Cyber-Physical System for Industrial Air Pollution Monitoring Using IOT

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***Abstract*- Using empirical analysis, conventional air automatic monitoring system has high precision, but large bulk, high cost, and single datum class make it impossible for large-scale installation. Based on in triducing Internet of Things(IOT) into the field of environmental protection, this paper puts forward a kind of real-time air pollution monitoring and forecasting system. By using IOT, this system can reduce the hardware cost into 1/10 as before. The system can be laid out in a large number in monitoring area to form monitoring sensor network. Besides the functions of conventional air automatic monitoring system, it also exhibits the function of forecasting development trend of air pollution within a certain time range by analyzing the data obtained by front-end perception system according to neural network technology. Targeted emergency disposal measures can be taken to minimize losses in practical application.**

INTRODUCTION

Any activity involving burning things/fuels and mixing substances that cause chemical reactions may release toxic gases in the process and some activities like construction, mining, transportation, etc. produce large amounts of dust which has the potential to cause air pollution.As generation of toxic gases from industries, vehicles and other sources is tremendously increasing day by day, it becomes difficult to control the hazardous gases from polluting the pure air. Air pollution not only brings serious damage to human health but also causes negative effects to natural environments. The air pollution occurs due to contamination of air with Carbon monoxide (CO), Carbon dioxide(CO2), Nitrogen dioxide(NO2), Sulfur dioxide(SO2) and many other harmful pollutants. This pollutant causes serious damage to environment. It also has hazardous effects on human health. Carbon monoxide reduces oxygen carrying capacity of the body's organs and tissues which may lead to cardiovascular disease. Carbon monoxide causes visual impairment, reduced manual dexterity, reduced work capacity, poor learning ability.

So it becomes more and more important to monitor and control air pollution. It will become easy to control it by monitoring the concentration air pollutant parameters in air. Using laboratory analysis, conventional air automatic monitoring system has relatively complex equipment technology, large bulk, unstable operation and high cost. This system can only be installed in key monitoring locations of some key enterprises, thus system data is unavailable to predict overall pollution situation. Using empirical analysis, conventional air automatic monitoring system has high precision, but large bulk, high cost make it impossible for large-scale installation. Nowadays, air pollution is monitored by static air quality measurement stations which are highly reliable and can measure the pollutants in air to a high level of accuracy and precision using analytical instruments, such as mass spectrometers, operated by official authorities. However, extensive cost of acquiring and operating such stations limits the number of installations. To monitor air quality, wireless sensor networks (WSNs) might be a great tool, because they can automatically collect air quality data. It will also help us to keep a working staff away from danger and a high security can be achieve and it will also help the Government authorities to monitor the air pollution.

The proposed system will focus on the monitoring of air pollutants concentration with the help of combination of Internet of things with wireless sensor networks. The analysis of air quality can be done by calculating air quality index. This information will be displayed on the webpage via internet in real time. By the combination of internet of things and wireless sensor networks for purpose of air pollution

monitoring it becomes easy to keep the air quality data updated in real time. Also the system is cost effective which make its installation possible in various areas. The system existing before was based on microcontroller based toxic gas detecting and alerting system and the developing system will have a complete monitoring system which is IOT based. Also the information will be directly sent to the internet from system; no need of computer for transmission purpose which reduces the cost further.

CONCLUSION

We describe a real-time monitoring system for the monitoring of concentration of air pollution and sound pollution in the environment. For this purpose, a hardware system is designed to detect the carbon monoxide, carbon dioxide and smoke concentration. The output of the system obtained from the sensor and processor collaboration is in digital form. A network using Wi-Fi technology can transmit the information of sensor modules to the another location. The proposed system is supposed to measure the pollution levels of various places or sites so that the authorities will be able to control the pollution caused by taking necessary precaution and measures

LITERATURE REVIEW

1. Walter Fuertes and team have developed a low-cost wireless monitoring system that capable of measuring CO, CO2 and the density of dust parameters based on a multilayer distributed model with an Arduino platform. Agile methodologies such as Scrum and Extreme Programming were used in software. They have developed a low-cost wireless monitoring system that enables air quality referential parameters measurements based on a multilayer distributed model with an Arduino platform. This is an Internet of Things application, of which a physical object is embedded with electronics, software, sensors and wireless connectivity to allow monitoring air pollution on real-time. Agile methodologies such as Scrum and Extreme Programming were used in order to ensure software quality. The electronic device is equipped with three sensors, which determines carbon monoxide (CO) as well as carbon dioxide (CO2) concentrations and powder density, using an API developed in C++ language. The validation of the mentioned concept has been realized in a variety of sites in Ecuador, namely in the cities of Quito, Amaguaña and Tena. The obtained results of air pollutants concentration are compared and conformable with the referential values established by international environment organizations like World Health Organization (WHO) and US EPA
2. Chen Xiaojun and two others proposed a system where environmental sensors including SO2,NO2,CO,CL,HCL,HF sensors and Meteorological sensorsare installed in some of the monitoring points. Meteorologicalparameters including wind direction, wind speed, temperature, humidity and air pressure can be perceived in real time to assist in pollution situation analysis and pollution diffusion forecast.
3. Jadhav D. A. proposed a system by interfacing various sensors to measure the common air pollutants. Air pollution has harmful effects that cause acid rain global warming. To reduce these effects air pollution monitoring system is important. A low power wireless sensor network and control of inter-node data reception for use in the real time acquisition and communication of air pollutants such as SO2, CO, NO2 and NO etc. The main objective is achieved by interfacing various sensors to measure the common air pollutants. The measured data is displayed on the monitor using the graphical user interface (GUI). The data based server is attached to the pollution server for storing the pollutants level. Pollution server is interfaced to Google maps to display real time pollutants, pollutants level and locations in large areas.
4. The system stated by ShwetalRaipure and Deepak Mehetre is based on AVR ATmega-32 Microcontroller. This study proposes air pollution and monitoring model which detects pollution in air on the basis of data mining algorithm. The sensor grid is used to detect the sensor values from different gas sensors. They have considered parameters MQ5, MQ7, temperature and humidity dataset. Microcontroller is used to transfer the values from ADC to server. Data mining is used to

calculate the pollutants from different areas. ID3 algorithm is used to calculate the values base on probability. Bluetooth module is used to connect the controller with client and the client connects with the server via web services. Wireless sensors are used to calculate the percentage of harmful gases present in the air that ultimately helps to provide the reduction in pollution. This system not only calculates the pollutants present in the air but also can make forecast to avoid future pollution in and can send the warning message to the particular polluted area. Here they consider mainly the chemical Industry near Pune and the I.T. area like Hinjewadi.

HARDWARE REQUIREMENTS

1. ESP8266 WiFi Module:

ESP8266 is an impressive, low cost WiFi module suitable for adding WiFi functionality to an existing microcontroller project via a UART serial connection. The module can even be reprogrammed to act as a standalone WiFi connected device–just add power! The feature list is impressive and includes:

802.11 b/g/n protocol
Wi-Fi Direct (P2P), soft-AP
Integrated TCP/IP protocol stack

2. LIQUID CRYSTAL DISPLAY

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other. Many microcontroller devices use 'smart LCD' displays to output visual information. LCD displays designed around Hitachi's LCD HD44780 module, are inexpensive, easy to use, and it is even possible to produce a readout using the 8x80 pixels of the display.

They have a standard ASCII set of characters and mathematical symbols. For an 8-bit data bus, the display requires a +5V supply plus 11 I/O lines. For a 4-bit data bus it only requires the supply lines plus seven extra lines. When the LCD display is not enabled, data lines are tri-state and they do not interfere with the operation of the microcontroller. Data can be placed at any location on the LCD. For 16×2 LCD, the address locations are:

First line 80 81 82 83 84 85 86 through 8F
Second line C0 C1 C2 C3 C4 C5 C6 through CF

3. SIGNALS TO THE LCD

The LCD also requires 3 control lines from the microcontroller:

1) Enable (E): This line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled and ignores signals from R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly.
2) Read/Write (R/W): This line determines the direction of data between the LCD and microcontroller. When it is low, data is written to the LCD. When it is high, data is read from the LCD.
3) Register selects (RS): With the help of this line, the LCD interprets the type of data on data lines. When it is low, an instruction is being written to the LCD. When it is high, a character is being written to the LCD.

Logic status on control lines:
• E - 0 Access to LCD disabled
- 1 Access to LCD enabled
• R/W - 0 Writing data to LCD
- 1 Reading data from LCD
• RS - 0 Instructions
- 1 Character

Writing and reading the data from the LCD

1. Writing data to the LCD is done in several steps:
1) Set R/W bit to low
2) Set RS bit to logic 0 or 1 (instruction or character)
3) Set data to data lines (if it is writing)
4) Set E line to high
5) Set E line to low

2. Read data from data lines (if it is reading):
1) Set R/W bit to high

2) Set RS bit to logic 0 or 1 (instruction or character)
3) Set data to data lines (if it is writing)
4) Set E line to high
5) Set E line to low

4. ATmega328

The Atmel 8-bit AVR RISC-based microcontroller combines 32 KB ISP flash memory with read-while-write capabilities, 1 KB EEPROM, 2 KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. The device achieves throughputs approaching 1 MIPS per Mhz.

Features

- High Performance, Low Power AVR 8-Bit Microcontroller
- Advanced RISC Architecture
  1. 131 Powerful Instructions – Most Single Clock Cycle Execution
  2. 32 x 8 General Purpose Working Registers
  3. Fully Static Operation
  4. Up to 20 MIPS Throughput at 20 MHz
  5. On-chip 2-cycle Multiplier

5. Temperature sensor:

Temperature plays an important role in the analysis of the atmospheric condition. The temperature of atmosphere can be detected by this sensor. These are widely used for measurement, instrumentation and control systems. It is convenient in many applications to use temperature sensors that produce readily interpretable temperature readings in a digital format. Such smart temperature sensors combine a sensor and interface electronics on a single chip, and are preferably manufactured in a low standard CMOS process. In this project we are using a semiconductor material based LM35 sensor to measure and sense the temperature. The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature in oC. The sensor circuitry is sealed and not subjected to oxidation, etc. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. It is rated in the temperature range from -55o to +150o.The accuracy guaranteed by LM35 is 0.5o.As due to the system proposed, we can get the monitored data from remote location therefore we are using this sensor in the proposed system as it is best suitable for remote application .Also due the low cost available due to wafer- level trimming it is preferred here.

6. GAS SENSORS

Air pollution consists of various constituents which are harmful for human beings. Out of several constituents here carbon monoxide, smoke and cooking fumes and carbon dioxide are detected .The sensors used are MQ7, MQ6 and MQ135 respectively. The concentration level of these toxic gases is continuously sensed by their respective sensors. The measured value is displayed on the LCD continuously. The sensor requires 5V input which is given by the power supply in the system. The sensor is calibrated with the processor such that it gives output in the percentage of the level of concentration of carbon monoxide in the atmosphere. The particular threshold value is set at the load resistance. When the value exceeds threshold value then the authorities will come to know that the pollution level has increased of that particular site.

7. BUZZER or BEEPER

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke.

SOFTWARE REQUIREMENT

1. Embedded ‘C’

Embedded ‘C’ is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems. Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations. In 2008, the C Standards Committee

extended the C language to address these issues by providing a common standard for all implementations to adhere to. It includes a number of features not available in normal C, such as, fixed-point arithmetic, named address spaces, and basic I/O hardware addressing. Embedded 'C' use most of the syntax and semantics of standard C, e.g main() function, variable definition, data type declaration, conditional statements loops functions, arrays and strings, structures and union, bit operations, macros, unions, etc. The 'C' Programming Language was originally developed for and implemented on the UNIX operating system, by Dennis Ritchie in 1971. Characteristic of an Embedded 'C' programming environment:

- Special keywords and tokens (@, interrupt, tiny).
- Many different pointer kinds (far / near / rom / uni).
- Critical timing (Interrupt Service Routines, tasks)
- Hardware oriented programming

2. ARDUINO IDE SOFTWARE

- IDE stands for integrated development environment. It is a computer program that encompasses the tools required by programmers to develop software. Common elements found in an IDE include a source code editor, compiler, builder and debugger.
- Programmers use IDEs over simple text editors because of the convenience they provide when writing code. Examples of IDEs include Visual Studio Express, Eclipse and Net Beans. Every IDE has its unique features and benefits, along with their own drawbacks. IDEs have specific language support, with some being limited to only one programming language. They also vary according to the different kinds of software development, such as mobile, web and desktop.

APPLICATIONS

- The main objective of this system is to monitor air pollution by using internet of things application.
- Also to obtain cost effective system that will help to keep track of concentration of pollutants in air.
- To find effect of concentration of pollutants on air in terms of air quality index.
- To achieve real time monitoring by continuously updating the data on webpage via internet.

ADVANTAGES

1. The air pollution occurs due to contamination of air with Carbon monoxide (CO), Carbon dioxide (CO2), Nitrogen dioxide (NO2), Sulfur dioxide (SO2) and many other harmful pollutants. This pollutant causes serious damage to environment and has hazardous effects on human health. It becomes a need to control the air pollution. It will become easy to control it by monitoring the concentration air pollutant parameters in air. The conventional air pollution monitoring and analysis methods are quite costlier and bulky which is not suitable to install at large scale. Also it is hard to analyze the air quality at real time monitoring in previous systems.
2. We describe a real-time monitoring system for the monitoring of concentration of air pollution and sound pollution in the environment. For this purpose, a hardware system is designed to detect the carbon monoxide, carbon dioxide and smoke concentration. The output of the system obtained from the sensor and processor collaboration is in digital form. A network using Wi-Fi technology can transmit the information of sensor modules to the another location. The proposed system is supposed to measure the pollution levels of various places or sites so that the authorities will be able to control the pollution caused by taking necessary precaution and measures