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Cost Effective Air Quality Monitoring System Based on Xbee Wireless Sensor Networks

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Abstract

Background/Objectives: Owing to an enormous technological advancement, much research has been done in the communication field related to the Internet Of Things (IOT). Wireless Sensor Network devices (WSN) are the independent devices which can be used to monitor the physical and the environmental conditions for a wide array of applications across different fields. With advancement in technology and increase in population, Air pollution is the most important environmental problem which affects the human lives. **Methods:** LSM (Least Square method) is used to process the sensor data in order to get the accuracy. The sensors like CO_2, CO are used to detect the air pollution levels. For monitoring the air pollution constantly, the WSN nodes with Zigbee communication have been deployed. Xbees are used to transmit and receive the data from one node to another. Arduino Mega will be acting as a web server in-order to store the data into the cloud or server and will be used to connect the IP-enabled device to monitor the pollution. The values detected by the sensors will be accessed or monitored through the IP enabled Android device with an 'Android App'. **Findings:** The Air pollution monitoring systems currently available now are very costly. Hence, an indoor air quality monitoring system is proposed using an Arduino and Zigbee modules, and gas sensors, which is very cost-effective. The possibility of the real-time monitoring and tracking levels of the pollutants in different time periods is also done. **Improvements/Applications:** This method reduces the process and observation noises and also increases the data accuracy.

Keywords: Air Pollution, Internet Of Things, Least Square Based Method, Wireless Sensor Networks

1. Introduction

WSN[1] encompasses a vast number of the router nodes, coordinator nodes and mainly the communication connectivity between the nodes which are deployed in the field. WSN node is having the responsibility to transmit information from one node to another node with their sensing capabilities. The wide range of parameters like hazardous gases, smoke & fog and dust particulates that cause the air pollution in the environment can be measured by the sensors of the WSN. Due to the exponential increase of air pollution and dangerous gases in the environment[2], the constant monitoring of air pollution is having more importance in order to save the lives of human beings.

1.1 Air Pollution

Air Pollution can be categorized mainly into two types. They are indoor and outdoor pollution. Indoor pollution is mainly due the presence of indoor VOC i.e. Volatile Organic Compounds. It is produced by means of inefficient cooking and heating practices which leads to the generation of damaging pollutants like fine particles and CO. Outdoor pollution is mainly due to the presence of hazardous gases like CO_2, SO_2, and NO_2.As per the WHO (World Health Organization) humans are dying more only because of the indoor pollution, i.e., Due to the availability of VOC (Volatile Organic Compounds). Hence, the indoor pollution can be monitored constantly in addition to the outdoor pollution. The air pollution and its changes in the environment cause the instability,

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disorder, and discomfort to the human lives. The strategy of a useful small scaled WSN network[3] at nuclear-powered facilities can be allowed to do the smart real-time monitoring of the radiation levels. The network accumulated by the radiation sensor and the related peripheral devices has been established and applied to the Zigbee technology. The Wireless Sensor Network permits the operators for recording and controlling the levels of the radiation that will be released into the atmosphere and can be maintained through the cushioning system for the exposure of the radiation discharge. A correct planning and a correct investigation are required for the Wireless Sensor Network with the high coverage indoor applications. The ray tracing simulator can be assumed for allowing WSN node deployment prior to the placement. A precise smartphone-centric architecture[4] in which the smartphones are engaged with the health information hubs, sensing, transmitting and processing the devices. Smartphones include the short and the long range of communication. Processing and the sensing can also be able to done smartphones because of their capabilities implemented through different sensors, embedded with GPS, GSM, and Wi-Fi etc. The heterogeneous data should be collected from the patients and the atmosphere. The Zigbee based WSN network[5] can be able to get the real-time values of VOC's, which contains the internal pollutants. The network contains the end devices as the sensors with the detectors like photo ionization, routers can be able to spread the network above the longer distances, and coordinator which connects with the PC. ATmega16 microcontroller can be used for processing data accurately and the Atmel RF230 based ZigBee module can be used for lower power consumption. By integrating several protocols for low power consumption and sensor efficiency. The VOC monitoring system along with the residential integrated ventilation controller is used for getting the sensor values correctly. The improvement of the estimated PM concentration[6] can be achieved by supplementing the surviving higher precision and affluent PM devices by low cost and lower precision nodes. The PM estimation accuracy will improve when the low precision nodes having the higher densities.

2. Proposed Architecture

The block diagram in Figure 1 gives the description of Air Pollution Monitoring Model in which the different number of modules is included. The detailed description of the modules will be described. The two main modules that are present in the block diagram in Figure 1 is Stationary or Router node and the Coordinator node. On the Router node side, the Sensors like MQ135 and MQ7 sensors are used to detect the concentration of the CO_2 and CO gases. These sensors will be connected to Router nodes (Arduino Sensor Nodes 1 and 2) i.e. Arduino UNO boards. Zigbee is used for transmitting the data wirelessly from one node to another node. On a Coordinator node i.e. on Base Station side, webserver is used to store the data and to process the incoming request which comes from the Android Mobile Client.

2.1 Implementation

Implementation of the Air pollution monitoring model involves the kind of procedures which will be explained in the following. In Figure 1 the end devices will be the gas sensors like MQ 7 gas sensor which will detect the CO (carbon monoxide) which is present in the environment and the MQ 135 gas sensor which is specifically used for the detection of the CO_2 (Carbon dioxide). The Arduino UNO board will be acting as a wireless sensor node by the addition of a Zigbee device which is used to transmit the values of Coordinator node present at the base station (PC). The two router nodes transmit the sensor values to the Coordinator node at the base station. Arduino Mega 2560 in Figure 1 will be acting as the Coordinator node after adding the Zigbee device to it. It receives both the CO and CO_2 values in the PPM. And the received sensor values will be calibrated for better accuracy. The Least Square Method is used here for processing the sensor data for the accuracy of the sensors that are presently used in the system. The Arduino Mega will be acting as a web server in-order to store the data into the cloud or server and will be used to connect the IP-enabled device to monitor the pollution[7]. Hence, the air quality monitoring system is made using the modules like the Arduino board and the Zigbee, as well as the sensors. It will be easily deployable in urban and remote areas. The system which is going to be used is the very cost-effective belongs to the Wireless Sensor Networks (WSN). It's not like an ambient air pollution monitoring system[8]. This system can be deployable easily in remote areas and inside the buildings. Whenever the user or the customer requires the information regarding the CO and CO_2 values in the atmosphere, he/she can send their request to

the Webserver i.e. the Arduino Mega 2560. It will process the current data and will be given to the android mobile which is IP enabled.

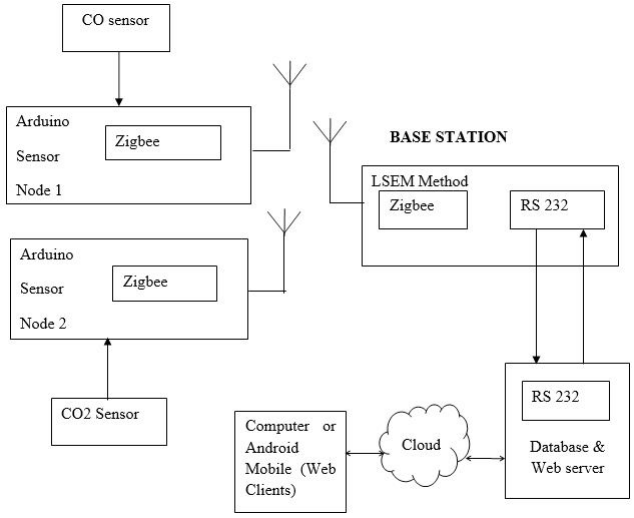

Figure 1. Block diagram of air pollution monitoring model.

2.2 LSM Method (Least Square Based Method)

The LSM method is used for the calibration of sensor data in order to get the accuracy of the sensor data. This method involves linear conversion model called the Liner Quadratic Based Estimation (LQE) model. This model detects and processes the linear data of the gas sensors and then it gives the accurate values without any noises. To CO_2 sensor i.e. MQ 135 gas sensor the linear conversion model, if the output voltage at the value decreases, the sensor level gets rises. Likewise, the model for CO sensor i.e. MQ7 sensor, if the output voltage of sensor value rises, the value of CO also increases. The sequence of measurements over the period of time can be taken might have some noises and inaccuracies. This kind of things can be filtered by using the Linear Quadratic model and it gives the accurate and precise results. And the new state estimate can be as,

$$Ns = G\,(Ac\text{-}Bp) + Cp \quad (1)$$

Where Ns is new state estimate; Ac is sensor current state value; Bp is sensor previous state value; Cp is sensor present state value and the G as,

$$\text{Gain } (G) = \frac{\textbf{Process Noise}}{\textbf{Process Noise} + \textbf{Observation Noise}} \quad (2)$$

The sensors get the values of CO and CO_2. These values can be processed to get the accurate results. The accurate values of sensors can be accessed or monitored through the IP enabled Android device with an 'Android App'. The possibility of the real-time monitoring and tracking levels of the pollutants in different time periods is also done. And the history of levels of the pollutants in different time periods can be represented by the graph. Environmental pollution monitoring improves the lives of human beings by knowing the pollution status in an area. If the area is fully polluted, we can able to reduce the pollution by growing trees, wearing masks and also able to apply some special traffic rules like Odd and Even method etc.

3. Results

The experimental results of the air pollution monitoring are shown in the following figures. The Figure 2 represents the CO_2 sensor i.e. Router node, Figure 3 represent CO sensor node Figure 4 represents Web server and Figure 5 represents the Air quality status of Android App.

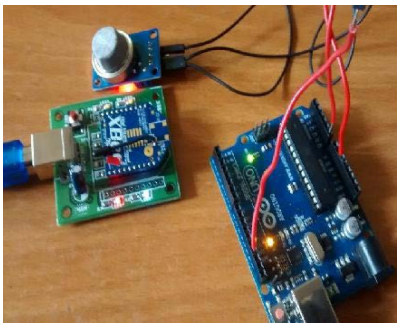

Figure 2. Router node with CO2 sensor.

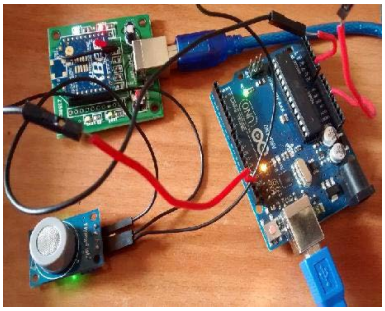

Figure 3. Router node with CO sensor.

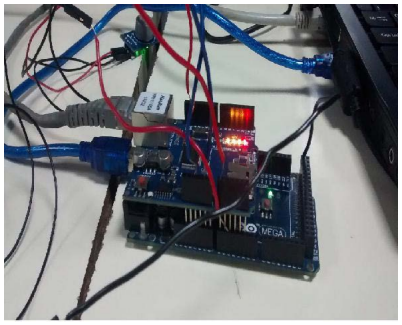

Figure 4. Arduino Mega 2560 as webserver at coordinator node.

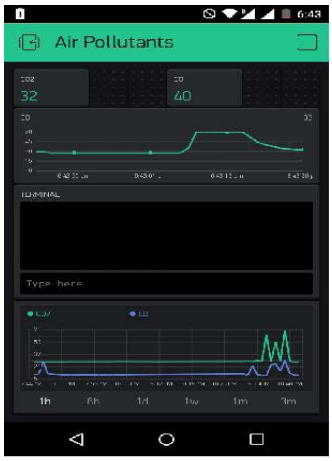

Figure 5. Air quality status through android App.

4. Conclusion

The very cost-effective proposed methodology is implemented in the field of the Wireless Sensor Networks (WSN). LSM (Least Square method) with the help of LQE can be used to process the sensor data in order to get the accuracy. In this proposed method the sensors like CO_2, CO are used to detect the air pollution levels in the environment. Xbees are used to transmit and receive the data from one node to another. Hence, the air quality monitoring system is made by using the modules, and gas sensors. It will be easily deployable in urban and remote areas. If the area is fully polluted, we can able to reduce the pollution by growing trees, wearing masks and also able to apply some special traffic rules like Odd & Even method etc.

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6. References

1. Chi Q, Yan H, Zhang C, Pang Z, Xu LD. A reconfigurable smart sensor interface for industrial WSN in Iot environment. IEEE Transactions on Industrial Informatics. 2014 May; 10(2):1417–25.
2. Mihai TL. Design of A WSN platform for long-term environmental monitoring for Iot applications. IEEE Journal on Emerging and Selected Topics in Circuits and Systems. 2013 May; 3:45–54.
3. Gomaa, Ibrahim R. Real-time radiological monitoring of nuclear facilities using Zigbee technology. IEEE Sensors Journal. 2014 Nov; 14(11):4007–13.
4. Bisio I. Smartphone-centric ambient assisted living platform for patients suffering from co-morbidities monitoring. IEEE Communications Magazine.2015 Jan; 53(1):34–41.
5. Peng C, Qian K, Wang C. Design and application of a VOC-monitoring system based on a Zigbee wireless sensor network. IEEE Sensors Journal. 2015 Apr; 15(4):2255–68.
6. Sutharshan R, Havens TC, Karunasekera S, Leckie C, Bezdek JC. High-resolution monitoring of atmospheric pollutants using a system of low-cost sensors. IEEE Transactions on Geoscience Remote Sensing. 2014 Jul; 52(7):3823–32.
7. Analysis study of seamless integration and intelligent solution in any situation by the future advanced mobile universal systems 4G - (FAMOUS 4G)[Internet]. [cited 2013]. Available from:https://www.deepdyve.com/lp/institute-of-electrical-and-electronics-engineers/analysis-study-of-seamless-integration-and-intelligent-solution-in-any-uJ6X0IfC1c.
8. A secure Ambient Assisted Living (AAL) environment: An implementation view. 2012 International Conference on Computer Communication and Informatics (ICCCI), 2012 Jan 10-12; 2012 Mar.