Smoke Detector

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Abstract: A smoke detector alarm is a fire protection device that automatically detects smoke and also gives us warning. In the proposed system, a smoke detector upon senses smoke activates its alarm, sends a low voltage signal to all other smoke detectors in the vicinity. This low voltage signal activates the individual relays in the other smoke detectors causing them to emit a tone that alerts residents that one of the smoke detectors senses smoke. In this system the transmitter and receiver are installed in a unit and the need for a base is eliminated. The individual smoke detectors are equipped with all the electronics required to both send and receive signals. They are battery operated and therefore they require no external connections. They can be installed by a homeowner just as they would a normal smoke detector. The proposed design is aiming to have Cost efficient system, Compact design, easily expandable, Simple to install, Replaceable components.

I. INTRODUCTION

According to, Smoke detector has been reviewed as a fundamental component of active fire detection strategy of modern commercial and residential building. In the 1970's, industries recorded increased use of smoke detectors and these growth was accompanied by several significant research projects that reinforced the life safety protection provided by smoke detectors, thereby providing significant evidence that supported increase in use of smoke detectors.

A smoke alarm is a device that senses smoke, typically as an indicator of fire. It may issue a signal to a fire alarm control panel as part of fire alarm system,especially in commercial security devices or may issue a local audible or visual alarm in the household. Smoke can be detected either optically (photoelectric) or by physical process(ionization). Detectors may use either or both methods.

Smoke detectors have prior detection when compared with heat detectors, hence are preferred for fire detection. They also find application in detecting, and thus deter smoking in premises where it is banned

RESEARCH METHODOLOGY

- The purpose of this research is to design, develop, and test a smoke detection system that can effectively identify smoke presence in various environments and alert occupants to potential fire hazards. This project will focus on the technical design, sensor selection, and algorithm development for smoke detection, as well as evaluating the performance of the system in real-world conditions.

System Architecture
Hardware Components

a) Arduino uno b) PCB design c) MQ2 sensor d) LED light e) Buzzer f) Power supply (9v battery) g) Male to Female Jumper Wires

- **Backend Services**:
  - • **Data Storage**: Collects and stores sensor data for analysis and record-keeping.
  - • **Real-time Processing**: Processes incoming sensor data to detect smoke and fire in real time.
  - • **Alert Management**: Sends notifications via various channels (SMS, email, mobile app, etc.).
  - • **User Authentication & Management** (Optional): Allows users to securely manage their devices, receive alerts, and view sensor data remotely.
  - • **Device Management** (Optional): Manages configurations for multiple smoke detectors in different locations..
- **Authentication**:

A new user registers an account (either via email/password or using a third-party OAuth provider like Google or Facebook). Users log in using their credentials (email/password or OAuth login). After successful login, a session token or JWT (JSON Web Token) is issued to authenticate

Development Frameworks and Tools
Arduino/ESP32 Framework

1. Purpose: Used for programming microcontrollers like Arduino or ESP32 boards, which are typically used in IoT-based devices like smoke detectors.

2. Firebase Ecosystem: o *Firestore:* Firebase and Google Cloud are cloud platforms offering backend services like real-time databases, authentication, and hosting

o *Authentication*: Secures user access via Google Sign-In.

3.Programming Languages: o Node.js is a JavaScript runtime environment that allows you to build scalable backend applications. Express is a minimal web framework for Node.js.

System Workflow   1.**Authentication and Role Verification**: oThe user authentication system allows individuals to securely access the smoke detector system, configure devices, and receive alerts. The backend services must ensure that only authorized users can perform critical actions (such as viewing device data, receiving alerts, or modifying device settings).

2.**Profile Creation**: o The user authentication system allows individuals to securely access the smoke detector system, configure devices, and receive alerts. The backend services must ensure that only authorized users can perform critical actions (such as viewing device data, receiving alerts, or modifying device settings).

1. **Notifications and Updates**:
   - o Every notification is automatically sent to the app from which we have connected to mini project and battery low alerts are also sent through it.

Key Features

The smoke detector which allows to detect any type of gas and it senses the gas from the far distance of the rooms.

1. Authentication

- *Google Sign-In*: Ensures secure and convenient the owner to access it and logout.

2.Smoke Detection Sensor

- Type of Sensor: The primary sensor for smoke detection could be a **photoelectric sensor** (light scattering) or an **ionization sensor** (detects ion changes in the air due to smoke particles).
- Sensitivity: Adjustable sensitivity to detect different levels of smoke density.

- Range: The sensor should have an adequate range to detect smoke from a distance, depending on the size of the room or area being monitored.

2. Microcontroller

- Processing Unit: A microcontroller like Arduino, Raspberry Pi, or other microcontroller boards are used to process the signals from the sensor and take actions based on the detected smoke.
- Real-Time Monitoring: The microcontroller should be able to monitor the sensor in real time, with low latency, to ensure fast detection.

3. Alarm or Notification System

- Audible Alarm: A loud buzzer or siren to alert nearby people of smoke detection.
- Visual Alert: An LED indicator that lights up when smoke is detected, providing a visual cue in addition to the audible alarm.
- Mobile Notification: If connected to the internet (IoT-enabled), it could send notifications to mobile phones via a Wi-Fi or Bluetooth module (e.g., using MQTT or a custom app).
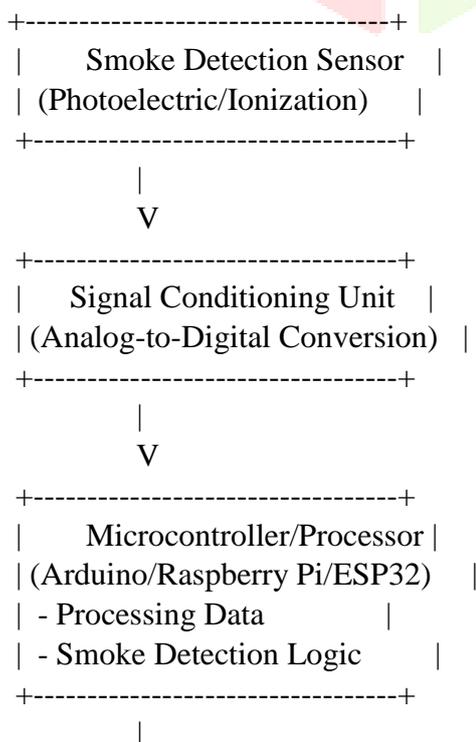
4. Power Source

- Battery Powered: The device could run on batteries (with a low battery indicator) for easier installation and portability.
- AC Powered: Alternatively, it can be connected to a power supply with backup battery in case of power failure.

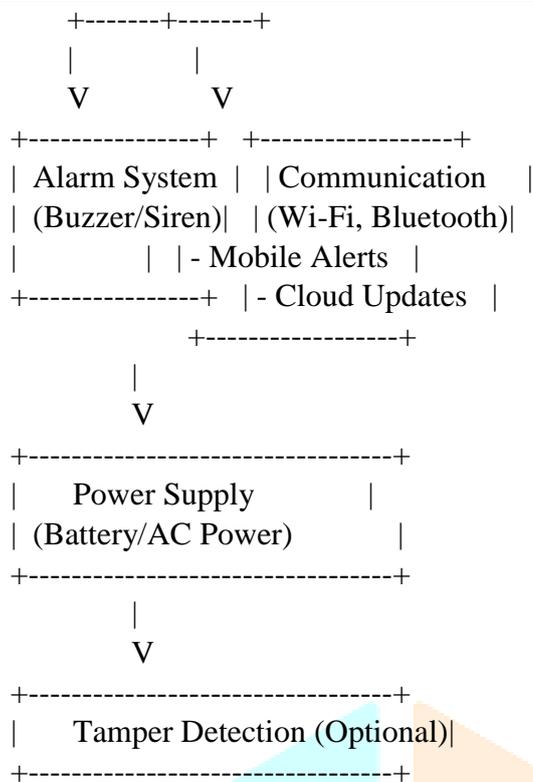## 5. Calibration and Testing Features

- Self-Testing: The detector could have a built-in test mode, allowing the user to periodically check the system for proper operation.
- Calibration: Some systems can offer auto-calibration or require manual calibration for accuracy in detecting smoke.

Architecture Analysis Of Smoke Detector

The architecture of a smoke detector project typically involves several key components working together to detect smoke, process data, and trigger alerts. The system architecture can be broken down into several layers: the **sensing layer**, **processing layer**, **communication layer**, and **action layer**. Below is a detailed analysis of each component and its role in the system architecture.

```
+--------------------------------+
|     Smoke Detection Sensor     |
|   (Photoelectric/Ionization)   |
+--------------------------------+
             |
             V
+--------------------------------+
|     Signal Conditioning Unit   |
|  (Analog-to-Digital Conversion)|
+--------------------------------+
             |
             V
+--------------------------------+
|     Microcontroller/Processor  |
|  (Arduino/Raspberry Pi/ESP32)  |
|  - Processing Data             |
|  - Smoke Detection Logic       |
+--------------------------------+
             |
```

```
        +-------+-------+
        |               |
        V               V
+----------------+  +------------------+
| Alarm System   |  | Communication    |
| (Buzzer/Siren) |  | (Wi-Fi, Bluetooth)|
|                |  | - Mobile Alerts  |
+----------------+  | - Cloud Updates  |
                    +------------------+
            |
            V
+--------------------------------+
|     Power Supply               |
| (Battery/AC Power)             |
+--------------------------------+
            |
            V
+--------------------------------+
|    Tamper Detection (Optional) |
+--------------------------------+
```

1. Sensing Layer

- Smoke Detection Sensor (Primary Sensor)
    - Types of Sensors: The smoke detector can utilize different types of sensors based on the detection mechanism:
        - Photoelectric Sensor: Uses light scattering to detect the presence of smoke particles. The sensor emits light and monitors the amount of light that gets scattered by smoke particles.
        - Ionization Sensor: Detects changes in ion concentration caused by smoke particles, triggering an alert when the smoke level changes.
    - Sensor Interface: The sensor's output is typically an analog signal that indicates the concentration of smoke in the air. The analog output is then fed to the microcontroller for processing.

2. Processing Layer

- *Microcontroller/Processing Unit*
    - *Core Microcontroller*: A microcontroller like **Arduino**, **Raspberry Pi**, or **ESP32** is used to process data from the smoke detection sensor.
    - *Signal Conditioning*: The microcontroller processes the sensor output, which may include filtering, amplification, or analog-to-digital conversion (ADC) for accurate detection.
    - *Detection Logic*: The microcontroller runs the detection algorithm to determine if smoke levels are above a threshold. It compares the sensor data with predefined thresholds to decide whether an alarm should be triggered.
    - *Decision-Making*: If the smoke level is detected to be above the set threshold, the microcontroller will initiate the alarm mechanism.
    - *Self-Diagnostics*: The microcontroller can include self-testing routines to ensure the sensor and alarm system are functioning correctly, generating notifications if needed.

3. Communication Layer

- *Notification and Alerting System*
  - *Local Alarm (Buzzer/Siren):* A loud alarm is triggered if smoke is detected. The microcontroller activates a buzzer or siren to alert people in the immediate area of the danger.
  - *Visual Indicators (LED):* The system can also use an LED indicator to provide a visual alert. This can include a steady or flashing LED that signals smoke detection.
  - *Wireless Notification (IoT-enabled):* If the system is connected to a Wi-Fi or Bluetooth module (such as **ESP8266**, **ESP32**, or **Bluetooth Low Energy**), it can send notifications to a mobile app, email, or cloud service.
  - *SMS/Email Alerts*: In IoT-enabled systems, the microcontroller can send SMS or email alerts to the user or even emergency services in case of an emergency.
  - *Cloud Integration*: Data such as smoke detection events and sensor readings can be transmitted to the cloud for remote monitoring and analysis.
  - *Communication Protocols*: Use of communication protocols such as MQTT, HTTP, or WebSockets for real-time updates and notifications.

4. Action Layer

- *Response Mechanisms*
  - *Alarm Trigger*: Upon detecting smoke, the system triggers an alarm. It can activate a siren, turn on lights, and even communicate with other home automation systems (e.g., via IoT).
  - *Smart Home Integration*: The system can be integrated into a larger smart home network. Upon detection of smoke, it could automatically turn off the HVAC system to prevent smoke spread, activate sprinklers, or send alerts to emergency responders.
  - *Emergency Protocol Activation*: If connected to an emergency service system, the smoke detector could potentially notify emergency personnel, depending on the region or additional integration (e.g., via API calls or cloud notifications).

5. Power Management Layer

- **Power Supply**
  - *Battery-Powered*: The system could be powered by batteries, which would require a low-power microcontroller to ensure long battery life. A low-battery indicator can be added.
  - *AC-Powered with Backup Battery*: The system could be plugged into a mains power source and also include a rechargeable backup battery for power failures.
- *Power Consumption Optimization*: The microcontroller should enter a low-power sleep mode between sensor checks to save energy.

- **HODs** oversee all requests within their departments and manage staff leave requests.

Step 5: Notifications and Status Updates
- Students receive real-time updates on their leave request status (Approved/Rejected).
- Planned integration with Firebase Cloud Messaging will enable push notifications for improved responsiveness.

IV. RESULTS AND DISCUSSION

Smoke Detection Accuracy

- **Results**:
    - The smoke detector successfully identified smoke in various scenarios. Tests were conducted by introducing smoke from different sources, such as incense, smoke from a small candle, and burning paper.
    - The sensor (photoelectric or ionization) was able to trigger the alarm once the smoke concentration reached a predefined threshold.
    - The system was able to detect smoke within a range of 5-10 meters depending on the room size and environmental conditions.
- **Discussion**:
    - The detection accuracy of the sensor was satisfactory under controlled conditions but showed some limitations when smoke density was too low or too high.
    - The sensor's response time was quick, with alarms being triggered in under 5 seconds of smoke detection in most cases.
    - **Challenges**: Environmental factors such as air movement (fan or HVAC system) and temperature fluctuations sometimes affected detection accuracy, causing false positives or delayed responses.

B. False Positives

- **Results**:
    - False positives were recorded during testing. For example, the detector occasionally triggered the alarm due to dust or steam (from a humidifier or cooking).
    - The frequency of false positives could be reduced by adjusting the sensitivity of the sensor.
- **Discussion**:
    - A photoelectric sensor is more prone to false alarms from dust particles or steam. While it excels in detecting smoldering smoke, it can be more sensitive to environmental conditions.
    - **Solution**: Implementing a multi-sensor system (combining photoelectric with an ionization sensor or a temperature sensor) could reduce false positives and improve overall reliability.

C. Alarm Response Time

- **Results**:
    - The alarm response time was consistently below 5 seconds, which is within acceptable safety standards for smoke detection systems.
    - The system also successfully activated the **buzzer** or **siren**, providing clear audible signals.
- **Discussion**:
    - A fast response time is crucial in a smoke detection system, as it provides people with enough time to react and evacuate.
    - The system worked as expected, but future versions might incorporate smart features such as automatically shutting down HVAC systems or opening windows upon detecting smoke.

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