Citisense: Mobile Air Quality Sensing for Individuals and Communities

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Abstract

Air quality has great impact on individual and community health. In this demonstration, we present Citisense: a mobile air quality system that enables users to track their personal air quality exposure for discovery, self-reflection, and sharing within their local communities and online social networks.

Categories and Subject Descriptors D.2.11 [*[Sofware Engineering] Software Architectures*]: Service-oriented architecture (SOA)

General Terms Design, Reliability, Security, Human Factors

Keywords ubiquitous systems, air pollution, mobile systems

1. Background

During daily activities, we are exposed to many invisible environmental hazards, such as pollutants from automobile exhaust, ozone, and methane. According to the EPA, in 2007, 158.5 million people across the US lived in counties which had air conditions worse than the national ambient air quality standard [1]. These pollutants, such as diesel exhaust, are not uniformly distributed across locations and time. Similarly, residents are often not equally active during the day and some individuals may be especially susceptible to pollution related risk due to asthma or heart disease.

In this demonstration, we present CitiSense: a new kind of "citizen infrastructure" to monitor environmental conditions and pollution that users are exposed to [2]. CitiSense is developed at UCSD (University of California, San Diego). It gives real-time feedback to everyday people about the pollutants they are exposed to during the course of their day.

The architecture of CitiSense is shown in Figure 1. The system includes affordable, small sensors carried by users, Android mobile phones, and a backend cyber-infrastructure that stores the collected data and performs analysis, modeling and learning. The results of this analysis helps other stakeholders of the system better understand how diseases such as asthma develop and coordinate efforts within a user's community to improve conditions.

2. Demonstration Description

In this demonstration, we present how the CitiSense system works end-to-end. Pollution and sensor data, such as ozone, carbon monoxide, and temperature, are collected with the portable sensor-board we developed. The sensor-board has small velcro straps that make it easy to attach to a belt or backpack. The collected data is tagged with the location of each user as she moves.

Each user also carries an Android phone. The data collected by the sensor-board is transmitted, over bluetooth, to the Android phone that is coupled with the sensor-board. The phone has an application that analyzes the data as it arrives and provides real-time feedback to users about the ambient air pollution (see Figure 2). The main screen of the application, in Figure 2(a), shows the current pollution inside a cloud using the air-quality-index (AQI). When the air is clean, the cloud is green. As it gets worse, the color of the cloud changes to reflect the detected air pollution. The color scheme for AQI has been developed by EPA to provide easy-to-understand information to non-expert users. Our application has a link to the color chart prepared by the EPA.

The Android application also provides more fine-grained information about the pollution detected at the user's location (see Figure 2(b)), and a plot of the maximum AQI recorded during the past hours of the day. The application also has buttons to share the current AQI on the popular social networks.

The Android application transmits the data to the backend cyber-infrastructure (CI). The CI performs modeling and

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analysis of the data, and provides a web interface to show users their personal data collected over the day on a Google map (see Figure 3). Each bubble on the map is colored according to the EPA AQI color scheme, and numbered to show how a user moved during the day, eg. from home to work.

Furthermore, users are provided a timeline of the AQI values recorded, to see when they were exposed to more pollution. This timeline has more detail than the one provided on the phone.

3. CitiSense Development Challenges

There have been many challenges in the development of the CitiSense system. The system collects real-time data, performs real-time analysis on it, and also provides a web interface to view the data. We have run user studies with human participants who carried the sensor-board and the Android phone.

The first challenge was the large amount of data transmitted from the sensor-boards to the backend during user studies. The CI summarizes and aggregates the data in real-time and caches the results. This dramatically improves page loads and the user experience for user-facing web pages.

Another challenge was the battery usage of the mobile components. Our sensor-board can run for a week on a single recharge. Since the Android phones use GPS, it was challenging to optimize the application to allow the battery to last throughout the work day.

Another challenge was the security of user data, and making some of that data publicly available over social networks. We designed a permissioning system that allow users to configure publicly accessible time windows of their data.

4. Presenters

Celal Ziftci is a PhD student at UCSD, where he conducts research and participates in the development of the CitiSense project. He oversees the end-to-end system development, and was part of the development efforts on the Android platform, the backend CI and the web interface.

Acknowledgments

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References

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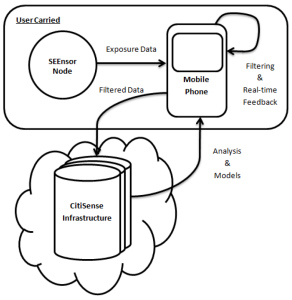

Figure 1. The CitiSense system architecture. Portable sensor-boards collect pollution data and transmit them to the Android phone. The phone provides real-time feedback, and transmits the data to the backend cyber-infrastructure (CI). The CI performs modeling and analysis on the collected data.

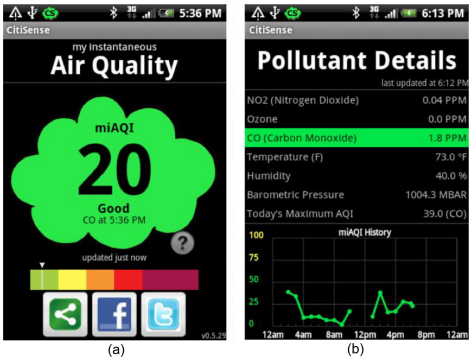

Figure 2. The Android application. The application shows real-time feedback about the pollution at the current location, as well as details about the detected AQI value, and a plot of the historical data for the day's AQI. There are also buttons to share the AQI on the popular social networks.

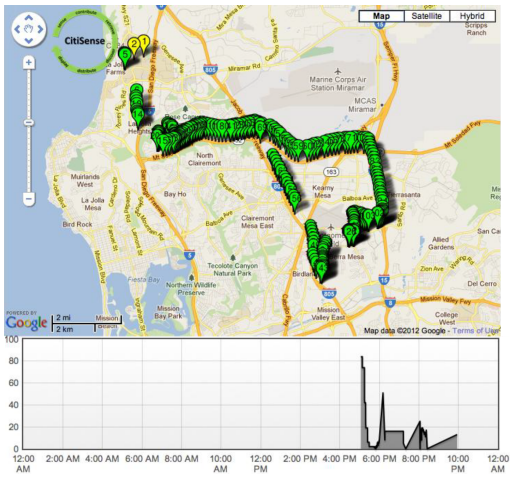

Figure 3. The map to view the data collected during the course of day. The bubbles have information about the pollution collected at a specific location. The timeline below shows the AQI over the course of day.