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Personal Pollution Exposure Monitoring using Pollution Sensors and Health Prediction

Dr. C. M. Jadhao
Department Of EXTC
Principal, MGI-COET, Shegoan,
Shegoan,India
cmjadhao@gmail.com
Mobl.no.8308848692

Prof. R. R.Ambalkar
Department Of EXTC
Assistant Professor, MGI-COET,
Shegoan
Shegoan,India
ambalkar.rahul@gmail.com
Mob no.7722027505

Miss S. M. Naphade
Department Of EXTC
MGI-COET, Shegoan,
India
snehalnaphade826@gmail.com

Abstract— The aim of this paper is to outline air pollution mapping system for an individual. For this it incorporates interfacing some pollution related sensors (CO2, CO and clean sensor) to the clients body which will continually screen the encompassing air pollution levels and figure the correct measure of dangerous gasses breathed in by the client contingent on the breathing rate of the client. Contingent on these qualities, the client will be alerted continuously by indicating notices where pollution level has out performed the allowable breaking point. The data will be preserved (on-chip) and later analyzed using graphs and diagrams prepared in Excel using Visual Basic. The data analysis will provide the user with health prediction.

Keywords: *Air pollution monitoring, Personal pollution mapping, Real time alerts, Data server, Health prediction.*

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I. INTRODUCTION

Air pollution has become an intense issue as of late.The issue is more serious in substantial mechanical urban areas.Air pollution has known to have a serious health effects on human body.The World Health Organization (WHO) approximates that around 1.4 billion urban residents worldwide are living in areas with air pollution above recommended air quality guidelines. Chronic exposure to air pollution increases the risk of cardiovascular and respiratory mortality and morbidity, while acute short-term inhalation of pollutants can cause changes in lung function and the cardiovascular system exacerbating existing conditions such as asthma, chronic obstructive pulmonary disease (COPD), and ischemic heart disease. Indeed, it is evaluated worldwide that air pollution kills a greater number of individuals every year than street mishaps.The World Health Organization information demonstrates a few million individuals are being affected via air pollution related sicknesses what's more, pass on rashly because of air pollution instigated sicknesses. In this way, observing and controlling encompassing air pollution is high on general society awareness in both creating and created nations.Hence, it becomes very important for an individual to know the amount of toxic gases his body is being exposed to know the ill effects of air pollution on health. Fortunately we have various destinations checking air pollution record and proportion of poisonous gasses introduce noticeable all around in different parts of the urban communities (Like we do have a site in Shivajinagar area of Pune). But these sites are fixed at a point and consider aggregates of pollution levels and use coarse data to calculate actual amount of pollution which is not very accurate. Moreover, these sites are located at some distance from the actual polluting machines or vehicles. Hence it can never calculate the amount of pollution to which a particular individual is actually exposed (consider a biker driving behind a polluting lorry). The amount of harmful gases actually consumed by the biker will differ a lot from the amount calculated by the pollution monitoring site. Secondly,the general public does not really understand the seriousness and consequences of pollution data displayed by these sites. They have no means to understand the health effects of the pollution levels they are exposed. Hence, these existing pollution monitoring sites shows only the aggregates of the data and are least useful at the individual level.

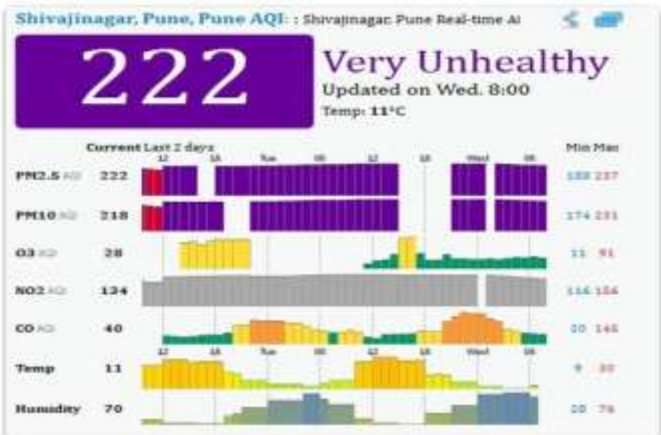

Figure 1.1: The Air Quality Index (AQI) showing status Very Unhealthy for Shivaji nagar area of Pune

The amount of pollutants breath in by an individual also varies from person to person due to difference in body structures and the activity that a person is currently exhibiting. For example, consider two individuals who are both in the same place at the same time, but one is driving while the other is sitting idle.

They will experience the impact of air pollution in different ways since they will inhale different amounts of air due to their different breathing rates. Hence, person who is jogging is likely to be more affected than the person who is sitting idle. Also, they may additionally have different medical predispositions to the exposure. When these differences are accumulated overa long period, they can become signiffcant, leading to different health outcomes. The sites monitoring air pollution never considers the level to which an individual is actually being exposed. Hence, it is almost impossible to calculate and predict the health effects of air pollution on individual health.

AQI Mark	AQI Colours	Category	Description of AQI effects
	Maroon	Hazardous	-
	Maroon	Hazardous	The entire population is more likely to be affected.
	Purple	Very Unhealthy	Everyone may experience more serious health effects
	Red	Unhealthy	Everyone may begin to experience health effects.
	Orange	Unhealthy for Sensitive Groups	People likely to be affected at lower levels than the general public
	Yellow	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people.
	Green	Good	Air quality is considered satisfactory, and air pollution poses little or no risk

Figure 1.2: Various levels of Air Quality Index (AQI) and corresponding health concerns

II. LITERATURE SURVEY

Air pollution is a serious concern worldwide and several projects have emerged over the past few years to develop an effective system to measure and monitor air pollution and study its effects on human health. This chapter discusses few of the previous works done on air pollution monitoring.

Over the past few years several projects have emerged that attempt to crowd source data from low-cost portable mobile sensors to obtain air pollution approximates of high spatial granularity. Notable ones include the MESSAGE [10] (Mobile Environmental Sensing System Across Grid Environments) project in the UK, the MAQUMON project from Vanderbilt University, the Common Sense project supported by Intel, and the Open Sense project ongoing at EPFL Switzerland. Another notable project called HazeWatch [2] that monitors and maps Sydney air pollution in real time via vehicle mounted pollution sensors using both custom-built and off-the-shelf hardware. All these frameworks concentrate on social occasion the pollution information, and less on utilization of information by people personalizedly. Haze Watch Haze Watch [2] aims to crowd-source fine-grained spatial measurements of air pollution in Sydney, and t Haze Watch [2] aims to crowd-source fine-grained spatial measurements of air pollution in Sydney, and to engage users in managing their pollution exposure via personalized tools. The Haze Watch project uses several low-cost mobile sensor units attached to vehicles to measure air pollution concentrations, and users mobile phones to tag and upload the data in real time. It includes development of a portable sensing unit mounted on vehicles, a mobile phone application for data tagging and uploading, and a centralized repository for hosting the data. The greater spatial granularity of data thus collected enables creation of pollution maps of metropolitan Sydney viewable in real-time over the web, as well as personalized apps that show the individuals exposure history and allow for route planning to reduce future exposure. This includes appropriate models for interpolating the spatial-temporal data points, visualization of pollution over a geographical map of the area, and mobile apps that show personal exposure and low pollution travel routes. The developers test and deploy the system with a small number of users to show that it yields much more accurate estimates of personal exposure than existing systems based on coarse-grained data from static sensors, demonstrating the potential benefits that larger scale deployments can bring to our understanding of the relationship between pollution exposure and health.

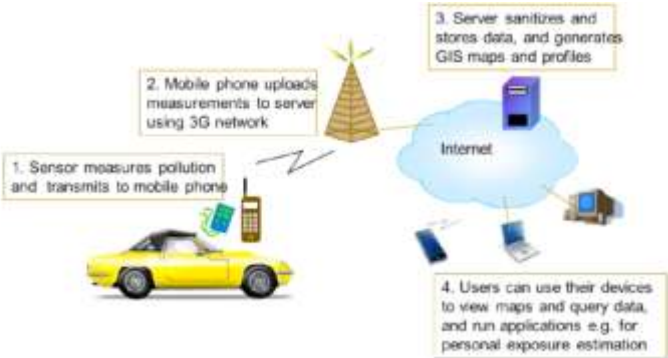

Figure 2.1: HazeWatch Architecture

A. MESSAGE

From Cambridge University and partners in the UK,the most appreciated projects in this domain is the MESSAGE (Mobile Environmental Sensing System Across Grid Environments) project, which aims to develop fixed and portable devices for high-density measurement of concentrations of carbon monoxide and nitrogen oxides in urban areas. They have very recently reported their development and deployment experience in the Cambridge area, and demonstrated that the use of low-cost fixed and portable devices deployed in high densities can give a much more accurate picture of the spatial and temporal structure of air quality in the urban environment. The scale and scope of this project is commendable, and the contributions in building the devices, deploying them city-wide, and modeling the collected data are noteworthy; however, these portable devices are relatively expensive and bulky for regular use by pedestrians/bicyclists, and personalized tools for estimating and managing exposure remain under-explored.

B. MAQUMON

Vanderbilt University, supported by Microsoft, embarked upon a similar project, called MAQUMON [3](Mobile Air Quality Monitoring Network). The system consists of number of developed car mounted portable wireless sensor units for measuring ozone, nitrogen dioxide and carbon monoxide. The data points are tagged with location and time utilizing an on-board GPS. Periodically, the measurements are uploaded to a server, processed and then published on the Sensor Map portal. Given a sufficient number of nodes and diverse mobility patterns, a detailed picture of the air quality in a large

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area will be obtained at a low cost. The units are autonomous, having on board ash (for storage), GPS (for location) and GSM (for communication) capabilities, making them much more bulky and expensive. The developers also developed innovative web-based visualization (e.g. contour-maps) and personalization (e.g. route-planning) tools, making it more accessible for lay users.

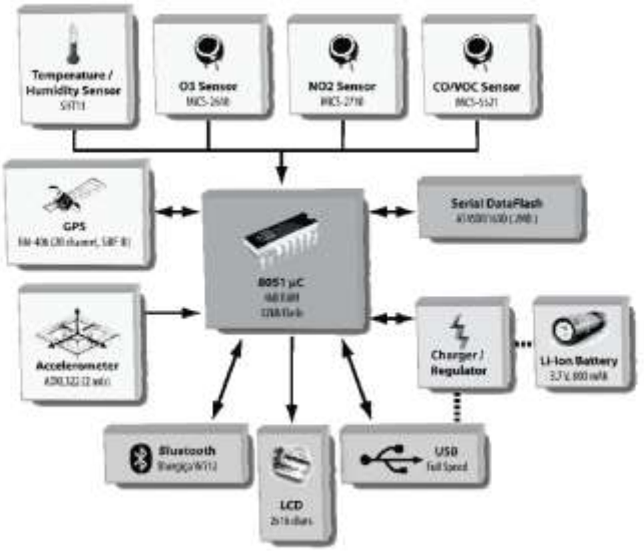

Figure 2.2: MAQUMON Block Diagram

C. COMMONSENSE PROJECT

Intel has also been developing as part of the CommonSense project, a prototype that is a portable handheld device capable of measuring various air pollutants. This data can be uploaded in real time and viewed on Google Maps. The Common Sense project is currently running trials with these devices attached to the rooftops of street cleaners in the city of San Francisco. Several other projects, such as Sensaris, iSniff, etc. have similar goals, but probably the most noteworthy is the well-funded Open Sense project that is on going at EPFL Switzerland. They have successfully deployed several air monitoring units on top of public buses. In spite of the replication of effort across these several projects, they are all worthwhile efforts since they collectively explore different deployment scenarios (e.g. buses versus private cars) in different regions of the world. Exposure Sense

A research group in Barcelona, Spain designed a survey that tried to compare the exposures with different travel modes. They asked commuters to use different transport modes going along the same route to find out their relative inhalation dose. The inhalation rate algorithm they used was developed by other researchers, which assumed that inhalation rate ratio between different travel modes were constants. The referenced inhaled dose calculated by them can be neither real-time nor sufficiently accurate. Another group of researchers discussed how to combine individual time-activity patterns and air pollution concentrations, and gave a model to integrate the data. They designed a system called Exposure Sense which can combine smart phone accelerometer, external air quality data and pluggable sensors for personal pollution exposure estimation. In these projects, only personal location and acceleration information were considered as activity data, which can estimate the ambient air pollution concentrations, instead of personal real-time inhaled dose.

CalFit. There also exist studies in the literature that try to associate human activity levels with pollution exposure concentrations. Few studies use physical activity times to estimate personal exposure, and its effect on Ischemic Heart Disease Mortality. However, these studies only use the users home location to estimate their exposure, without regard to the mobility pattern of the individual. A group of researchers from Europe developed a tool called CalFit that records the individuals location and activity information. However, their study did not use participatory sensor networks, and instead relied on historical data from fixed monitor sites and derived exposure estimates based on an Atmospheric Dispersion Modeling System (ADMS). One can say that using data with such low spatial density can lead to incorrect exposure estimates and hence biased medical inferences. Personalizing Pollution using Wearable sensors The system being developed by researchers from Sydney, Australia is very much similar with the objectives of this project. In this study presented in paper titled, Personalizing Pollution Exposure Estimates using Wearable Sensors authors combined ambient pollution levels taken from participatory system (i.e. a mobile node user is carrying) with an individuals activity levels to estimate the personal inhalation dosage, which can then be used to make further medical inferences for that individual. They developed a system for estimating personal air pollution inhalation dosage. The system comprises a mobile app that interfaces with wearable personal activity sensors to determine breathing rate, and combines it with ambient pollution concentration determined from participatory pollution monitoring system. The group also conducted field trials with the system in Sydney, and obtained real-time pollution inhalation dosage estimates showing that different levels of activity (driving, cycling, and jogging) entail very different levels of exposure. The improved estimates obtained from the system compared to earlier systems that do not include personal activity information allow for more accurate medical inference. This system is one of the most appreciated among the systems discussed till now as far as calculating the individuals exposure to air pollution
is considered.

Figure 2.3: System Architecture

	Inhaled dose($\mu g\ min^{-1}$)			
	FS CO data + constant RMV	FS CO data + real-time RMV	PS CO data + constant RMV	PS CO data + real-time RMV
Jogging	2.6(2.5-2.6)	10.0(4.9-11.4)	55.3(25.3-115.1)	215.5(77.3-479.5)
Bicycling	2.6(2.5-2.6)	6.6(4.1-8.0)	84.4(17.3-247.2)	220.3(36.8-690.1)
Driving	2.6(2.5-2.6)	3.1(2.7-3.4)	94.3 (22.9-477.2)	114(25.1-563.3)

FS- Fixed Site , PS- Participatory system (mobile system)
RMV- Respiratory Minute Volume (Air inhaled per minute)

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Figure 2.4: Variations observed for inhaled concentration of CO with individual activity and type of pollution monitoring system (i.e. fixed site or mobile site)

But this system does not have any continuous real time display or warning mechanism pollution levels. Hence, the user is not aware of the levels of pollutants he is consuming in real time.

Secondly, the system carries out data analysis and provides the user with the levels of pollution the user was exposed and the also the amount of pollutants entered into users body. But it does provide the user any information about the related health risks the user is subject to as there is no mechanism to provide any kind of health related analysis of the user with the given pollutant consumption of the user. Hence, as the lay user has no idea about the serious health ill-effects of the air pollutants, the user is left no choice to carry the data to the expert and take advice about the health risks which is another costly and time consuming for the user. Several studies have involved volunteers carrying portable pollution monitors. A group of researchers from USA designed a study to find out the impact of time-activity patterns on personal exposure. They followed sixteen participants, obtaining their temporal-spatial information with a PDA, and black carbon concentrations with a potable monitor. Their results showed that transportation contributed the highest black carbon concentrations. Nevertheless, their study ignored the human activity levels and only estimated the pollution concentration around the participants rather than their personal inhaled dosage. The proposed system considers all the shortcomings of the above discussed systems worldwide and tries to develop a system which can be very effective in the Indian scenario in terms of technology as well as cost. The details about the proposed working of the system are discussed in the later chapters.

III. PROPOSED SYSTEM

The main aim is to design an air pollution mapping for the individual. For this it includes interfacing some pollution related sensors (CO2, CO and dust sensors) to the user's body which will constantly monitor the surrounding air pollution levels and exact amount of toxic gases inhaled by the user. The system exactly calculates the amount of polluted air inhaled by the user. The system will carry out the analysis and display real time alerts to the user related to the pollution levels. Depending upon the intensity of alerts, the user may consider any alternate option available to avoid pollution. In addition, the data will be preserved which will be available later for analysis using graphs and diagrams prepared in Excel using Visual Basic. The user can have the whole database of daily pollutions levels of the area where user is travelling on a daily basis and also the daily pollutants consumption levels of the user. The data analysis will provide the user with health prediction i.e. probability of immediate or long term effects of various poisonous gases levels.

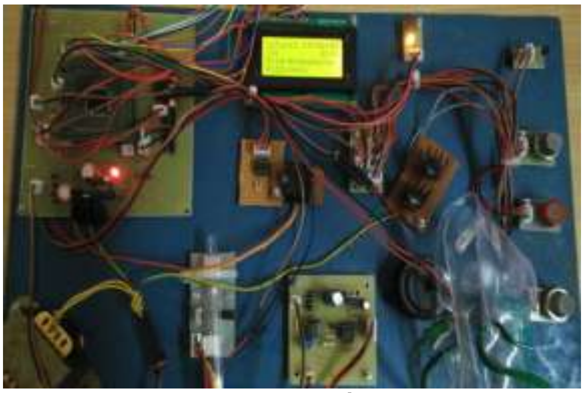


Fig. 1. Experimental Setup

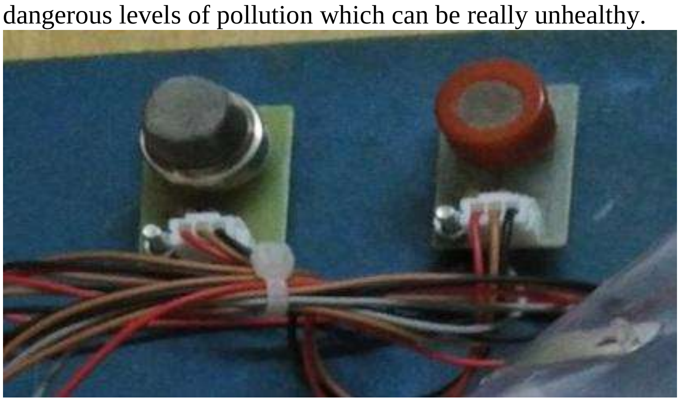
Also, user can share the data with an expert to know how it may affect in a way to increase in severeness of person already having an air pollution related disease considering the previous records of the user's disease. Also, individuals with heart disease (coronary artery disease or congestive heart failure), lung disease (asthma, emphysema or chronic obstructive pulmonary disease (COPD), pregnant women etc. are very sensitive to toxic gases such as CO, CO2.Such system can prove really helpful to these people who are very susceptible to air pollution related diseases which can severely affect their health.

IV. SYSTEM COMPONENTS AND METHODS

1. Air pollution Monitoring: The air pollution monitoring node consists of hardware and pollution sensors such as carbon dioxide, carbon monoxide and dust sensor. These sensors are used to check the pollution levels in the surrounding area. Also pollution reading is noted along with time for further analysis.

2. Activity Monitoring: The body temperature and pulse rate/ respiration rate of the user will be monitored to calculate the breathing rate of the user so as to calculate the exact amount harmful gases consumed by the user.

3. Real Time Alerts: The recorded data will be analyzed in real time also displayed on LCD attached to the users module. The alerts and warnings is provided to alert the user in case the user is exposed to high levels of harmful gases more than the permissible limits and inhaled by the user. The real time alerts given can prompt the user to manage alternatives to avoid dangerous levels of pollution which can be really unhealthy.



4. Information record: The data obtained from sensors and user activities will be stored on the device memory along with time. The data will consist of exact amount of toxic gases consumed by the user which is necessary for health analysis.

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5. VB server: The information saved money on the gadget can be exchanged by the client by the day's end to the database utilizing serial correspondence. The database will store every one of the information of the client and furnishes the client with information changed over to exceed expectations sheet alongside charts and pie graphs for itemized investigation.

Fig.3:Real time alerts on LCD

6. Health Analysis: The data saved on the device can be transferred by the user at the end of the day to the database using serial communication. The database will store all the data of the user and provides the user with data converted to excel sheet along with graphs and pie charts for detailed analysis.

V. CONCLUSION

In this paper we have presented a novel system for monitoring personal air pollution Exposure. In this article, system design does not consider any aggregates of data but calculate the exact amount of polluted air inhaled and correspondingly calculate the concentration of each pollutant in the air (CO2, CO and dust). The system senses the amount of pollution levels using onboard pollution sensors, stores the data and provides the user with detailed health effects of the consumed pollution levels. The system to be designed should be light weight and battery operated. The system should require less power and must be robust .The cost of the system must be in the affordable limits for common man.

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