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IOT-Based Air Purifier for Indoor Applications

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Abstract

Air pollution has become a critical global issue affecting human health and environmental sustainability. This paper presents the design and implementation of an Internet of Things (IoT)-based air purifier system that monitors and improves indoor air quality in real time. The system integrates *an ESP8266 microcontroller, MQ135 gas sensor, DHT temperature and humidity sensor, a HEPA filtration unit, and an AC fan controlled via a 5V relay module. Sensor data is transmitted to the Thing Speak IoT platform for remote monitoring and analysis. The system provides an efficient, low-cost, and smart solution for maintaining clean indoor air.*

1. Introduction

Air pollution is one of the most serious problems in today's world, especially in indoor environments where people spend most of their time. Dust, harmful gases, and humidity imbalance can affect human health, causing respiratory issues and allergies. To address this problem, an intelligent air of Things (IoT) technology. This project focuses on designing an IoT-based air purifier that not only cleans the air but also continuously monitors environmental conditions and sends real-time data to an online platform. The system uses sensors to

A purification system can be developed using the Internet to detect air quality, temperature, and humidity, and automatically control a fan to purify the air using a HEPA filter.

2. Literature Survey

Recent advancements in the Internet of Things have enabled the development of smart air quality monitoring and purification systems. Many studies focus on using sensors and microcontrollers to monitor environmental conditions and transmit data to cloud platforms for real-time analysis. Research such as "Air Quality Monitoring System: A Comprehensive Overview of an advanced Air Quality monitoring system using Arduino" [8] highlights the use of gas sensors for detecting pollutants and sending data to online platforms. However, most of these systems are limited to monitoring and do not include automatic purification. Sharma P. et al. (2021) [6][10] proposed an IoT-based air purifier that activates automatically when pollution levels rise. Their work demonstrates the importance of combining sensing and control, though it lacks detailed environmental monitoring. Cloud platforms like ThingSpeak [5][7] are widely used for storing and visualizing sensor data, enabling remote monitoring. Hardware components such as the ESP8266 Wi-Fi Module [1][9], MQ135 Gas Sensor [2], and DHT11 Sensor [3] are commonly used due to them Indoor Applications IOT-Based. low cost and efficiency. Filtration methods based on High-Efficiency Particulate Air Filtration [4] are proven to effectively remove airborne particles. However, many existing systems lack integration of monitoring, automation, and purification, which this project aims to achieve in a single smart solution.

3. Research objectives

The principal aims of this inquiry encompass: creating a multi-sensor air quality monitoring system and developing an elegant user interface for both local and remote access, engagement, execution of an adaptive control algorithm for automated purification, and assessment of system performance under regulated environmental circumstances.

4. System architecture & research methodology

4.1 Hardware Configuration

4.1.1 ESP8266 Microcontroller

The ESP8266 is the main controller used in this project. It is a Wi-Fi-enabled microcontroller that allows the system to connect to the internet and communicate with cloud platforms.

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It receives input from the sensors and processes the data to determine whether the air quality is acceptable or not. Based on this decision, it sends signals to the relay module to control the fan. Additionally, it uploads all collected data to the Thing Speak platform using internet connectivity.

Its built-in Wi-Fi capability makes it ideal for IoT applications, as it eliminates the need for additional communication modules.

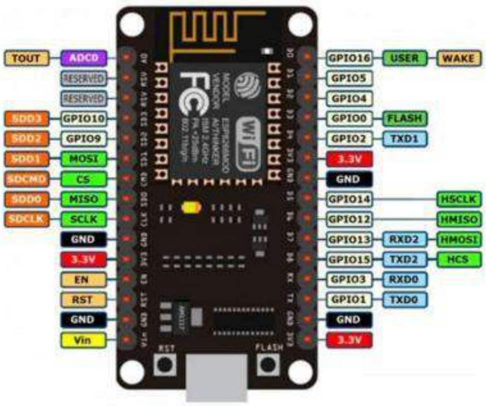

Figure 1: ESP8266

Internal Working

The ESP8266 contains:

- A microprocessor (CPU) that executes program instructions
- GPIO pins for connecting sensors and relay
- A Wi-Fi module that allows internet communication
- Memory for storing code and temporary data

Working Principle

1. ESP8266 connects to Wi-Fi
2. Data is sent using HTTP request with API key
3. Thing Speak receives and stores data
4. Data is displayed as graphs and charts

Role in the the Project

- Reads analog data from MQ135 sensor
- Reads digital data from DHT sensor
- Processes environmental conditions
- Sends commands to relay module
- Uploads sensor data to Thing Speak via Wi-Fi

4.1.2 MQ135 Gas Sensor

- The MQ135 sensor is responsible for detecting air pollution levels. It can sense various harmful gases such as carbon dioxide (CO_2), ammonia (NH_3), benzene, and smoke.

- The sensor produces an analog output based on the concentration of gases in the air. This output is read by the ESP8266 and used to estimate air quality.
- When the concentration of pollutants increases, the sensor value rises. The system uses this information to decide when to activate the air purification process.

Figure 2: MQ135

Working

The MQ135 sensor works based on a chemiresistive sensing principle.

It contains:

A sensing element (SnO_2 – Tin dioxide layer)

A heating element

When the sensor is powered:

The heating element heats the sensing material.

In clean air, the sensor has a certain resistance.

When harmful gases (CO_2, NH_3, smoke, benzene) are present:

The resistance of the sensing material changes

This change produces a different voltage output

This voltage is read as an analog signal by the ESP8266.

these factors influence air quality and human comfort.

The collected data is also sent to ThingS peak, allowing users to observe environmental conditions along with air quality

4.1.3 DHT Sensor (Temperature and Humidity Sensor)

Figure 3: DHT Sensor

The DHT sensor (either DHT11 or DHT22) measures temperature and humidity in the environment

The DHT sensor contains:

- A thermistor (for temperature measurement)
- A capacitive humidity sensor
- An internal ADC (Analog to Digital Converter)

Temperature Measurement

- Uses thermistor (resistance changes with temperature)
- Converts resistance into temperature value

Humidity Measurement

- Uses a moisture-sensitive capacitor
- Capacitance changes with humidity level

The sensor processes both readings internally and sends digital output to ESP8266.

Role in the Project

- Measures room temperature
- Measures humidity level
- Sends data for monitoring on ThingSpeak

4.1.4 HEPA Filter

The HEPA (High-Efficiency Particulate Air) filter is a critical component of the air purifier. It is designed to remove very small particles from the air.

HEPA filters can trap up to 99.97% of particles as small as 0.3 microns, including dust, pollen, smoke, and bacteria.

In this system, when the fan is turned ON, air is forced through the HEPA filter. The filter captures harmful particles and ensures that only clean air is released back into the room.

HEPA filters use mechanical filtration to trap particles. They consist of a dense mat of randomly arranged fibers

Air passes through the filter, and particles are captured using three mechanisms

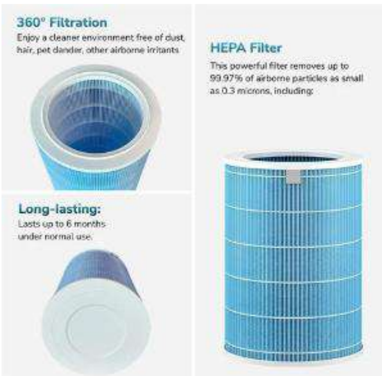

Figure 4: HEPA

1. **Interception**
   - Particles stick to fibers when passing close
2. **Impaction**
   - Larger particles collide directly with fibers
3. **Diffusion**

- Very small particles move randomly and get trapped

Efficiency

- Removes 99.97% of particles ≥ 0.3 microns
- Effective against:
- Dust
- Pollen
- Smoke
- Bacteria

Role in the Project

- Filters polluted air drawn by the fan

Improves indoor air quality significantly particles such as dust, smoke, and allergens, and releases clean air back into the environment.

At the same time, all sensor data is transmitted via Wi-Fi to the ThingSpeak IoT platform, where it is displayed in the form of graphs. This allows users to monitor air quality remotely in real time.

When powered ON, the ESP8266 runs the programmed code. It continuously reads input signals from connected sensors such as MQ135 and DHT. Based on these inputs, it performs logical decisions and controls output devices like the relay.

It provides digital output, which makes it easy to interface with the ESP8266. Monitoring temperature and humidity is important because

4.1.5 AC Fan

- The AC fan is used to circulate air through the purifier. It draws polluted air into the system and pushes it through the HEPA filter.
- The efficiency of the purification process depends on the airflow generated by the fan. A stronger airflow results in faster purification of the air.
- The fan operates only when needed, which helps in saving energy.

Role in the Project

- Creates air flow required for filtration
- Ensures continuous air purification

4.1.6 5V Relay Module

- The relay module acts as a switch that allows the ESP8266 to control the AC fan.
- Since the fan operates on high voltage and the ESP8266 works on low voltage (3.3V), direct connection is not possible. The relay provides electrical isolation and allows safe switching.

When the ESP8266 sends a signal to the relay, it either turns the fan ON or OFF depending on air quality conditions.

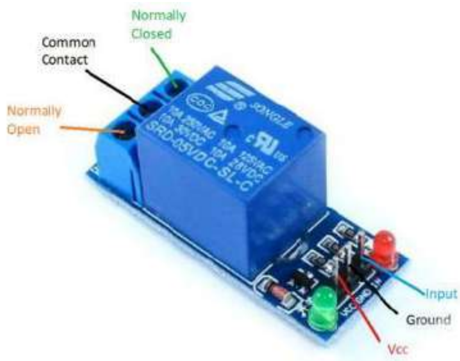

Figure 5: Relay

Internal Working

- A relay consists of:
- Electromagnetic coil
- Switch contacts (NO/NC)

When a voltage is applied:

- Current flows through the coil
- A magnetic field is generated
- The switch contacts change position
- Circuit is either completed or broken

Role in the Project

- Acts as interface between ESP8266 and AC fan
- Turns fan ON/OFF based on air quality

4.2 Software Implementation

Thing Speak IoT Platform

- ThingSpeak is a cloud-based platform used to store and visualize data collected from the system.
- The ESP8266 sends sensor data to ThingSpeak using an API key over the internet. The platform displays this data in graphical form, making it easy to analyze trends over time.

Users can access this data remotely from anywhere, which makes the system highly convenient and efficient

4.3 Working Principle of the System

The device operates by perpetually monitoring ambient air conditions and responding accordingly. The MQ135 gas sensor identifies hazardous chemicals in the atmosphere, whereas the DHT sensor gauges temperature and humidity levels. The sensor values are transmitted to the ESP8266 microcontroller, which serves as the central processing unit. The ESP8266 evaluates the air quality level and juxtaposes it with a predetermined threshold. In the event of subpar air quality, the controller engages a relay module that operates the AC fan.The fan subsequently draws contaminated air through the HEPA filter. The HEPA filter captures detrimental particles. 4.4 System Operation Flow

1. Sensors continuously monitor air quality, temperature, and humidity.

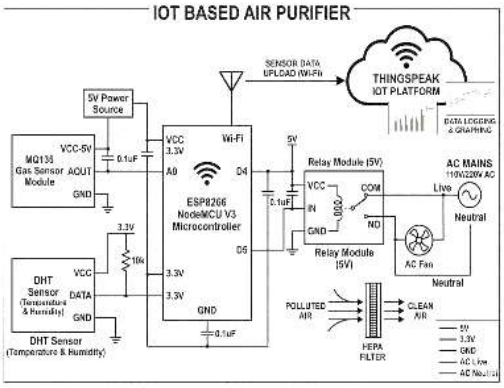

Figure: 6 Block Diagram

2. ESP8266 reads and processes sensor data
3. If pollution level exceeds the threshold:
4. Relay is activated
5. Fan turns ON
6. Air is purified through HEPA filter
7. If air quality is normal:
8. Fan remains OFF
9. Data is sent to ThingSpeak for remote monitoring

4.5 Cloud integration and system operation flow

Thing Speak is a cloud-based platform utilized for the storage and visualization of data gathered from the system. The ESP8266 transmits sensor data to Thing Speak using an API key via the internet. The platform presents this data graphically, facilitating the analysis of trends over time. Users can remotely access this data from any location, rendering the system exceptionally accessible and efficient. The operational mechanism involves the ESP8266 establishing a Wi-Fi connection and transmitting data via an HTTP request accompanied by an API key, whereby Thing Speak receives, archives, and visualizes the data through graphs and charts for remote surveillance. The system operates by utilizing sensors that continuously measure air quality, temperature, and humidity. The ESP8266 acquires and analyzes this sensor data. Upon surpassing the pollution threshold, the relay activates, the fan engages, and air is cleansed via the HEPA filter. If the air quality is normal, the fan remains OFF, and the sensor data is relayed to Thing Speak for remote monitoring. monitoring.

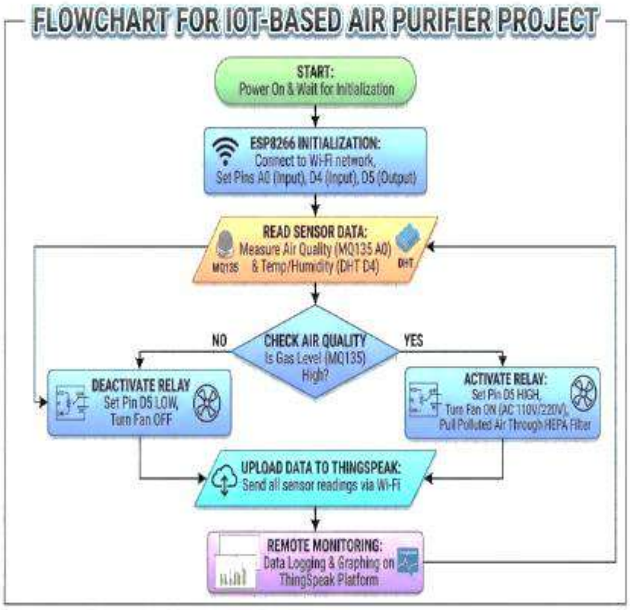

Figure 7: Flow chart

5. Conclusion

This research demonstrates the effective design and execution of an IoT-based air purification system that incorporates real-time monitoring alongside automatic air purification. The system integrates sensors, a microprocessor, and cloud connectivity to detect environmental changes and respond intelligently, thereby ensuring optimal indoor air quality.

The MQ135 gas sensor and DHT sensor provide ongoing monitoring of air pollution, temperature, and humidity, while the ESP8266 guarantees effective data processing and wireless communication. The automatic fan activation via a relay module, along with HEPA filtration, constitutes an efficient method for eliminating dangerous airborne particles. The interface with the Thing Speak platform enables users to remotely monitor environmental conditions, hence improving usability and awareness.

The suggested system provides a cost-efficient, energy-conserving, and scalable approach for managing indoor air quality. It illustrates the practical implementation of IoT in environmental surveillance and regulation. Future enhancements may encompass the use of sophisticated sensors for enhanced pollution detection, mobile application support, and machine learning algorithms for predictive air quality assessments, thereby becoming the system more intelligent and adaptive.

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