The City of the Future: The Urban (Un) Seen
Connecting Citizens and Spaces via Community Sensing

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Abstract. Maximizing the potential of digitalization, technologies of the virtual realm present an opportunity to rethink the experience of space, society, and culture. Cities designed with integrated smart technologies and sustainable energy sources can improve urban life. Given the impact of these technologies, this paper examines the connections between data, infrastructure, and the public realm. Artificial intelligence (AI) can transform the environment we live in, and cities are facing the rise of urban intelligence (UI). Mobile sensors and handheld devices, referred to as “urban tech,” allow cars, buses, bicycles, and citizens to collect data about air quality, noise pollution, and the urban environment at large. Smart urban infrastructures can address issues such as crime, environmental pollution, and public health and help improve quality of life. How will our lives change intellectually, physically, and emotionally as the Internet of things (IoT) migrates into urban environments? Twenty-first-century architecture can find new purpose by adopting a coherent vision for the future. Virtual space can function as a mediating layer between the real and the yet to come, between cultural identities and a truly global technological existence.

1) Introduction
Utilizing the potential of digital sensing and data collection, emergent technologies of the digital realm present an opportunity to rethink our experience of space, society, and culture. Cities designed with integrated smart technologies and sustainable energy sources can improve the lives of all those who inhabit them—offering improved air quality, efficient mass transit, and globally networked communications systems.[1] As the implementation of digital technologies has become prevalent, cities are serving as global hubs for data-driven innovation. Mobile sensors, referred to as “urban tech,” allow cars, buses, bicycles, and citizens to collect information about air quality, noise pollution, and urban infrastructure at large. Once aggregated, this data can be captured, processed, and made accessible to urban communities and stakeholders. Visualizing the data aggregated by smart city technologies—capitalizing on the feedback loop between human sensing and machine sensing—permits the development of new modes of urban analysis predicated on bottom-up participatory models rather than top-down schemes. [2]

This paper examines the connections between data, infrastructure, and the public realm—taking the visualization of this data as a model for community-led urbanization. As technological evolution has defined the modern city, inevitably, advances in digital technology will continue to transform public and private spaces. These technologies promise the means of creating urban environments that are sensitive to the needs and desires of their communities, enabling us to design responsive structures rather than to merely install static technical systems. As the world’s population
increasingly moves into urban centers, the need to rethink the design of our urban environments becomes critical. According to the United Nations, approximately 55% of the world’s population resides in urban areas. Projections show that urbanization, the gradual shift of the human population from rural to urban areas, could add another 2.5 billion people to urban areas by 2050, with close to 90% of this increase taking place in Asia and Africa. [3]

Aggregating and analyzing data collected by cities and citizens, and instrumentalizing it to contribute to the quest in addressing environmental pollution and inequality through the lens of the UN Sustainable Development Goals, is critical in the face of increasing global urbanization.

While many schemes for the integration of smart and sustainable planning initiatives are imposed top-down by governments or transnational organizations, we believe that machine sensing offers another option for the integration of digital technologies into the urban environment, one that centers community involvement and bottom-up feedback in the development of informed solutions. As demonstrated by the work of researchers at the MIT SENSEable City Lab and its director Carlo Ratti, the collection and processing of user-generated urban data provides a rich means of understanding the contemporary city. [4] In recent projects, we have explored a variety of means by which to encourage citizens’ awareness of and engagement with data generated by and about the urban environment.

2) The Urban (Un) Seen

In a recent project for the 2019 Bi-City Biennale of Urbanism and Architecture, held in Shenzhen and Hong Kong, we explored these ideas. The Urban (Un) Seen is addressing sustainable urbanization by measuring, visualizing, and sonifying data with a focus on global urban noise pollution. Our audiovisual installation is driven by a noise sensor network that is data-driven, community-driven, and art-driven; the goal is to maximize community participation, awareness, and sensor network scaling to enable the creation of a real-time soundmap of global cities. At the core of the Urban (Un) Seen project are several noise sensors around the exhibition and throughout Shenzhen; residents were invited to experience the city through the sonic spatial data they provide.

![Figure 1: The Urban (Un) Seen](image-url)
The *(Un)* Seen enriches the perception of space by bringing in urban environmental sound that cannot be seen, touched, or smelled, even though omnipresent. A facet of the urban environment, noise pollution calls attention to an invisible but critical issue facing the contemporary city. Noise pollution affects both urban quality of life as well as contributing to negative health consequences for urban dwellers. [5]

Three modules comprised the audiovisual installation: 1) abstract model of the 3D cityscape, 2) Citygram generative sound modules embedded within the 3D cityscape, and 3) sensors that were designed to measure and stream data to the 3D cityscape.

The audiovisual installation blurred physical space with “unseen” digital space, incorporating elements of the Internet of Things (IoT), networks, VR/AR, and sensor technology for sound. Integrated speakers transmitted real-time noise data that could be experienced. An AI-driven sensor network around the exhibition and throughout Shenzhen captured urban soundscapes and formed the main data powering the audiovisual installation. The audience was enabled to explore the city beyond time and space.

Residents and visitors were able to engage with smartphones and tablets inside and outside the exhibition by measuring noise through an AI-driven sensor network. *(Un)* Seen enriches the perception of space by bringing in urban environmental sound that cannot be seen, touched, or smelled, even though omnipresent. The installation’s visual, sonic, and physical elements provided a multisensory experience that could be felt, touched, and heard beyond space and time. The sonifications and visualizations were generated by real-time data and archived data feeds during the exhibition.

*The Urban (Un) Seen* project enriched visitors’ perception of space, abstracting urban environmental data from its direct form and context and transmuting it into a multisensory experience sono-visually projected onto the 3D cityscape. The installation’s visual, sonic, and physical elements translated this omnipresent but perceptually and temporally elusive data into an environment that visitors could feel, touch, and hear across space and time. In addition to the acoustic projection of the collected sonic data, visualizations were projected across the surfaces of the installation, imaging the otherwise invisible information. The installation encouraged visitors to sit, rest, and observe the sonic and visual elements. These visualizations and sonifications, generated through both real-time and archived data feeds, collapsed real and virtual space into a multisensory experience.

The generative sound modules (GSM) were designed to bring environmental sound into the exhibition space. Embedded in an environment built for the exhibition, GSMs are driven via low-level sound feature vectors extracted at the sensor side to create a virtual soundscape layer, artistically reflecting the ebb and flow of urban noise patterns. Sensor data streamed to the installation space and created a 25 GSM audio channel soundscape experience.

To highlight the community-driven element of urban noise sensing, the core of *The Urban (Un) Seen* was formed by DIY sensors and a computing device with a standard web browser. This invited residents to contribute to the installation, allowing them to experience the city through the sonic spatial data they recorded. This effort also simultaneously addressed spatiotemporal network scaling around areas where it matters most—where citizens live.

While *The Urban (Un) Seen* was imagined as an audiovisual installation, this model of collective sensing offers a model for a new type of participatory, community-based urbanism and digitalization of the built environment. As Shannon Mattern has observed, the “point of engagement” between citizen and smart cities is a critical but understudied facet of smart urbanism. [6]
In addition to experiencing noise-pollution data within the physical space of the exhibition, visitors can also engage with the project outside of it through smartphones and tablets, measuring noise through a community-driven sensor network. This design makes it feasible for users to continue to measure the soundscapes of their urban environment, even after the end of the Bi-City Biennale, offering citizens a means of contributing to urban noise reduction studies and advocating for healthy urban soundscapes. The Citygram technology puts forth a mechanism allowing sensor scalability: 1) DIY microphone systems, 2) computer software that can run on devices with a standard web browser, and 3) potential for further scalability and the use of sticker microphones for exterior use, which allow community participation.

**Toward a Sustainable Future**

With growing populations, global metropolises have become hubs for cultural, social, artistic, economic, entertainment, technological, and political discourse and exploration. To run and manage these cities, humans have become ever more reliant on digital technologies to help us manage and efficiently process tasks, get us from “A to B,” and store, achieve, and share information at the press of a button. This acceleration has signaled a need to anticipate future developments and sustain a workable, environmentally conscious strategy in order to ensure the well-being of residents who gravitate toward such urban metropolises, all while embracing digitalization and collective experiences to build more resilient communities.

Sustainable urbanization can find new purpose by adopting a coherent vision for the future, concerned with modes of existence and innovation evolving out of the Digital Industrial Revolution. [7] Designing resilient cities with integrated smart technologies and sustainable energy sources can improve life for all who inhabit them, as well as positively impact the health of the planet as a whole.

As observed by Kitchin and Lauriault, data collected by individuals or small groups can now be fluidly combined with other data sets, increasing its value through distribution. [8] We have revisited the built environment through the lens of urban acoustic patterns and their potential to create healthy urban soundscapes by using acoustically informed urban design. In an effort to mitigate global urban noise pollution, we will continue to measure urban soundscapes and initiate community participation to make cities more sustainable and resilient and contribute to the well-being of their inhabitants.

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