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AUTONOMOUS AIR PURIFIER USING IOT WITH CLOUD-BASED MONITORING

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ABSTRACT

Air pollution has emerged as a major environmental and health concern due to rapid industrialization and urban expansion. Indoor air contamination, in particular, can lead to respiratory disorders, allergies, and reduced quality of life. This paper presents the design and implementation of an autonomous air purification system integrated with Internet of Things (IoT) technology and cloud-based monitoring. The system employs gas sensors to continuously detect pollutants such as carbon dioxide, smoke, and harmful gases. A NodeMCU microcontroller processes the sensor data and automatically regulates the purification mechanism without human intervention. Real-time monitoring is achieved using a cloud platform, enabling users to visualize air quality data and receive alerts through a mobile application. The proposed system offers a cost-effective, energy-efficient, and intelligent solution for maintaining healthy indoor environments.

KEYWORDS: IoT, Air Quality Monitoring, Node MCU, Autonomous System, Cloud Computing, Air Purifier

I. INTRODUCTION

Air quality plays a critical role in human health and environmental sustainability. Increasing levels of pollutants such as particulate matter, carbon monoxide, and volatile organic compounds have raised serious concerns globally. Poor indoor air quality is associated with respiratory diseases, cardiovascular problems, and decreased productivity. Traditional air purifiers operate manually and do not respond dynamically to changes in air quality. This leads to inefficient energy usage and delayed purification. With the advancement of Internet of Things (IoT) technology, intelligent systems can be developed to monitor and control air quality automatically. This paper proposes an IoT-based autonomous air purifier that continuously monitors indoor air quality and adjusts its operation accordingly. The system integrates sensors, a microcontroller, and cloud connectivity to provide a smart and efficient solution.

A. Need for Autonomous Air Purification

Air pollution has become a major concern in modern environments due to rapid urbanization and industrial activities. Indoor air quality is often more critical than outdoor air, as people spend a significant amount of time inside homes, offices, and other enclosed spaces. Pollutants such as carbon dioxide, smoke, and volatile organic compounds can accumulate indoors and lead to serious health issues.

Traditional air purifiers operate manually and are not capable of responding dynamically to changes in air quality. This results in inefficient operation, increased power consumption, and delayed purification. Therefore, there is a growing need for intelligent systems that can monitor air quality in real time and automatically adjust their operation.

Research Paper

An autonomous air purification system addresses these challenges by integrating sensors, microcontrollers, and IoT technology. It continuously monitors environmental conditions and activates purification mechanisms only when required. This improves efficiency, reduces energy consumption, and ensures a healthier indoor environment.

II. LITERATURE REVIEW

Recent research has focused on IoT-based air quality monitoring systems that utilize sensors and microcontrollers to collect environmental data. Many systems use ESP8266 or ESP32 controllers along with MQ-series gas sensors to detect pollutants in real time.

Cloud platforms such as Blynk and ThingSpeak are widely used for data visualization and remote monitoring. Some advanced systems integrate machine learning algorithms to predict pollution trends and optimize performance.

However, most existing systems focus only on monitoring and lack autonomous control of purification mechanisms. The proposed system addresses this limitation by combining real-time monitoring with automatic purification, ensuring efficient and responsive operation.

A. IoT-Based Air Quality Monitoring Systems

Recent developments in Internet of Things (IoT) technology have enabled the design of smart systems for monitoring indoor air quality. These systems typically use environmental sensors to measure parameters such as carbon dioxide (CO_2), volatile organic compounds (VOCs), particulate matter, temperature, and humidity. The collected data is processed using microcontrollers such as ESP32 or NodeMCU and transmitted to cloud platforms for real-time monitoring and analysis.

B. IoT-Based Air Purification and Automation Systems

- In addition to monitoring, recent research has focused on integrating air purification mechanisms with IoT systems to enable automated control. These systems use gas sensors such as MQ-135 to detect harmful gases including carbon dioxide, ammonia, and smoke. Based on the sensor readings, the microcontroller controls purification components such as fans and filters.
- Some systems employ threshold-based control strategies, where the purification process is activated when pollutant levels exceed predefined limits. Advanced implementations also include cloud connectivity for real-time data visualization and user alerts. The use of IoT platforms enables remote monitoring and control, improving system usability and efficiency.

III. PROPOSED SYSTEM

The proposed system is an IoT-based autonomous air purification system designed to monitor indoor air quality in real time and control purification mechanisms automatically. The system utilizes gas sensors such as MQ-135, MQ-4, and MQ-6 to detect harmful gases including carbon dioxide, smoke, and other pollutants present in the environment. A NodeMCU (ESP8266/ESP32) microcontroller acts as the central processing unit, acquiring sensor data, analyzing air quality levels, and making decisions based on predefined threshold values. When the pollution level exceeds safe limits, the microcontroller activates a relay module to operate the fan and filtration system, thereby purifying the air. Once the air quality improves, the system reduces its operation or turns off to conserve energy. Additionally, the system is integrated with a cloud-based IoT platform, enabling real-time monitoring, data visualization, and alert notifications through a mobile application. This approach ensures efficient, intelligent, and energy-optimized air purification with minimal human intervention.

A. System Architecture

The proposed system consists of three main units: sensing unit, control unit, and actuation unit. The sensing unit includes MQ-135, MQ-4, and MQ-6 gas sensors that detect harmful gases and pollutants. The control unit is based on the NodeMCU (ESP8266/ESP32), which processes the sensor data and determines the air quality level. The actuation unit consists of a relay module, fan, and filter system that performs air purification based on the control signals.

B. Working Principle

The system operates by continuously monitoring air quality using sensors. The Node MCU reads sensor data and evaluates the air quality level. If the pollution level exceeds a predefined threshold, the system automatically activates the fan and filter to purify the air. Once the air quality improves, the system reduces its operation or turns off to conserve energy. This ensures efficient and autonomous functioning.

C. Cloud Integration

The system is integrated with a cloud platform using IoT technology. The Blynk IoT platform is used to display real-time air quality data through a mobile application. Users can monitor air quality levels, receive alerts when pollution exceeds safe limits and remotely control the system if required. This enhances accessibility and user convenience.

IV. HARDWARE IMPLEMENTATION

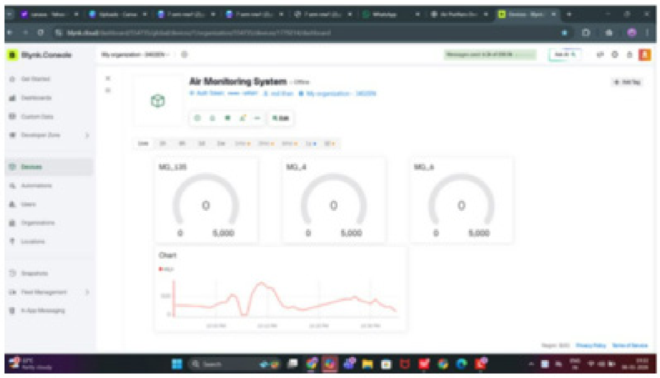
Fig. "Air Purifier"

The hardware components used in the system include NodeMCU (ESP8266/ESP32), MQ-135 gas sensor, MQ-4 and MQ-6 sensors, relay module, DC fan, air filter, OLED display, and power supply unit. The NodeMCU acts as the central controller, collecting sensor data and controlling the operation of the fan and filter through the relay module. The OLED display provides real-time air quality information.

V. SOFTWARE IMPLEMENTATION

The system software is developed using Arduino IDE. The program reads sensor values, processes the data, and determines the air quality index. Based on the processed data, control signals are sent to the relay module to operate the fan and filter. The system also communicates with the Blynk IoT platform to upload data for real-time monitoring and alert generation..

VI. RESULTS AND DISCUSSION



The implemented system successfully monitors indoor air quality and responds automatically to pollution levels. When pollutant concentration increases, the purification system is activated immediately, resulting in improved air quality. The cloud-based dashboard provides real-time data visualization and alerts, enhancing user awareness. The system demonstrates reliable performance, efficient energy usage, and accurate monitoring.

VII. ADVANTAGES AND APPLICATIONS

A. Advantages

The system offers several advantages, including autonomous operation, real-time monitoring, energy efficiency, low-cost implementation, and remote accessibility through IoT platforms.

B. Applications

The proposed system can be used in homes, offices, hospitals, smart buildings, and industrial environments where maintaining air quality is essential.

VIII. CONCLUSION AND FUTURE SCOPE

This paper presents an IoT-based autonomous air purifier capable of monitoring and controlling indoor air quality efficiently. The system ensures improved air quality with minimal human intervention while optimizing energy consumption. Future enhancements may include the integration of advanced sensors such as PM2.5 and temperature sensors, implementation of machine learning algorithms for predictive analysis, and deployment in smart city environments.

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