



myCityMeter

Helping Older Adults Manage the
Environmental Risk Factors for
Cognitive Impairment

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By 2040, 20% of the urban households is expected to be 65 years or older.



Exposure to urban pollution is linked to many health risks, particularly affecting the aging population.



Long-term exposures to air pollution (PM_{2.5}) and noise have been shown positively associated with mild-cognitive impairment (MCI).



MCI is a precursor to dementia. It is estimated that by 2020, 42.7–48.1 million people worldwide will suffer from dementia.



Normal Aging

Everyone experiences slight cognitive changes during aging

Cognitive Decline



Preclinical

- Silent phase: brain changes without measurable symptoms
- Individual may notice changes, but not detectable on tests
- "A stage where the patient knows, but the doctor doesn't"

MCI

- Cognitive changes are of concern to individual and/or family
- One or more cognitive domains impaired significantly
- Preserved activities of daily living

Mild

Moderate

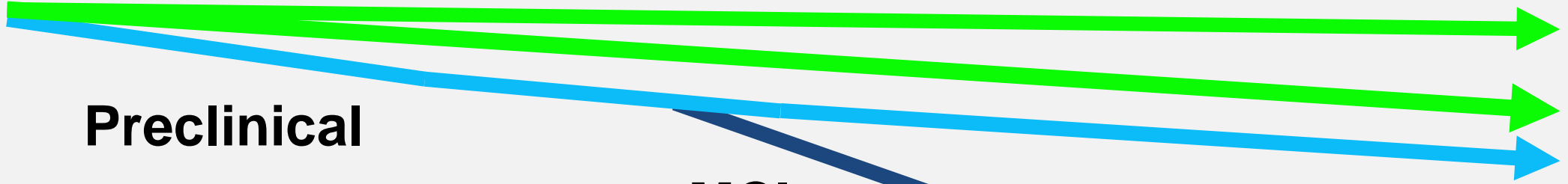
Moderately Severe

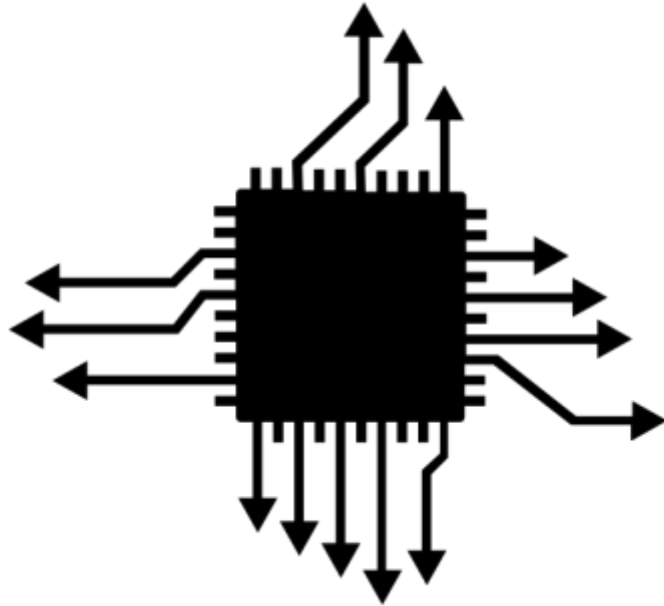
Dementia

- Cognitive impairment severe enough to interfere with everyday abilities

Severe

Time (Years)





Ubiquitous computing offers the promise of estimating pollution exposures

How much dust (particulate matter) did I inhale last month?

When was I most exposed to ambient noise today?

Am I currently exposed to a high level of air pollution?

Should I take another route for my evening walk?



Personally tracking pollution exposures is challenging—especially by the vulnerable populations

Although, pollution exposure assessment at the population level is an established enterprise for environmental scientists.

Three important challenges

Wearable, portable, environmental sensors are **low-cost but suboptimal** and sensitive to interference due to people's daily life activities, such as human skin emissions or textile emissions.

Measurements from **central-site monitors**, the gold standard metric of exposure, are accurate but **lack spatial and temporal resolution** (e.g., 1-in-6-day schedule).

Current wearable pollution monitoring tools are essentially **designed for citizen scientists** and tech enthusiasts—lacking the design requirements to support at-risk communities.



Middleware
RESTful API



Array of Things (AoT)



National monitoring sites

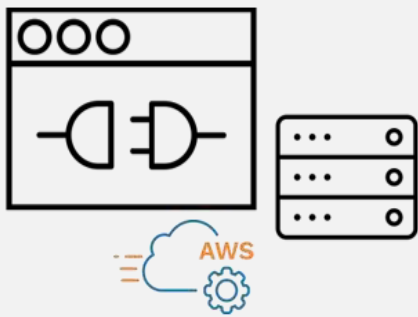
Fixed Monitoring Stations

myCityMeter—a pollution exposure monitoring tool

Uses a set of neighborhood-level stationary and personal mobile sensors

Helps users to monitor long-term air and noise pollution exposures

Allows users to journal cognitive performances to help diagnose MCI



Middleware

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National monitoring sites

Fixed Monitoring Stations

A core challenge in using mobile pollution monitoring sensors is **low measurement accuracy** compared with professionally maintained fixed pollution monitoring stations.

To complement wearable sensing, we collect noise and PM_{2.5} data from Chicago's **Array of Things** (AoT) urban sensing nodes (~100) and US **EPA** monitoring stations (4).

The middleware of myCityMeter is hosted in an **AWS cloud** which gets data from AoT and EPA and communicates with the **mobile client app using a RESTful API**.



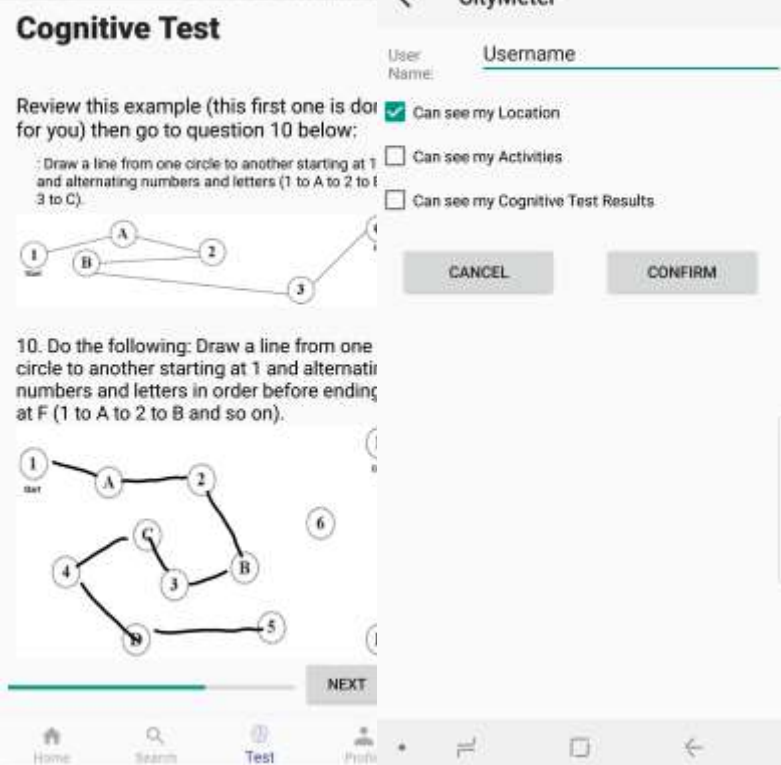
myCityMeter's mobile sensing module functions in conjunction with its companion smartphone (or tablet). The sensing module is a wireless embedded sensing system and uses **Raspberry Pi 3b+**.

An off-the-shelf particle concentration sensor, **Plantower PMS 5003**, is mounted on the Pi, which uses a **laser scattering principle** to measure $PM_{2.5}$. The phone records ambient **noise** and transforms it with **A-weighting** [dB(A)].

Pi sends readings to **AWS** when Wi-Fi is available; else to the phone via Bluetooth which then transmits the data to the server via LTE. If both Wi-Fi and Bluetooth are unavailable, readings are stored locally in the Pi. Each reading is **geotagged** (using the phone's GPS) and **timestamped**.



The phone app allows users to look up current pollution and their daily and yearly pollution exposures—**PM_{2.5}**, **day-time noise** and **night-time noise**—at both **current** and a **future** location.



Actions to avoid pollution are suggested. The Self-administered Gerocognitive Examination (**SAGE**) is provided to journal cognitive performances.

Users can **add their caregivers** and provide different permissions, such as to **score** and monitor their **cognitive tests** or access their current location.



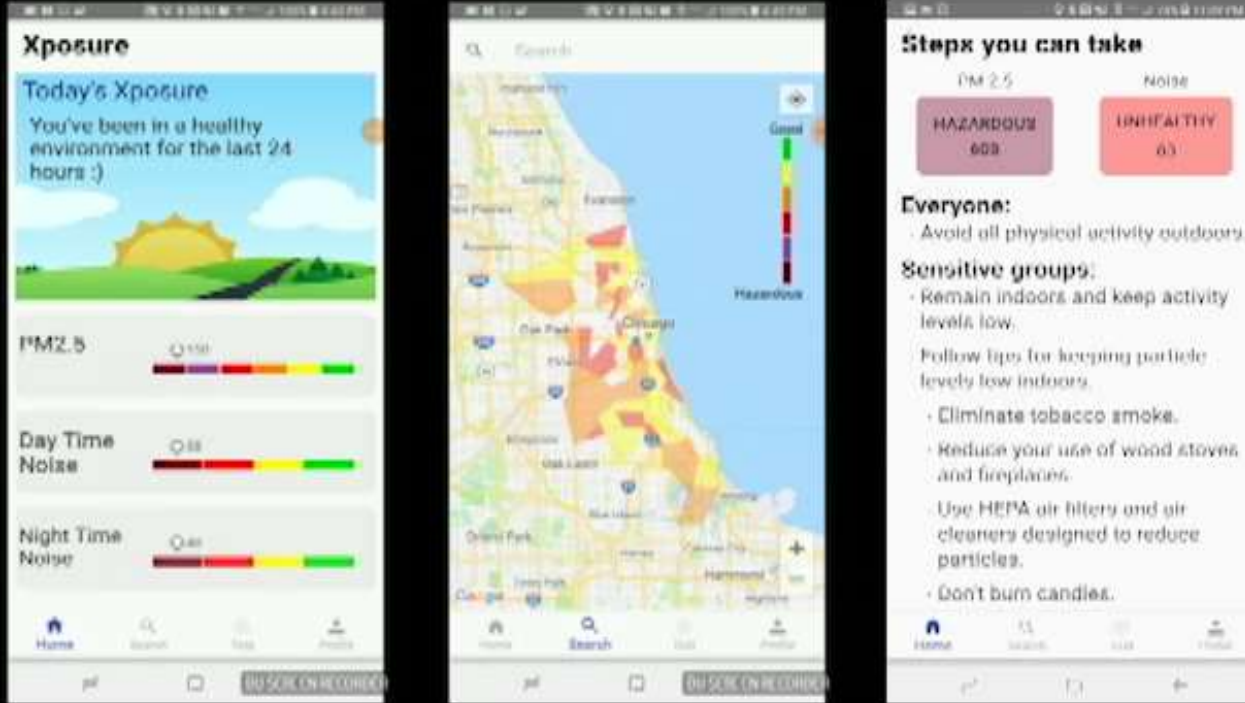
Ongoing work...

Fabricating wearable sensors

Conducting measurement studies

Data blending from different environmental sensing sources using Bayesian inference

Organizing participatory design workshops with older adults and their caregivers to generate design requirements



We present a pollution exposure management tool for older adults and their caregivers.

Collaborate with us!

We are looking to collaborate with end-users, public health researchers and caregivers working with older adults and MCI patients.

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