Demo Abstract: Common Sense - Participatory Urban Sensing using a Network of Handheld Air Quality Monitors

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Abstract

Poor air quality is a global health issue, causing serious problems like asthma, cancer, and heart disease around the world. Earlier this decade, the World Health Organization estimated that three million people die each year from the effects of air pollution [6]. Unfortunately, while variations in air quality are significant, today's air quality monitors are very sparsely deployed. To address this visibility gap, the Common Sense project is developing participatory sensing systems that allow individuals to measure their personal exposure, groups to aggregate their members' exposure, and activists to mobilize grassroots community action.

Categories and Subject Descriptors

B.0 [**Hardware**]: General; B.4 [**Hardware**]: Input/Output and Data Communications; H.5.m [**Information Interfaces and Presentation (e.g., HCI)**]: Miscellaneous

General Terms

Design, Human Factors, Measurement

Keywords

Air Quality Sensing, Mobile Participatory Sensing

1 Overview

Data about air quality could enable important advances in medicine, science, and policy. However, only limited air quality readings are currently available. At present, air quality readings are typically taken by official organizations in a relatively small number of fixed locations. These readings are made with carefully calibrated professional equipment, and therefore often have the advantage of being highly accurate. This system offers many benefits and meets regulatory specifications. However, it has nonetheless been critiqued as being limited in the number of monitoring sites (e.g., only one site for the City of San Francisco), as well as for failing to represent the air that citizens breathe on a day-to-day basis (due in part to the fact that regulations require monitoring intakes to be located high above the ground and well away from highways, railroads, and other identified pollution sources to ensure that sites collect "representative" values rather than "peak" values).

In this demo, we will present a mobile participatory sensing [1] approach to collecting air quality data. Mobile participatory sensing uses consumer electronics (e.g., mobile Internet devices and mobile phones) to capture, process, and disseminate sensor data, complementing alternative architectures (e.g., wireless sensor networks) by "filling in the gaps" where people go but sensor infrastructure has not yet been installed. While some types of sensors are already commonly present in consumer devices (e.g., geolocation, motion, sound, etc.), other kinds of compact, low-power sensors (e.g., air quality) are not yet commonly included but offer the ability to collect additional data of individual and social interest. Our work is in the spirit of "citizen science" [5] or "street science" [2], in the hopes of enabling everyday citizens to collect politically relevant data and participate in the decision making process.

2 Implementation

If the kind of sensing-based applications we envision prove out, we would expect the required sensors to be integrated directly into mobile devices. For prototyping, however, we are developing a suite of board designs and embedded software that can be deployed with associated mobile devices or in a stand-alone configuration, as Figures 1(a) and 1(b) show. Sensor readings and GPS space-time stamps are sent to a database server using a GPRS radio. We are also developing mobile and Internet-based visualization tools and community features to support collaborative online interpretation of interesting phenomena and collective development of strategies for action, as Figures 1(c) and 1(d) show.

The design of handheld air quality monitors raises a range of research challenges. Since monitor "deployment" is not a carefully controlled process – different users will carry or mount the monitors in different ways – there may be time-varying biases in the readings that must be detected and corrected. Sensor data can be acquired on different timescales, triggered by different actions, and delivered in a multitude of different ways. For example, sensor data may be collected periodically, randomly, or non-uniformly. Sensor data acquisition, and especially GPS position fixes, may be triggered in response to detected motion rather than continuously, to save battery drain and extend lifetime. Similarly, sensor readings may be delivered via Bluetooth, 802.15.4, or GPRS radios, depending on either user interest or data entropy.

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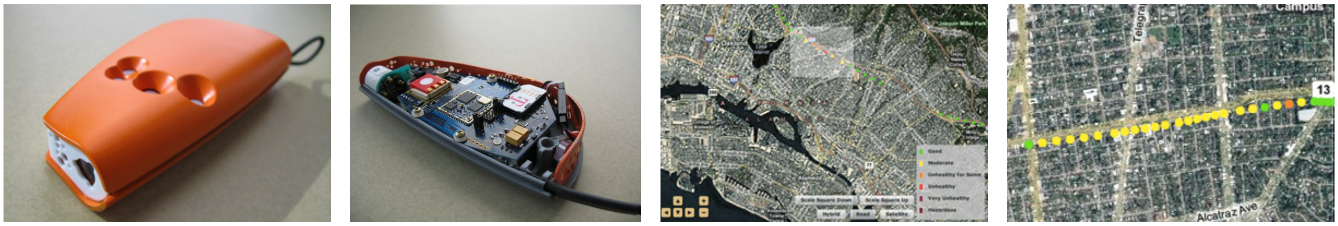

(a) Enclosure (b) Electronics (c) Web Interface (d) Web Interface – detail

Figure 1. The current hardware can be selectively populated with commercial carbon monoxide, nitrogen oxides, and ozone gas sensors as well as light, temperature, relative humidity, and orientation sensors. This sensor data is acquired and processed locally using the Epic Core module [3], which also provides an 802.15.4 interface suitable for connecting with other sensors or low-power networks. The handheld monitor can be tethered to a mobile phone using the handheld's integrated BlueSmiRF Bluetooth module from SparkFun which allows sensor readings to be easily visualized on a mobile phone. Finally, a Cinterion GPRS radio and GPS receiver enable the sensor samples to be space-time stamped and uploaded to a hosted server for dissemination, visualization, and analysis over the web. Photos (a) and (b) by Mazzarello Media and Arts.

Striking a balance between the needs of the individual and the needs of the group – between longer sensor life and higher global data fidelity or between privacy and accountability – remains a dynamic challenge. Privacy concerns, in particular, complicate matters since sensor data may include personally identifiable space-time stamps.

3 Demonstration

We will demonstrate the Common Sense distributed air quality monitoring system, which combines handheld environmental air quality monitors with a browser-accessible web portal. More specifically, our demonstration will include:

1. **Handheld.** Handheld monitors and a portable ozone generator will be available for attendees to explore the sensor response and view the results in real-time. We will also feature the enclosures we have built for the handheld monitors. The enclosure design addresses a range of challenges, such as buffering the enclosed sensors from vibration as well as making the handheld monitors comfortable to carry. Several handheld monitors will be available for attendees to inspect. The authors will be available to discuss many of the research and engineering challenges with integrating low power sensors and mobile phone electronics.

2. **Web Portal.** Attendees will be able to select start/end times, geographical extents and sensor identifiers, and view a combination of historical and real-time data. This interface allows users to compare how observations from the same sensor differ over space and how well different sensors correlate with each other over the same space (and time) extents.

3. **Mobile Phone.** In the future, we hope that environmental monitoring sensors will be available as mobile phone accessories. Meanwhile, time permitting, our demonstration will approximate that experience by displaying personal exposure to pollutants either by using a mobile phone's Bluetooth interface to collect data directly from a handheld monitor or by collecting this data from the web portal. The phone-based application will process local data, and potentially integrate the results with remote data, to present a unified view of one's personal exposure and surrounding environment.

4 Acknowledgments

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