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IOT BASED AIR POLLUTION MONITORING SYSTEM

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Abstract: Air pollution has become a significant global issue, primarily due to the release of harmful gases such as CO2, SO2, NO2, and CO into the atmosphere. These hazardous gases mix with the air and are difficult to predict. Therefore, there is a need for a tool to assess air quality. Monitoring air pollution can be achieved through internet-connected devices like the Internet of Things (IoT). IoT devices can gather data and analyze it to determine whether the air quality is acceptable. Consequently, the air quality in specific areas can be tracked using IoT devices and sensors, such as those based on Arduino technology. This research aims to gather information on environmental factors and facilitate seamless integration into various internet-based systems (IoT), enabling the use of sensors that collect data related to smart city environmental measurements, ultimately providing insights into pollution related information. The proposed system consists of a display, a cloud server, sensors, microcontrollers, and a Wi-Fi module. Sensor nodes are strategically placed in various locations to wirelessly transmit air quality data to a gateway. Once collected, the gateway forwards the data to the cloud server for further processing and analysis. The system's online interface offers real-time updates on air pollution levels, while the cloud server manages the data analysis. Additionally, the technology can notify users when air quality declines, helping them take necessary precautions. This system can aid policymakers in implementing effective strategies to reduce air pollution and safeguard public health by providing real-time air quality information.

***Index Terms* -** Gas sensor, Node mcu, DHT11, Wi-fi module.

INTRODUCTION

Air pollution is a significant issue for every country, regardless of its level of development. The release of harmful gases can lead to serious health problems for both humans and animals, including lung cancer, eye irritation, and respiratory issues. Other negative effects of pollution include mild allergic reactions in the throat, eyes, and nose, as well as more severe conditions like bronchitis, heart disease, pneumonia, and worsened asthma. These health issues often arise when industries fail to adhere to government regulations aimed at reducing emissions. The rate of health problems is increasing, particularly in urban areas of developing nations, where industrial growth and a rising number of vehicles contribute to most levels of air pollution.

In today's technological age, the IoT is rapidly evolving. Manufacturing and other industries are placing a high priority on employee health and safety. The IoT connects physical devices to wireless networks, enabling remote monitoring and control. Environmental issues, particularly air and noise pollution, can lead to significant disasters. The main objective is to identify and measure air pollution levels. Every nation, whether developed or developing, grapples with the critical challenge of air pollution. The initiative aims to enhance environmental conditions by effectively, reliably, and accurately monitoring pollution levels in industrial settings. This involves tracking hazardous gas-es and comparing high pollution rates to standard levels, alerting individuals when air quality drops below a certain threshold to ensure safety. The current monitoring system utilizes an Arduino controller along with two sensors (MQ6 and MQ135), displaying results on an LCD (Liquid Crystal Display). Advances in technology have made it feasible and economical to develop low-cost sensors, allowing us to focus on factors that affect both human and environmental health. The main goal of the Internet of Things (IoT) is to connect physical devices, referred to as "things," that are equipped with sensors, software, and other technologies to share and exchange data over the internet. An IoT ecosystem includes smart devices that utilize embedded systems like processors, sensors, and communication hardware to gather, transmit, and respond to data from their surroundings. These devices can monitor various air quality indicators, including particulate matter, carbon monoxide, Sulphur dioxide, and nitro-gen oxides. Sensors are generally divided into two types: physical sensors, which track parameters like temperature, humidity, and pressure, and chemical sensors, which detect air pollutants.

IoT plays a vital role in combating air pollution by collecting real-time data and facilitating informed decision making. For instance, air quality sensors can assess pollutant levels in different settings such as urban areas, industrial sites, and homes. This information can be analyzed to pinpoint pollution sources, implement targeted strategies for reduction, and evaluate the success of pollution control efforts. IoT driven smart city initiatives enhance transportation, waste management, and energy use, leading to lower emissions and better air quality. Additionally, personal air quality monitors powered by IoT technology enable individuals to make educated decisions and steer clear of pol-luted areas. By harnessing IoT capabilities, we can pro-actively tackle air pollution, develop sustainable solutions, and foster healthier environments for current and future generations. As the population increases, so does travel, energy consumption, and waste generation, con-tributing to severe air pollution that poses a significant threat to all living beings. Monitoring and safeguarding air quality in urban areas, especially with the rise in businesses and residents, has become a pressing concern.

3.1 RELATED WORKS

Air pollution poses a significant challenge in developing nations such as India, leading to early deaths and economic repercussions. The rapid growth of urban areas contributes to environmental and traffic problems, resulting in the depletion of resources in densely populated cities. The idea of smart sustainable cities can aid in managing resources effectively and curbing overconsumption, which contributes to air pollution. Utilizing the Internet of Things for air pollution prediction and monitoring is vital for environmental protection. The adoption of electric vehicles and bicycles can help mitigate air pollution, and forecasting pollution levels is crucial for individuals to select optimal travel routes. This study highlights the necessity for prompt and effective measures to address air pollution [1]. Air pollution poses a significant challenge in developing nations such as India, leading to early fatalities and economic repercussions. The rapid growth of urban areas contributes to environmental and traffic problems, resulting in the depletion of resources in densely populated cities. The idea of smart sustainable cities can aid in managing resources effectively and curbing overconsumption, which contributes to air pollution. Utilizing the Internet of Things for air pollution prediction and monitoring is vital for environmental protection. The adoption of electric vehicles and bicycles can help mitigate air pollution, and forecasting pollution levels is crucial for individuals to select optimal travel routes. This study highlights the necessity for prompt and effective measures to address air pollution [2]. This paper introduces an IoT platform designed for monitoring air pollution, with the goal of streamlining the process, delivering real-time data to the public, and encouraging citizen involvement in monitoring efforts. The platform utilizes affordable, readily available hardware for sensor nodes, which can be either portable or mobile, along with an innovative sensor management middleware that allows for remote control of operational settings and minimizes data volume. Two data visualization applications have been created: a mobile-friendly air pollution meter and a spatial representation of air pollution levels using Geographic In-formation System (GIS) technology. The platform has undergone testing in several measurement campaigns, with one campaign in Rabat, Morocco, demonstrating its effectiveness [3]. Air pollution is a major problem caused by industrial and technological progress, which has led to the irresponsible exploitation of natural resources. This issue includes the release of various pollutants such as cigarette smoke, fungi, fermentation byproducts, and carbon dioxide. The research focuses on monitoring, illustrating, and predicting pollution levels through AI methods. It utilizes IoT and AI technologies to enhance the effectiveness of pollution control systems. The study explores the need for im-proved sustainable toxicology in air pollution detection through AI, aiming to promote public health and over-come the shortcomings of traditional monitoring sys terms while reducing overall expenses. The proposed redesign seeks to implement advanced technology and established functions to quickly assess air quality when harmful pollutants are detected [4]. Air pollution is a prevalent issue today, characterized by the contamination of the air through physical, biological, or chemical changes that can harm living organisms and hinder their survival. The primary contributors to air pollution are the release of harmful gases from industrial waste and the burning of fossil fuels. The consequences of air pollution are severe, leading to climate change, soil degradation, various health issues, and more. There-fore, it is crucial to monitor air quality, as long-term exposure to polluted air can lead to serious health problems such as heart disease and lung cancer. We have developed a system that utilizes sensor-based hardware to measure air contamination levels, which transmits data directly to a connected server, allowing users to access it easily via a mobile application. Sensors will be strategically placed in various locations, such as industrial areas and traffic zones, to assess air pollution levels, helping users choose safer routes. A key feature of this system is its ability to identify areas with lower pollution levels near roads and industrial sites, enabling protective measures to be implemented [5].

This section included an overview of the Current Methodology as well as a description of the particular operating procedures of the suggested Methodology. In an IoT (Internet of Things) scenario, the sensor data will be gathered and sent to the MCU node for data collection. The analog output produces a voltage be-tween 0 and 4 V, corresponding to the level of hazardous gas present, when the concentration of hazardous gas in the environment surpasses a preset threshold that can be adjusted using a potentiometer on the mod-ule. 0 V denotes the lowest concentration of hazardous gas, while 4 V denotes the highest concentration.

The main aim of the IOT Air Monitoring System is to address the increasing problem of air pollution in con temporary society. Monitoring and managing air quality is crucial for the health and well-being of everyone in the future. The IoT offers an affordable and flexible solution that is becoming increasingly popular. Urbanization has led to a rise in the number of vehicles on the roads, and weather conditions play a significant role in this issue. Pollution can cause more significant health issues like lung infections, heart disease, pneumonia, bronchitis, and developing asthma in addition to mild allergic reactions like irritation of the nose, throat, and eyes. We can efficiently analyze, interpret, and present the results by keeping an eye on the levels of air and noise pollution.

An air pollution monitoring system utilizing IoT technology is an effective resource for governments, organizations, and individuals to track and manage air quality in their daily lives. This system employs sensors to detect airborne pollutants and sends the data to a server in real-time. The information is subsequently analyzed and presented in accordance with environmental standards, and an application is provided for authorized users to monitor air quality remotely.

In this model, the Arduino Uno, which communicates with all the sensors, is connected to the power source. The gadget evaluates the surroundings in a matter of minutes and shows the results on the LCD screen. Using the ESP8266 Wi-Fi module, the Arduino Uno establishes a connection to the cloud server (Thing-Speak), which is where all the data and graphs are generated. Data collection and transmission via the Wi-Fi module to the Thing Speak server are managed by the Arduino Sketch. The Arduino IDE is used to develop, compile, and upload the Arduino sketch to the board. Additionally, a buzzer is integrated into the system to sound an alarm if the gas sensor detects levels exceeding 200 PPM, indicating air pollution.

The approach for this project involves analyzing the rising levels of air pollution in a specific area. To accurately measure gas levels at different locations, various types of sensors need to be deployed. Several sensors have been connected to the microcontroller using the ADS1115. Each sensor captures the analog values of different pollutants, and the real-time data gathered is processed before being sent to the microcontroller via the ADC for further analysis. After processing, the Node MCU will relay the sensor data to both the LCD connected to the microcontroller and the Internet. Thing Speak is used to monitor the results from the Node MCU. Whenever the Node MCU connects to the Internet, the readings can be observed.

3.2 SYSTEM MODEL AND PROBLEM STATEMENT

This model based on IoT technology is presented, featuring an air quality sensor called "Smart-Air" along with a web server. This system leverages IoT and cloud computing to allow for remote monitoring of indoor air quality at any time. Smart-Air was designed using IoT technology to effectively track air quality and transmit data to a web server in real time via LTE. The device includes a microprocessor, sensors for detecting pollutants, and an LTE modem. It is designed to measure aerosol concentrations, volatile organic compounds (VOCs), carbon monoxide (CO), carbon dioxide (CO2), and temperature-humidity levels.

PROPOSED METHODOLOGY

The proposed system aims to provide information on temperature, humidity, and air quality by using the MQ-135 sensor, which can be calibrated to detect and display various gases. The MQ-135 is a type of gas sensor that identifies, measures, and monitors a wide array of airborne chemicals, such as ammonia, alcohol, benzene, smoke, and CO2. It operates on a 5V power supply and has a current consumption of 150mA. For accurate readings, it requires a 20-second preheating period before use. To address these challenges, a public Android application is being developed, allowing users to access real-time pollution data in their vicinity. This app integrates with an Arduino to monitor individual gases. Components:

A. DTH11-Temperature and humidity sensor
B. MQ-135 Gas sensor
C. Node MCU ESP2866
D. Bread Board

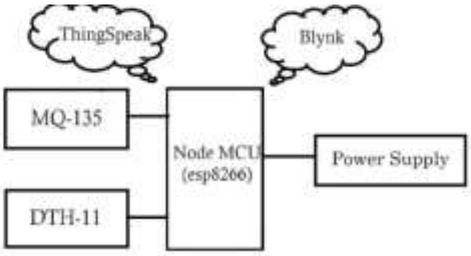

Figure 1:Block Diagram.

A. DHT-11 Sensor

The DHT11 is a widely utilized sensor for measuring temperature and humidity. It features a dedicated NTC thermistor for temperature detection and an 8-bit microcontroller that outputs temperature and humidity data in a serial format. This sensor is factory calibrated, making it easy to connect with other microcontrollers. It can measure temperatures ranging from 0℃ to 50℃ and humidity levels from 20% to 90%, with an accuracy of ±1℃ and ±1%. Therefore, if you need measurements within these parameters, the DHT11 may be a suitable option for you.

The DHT11 operates using a capacitive humidity sensing element and a thermistor for temperature measurement. The humidity sensor consists of two electrodes separated by a moisture-retaining dielectric material, which causes changes in capacitance as humidity levels fluctuate. The integrated circuit processes these changes in resistance and converts them into digital data. For temperature measurement, the sensor employs a Negative Temperature Coefficient (NTC) thermistor, which decreases in resistance as temperature rises. To achieve a significant resistance, change even with minor temperature variations, the sensor is typically constructed from semiconductor ceramics or polymers. The DHT11 has a temperature range of 0 to 50 degrees Celsius with a 2-degree accuracy and a humidity range of 20 to 80% with a 5% accuracy. It has a sampling rate of 1Hz, providing one reading per second. The DHT11 is compact and operates on a voltage of 3 to 5 volts, drawing a maximum current of 2.5mA during measurements.

Figure 2:DHT-11 Sensor.

B. MQ-135 Gas Sensor

The MQ-135 gas sensor is designed to identify smoke and various harmful gases. It can detect a range of dangerous gases, including ammonia (NH3), nitrogen oxides (NOx), alcohol, benzene, smoke, and carbon dioxide (CO2). This sensor is particularly sensitive to ammonia, sulphide, and benzene vapours, as well as smoke and other toxic gases. The module incorporates the MQ-135 air quality and hazardous gas detection chip, along with components like the LM393 analogue comparator chip, facilitating its integration into projects aimed at detecting harmful gases. It operates on a 5V power supply and offers both a digital logic output (1 or 0) and an analogue output (0-4V). The digital output is LOW (0) when no gas is present, but it switches to HIGH when the concentration of hazardous gas in the environment exceeds a threshold set by a potentiometer on the module. The analogue output voltage varies from 0 to 4V, reflecting the concentration of hazardous gases, with 0V indicating the lowest concentration and 4V indicating the highest.

Figure 3:MQ-135 Sensor.

C. Node MCU ESP8266

Node MCU V3 is an open-source firmware and development kit that is essential for creating your own IoT products using just a few lines of Lua code. The board features multiple GPIO pins, allowing it to connect to various peripherals and support PWM, I2C, SPI, and UART serial communications. The Node MCU (Node Micro Controller Unit) is built around the affordable ESP8266 System-on-a Chip (SoC), which is an open-source software and hardware development platform. Manufactured by Espressif Systems, the ESP8266 includes key computer components such as a CPU, RAM, Wi-Fi networking, and even a modern operating system and SDK, making it ideal for a wide range of Internet of Things (IoT) applications. Node MCU comes in different package styles, but all share the same ESP8266 core. While some designs maintain the standard 30-pin layout, they may differ in footprint size, with some using a narrow (0.9) design and others a wider (1.1) design, which is an important factor to consider. The most popular Node MCU models include the Amica, which has the standard narrow pin spacing, and the LoLin, which features wider pin spacing and a larger board. The open-source nature of the ESP8266 allows for the continuous development of new Node MCU variants in the market.

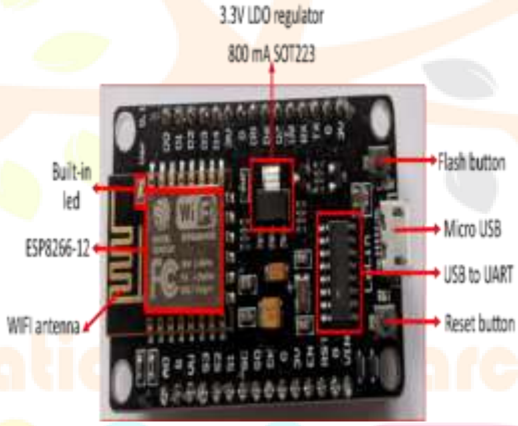

Figure 4:Node MCU ESP8266.

D. Bread Board

A breadboard is a plastic board featuring a series of interconnected holes that facilitate the easy insertion and connection of components using jumper wires. Its main characteristics include interconnected holes, power rails, binding posts, and removable sections. Breadboards are widely utilized for circuit prototyping, testing and debugging, educational purposes, experimentation, and temporary projects. To operate a bread-board, you insert components such as resistors, capacitors, transistors, and Integrated Circuits (ICs) into the holes, connect them with jumper wires, and link power sources to the power rails. Typically, breadboard lay-outs consist of horizontal rows that are internally connected and vertical columns linked to power rails. When using a breadboard, it's important to plan the layout to reduce the need for long jumper wires, keep wires short to prevent clutter, and ensure that all connections are secure and correctly positioned. Bread-boards are vital tools for both novices and seasoned engineers, offering a versatile and reusable platform for circuit design and testing.

Figure 5:Bread Board.

IV. RESULTS AND DISCUSSION

Data on various air contaminants were efficiently collected by the IoT-powered air pollution monitoring system with Node MCU. The air quality variations that were detected over time by the sensors used in this study were detectable, and the data was transmitted to the cloud platform without any problem. The information that was collected was visualized using appropriate visualization and analysis tools, and the results are listed below.

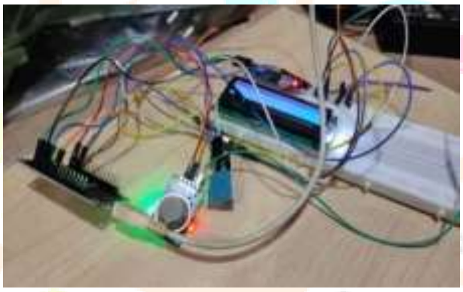

Figure 6:Working Model.

V. CONCLUSION

In this research, we created and deployed an IoT-enabled air pollution monitoring system that can collect, transmit, and analyze data in real-time. Our system effectively tracked air quality by assessing important environmental factors, including temperature, humidity, and levels of different pollutants (such as CO_2, SO_2, NO_2, and CO). The gathered data was saved in a CSV file format for later analysis. To improve our insights and forecasting abilities, we utilized various machine learning algorithms on the dataset, primarily concentrating on predicting the heat index, temperature, and humidity using the available information.

1. Heat Index Prediction:
    - We employed the Random Forest Regressor to predict the heat index from temperature and humidity data.
    - The model demonstrated strong performance with a Mean Squared Error (MSE) and an R^2 score indicative of a high degree of accuracy in its predictions.

2. Temperature Prediction:
    - Using the humidity and heat index as features, we trained a Random Forest Regressor to predict the temperature.
    - The model's evaluation metrics (MSE and R^2 score) confirmed its reliability and effectiveness in temperature prediction.

3. Humidity Prediction:
    - Similarly, we trained a Random Forest Regressor to predict humidity levels using temperature and heat index as inputs.
    - The model achieved a satisfactory performance, as evidenced by its MSE and R^2 score.

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