WearAir: Expressive T-shirts for Air Quality Sensing

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ABSTRACT
We designed and prototyped WearAir, an expressive T-shirt to sense the wearer's surrounding air quality as indicated by the measured volatile organic compounds (VOCs) and publicly express those levels through visually expressive patterns. Although poor air quality has been shown to affect human health, our daily exposure to such pollutants has been inadequately captured and publicly shared. Our work is designed to accurately measure and publicly express the immediately local air quality. Obtaining information regarding air quality indirectly from others might help people to increase their awareness to air quality.

Author Keywords
Air quality, expressive interface, wearable, sensing.

ACM Classification Keywords
H.m. [Information Systems]: Miscellaneous.

General term Design

INTRODUCTION
Many people are unaware of or unconcerned about air quality around them. In fact, air quality is one important factor that can damage body functions substantially and cause various health problems in humans [3]. There are several reasons people have little connection with their local air quality: (1) it is difficult for humans to sense significant changes in air quality, (2) the health effects of exposure to poor air quality are not publicly communicated, and (3) methods to communicate air quality data such as via government websites and daily print newspaper weather pages are ineffective. However, recently low cost gas sensing technologies and Do-It-Yourself (DIY) hardware prototyping platforms have enabled everyday citizens to develop personalized air quality sensing tools. Our work acknowledges these projects and develops a design to allow a more public "broadcasting" of such public health data through expressive air quality clothing. We are interested in a new level of not just citizen science but citizen persuasion where individuals publicly express, via their clothing, public health concerns. Through this expressive medium, people who have a great concern about air quality might be able to educate and persuade people who less concern about air quality.

Our design prototype of WearAir is an expressive T-shirt integrated with an air quality sensor and arrays of LEDs (light-emitting diodes). The T-shirt illuminates in response to the sensed air quality. This allows not only the wearer but also people nearby to get a sense of the quality of the air around them. We expect the expressiveness and interactivity of the T-shirt to draw attention to air quality and health from people who are less proactively concerned with air quality.

AIR POLLUTANT: VOLATILE ORGANIC COMPOUNDS
Different types of air pollutants contribute to air quality in different locations: Ozone, CO, NOx and VOCs are major contributors to outdoor air pollution; and particulate matters, VOCs, carbon monoxide and lead are common air pollutants for indoor air. We decided to measure the level of VOCs because our prototype is clothing worn both outdoors and indoors and VOCs are an important air pollutant both outdoors and indoors.

VOCs are gases emitted from certain solids or liquids including variety of chemicals. The level of VOCs is higher indoors than outdoors, up to ten times higher in some places [3]. The sources of indoor VOCs include paints, cleaning supplies, building materials and furnishings. In urban air pollution, VOC emissions from motor vehicles result in general from incomplete combustion [4]. Common symptoms of exposure to VOCs include irritation, headache and nausea by short-term exposure, and cancer, liver and central nervous system damage by long-term exposure [3].

RELATED WORK
A few mobile/wearable air quality sensors are available from academia and industries. Sensaris has introduced a GPS-equipped and Bluetooth-enabled sensor that can be worn on the wrist and allows users to measure real-time air quality [9]. AIR is a portable air-monitoring device to sense neighborhoods for pollution and fossil fuel burning hotspots [1], and CommonSense project group designed a handheld device that has carbon monoxide, ozone, NOx, temperature and humidity sensors [2]. All these are designed for use by a layperson for measuring air quality. The main difference

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Figure 1. WearAir, a lightening T-shirt. Four arrays of LEDs lighten in a sequence from left to right.

between our work and others is that ours can give a sense of air quality level to both the user and people around, whereas others report air quality only to the user.

Meanwhile, designers and researchers have been exploring ways to infuse dynamics in fabrics. Lumalive is a textile integrated with multicolor LEDs to convey emotion and messages by various lighting patterns [8]. Jacket Antics are a pair of garments that have unique texts scrolling through the LED array on their backs [5]. What differs from other works is that we convey environmental status information, air quality, not a wearer's emotion, activity or personal messages. In several related projects, clothing has been used to express measured data such as carbon dioxide and the stock market [6,7].

PROTOTYPE

We adopted a metaphor of a car emitting exhaust (see Figure 1). We used a Figaro TG2620 VOC sensor and a Lilypad Arduino main board and other Lilypad parts for the circuit (see Figure 2). Four vertical arrays of LEDs light in a sequence from left to right at different frequencies depending upon the measured VOC values. When the level of VOCs is low, it animates the sequence of lights every two seconds. During higher VOC readings the sequence speeds up to 20 Hz, Thus, when the T-shirt is exposed to dense VOCs, it looks like the entire LEDs are blinking rapidly without a sequence mimicking an alert.

Figure 2. Parts used for the prototype: battery holder, Lilypad Arduino, LEDs, VOC sensor, resistor (from top left, clockwise, left) and the VOC sensor attached on a T-shirt (right)

PRELIMINARY USER STUDY AND RESULTS

To gauge reaction and interst the WearAir was publicly worn to three separate locations, each for approximately 10 minutes: a university campus, a bus stop and a commons in a research lab. In the first two locations the wearer encounters strangers, and in the last location is where the wearer is surrounded by familiar others. We did not get any reactions from strangers about our prototype in first two locations. However, we received many questions and comments from almost all the familiar others around in the third location. The most common questions were *"What is it doing and why is it blinking?"* and *"What does it measure?"* A few people asked the wearer to come to other locations where they wondered about air quality such as their offices, fabrication labs and restrooms to see the VOC level. Many people thought the prototype will help to remind people about air quality and that is easy to use. One person commented *"It is very easy to interpret. What is better is I do not need to have that T-shirt"*.

CONCLUSION

Our work outlines early results in developing expressive wearable clothing for conveying environmental status information. We describe the design and feedback to the system from a preliminary study of WearAir, a sensor-integrated into clothing as an expressive medium for environmental status. We hope that our work can be useful to motivating others to study ways to convey environmental information to laypeople more effectively.

REFERENCES

1. AIR: Area's Immediate Reading, http://www.pm-air.net
2. Aoki, P.M., Honicky, R.J., Mainwaring, A., Myers, C., Paulos, E., Subramanian, S., and Woodruff, A. Common Sense: Mobile Environmental Sensing Platforms to Support Community Action and Citizen Science. *Adjunct Proceedings Ubicomp 2008,* Sep. 2008, 59-60.
3. EPA. Building and the Environment: A statistical Summary, *U.S Environmental Protection Agency,* 2004
4. Fenger, J., Hertel, O., Palmgren, F., Urban air quality, Atmos. Environ. 33(29), 4877– 4900, 1999.
5. Layen, B. *Jacket Antics.* Fashion Show at Siggraph 2007, 7-9 August, San Diego, CA, USA.
6. OFriel, K., CO2RSET, http://itp.nyu.edu/shows/spring2008/co2rset/
7. Patterson, N., Stock market Skirt, http://www.vacuumwoman.com/MediaWorks/Stock/
8. Philips Lumalive, http://www.lumalive.com/
9. Sensaris, http://www.sensaris.com