Blending Hardware and Software Innovations in Mobile Urban Sensing Technologies

This research focuses on the development and integration of low-cost Mobile Urban Sensing Technologies (MUST) and immersive environmental data exploration mechanisms with the ambition to inform citizens about their environment and aid scientists in uncovering the relations between the surface attributes and the urban environment.

Air quality data are generally collected from fixed weather stations, which generally offer a low spatial resolution coverage. Aiming for the acquisition of air quality dynamics and gradients of the contaminant concentrations across the city at higher spatio-temporal resolutions, we have deployed autonomous air quality sensing kits on mobile platforms, such as private vehicles or public transportation.

The main advantage of the proposed sensing kit resides in its capability to be coupled to any mobile vehicle. An enclosure has been purposely designed to protect the electronic circuit from incoming rain water while enabling sufficient air exchanges in the sensing chamber. Furthermore readily available and cheap sensors have been used to enable the scalability of the project. Sensors for carbon monoxide, ozone, particulate matter, carbon dioxide, temperature and humidity have been included. The sensing kit is also equipped with a cellular antenna and a GPS shield to enable real-time and geo-localized data acquisition. 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.

The second part of the research has focused on the exploration of immersive urban environmental data visualization strategies. 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 placed on the development of immersive and interactive spatio-temporal visualization techniques. Environmental data are generally visualized as tabular data or two-dimensional plots which fail to enable an experiential visualization of the microclimatic data. Three-dimensional immersive environmental visualization techniques on the other hand, can potentially enable a user-centered interactive analysis and rationalization of the available urban environmental data in relation to further urban considerations. With this ambition, we have developed three mobile apps that apply Augmented Reality visualizations to data acquired from urban Geographic Information System (GIS), online sensing network databases, and from our mobile urban sensing technologies implementations. The three apps are:

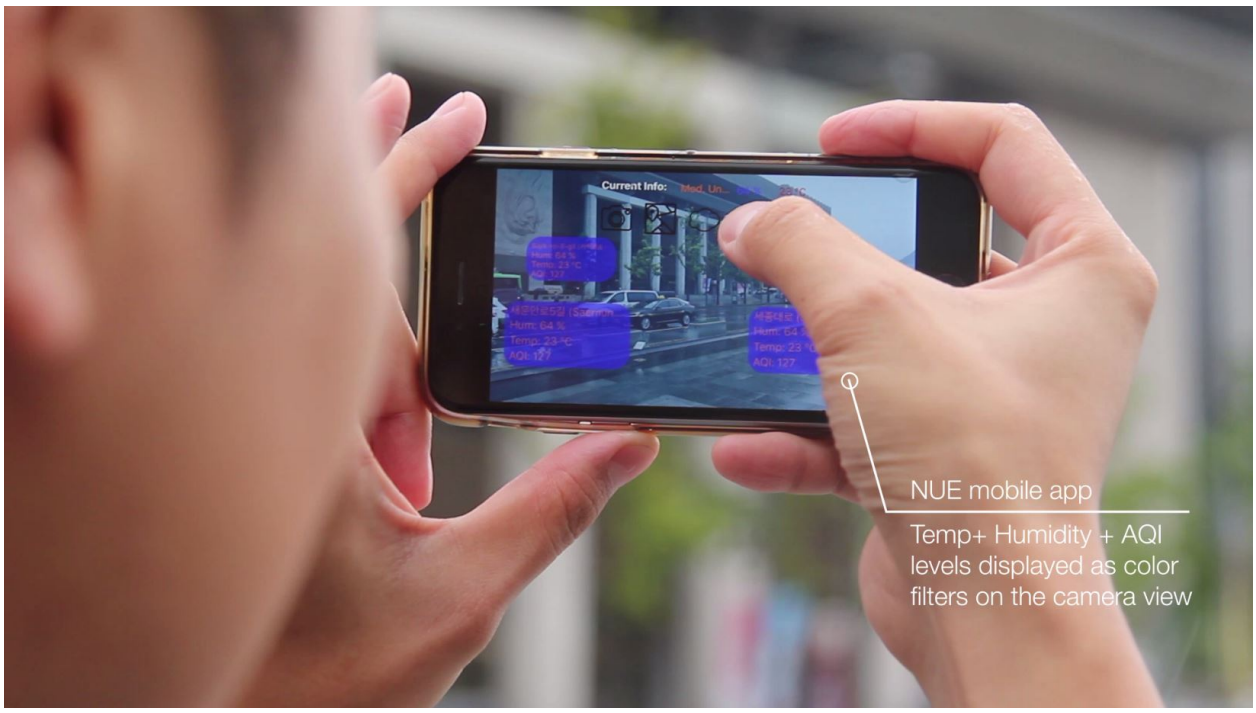
i) Navigating Urban Environments (NUE) is an AR mobile app which has been designed for on-site air quality visualization. The user is guided by the app to navigate the city informed by environmental parameters, such as temperature, humidity or AQI. A first-person view and the map view are enabled. In the first-person view, locational services of the user's mobile device are accessed, and the geotagged environmental data is overlaid on the camera view as graphic color filters.

ii) Visualizing Urban Environments (VUE) is an AR app which has been designed for off-site immersive environmental visualization. VUE utilizes computer vision to detect a designated image (marker) in order to align virtual representations with the physical space. This allows the VUE users to spatially experience the urban environmental data against other parameters, such as urban green areas, or building densities. VUE enables a historical view of the urban environmental data, as well as the real-time representation. Such visualization enables urban parameters, such as streets and buildings, as well as their surface characteristics to be studied against urban environmental data.

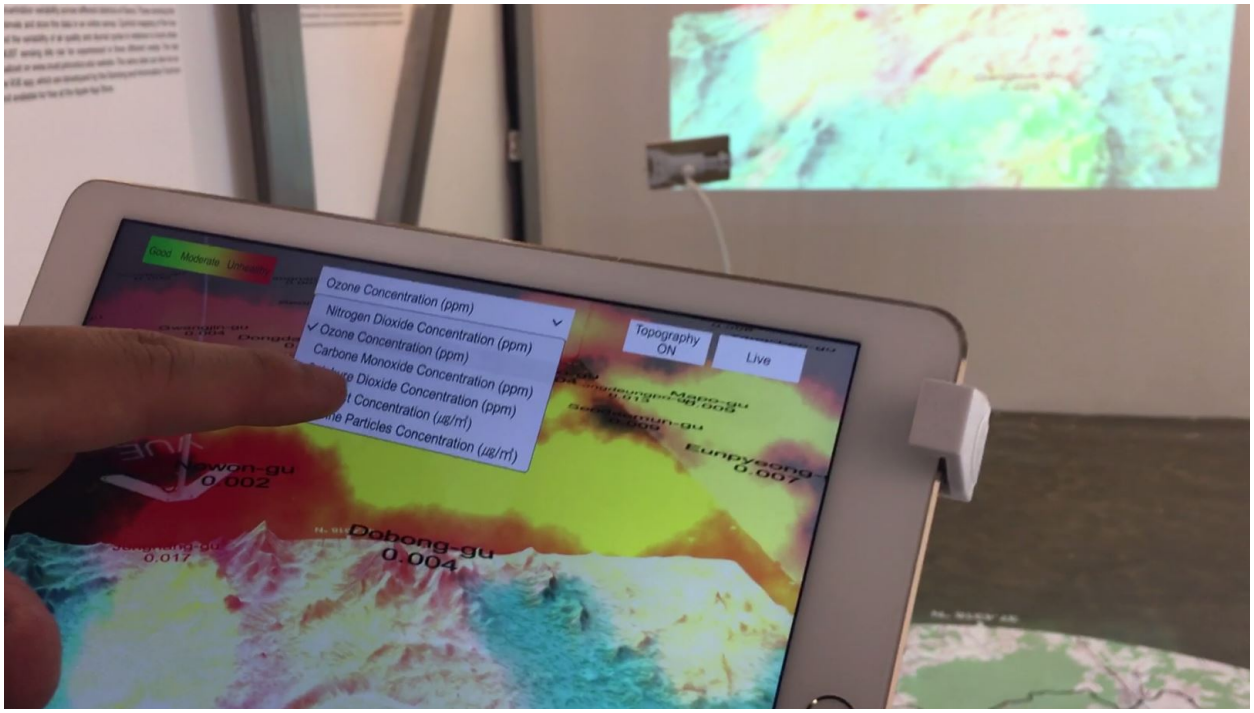
iii) Holographic Urban Environments (HUE) is an AR app which is using a mixed-reality holographic head-mount (Microsoft HoloLens) in order to visualize and interact with the urban microclimatic data in real-time. HUE allows the user to walkthrough holograms of three-dimensional GIS models overlaid with dynamic environmental data.

MUST sensing kits and AR apps were deployed in a pilot project for the Seoul 2017 Architecture and Urbanism Biennale.

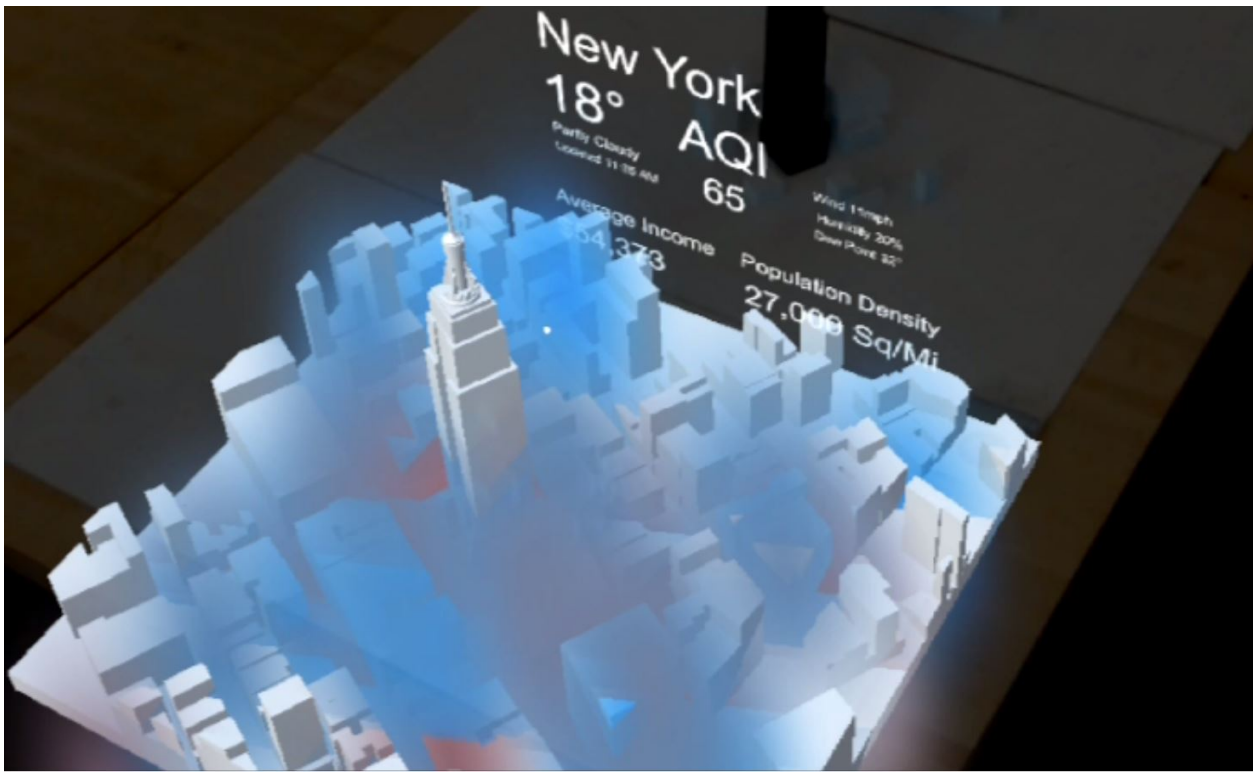
Mobile Urban Sensing Technologies (MUST) sensing kit mounted over Seoul City bus network



Navigating Urban Environments (NUE) app



Virtual Urban Environments (VUE) app



Holographic Urban Environments (HUE) app