Demo Abstract: IASA - Indoor Air Quality Sensing and Automation

Kyeong T. Min
University of Utah
Salt Lake City, Utah 84112
kyeong.min@utah.edu

Philip Lundrigan
University of Utah
Salt Lake City, Utah 84112
philipbl@cs.utah.edu

Neal Patwari
University of Utah
Salt Lake City, Utah 84112
npatwari@ece.utah.edu

ABSTRACT

Using an air purifying system can remove indoor air pollutants, but because it increases electric power utilization, results in broader increases in air pollution. To explore the tradeoff between energy consumption and healthful air, we demonstrate the indoor air sensing and automation (IASA) system, an internet-of-things system. The IASA system uses an air quality sensor, gateway device, and smart thermostat to control the fan in a home's heating and cooling system. When fine particulate matter is high, the system operates the fan to pull air through a furnace filter and remove the pollution from the indoor air. We describe our system design, deployment, and collected data. To date, we have collected 861,000 air quality measurements with IASA.

1. INTRODUCTION

Advances in embedded systems and the internet-of-things (IoT) have made it possible to continuously monitor indoor air quality and other in-home environmental exposures for use by home occupants and by researchers studying the relationship between exposure and health. [2, 3] One such health concern is asthma. Asthma is one of the most common lung diseases in children and adults. The CDC reported in 2014 that 17.7 million adults and 6.3 million children have asthma in the United States [1]. People spend approximately two-thirds of their day indoors and exposure to irritants, such as allergens and small airborne particles can trigger asthma exacerbations. An exacerbation makes it difficult to breathe and sends people to an emergency department (1.6 million such visits happened in 2013) and can result in death (3651 US deaths in 2014) [1].

IPSN 2017 April 18–21, 2017, Pittsburgh, PA, USA

DOI:

More generally, increased exposure to airborne particulate pollution is associated with increases in rates of lung and heart disease and shorter lifespans [4].

Reducing the concentration of airborne particles in a home makes asthma exacerbation less likely and generally improves the heart and lung health of its residents. Using an air purifier or furnace fan can filter the particulate matter [5], however, these devices consume significant energy. Universal and continual use of air filtration would increase energy consumption, which when energy is produced with the burning of fossil fuels, paradoxically, increases the air pollution overall.

We propose to integrate air quality sensors which measure airborne particulate matter with automation devices which turn on a furnace fan to reduce a person's exposure to pollutants in an energy-efficient manner. We have developed a testbed which allows us to study the performance of such a system. We deploy the testbed in a home and show numerical sensing data collected from the multiple air quality sensors that we have developed. We show that turning on the thermostat fan reduces the concentration of small particles. We show this feedback allows the system be effective in controlling the indoor air quality and energy efficiently because the thermostat fan does not need to be running when it is not needed.

2. SYSTEM DESCRIPTION

The IASA system consists of a Utah-modified Dylos sensor (UMDS), a gateway, and a smart thermostat.

2.1 UMDS Sensor

The Utah-modified Dylos sensor (UMDS) is an air quality sensing device consisting of an RGB LCD, temperature and humidity sensors, and a DC1100 pro air quality monitor capable of detecting particles down to 0.5 micron and the large particle size ranging from 2.5 microns and above. The UMDS collects and uploads a PM2.5, PM10, temperature and humidity measurement to the gateway via WiFi each minute.

2.2 IASA Gateway and Actuator Engine

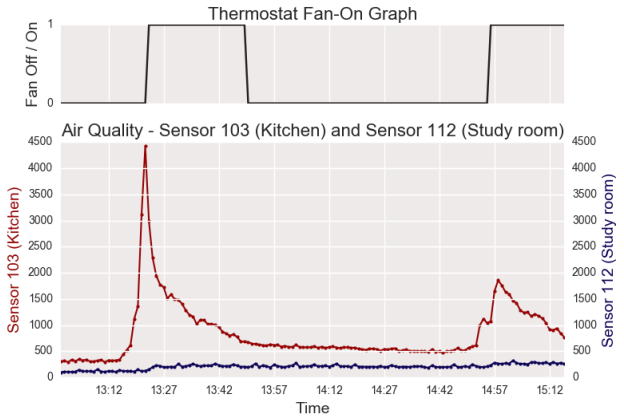

Figure 1: (Bottom) PM2.5 sensor value for UMDS in kitchen (red) and study room (blue); and (Top) furnace fan state. The fan is triggered by, and then helps to reduce, the high pollutant level in the kitchen, but its use marginally increases pollution in the study room.

The IASA gateway is a Raspberry Pi that runs two automation services to operate the home thermostat. The automation sensor captures the UMDS data and current status of the heater fan (on or off) and uploads the data to a server for real-time visualization and future analysis. An example data plot is shown in Figure 1. The actuator engine processes the data stored on the gateway to control the home thermostat fan, via rule-based control logic.

2.3 Rule-Based Control Logic

We used rule-based declarative control logic to decide if the thermostat fan should turn on or off. The actuator engine executes a ON or OFF command when the indoor air quality becomes poor, specifically, when the fine particulate matter reading (PM2.5) exceeds the current threshold defined in the rule. The setting of this threshold should be personalized for the particular home and sensor using past sensor readings and a model, which manages the tradeoff between energy efficiency and exposure.

Table 1: Home activities for air quality

Activity	PM2.5	Quality
`Cooking`	26498	Very Poor
`Hair Spray`	37580	Very Poor
`Vacuuming`	1675	Poor
`Burning a candle`	7487	Very Poor

3. PRELIMINARY RESULTS

In general, operating the furnace fan helps reduce indoor air pollution, as shown in Figure 1. We collected data from labelled indoor activities, such as cooking, vacuuming, and spraying hair spray, which caused spikes in the air pollution (see Table 1). Use of the furnace fan decreases the pollution level faster than without the furnace fan on. We have been running the system for 3 months (with more than 861k data points), which is being used to model the air particulate matter process over space and time, and as a function of the furnace fan state.

4. DEMONSTRATION

We will demonstrate the real-time performance of an IASA system which is deployed in a house. The sensor data and fan state is uploaded in real time, and we will view the sensor data on a graph during the demonstration, using either a WiFi or Ethernet connection. In the house, which is remote from the conference, we will spray materials we know to cause air pollution in the rooms in which the UMDS sensors are deployed in order to cause an air quality event. The IASA gateway will process the collected sensor data and trigger the thermostat to run the furnace fan in order to reduce the air pollution, and we will see the results in real time.

We will also bring to the conference the UMDS sensor and gateway for display purposes.

5. ACKNOWLEDGMENTS

Research reported in this publication was supported by the NIBIB / NIH under award #1U54EB021973-01.

6. REFERENCES

[1] National Center for Health Statistics. https://www.cdc.gov/nchs/fastats/asthma.htm.

[2] S. Bhattacharya, S. Sridevi, and R. Pitchiah. Indoor air quality monitoring using wireless sensor network. In *Intl. Conf. on Sensing Technology (ICST),*, pages 422–427, 2012.

[3] J.-Y. Kim, C.-H. Chu, and S.-M. Shin. Issaq: An integrated sensing systems for real-time indoor air quality monitoring. *IEEE Sensors Journal*, 14(12):4230–4244, 2014.

[4] C. A. Pope III, M. Ezzati, and D. W. Dockery. Fine-particulate air pollution and life expectancy in the United States. *New England Journal of Medicine*, 2009(360):376–386.

[5] J. W. Thornburg, C. E. Rodes, P. A. Lawless, C. D. Stevens, and R. W. Williams. A pilot study of the influence of residential hac duty cycle on indoor air quality. *Atmospheric Environment*, 38(11):1567–1577, 2004.