AIR POLLUTION DETECTOR

A progress report submitted for the course named Project II(CS-300)

BY

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Abstract

Air pollution affects our day to day activities and quality of life. It poses a threat to the ecosystem and the quality of life on the planet. The dire need to monitor air quality is very glaring, owing to increased industrial activities over the past years. People need to know the extent to which their activities affect air quality. This project proposes an air pollution monitoring system. The system is developed using the Raspberry Pi 4 and Arduino micro-controller. The air pollution monitoring system is designed to monitor and analyze air quality in real-time and log data to a remote server, keeping the data updated over the internet. Air quality measurements are taken based on the Parts per Million (PPM) metrics and analyzed using Android application. The air quality measurements taken by the designed system is accurate. The result is displayed on the designed Android application and prediction of next week weather forecast based on past data using supervised Machine Learning approach.

Keywords - Raspberry Pi, Arduino UNO, Internet of Things, Pollution, Air, Parts per Million, Android, Python3, Gas Sensors.

Chapter 1

Introduction

"Be A Part OF The Solution Not Part OF The Pollution"

Air is one of the essential elements of man's surroundings. The earth's atmosphere is full of air which contains gases such as Nitrogen, Oxygen, Carbon Monoxide and traces of some rare elements. Humans need an atmosphere of air that is free from contaminants. This is very crucial for human life and health. Any change in the natural composition of air may cause grave harm to life forms on earth. Air pollution is the presence of one or more contaminants in the atmosphere such as gases in a quantity that can harm humans, animals and plant . Air pollutants are measured in Parts per Million (ppm) or ug/m3. Primary pollutants are released directly into the atmosphere. Secondary pollutants are produced when the primary pollutant reacts with other atmospheric chemicals . Air quality affects public health. The effect of air pollution ranges from difficulty in breathing, coughing, aggravation of asthma and emphysema. Polluted air can also impair visibility. Air pollution is accountable for the death of 7 million persons worldwide each year or one in eight premature deaths yearly . Almost 570,000 children under the age of five die every year from respiratory infection linked to indoor/outdoor pollution and second-hand smoke. Children exposed to air pollution have an elevated risk of developing chronic respiratory problems such as asthma. In the monitoring of air pollution, several researchers worldwide have developed models to monitor many of the pollution gases such as Sulphur Dioxide (SO2), Carbon Monoxide (CO), Carbon Dioxide (CO2), Nitrogen Oxides (NO) etc. This thesis project focuses on the design and implementation of a smart air pollutant monitoring system. It discusses how the level of pollutants in the air can be monitored using a gas sensors, Raspberry Pi 4 & Arduino micro-controller. The main objective of this project is to design a smart air pollution monitoring system that can monitor, analyse and log data about air quality to a remote server, keep the data up to date over the internet and predict weather forecast of next week based on past data.

1.1 Outline of the report

This report is organised around three main parts.

Chapter 1 Introduction to the project

Chapter 2 Describes the existing System Study

Chapter 3 Describes methodology of this project

1.2 Problem Statement

The aim of this thesis project is to fulfill the following goals.

1. Create a system which will monitor the quality of air of our environment.
2. Collect information about the air pollution level after every certain period.
3. Content of different gases present in air or area around us.
4. To collect information about the air pollution level after every certain period.
5. Sense how much amount of gasses are present in air and display it in real time on smartphone.
6. Send the information of current air pollution level and weather forecast of next upcoming days to user smartphone.

1.3 Internet of Things(IOT)

Internet of Things (IOT) is a network of devices that connect directly with each other to capture and share data through a secure service layer that connects to a central command and control server in the cloud. The closure look suggest that the way people collect, record and analyze data not just in health care but in every industry today. The idea of devices connecting directly with each other is basically called Internet of Things.

The Internet of Things also called the Internet of Objects, refers to a wireless network between objects, usually the network will be wireless and self-configuring. Internet of Things (IOT) is one of the major component advances in present time that links the internet with everyday sensor and working devices. Smart objects play an important role in the Internet of Things vision, since embedded communication and information technology would have the potential to change the utility of these objects. Using sensors they are able to recognize their condition, and via built-in connecting power they would be able to interact with each other.

Internet of Things (IOT) came into existence in 2009. It encircles the idea of connecting all gadgets and devices to the internet. The concept of Internet of Things is actually trying to change our world by connecting everything with each other. It is basically making our health, and businesses, society by developing products which would lead to a comfortable life. By 2020 it is estimated that, about 50 billion devices would be linked to the Internet and the market would be worth around 14 trillion USD.

IOT in different application domains alike web property of everyday objects may be accustomed remotely confirm their state in order that we will perpetually collect the info and knowledge on physical objects and processes. This qualifies several options of the important world to be spot at a antecedently unattained level of detail and at terribly

low value nearly too negligible. This could not afford an improved understanding of the underlying processes, however additionally for a lot of economical management and management. The potential to react to events during this world in associate automatic manner not solely disclose new opportunities for addressing composite or unfavorable things, however additionally allows a large type of business processes to be optimized.

1.4 Air Pollution

Air pollution occurs when harmful or excessive quantities of substances are introduced into Earth's atmosphere. Sources of air pollution include gases (such as ammonia, carbon monoxide, sulfur dioxide, nitrous oxides, methane and chlorofluorocarbons), particulates (both organic and inorganic), and biological molecules. It may cause diseases, allergies and even death to humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Both human activity and natural processes can generate air pollution.

Air pollution is a significant risk factor for a number of pollution-related diseases, including respiratory infections, heart disease, COPD, stroke and lung cancer. The human health effects of poor air quality are far reaching, but principally affect the body's respiratory system and the cardiovascular system. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, and the individual's health status and genetics. Indoor air pollution and poor urban air quality are listed as two of the world's worst toxic pollution problems in the 2008 Blacksmith Institute World's Worst Polluted Places report. Outdoor air pollution alone causes 2.1 to 4.21 million deaths annually. Overall, air pollution causes the deaths of around 7 million people worldwide each year, and is the world's largest single environmental health risk.

Chapter 2

Literature Review

Outline: This chapter presents the following:

1. Efficient Noise and Air Pollution Monitoring System
2. IOT Based Air Pollution Monitoring System
3. IOT Based Air and Noise Pollution Monitoring using Raspberry Pi
4. Air Pollution Monitoring System Using Mobile GPRS Sensors
5. Embedded device for measuring noise and air levels in atmosphere
6. IOT Based Air and Noise Pollution Monitoring in Urban and Rural Areas

2.1 AnjaiahGuthi "Efficient Noise and Air Pollution Monitoring System" (2016)

This paper deals with smart sensor network that are an emerging field of research which combines many challenges of computer science, wireless communication and electronics. In this research paper a solution for monitoring the noise and air pollution levels in industrial environment or any other area of interest using wireless embedded computing system is proposed.

The running representation of the initiated hardware is evaluated using original implementation, consisting of Arduino hardware support package. The hardware is tested for two or three parameters like noise, CO2 and radiation levels with respect to the normal behavior levels or given specification which provide a control over the pollution monitoring to make the environment smart.

2.2 PalaghatYaswanthSai(2017)

This document deals with the IOT Based Air Pollution Monitoring System in which we will gather the air value in PPM(Parts Per Million) as well as sound value in decibel over a web using internet and with the help of Wi-Fi module and will trigger an alarm when the air quality goes down further a certain level, means when there are sufficient amount of harmful gases are present in the atmosphere like CO2, smoke, alcohol, benzene and NH3. It will show the air quality in PPM on the LCD 16x2 display and as well as on web so that we can gather information very easily. In this MQ-135 gas sensor is used which is the best choice for monitoring air quality as it can detect most harmful gases and can measure their value efficiently. In this project, you can gather the level of air pollution and noise from anywhere using your computer or mobile. System can be set anywhere in the world and we can also activate some objects like for example when pollution goes beyoud some set level we can switch on the exhaust fan.

2.3 Uppugunduru Anil Kumar, G Keerthi (2017) IOT Based Air and Noise Pollution Monitoring using Raspberry Pi

A systematic environment monitoring hardware is required to monitor the conditions in case of exceeding the level of parameters(e.g., noise, CO2). When the things like envi-

ronment equipped with sensor devices, micro-controller and various software applications becomes a self-protecting and self-monitoring environment. People need different types of monitoring hardware which are depends on the type of data monitored by the sensor. Event Detection based and Spatial Process Estimation are the two categories to which applications are classified. Initially the sensor devices are deployed in environment to detect the parameters(e.g., noise, CO, and radiation levels etc.) which the data acquisition, computation and controlling action e.g., the variations in the noise and CO level with respect to the specified levels). Sensor devices are placed at different location to collect the data to predict the behaviour of a particular area of interest. The main focus of the this document is to model and implement an efficient monitoring hardware through which the required values are measured remotely using web and the information gathered from the sensors are stored in the cloud and to project the estimated trend on the web browser.

2.4 Ashvini S .kale in Air Pollution Monitoring System Using Mobile GPRS Sensors

This paper contains brief introduction to vehicular pollution. The proposed system consists of a transmitter and receiver part. The transmitter part is integrated with single chip micro-controller, air pollution sensors array a General Packet Radio Service Modem (GPRS Modem) and a Global Positioning System Module (GPS Module) for transmitting the information.

2.5 L.Ezhilarasi, K.Sripriya, "A SYSTEM FOR MONITORING AIR AND SOUND POLLUTION USING ARDUINO CONTROLLER WITH IOT TECHNOLOGY" (2017)

The document contains embedded device for measuring noise and air levels in atmosphere and to make the environment in intelligent or interactive with things. The proposed model is flexible and distributive in nature to measure the environmental parameters. The architecture is developed for noise and air pollution monitoring Smart sensor network are the coming field of research and investigation which may lead to many challenges of computer science, wireless communication and electronics.

2.6 Dr. Siva yellampalli "IOT Based Air and Noise Pollution Monitoring in Urban and Rural Areas, Important Zones like Schools and Hospitals in Real Time" (2017)

Today's major environment & public issue is air pollution. According to the report of World Health Organization(WHO), air pollution is significant risk factor for multiple health conditions including skin & eye infection, irritation of nose, throat & eyes. It also causes serious condition like heart disease, lung cancer difficulty in breathing & many. Parking management is also main public issue in most of metropolitan cities and that is also the reason of many problems. The main objective of project is by using various sensors, GSM/GPRS module and Cloud/server to design an efficient and remote system to monitoring the level of various pollutants causing pollution and to minimize the effect of these parameters without affecting the natural environment and provide live updates to avoid conflicts.

Chapter 3

System Design, Methodology

Outline: This chapter presents the following:

1. A brief of system design
2. A brief of methodology

3.1 System design

The simplified diagram of the proposed system is demonstrated in Fig.3.1. Raspberry pi is the major node controlling our system. The sensors are being used for detecting different environmental parameters like particulate matter, Carbon Monoxide, Carbon Dioxide, Temperature, Humidity and Pressure. The sensors are connected to Arduino Board and Raspberry pi is interfaced with Arduino Uno through USB cable. The data sensed by the sensors are continuously transmitted through Raspberry pi to the cloud over the internet because of its good network connectivity. The sensors DSM501A is a PM sensor whose output is PWM, used for measuring the particulate matter i.e. smoke and dust present in our environment, DHT11 and BMP180 are having digital outputs used for measuring temperature, humidity and pressure. The sensors, MQ9 (Gas sensor) as well as MQ135(air quality sensor) are analog sensors used for measuring Carbon monoxide and carbon dioxide.

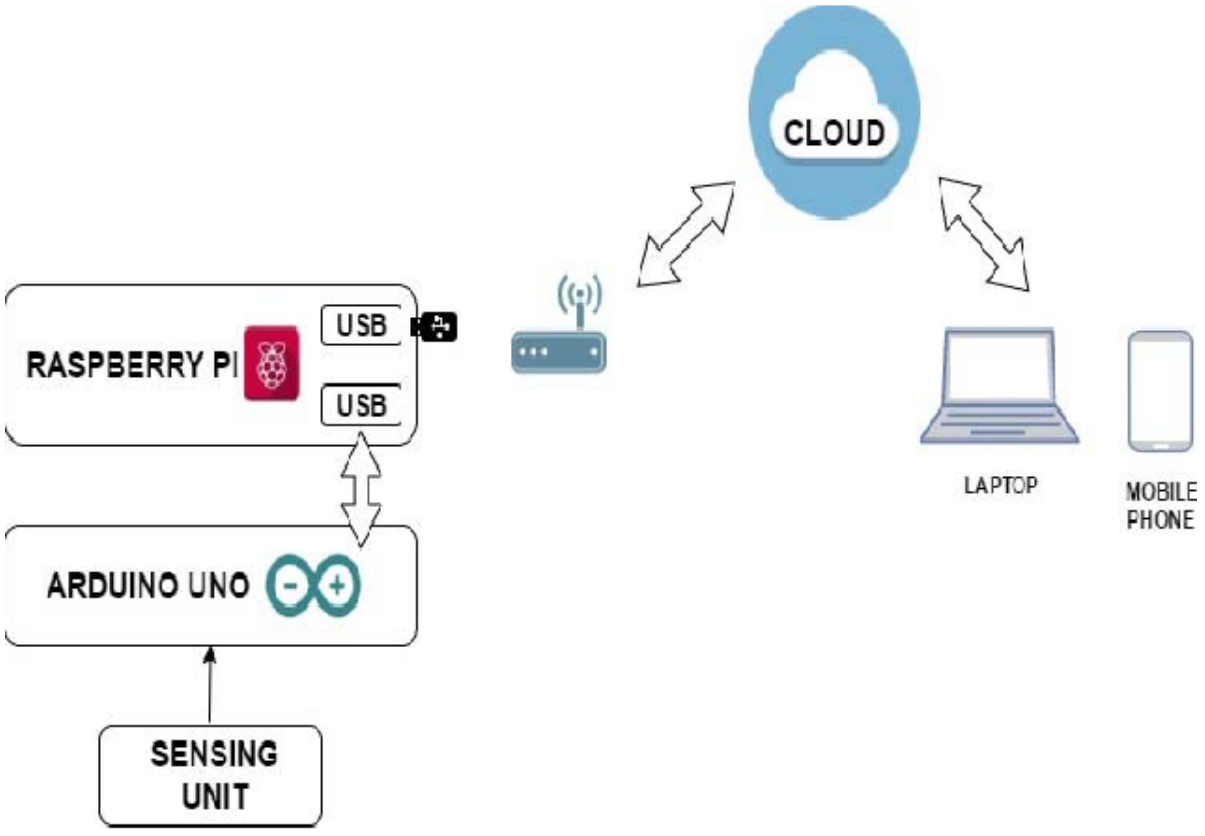

Figure 3.1: Simplified diagram of Proposed System

Arduino Uno is a low-cost micro-controller board based on ATMEGA-328P which can be easily interfaced with Raspberry pi and has a very effective ADC. Since Raspberry pi 4 has built in Wi-Fi adapter support therefore Wi-Fi adapter is not used for providing

the internet to the complete system. The light weight protocol MQTT (Message Queuing Telemetry transport). MQTT plays an important role in establishing communication between the sensors and the clients. The client can access the data that is being displayed on the dashboard by using the device id but the client will be not able to do any modification to the data received.

3.1.1 Raspberry Pi

Raspberry Pi is a single board computer. It has ARM Cortex A8 CPU and 1 GB LPDDR4 RAM which makes it a faster and powerful than the previous available models. It has Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) processor which is running at 1.5 GHz but it can be overclocked. It has 2 × USB 3.0 ports and 2 × USB 2.0 ports, Standard 40-pin GPIO, 2 × micro HDMI ports (up to 4Kp60 supported), 2.4 GHz and 5.0 GHz IEEE 802.11b/g/n/ac wireless LAN, Bluetooth 5.0, 3.5 mm audio jack and composite video, camera interface (CSI), the display interface (DSI). It has a separate slot for Micro SD card slot which is used for storing operating system as well as other software's and drivers needed. Raspberry Pi can support different operating systems such as Raspbian, Windows 10, Ubuntu etc. Raspbian operating system is used for implementation of system. Node Red is a visual programming tool for IoT which is very easy to use. Node Red has an inbuilt library consisting of thousands of flows and nodes which enable the users to connect all kind of devices and services. Once the flow is made it can be deployed and data can be seen on the dashboard.

3.1.2 Sensing Unit

Sensing Unit comprises of five sensors for monitoring the air pollution. Table 1 shows the technical specifications of the three air quality sensors, Temperature, Humidity and pressure sensors. DSM501A is a low-cost dust sensor module has a very high sensitivity as it can even detect the fine particles having the diameter greater than 1 micron. MQ9 is highly sensitive to carbon monoxide / combustible gases. It has a simple drive circuit and has a prolonged life. With the rise in concentration of the gases in air, conductivity of the sensors also increases. MQ135 has wide scope for detection of NH3, alcohol, CO2, smoke, etc. with a very low response time. DHT11 is a four-pin, resistive type having digital output relative humidity and temperature sensor. BMP 180 is a low- cost sensor used for monitoring barometric air pressure and can also be used as an altimeter as the pressure changes with the variations in altitude.

Sensors List		
Parameter	Operating Voltage	Measuring Range
Particulate Matter	5 V	10 to 10000 ppm
Carbon Monoxide	1.5 V	10 to 10000 ppm
Carbon Dioxide	5 V	10 to 10000 ppm
Temperature	3.3 V	-40 to +80 degree Celsius
Relative Humidity	3.3 V	0 to 100 % RH
Pressure	5 V	300 to 1100 hPa

Table 3.1: Sensors voltage range

3.1.3 Software Architecture

It involves Node-Red and Integrated Development Environment.

3.1.3.1 Node-RED

Node-RED is an easy to use, fundamental and an open source programming tool for IoT applications. It is highly used visual programming tool which help IoT developers to integrate Hardware devices, APIs and online services in a very interesting and creative manner. Built in Library of Node-Red consist of thousands of flows and nodes that enable the user to connect all kind of devices and services. Flows can be run at the edge of network on the hardware like Raspberry pi or in the cloud since node-red runtime includes node.js. Node-Red provides a simple click mechanism to deploy the flows by the IoT developers to a light weight runtime environment.

3.1.3.2 Integrated Development Environment

Arduino programs can be written in any programming language that has a complier for a conversion of program code into the binary code. IDE is platform independent acting as the base for Arduino hardware. It is a very powerful for programmers, project development professionals and researchers to develop various Arduino projects employing different kind of sensors. Arduino IDE is an open source design/ software which has originated from the integrated development environment for the languages processing and wiring projects. As IDE is platform independent, it can run on Windows, Linux based operating system as well as Mac OS. Some of the key features of IDE include a text console, message area, toolbar for common functions. A program for Arduino using IDE platform is known as sketch, languages like C, C‘++ are supported by Arduino IDE for programming.

3.1.3.3 MQTT Protocol

MQTT is extremely light weight connectivity protocol for internet of things applications. It is designed for devices and high latency, low bandwidth, unreliable network. Its main-principle is to minimize device resource requirement and network bandwidth. IANA reserved TCP/IP port 1883 for use with MQTT over SSL. Unlike HTTP protocol it does not MQTT is extremely light weight connectivity protocol for internet of things applications. It is designed for devices and high latency, low bandwidth, unreliable network. Its mainprinciple is to minimize device resource requirement and network bandwidth. IANA reserved TCP/IP port 1883 for use with MQTT over SSL. Unlike HTTP protocol it does not follow request/response architecture instead it follows publish/subscribe architecture.

3.2 Methodology

Our sensor based Air quality monitoring system measuring the ambient pollution is highly accurate, affordable, easy to use. DSM501A is a PM sensor connected to digital pin 5 of Arduino, DHT11, BMP180 are connected to the Digital pi3 and 4 of the Arduino where as MQ135 and MQ9 are interfaced to analog pin 2 and 3 of Arduino. Arduino is interfaced with Raspberry pi via a USB cable. Raspberry pi is connected to internet with the help of Wi-Fi adapter and the adapter is connected to Raspberry pi at USB port.

Initially operating system has to be installed into Raspberry pi by downloading image from the Raspberry pi official website. The file having .zip extension has to be unzipped to retrieve .img file and write the image to the SD card. As of November 2015, version of Raspbian Jessie,

As of November 2015, version of Raspbian Jessie, SD card image is preinstalled with Node-RED and it is necessary to upgrade it. When Pi boots up using the command “sudo systemctl enable nodered.service” Node-RED starts running automatically. In order to use cloud services of IBM, an account is created at IBM Bluemix and at the same time device is to be registered. Once the device is registered, Bluemix IoT platform will acknowledge the user by providing the Auth token which can be used for the communication of data from device to Bluemix IoT platform.

The sensors are already connected to the Arduino board and Raspberry pi is interfaced with Arduino. So, by deploying a flow containing Serial in node to receive the data coming from Serial port to raspberry pi, Serial in node is connected to Watson IoT node for sending the data to the cloud. The data can be seen on the dashboard of IBM Bluemix IOT platform anywhere in the world, only requirement is that device should be connected to internet.