectors: Photoelectric smoke sensors (ceiling-mounted)
- Heat detectors: Fixed temperature or rate-of-rise sensors in service areas
- Flame sensors: IR/UV for stage machinery areas (optional)
- Gas (CO) sensor: optional for fuel-powered equipment rooms
- Occupancy sensors: PIR + ultrasonic or seat sensors for accurate detection
- Ambient light sensor (LDR) for daylight-linked control
- Contactors / Motorized circuit breakers for mains loads (lighting, HVAC, projector)
- Solid-state relays or mechanical relays for low-voltage circuit
- HMI: 7–10" touchscreen or keypad + status LEDs
- Communication: ESP32 Wi-Fi / Ethernet module / GSM module (for SMS)
- UPS / Inverter for emergency circuits
- LCD display

VI. CONCLUSION

The Auditorium Power Control and Fire Detection System successfully integrate automation, safety, and energy management into a single intelligent platform. By combining microcontroller-based control with sensor technology, the system ensures efficient power usage while providing reliable fire detection and emergency response. Through the use of sensors such as PIR (for motion detection), LDR (for lighting control), and smoke or flame sensors (for fire safety), the system can automatically regulate the electrical equipment in the auditorium based on real-time conditions. This not only helps in reducing energy wastage but also enhances operational convenience by minimizing manual intervention.

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