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Health Prediction and Personal Pollution Exposure Monitoring using Pollution Sensors

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Abstract: The aim of this paper is to outline a wearable air pollution mapping system for an in- dividual. For this it incorporates interfacing some pollution related sensors (CO2, CO and clean sen-sor) to the clients body which will continually screen the encompassing air pollution levels and gure the correct measure of dangerous gasses breathed in by the client contingent on the breath- ing rate of the client. Contingent on these qualities, the client will be alerted continuously by indicating notices where pollution level has outperformed the allowable breaking point. The data will be pre- served (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 pol- lution 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 me- chanical urban areas.Air pollution has known to have a serious health e ects 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 recom- mended air quality guidelines. Chronic exposure to air pollution increases the risk of cardiovas- cular and respiratory mortality and morbidity, while acute short-term inhalation of pollutants can cause changes in lung function and the cardio- vascular system exacerbating existing conditions such as asthma, chronic obstructive pulmonary disease (COPD), and ischemic heart disease. In- deed, it is evaluated worldwide that air pollution kills a greater number of individuals every year than street mishaps.The World Health Organiza- tion information demonstrates a few million indi- viduals are being a ected via air pollution related sicknesses what's more, pass on rashly because of air pollution instigated sicknesses. In this way, ob- serving and controlling encompassing air pollution is high on general society awareness in both cre- ating 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 e ects of air pollution on health. Fortunately we have various destinations checking air pollu- tion record and proportion of poisonous gasses introduce noticeable all around in di erent parts of the urban communities (Like we do have a site in Shivajinagar area of Pune). But these sites are xed at a point and consider aggregates of pollu- tion 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 pol- lution to which a particular individual is actually exposed (consider a biker driving behind a pollut- ing lorry). The amount of harmful gases actually consumed by the biker will di er 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 e ects 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.

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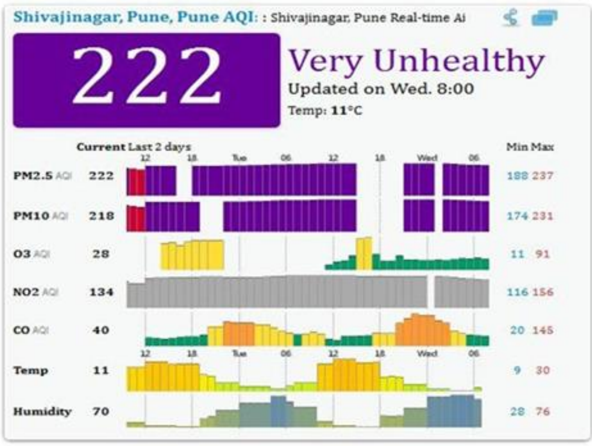

Figure 1.1: The Air Quality Index (AQI) showing status Very Unhealthy for Shivaji nagar area of Pune

The amount of pollutants breath in by an indi- vidual also varies from person to person due to di erence 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 di erent ways since they will inhale di erent amounts of air due to their di erent breathing rates. Hence, person who is jogging is likely to be more a ected than the per- son who is sitting idle. Also, they may additionally have di erent medical predispositions to the expo- sure. When these di erences are accumulated over a long period, they can become signi cant, leading to di erent 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 e ects 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 and e ective system to measure and monitor air pollution and study its e ects on human health. This chapter discusses few of the previous works done on air pollution moni- toring. Over the past few years several projects have emerged that attempt to crowdsource 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 En- vironments) 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. An- other notable project called HazeWatch [2] that monitors and maps Sydney air pollution in real time via vehicle mounted pollution sensors us- ing both custom-built and o -the-shelf hardware. All these frameworks concentrate on social occa- sion the pollution information, and less on uti- lization of information by people personalizedly. From Cambridge University and partners in the UK,the most appreciated projects in this domain is the MESSAGE (Mobile Environmental Sens-ing System Across Grid Environments) project, which aims to develop xed and portable devices for high-density measurement of concentrations of carbon monoxide and nitrogen oxides in ur- ban areas. They have very recently reported their development and deployment experience in the Cambridge area, and demonstrated that the use of low-cost xed 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 con- tributions 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.Vanderbilt University, supported by Mi- crosoft, embarked upon a similar project,called MAQUMON that developed portable wireless sensor units for measuring ozone, nitrogen dioxide and carbon monoxide.

Figure 2.1: System architecture of Project Hazewatch.

Their units are autonomous, having onboard ash (for storage), GPS (for location) and GSM (for communication) capabilities, making them much more bulky and expensive. Innovative web-based visualization (e.g. contour maps) and personaliza- tion (e.g. route-planning) tools have also devel- oped by making it more accessible for lay users. But, this project did experiments has not under- taken any long-term deployments. Intel has also been developing as part of the Common Sense project [3] a prototype that is a portable hand- held device capable of measuring various air pol- lutants. This data can be uploaded in real time and viewed on Google Maps. The Common Sense project is currently running trials with these de- vices attached to the rooftops of street cleaners in the city of SanFrancisco. Several other projects, such as Sensaris, iSni , etc. have similar goals, but probably the most noteworthy is the well- funded OpenSense project [2] that is ongoing at EPFL Switzerland. Ontop of public buses sev- eral air monitoring units have successfully de- ployed by them.In spite of the replication of e ort across these several projects,they are all worth- while e orts since they collectively explore dif- ferent deployment scenarios (e.g. buses versus private cars) in di erent regions of the world. There also exist studies in the literature that try to associate human activity levels with pollution exposure concentrations. Few studies use physi- cal activity times to estimate personal exposure, and its e ect on Ischemic Heart Disease Mortal- ity. 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 [7] that records the individ- uals location and activity information.However, their study did not use participatory sensor net- works, and instead relied on historical data from xed 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 in- ferences. Several studies have involved volunteers carrying portable pollution monitors. A group of researchers from USA designed a study to end out the impact of time-activity patterns on personal exposure. They followed sixteen participants, ob- taining their temporal-spatial information with a PDA, and black carbon concentrations with a potable monitor. Their results showed that trans- portation 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.A re- search group in Barcelona, Spain designed a survey that tried to compare the exposures with di erent travel modes. They asked commuters to use dif- ferent transport modes going along the same route to nd out their relative inhalation dose. The in- halation rate algorithm they used was developed by other researchers, which assumed that inhala- tion rate ratio between di erent travel modes were constants. The referenced inhaled dose calculated by them can be neither real-time nor su ciently 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 loca- tion and acceleration information were considered as activity data, which can estimate the ambient air pollution concentrations, instead of personal real-time inhaled dose. The system developed by researchers in [1] from Sydney, Australia is very

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much similar with the objectives of this project. In this study [1] they have 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 eld trials with the system in Sydney, and obtained real-time pollution inhalation dosage estimates showing that di erent levels of activity (driving, cycling, and jogging) entail very di erent 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.

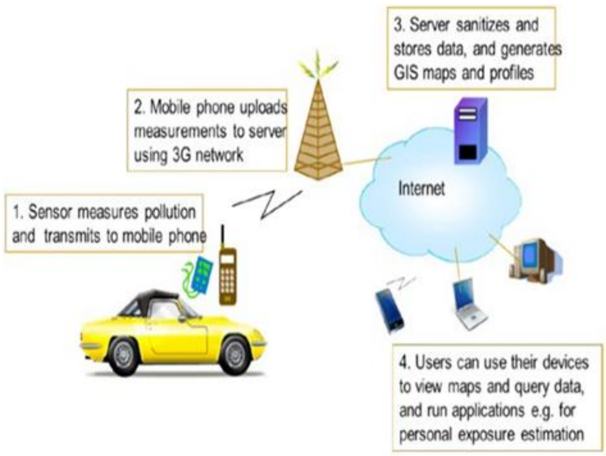

Figure 2.2: System Architecture of [1]

But this system does not have any continuous real time display or warning mechanism to provide the user with real time alerts about the hazardous lev- els of surrounding pollution levels. Hence, the user is not aware of the levels of pollutants he is con- suming 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 informa- tion about the related health risks the user is sub- ject 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-e ects of the air pollutants, the user is left no choice to carry the data to the expert and take ad- vice about the health risks which is another costly and time consuming for the user

III. SYSTEM COMPONENTS AND METHODS

1. Air pollution Monitoring: The air pollution monitoring node consists of hardware and pollution sensors such as carbon dioxide, carbon monox- ide 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 man- age alternatives to avoid dangerous levels of pol- lution 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.
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 ex- pectations sheet alongside charts and pie graphs for itemized investigation.
6. Health Analysis: The data saved on the device

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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.

IV. 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 cal- culate 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 e ects 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 a ordable limits for common man.

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