

SpaceSound: Exploring Sound Design through Immersive Soundscape Creation

Lisa Neufeld

Technische Hochschule Ingolstadt
Ingolstadt, Germany
lin8347@thi.de

Dahyeon Park

Technische Hochschule Ingolstadt
Ingolstadt, Germany
dap6728@thi.de

Aaron Plörer

Technische Hochschule Ingolstadt
Ingolstadt, Germany
aap8269@thi.de

Lioul Desta

Technische Hochschule Ingolstadt
Ingolstadt, Germany
lid5188@thi.de

Massimo Pietrucci

Technische Hochschule Ingolstadt
Ingolstadt, Germany
map3368@thi.de

Julian Priebe

Technische Hochschule Ingolstadt
Ingolstadt, Germany
jup7957@thi.de

Jakob Peintner

Technische Hochschule Ingolstadt
Ingolstadt, Germany
Jakob.Peintner@thi.de

Andreas Riener

Technische Hochschule Ingolstadt
Ingolstadt, Germany
Andreas.Riener@thi.de

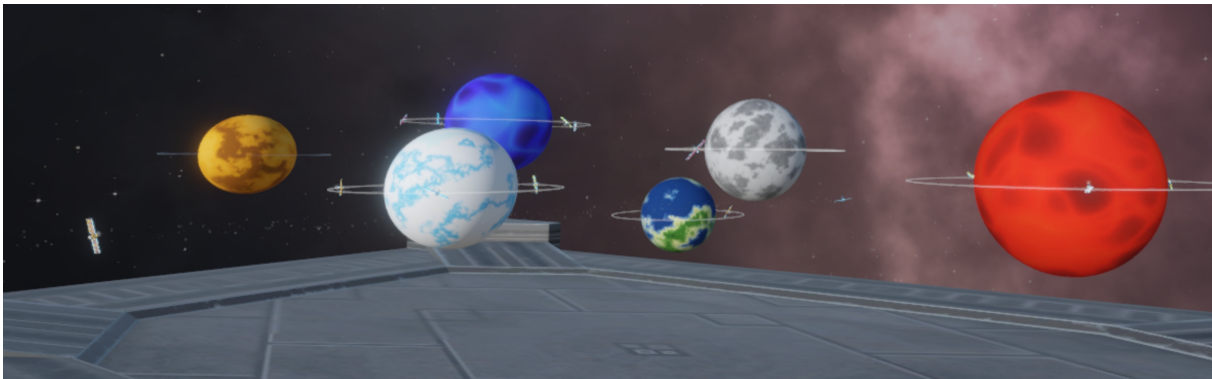


Figure 1: Illustration of the SpaceSound virtual environment with planets as loop-based sound sources and satellites as sound modifiers.

Abstract

Traditional music production tools often require technical knowledge, which can discourage novice users from exploring sound design freely. We present SpaceSound, an immersive virtual reality installation that enables users to create ambient soundscapes by interacting with planets and satellites in a virtual environment. The environment in SpaceSound represents outer space and consists of six planets with satellites orbiting around them. Each planet serves as a loop-based sound source, representing instruments such as drums, pads, bass, keys, plucks, and an arpeggiator, while satellites act as sound modifiers, providing effects such as filtering, chorus, reverb, tremolo, and distortion. Users can activate, combine, and

modify sound sources through direct spatial interaction and receive immediate auditory feedback and optional contextual explanations. To support creative exploration without overwhelming users, the system restricts the combinations of these sounds to ensure that they remain harmonically coherent. SpaceSound demonstrates how immersive interaction and metaphor-based design can make sound synthesis concepts more accessible while supporting calm, collaborative, and expressive soundscape creation¹.

CCS Concepts

• **Human-centered computing** → **Interactive systems and tools**; *Visualization systems and tools*; • **Applied computing** → Sound and music computing.

Keywords

Sound Design, Immersive Installations, Virtual Reality, Experiential Learning, Harmonic Exploration.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

Mensch und Computer 2026 – Tagungsband, Gesellschaft für Informatik e.V., 30. August - 02. September 2026, Duisburg, Germany

© 2026 Copyright held by the owner/author(s). Publication rights licensed to GI.
<https://doi.org/10.18420/muc2026-mci-demo-270>

¹ *Supplementary material.* Example of interaction with the environment for soundscape composition. *Demo Video:* <https://youtu.be/JeWA4kg-gH4>.

1 Introduction

Immersive technologies are increasingly used to lower the barrier between novice users and sound creation [3], shifting away from parameter-heavy interfaces toward embodied, spatial forms of interaction. For instance, sound design tools such as synthesizers and audio production software offer a complex set of interconnected controls including mixers, filters and they have a steep learning curve. This initially makes it difficult for novice users. Small adjustments can produce undesired sound which discourages users from experimenting freely. Interactive sound installations such as Reactable [2] have responded to this by replacing technical controls with gestural or spatial input, allowing users to shape sound through movement rather than knobs and sliders. These systems succeed at making sound manipulable, but typically leave the relationship between action and acoustic outcome opaque and place no constraints on the resulting composition. Users can produce pleasing sound, or just as easily produce chaotic sound, with little sense of reasoning behind. SpaceSound takes a different approach. Rather than removing technical structure, it translates that structure into a spatial metaphor and encourages experiential learning of synthesizer concepts. Users shape an evolving soundscape by interaction with celestial objects in a virtual space environment.

The primary **contribution** of SpaceSound to the HCI community is an **artifact** [5] that combines exploratory interaction with the installation while restoring the sense of intentional control often lacking in comparable systems.

2 SpaceSound Installation Design

2.1 Design Goals

The design of SpaceSound was guided by three central goals. First, the installation aims to preserve harmonic coherence, allowing users to experiment with sound sources and modifiers without creating unpleasant or dissonant combinations. The sound loops were designed so that different combinations would remain aesthetically compatible and contribute to an evolving ambient composition. Second, SpaceSound supports the experiential learning of sound design concepts. Users with no prior musical knowledge can explore planets and satellites and receive immediate auditory feedback along with optional contextual explanation. This allows them to gradually understand how different sound characteristics, such as pad, bass, or arpeggiator, and audio effects, such as tremolo, chorus, or reverb, shape the overall soundscape. Third, the installation aims to encourage artistic expression in an immersive environment. Users should feel calm, in control, and creatively involved as they form a harmonic soundscape through embodied interaction in a virtual space.

2.2 Space Metaphor and Narrative

SpaceSound uses outer space as a metaphor for silence, openness, and gradual composition. Since sound cannot travel through a vacuum without a material medium, space represents a quiet and undefined environment [1, 4]. We deliberately use this contrast, as users enter a silent virtual space and gradually bring it into an ambient composition through interaction. All planets are initially muted, giving users time to orient themselves in the **Virtual Reality**

(VR) environment before the soundscape emerges. The composition begins with the activation of the first planet and evolves step by step as each additional planet introduces a new layer of sound. Rather than simply triggering sounds, users shape the relationship between different sound sources and effects. To clarify this process, the experience begins with a short, narrative onboarding. A narrator introduces a system in which planets once formed a living composition, but lost their connection. The satellites are presented as control fragments that help restore resonance. This gives users a clear mission without defining a correct outcome. The narrative also facilitates a calm transition into VR. While listening to the introduction, users can get accustomed to the virtual space before interacting with it. Afterwards, in-world explanations help users understand the planets and satellites they encounter.

2.3 Interaction Design

The interaction design is based on direct manipulation within a confined virtual environment. The scene consists of a larger visible area of 45×40 meters and a smaller interaction area of 10×5 meters. Satellites can appear and move within the visible area, creating the impression of an infinite space. The interaction area corresponds to the physical tracking space. This is the zone in which users can safely walk, reach, and manipulate planets and satellites. It is visually represented by a platform on which the user can walk. This separation makes the environment feel larger than the available physical space and keeps all active interactions within reach.

The central elements of the installation are the planets, satellites, contextual information panels, and the platform. The planets represent loop-based sound sources that differ in sound and appearance. Users can activate the planets to unmute them. In the muted state, a planet does not produce sound, remains motionless, and appears relatively dark. Once activated, a planet plays a loop, begins slow rotation, and can be affected by satellites. All planets can cycle through three loop variations or be muted again by pointing to the desired planet with the VR controller and pressing the “Trigger” or “Grip” button. The satellites represent sound modifiers. They move through the visible area and can be grabbed by the user with the “Trigger” or “Grip” button when entering the interaction area. Users can attach a satellite to a planet by moving it into the snapping area of the planet and releasing it. Vibrotactile feedback indicates when the satellite has entered the snapping area. Once attached, the satellite orbits the planet and applies its modifier to the corresponding sound source. Satellites can also be removed, enabling users to continuously reshape the soundscape. To prevent visual and auditory overload, the satellite system adheres to state-based logic. Satellites spawn and float through the scene along predefined vector paths. They can also be grabbed and repositioned. After release, they move freely. Satellites can become snap candidates near planets and enter an orbiting state once attached. If a satellite leaves the visible area, it respawns to maintain a stable number of available modifiers. Some modifier categories allow only one active value at a time, such as delay or reverb. Therefore, each planet can contain only one satellite of the same modifier category. If users attempt to attach a second satellite in an already active category, the planet will not enter the snapping state. This is indicated by an absence of inflation and glow feedback. The existing satellite must

first be removed from the planet's orbit before another satellite of the same category can be added. This logic allows users to continuously reshape the soundscape. Contextual explanations offer optional guidance for users without prior musical knowledge. Users can access contextual information panels explaining the role of a sound source or the effect of a modifier by pointing to a planet or satellite of interest and pressing the "X" button on the controller in their left hand. These explanations facilitate learning without disrupting the immersive experience, enabling users to explore intuitively and access additional information as needed. The installation is designed to support collaborative soundscape creation. In two-user mode, both users inhabit the same virtual environment and see each other as human-shaped energy sources. They can also interact with planets and satellites simultaneously. This allows to create compositions through shared exploration. We also included an export function. Once users are satisfied with their soundscape, they can end the interaction and export the generated composition as an audio file. A QR code will then provide access to the resulting recording, enabling users to remember their experience beyond the actual installation.

2.4 Audio Design

The sound design of SpaceSound combines loop-based audio with real-time modification. The overall composition incorporates sound characteristics from six planets, including drums, pads, keys, bass, plucks, and an arpeggiator. Each planet has three five-second loops composed to be harmonically compatible with loops of the other planets. This enables users to activate and combine sound sources, changing their active loops without producing dissonant or unpleasant results. Satellites extend this composition through five categories of audio effects: filter, chorus, reverb, tremolo, and distortion. Users can apply each modifier to different planets to hear how the same effect changes depending on the underlying sound material. For example, tremolo can create a pulsing effect on a bass loop, and reverb can add an echo and a sense of space to a pad. Thus, the installation supports the creation of artistic soundscapes and the experiential learning of sound design concepts. A central design decision was to constrain the creative space rather than provide unrestricted sound manipulation. Although users can freely explore, combine, and modify sounds, the underlying loops and replacement logic prevent the composition from becoming chaotic. This creates a bounded creative environment in which all interactions contribute to a coherent ambient soundscape, ensuring that all combinations remain harmonic.

2.5 Demonstration Setup

The installation runs on a Meta Quest 3 and was developed in Unity 6.0 LTS. The sound was composed in FL Studio 24.1.2 and integrated using FMOD 2.03.13, which is an audio middleware tool used to implement interactive sound playback and real-time audio processing in game engines. It was designed from the outset as a walk-up public demo, which required an interaction area of 10×5 meters. Beyond a brief verbal introduction to the VR controllers, users do not require further instruction before they can begin shaping the soundscape on their own. The accompanying demo video shows the experience running in Unity, illustrating both the interaction

loop and the audible effect of the constrained modifier system on the user's resulting composition.

3 Conclusion

SpaceSound aims to support meaningful musical exploration through spatial interaction without restricting creativity. During development, the main challenge was ensuring the compatibility of the available loops and modifiers across the many combinations users could create. Therefore, the value of SpaceSound lies in offering a bounded creative space. Users can freely explore, combine, and modify sounds while the system maintains a coherent ambient soundscape. We see potential in extending the system through procedural composition, where loops are generated dynamically rather than being predefined. This presents an opportunity to further investigate how much creative freedom can be given to users and how such boundaries can be integrated into the experience itself rather than being perceived as limitations.

Acknowledgements

ChatGPT (GPT-5.6, July 2026 version) was used for language polishing and proofreading. All generated suggestions were manually reviewed and approved.

References

- [1] Timothy H. Boyer. 1985. The Classical Vacuum. *Scientific American* 253, 2 (1985), 70–79.
- [2] Sergi Jordà, Günter Geiger, Marcos Alonso, and Martin Kaltenbrunner. 2007. The reacTable: exploring the synergy between live music performance and tabletop tangible interfaces. In *Proceedings of the 1st International Conference on Tangible and Embedded Interaction* (Baton Rouge, Louisiana) (TEI '07). Association for Computing Machinery, New York, NY, USA, 139–146. <https://doi.org/10.1145/1226969.1226998>
- [3] Ruben Schlagowski, Fabian Wildgrube, Silvan Mertes, Ceenu George, and Elisabeth André. 2022. Flow with the Beat! Human-Centered Design of Virtual Environments for Musical Creativity Support in VR. In *Proceedings of the 14th Conference on Creativity and Cognition* (Venice, Italy) (C&C '22). Association for Computing Machinery, New York, NY, USA, 428–442. <https://doi.org/10.1145/3527927.3532799>
- [4] Geoffrey Wickham. 2013. Sound. In *Primary Science*. Routledge, 161–171.
- [5] Jacob O. Wobbrock and Julie A. Kientz. 2016. Research Contributions in Human-Computer Interaction. *Interactions* 23, 3 (April 2016), 38–44. <https://doi.org/10.1145/2907069> <https://dl.acm.org/doi/10.1145/2907069>.