Soundscapes for experiencing architecture in virtual reality – elements and considerations

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Abstract

Immersive technologies are increasingly being explored in museum settings. The research project *The Forest in the House* (2018) was an intervention-based research project about construction and use of virtual reality in architectural exhibitions, realized as collaboration between University of Oslo (UiO), the National Museum, Notam and Atelier Oslo architects. Physically, the project consisted of a full-scale, multi-level model where the visitors could walk, and they would be able to switch between two virtual environments experienced through VR-goggles, headset and loudspeakers. Two dynamic soundscapes were constructed to fit with the visual models, and novel combinations of sound diffusion models were employed. Visitor reactions recorded on video, in questionnaires and in post-exit structured interviews were the basis for the project's findings.

Key findings:

Visitors' sense of "being there" was high, despite typical low retention of details in the presented soundscapes. Difficult acoustic conditions in the exhibition space did not seem to affect the overall appreciation of the soundscapes, and the unconventional delivery method of combining a pseudo-VBAP loudspeaker setup with headset delivery did not trigger any reservation among the visitors. Indoor and outdoor composed acoustic environments were accepted as credible and of positive value to the visitors, indicating that the simplified acoustic modeling of indoor and outdoor soundscapes, as well as the simplified delivery methods, was of lesser importance than the semantic connotations of the content.

1. Soundscapes in museum practice

Since the term soundscape was coined (Schafer 1977), it has increasingly become a basis for musical exploration, often in keeping with what Davis et. al. (2012) describe as a complete sonic environment. In further development of Schafer's thoughts on how sound can be an acting, dynamic element in social environments, it has also been argued that soundscapes are constructs. Meaning is constructed from resonance and recognition in the balance between realism and expectation (Rudi 2008). This is further underpinned by research in neurobiology on audiovisual integration. (Degerman et al., 2007).

Studies confirm that sound can contribute to and enhance the sense of presence (Nordahl and Nilsson 2014), and that it has potential to support narratives by reducing the distance between exhibit and visitor while increasing a sense of agency (Bubaris, 2014), opening possible trajectories of action for the visitor (Emirbayer & Mische, 1998). Similarly, adding sound to a virtual reality environment increases the sense of "being there" in the specific modeled location or context (Serafin and Serafin 2004). This does not necessarily depend on absolute realism, but rather on fulfillment of expectations (Chueng and Marsden 2002), and this calls on what d'Escrivan (2009) has described as "imaginary listening." The links to electroacoustic music composition are obvious, and this type of engagement with other media content is already a clear development in new media art and what has been discussed as hybrid and/or postacousmatic practices.

Literature that describes sound in museum settings often argue for the value of including sound (Binter, 2014; Boon, 2014; Hutchison & Collins, 2009), and encourages meaning making in a broad sense. However, "systematic development of principles and potentials for their use is still lacking" (Bubaris 2014: 399). Stocker (1994) points out that there is a need in the museum sector for increased competence in acoustics and hardware such as speakers and (sound) control systems. With the growing interest in immersive experiences that is reported by among others Kidd & McEvoy (2019), it becomes interesting to know more about the importance of quality and technical implementations in soundscape design for these particular arenas. In our project, this was investigated through specific soundscape composition and employment of different delivery methods.

2. Soundscape design and delivery

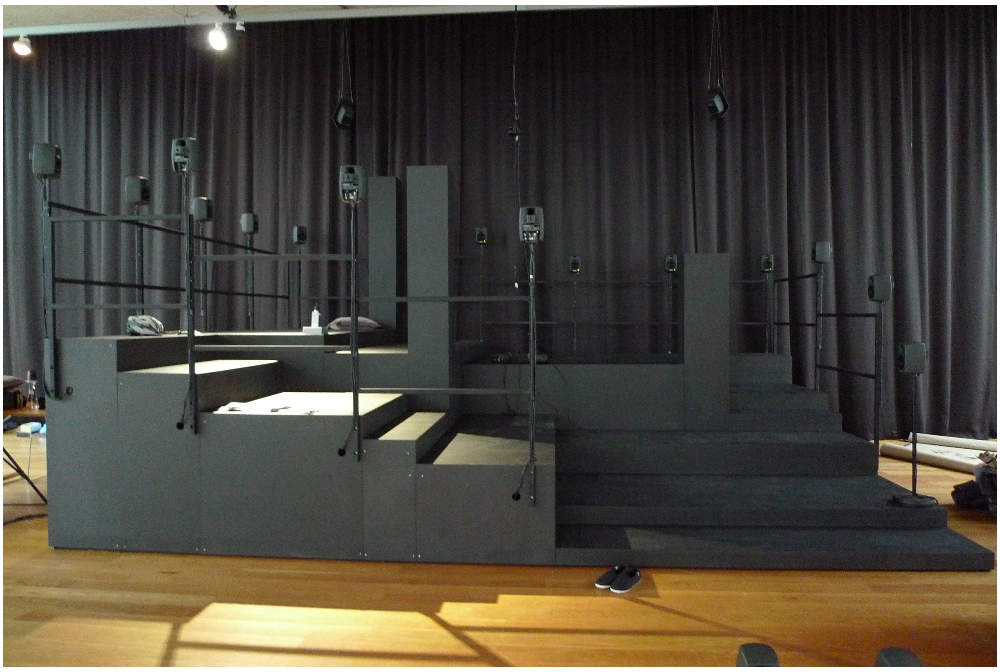

Figure 1. The physical installation with speakers mounted to the surrounding railing, designed to stop visitors from going over the side. Make note of the vertical elements that corresponded to columns and trees in the virtual models.

The physical installation (Approx. 5m*4m, fig. 1) was a simplified model of a virtual architecture (Fig. 2) where the building forms were derived from the natural forms of an arbitrarily chosen biotope by the seaside in Oslo. The location was laser scanned (Fig. 3), and the scan served as the basis for both the physical and the virtual models. The acoustic characteristics of the site were recorded as impulse responses, making it possible to recreate accurately the overall character of the location. To extend site sense of site fidelity, sound recordings of typical audible events were made with appropriate microphone techniques. In combination with other sounds typical for the site, but recorded elsewhere, these were the basis for the construction of the outdoor soundscape for the outdoor virtual view.

The view inside the virtual architecture necessitated a new acoustic profile different from the outdoor soundscape. A subset of the outdoor sounds was used, and some new sounds added in. The space was modeled acoustically from the architect's drawings (that were also the basis for the virtual architecture); taking spatial dimensions, materials and shapes into consideration. The intention was to meet visitor expectations of a distinct change in the sound environment when inside. The acoustic modeling of the indoor environment was additionally modified with variables from visitor position, rotation and movement in the installation, which made the acoustics behave as in a physical building. The variation in acoustics was significantly more detailed than what would have been feasible with the more general methods utilized in most reverb packages for music composition. The result was intended to provide an increased the sense of realism in relation to the visual imagery.

Figure 2. The architect's virtual view of the architecture, derived from the natural forms at the biotope. Figure 2 and 3 are rendered from the same perspective.

Figure 3. The virtual view of the natural environment, modeled from a laser scan.

Sounds mapped to the environments were positioned and moved in space, and in order to create both the consistency and variation the visitors would expect to hear, they were organized in 12 banks of different sound types, where the contents of each bank was cycled through in a structured, semi-random fashion before repetition took place. The structuring of material and spatialization were realized through Max and Spat softwares, as well as custom scripts for connecting position and rotation data from the game engine (used for the visual virtual environment) with the spatialization algorithms.

The acoustics of the space were less than ideal, as to be expected in museum settings. Thus, it became important to design a sound delivery system that could overcome the problems and make use of the acoustics that were there. The largeness and heavy reverberation of the space were used for creating distance, by way of placing four speakers on the floor, (at the bottom end of Fig. 4) activating the echo between floor and ceiling, and playing distant ocean sounds Additionally, four speakers above the installation gave a similar sense of an open space, playing sounds of (distant) birds and an occasional airplane. No artificial reverberation was needed. As seen in Fig. 1, there were loudspeakers mounted along the railing of the physical installation, which were used for a pseudo-VBAP (Pulkki 1997) delivery of all surrounding, environmental sounds. A more true VBAP projection was not possible because the speakers were too close to the visitors.

In order to create sense of presence in the visitors, additional sounds in the near field were needed. These were delivered through an open headset that also allowed sounds from speakers to be heard. Soft, unidentifiable sounds of rubbing branches, small clicks, and a bee that would circle the head, filled the near field soundscape, which could not have been projected from speakers, due to the acoustic conditions in the exhibition space.

The soundscape for the indoor environment was reduced. The amplitudes were generally lower, and fewer loudspeakers were used. The idea was to simulate the virtual door and window openings in the architecture. All the sounds from the speakers were processed by the acoustic modeling of the room resonances, and projected to the listeners via the headset only, coded binaurally. In combination with the acoustic changes that followed from movement, rotation and movement, these acoustics gave visitors good auditory clues as to where they were in the virtual room. A file of conventional music (From Miles Davis' Kind of Blue) was also being used, projected from only one corner speaker. The music itself was not heard, visitors could just hear the reverberation, like music from a radio sounding through the house.

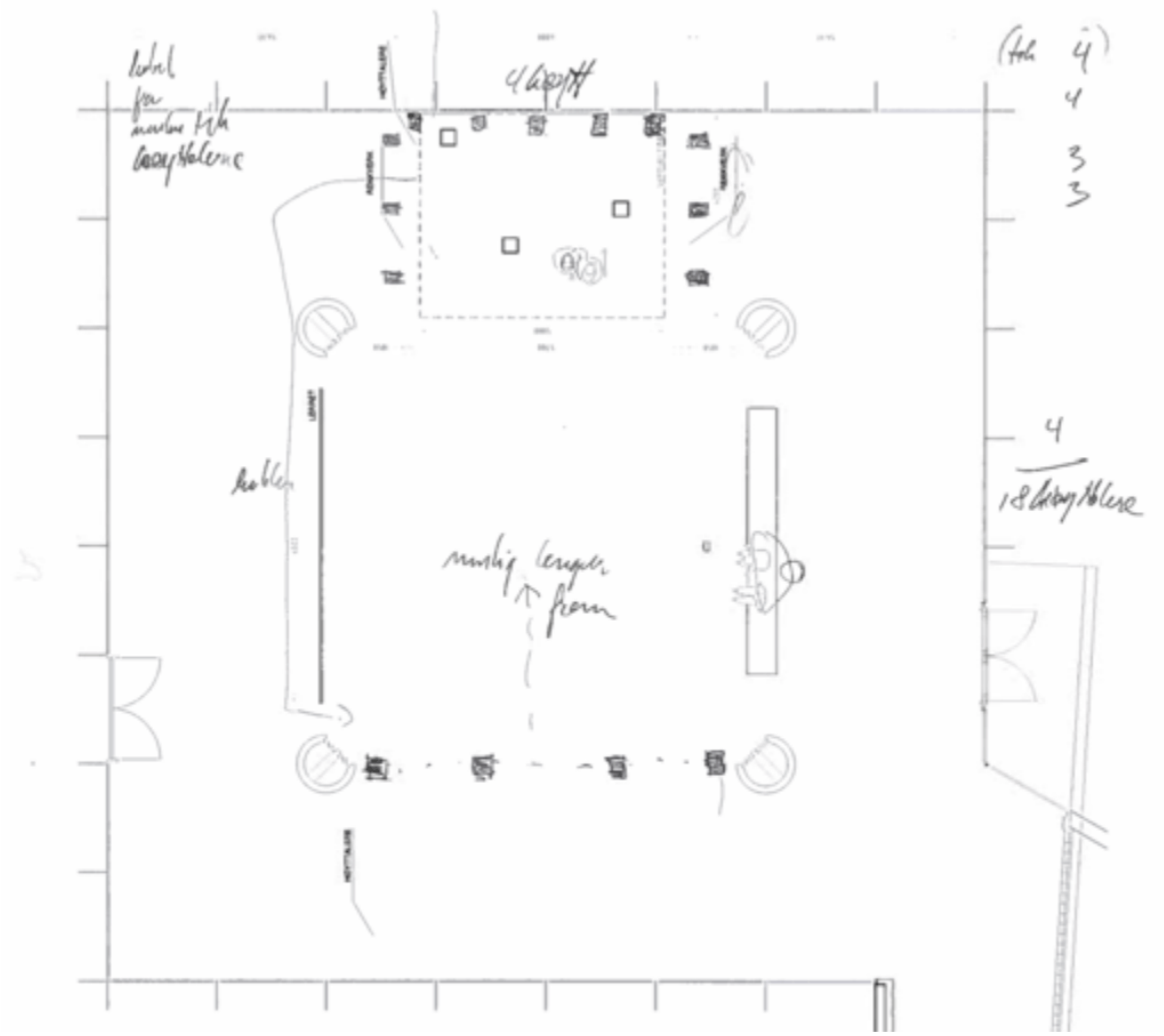

Figure 4. Hand drawing of the exhibition space, with installation and loudspeaker placement.

Adding interaction sounds that would seem to triggered directly from the visitors' movement (such as step sounds) was considered, however as pointed out in Nordahl et. al. (2010), step sounds are highly dependent of the type of shoes and the kind of surface the visitor is walking on. The idea of direct interaction sounds was abandoned, and the fact that all visitors were equipped with woolen slippers before entering the installation weighed in on that decision.

3. Data collection, results, analysis

A visitor studies perspective was adopted in order to harvest relevant data from the primary target group; the average museum visitors. Exit interviews with randomly selected visitors on the sound experience (N=82) were primary data for the sound-oriented section of the study.

Visitor responses to questions related to sound (N=320) and data collected from interviews and observations of recruited visitor pairs (N=16) were complementary data.

Upon exiting the installation, visitors were asked to take part in a structured interview. In order to have them be “unprimed” and reduce the chance of inaccurate responses, the visitors had not been told about this possibility ahead of their visit. The interview questions about sound were organized in three groups regarding: 1) the relevance and meaning of sound; how the soundscape impacted the visitor experience in the virtual reality installation, 2) credibility of the soundscapes; to what extent a sense of realism was essential to the sense of presence, and 3) assessment of importance of the technical quality in modeling and delivering of sound. Each interview lasted about 20 minutes, and the interviews were made over a three-day period.

These aspects are all essential in perception of audio scene identities and human acoustic orientation, and they were expected to have bearing on the degree of realism and relevance visitors experienced in the virtual reality environment.

4. Key findings

Key findings indicated that visitors (96%) found sound to be an essential component in the VR environments, and 68% found the soundscapes seemingly authentic; in keeping with the visual counterparts. It was clear that the principles employed in the construction of the soundscapes led to an overall high success rate for their experience of realism and of “being there,” despite low retention of details in the presented soundscapes, except for sounds that appeared in the intimate sphere (as described in literature on proxemics). The visitors remembered an average of 3,3 sound types out of twelve. A little more than 50% did not notice changes in the soundscapes. 70% noticed sounds coming from different distances, and 78 % noticed that sounds came from different directions, mentioning insect sounds, birds and indoor acoustics. A little more than half (44 of 82) noticed sounds that moved. These types of attention correlate well with hearing and listening in normal acoustic conditions.

According to a majority of the visitors, sounds of interaction would have been desirable, suggesting that a sense of embodiment could beneficially be simulated and used for compositional purposes also in this context.

Difficult acoustic conditions in the exhibition space did not seem to affect the overall appreciation of the soundscapes, and the unconventional combination of a pseudo-VBAP loudspeaker setup with headset delivery did not trigger any reservation among the visitors.

Indoor and outdoor composed acoustic environments were accepted as credible and of positive value by the visitors, indicating that the relatively simple acoustic modeling of indoor and outdoor soundscapes, as well as the simplified delivery methods was of lesser importance than the semantic connotations of the content. This finding might be of particular importance for future installation and implementation of 3D sound compositions and environments in galleries, museums and public spaces, as it underpins the perception of VR as a welcome technology in exhibition contexts.

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