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Urban Climate Monitoring System Based on IoT using Arduino Uno

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Abstract—*Air pollution is the biggest environmental problem caused due to large urban agglomerations. WHO reported in 2016 that globally 9 out of 10 people are breathing poor quality air. Particulate matter is the most important contributor in increasing air pollution and has adverse effects on human health such as cardiovascular diseases, respiratory diseases and lung cancer. Annually air pollution is killing around eight lakh people in South East Asian region. Appropriate decision should be taken in timely period. So, there is a strong need of multi parameter urban climate monitoring system. This paper presents a cost effective, stand-alone, multi parameter, urban climate monitoring system for analysis of major air pollutants present in the atmosphere. The system is based on Internet of Things and cloud computing. Internet of Things is the network of internet connected objects which are capable of collecting and exchanging data with the help of embedded sensors. The system is using low cost Arduino Uno Board which collects the data coming from different sensors and transmits the data to the cloud using Ethernet shield. The real-time data sent to the cloud can be monitored in the form of labeled data and graphs anytime on blynk app preinstalled on Android or iOS based mobile phones having internet connectivity. The system has been tested in Delhi and the observation was compared with the data of local environment control authority station. The system gives access to various real time urban air quality parameters: PM 2.5, carbon dioxide, carbon monoxide, temperature, humidity and air pressure.*

Keywords*: Urban Climate Monitoring, Internet of Things, Arduino UNO, Ethernet shield, Blynk Mobile application.*

I. "Introduction"

Air pollution occurs due to presence of harmful substances such as particulates and biological molecules into the earth's atmosphere. Common sources of air pollution are motor vehicles, household combustion devices, forest fires and industrial facilities. It results in allergies, diseases to humans and also harm other living organisms such as food crops and animals [4].

According to WHO report in 2016, more than 80% of the people across the world who are living in urban areas are exposed to air quality exceeding WHO limits [6]. However, this reduces to 56% in high income countries and increases to 98% in low and middle income countries.

Particulate matter above the certain limits in the environment is very harmful and can result in cardiopulmonary diseases and lung cancer [7]. Researchers have paid less attention in monitoring particulate matter. Thus, to address this problem a system is proposed for monitoring PM 2.5 along with other harmful gases such as carbon dioxide, carbon monoxide. Air pressure, Temperature and Humidity are also measured.

Internet of Things converging with cloud computing becomes very powerful. Internet of Things is the network of internet connected objects which are capable of collecting and exchanging data with the help of embedded sensors [2]. Cloud computing is a practice to store, manage and process data on remote server hosted on internet rather than a local server.

In paper, Section II provides the details of related work. The details of the proposed system are described in Section III-V. The readings of measured parameters being monitored are shown in Section VI. Section VII concludes the paper along with the future scope of the study.

II. "Related Work"

Agrawal S., Shete R. [1] proposed a low cost, low power system for monitoring the environmental conditions remotely. Single board minicomputer Raspberry pi is used for implementing the system. Pollutants like carbon dioxide, carbon monoxide and barometric pressure and temperature are measured but particulate matter which has huge contribution in increasing air pollution is left.

Mukesh Jha et. al [2] proposed a complete system which included monitoring of environmental parameters, their modeling and manipulation of urban climate using the available data. According to the authors, after the proper analysis of urban climate there is a scope for improvement in urban infrastructure which in turn can reduce air pollution to some extent.

Elena, Baralis et al [3] provides the framework of APA. The motivation behind the work is to create awareness among the general public about the deteriorating environment due to human activities, increasing industries, increasing vehicles etc. The intelligence engine proposed in this paper collected data

regarding air pollution from different sources like authorities concerned with environment, toxic gases, pollutants etc.

Marin B., Marinov et al [4] used microcontroller based on PIC for monitoring environmental conditions with the help of air quality and gas sensors. The setups are installed in different areas of city for better monitoring. To display the results, authors have made the use of google maps.

Orlando, Xing liu [5] performed a complete study on different objects, smart sensors, devices connected either with each other or with other things present in network over the internet which defines Internet of Things. Tables containing the differences and similarities are presented.

III. "System Design"

The schematic diagram of the proposed system is shown in Fig.1. The system can be further divided into two parts - Software Architecture and Hardware Architecture.

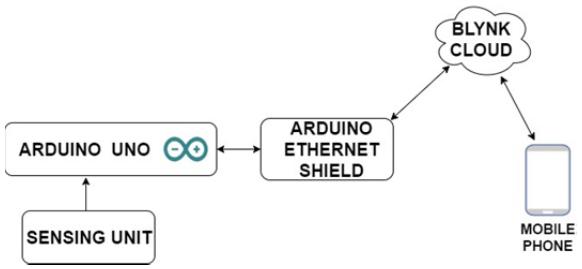

Fig. 1. Schematic Diagram of proposed system

A. "Hardware Architecture"

Hardware Architecture consists of Arduino Uno, Arduino Ethernet Shield and Sensing unit.

1. Arduino Uno

Arduino Uno is a microcontroller board which is based on Atmega 328P. It consists of a 16 MHz quartz crystal, 6 analog inputs, 14 digital input/output pins, a power jack, an ICSP header, a USB connection and a reset button. It can be connected to a computer with a USB cable. Board can operate on 6 to 20 V but the recommended range of operation is 7 to 12 V, but if more than 12 V is applied voltage regulator may overheat and board can be damaged.

2. Arduino Ethernet Shield

Arduino Ethernet shield is used to connect the Arduino Board to the internet using IEEE802.3 af compliant with an RJ45 cable. It is based on Wiznet W5500 Ethernet chip. W5500 provides a network(IP) stack capable of both TCP and UDP. Onboard micro-SD card slot can be used to store files to serve over the network.

3. Sensing Unit

It consists of total 5 sensors. DHT22 is highly accurate and low cost digital humidity and temperature sensor. MQ9 is highly sensitive to CO, methane and propane. It detects CO when heated at 1.5 V. DSM501A is a sensor with high sensitivity used to measure fine particles bigger than 1 micron. MQ135 is suitable for detecting wide range of gases such as Benzene, carbon dioxide, smoke, alcohol etc. BMP180 is a sensor used for measuring barometric pressure.

Table. 1 Sensing Unit

Parameters	Operating Voltage	Measuring Range
Temperature	3.3 V	-40 to +80 degree Celsius
Relative Humidity	3.3 V	0 to 100 % RH
Carbon dioxide	5 V	10 to 10000 ppm
Particulate matter	5 V	10 to 10000 ppm
Carbon monoxide	1.5 V	10 to 10000 ppm
Pressure	3.3 V	300 to 1100 hPA

B. "Software Architecture"

1. Arduino IDE

Arduino IDE is java based software application used to upload program to the microcontroller used in Arduino boards. Sketches are the program written using Arduino IDE and is saved with .ino file extension. Extra functionality in the sketches can be provided by libraries, few comes preinstalled and other can be downloaded from various sources through library manager. Serial data sent from Arduino board can be displayed on the serial monitor.

2. BLYNK

Blynk is an IoT platform with Android and iOs app to control development boards and shields. It is not tied to a specific hardware. It can support wide varieties of hardware such as Arduino, Raspberry pi, intel edision and many more. Device should be connected to internet either by Ethernet, Wi-Fi or in any other way. Data from sensors can be sent to cloud and visualized on blynk app installed on your mobile phone in the form of labeled value, graph by using different widgets available. Once the project is made, it can be published to Google play and App store with your app name and icon on it.

IV. "Methodology"

Blynk app is downloaded on Android or iOs based mobile phone. The New project is created on blynk, the device type like in our case is Arduino Uno and connection type is Ethernet. Blynk provides an Auth Token which is to be used in Arduino code. Now on the other side, Sensors are connected to the analog and digital pins of Arduino Uno. Since it does not have inbuilt internet connectivity so Ethernet shield is used and is mounted at the top of Arduino Uno to connect it to the internet. Arduino Uno is connected to the computer with a USB cable with the help of which sketch is uploaded to the board. Then it is disconnected from the computer and is powered by the external supply. Data coming from the sensors can be seen on the mobile phone in the form of labeled value, graph and much more ways as it depends on the widget used.

V. "Experimental Setup"

The complete experimental setup of the proposed system is shown in Fig. 2. The sensing unit is connected to Arduino UNO, which in turn is connected to Ethernet Shield. Shield is mounted over the Arduino board and providing internet connectivity to whole system. Finally, the data is displayed on Blynk application preinstalled in the android device or iOs.

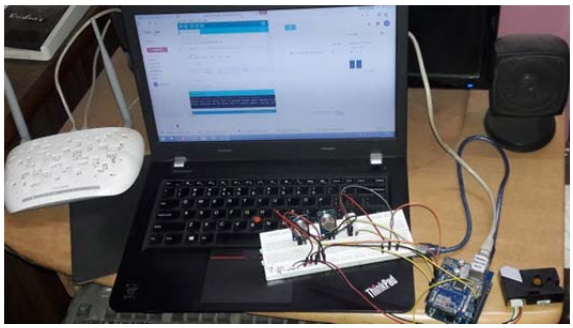

Fig. 2. Experimental Setup of Proposed System

VI. "Results"

The values obtained from different sensors in the Morning time is shown in Table 2.

Table. 2 Comparative Results in Morning Time

Parameters	Measured Value	Expected Value
PM 2.5 (ppm)	87	92
CO (ppm)	55	59
CO2 (ppm)	380	390
Temperature (degree Celsius)	21.5	22
Humidity (percentage)	33.5	34
Pressure (kilo pascal)	98.4	100.23

The values obtained from different sensors in the Evening time is shown in Table 3.

Table. 3 Comparative Results in Evening Time

Parameters	Measured Value	Expected Value
PM 2.5 (ppm)	110	115
CO (ppm)	55	59
CO2 (ppm)	392	402
Temperature (degree Celsius)	23.5	24
Humidity (percentage)	31.5	32
Pressure (kilo pascal)	97.2	99.5

The values from different sensors displayed on the Dashboard of the Blynk app has been shown in Fig. 3.

Fig. 3. Dashboard of Blynk app

VII. "Conclusion and Future Work"

Urban climate monitoring system based on IoT bearing low power and cost has given good results. The system makes the use of air quality and gas sensors to monitor major air pollutants like carbon dioxide, carbon monoxide, PM 2.5. Apart from these, temperature, humidity and air pressure are also measured to have detailed information about the environmental conditions. The system is implemented using Arduino UNO and Blynk. With the help of Ethernet shield, the data collected by the sensors is sent to the cloud and at the same time the results are displayed on mobile application of Blynk. The system is very efficient in terms of hardware and reliable as the sensors used are highly accurate. With the help of this data, appropriate steps can be taken timely to regulate the deteriorating environmental conditions.

Sensors for monitoring the concentration of pollutants like ozone, sulfur dioxide, PM10 etc. can also be included in the existing system to have a complete view of city's environment.

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