

Sensing Atmosphere

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ABSTRACT

The World Health Organization reports that 2 million people die each year from the effects of air pollution, twice the number of fatalities as from automobile accidents [1]. Direct causes of air pollution related deaths include aggravated asthma, bronchitis, emphysema, lung and heart diseases, and respiratory allergies. While civic agencies address large-scale environmental health problems from the top down by working directly with governments and industries, we explore the design of personal platforms for sensing our natural environment and empowering collective action across blocks, neighborhoods, cities, and nations. In this paper, we report early findings from two field studies of human centered air quality measurements and a simple technology deployment in the spirit of this new *Participatory Urbanism*: (1) an interview survey of air quality awareness, (2) a field study using several mobile air quality environmental sensors deployed across Accra, Ghana, and (3) the release of an on-the-go air quality awareness mobile SMS tool.

1. INTRODUCTION

On January 8, 2007 a strong odor suddenly overwhelmed residents of New York City. Emergency crews were unable to pinpoint any gas leaks or other causes. The uncertainty caused anxiety and fear in citizens even after the odor dissipated the next day. After searching 140 industrial facilities, officials declared that they were giving up all hope of finding the source of the mysterious odor [2]. Even with one of the densest monitoring systems of any metropolitan city, with approximately 25 air measurement stations drawing in samples of air every half hour to calculate the concentration of these contaminants, city officials were unable to pinpoint the source.

While we may never know the actual cause of the odor, imagine if even a fraction of the mobile phones carried by the nearly 22 million citizens of New York City were augmented with a low cost air quality sensors to measure air pollutants from not just 25 fixed locations but literally millions of actual places people transit within the city – from bus stops, subways, and elevators to parking garages, parks, and offices. By promoting an open model for authoring, sharing, and remixing these people centric personal air quality measurements, the resulting denser data sets would likely produce a more detailed picture of phenomena and hopefully lead to solving the mystery. This is one of the goals of Participatory Urbanism.

Participatory Urbanism is a computing paradigm that contradicts the typical usage model of mobile devices as communication tools and recasts them as “networked mobile personal measurement instruments”. These new “measurement instruments” enable entirely new mobile device usage models by promoting the open

authoring, sharing, and remixing of people centric environmental measurements.

Our strategy is to design and deploy a series of networked measurement instruments that are embedded within our everyday places as well as coupled to personal mobile devices to collectively capture a view of our environment. More importantly, our research positions citizens as the driving element for collecting, reporting, interpreting, and collectively improving the health of our natural environment. Our hypothesis is not only that a wealth of novel and important untapped computing interactions exist in this research space, but that such experiences are certain to become a dominant paradigm in our evolving relationship with technology.

1.1 Related Work

Participatory Urbanism builds upon a large body of related projects where citizens act as agents of change. There is a long history of such movements from grassroots neighborhood watch campaigns to political revolutions. Due to space within this paper we simply outline them briefly here.

Our primary motivation from a social urban standpoint comes from the insights of leading urban practitioners such as Jason Coburn [3], Jane Jacobs [4], and the sociologist Ulrich Beck [5]. More recently, a collection of people centric sensing projects have been developed such as the EQUATOR e-science project that mapped carbon dioxide levels across London [6], UCLA’s Participatory Sensing initiative within the Center for Embedded Network Sensing that has developed tools and infrastructure for enabling individuals and groups to setup their own public “campaigns” using networked mobile devices and sensors [7], Microsoft’s SenseWeb [8] and SensorMap [9] for sharing and remixing sensor data, Nokia’s Sensor Planet project [10], and Preemptive Media’s AIR (Areas Immediate Reading) mobile device [11].

1.2 Goals and Studies

We are currently designing hardware and software tools to study the social and intimate experiences to begin to understand the experience of daily living with people centric air quality sensors integrated with everyday mobile phones. In this paper we describe results from two studies into Participatory Urbanism and air quality.

2. PERCEPTIONS OF AIR QUALITY

What does “air quality” mean? How is it measured? Where? How often do people think about their air quality? Where can you find the reported/forecast air quality? We were interested in understanding people’s perceptions of air quality and their interest in taking personal measurements. We conducted personal interviews with 12 residents (9M/3F 23-56 years old) that were approached on public streets of a major metropolitan US city using the questions above as well as others. The small sample

size prohibits statistically significant data but several insights can be drawn. Mentioning the term “air quality” elicited responses such as pollution, smog, Los Angeles, Athens, soot, pollen, asthma, vehicles, breathing, smells, cleanliness, quality of life, and even global warming. None of the participants had a clear understanding of how and where air quality was measured in their own city and only one knew that reported forecasts could be found in the weather section of the local newspaper. When participants speculated on where air samples were taken, the dominant model was samples at multiple locations - “at least in every district in the city”, “hundreds if not more near factories, close to highways, etc”, and “all around”. Some voiced concern over the management of the data - “I don’t trust the government to collect and report air quality”. However, every participant expressed some degree of interest in personally being able to sample air quality, most of them enthusiastically positive responses - “definitely...what a cool idea”, “absolutely”, “yes, it has a lot to do with how we breath”, “I would try to spread the new across the world”, “I want to be part of the solution”, “I am concerned and want to be involved and monitor it”, “yes, especially if it was useful to other people”, “that would be cool ... I’d love to do that”, and “definitely but only if it could bring about some global change in policy or action”. This led us to further understand the existing air quality system and how we could enable personal sampling.

3. ACCRA, GHANA FIELD STUDY

What would be the experience of daily living with a personal mobile environmental measurement device? How can we understand the challenges associated with large, distributed, geo-logged data collection schemes by non-experts across everyday urban life?

We recruited 7 tax drivers and 3 students in Accra, Ghana for a two-week study. We chose Accra because of its poor air quality and common practice of domestic cooking outside using wood, charcoal, and other biofuels, generating harmful pollutants across the city. Subjects were modestly compensated even if they did not participate in the full study. Each taxi driver was provided with a dash mounted GPS logger and a tube to hang from their passenger window that contained a carbon monoxide sensor and (a sulfur dioxide sensor or a nitrogen dioxide sensor). Similarly, 3 students were each given a mobile clip sensor pack containing a GPS logger, carbon monoxide sensor and (a sulfur dioxide sensor or a nitrogen dioxide sensor). At the end of each day, the sensor pack was dropped off at a convenient location where the data was extracted and the sensors charged. The system was setup to automatically log sensor data every second. Subjects were asked to carry the sensor/GPS loggers as much as possible and during normal everyday activities, including those surrounding work, family, and relaxed social activities. This study allowed us to collect actual geo-logged air quality sensor data by citizens across an urban landscape and influence our design for an integrated air quality sensor with a mobile phone.

Again space limits a complete discussion of the results, however even rendering a small sample of only carbon monoxide over just a single 24 hour period from the full three-gas two-week dataset, exposes a previously unmeasured and diverse range of air quality across the city (see Figure 1). A standard Gaussian distribution model was used to render the heat map visualization from the actual readings. The red circles represent locations where actual measurements were taken.

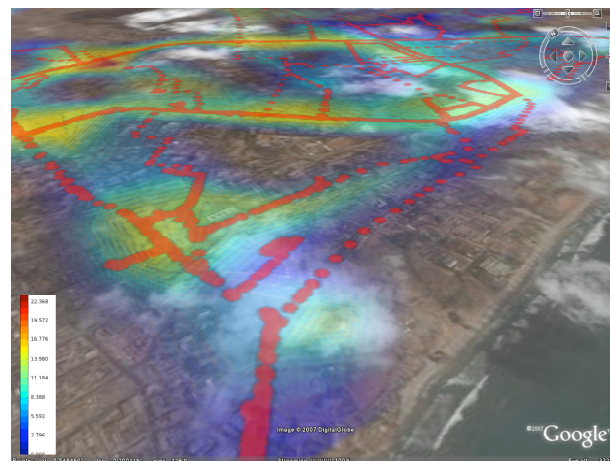


Figure 1. A heat-map visualization of carbon monoxide readings across Accra, Ghana rendered atop Google Earth. Colors represent individual intensity reading of carbon monoxide during a single 24-hour period across the city. Red circles are locations where actual readings were taken.

4. ERGO: AIR QUALITY ON-THE-GO

To further study the experience of receiving air quality data on a mobile platform while on-the-go, we designed a public tool called Ergo. Ergo is a simple SMS system that allows anyone with a mobile phone to quickly and easily explore, query, and learn about his or her air quality on-the-go. Ergo uses data from the United States Environmental Protection Agency (EPA) based on fixed metropolitan air quality measurement stations. Sending a text message containing a zip code causes Ergo to deliver current air quality data (usually less than 20 minutes old) and up to three days of forecast for the area. Similar SMS commands to Ergo allow users to request the worst three polluted locations within the United States that day as well as schedule daily air quality reports to be delivered to their mobile device at any specified frequency. Ergo has delivered nearly 10,000 air quality reports and generated a range of positive feedback including comments from individuals with respiratory problems. For example, several individuals have reported on how the system has improved their lifestyle and provided them with easy access while on-the-go to real-time geographically measured air quality reports.

5. CONCLUSION

As we move towards this new paradigm of mobile phone as measurement instrument, we will need a deeper understanding of how these new personal and collective mobile sensing experiences affect our urban lives – how communities and groups can author, share, and remix these collective datasets. More importantly how will these individuals and groups act on these datasets and promote societal level net positive changes? We have attempted to present a series of brief overviews into this design space through several insightful studies of this *Participatory Urbanism* with a focus on using this data to inform the design of our mobile phone based air quality sensor project.

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