

Design and Implementation of a Surveillance System to monitor Air and Noise Pollution through IOT and GPS

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Abstract— The rapid growth in infrastructure and industrial plants creating environmental issues like climate change, malfunctioning and pollution has greatly influenced for the need of an efficient, cheap, operationally adaptable and smart monitoring systems. In this paper, a solution for monitoring the noise and air pollution levels in industrial environment or particular area of interest using wireless embedded computing system is proposed. The solution includes the technology Internet of Things (IOT) which is outcome of merged field of computer science and electronics. Here the sensing devices are connected to the embedded computing system to monitor the fluctuation of parameters like noise and air pollution levels from their normal levels. This model is adaptable and distributive for any infrastructural environment that needs continuous monitoring, controlling and behavior analysis. The working performance of the proposed model is evaluated using prototype implementation, consisting of Raspberry pi 3 board, sensor devices, GPS. The implementation is tested for three or four parameters like noise, CO₂, light, humidity, temperature and radiation levels with respect to the normal behavior levels or given specifications that provide a control over the pollution monitoring to make the environment smart and alert the people living in that locality and it is possible to track the location. In order to run the program in Raspberry Pi MobaXterm software is used.

Keywords— Internet of Things (IOT), GPS, Raspberry Pi 3, MobaXterm, WSN

I. INTRODUCTION

The technologies that are been developing nowadays mainly focus on controlling and monitoring of different activities. These are increasingly emerging to reach the human needs. Most of this technology is focused on efficient monitoring and controlling different activities. An efficient environmental monitoring system is required to monitor and assess the conditions in case of exceeding the prescribed level of parameters (e.g., noise, CO and radiation levels). When the objects like environment equipped with sensor devices, microcontroller and various software applications becomes a self-protecting and self-monitoring environment and it is also called as smart environment.

The human health consequences of air pollution are alarming. The world health organization (WHO) estimates that 800 000 people per year die from the effects of air pollution. In addition to posing a serious public health problem, poor indoor air quality affects worker productivity. Human exposure was defined as the interface between humans and the environment; the impacts of air pollution on an individual's health are related to their exposure concentrations in the different locations in which they spend time. In general, occupational environment is a space which worker exposure can be assessed with difficulty.

Two fundamental information are necessary to estimate personal exposure the concentration of pollutant in different environments and individual time activity. Last, recent development in communication and information technology allows occupational exposure monitors to be ubiquitous and part of everyday activities without significantly impact personal daily function. Real time environmental sensing is the integration of different micro environmental detection sensors with data communication device into one system, in which the data acquired, can be used for further processing and visualization. Ubiquitous sensing enabled by Wireless Sensor Network (WSN) technologies offers the ability to measure, infer and understand environmental indicators. A WSN consists of autonomous sensor nodes that sense some physical phenomena in their surroundings and transmit the sensed data to a centralized unit, through single or multi-hop connectivity. WSNs have gained more significance as the foundation infrastructure for a new and interesting technology era: the Internet of Things (IOT). IOT can be represented as a main enabling factor of promising paradigm for integration of several technologies for communication solution. An IOT is "A dynamic global network infrastructure with self-configuring capabilities based on standard and

interoperable communication protocols where physical and virtual “things” have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network”. IOT has emerged to be attractive in many applications such as, health care, target tracking and surveillance.

This paper proposes the implementation of an IOT-based real time occupational exposure monitoring system using multi-pollutant sensors nodes to measure air pollutants concentrations in different indoor microenvironments and wearable tags for real time indoor personal tracking.



FIGURE 1: INDUSTRIAL AIR POLLUTION

II. RELATED LITERATURE SURVEY

An Environmental Air Pollution Monitoring System for monitoring the concentrations of major air pollutant gases has been designed, developed, and tested complying with the wireless standard. This system measures concentrations of gases such as CO, NO₂ and SO₂, and using semiconductor sensors. The hardware unit integrates a single-chip microcontroller, air pollution sensors array, a GSM-Module. The Central-Server is a high-end personal computer application server with internet connectivity. The hardware unit gathers air pollutants levels (CO, NO₂, and SO₂), and packs them in a frame with the GPS physical location, time, and date. The frame is subsequently uploaded to the GSM-Modem and transmitted to the Central-Server via wireless network. In this paper, 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. 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 network.

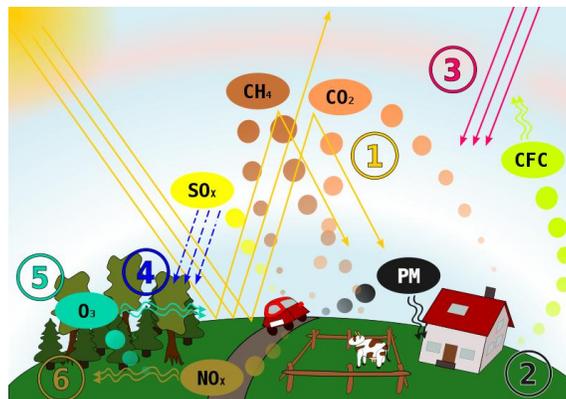


FIGURE 2: EMISSION OF VARIOUS GASES PRESENT IN AIR

III. EXISTING SYSTEM MODEL

Existing system model is presented in figure 3 uses Zigbee based wireless sensor networks to monitor physical application in different fields. The sensor nodes directly and environmental conditions with thousands of communicated with the moving nodes deployed on the object of interest which avoided the use of complex routing algorithm but local computations are very minimal. A Wireless Sensor Network consists of many inexpensive wireless sensors, which are capable of collecting, storing, processing environmental information, and communicating with neighboring nodes. In the past, sensors are connected by wire lines.

The access method of sensor gateway node is convenient because data can be received from a sensor via the gateway at any time and any place. The gateway acts as the network coordinator in charge of node authentication, message buffering where you can collect, process, analyze, and present your measurement data. Wireless sensor network management model consists of end device, router, gateway node and management monitoring center.

End device is responsible for collecting wireless sensor network data, and sending them to parent node, then data are sent to gateway node from parent node directly or by router. After receiving data from wireless sensor network, gateway node extracts data after analyzing and packaging them into Ethernet format data, sends them to the server.

Then through Zigbee module the alert data is sent to all the people whose data values are stored. The services or information in the servers are provided through to the user through Zigbee and alert message can be viewed via smartphone.

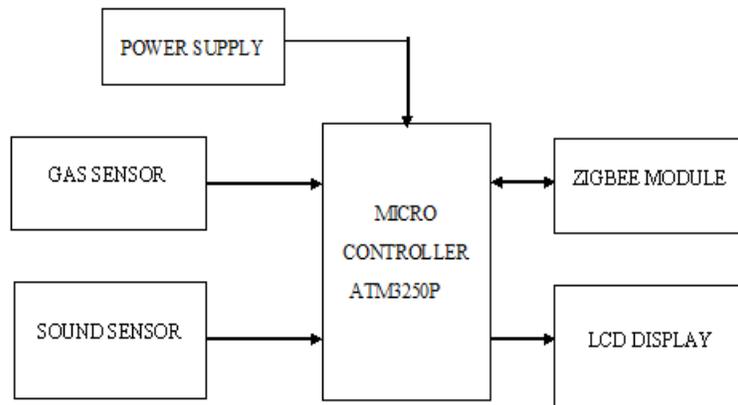


FIGURE 3: EXISTING SURVEILLANCE MODEL

IV. PROPOSED SYSTEM

A wireless sensor network (WSN) is an infrastructure comprised of sensing, computing and communication elements that allows the administrator to monitor & control of the specified parameters in the network. Typical application of WSN includes data collection, monitoring, surveillance & medical telemedicine.

The embedded computing device system is for monitoring noise and CO₂ levels in the atmosphere to make the environment intelligent or interactive with the objects through wireless communication. Which means it will identify the variations in the sensor data and fix the threshold value depending on the identified level of CO₂ or noise levels.

Here the heart of the system is Raspberry Pi controller. The reason for using raspberry Pi 3 is it is more efficient and has perform multiple operation on a single board and cost effective. The raspberries Pi coding is written in Embedded C in UNIX platform. The controller is interfaced with sensor devices such as temperature, humidity, gas, noise and light sensor.

The analog data that has been collected from these sensor devices are converted into digital data. Here the conversion is done through ADC interfaced with the I2C pin of the Raspberry Pi. For the collection of data from the area of interest the GPS tracking system is used. Then through LAN connection the network connectivity is given to the controller.

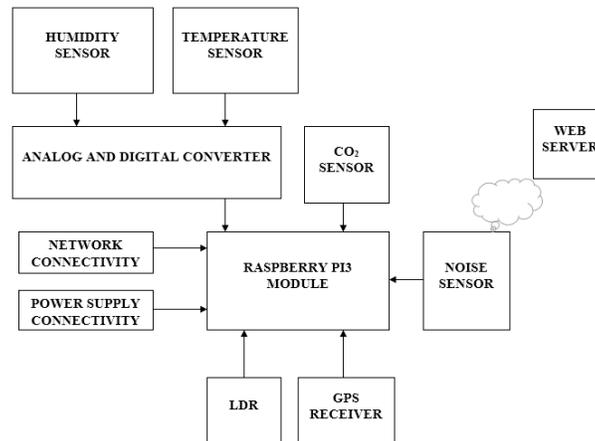


FIGURE 4: PROPOSED SURVEILLANCE MODEL

To display the collected data to the user who are in need of it a webpage has been created. By browsing the web address one can get the pollution levels in a particular area of interest at one single click. In this sensed data has been processed, stored in the cloud i.e.in to the Google spread sheets and also it shows a trend of the sensed parameters with respect to the specified values. The end users can browse the data using mobile phones, PCs etc. With the help of IOT the alert message is viewed by all the people and safeguard themselves and move away from the polluted area and it is possible to create individual URL address as per the user constrain based on wed based processing.

A server is an instance of a computer program that accepts and responds to requests made by another program; known as a client. Less formally, any device that runs server software could be considered a server as well. Servers are used to manage network resources. The service or information in the server are provided through the Internet that are connected through LAN and made available for users via smart phones, web browser or other web browser devices to make the system more intelligent, adaptable and efficient.

4.1 Computational Analysis on Environmental Parameters

Here we include some basic analytics methods to calculate the pollution parameters, like noise levels and CO levels in the surrounding environment.

The common unit of measurement for sound is decibel, dB and its intensity is measured in Sound Pressure Level (SPL). The noise levels are measured in the A-weighted (low-level sensitivity) SPL, abbreviated as dB (A). Sound of frequencies from 800 to 3000Hz is covered by the A-weighted scale.

If the SPL, L1 in dB is measured at r1 meters, then SPL, L2 in dB at r2 meters is given by

$$L2 = L1 - 20 \log_{10} (r2/r1)$$

Day – Night equivalent noise levels (L_{dn}) of a community can be expressed as

$$L_{dn}, dB(A) = 10 * \log_{10} [15/24(10^{L_d/10}) + 9/24(10^{(L_n+10)/10})]$$

Where,

L_d = day- equivalent noise levels (from 7AM – 10PM), dB (A)

L_n = night-equivalent noise levels (from 10PM – 7AM), dB (A)

Based on intensity, the sound intensity I may be expressed in decibels above the standard threshold of hearing I_0 . The expression is

$$I \text{ (dB)} = 10 \log_{10} [I/I_0] \text{ intensity in decibels}$$

TABLE 1
STANDARD NOISE VALUES

Standard for noise values		Type of region
Night (10pm -7am) in dB	Day (7am-10pm) in dB	
45	55	Residential
40	60	Residential - commercial
55	65	commercial
60	70	Residential-industry
65	75	Industry

Table 1 shows the standard noise values present during day and night time. Based on the values the type of region can be identified.

TABLE 2
STANDARD AIR PARAMETERS VALUES

S.No	Parameters	Test Results ($\mu\text{g}/\text{m}^3$)	NAAQ Norms
1	Sulphur dioxide(SO_2)	9.8	80.0
2	Nitrogen dioxide(NO_2)	28.7	80.0
3	Particulate matter(PM_{10})	127.0	100.0
4	Ozone(O_3)	16.0	180.0
5	Lead(Pb)	0.24	1.0
6	Carbon monoxide(CO)	0.486	2.0
7	Ammonia(NH_3)	3.5	400.0
8	Benzene(C_6H_6)	0.26	5.0
9	Arsenic (As)	1.0	6.0
10	Nickel (Ni)	1.8	20.0

Table 2 shows standard air parameter values where these gases are checked in real time. The usual reference method for the measurement of carbon monoxide concentration in air is based on the absorption of infrared radiation by the gas in a non-dispersive photometer.

V. IMPLEMENTATION

Based on the framework shown in figure 4, we have identified a suitable implementation model that consists of different sensor devices and other modules, their functionalities are shown in figure 5. In this implementation model we used Raspberry pi 3 board with GPS module as an embedded device for sensing and storing the data in cloud. Raspberry pi 3 board consists of analog input pins, digital output pins and it is accessed through GPIO pins, inbuilt ADC and Wi-Fi module connects the embedded device to internet.

Sensors are connected to Raspberry pi 3 board for monitoring, ADC will convert the corresponding sensor reading to its digital value and from that value the corresponding environmental parameter will be evaluated.

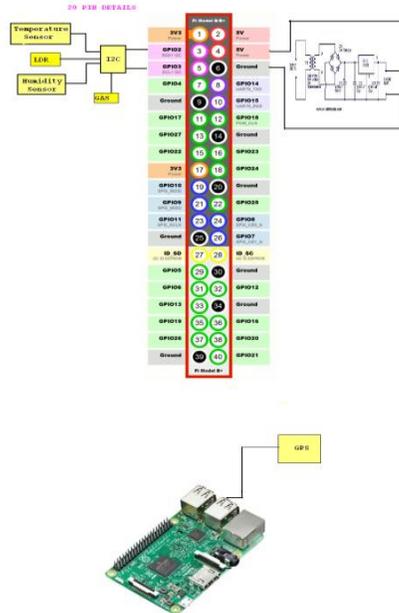


FIGURE 5: CIRCUIT DIAGRAM OF PROPOSED SURVEILLANCE SYSTEM

The LAN connection has to be established to transfer sensors data to end user and also send it to the cloud storage through IOT by creating web page. Before sending the sensed data to cloud, the data will be processed in UNIX platform and visualize data to end user. The data analysis in UNIX platform makes easier to us to set threshold level and to perform necessary controlling actions.

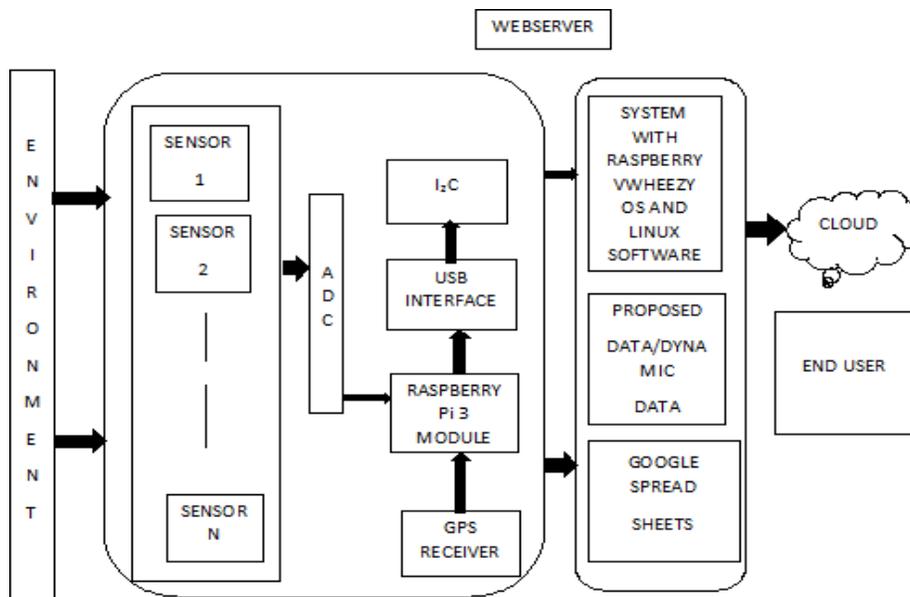


FIGURE 6: PROPOSED RASPBERY PI 3 INTERFACED WITH WEBSERVER

An embedded system designed for environmental monitoring and its components are shown in figure 6. The embedded device is placed in particular area for testing purpose. The sound sensor detects sound intensity levels in that area and Carbon Monoxide (CO) sensor will record the air quality in that region, if the threshold limit is crossed the corresponding controlling action will be taken (like issuing message alarm or buzzer or LED blink). All the sensor devices are connected to internet through Wi-Fi module or LAN connection.



FIGURE 7: PROPOSED AIR AND NOISE MONITORING SYSTEM

Figure 6 shows the embedded system with its components for reading and to store the pollution parameters in cloud. After successful completion of sensing, the data will be processed and stored in database for future reference. After completing the analysis on data the threshold values will be set for controlling purpose.

VI. RESULT

After sensing the data from different sensor devices, which are placed in particular area of interest. The sensed data will be automatically sent to the web server, when a proper connection is established with sever device.

The figure 5 shows the web server page, which will allow us to monitor and control the system. By entering IP address of server, which is placed for monitoring, we will get the corresponding web page. The web page gives the information about the intensity of sound and the CO level variations in that particular region, where the embedded monitoring system is placed.

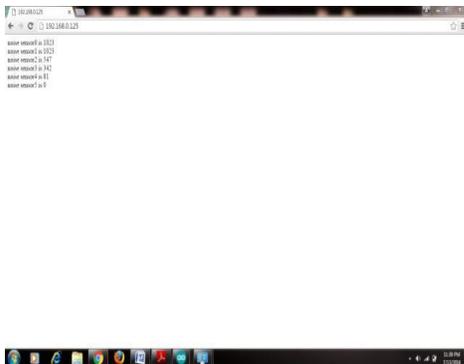


FIGURE 8: WEB SERVER PAGE

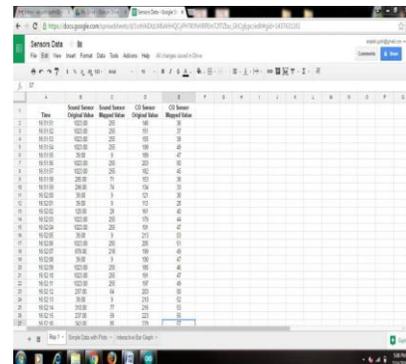
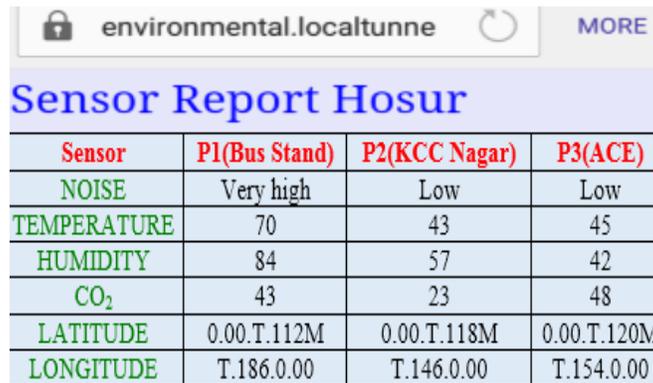


FIGURE 9: CLOUD STORAGE (GOOGLE SPREADSHEETS) FOR SENSORS DATA.

The sensed data will be stored in cloud (Google Spread Sheets). The data stored in cloud can be used for the analysis of the parameter and continuous monitoring purpose. The figure 9 shows the noise intensity levels and CO levels in air at regular time intervals.



Sensor	P1(Bus Stand)	P2(KCC Nagar)	P3(ACE)
NOISE	Very high	Low	Low
TEMPERATURE	70	43	45
HUMIDITY	84	57	42
CO ₂	43	23	48
LATITUDE	0.00.T.112M	0.00.T.118M	0.00.T.120M
LONGITUDE	T.186.0.00	T.146.0.00	T.154.0.00

FIGURE 10: WEB PAGE OUTPUT

The above figure 10 shows about various noise and air parameter present in air and its value is measured in real time. The heart surveillance system is Raspberry pi3, where the program are made in c language and made to run in Unix platform using MobaXterm software processing in this software is very easy and modification can be done in fraction of seconds.

The temperature is read in degree Celsius and CO₂ is read in $\mu\text{p}/\text{m}^3$ unit. GPS is used to track the location and area can be identified based on latitude and longitude value. Based on the water content present in atmosphere, humidity values goes on changing. By the help of these contents user can safeguard themselves from harmful situation and travel to safer places and alert message can be viewed via smart phones or PC's and move themselves to safer location.

VII. CONCLUSION

By keeping the embedded devices in the environment for monitoring enables self-protection (i.e., smart environment) to the environment. To implement this need to deploy the sensor devices in the environment for collecting the data and analysis. By deploying sensor devices in the environment, we can bring the environment into real life i.e. it can interact with other objects through the network. Then the collected data and analysis results will be available to the end user through the Wi-Fi or LAN.

The smart way to monitor environment and an efficient, low cost embedded system is presented with different models in this paper. In the proposed architecture functions of different modules were discussed. The noise and air pollution monitoring system with Internet of Things (IOT) concept experimentally tested for monitoring two parameters. It also sent the sensor parameters to the cloud (Google Spread Sheets).

This data will be helpful for future analysis and it can be easily shared to other end users. This model can be further expanded to monitor the developing cities and industrial zones for pollution monitoring. To protect the public health from pollution, this model provides an efficient and low cost solution for continuous monitoring of environment.

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