

Designing Interactive Systems for Community Citizen Science

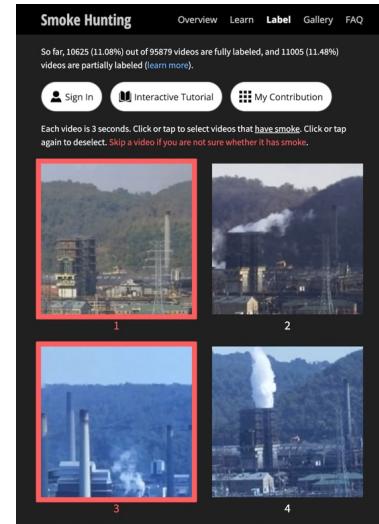
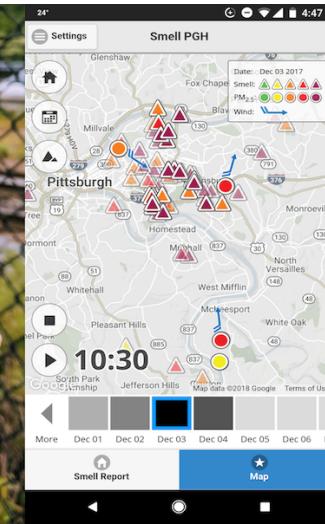
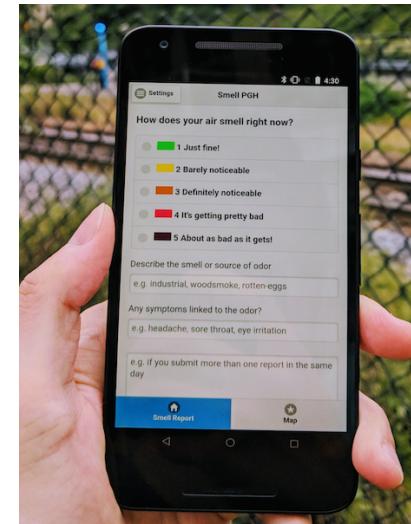
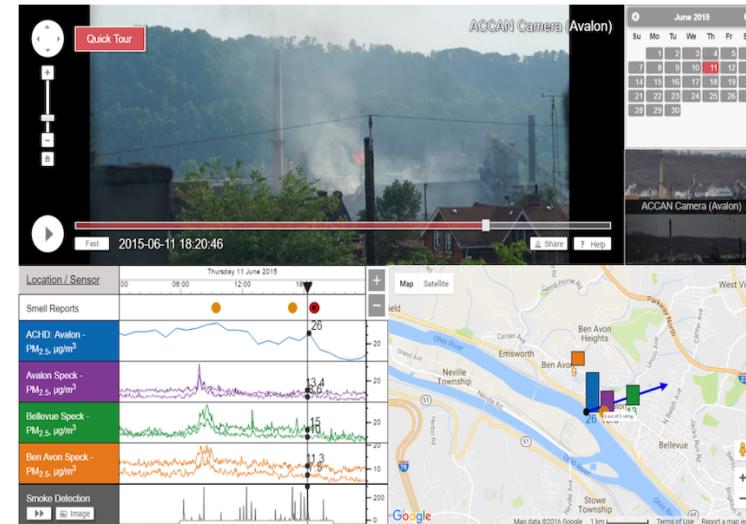
Yen-Chia Hsu, <http://yenchiah.me>

Project Scientist

Carnegie Mellon University
The Robotics Institute

CREATE Lab

Community Robotics, Education and Technology Empowerment



Research goal: we can **empower communities** through citizen-scientist collaboration and technology infrastructure.



- How can citizens and scientists **collaborate** in research?
- What are the important **technological and social aspects** to consider during the collaboration?

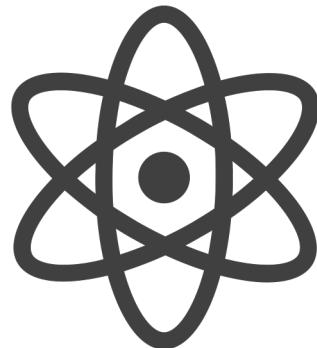
This seminar will cover:

1. Introduction to Community Citizen Science
2. Three deployed interactive systems
3. Implications and future directions

Introduction

What is Community Citizen Science?

Citizen Science refers to the framework that empowers citizens and scientists to form partnerships and produce scientific knowledge jointly.



Scientists



Citizens as Scientists



Citizens

eBird invites birdwatchers to contribute bird lists, photos, and sounds for archiving species distribution and abundance.

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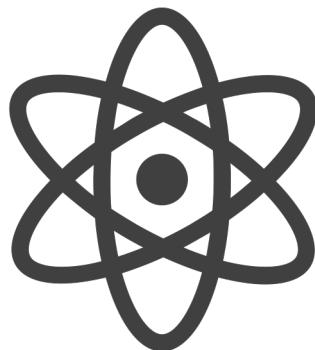
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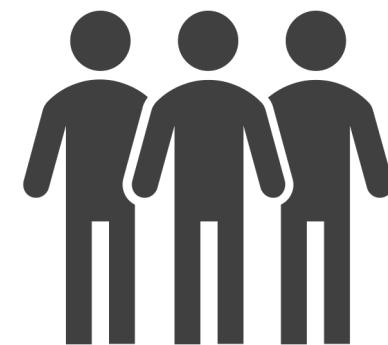
Community Citizen Science emphasizes:

1. Targeting hyperlocal community concerns directly
2. Co-designing solutions with communities
3. Rebalancing power relationships among stakeholders



Scientists

Scientists as Citizens



Citizens

Air Quality Monitoring System

Integrating smoke videos, sensor readings, and smell reports

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RESEARCH-ARTICLE • 

Community-Empowered Air Quality Monitoring System



Authors:  Yen-Chia Hsu,  Paul Dille,  Jennifer Cross,  Beatrice Dias,  Randy Sargent,  Illah Nourbakhsh

[Authors Info & Affiliations](#)

Publication: CHI '17: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems • May 2017

• Pages 1607–1619 • <https://doi.org/10.1145/3025453.3025853>

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Community



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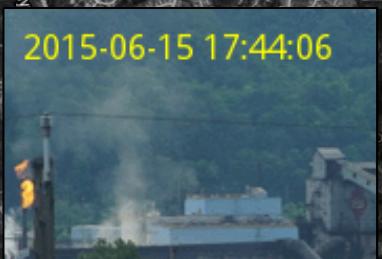


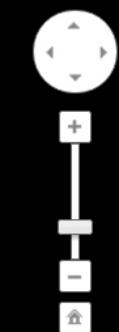
Sensor

Camera

- Co-design to collect evidences of air pollution
- Present them to the government or media
- Raise the public awareness of air quality issues

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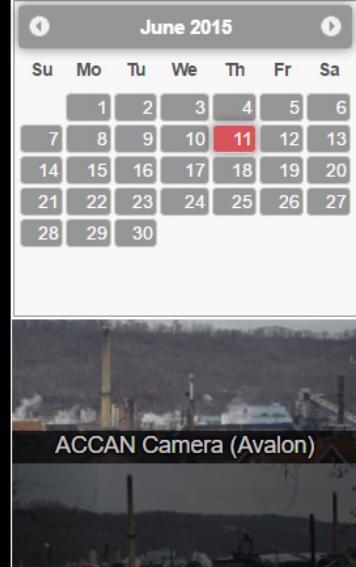




Quick Tour



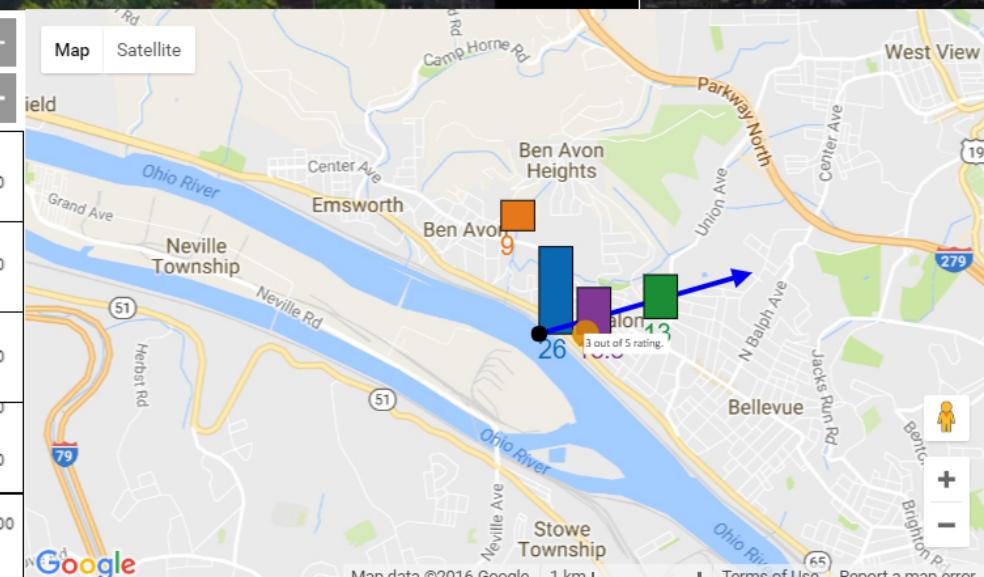
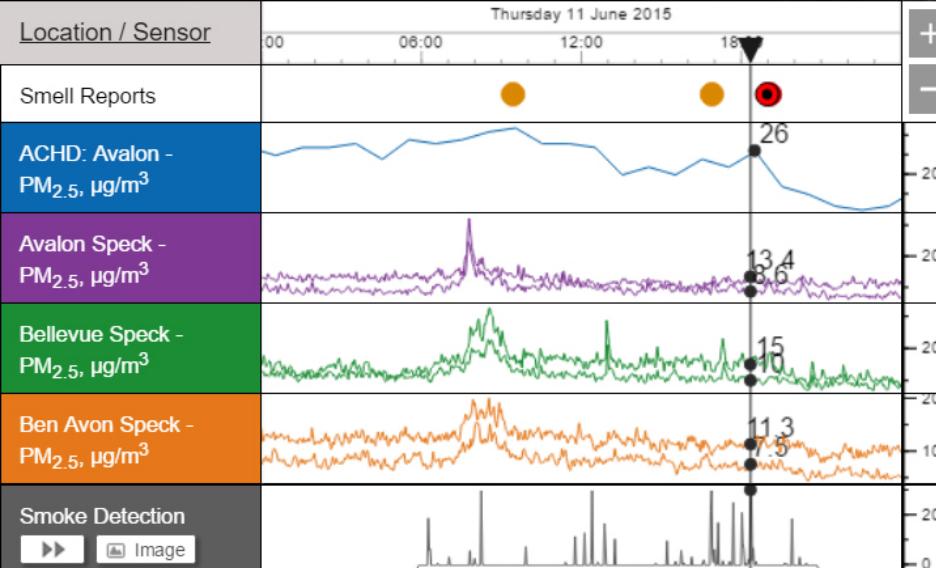
ACCAN Camera (Avalon)



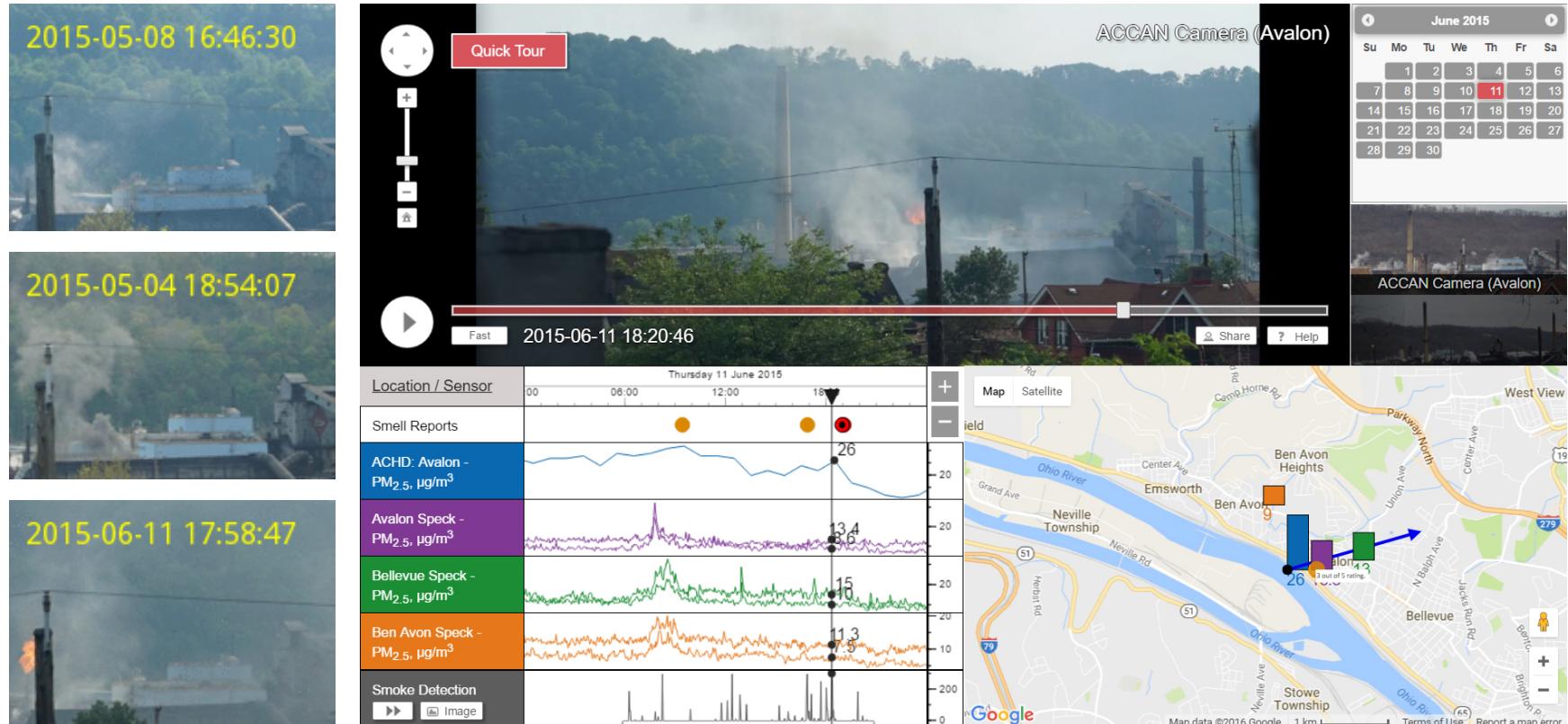
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Help



Scientific evidence of air pollution, when combined with personal experiences, has the power to influence regulators' attitudes and increase the community's confidence.



- How can we measure the impact after system deployment?

"But what I see in the video," the acting director of EPA Region III Air Protection Division said, referring to videos from the system that were projected on a screen at the front of the meeting room, **"is totally unacceptable."**

Pittsburgh Post-Gazette

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Regulators reviewing Shenango Coke Works' compliance with 2012 consent decree



DON HOOLEY

Pittsburgh Post-Gazette

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Four Quick Questions

Are you confident the summit between President Trump and Kim Jong Un, declared to be "back on" Friday, will lead to a softening of tensions between the countries?

Yes, very confident



Federal and county regulators are reviewing whether recent, continuing, air pollution emissions problems at DTE Energy's Shenango Coke Works on Neville Island put the facility in violation of its 2012 federal consent decree.

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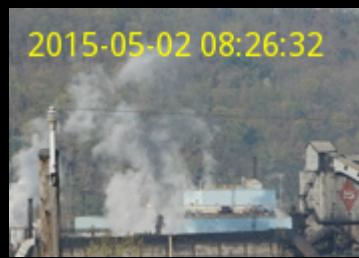
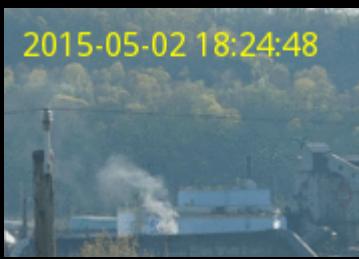
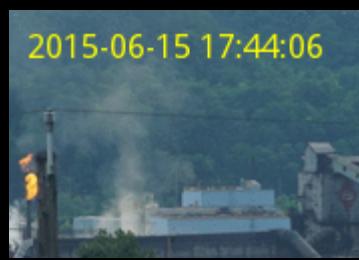
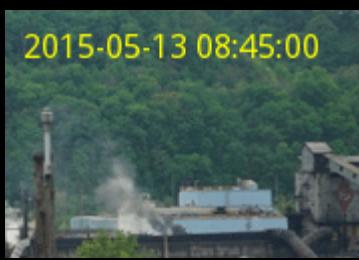
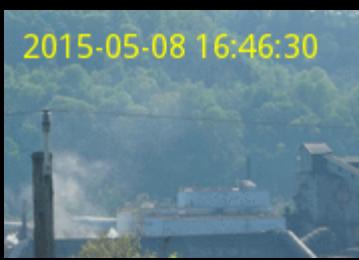
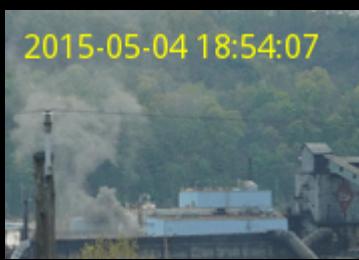
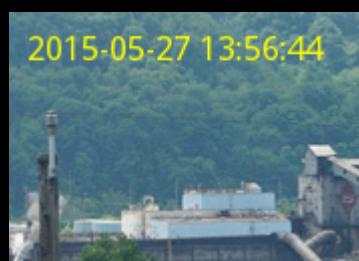
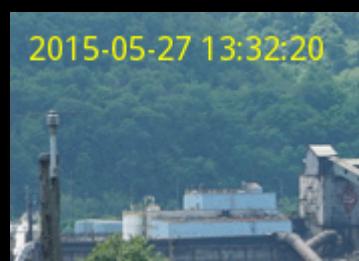
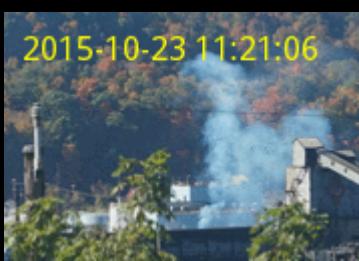
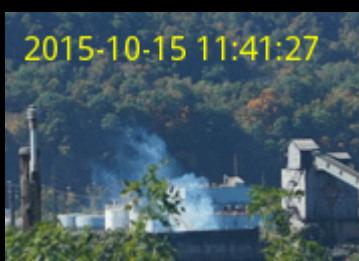
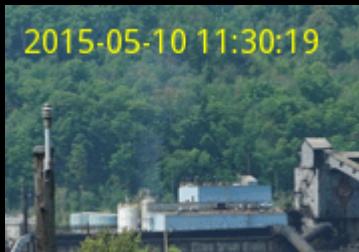
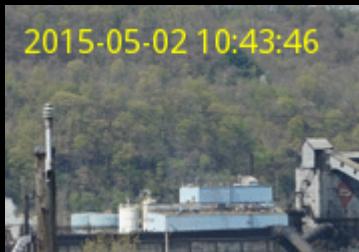


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- How can we evaluate community engagement?

Open responses in the survey show that the system could encourage discussion and increase confidence in taking action.

"I made screenshots of the [system name] dashboard at different times/days when wind was strong and in the direction of my community. I inserted these screenshots into Powerpoint slides. I shared printed versions of these slides with my Township commissioner when asking for assistance in reducing emissions."

"I continually spoke at regional meetings, City, County, Health Department, Clairton, Lawrenceville, etc. Wrote numerous letters to the editor, most did get published, not all."

Open responses in the survey show that the system could encourage discussion and **increase confidence in taking action**.

*"I felt that the more information/proof that I made available might help justify my concern and spur action. I **felt** that my concerns with what I was experiencing were **grounded in actual imagery, wind data and spatial data.**"*

*"I **believe** that the [system name] was very important in helping us **get the attention of regulators** (ACHD and EPA) and get them to take our concerns seriously."*

Smell Pittsburgh

Crowdsourcing and visualizing pollution odors

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RESEARCH-ARTICLE •

Smell Pittsburgh: community-empowered mobile smell reporting system



Authors: [Yen-Chia Hsu](#), [Jennifer Cross](#), [Paul Dille](#), [Michael Tasota](#), [Beatrice Dias](#), [Randy Sargent](#),
 [Ting-Hao \(Kenneth\) Huang](#), [Illah Nourbakhsh](#) [Authors Info & Affiliations](#)

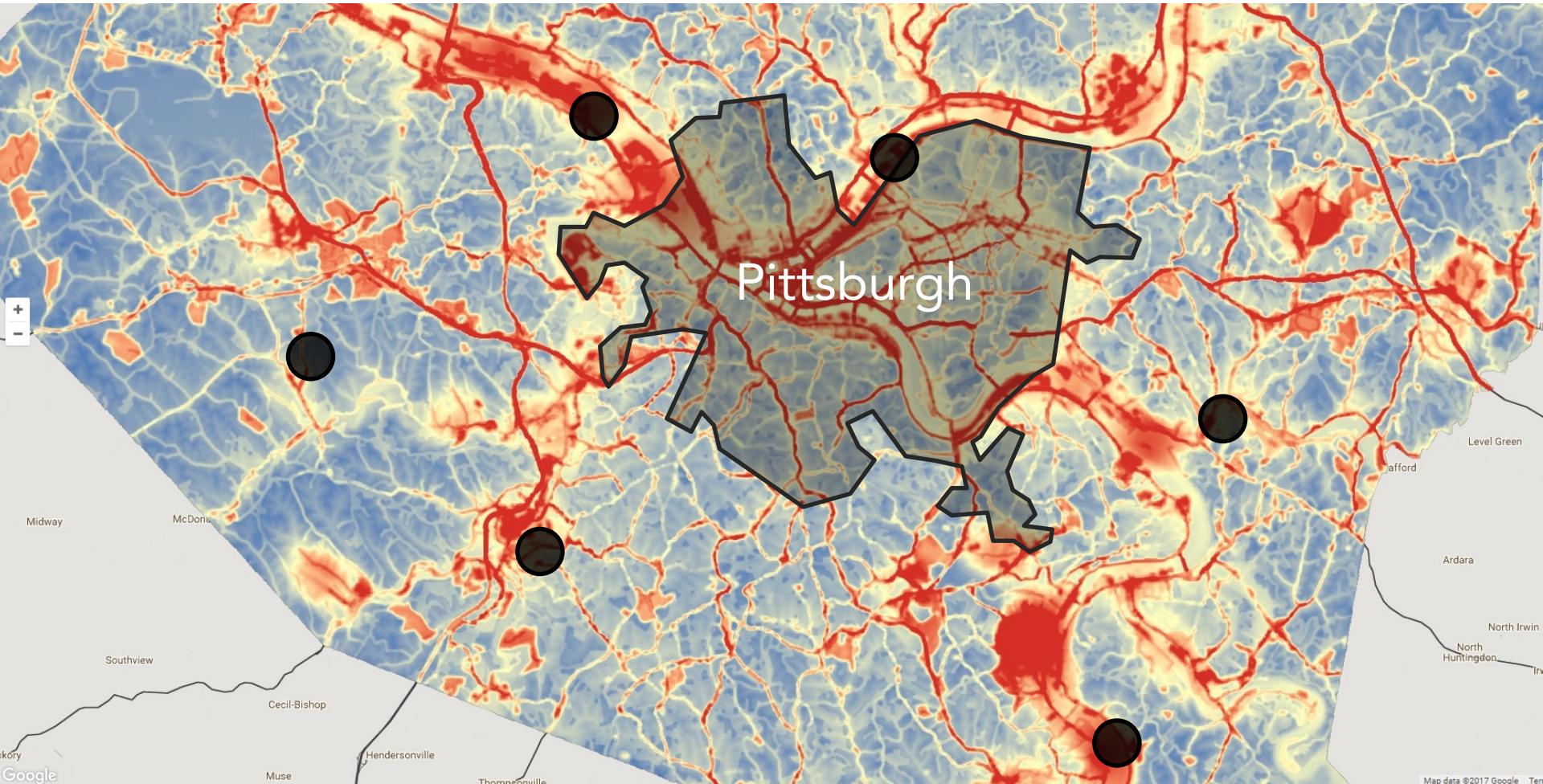
Publication: IUI '19: Proceedings of the 24th International Conference on Intelligent User Interfaces • March 2019 • Pages 65–79 • <https://doi.org/10.1145/3301275.3302293>

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How can we effectively collect the smell experiences on a **city-wide scale** with more than 300,000 residents over many years?





REPORT AN AIR QUALITY COMPLAINT FORM

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Report an Air Quality Complaint

Use this form to send us a comment or to register a complaint with the Health Department's Air Quality Program.

Enforcement inspectors respond to every citizen complaint received via the complaint line (412-687-ACHD) or this form. Please remember to include your name and email address if you wish to receive a response. Comments or complaints cannot be acknowledged without an email address.

Please note: Be as specific as possible. When filing a complaint about open burning or foul odors, please include the time, location (neighborhood or zip code), and a brief description of the odor or smoke associated with your complaint.

An asterisk (*) denotes a required field. Name and email are suggested.

Air Quality Program Office:

301 39th St.

Building 7

Pittsburgh, PA 15201

 [Google Directions](#)

Name:

Email:

Subject:

*Time, Location, Nature of Complaint:

* Denotes a required field.

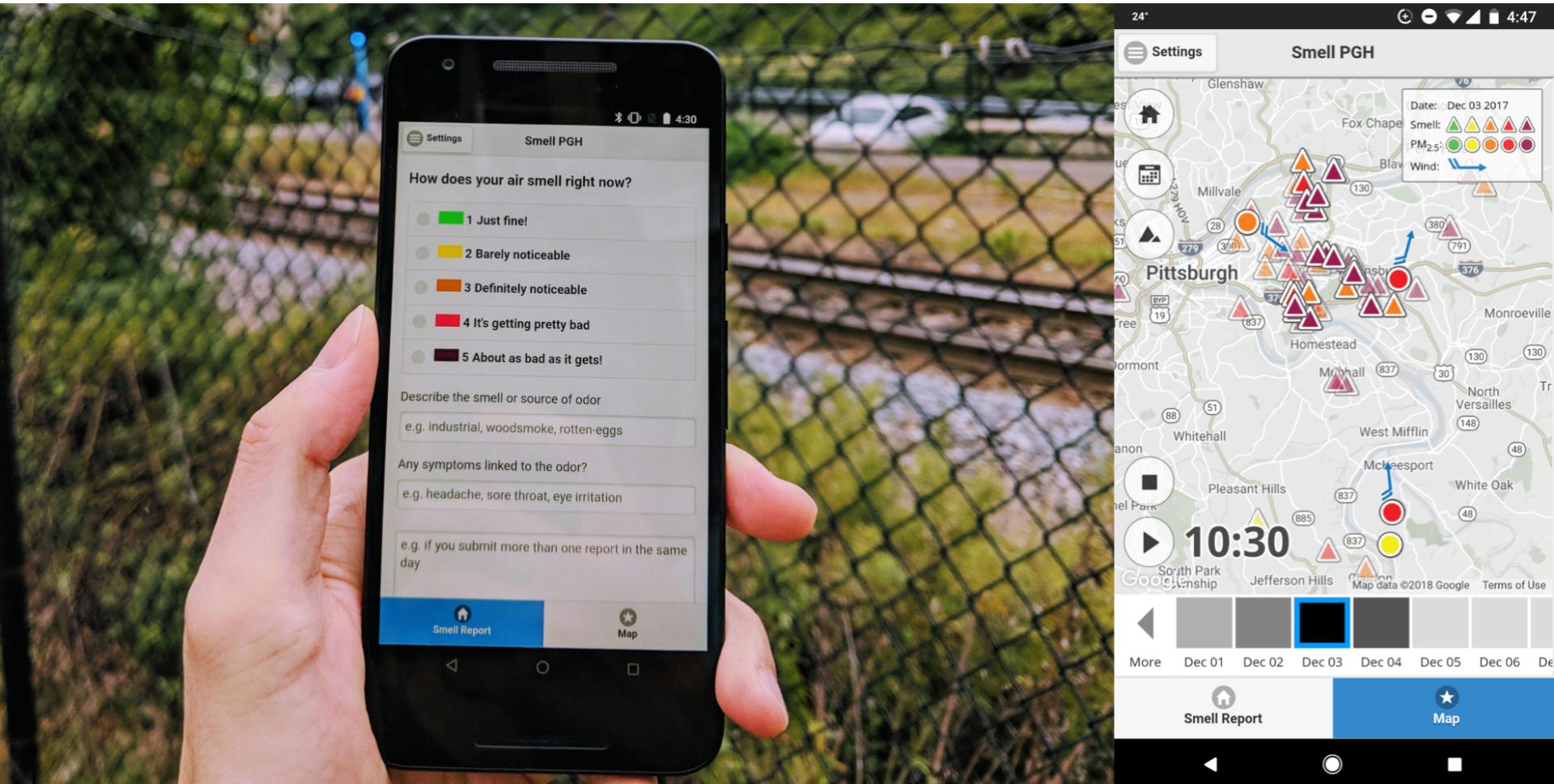
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The prior approach that asks citizens to report odor complaints post hoc via forms or phone calls suffers from:

- poor data quality
- non-transparency

<https://www.alLEGHENYCOUNTY.us/Health-Department/Programs/Air-Quality/Report-an-Air-Quality-Complaint-Form.aspx>

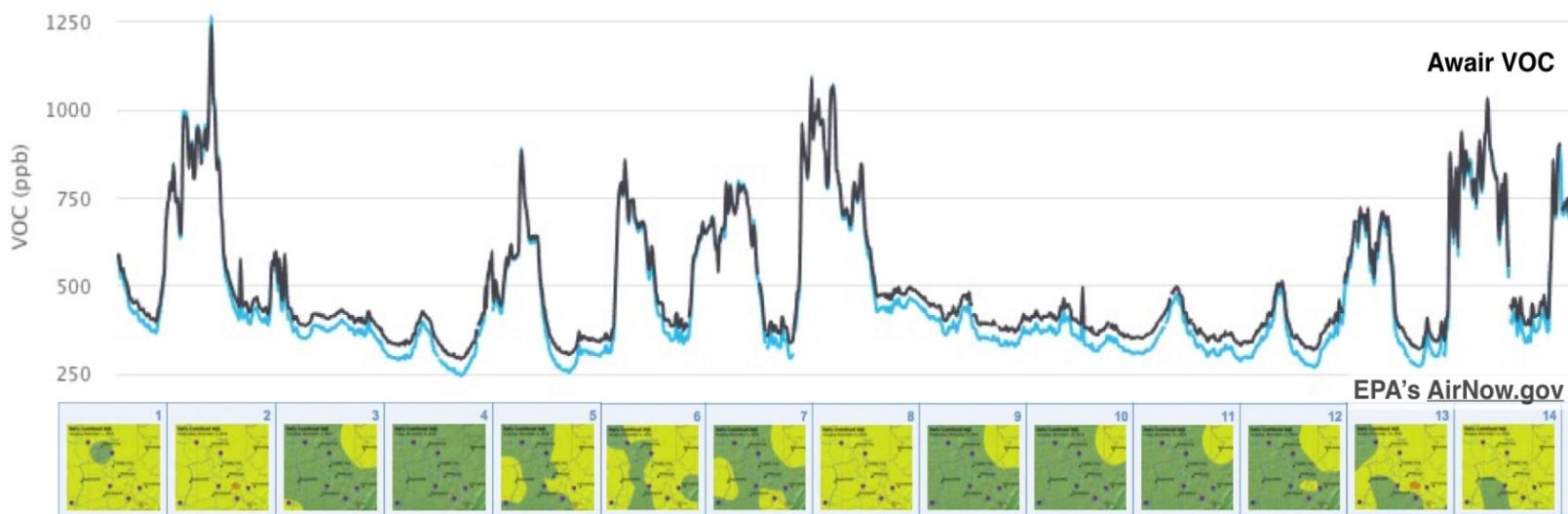
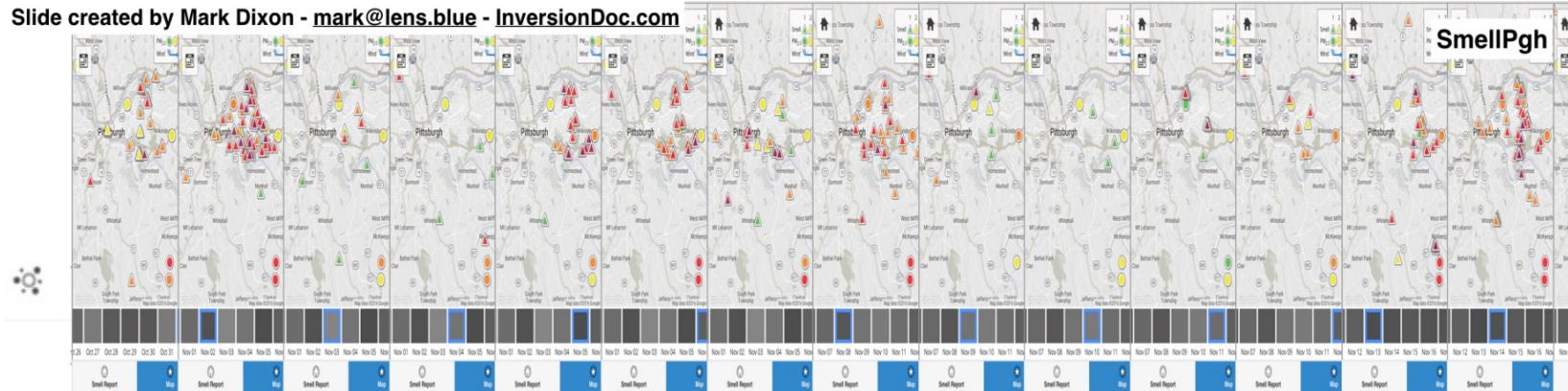
Smell Pittsburgh enables communities to contribute odor reports in real-time and visualize air pollution collaboratively.



- How can we measure the impact after system deployment?

Community members plot smell reports with self-operated VOC (volatile organic compounds) sensors to find correlations.

Slide created by Mark Dixon - mark@lens.blue - InversionDoc.com



The deputy director of environmental health in ACHD mentioned that “Every aspect of the activity and operation of these coke plants will have a more stringent standard applied.”

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NEWSLETTERS



Air advocates read 'scroll of smells' at health board meeting



Photo credit Don Hopey

- How can we evaluate community engagement?

Open responses in the survey show that nine participants (36%) mentioned the technical affordance **to contribute data as scientific evidence** efficiently and intuitively.

"I used to try to use the phone to call in complaints, but that was highly unsatisfactory. I never knew if my complaints were even registered. With Smell Pittsburgh, I feel that I'm contributing to taking data, as well as to complaining when it's awful. [...]"

*"The Smell app **quantifies observations in real time**. [...] Added benefit is to have ACHD receive this information in real time **without having to make a phone call or send separate email**. I have confidence that the recording of Smell app data is **quantified more accurately** than ACHD's."*

Six participants (24%) mentioned **altruism**, the concern about the welfare of others, as motivations.

"I use [Smell Pittsburgh] to demonstrate to others how they can raise their own awareness. [...] many who have grown up in this area of Western PA have grown up with so much pollution, to them air pollution has become normalized and many do not even smell the pollution any more. [...]"

"[...] It is basically a very easy onramp for potential new activists. The app also acts as a way for non-activists to see that they are not alone in their concerns about stinky air, which I believe was a major problem for building momentum in the air quality community prior to the app's existence."

Four participants (16%) indicated the affordance to validate personal experiences based on the data provided by others.

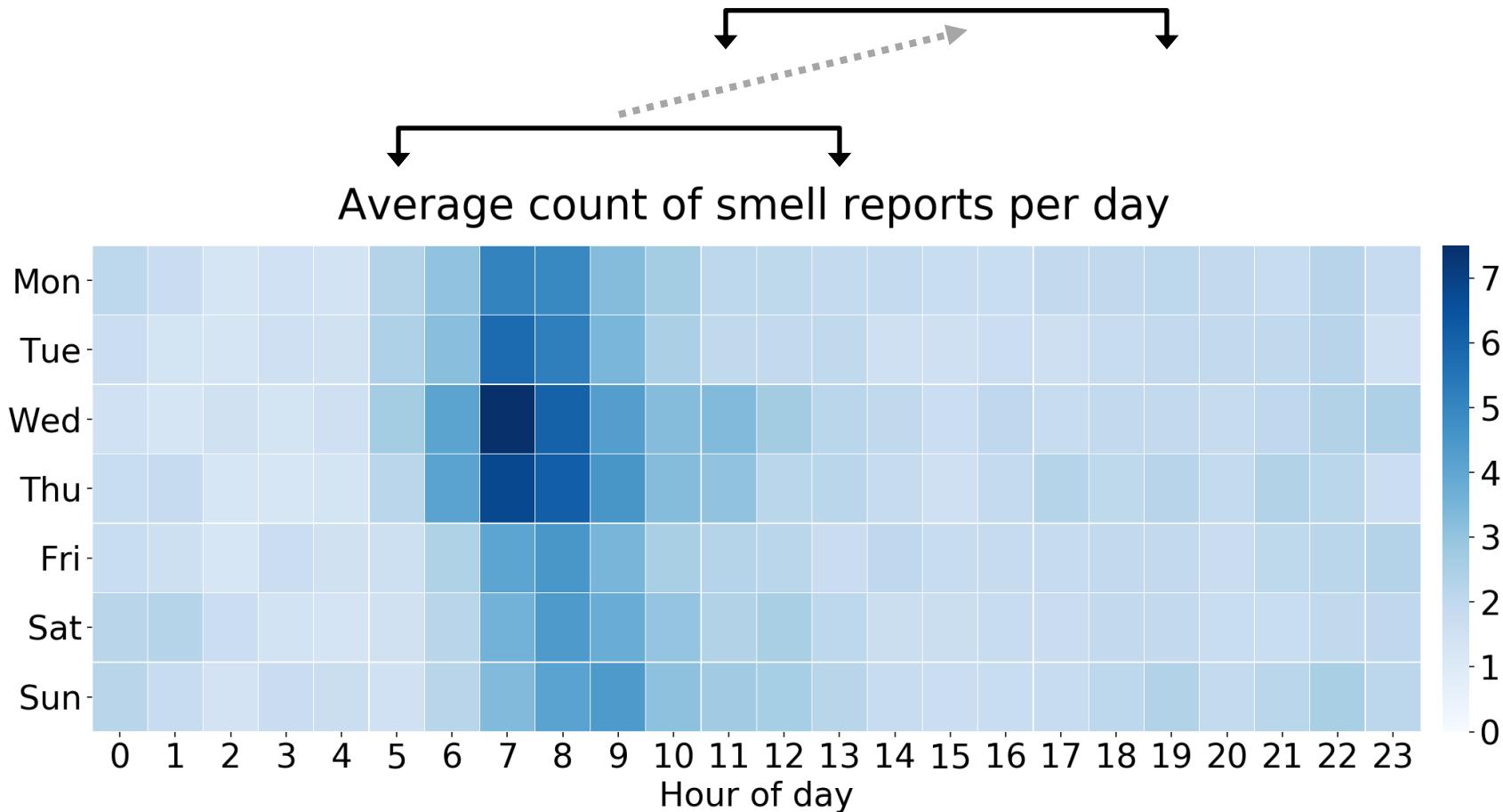
"I used to (and sometimes still do) call reports in to ACHD. I love how the map displays after I post a smell report. **Wow! I'm not alone!"**

"It **validates my pollution experiences** because others are reporting similar experiences."

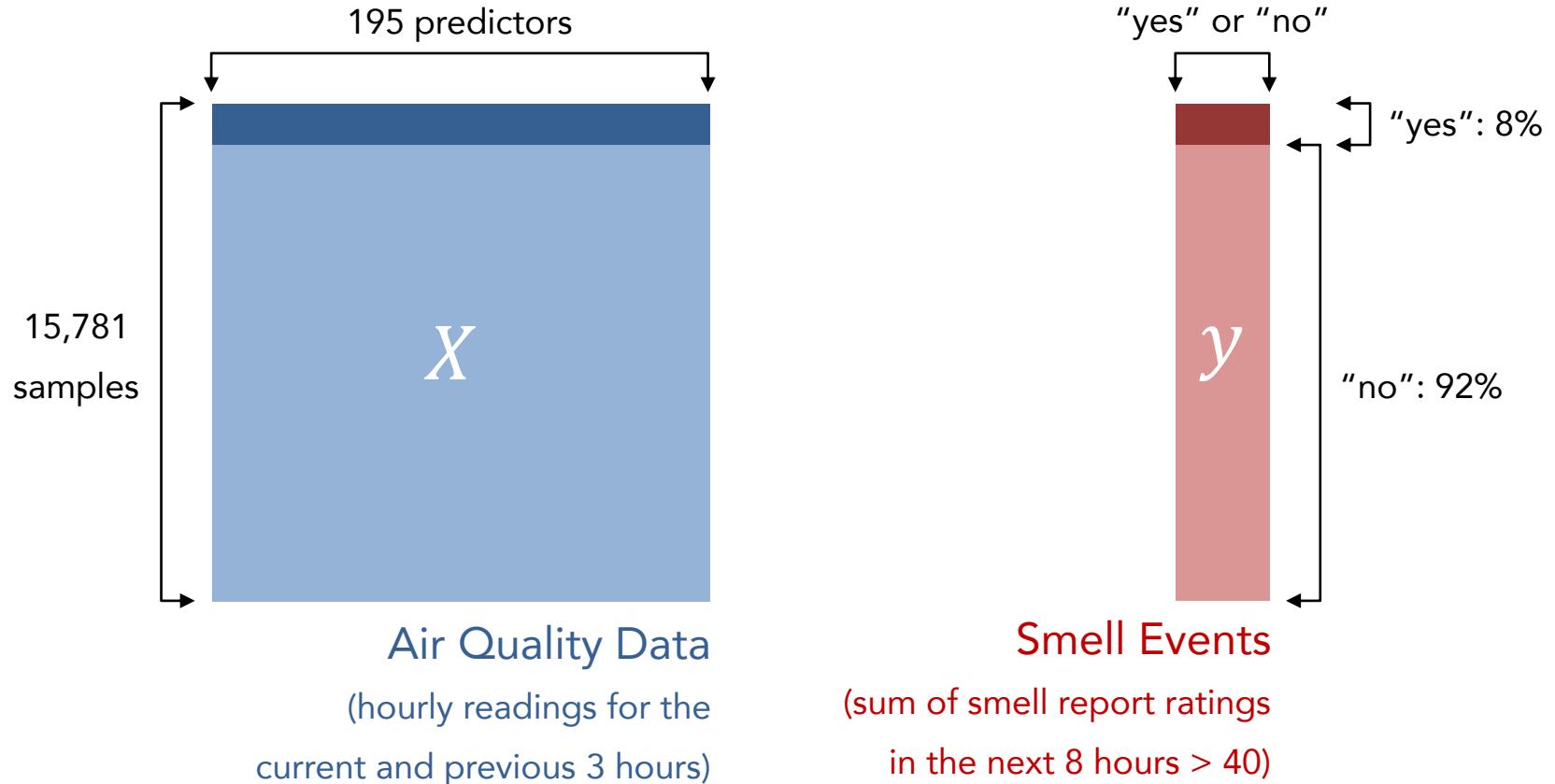
"I like using it for a similar reason that I like checking the weather. It helps me understand my environment and **confirms my sense of what I'm seeing** (or in this case smelling)."

- Is smell data useful in predicting local air pollution events and identifying patterns?

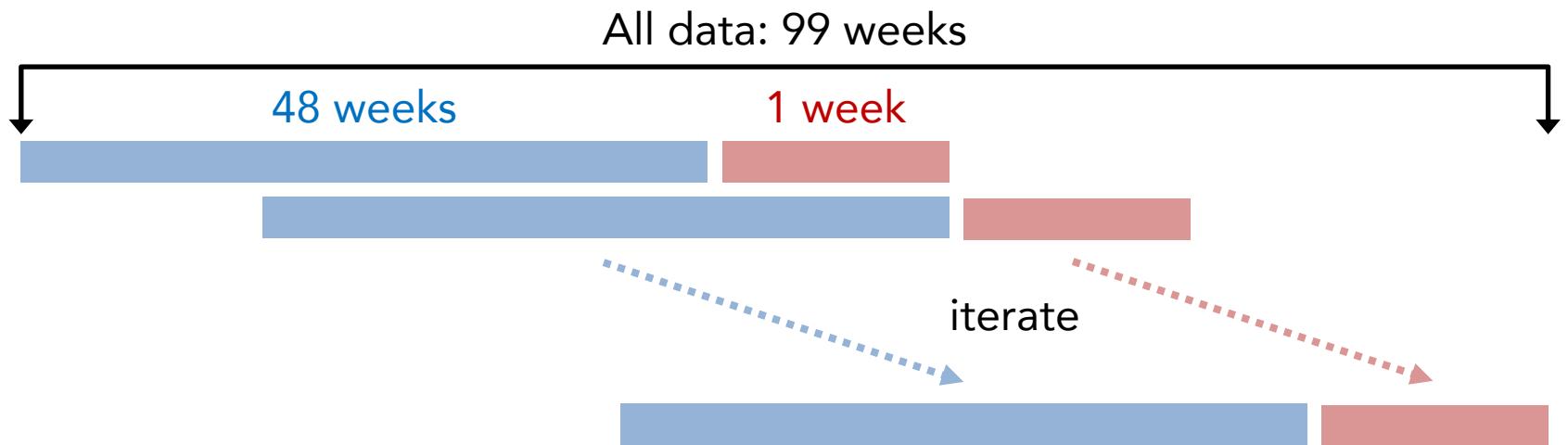
We predict if pollution odor events **will occur** in the next 8 hours during the **daytime** period.



To enable odor prediction, we use Random Forest to map air quality data (predictors) to smell events (responses).

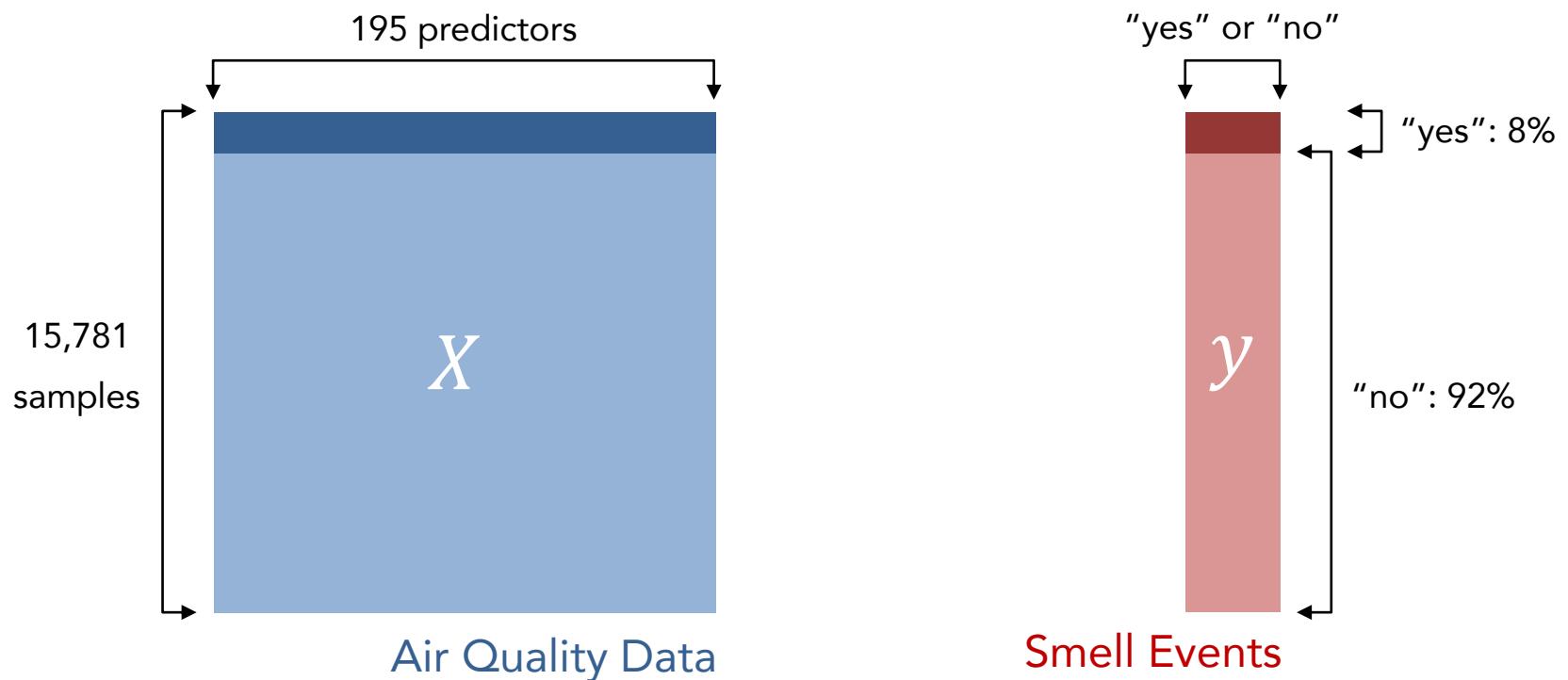


We apply time series cross-validation of several pairs of training and testing sets to evaluate the model performance.

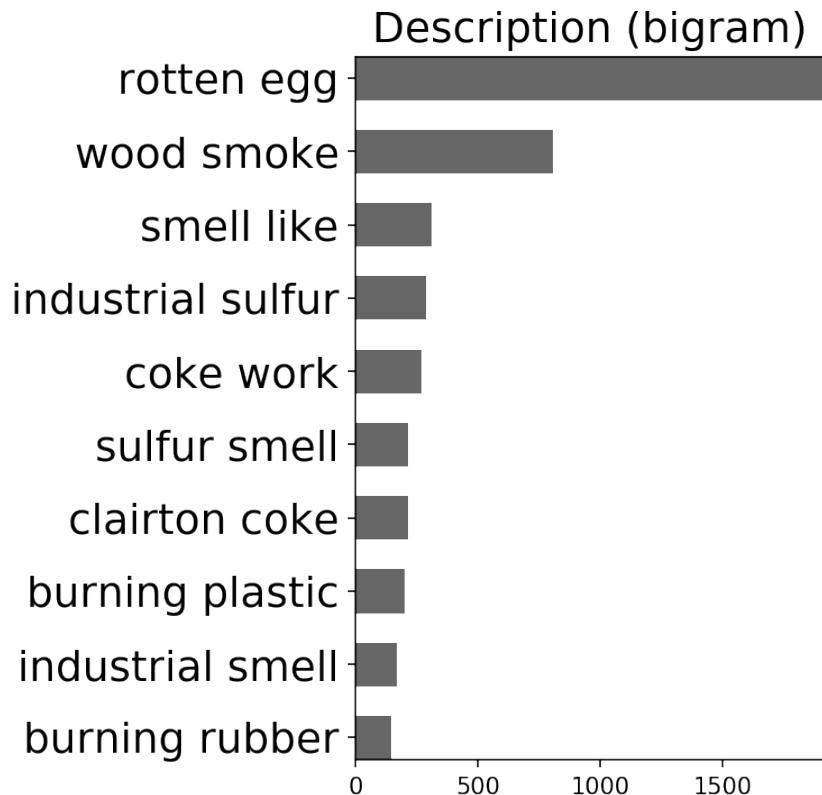


	Precision	Recall	F-score
Our Best Model	0.87 ± 0.01	0.59 ± 0.01	0.70 ± 0.01
Always Yes	0.2	1	0.33

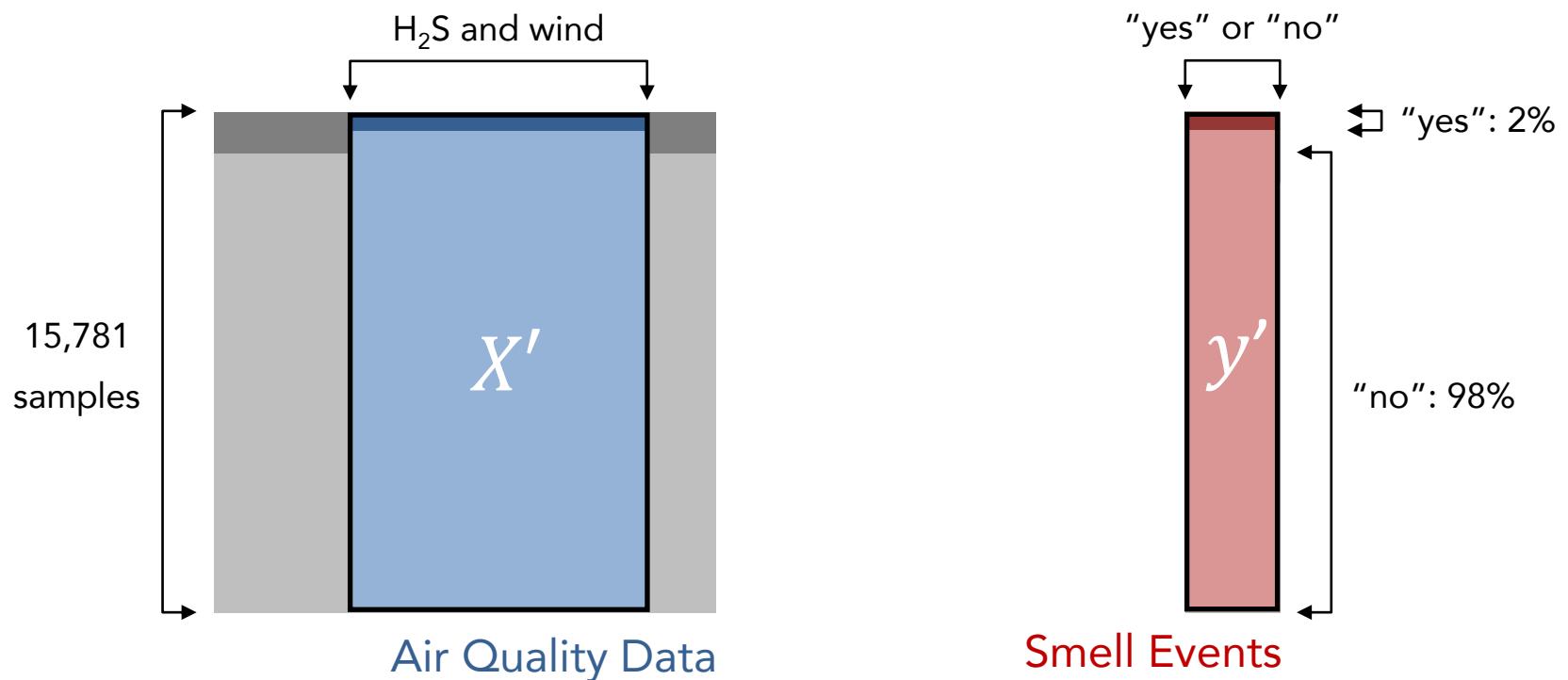
Although the prediction shows that smell data are not random noises, we want to know **the joint effects among critical environmental factors.**



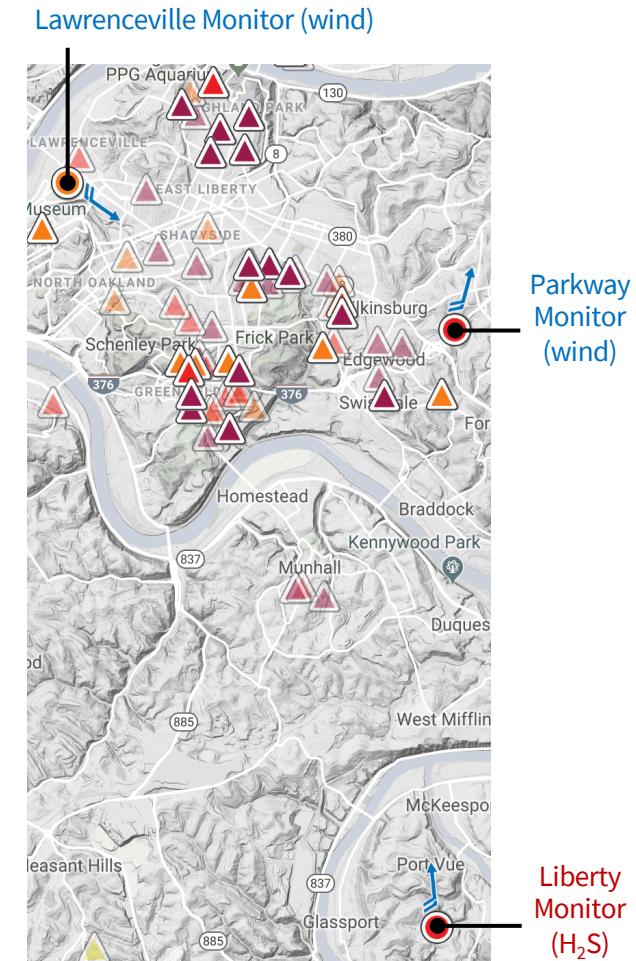
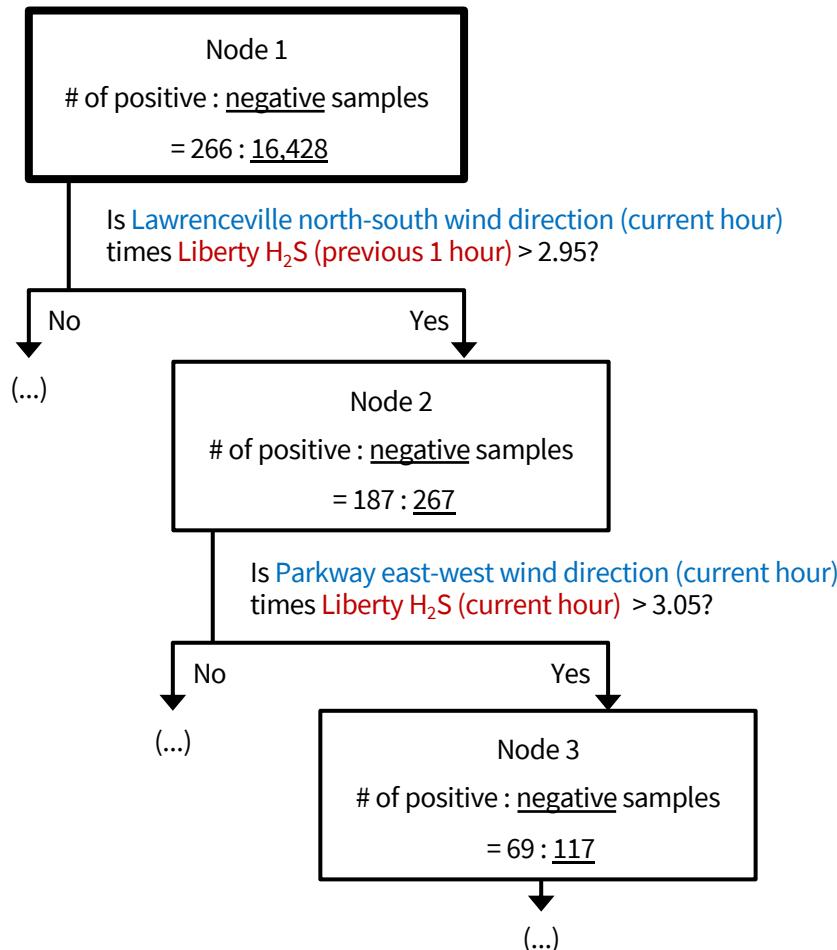
High-frequency words and phrases in smell reports mostly describe **industrial pollution odors**, like **hydrogen sulfide**.



We apply Decision Tree to explain a subset of predictors
(selected by community knowledge) and positive samples
(selected by cluster analysis).



The tree explains about 30% of the smell events, which is a joint effect of **wind information** and **hydrogen sulfide**.



Smoke Labeling System

Annotating and recognizing industrial smoke emissions



Cornell University

We gratefully acknowledge support from
the Simons Foundation and member institutions.

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Computer Science > Computer Vision and Pattern Recognition

[Submitted on 13 May 2020 ([v1](#)), last revised 20 May 2020 (this version, v4)]

RISE Video Dataset: Recognizing Industrial Smoke Emissions

[Yen-Chia Hsu](#), [Ting-Hao 'Kenneth' Huang](#), [Ting-Yao Hu](#), [Paul Dille](#), [Sean Prendi](#), [Ryan Hoffman](#), [Anastasia Tsuhlares](#), [Randy Sargent](#), [Illah Nourbakhsh](#)

Industrial smoke emissions pose a significant concern to human health. Prior works have shown that using Computer Vision (CV) techniques to identify smoke as visual evidence can influence the attitude of regulators and empower citizens in pursuing environmental justice. However, existing datasets do not have sufficient quality nor quantity for training robust CV models to support air quality advocacy. We introduce RISE, the first large-scale video dataset for Recognizing Industrial Smoke Emissions. We adopt the citizen science approach to collaborate with local community members in annotating whether a video clip has smoke emissions. Our dataset contains 12,567 clips with 19 distinct views from cameras on three sites that monitored three different industrial facilities. The clips are from 30 days that spans four seasons in two years in the daytime. We run experiments using deep neural networks developed for video action recognition to establish a performance baseline and reveal the challenges for smoke recognition. Our data analysis also shows opportunities for integrating citizen scientists and crowd workers into the application of Artificial Intelligence for social good.

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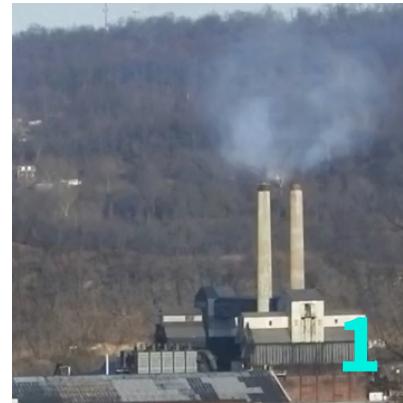
We aim to apply deep neural networks to **recognize smoke emissions**, but existing datasets are relatively small.

	# of scenes	# of labeled clips	# of frames (images)	Average # of frames per clip	Ratio of smoke frames	Has temporal data?
This Work	19	12,567	452,412	36	41%	yes
Bugaric <i>et al.</i> [6]	10	10	213,909	21,391	100%	yes
Ko <i>et al.</i> [30, 53]	16	16	43,090	1,514	37%	yes
Dimitropoulos <i>et al.</i> [12, 16]	22	22	17,722	806	56%	yes
Toreyin <i>et al.</i> [11, 52]	21	21	18,031	820	98%	yes
Filonenko <i>et al.</i> [15]*	...	396	100,968	255	61%	yes
Xu <i>et al.</i> [57, 62]	5,700	...	49%	no
Xu <i>et al.</i> [55, 62]	3,578	...	100%	no
Xu <i>et al.</i> [56, 62]	10,000	...	50%	no
Ba <i>et al.</i> [5]*†	6,225	...	16%	no
Lin <i>et al.</i> [34, 62]*	16,647	...	29%	no
Yuan <i>et al.</i> [14, 60]*	24,217	...	24%	no

We invite community members to annotate if the videos
(obtained from the cameras) have industrial smoke emissions.



<http://smoke.createlab.org>



High-opacity smoke



Low-opacity smoke



Steam only



Smoke and steam

So far, 10625 (11.08%) out of 95879 videos are fully labeled, and 11005 (11.48%) videos are partially labeled ([learn more](#)).

[!\[\]\(0b9e2e386fe163003656c0c1fc02970c_img.jpg\) Sign In](#)[!\[\]\(1c66d28bceb5f8993d19d1bc5eed071f_img.jpg\) Interactive Tutorial](#)[!\[\]\(7f50a65ef176fba5c4484a605d815a8e_img.jpg\) My Contribution](#)

Each video is 3 seconds. Click or tap to select videos that have smoke. Click or tap again to deselect. **Skip a video if you are not sure whether it has smoke.**



1



2



3



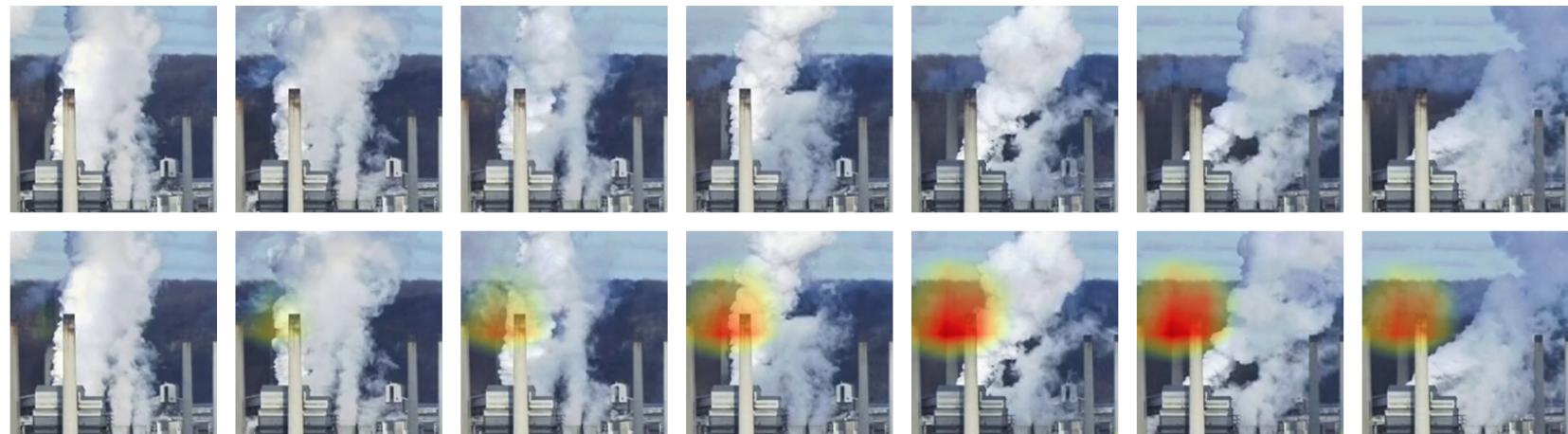
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19
Views



The dataset enables Computer Vision applications using deep neural networks, and our baseline model can find smoke emissions with reasonable precisions.



	Precision	Recall	F-score
Our Best Model	0.86	0.79	0.82
Always Yes	0.41	1	0.58

Implications and Future Directions

Community Citizen Science + HCI + AI

These three deployed systems offer the following **implications**:

1. Community Citizen Science serves community welfare directly, is **hyperlocal**, and depends on the local context.
2. It can be more beneficial to ask "**Is the system influential?**" instead of "**Is the system useful?**"



I plan to establish Community Citizen Science (CCS) as a field that emphasizes going from research to practice to impact.

Smell Pittsburgh: Community-Empowered Mobile Smell Reporting System

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ABSTRACT

Urban air pollution has been linked to various human health considerations, including cardiopulmonary diseases. Communities who suffer from poor air quality often rely on experts to identify pollution sources due to the lack of accessible tools. Taking this into account, we developed *Smell Pittsburgh*, a system that enables community members to report where smells that they experience are frequently concentrated. All smell reports are publicly accessible online. These reports are also sent to the local health department and visualized on a map along with air quality data from monitoring stations. This visualization provides a comprehensive overview of the local pollution landscape. Additionally, with these reports and air quality data, we developed a model to predict upcoming smell events and send push notifications to inform communities. Our evaluation of this system demonstrates that engaging residents in documenting their experiences with pollution odors can help identify local air pollution patterns, and can empower communities to advocate for better air quality.

CCS CONCEPTS

- Human-centered computing → Interactive systems and tools;
- Computing methodologies → Machine learning.

KEYWORDS

Citizen science, smell, air quality, sustainable HCI, machine learning, community empowerment.

ACM Reference Format:

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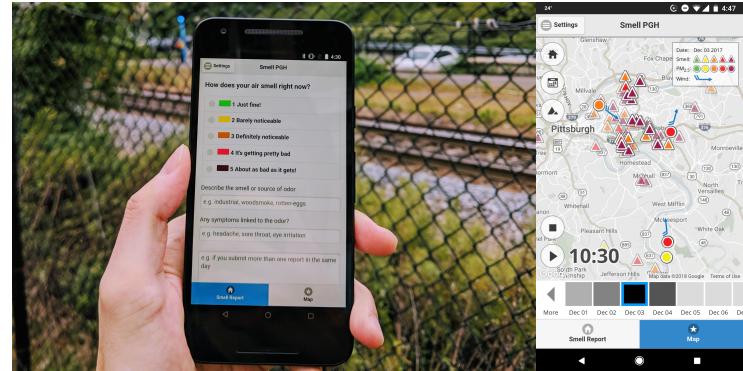
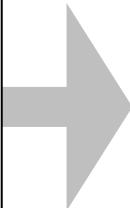
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<https://doi.org/10.1145/3302175.3302293>

1 INTRODUCTION

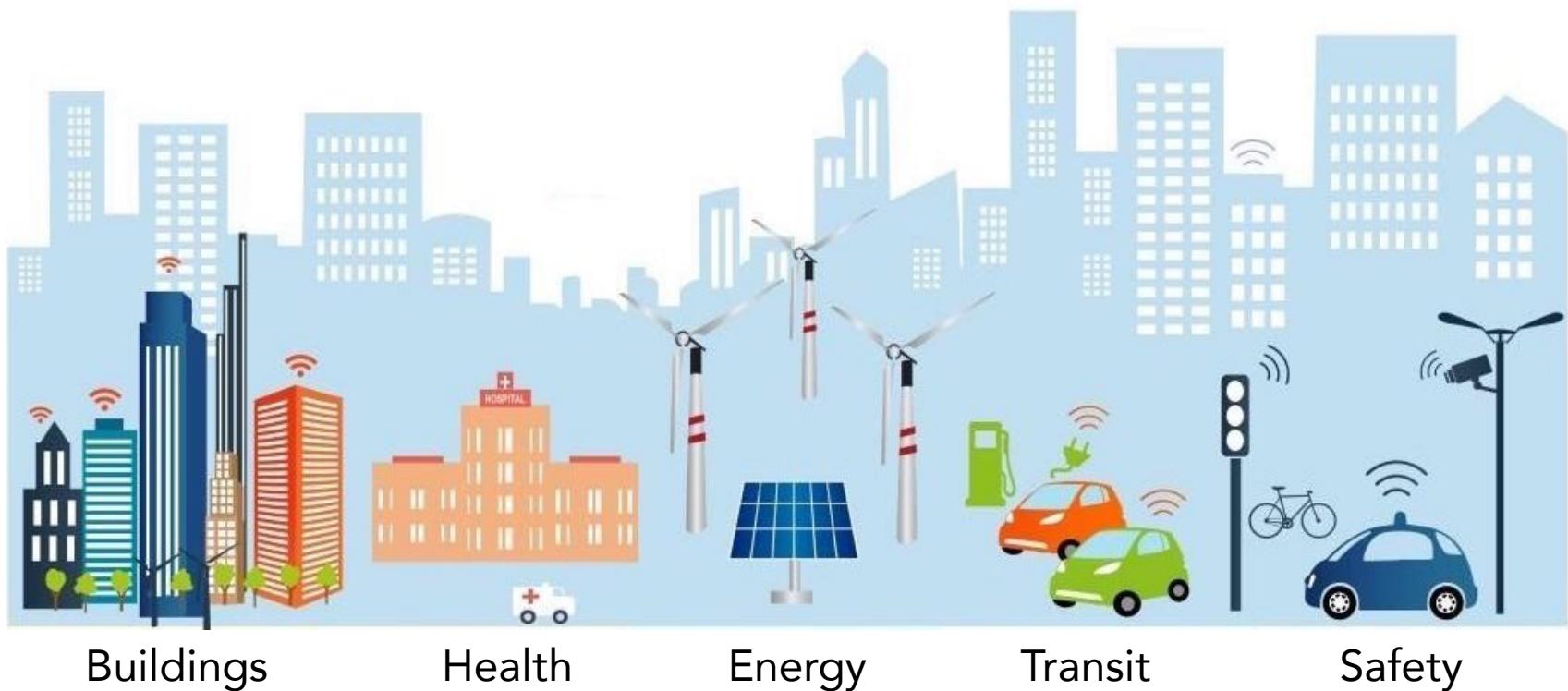
Air pollution has been associated with adverse impacts on human health, including respiratory and cardiovascular diseases [49, 72, 101, 105, 126]. Addressing air pollution often involves negotiations between corporations and regulators, who hold power to improve air quality. However, the communities, who are directly affected by the pollution, are rarely influential in policy-making. Their voices typically fail to persuade decision-makers because collecting and presenting reliable evidence to support their arguments is resource-intensive. Forming such requests requires collecting and analyzing large amounts of data, which is a rare, geographically, area and an extended period. This situation is changing due to the availability of financial resources, organizational networks, and access to technology. Due to the power imbalance and resource inequality, affected residents usually rely on experts in governmental agencies, academic institutions, or non-governmental organizations to analyze and track pollution sources.

A straightforward solution is to empower the affected communities directly. In this research, we investigate how citizen science can be leveraged to collect and report smell reports to gather evidence for advocacy. Data-driven evidence, especially when integrated with narratives, is essential for communities to make sense of local environmental issues and take action [94]. However, citizen-contributed data is often held in low regard because the information can be unreliable or include errors during data entry. Also, sufficient citizen participation and data transparency are required for the evidence to be influential. For instance, the city involved in this study, Pittsburgh, is one of the most polluted cities in the United States [4]. Currently, Pittsburgh does not have any problems to the local health department via its phone line or website.

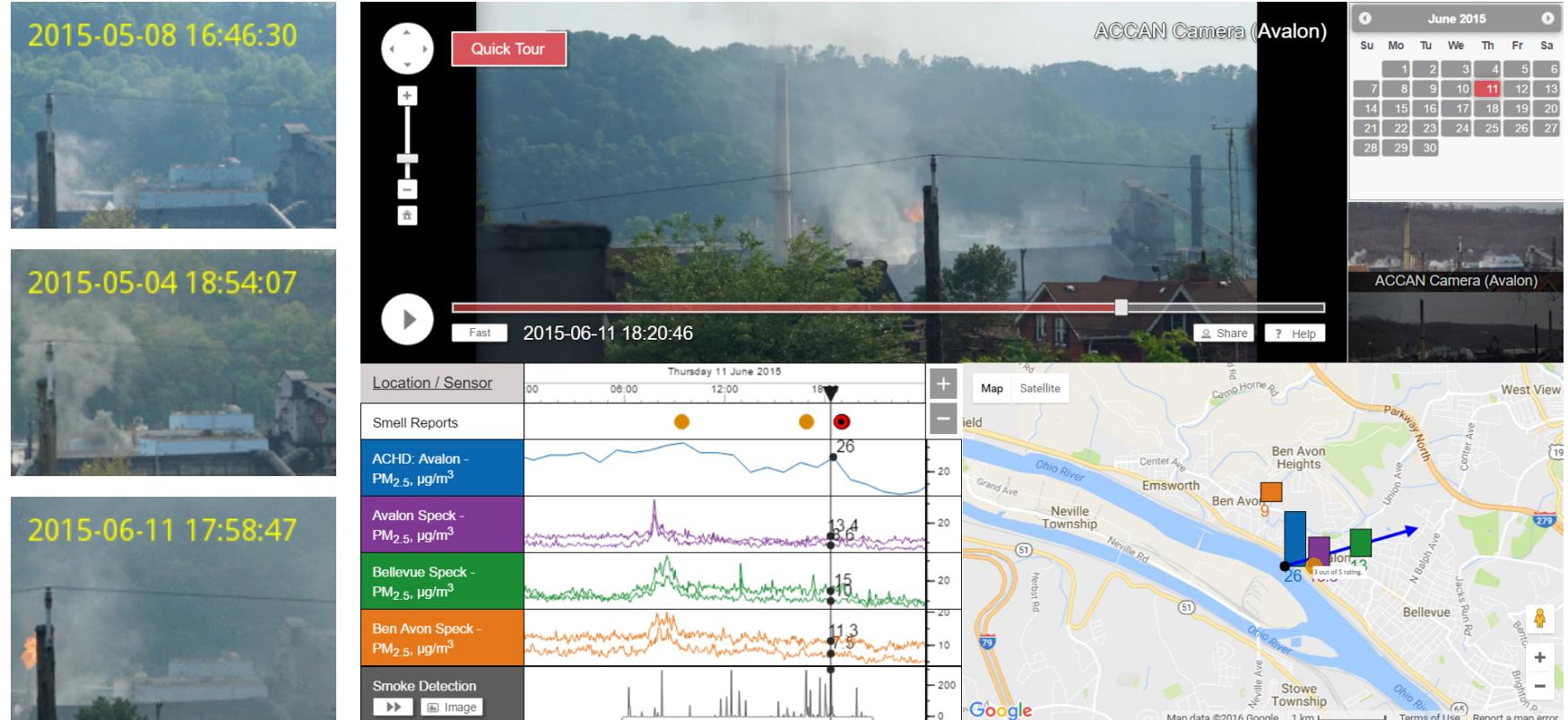
Nevertheless, the quality of the gathered data is doubtful. Citizens may not remember the exact time and location that pollution odors occurred. Asking citizens to submit complaints retrospectively is hard for capturing accurate details and prone to errors. Such errors can result in missing or incomplete data that can affect the outcome of statistical analysis to identify pollution sources [36].



CCS can be applied with cyber and physical technology to address local concerns and empower communities, especially but not limited to **smart city applications**.



CCS can be applied when visualizing community concerns with data-driven evidence, which is critical in influencing decision-makers and bringing about common discourse.



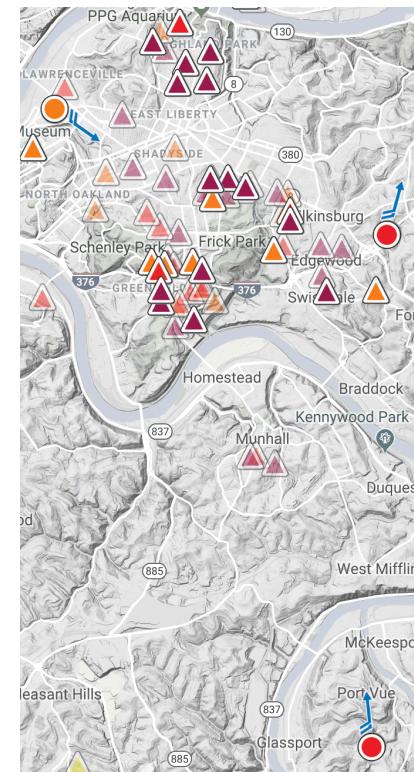
CCS can be applied to **human-centered AI**, which has the potential to help communities make sense of complex data and identify critical evidence.

The screenshot shows the 'Smoke Hunting' app interface. At the top, there are navigation links: Overview, Learn, Label (highlighted in red), Gallery, and FAQ. Below this, a message states: "So far, 10625 (11.08%) out of 95879 videos are fully labeled, and 11005 (11.48%) videos are partially labeled (learn more)". There are three buttons: Sign In, Interactive Tutorial, and My Contribution. A note below says: "Each video is 3 seconds. Click or tap to select videos that have smoke. Click or tap again to deselect. Skip a video if you are not sure whether it has smoke." Below this are four video thumbnails numbered 1 through 4. Thumbs 1 and 3 are highlighted with a red border. Each thumbnail has a play button icon in the bottom right corner.

Data Annotation

The screenshot shows a news article from TRIB LIVE. The header reads: "TRIB LIVE" and "Allegheny County Health Department defends air quality efforts, plans stricter coke plant rules". Below the header is a photo of a meeting room with several people seated around a table. A video player at the bottom shows a timestamp of "0:00 / 1:15". Below the video is a caption: "Activists read air complaints to Allegheny County Board of Health. Environmental activist groups read air quality complaints submitted through the 'Smell Pittsburgh' app during the Allegheny County Board of Health meeting on July 18, 2018."

Social Impact of AI



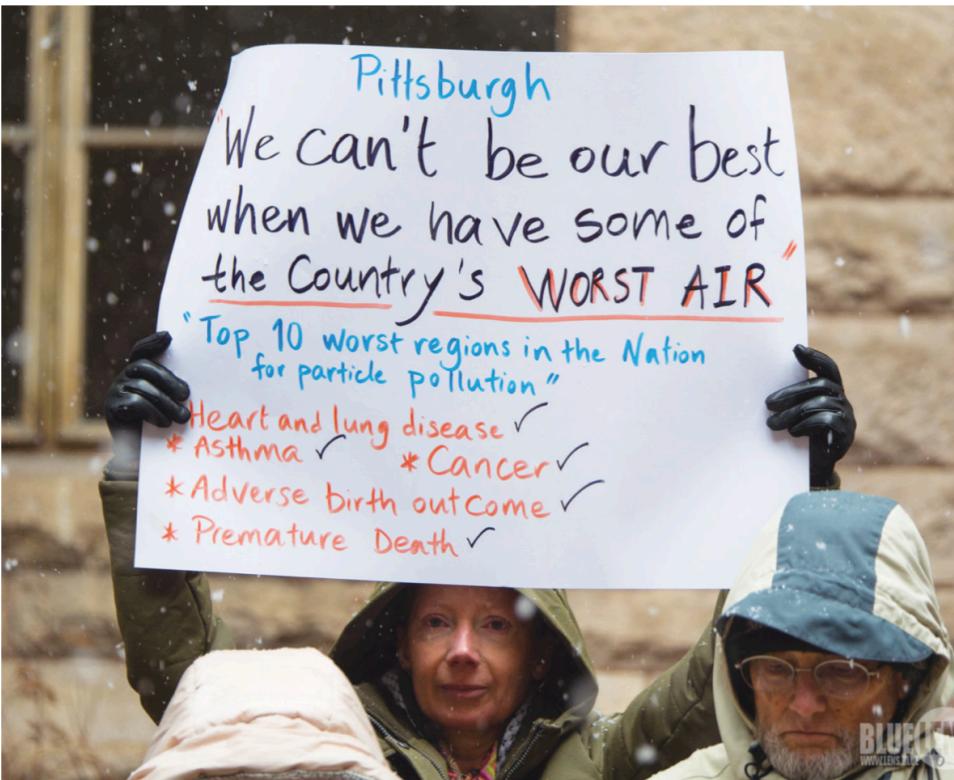
Explainable AI

Viewpoint

When Human-Computer Interaction Meets Community Citizen Science

Empowering communities through citizen science.

HUMAN-COMPUTER INTERACTION (HCI) studies the design and use of interfaces and interactive systems. HCI has been adopted successfully in modern commercial products. Recently, its use for promoting social good and pursuing sustainability—known as sustainable HCI—has begun to receive wide attention.⁴ Conventionally, scientists and decision-makers apply top-down approaches to lead research activities that engage lay people in facilitating sustainability, such as saving energy. We introduce an alternative framework, Community Citizen Science (CCS), to closely connect research and social issues by empowering communities to produce scientific knowledge, represent their needs, address their concerns, and advocate for impact. CCS advances the current science-oriented concept to a deeper level that aims to sustain community engagement when researchers are no longer involved after the intervention of interactive systems.



Participants in a Clean Air Rally in Pittsburgh, PA, in 2018.

feasible for experts to tackle alone.¹¹ | birdwatchers to contribute bird data

Thank you! Questions?

- Yen-Chia Hsu: <http://yenchiah.me>
- Air Quality Monitoring: <http://shenangochannel.org>
- Smell Pittsburgh: <https://smellpgh.org>
- Smoke Labeling Tool: <https://smoke.createlab.org>

Carnegie Mellon University
The Robotics Institute

CREATE Lab

Community Robotics, Education and Technology Empowerment

