

AtmoSPHERE

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CSE 477, Spring 2015

ABSTRACT

Air quality is an upstream component of human health, which cannot be addressed through primary care health facilities. In this work, we present AtmoSPHERE, a connected, wearable air monitor. Our system is comprised of a wrist-worn sensor suite, a connected smartphone, and a cloud service. The sensor suite measures two major categories of airborne health risks: particulate matter and volatile organics. The phone tags the data with location data and is used to communicate between the sensors and cloud. From the cloud service, we display a dashboard to highlight air quality in travelled areas. To evaluate the system, we collected data from 2 users over the course of a week of normal activity.

ACM Classification Keywords

J.3 Health

Author Keywords

Air quality; Upstream health; Wearable; Connected devices; Distributed sensors.

INTRODUCTION

Approximately half of all known health conditions originate from environmental factors[3]. These factors are generally labelled “upstream” factors due to how they are detached from a person’s immediate symptoms during illness. Upstream factors include variables such as the sanitation of a person’s home, the condition of their workplace, or the local air. The existing health care system is not equipped to handle issues outside the hospital or clinic. However, many upstream factors are simple to identify, straight forward to address. We envision a device that can inform the user and others in the vicinity about one subset of upstream health risks.

In this project, we introduce AtmoSPHERE, a wearable air monitor for both particulate matter and volatile organic compounds (VOC). Particulate matter (PM), is any microscopic matter suspended in the atmosphere. Particulates include dust as well as more dangerous varieties classified by their diameter in microns, known as PM10 and PM2.5. A PM sensor is comprised of an infrared emitting diode and a phototransistor placed diagonally[2]. As particles pass through the path between the two components, deflected light is recorded by the

phototransistor. This approach can detect visible dust as well as finer particles, such as PM2.5.

Volatile organic compounds (VOC) are compounds with high vapor pressure at room temperature. VOCs are numerous and varied, and include harmful compounds such as benzene, chlorofluorocarbons, and methylene chloride. A VOC sensor comes in many forms. A semiconductor VOC sensor uses a chemical reaction between the air and a heated substrate, such as Tin Dioxide[1]. As the concentration of VOC in the air increases, the corresponding resistance of the substrate drops by a measurable amount.

AtmoSPHERE is intended to allow distributed sensing of environmental risks. The wearable is linked to a smartphone and through that, our cloud service and data API. By aggregating data from multiple users, we can build substantial maps of local air quality. We expect this device can be used to inform lifestyle changes.

THEORY OF OPERATION

The only physical requirement of the AtmoSPHERE is sufficient air flow through the device. The wearable is designed to be worn on the wrist, where the movement of the arms will agitate air into the sensors. However, the device can be attached to any other location on the body. The wearable also doubles as a stationary air monitor, such as when taken off during charging. While stationary, diffusion is also an acceptable means of passing air over the sensor.

For data collection, the wearable should always be within a short distance of a paired Android phone. The wearable and phone communicate via Bluetooth, so the maximum separation of the two devices should not exceed 10 meters. At the same time, the phone should have location services enabled and at least an intermittent internet connection.

IMPLEMENTATION DETAILS

Figure 1 shows the system architecture and data flow. In this section, we will detail the hardware design, the software features, and the data API.

Hardware

The device captures a total of four variables: PM, VOC, temperature, and humidity. The PM sensor is the Sharp GP2Y1010AU0F. The VOC sensor is the AMS AS-MLV-P2. Temperature and humidity are captured together with the Amphenol ChipCap2. We used a TinyDuino Processor Board to collect the sensor values and a TinyShield Bluegiga BLE112 Bluetooth module to communicate with the phone (Figure 2). A RGB LED is used to alert the user in case any sensor values peak.

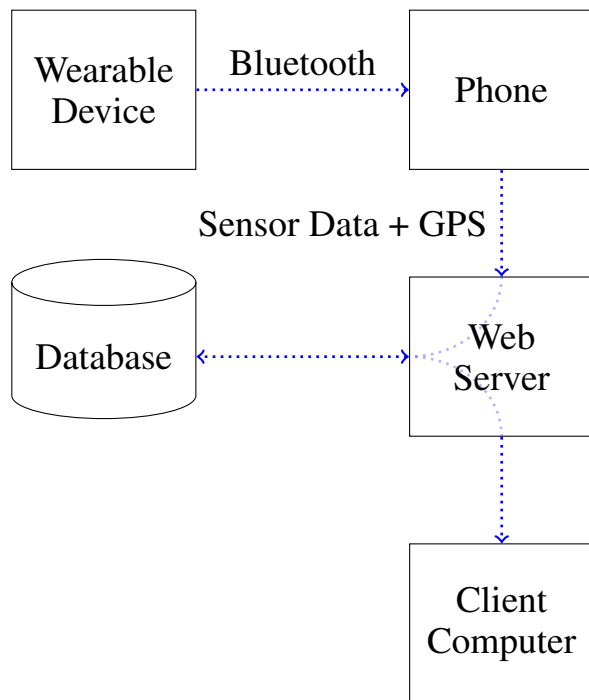


Figure 1. System architecture and data flow.

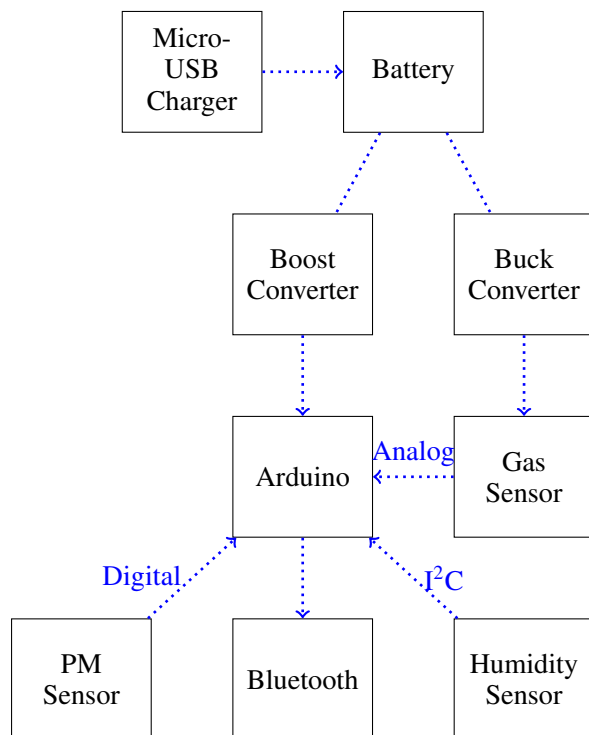


Figure 2. Components of the wearable device.

For the power source, we used a Lithium Ion Polymer battery. Due to the different voltage requirements of the sensors and microprocessor, the battery is attached to a boost converter, NCP1402, for most of the components; and a buck converter, ISL85415, for the VOC sensor. For charging the device, we added a Basic Micro-USB LiPo Charger. A switch toggles the connection to the battery, although the device is expected to stay powered continuously.

Phone Application

To connect our device with the cloud services, we require an Android phone of at least version 4.3.1 (Jelly Bean). This version of Android has built-in support for Bluetooth Low Energy, which we use to communicate between the phone and wearable. The Android application consists of four screens:

- The welcome screen performs some preliminary checks on the services the app requires, such as an internet connection and location services.
- The login screen authenticates the user grants the phone access to our cloud services, described in the next section.
- The Bluetooth screen scans and connects to our device.
- The data display screen shows several views of the data from the sensor. The display is fairly simple; more substantial views are available on our associated web site, described next.

Web Application

TODO

Data API

TODO

RESULTS

TODO

CHALLENGES

TODO

FUTURE WORK AND DISCUSSION

TODO

CONCLUSION

TODO

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