One Size Doesn't Fit All: Three Tools for Soundscape Simulation

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1 Introduction

We present a reflection on three soundscape simulators aimed at supporting participatory urban sound planning and interventions. Here, we define a soundscape simulator as a software for the auralization of a sound environment based on recordings, allowing to add, remove, and/or position individual sources in real time over a background.

The three prototypes were developed within the Sounds in the City partnership (https://www.sounds-in-the-city.org/) to help stakeholders consider sound in their projects. These prototypes built upon spatial sound demonstrations [1], used to raise sound-awareness for Professionals of the Build Environment (PBEs), which we define as any professional involved in shaping the built environment, such as urban planners and designers, but also artists or policy makers [2]. The goal was to develop more interactive solutions. The first interactive prototype in 2018-2019 (referred to as the Co-Design Sound Sketchpad (CDSS) here; [3]) helped highlight that different tools and approaches would be required for different stakeholders and design goals. From this point on, we started developing two more: second, a tool with immersive visuals that would be accessible to PBEs with little experience in sound (Citty Ditty, CD—2019-now; [4]) and third, one with more acoustic accuracy for public space sound installation simulation (Sound Art Simulator, SAS—2021-2022; [5]).

These tools have been used for early-stage conceptualization in co-design exercises with stakeholders [3] and individualized training [4], and prototyping public space sound installations through laboratory-based soundscape assessments [5], all raising sound awareness with different types of stakeholders ([3], [4], [5]). Demonstrations are available online:
https://www.youtube.com/@multimodalinteractionlab

The present work discusses these three tools, along with their similarities and differences, illustrating that there is no one-size fits all approach to the design and use of soundscape simulators. Indeed, when considering the phase of a project (e.g., early vs late-stage planning), which stakeholders are involved and their technical knowledge, and what the respective goals regarding their involvement are, different tools are required to ensure best practices and results. Furthermore, supporting better communication between, and involvement of, stakeholders during the lifecycle of a project in this manner can help ensure better long-term solutions to address the needs of the city and its inhabitants.

2 Different needs, different tools

The (re)development of a public space is a considerable process that can involve multiple stakeholders at different stages. In early stages, simple, non-technical communication is favored with a wider group of stakeholders before it can be handed to specialists. The Co-Design Sound Sketchpad [3] supports large groups of people to consider and plan a general feel and ambience to a space, free of many acoustical and visual constraints. This tool is highly supportive of collaboration through reproducing the sound environment in 3D audio (Ambisonics), which allows people to walk around and talk to each other. It is moderately easy to use due to a simple but basic interface, allowing to add, remove, and move the sources offered in the tool in real-time. The only visuals are a map of the space and the sources offered. However, while it can be used with binaural reproduction as well, using 3D audio reproduction requires large sound labs, limiting its operation to experts with large resources or access to such facilities.

City Ditty [4] seeks to make sound tools accessible to a range of people by using common hardware (e.g., personal PC or personal Virtual Reality (VR) set) and a simple interface to explore sound design and interventions with an audio-visual environment. The inclusion of a visual environment forces more constraints on the design space but allows for a multisensory audio experience, which is essential for considering the auditory experience. City Ditty also remains a light acoustic model, prioritizing real-time interaction and manipulation over complex acoustic modeling. This includes simple ways to alter both sound sources and environmental factors like time of day, season, and weather conditions. This keeps it in similar early-stage planning contexts as the Co-Design Sound Sketchpad, albeit further along in a project's planning process. It does, however, sacrifice collaboration abilities, as it relies on headphones on a single-user device.

After several potential designs are agreed upon, the flexibility required for quick prototyping can be traded for more stringent acoustic modeling to create an extensive reflection of how it will actually sound after implementation. The Sound Art Simulator [5], for example, supports a more accurate auralization of soundscape interventions. So far, it has been used for research-creation collaborations between soundscape researchers and sound artists to inform the design of public space sound installations. Specifically, it can auralize prototypes of a sound installation on top of Ambisonics playback of the public space's existing sound environment [5]. This allows to inform the composition of a sound

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installation proactively through listening sessions and laboratory evaluation with people familiar with the site.

3 Design Parameters

All three tools are the result of balancing between design parameters to enable adequate co-design exercises with different PBEs at different stages of public space design, from very early sketches (CDSS) to more advanced design considerations (CD), and eventually site-specific soundscape interventions (SAS). Overall, we identified three design dimensions relevant to characterize and differentiate each tool (see Figure 1).

The *interface* describes the available range of modifications (*real-time interactions*; e.g., add, remove source, etc.), the presence and nature of visuals (*visuals*), and the accessibility to non-experts (*ease of use*). This dimension is critical in early-stage designs, when many stakeholders should be involved, with likely close-to-no expertise on sound. In this matter, an extensive interface was required in CD to make it fully accessible to non-experts. Less advanced interaction was required in the more preliminary stages of sketching using CDSS. In contrast, SAS was designed to work with sound experts (typically, sound artists), and there is no proper interface: most modifications can be done only by modifying the tool's program itself.

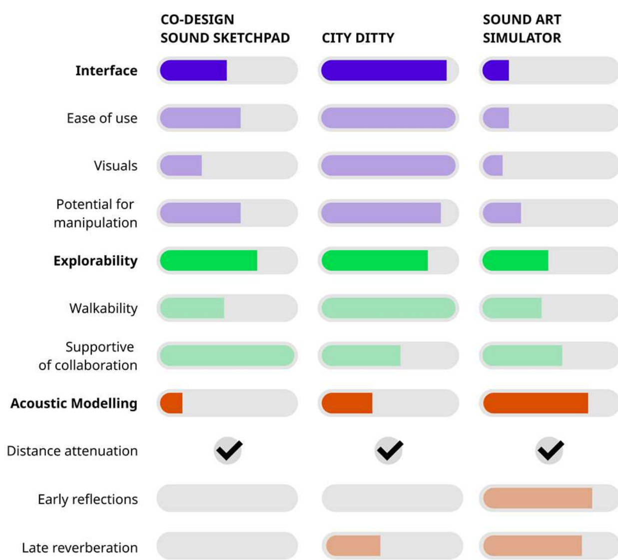

Figure 1: Design parameters of the three simulators using relative scores to highlight differences.

Explorability emphasizes the range of collaboration afforded by the tool (*supportive of collaboration*) and the potential for navigating within the listening space (*walkability*). This dimension can be operationalized in different ways. For instance, Ambisonics allows users to walk within the listening space—provided that the listening room is big enough, enabling live collaboration with multiple people in the same room (CDSS). But moving outside the sweet spot is not desired when designing more precise interventions (SAS). In contrast, navigation can be performed within a VR environment, enabling more extensive navigation but requiring one user at a time (CD).

Acoustic Modelling describes the extent to which acoustic features are modeled for *auralization*. This is less important in early-design processes when rough interventions are discussed such as with CDSS but is more important the more detailed the sound design discussed becomes. Acoustic accuracy is especially important when prototyping a soon-to-be-deployed soundscape intervention, such as with SAS. Overall and compared with CDSS that uses simple panning and distance attenuation, CD uses occlusion effect with reverberation, while SAS also includes acoustic modelling with early reflections.

4 Conclusion

Each tool results from a trade-off between specificity and flexibility to target different user groups (from groups of non-sound-experts with CDSS to one-on-one collaborations between sound experts with SAS), use cases (from preliminary exploratory stages with CD and CDSS to specific interventions with SAS), and scale (from small neighborhoods with CD to single public spaces with SAS). These simulators can complement full-fledged acoustic simulation at the design and evaluation stages to engage with a wide range of stakeholders.

These tools are also meant to complement each other, not only chronologically at different phases of a project, but also in terms of users, and could be used for similar purposes (e.g., all can be used for communication, depending on the target audience and goals). Additionally, all those tools will require some work (e.g., recording local sources, obtaining building models) to adapt to different projects.

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