Air Pollution Measuring System with Mobile Sensor Arrays

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Abstract— Environmental air pollution has significant influence on the concentration of constituents in the atmosphere leading to effects like global warming and acid rains. To avoid such adverse imbalances in the nature, an air pollution measuring system is utmost important. The traditional air quality monitoring system, controlled by the Pollution Control Department, is extremely expensive. Analytical measuring equipment is costly, time and power consuming, and can seldom be used for air quality reporting in real time. Wireless Sensor Networks are a new and very challenging research field for embedded system design automation, as their design must enforce stringent constraints in terms of power and cost. This paper attempts to develop an effective solution for pollution measuring using wireless sensor networks (WSN).The gas sensors are integrated with the ARM controller and location tracer GPS in User terminal. Other parameters like temperature are also sensed along with gas pollutant to enable data analysis through data aggregation techniques. Experimentation carried out using the developed air pollution measuring system under different physical conditions show that the system collects reliable source of fine-grain pollution data along with location of mobile vehicle. The system collects pollution data using mobile hardware modules, transmits the data regularly using GSM MODEM to a back-end server, and integrates the data to generate a pollution frame with geographical location and send to handheld devices of the user.

Index Terms— ARM Controller, Data Aggregation, GPS, GSM MODEM, WSN

1 INTRODUCTION

Air pollution has been aggravated by developments that typically occur as countries become industrialized: growing cities, increasing traffic, rapid economic development and industrialization, and higher levels of energy consumption. The high influx of population to urban areas, increase in consumption patterns and unplanned urban and industrial development has led to the problem of air pollution. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the Earth's ecosystems. The report, prepared by Global Scientific Inc., found that suspended particulate matter (SPM) including dust, fumes, mist, and smoke in the air in commercial, industrial and even residential areas of the city exceeds the National Ambient Air Quality Standards throughout the year. In the majority of the developed world, legislation has already been introduced to the extent that local authorities are required by law to conduct regular Local Air Quality reviews of key urban pollutants such as Benzene, SO2, NOx, CO or Ozone - produced by industrial activity and/or road transport [2]. In order to achieve this, pollutant concentrations must be monitored accurately and ideally so that sources may be identified quickly and the atmospheric dynamics of the process are understood. Furthermore, such data would lend itself to real-time environmental decision making.

1.1 Wireless Sensor Network

A sensor network is a group of specialized transducers with a communications infrastructure intended to monitor and record conditions at diverse locations.

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A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable. Every sensor node comprises of a transducer, microcomputer, battery, transceiver and power source. The transducer generates electrical signals based on sensed physical effects and phenomena. The microcontroller processes and stores the sensor output. The transceiver, which can be hard-wired or wireless, receives commands from a central server and transmits data to that computer. When such thousands of nodes are brought together that communicate through wireless channels for information sharing and Cooperative processing makes wireless sensor network. Traditionally, it has been used in the high-end application such as radiation and nuclear-threat detection systems, weapons sensors for ships, biomedical applications, habitat sensing and seismic monitoring. The paper proposed is also a application of wsn to monitoring and detection of air pollution and vehicular tracking.

1.2 Pollutant Sources

Human beings breathe in and out approximately once every four seconds, which equates to over eight million times a year. As a consequence our lungs process around four million litres (4,000m3) of air from the earth's atmosphere, every year. The primary airborne pollutants are: SO2, NOx, Ozone, CO/CO2, and particulate matter. Carbon dioxide (CO2) is a poisonous gas that forms when the carbon in fuels such as gasoline, heating oil, natural gas, wood and charcoal does not burn completely. Carbon dioxide cannot be seen or smelled, but it can be dangerous to our health and in high concentrations, even deadly.Motor vehicle exhaust contributes roughly 60 percent of all carbon dioxide emissions nationwide, and up to 95 percent in cities. Air concentrations of carbon dioxide can be particularly high in areas with heavy traffic congestion.

Other sources include industrial boilers, waste incinerators and natural events, such as wildfires.Levels of carbon dioxide in the air are typically highest during the winter, because vehicles work harder and burn fuel less efficiently in cold weather, and on winter nights, a strong inversion layer develops in the atmosphere, trapping pollution near the ground and preventing it from mixing with cleaner air above.

2 RELATED WORKS

Many air pollution systems in urban and rural areas that utilize smart sensor networks and wireless systems were reported in recent literature. An environmental air pollution monitoring system that measures CO, NO2, and SO2 was reported [1]. A high-resolution surveillance Web camera was used to monitor air quality via the Internet [2]. Another wireless sensor network system was developed to monitor indoor air quality[3].The existing monitoring system largely uses smart transducer interface module (STIM) with semiconductor gas sensors, which uses the 1451.2 standard[4].The use of sensor grids within Discovery Net to construct a distributed system for urban air pollution monitoring and control[5]. A system designed with Energy-Efficient Chain-type Wireless Sensor Network for Gas Monitoring [6].

3. SYSTEM OVERVIEW

The system block diagram for the measuring of pollutant gas concentration is presented in Fig.1The system consists of pollutant sensors, GPS and GSM Modem interfaced in ARM controller.

System can be developed as 3 phases:

(a) GPS Interfacing
(b) GSM Interfacing
(c) Pollutant Sensor Interfacing

3.1 System Architecture

LPC2148 Pro Development Board is a powerful development platform based on LPC2148 ARM7TDMI microcontroller with 512K on-chip memory. This board is ideal for developing embedded applications involving high speed wireless communication, USB based data logging, real time data monitoring and control, interactive control panels etc.Thus ARM 7 controller has been chosen for the processing of aggregated pollutant values and receiving vehicle exact location continuously henceforth air pollution data in that region can be analysed. These data stored in pollution server notifies the polluted area aiding Central Pollution Board or certain agencies to take immediate steps in quality fuel testing, industrial emission, and standard engines for vehicles can be implemented.

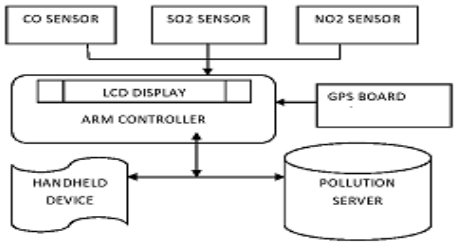

Fig.1: Block Diagram for the system

3.1.1 Arm Processor

The ARM7 based microcontrollers run on load-store RISC architecture with 32-bit registers and fixed op-code length. The architecture provides a linear 4GB memory address space. The ARM7 core is easy to use, cost-effective, and support modern object-oriented programming techniques.

3.1.2 Global Positioning System

GPS receivers are used for positioning, locating, navigating, surveying and determining the time and are employed both by private individuals and companies. During the development of the GPS system, particular emphasis was placed on the following two aspects:
(a) It has to provide users with the capability of determining position, speed and time, whether in motion or at rest.
(b)It should have a continuous, global, 3 dimensional positioning capabilities with a high degree of accuracy, irrespective of the weather.

Global Positioning System is essential standard used for navigation, tracking and location-aware data logging. Board can be interfaced with a microcontroller through UART. Data such as latitude, longitude of the area where vehicle located are received.Board features connector compatible with antennas. It can operate on 3.3V power supply only.

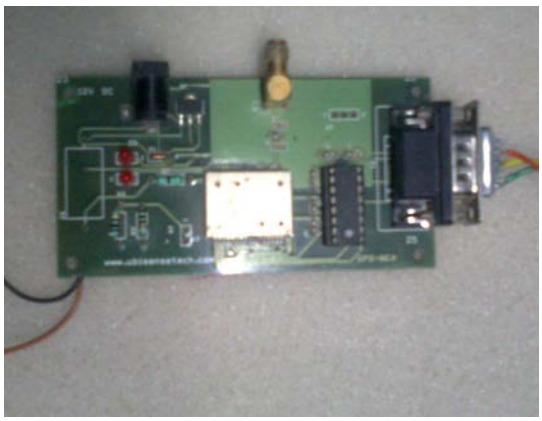

Fig. 2: Miniature GPS BOARD

3.2.3 GSM Modem

As the third generation GSM dual frequency module been used, it has the following features: compact and low power consumption supporting dual frequency of GSM900 and GSM1800 provide standard AT command interface to users; provide fast, reliable and safe transmission of data, voice, short message and fax . It is ideal for this system because of its high quality short message function. By combining wireless sensor network (WSN) and GSM technology, this paper designs a low-power consumption remote air pollution monitoring and alarming system that can detect the pollutant level, and send alarm message to the user mobile phone.

This is a plug and play GSM Modem with a simple serial interface used to send SMS by controlling it through simple AT commands from micro controllers and computers.The modem consists of all the required external circuitry required to start experimenting with the SIM300 module like the power regulation, external antenna, SIM Holder, etc.

3.1.4 Temperature Sensor

In the system a temperature sensor in LPC 2148 is used in measuring temperature of the locality. LM35 is a precision IC temperature sensor with its output proportional to the temperature (in ^{o}C). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self heating and does not cause more than 0.1 ^{o}C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every ^{o}C rise/fall in ambient temperature, i.e., its scale factor is 0.01V/ ^{o}C. Along with this a variable resistor output can also be set for voltage output.

3.1.5 Gas Sensor

They are used in gas leakage detecting equipments in family and industry, are suitable for detecting of Co2, alcohol and cooking fumes and cigarette smoke.

Features of the sensor:

The sensor has high sensitivity to LPG, CO, CO2 and propane gases. Any small sensitivity to alcohol, smoke is detected. Tey provide fast response with stable and long life with a simple drive circuit.

Fig.3: Gas Sensor

4. System Interfacing Methdology

LCD interfacing with ARM processor for Visualization

In this project a LCD module to view the data of Sensor Modules, GPS co-ordinates & and the status SMS sending GSM Modem. Since the LCD module is just used for basic Visualization a 2 line LCD display. The Display is interfaced with the ARM processor LPC 2148.

ADC coding for Sensor inputs in ARM processor

The outputs from the Pollution monitoring sensors are Analog hence thus an Analog to Digital converter to convert these values into corresponding digital values is used. The Arm processor has an inbuilt 32 bit ADC which is invoked in this project.

GPS Module Selection and Interfacing in ARM processor

A GPS module for detecting the Location co ordinates of the Place where monitoring of the Air pollution done.So, RS232 based GPS module in ARM processor has 2 RS232 ports are used.

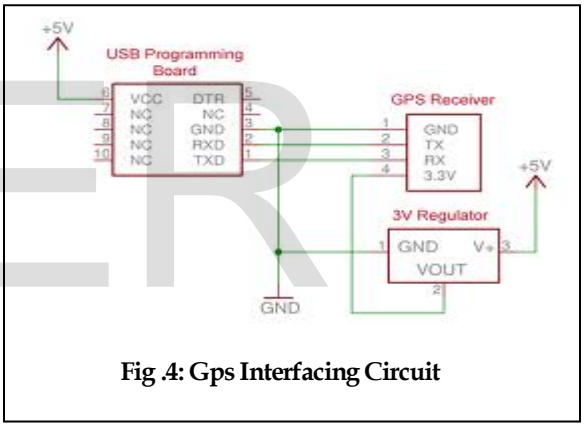

Fig .4: Gps Interfacing Circuit

GSM Modem Selection & Interfacing in ARM processor

This Module implements the job of sending SMS to the central pollution server to which the ADC values of the Sensors are recorded in the system.

Total code Integration in Arm Processor

This module performs the job of integration of all above said modules into a single code and downloading into the Target Processor.The programming done in keil C are loaded in the hardware using Flash Magic software.

Pollution server / Monitoring unit designing & realization

This is the software module which is implemented on the Personal Computer of the Monitoring server.

5. Experimental Results

The fig 5 shows the hardware setup required for the air pollutant measuring and displaying in LCD interfaced with ARM processor.GPS board is separately connected to

development kit.

5.1GPS Output

GPS can track up to 16 satellites while searching for new ones. Easily acquire GPS data with minimum settings and with lots of flexibility. Communication is done using UART or USB interface.

Fig .5: LPC 2148 with GPS

5.2Carbon Dioxide Sensor Output

The CO2 (Carbon Dioxide) Gas Sensor Module is designed by interfacing with ARM controller to measure when a preset Carbon Dioxide gas level has been reached or exceeded. The sensor module is mainly intended to provide a means of comparing carbon dioxide sources and being able to set an alarm limit when the source becomes excessive.

Fig .6 CO_2 Sensor Output

6. CONCLUSIONS

The important objective of this paper is to introduce a new simple, cost efficient method for air pollution monitoring. This system describes implementation of the air pollution monitoring system using WSN application in embedded system.A mobile air pollution measuring system was designed, implemented and tested using GSM network.The system utilizes public vehicle to collect pollutant gases such as CO, NO2, and SO2. The pollution data from various mobile sensors is transmitted to a central server that makes this data helpful to pollution board creating awareness among people. The data shows the pollutant levels and their conformance to local air quality standards. The advancement is made in near future to implement this kind of system in air pollution monitoring makes our environment pollution free.

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