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A WIFI Based Sensor Network for Airborne Air Pollution Monitoring System

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Abstract - The usage of Internet of Things (IoT)-based air quality monitors has accelerated due to increased urbanization and a better awareness of the detrimental health impacts of air pollution. Monitoring air pollution has recently become a critical concern in our culture. Despite the fact that crowdsensing methods may be an adequate answer for metropolitan regions, they cannot be used in rural locations. Instead, deploying unmanned aerial vehicles (UAVs) could be considered a viable option. This project embraces this technique and advocates the use of unmanned aerial vehicles (UAVs) equipped with commercially available sensors for air quality monitoring. Our Pollution Monitoring UAV is in Quadcopter configuration and is capable of monitoring industrial gasses, pollutants and particulate matters present in any environment. It also allows the user to hover the drone at fixed altitudes and to measure the mentioned parameters effectively.

INTRODUCTION

The impact of air pollution on the environment, economy, and health of citizens in afflicted countries cannot be overstated. Some of the major air pollutants include ozone (O3), particulate matter (PM), nitrogen dioxide (NO2), carbon dioxide (CO2), sulphur dioxide (SO2), and carbon monoxide (CO). Some of these pollutants are caused by natural environmental processes, while others are the result of human activities. PM pollution is a type of air pollution made up of extremely small particles and liquid droplets such as acids, chemical compounds, metals, and soil or dust particles. Airway inflammation, lung epithelial damage, and a decline in mucociliary clearance are all indications of ground-level ozone exposure.

A high quantity of NO2 in the respiratory system's airways can irritate them, making respiratory disorders like asthma worse and even creating them. Carbon monoxide pollution causes fatigue, decreased oxygen-carrying capacity, poor perfusion leading to hypoxic cardiac function, and cellular hypoxia. CO2 levels are high, contributing to global warming and affecting marine species' reproduction. In humans, CO2 pollution can cause irregular heartbeats and seizures, as well as severe acidosis and anoxia. Rapid burning of the nose, throat, and respiratory tract, as well as bronchial and alveolar edoema, airway injury, and respiratory trouble or failure, can all result from ammonia (NH3) exposure. Air pollution has an adverse effect on both the climate and agricultural produce.

We suggest in this study that unmanned aerial vehicles (UAVs) equipped with commercial and off-the-shelf (COTS) electronics and sensors be used to create an air pollution monitoring service that uses bioinspired approaches as its principal control mechanism. These options allow for automatic coverage of a specified area as well as the discovery of a broad area's pollution distribution by prioritizing the most contaminated zones within it.

RELATED WORK

Monika Singh et al. suggested an Air Pollution Monitoring System in August 2019. This system detects many types of gases in the atmosphere using an Arduino microcontroller and MQ135 and MQ6 gas sensors. It was then attached to a Wi-Fi module that connected to the internet, and an LCD was used to show the output to the user, with a buzzer notifying the user when the ppm surpassed a preset level. Their applications included industrial perimeter monitoring, indoor air quality monitoring, site selection for reference monitoring stations, and data distribution.

In November 2018, Yamuna Thangam et al. used IoT to measure gas concentrations using several sensors that were observed using an Arduino serial monitor. This data is captured in Thing Talk channels using an Ethernet shield, and it is available in real time for analysis.These studied data were visualized in a graphical way using thing speak. After that, using matlab analysis, the average pollution level was computed, and the time-controlled findings were displayed using an android app.The air quality index value was also obtained using the android app based on the location. In addition, the health implications of pollution were highlighted in this app so that users could stay informed about pollution levels.

Poonam Pal et al. created a method to monitor the air using an Arduino microcontroller in October 2017. They used an Arduino to manage the entire operation and a MQ135 gas sensor to identify several types of hazardous chemicals. The MQ135 gas sensor's output is in the form of voltage levels, which must be converted to PPM. A Wi-Fi module connected the entire process to the internet, and the visual result was shown on an LCD. The buzzer sounds and the LCD and webpage display "Poor Air, Open Windows" when the PPM value is less than 1000. When the PPM value exceeds the limit, the buzzer sounds and the LCD and webpage display "Poor Air, Open Windows." If it reaches 2000, the buzzer will continue to ring, and "Danger!" will be displayed on the LCD and on the internet. Take a breath of fresh air.

In 2019, Harsh Gupta and colleagues introduced an Internet of Things-based Air Pollution Monitoring System, which consists of sensors that continuously monitor humidity, temperature, carbon monoxide , LPG, smoke , PM2.5, and PM10 levels in the atmosphere. As part of their endeavour, they created a one-way communication between Thing Speak, an open source cloud platform, and an Android application. To connect the components, the Raspberry Pi was used as a gateway. After the firebase API was integrated into an Android or iOS app, features like Analytics, Authentication, Storage, Messaging, Hosting, Crash reporting, Real-time Database, and others were employed. The graphs were created in Thing Speak based on the sensor data and then presented in a tabular style in an Android app.

In 2017, Nitin Sadashiv Desai et al. presented a device that combines a Beagle bone with air pollution sensors such as carbon dioxide , carbon monoxide , and noise sensors.The sensor's analogue output was read using the Analog pin on the Beaglebone Black, which reads input signals in the range of 0 to 1.8 volts. With the help of python SQL, data from the sensor was uploaded to Azure Cloud.In the form of, a reserved database was built in the beagle bone itself. This is a CSV file. The same data is provided at the conclusion of each day. In the cloud database, a CSV file is uploaded. With the use of an automated shell script, old data in the beagle bone was removed.The Azure database was used to store data from several sensors. This data was retrieved from the database and used as input for the machine learning service.With the use of past data, a machine learning service was utilized to train the module. The sensor data fetched by the beagle bone black was represented using Power BI.

MATERIALS AND METHODS

The KK 2.1.5 board has the ATMEL Mega 664PA, an 8-bit AVR RISC microprocessor with 64K of memory.. It is simple to use for a beginner and comes with pre-installed firmware. The KK 2.1.5 piezo buzzer emits an audible warning when the board is activated or deactivated.Because it includes an inbuilt gyroscope, 6050 MPU, and auto level feature, it is the most stable board. Eight motor outputs, five control inputs, an LCD display, a polarity-protected voltage sensor input, an ISP header, a six-axis accelerometer/gyroscope, and a fuse-protected piezo output are all available on this board. The ATMEL 644PA IC receives user-defined signals from the K.K.board and processes them before sending them to the ESCs on the drone's frame.

ELECTRONIC SPEED CONTROLLER

It is a device that regulates the speed and direction of a motor. It changes the switching rate of field effect transistors in response to a speed reference signal. The speed of the transistor can be altered by altering the duty cycle or switching the frequencies.

BRUSHLESS DC MOTOR

It is a synchronous motor that is powered by a DC source and then converted to an AC electric current by an inverter to power each phase of the motor. It is built similarly to a permanent magnet synchronous motor. High speed and electronic control are two advantages of this motor.

PROPELLERS

Simply put, these are fans that convert the action of the motor into upward thrust. They're made of flexible fibre to avoid breaking in the event of a crash landing.

BATTERY

A lithium polymer battery, sometimes known as a Lipo battery, is a simple rechargeable battery that comes in a variety of current ratings and cell counts. Lithium ion is added to the polymer, which is an electrolyte, in this case.

TRANSMITTER AND RECEIVER

From the user's perspective, the Transmitter serves as a controller. It's a wireless control system that communicates via radio. Through the antenna, the signal from the transmitter is received by the receiver, which is positioned on the Drone's frame. The signal from the receiver is received by the KK board. All electronic speed controllers will receive a signal from this board, allowing the transmitter to control the motor's speed. Pulse position modulation is the modulation strategy utilized between the transmitter and receiver (PPM).

FRAME

Drone frames come in a variety of styles. They're made of fiber and come with a built-in PCB for soldering ESCs and battery cables.The Drone's direction was determined by different color coding.

METHODS

People who spend most of their time indoors are especially susceptible to poor air quality. Tobacco smoke, carbon monoxide, nitrogen dioxide, formaldehyde, asbestos fibres, pathogens, and allergens have all been connected to health problems in the past. Temperature and humidity monitoring are ubiquitous, but in the vast majority of buildings, real-time air quality monitoring is not. In this study, we present an IoT-based air quality measurement system for real-time, low-cost, and easy-to-install air quality monitoring. The proposed system continuously monitors ambient temperature and humidity, as well as harmful gases such as $CO2$, CO, PM10, and $NO2$. The presence of these monitored gases at dangerously high levels is communicated to consumers via a mobile application notification. The ESP32 module was used to build a completely wireless IoT solution that incorporates the IEEE 802.11 b/g/n network protocol.

The full assembly of the system is depicted in Figure 1. You can get real-time data on pollution levels in the environment with a real-time air quality monitoring equipment. It provides precise and detailed information on the air quality of the living environment and supports in the design of air quality actions. An ESP32 microcontroller-based sensor array with built-in Wi-Fi serves as the detection and communication unit, while an Android/iOS-based mobile user interface serves as the mobile user interface. An ESP32 module with a built-in Wi-Fi module is used in the air quality monitoring system. The low-cost, high-performance 32-bit controller is extensively utilised in IoT applications. Wi-Fi, Bluetooth, RF, IR, CAN, Ethernet, temperature sensor, hall effect sensor, and touch sensor are all incorporated into the ESP32, which has a dual-core design and various inbuilt modules for smart home applications. The Harvard Tensilica Xtensa LX6 32-bit Dual Core CPU, which is part of the ESP32 module structure, runs at 240 MHz.

The MQ135 is an air quality sensor that can detect a wide range of gasses, including ammonia (NH3), nitrogen oxide (NOx), benzene, alcohol, smoke, carbon dioxide, and others. For We are detecting carbon dioxide in our project (CO2) with the assistance of this sensor It has a measurement range of 0 to 100 PPM ranges from 10 to 1000. The output of this sensor is in the form of As a result, it must be transformed to a different voltage level. PPM. This can be accomplished by writing the necessary code.It is connected to the computer since it produces analogue output.ESP32's analogue pin.

The GP2Y1010AU0F dust sensor has been used to detect tiny particles such as dust and cigarette smoke, and it has proven to be quite successful. Optical phenomena are used in sensing. The sensor detects dust in the air by detecting reflected light. The pulse pattern of the output voltage allows it to easily distinguish smoke from household dust. It's a battery-powered sensor. It responds to extremely low levels. In less than a second, it reacts. It produces an analogue signal.

DHT11 is a digital temperature and humidity sensor with a very low power consumption, low cost, and a very tiny size. It generates digital data. With a 1°C precision, it can measure temperatures ranging from 0 to 50 degrees Celsius and humidity levels ranging from 20% to 90%.

EXPERIMENTAL SETUP

Fig-1 shows the overall assembly of the system consists of sensors with ESP32.

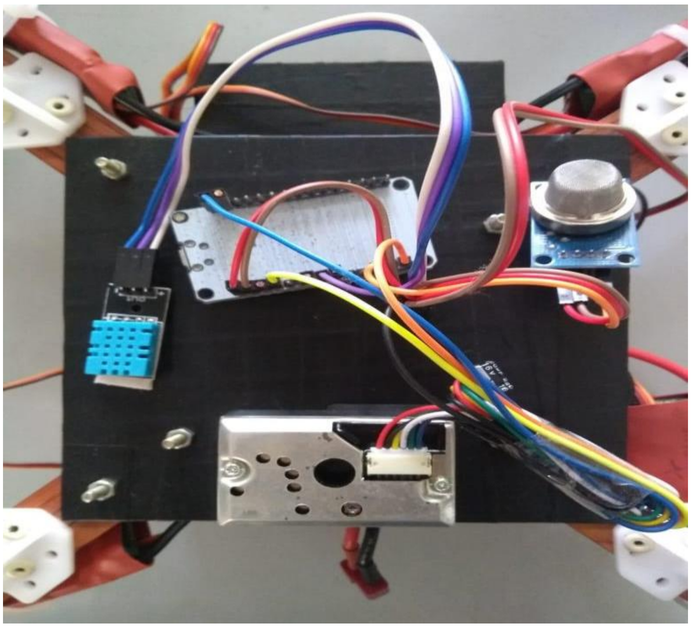

Figure-1: Overall Assembly

In fig-2, Program which was written in Arduino IDE software for uploading to the hardware.

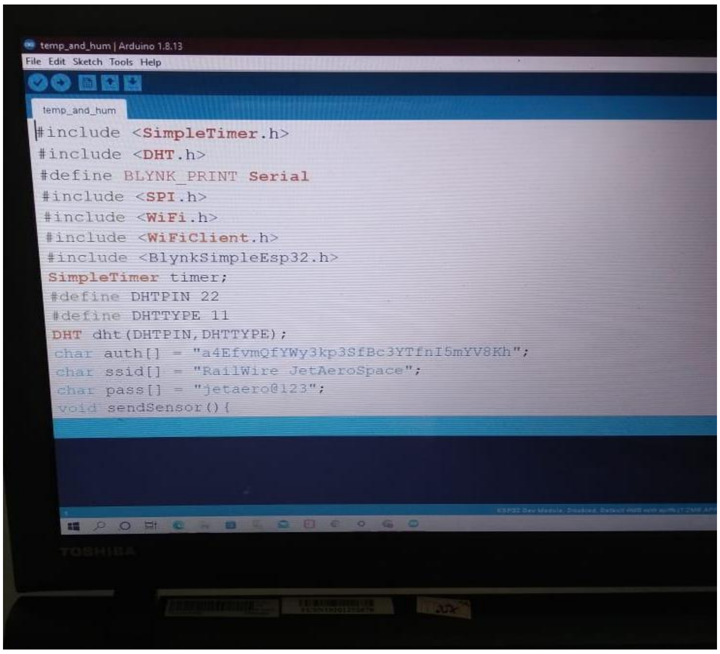

Figure-2: Program in Arduino IDE software

RESULTS

The Result will be displayed in the Blynk app which is downloaded from google play store. The x-axis is the horizontal axis. The y-axis indicates air pollution in parts per million, while the date and time are represented on the x-axis. The below result was taken from the room area of 400 square feet.

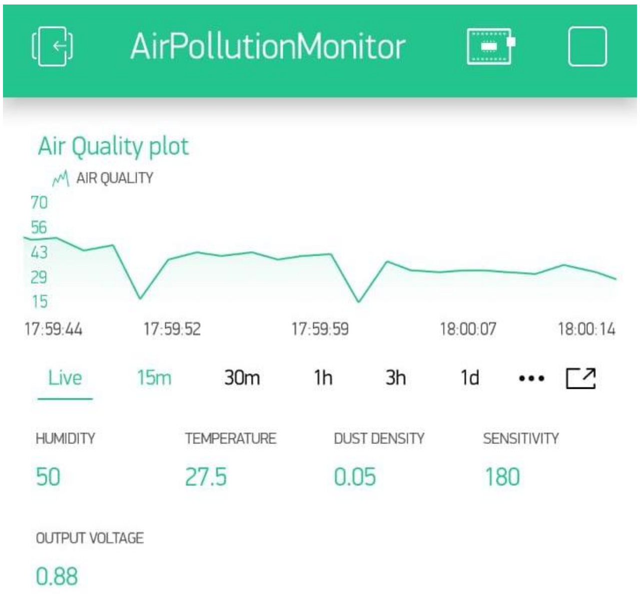

Figure-3: Result of the Project

CONCLUSION

This study offers a system that is cost-effective, low-power, and extremely accurate for monitoring air quality in real-time on a small scale using specialized sensors, alerting people when it exceeds a particular limit, and displaying the data in a way that anybody can comprehend.The air around the installed system may be monitored by anybody, from anywhere, using a phone or a computer, thanks to the Internet of Things concept.The constant updating of data allows users to take timely decisions whenever they are required. This contributes to reducing air pollution in the environment, which is a major concern. It not only saves money and energy, but it also takes up less space and can be installed almost anyplace. This results in increased efficiency and flexibility.

FUTURE WORK

Such a system can be used in two ways, one is as a stand-alone device as shown above or it can be installed in vehicles. By installing it in vehicles, it could make drivers educated and aware about driving patterns they follow and how it is impacting the surrounding and increasing the pollution. Adopting better driving habits will in turn lead to a reduction in pollution. It is going to benefit them as well as others by reducing pollution so everyone can breathe cleaner air.More sensors can be added to the system in the future, extending the system. We can also add a feature to the system that sends an SMS to the user when the amount of any gas in the atmosphere surpasses a specific value. Such systems can also be used on a big scale to assist in the creation of a smart city.

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