SEOUL ON-AIR Augmented Environments for Urban Activism

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While the study of urban sensing tools has been a consistent focus of research within the environmental, earth, and citizen science communities, little attention has been paid on the development of on-site visualization techniques and methods for an interactive exploration of urban environmental data. Environmental data are generally visualized as tabular data or two-dimensional plots, which fails to enable an experiential visualization of the microclimate and thus prevents citizens from gaining a detailed understanding of the site-specific variability of pollutant concentrations and thermal comfort in their cities. This research explores three-dimensional immersive environmental visualization techniques to enable a user-friendly interactive analysis of the urban air quality data. The research focuses on the implementation of low-cost mobile urban-sensing technologies and immersive environmental data exploration mechanisms with the ambition to enable citizens to reframe their role in the politics of urban air quality.

1. Introduction

Big data is changing urban science. Digitalization of information and ubiquitous sensing in cities are enabling the collection of data at unprecedentedly high temporal and spatial resolutions. This is most true in regard to urban environmental data. Sensor networks, remote sensing, thermal imaging, and crowd-sourced environmental monitoring are rapidly increasing the availability of urban environmental data.

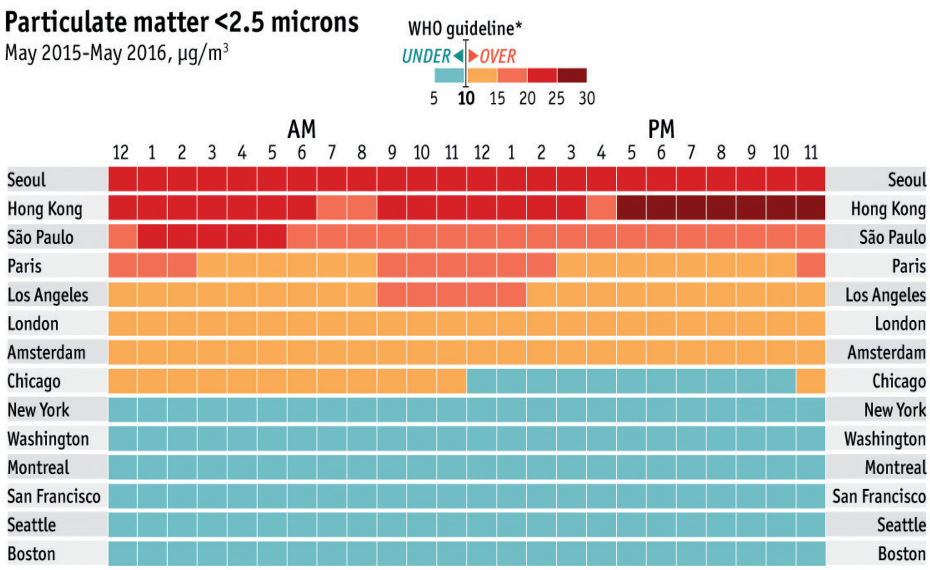
While high-spatiotemporal-resolution urban microclimate data are continuously becoming easier to collect, these data often fail to reach public audiences. Citizens are generally only aware of city scale mean pollutant concentration values, and fail to understand the variable environmental quality

Urban environmental fashion in Korea

conditions present in the urban fabric. One of the reasons for the persistence of this challenge is that while the study of urban sensing tools and strategies has been a consistent focus of research within the environmental and earth science communities, little attention has been paid on the development of data compilation and visualization techniques and methods for interactive exploration of environmental data for urban analysis.

Environmental data are generally visualized as tabular data or two-dimensional plots that generally fail to enable an experiential visualization of the microclimatic data. Three-dimensional immersive environmental visualization techniques, on the other hand, could potentially facilitate a user-centered interactive analysis and rationalization of the available urban environmental data.
With this ambition, the proposal *Seoul On-Air* for the 2017 Seoul Biennale focuses on the development of Augmented Reality (AR) visualizations of urban air quality data. The urban air quality data is analyzed in conjunction with urban data gathered from Geographic Information Systems (GIS) and real time video processing and object-analysis techniques. The combination of these technologies aims to enable an on-site and off-site visualization of urban air quality against city characteristics.
The proposed AR environmental visualization techniques will enable citizens to become active participants in the mediation of this common.

Air quality applications.
(a) Plume labs
(b) Airvisual

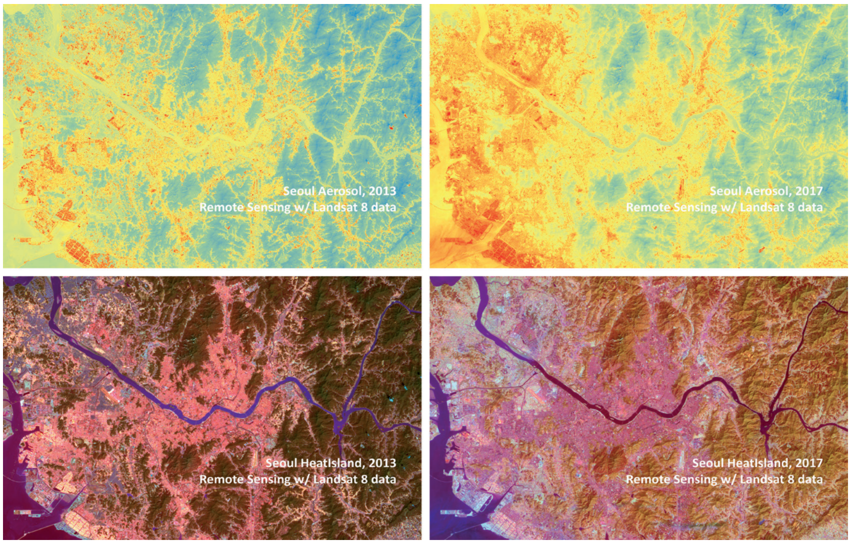


Comparison of PM 2.5 in cities around the world. (The Economist, Source: Plume labs. Url: https://www.economist.com/news/science-and-technology/21702743-air-quality-indices-make-pollution-seem-less-bad-it-breathtaking

2. Seoul air quality

The context of the 2017 Seoul Biennale is a particularly interesting forum for research on air quality, as Seoul citizens suffer from some of the most polluted on in the planet. Today the Namsan Tower alerts them on the mean concentration of ultrafine particles, PM10 in the air. If the lights projected over the tower are blue, it means Seoul is experiencing "good" air quality. The concentration levels can also be monitored by following the hourly tweets by *@yellowdust*. As per the national standards, concentrations below 45 µg m^{-3} are considered safe for performing outdoor activities. However, this limit is often exceeded, and the local standard more than doubles the maximum guidelines defined by the World Health Organization for fine and ultrafine particle concentrations. This is the case also with ozone concentrations which given the high temperatures and radiation present primarily in summer time, often exceed the recommended limits reaching alarming concentrations. Furthermore, the broadcasted mean concentration values are acquired from weather stations located in idealized conditions (sometimes elevated roofs or green space) that fail to reflect the real concentration values present in the city streets. Therefore, it is not surprising that Seoul citizens have a growing concern about the serious health risks associated with their exposure to poor air quality. In this context, the Seoul city government is exploring alternative urban sensing and air quality remediation strategies and has set out various policies to meet a 20% reduction target of ultrafine particle concentrations by 2018 (SMG 2016). Moreover, given the possibility that some of the pollution affecting Seoul is actually advected from China, the air quality of Seoul also takes a regional political dimension.

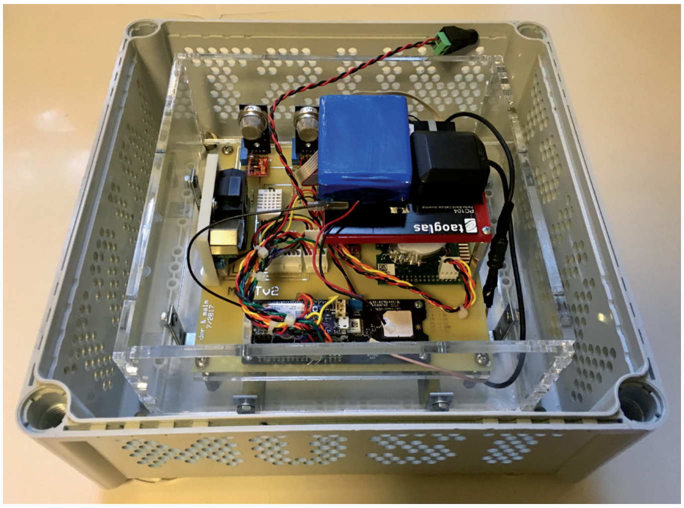
The Namsan Tower in Seoul



Seoul Aerosol and Heat Island Imagery. Comparison of data from 2013 and 2017.
Source: GSAPP AC 2017

In this context, the Seoul On-Air research aims to communicate high spatiotemporal air quality data to its citizens using more user-friendly and accessible means. The research has been organized into three sections: The first section focuses on the acquisition of high-spatiotemporal-resolution urban air quality data through Mobile Urban Sensing Technologies (MUST).

The second section focuses on the introduction of on-site immersive environmental visualization strategies. The third section focuses on the setting up of an off-site interactive citizen participation interface to actively engage Seoul citizens in the analysis and rationalization of the acquired data.



Mobile Urban Sensing Technologies (MUST). a) est of the sensing kit over a private vehicle in Princeton University campus. b) Sensing kit circuit.

3. Acquisition of high-spatiotemporal-resolution urban air quality data

In order to understand the local variability of the air quality across the different neighborhoods in the city, data with higher spatiotemporal resolutions are to be collected. For this purpose, we have developed novel mobile urban sensing technologies through the coupling of sensing kits to mobile platforms such as private vehicles or public transportation networks.

The main advantage of the proposed sensing methodology lies in its flexibility that allows mounting the kit on any type of mobile vehicle. Furthermore, readily available and cheap sensors are used to enable the scalability of the project. Through these two strategies, a high-spatial-resolution air quality collection is sought.

The proposed sensing kit contains sensors for Carbon Monoxide, Ozone, Particulate Matter, Carbon Dioxide, Temperature, and Humidity. The sensing kits are also equipped with a GPS shield that enables them to be geolocalized in real time. Furthermore, the kit also comprises a cellular antenna that enables the acquired data to be transmitted in near real time to an online database. The kit is powered by a Photovoltaic cell which is connected to a rechargeable Lithium-ion battery to enhance its flexibility to be coupled to diverse mobile platforms. Some of the sensing kits are also equipped with video cameras which, depending on the collected environmental values, are triggered, and snapshots of the context are saved in the online database.

4. Augmented environmental visualizations

Aiming for a qualitative display of the acquired air quality data, we sought a three-dimensional visualization strategy. With this ambition, the research focuses on the implementation of environmental representation platforms designed to visualize air quality data. Video processing techniques, Geographic Information Systems (GIS), and Augmented Reality (AR) technologies are combined to provide photorealistic live-streaming of the recorded air quality data over the local urban setting. This approach aims for an intuitive and informational understanding of local environmental conditions in relation to further urban parameters.

While the use of AR technologies for immersive representational purposes is becoming more wide-spread, their use for environmental visualization has not yet been explored. In this context, this research argues that the use of AR for environmental visualization may prove powerful for engaging citizens in the discussion of urban environmental quality. With this ambition, two AR environmental visualization strategies have been developed:

1. An AR mobile app has been designed for on-site air quality visualization. Its information visualization corresponds to real-time data acquired from urban GIS, sensing networks, and real-time video processing techniques.
2. An off-site AR immersive environmental visualization is also currently under development to display data also acquired from GIS and sensing networks.

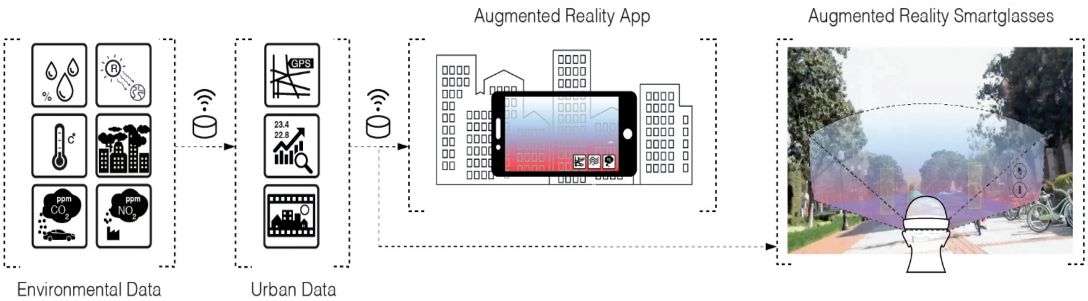
Both approaches will enable the visualization of urban parameters such as streets and buildings, as well as their surface characteristics against urban environmental and microclimatic data to inform citizens by uncovering relationships between air quality and further urban metrics.

4.1 AR app for environmental visualization on smartphones

We have been developing a mobile app that combines mobile GIS technologies with computer vision and video processing techniques to correlate urban and environmental parameters as comprehensible visualizations.

The goal is to create a user-centered app that enables a direct engagement with the surrounding environment.

Two AR environmental visualization modes will be enabled: the first-person view and the map view. In the first-person view, locational services



(a) The Collected Environmental Data is coupled with (b) Urban Data which is visualized through (c) An App interface (The example shows a temperature gradient visualization) as well as through d) Spatial environmental visualization over urban intersections

App interface design. Left, temperature gradient visualization.
Right, humidity gradient visualization

of the user's mobile device are accessed, and by referencing the mobile GIS platform, geotagged environmental data is overlaid on the camera view as graphic filters. The app also enables a map view of the environmental data by accessing geolocation and using Google Map API services over which environmental gradients are overlaid.

The local weather data for the app visualization are acquired from the sensing kit described in section 3 and through queries to online web services such as OpenWeatherMap and AQICN. Through these combined sources, data on temperature, humidity, and air quality are collected. Furthermore, through GeoNames geocoding, the location for the different urban intersections is stored. Intersection are then identified with markers and their spatially-distributed air quality values displayed. That is, when a user points the smartphone towards a nearby intersection, the app draws a marker over the intersection to show the street names as well as the relevant environmental data for that given intersection. Thus, the app allows the user to associate certain temperatures or AQI values with the urban fabric. Finally, the collected environmental data are stored in an online database, and these data can be queried by each user through the app based on their geolocation.

4.2 Augmented Reality exhibition space Seoul 2017 Biennale

The exhibition space for the Seoul 2017 Architecture and Urbanism Biennale is being designed as an off-site space for data analysis and rationalization. A narrative on the research methodology will be included along with the interactive data visualizations. AR interface handsets will be made available to the visitors so they can experience the collected air quality data as well as the historical air quality data available in the Seoul city archives.

The air quality data displayed at the city-scale visualization will be gathered through queries to online web services such as OpenWeatherMap and AQICN as well as Seoul city weather station databases. These data will be visualized alongside the air quality data gathered from MUST. The combination of weather station with pedestrian level recordings aims to offer a holistic description of the local air quality characteristics.

Exhibition AR work in progress

Through the AR interface, the visitor will be able to select environmental parameters and compare them against urban parameters such as building structures or urban surface characteristics. Through an immersive visualization, the user will be able to zoom in on the desired areas, look into the environmental parameters of interest, or establish correlations with other urban parameters. The interaction of Biennale visitors with the deployed visualization interface will be tracked in order to study user behavior. This backend survey will be exhibited along with the projections.

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