

# CPS: Frontier: SONYC: A Cyber-Physical System for Monitoring, Analysis and Mitigation of Urban Noise Pollution

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Juan Pablo Bello, Luke DuBois, Oded Nov and Claudio Silva (New York University); Anish Arora (Ohio State University)

Review Meeting  
NYC, February 8, 2018

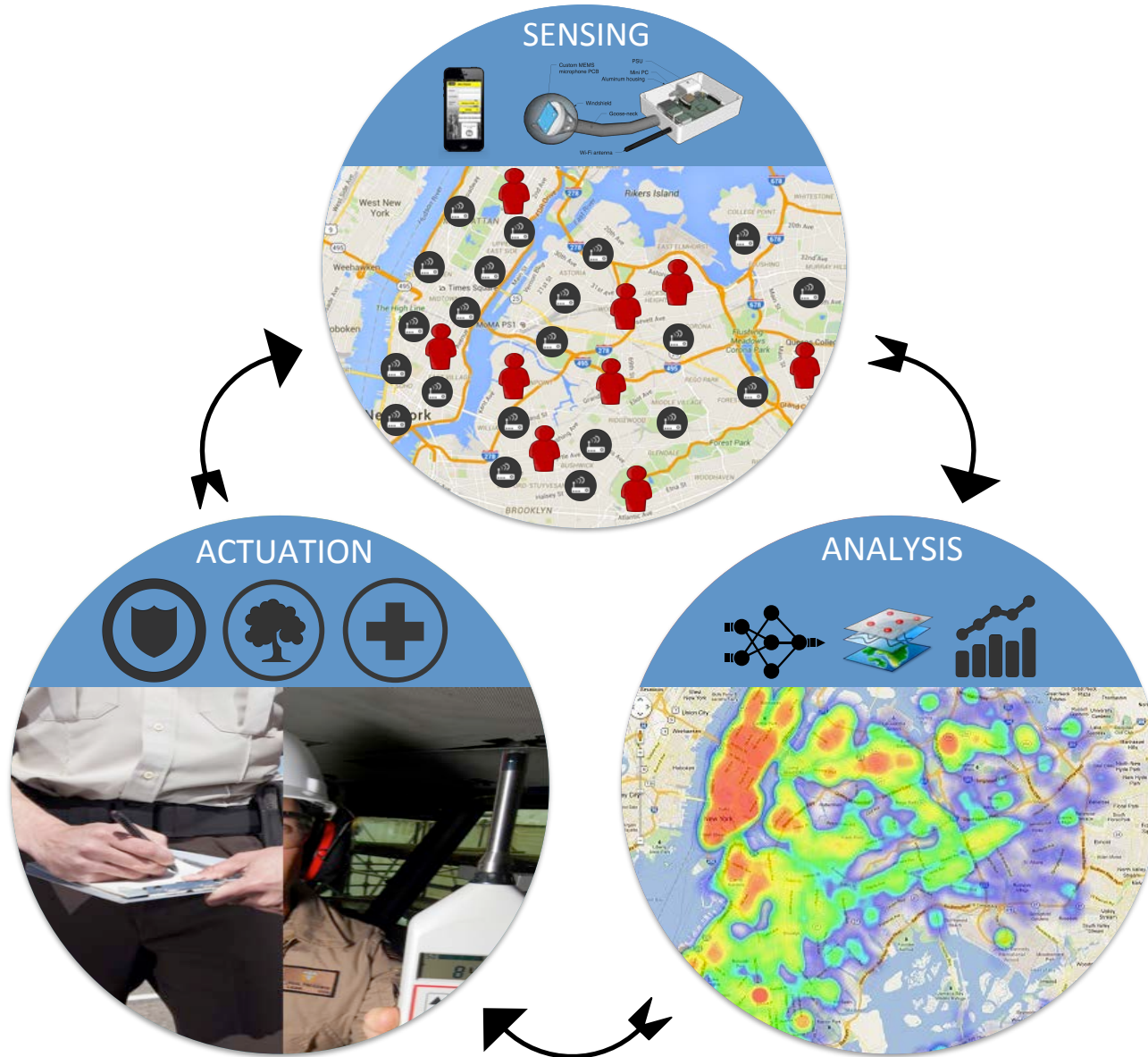


# SONYC

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Cyber-Physical System aimed at  
reducing urban noise pollution

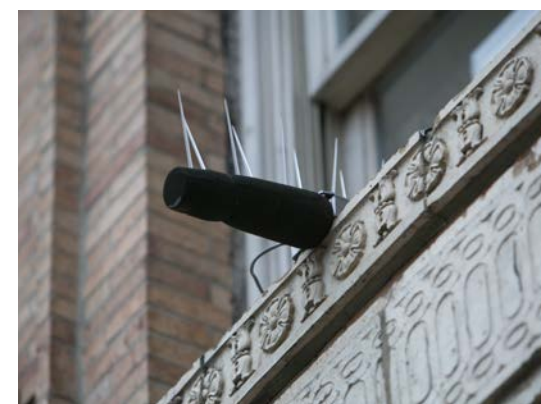
# SONYC



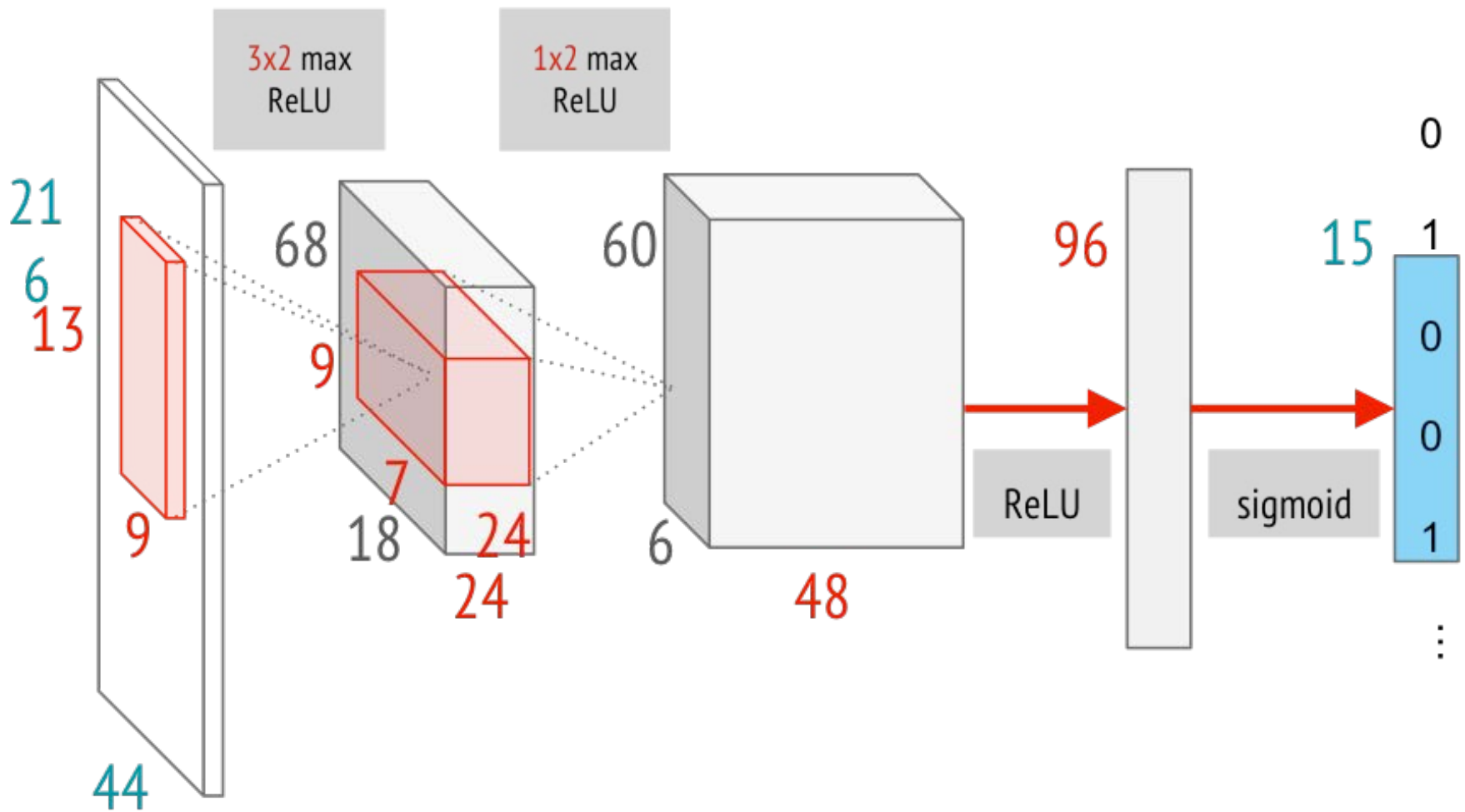
# Where are we?

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- **10.00am Sensor Network (Charlie Mydlarz / Anish Arora)**
- **11.00am Machine Listening (Justin Salamon)**
- **11.40am Crowdsourcing (Mark Cartwright)**
- 1-3pm Posters and Demos
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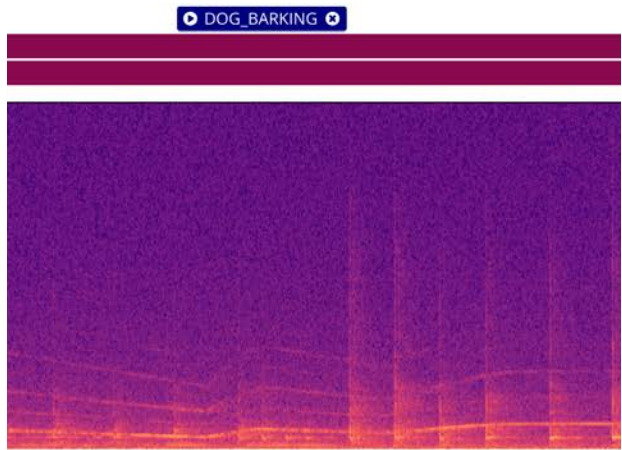
45 sensors, 3 boroughs, 17 years of audio, 34 years of SPL data



Deep Machine Listening

Automatic noise source ID

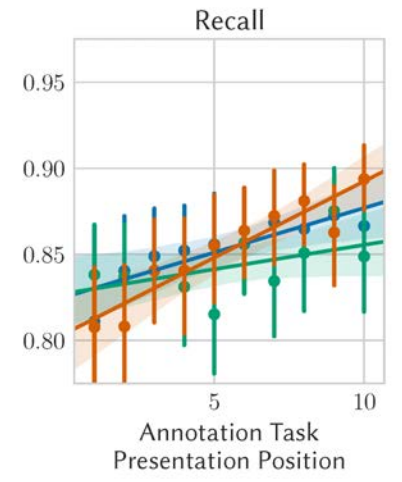
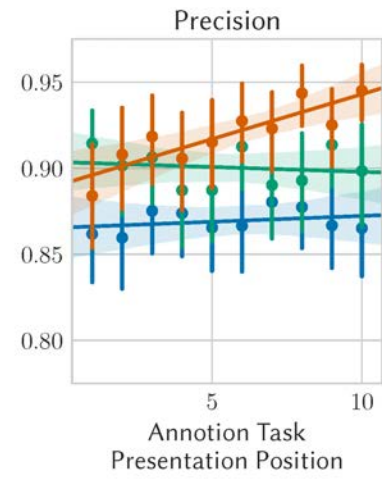
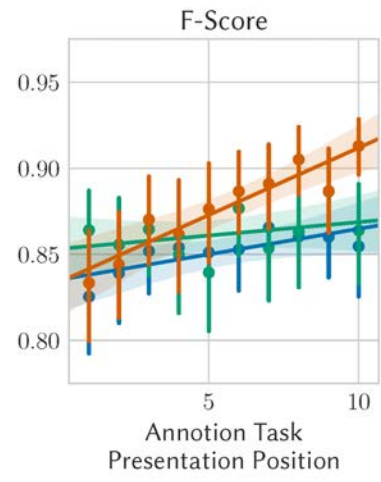
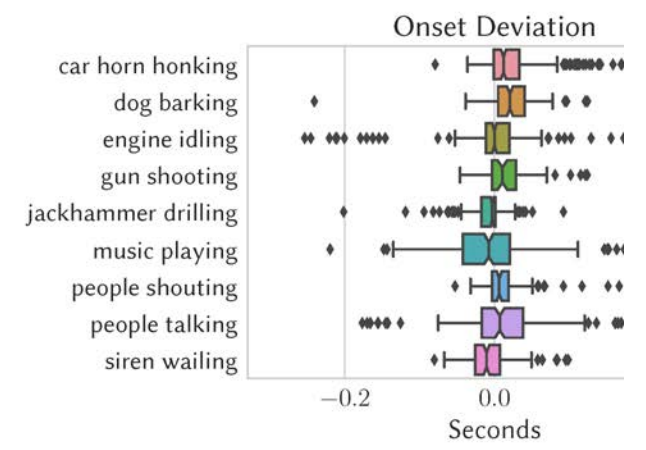
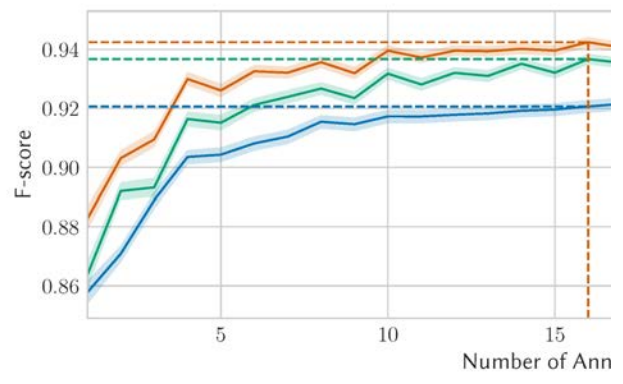




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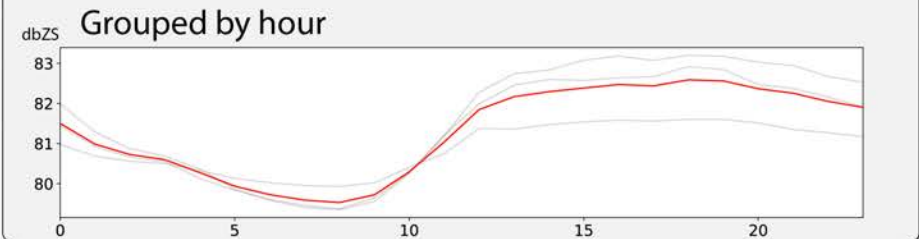
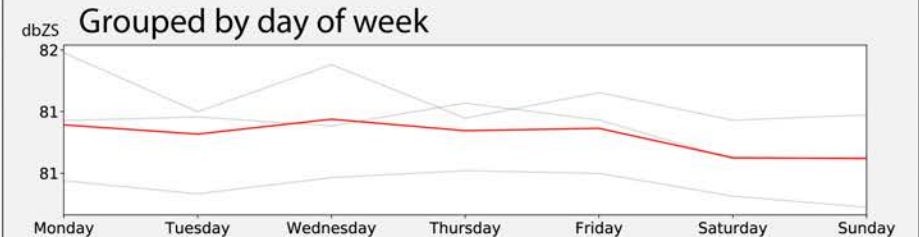
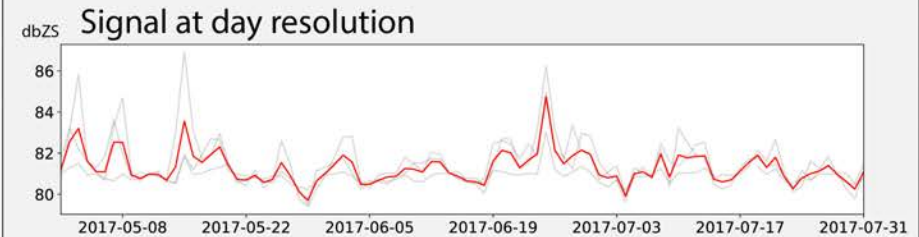
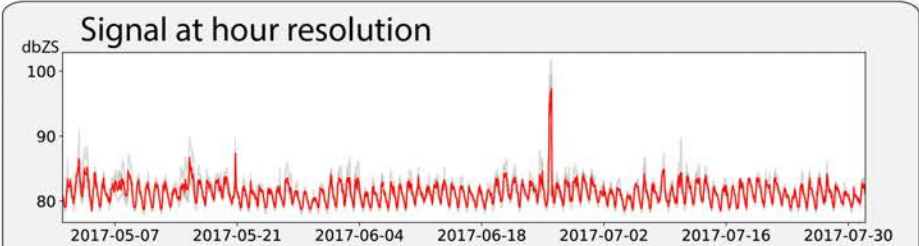
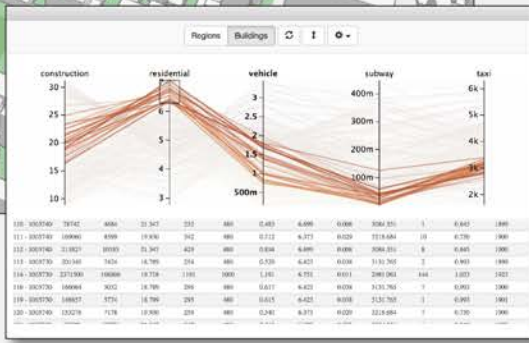
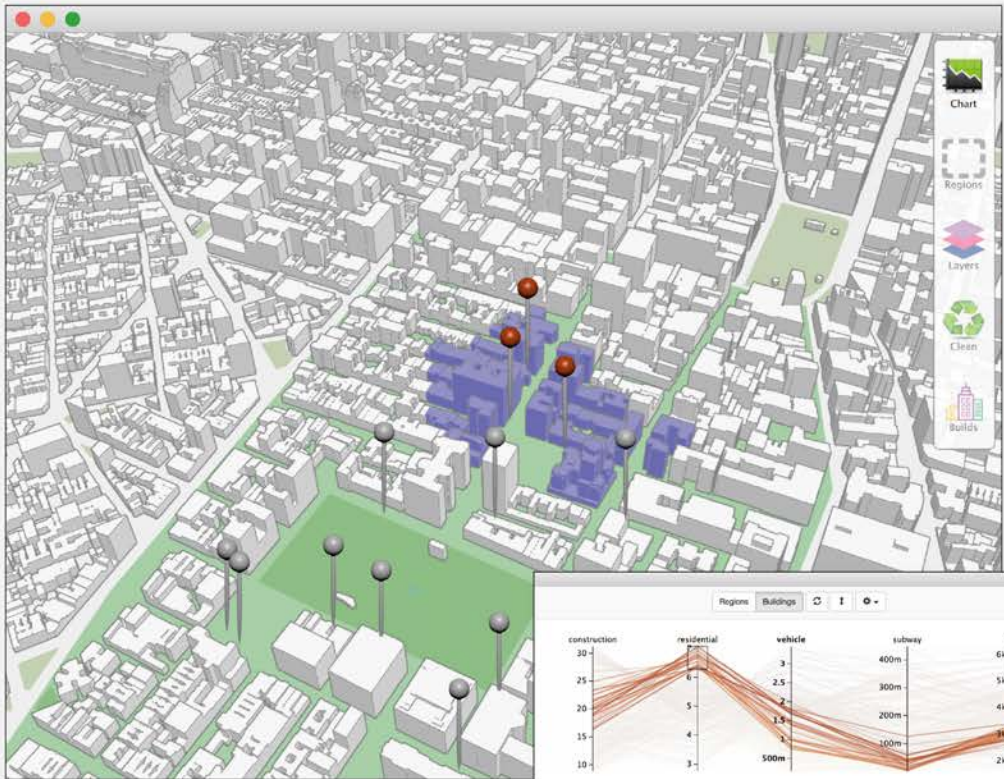
Annotation interface showing buttons for different audio classes:

- DOG\_BARKING
- ENGINE\_IDLING
- GUN
- MUSIC\_PLAYING
- PEOPLE\_SHOUTING
- NOT SURE



● no visualization ● waveform ● spectrogram

Crowdsourced audio annotation (Proceedings of the ACM, 2017)



Novel data structure for large-scale time-series analysis and visualization, pilot study on after-hours construction noise





20 students involved; 1 new course; K12 summer workshop in the works

# SONYC to date

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- Scientific publications: 18 articles (6 journals, 1 book chapter, 11 conference proceedings) plus 3 in review
- Open Data/Code: 4 datasets, 6 code repositories
- Infrastructure: fully operational sensor network; VM-based testbed for data ingestion, monitoring and storage; SoC development environments w/eMote
- Training/Education: 5 post-docs, 9 PhD, 6 MSc, 4 UG, 2 high school; participation on national ICORPS program
- Dissemination: media coverage (NY Times, Fox 5, AFP, NPR, PBS, Discovery Canada, BBC, etc); workshops for the CPS PI meeting, Oticon; guest talks at ICDCN, SANE, ASA, IBM, IIT, AESx, Tech for Good Meetup, Taste of Science.

# SONYC to date

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**Anish Arora**  
Co-PI



**Carlos Bautista**  
App Developer



**Juan Pablo Bello**  
Lead-PI



**Mark Cartwright**  
Postdoc



**Jason Cramer**  
Masters Student



**Yuri Piadyk**  
PhD Student



**Dhrubojyoti Roy**  
PhD Student



**Justin Salamon**  
Senior Research



**Harish Doraiswamy**  
Res. Asst. Prof.



**Graham Dove**  
Postdoc



**R. Luke DuBois**  
Co-PI



**Ben Esner**  
Senior Personnel



**Peter Li**  
PhD Student



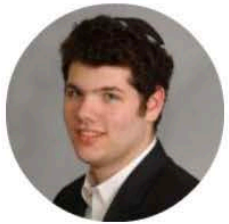
**Claudio Silva**  
Co-PI



**Yu Wang**  
PhD Student



**Ho-Hsiang Wu**  
PhD Student



**Yitzchak  
Lockerman**  
Postdoc



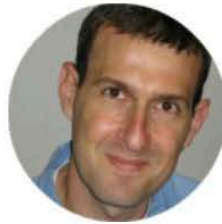
**Ana Elisa  
Mendez**  
PhD Student



**Fabio Miranda**  
PhD Student



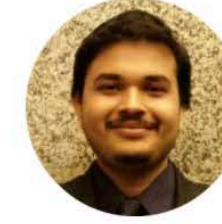
**Charlie Mydlarz**  
Senior Research  
Scientist



**Oded Nov**  
Co-PI



**Ayanna Seals**  
PhD Student



**Mohit Sharma**  
Asst. Research  
Scientist

# Agenda

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Washington Heights is among the city's noisiest neighborhoods, according to a recent study of 311 noise complaints. (Credit: Linda Rosier)



NEWS

# 311 noise complaints on the rise in Washington Heights, Inwood

By Lisa L. Colangelo [lisa.colangelo@amny.com](mailto:lisa.colangelo@amny.com) January 30, 2018

New Yorkers are making a lot of noise about noise.

There were 1.6 million noise complaints made to 311 between 2010 and 2015, according to a new report released Monday by State Comptroller Thomas DiNapoli.

“Noise in New York City is a significant quality of life and public health concern,” DiNapoli said. “The city has a model noise code and should be commended for taking steps to better enforce local law, but there is more that city agencies can do to control noise disruptions.”

The study showed residents of Community Board 12 in Manhattan, which includes Washington Heights and Inwood, called 311 most often followed by Community Board 10 in Central Harlem and Community Boards 4 and 5 in Chelsea and the Midtown Business District.

# Construction noise complaints build up in the city

BY GLENN BLAIN

NEW YORK DAILY NEWS Thursday, August 31, 2017, 2:20 PM



Construction noise complaints called into the 311 system jumped from 14,259 in 2010 to 37,806 in 2015, with the vast majority involving work taking place late at night or early in the morning. (HOWARD SIMMONS/NEW YORK DAILY NEWS)

ALBANY — Booming construction and lax efforts by city agencies to control it have led to soaring noise complaints in the five boroughs, a new report Thursday revealed.

Construction noise complaints called into the 311 system jumped from 14,259 in 2010 to 37,806 in 2015, with the vast





(/new-york-kids/sear

NEWS CITY LIFE

ADD COMMENT

LOVE IT

SAVE I

## Yikes! NYC's noisiest neighborhoods are no place for exhausted parents



By Danielle Valente

Posted: Wednesday January 31 2018, 12:31pm





N.Y. / REGION

# New York Becomes the City That Never Shuts Up

By WINNIE HU JULY 19, 2017

Richard T. McIntosh has never heard such a racket outside his window.

Traffic roars through his neighborhood on the Upper East Side of Manhattan at all hours. The whine of refrigerated grocery trucks by the curb makes things worse. And construction of a new apartment tower across the street forces him to flee his own home. There is the deafening rat-a-tat of jack hammers and the incessant banging and high-pitched wail of construction equipment that echoes in his head.

“I’ve had two years of absolute violation of my right to peace and quiet,” said Mr. McIntosh, a television producer who has lived on the Upper East Side for more than five decades. “I think it’s against the Geneva Conventions to have this much noise.”

New York City has never been kind to human ears, from its screeching subways and honking taxis to wailing police sirens. But even at its loudest, there were always relatively tranquil pockets like the Upper East Side that offered some relief from the day-to-day cacophony of the big city. Those pockets are vanishing. As the city grows more crowded, with a record 8.5 million residents and a forest of new buildings, finding respite from loud cellphone chatter, rooftop parties, backhoes digging foundations, or any other aural assault has become harder and harder.

In other words, New York is really living up to its reputation as the city that never sleeps.

# NY State Comptroller Reports — 08/17, 01/18

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- Construction noise audit: 30-month (2014-16), 50 locations across 5 boroughs
- 2,683 construction-related noise complaints
- 2,044 of those related to after-hours construction (76%)
- 2,632 after-hours variances (AHV) issued during that same period and locations
- DEP: response time 5 days in average; inspectors generally find there is no excessive noise and no violations are issued; there is no record of noise meter readings on inspector reports.

# NY State Comptroller Reports — 08/17, 01/18

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- Survey of 4,000 residents + 311 data analysis
- 92% percent who reported a noise complaint said it was recurring: more than half of 1.4M complaint locations since 2010 have logged 10+ complaints.
- 61% felt noise had increased since moving to their address.
- 83% were dissatisfied with how their complaint was handled, with more than 1,100 saying there was no follow-up and nearly 500 saying they felt their complaint was not taken seriously.
- Nightlife and construction noise complaints were the most vexing.



New York Post, Friday, September 1, 2017 [nypost.com](http://nypost.com)



**Bombers bash BOSOX**  
SEE SPORTS



**HARVEY:**  
Picking up the pieces  
SEE PAGES 6-7

# CITY THAT NEVER SHUTS UP



No matter how many times residents complain about late-night noise, construction companies are given waivers to work into the wee hours, a review by Comptroller Thomas DiNapoli found.  
**SEE PAGE 4**

**Why is this aloud?  
Night work OK'd despite outrage**



# Recommendations and follow-up

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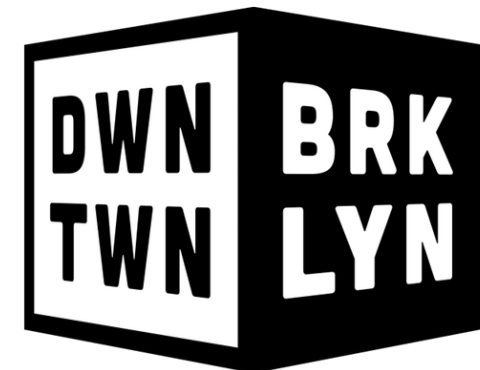
- Shorten response times
- Include readings in inspection reports
- Leverage 311 data to systematically identify recurring/problematic locations
- Improve coordination between DEP and DOB, particularly for after-hours variances (AHV)
- January 2018: Mayor signs new legislation on construction noise

# Partners and Guests

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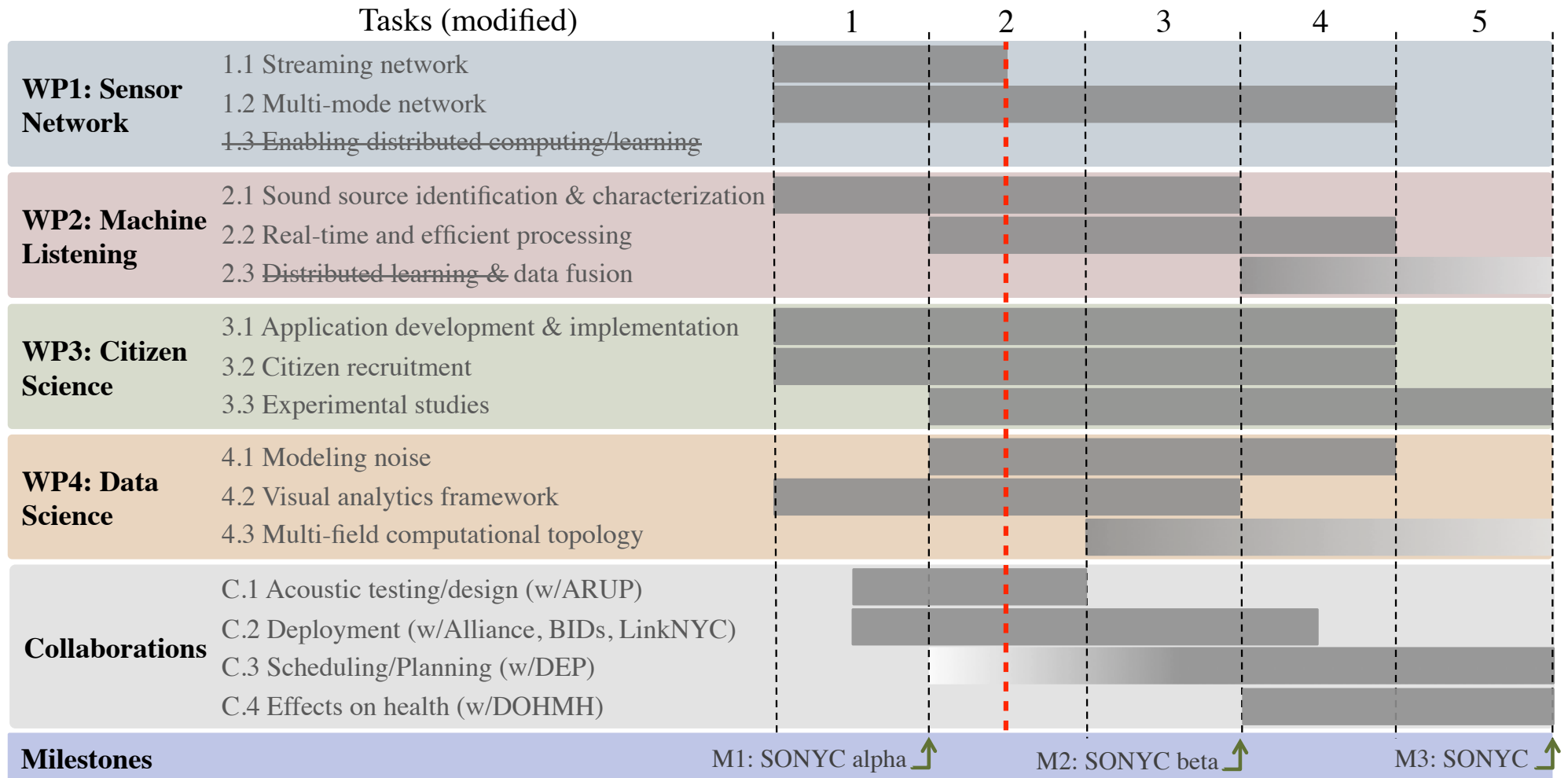
**Intersection**



# Goals for 2018

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# Timeline





# Goals

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- WP1.1 — Deployment of high-power streaming network:
  - 100 NYC locations: work with DEP, Parks, CUNY Hostos, Downtown Brooklyn, Intersection (**Overdue**)
  - Pilot studies w/ DEP, DOHMH, DOT and ARUP
- WP1.2 — Multi-mode network
  - Experiments on radio mesh networking
  - Low-power audio event detection on Ineda SoC, w/ Ineda
  - Acoustic front-end of mote

# Goals

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- WP2.1 — Robust, multi-label source classification:
  - Develop/benchmark novel solutions based on self-supervised learning
  - Retrain models w/ data from WP3.1, extended class set
- WP2.2 — Real-time and efficient processing:
  - Investigate novel solutions to model compression / binarization
  - Deploy compressed models on current network

# Goals

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- WP3.1 — Applications
  - Crowdsourcing audio annotations with citizen scientists (**Overdue**)
  - Development of public-facing SONYC web-apps
- WP3.2 — Citizen Recruitment:
  - User discovery research for citizen science applications
- WP3.3 — Experimental studies:
  - Zooniverse experiments on annotation specialization
  - Engagement in annotation and reporting

# Goals

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- WP4.1 - Noise modeling
  - Preliminary research on sound propagation using ray tracing and 3D modeling of NYC
- WP4.2 — Visualization / analytics framework:
  - Integration of sensor data into UrbanGIS framework
  - Data mining of sensor, 311, AHV and other city data



# Goals

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- Education and Outreach:
  - Running the Science of Smart Cities' SONYC workshop for high-school students in Summer 2018
  - Pre-college (ARISE) and UG (REU) research experiences for spring and summer 2018, with a strong focus on local communities and increasing diversity.