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MONITORING REAL-TIME URBAN SULPHUR DIOXIDE AND AMMONIA EMISSIONS USING THE WIRELESS SENSOR NETWORKS

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ABSTRACT

In this paper, a cost effective system using wireless sensor networks (WSN) is developed for monitoring air pollution at a large scale. The proposed system has the potential to collect information air related to pollutants on a real time basis comprising Audrino based core with off the shelf pre-calibrated sensors to detect gases like Sulphur Dioxide (SO_2), and Ammonia (NH_3) in the air. This design is made up of Audrino board with gas sensors, Global System for Mobile Communications (GSM) wireless link and a low-cost ZigBee module as well. These wireless sensor motes are utilized for to monitor urbansulphur dioxide and ammonia emissions on a realtime basis. Wireless sensor network formed with ZigBee links can be scaled up using the GSM connectivity to interface with the external world. Air Pollution is monitored using a system of sensor nodes with wireless communication via ZigBee protocol. A static Wireless Sensor Network to monitor air pollution through the use of WSN implemented over the zigbee protocol is proposed in this study. A prototype version of the model is realized and tested. Experimentation with the developed wireless air pollution monitoring system under different physical conditions has produced reliable fine-grain pollution data.

Keywords: air pollution monitoring, Zigbee protocol, WSN mote, pre calibrated sensors, static wireless sensor network.

1. INTRODUCTION

In today's date the exercise of urbanization and industrialization has become expeditious. The world is depending more on machines and this mechanization has resulted in contamination of air leading to environmental havoc. Air pollution [1] occurs when detrimental matters like poisonous gases, particles and biological molecules are present or come in contact with the aerosphere. Living in such a pollutant environment and drawing in of the impure air on daily basis is threatening to the well-being of mankind. Intake of polluted air can result in many health issues like respiratory problems, which can lead to heart failure as well. Considering the adverse effects of air pollution on the human race, animal and plant kingdom; the need of the hour demands for an affordable air monitoring system. More researchers should show interest in developing an economical device which will work for the improvement of the environment.

Air pollution monitoring system [2] will make it easier for the local government or the policy makers to get assistance and implement the laws for controlling the level of air pollution. Although the customary air pollution systems provide thoroughly dependable and accurate data, they cannot extend to air pollution on the real-time base. The pitfalls of conventional techniques are their massive weight with tremendous size and expense, which deliver low resolution sensing data. These systems are inadequate in providing data on air contamination in high spatio-temporal resolution due to non-scalability and restricted amount of data.

With the present-day progress in the discipline of integrated circuits and communication, there is a significant growth in Wireless Sensor Networks (WSN) [10]. WSN is extensively used in the real time application to gather and examine the data in a smart and better way, without the need of human participation.

2. RELATED WORK

Cambridge Mobile Urban Sensing, known as CamMobSense [3] is an economical platform, comprised of a data logger and a ZigBee module, transfers the gathered data to the central server through gateway. It monitors temperature, humidity, noise, CO, NO_2, vehicle occupancy, position, movement etc. RAE systems [4] are battery operated solutions consisting of multiple gas sensors on their boards. These solutions are voluminous, entail high energy and somewhat exorbitant, which hinders their extensive operation on a large scale. ENVIROMOTE [5] is capable of detecting gases like CO_2, CO, NO_2, SO_2 and humidity. It is a micro controller, TI's MSP430 platform, with multiple sensors on the board, suitable for the large scale deployment as it exploits the capabilities of GSM network and ZigBee. Environment Observation and Forecasting System (EOFS) [6] uses adaptive sample rates [7] for the geo-sensor system with proper controls. These systems are unsatisfactory for massive deployment, because of their sizes and high initial costs. RESCATAME [8] is a project for traffic management in the city of Salamanca, Spain; which uses prediction model for the WSN based environment monitoring. IIM, Kolkata, initiated the WSN based environmental monitoring for the protection of public places in India. IIM, Pune, undertook a vital project named "System of Air Quality Forecasting and Research (SAFAR)" [9].

3. PROPOSED DESIGN

To obtain the air pollutant data of the gases, a real-time air pollution monitoring system [10] using static wireless sensor networks was designed and developed. Wireless using the multi-hop meshes network architecture [13] as shown in the Figure-1.

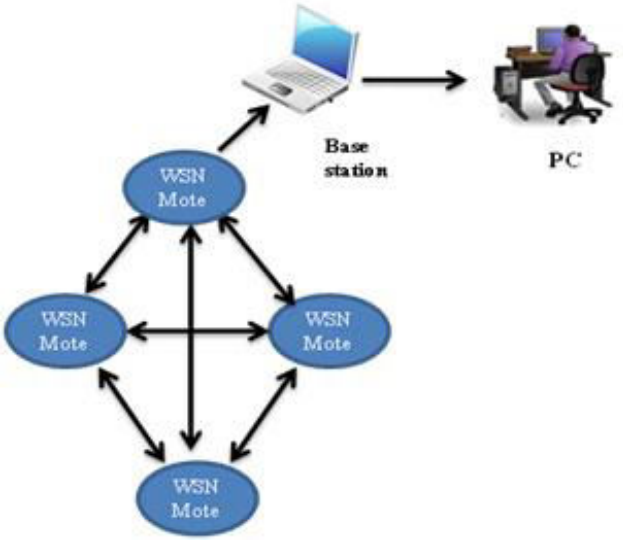

Figure-1. Architecture of the pollution monitor system.

3.1 Hardware Description

Each Wireless Sensor Network Mote [12] is a battery operated wireless platform developed on Audrino with off the shelf sensors to detect gases like SO_2, and NH_3 in the air. It consists of GSM wireless link and also a low-cost ZigBee module. Wireless sensor network formed with ZigBee links can be scaled up using the GSM connectivity to interface with the external world. Figure-2 shows the block diagram of the proposed design with various sub-modules on the platform and Figure-3 shows the prototype of the designed platform.

3.2 Software Description

Arduino comprises of both a physical programmable circuit board and software, or IDE (Integrated Development Environment) used to write, upload code to the physical programmable circuit board.

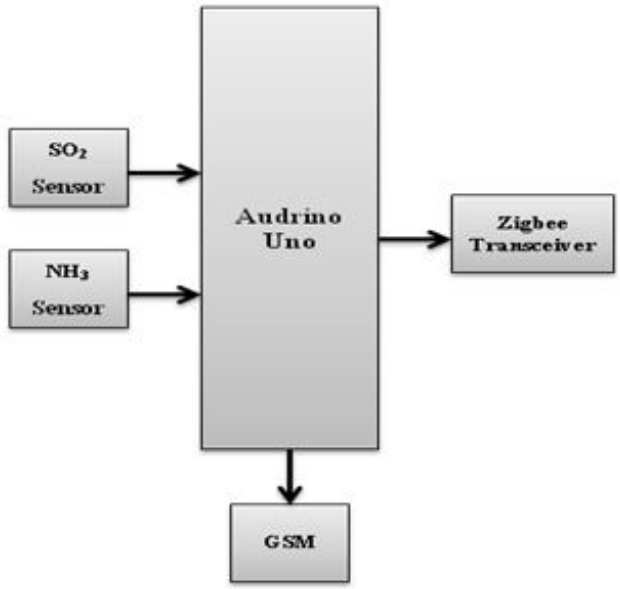

Figure-2. Block Diagram of the WSN Mote.

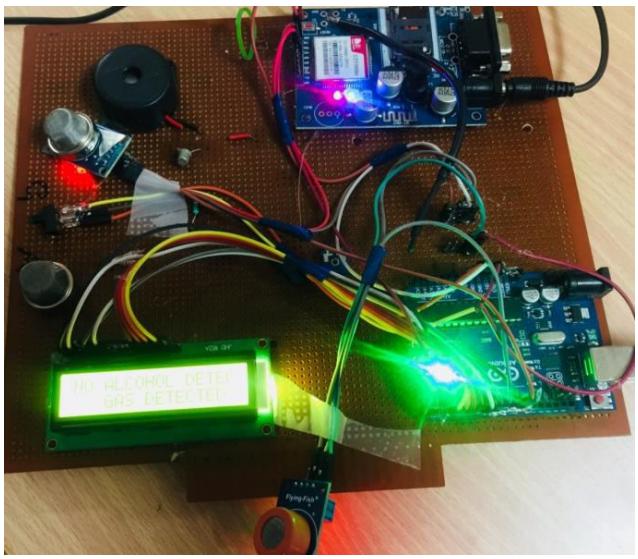

Figure-3. Prototype of the Design.

Wireless Sensor Network, built with ZigBee links can be scaled up by using the GSM connectivity to build an interface with the outside world.

WSN motes are battery operated powered devices which are intended to deploy at various locations on the field. Table-1 show that various sensors on the board consume 50% of the power and also the significant cost of the prototype is due to high cost of sensors. In large scale production, these modules can still be cost effective.

Power consumed by various components in the model is shown in the Tables 1 & 2.

Table-1. Power Consumed by various components.

S. No	Components	Power/Energy
1	SO_2 Sensor - MQ-136	<340mW
2	NH_3 Sensor - MQ-137	750mW
3	Arduino Uno SMD	0.2mA @ DC Volt 1.8V
4	ZigBee Module CC2520	81mW
5	GSM Module - SIM300	3.045W
6	16x2 LCD display	5mA @ DC Volt of 5V

Table-2. Cost BreakUP

S. No	Components	Cost per Unit
1	SO_2 Sensor - MQ-136	1000
2	NH_3 Sensor - MQ-137	650
3	Arduino Uno SMD	800
4	ZigBee Module CC2520	350
5	GSM Module - SIM300	2200
6	16x2 LCD display	275

The sources of Sulphur dioxide are burning of coal and oil which contains sulphur. Sulphur dioxide when combined with smoke, increases the risk of respiratory diseases and causes suffocation and irritation of throat and eyes. Sulphurdioxide combining with atmospheric water vapour results in the acid rain leading to acidification of lakes and soils. High concentration of Sulphur dioxide corrodes buildings.

The main sources of ammonia which are man-made sources are the usage of fertilisers and waste disposal from the industrial processes. Low concentrations of ammonia released into air results unpleasant odour which can be detected. High concentrations of ammonia can harm vegetation ie plant and animal life. Exposure to ammonia at environmental concentrations is will have no adverse effects on health. But, exposure to high concentrations could cause irritation of the eyes, nose and throat as well as burning the skin where there is direct contact.

4. RESULTS AND DISCUSSIONS

The designed air pollution monitoring wireless sensor motes were planted at four separate spots, within the coverage area of Faculty of Science and Technology, IFHE campus, Hyderabad. All the four motes were diligently observed first for an hour, then for a week and later for a month. The data was obtained through the means of LCD and SMS, later plotted through Matlab. The concentration of the air pollutants, Sulphur Dioxide (SO_2), [12] and Ammonia (NH_3) [14] were plotted in manner of hours, weeks and months. In the results, there were some deviations observed because of incorrect sensor calibration. Proper sensor calibration is required to capture the accurate results of the concentrated gases. However, the results of the designed setup were found promising, in concern to the performance and capability to obtain the data as a pollution monitoring device. Incorporated with the ZigBee link, WSN is capable of creating an interface with the external world by using GSM connectivity. Air pollution monitoring is performed using a system of sensor nodes with the help of wireless communication via ZigBee protocol [11].

Figures 4-6 show the plot of data acquired by the motes for the concentrations of Sulphur dioxide SO_2 in PPM versus one Hour, One week and One Month respectively.

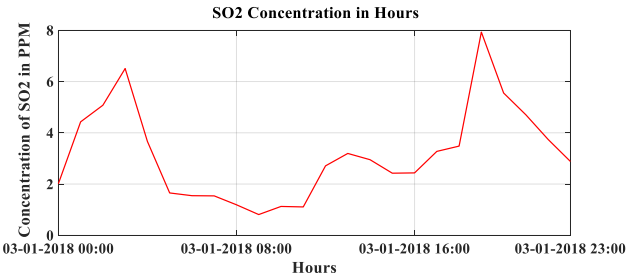

Figure-4. Concentration of SO_2 in PPM in Hours.

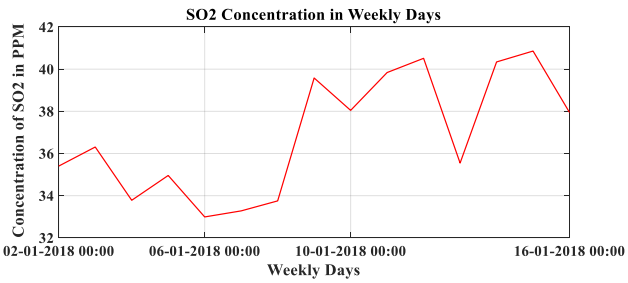

Figure-5. Concentration of SO_2 in PPM in Week Days.

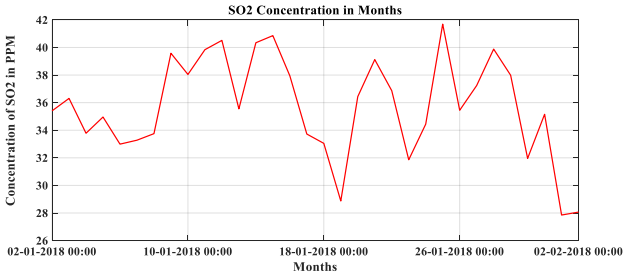

Figure-6. Concentration of SO_2 in PPM in Months.

Figures 7-9 show the plot of data acquired by the motes for the concentrations of Ammonia, NH_3 in PPM versus one Hour, One week and One Month respectively. The wireless sensor motes [15] are used for the field deployment to monitor the real time urban sulphur dioxide and ammonia emissions.

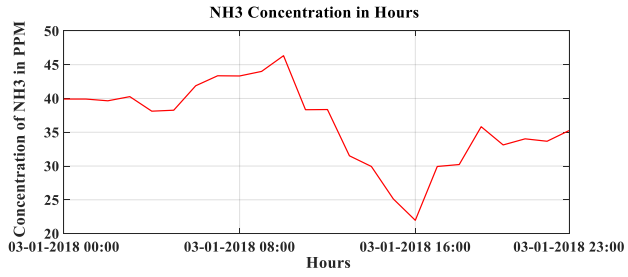

Figure-7. Concentration of NH_3 in PPM in Hours.

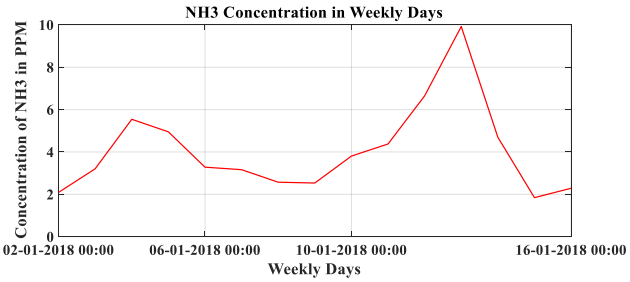

Figure-8. Concentration of NH_3 in PPM in Week Days.

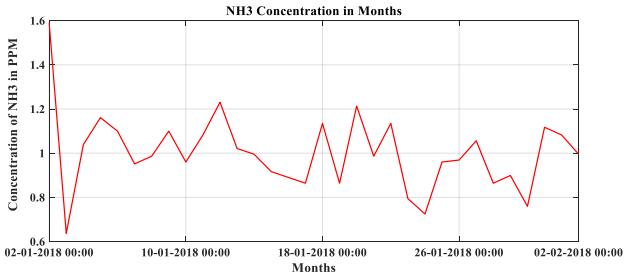

Figure-9. Concentration of NH_3 in PPM in a Month.

5. CONCLUSIONS

An effective system for a large scale air pollution monitoring using wireless sensor networks (WSN) on a real time basis was developed. It is a Audrino based core with off the shelf sensors to detect gases like Sulphur Dioxide (SO_2), and Ammonia (NH_3) in the air. It consists of Global System for Mobile Communications (GSM) wireless link and also a low-cost ZigBee module. Wireless sensor network formed with ZigBee links can be scaled up using the GSM connectivity to interface with the external world. We proposed a static Wireless Sensor Network to monitor air pollution through the use of WSN. A prototype version of the platform is realized and tested. Experimentation carried out using the developed wireless air pollution monitoring system under different physical conditions show that the system collects reliable source of real time fine-grain pollution data.

ACKNOWLEDGEMENT

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