Effortless: AI-Augmented Music Composition and Live Performance in Virtual and Mixed Reality

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Abstract

We present Effortless(1), an immersive multiplayer system for the Meta Quest platform(2) that enables new modes of music composition and performance through the integration of virtual reality (VR), mixed reality (MR), and artificial intelligence (AI). Multiple players interact in shared VR worlds or physical environments via passthrough, where musical elements appear as tangible objects. AI-assisted instruments support prompt-based sound generation, real-time synthesis, and transformation of MIDI material. Musical elements are structured hierarchically into palettes, movements, and complete compositions. The system introduces a paradigm for collaborative, embodied, and AI-augmented music creation.

1 Introduction and Motivation

Our goal is to enable a compact and portable system where anyone, from beginners to experienced musicians, can create and perform music anywhere without requiring traditional studio hardware or instrumental training. By treating sound as something that can be physically manipulated in space, the system supports intuitive expression, collaborative play, and performance settings ranging from private experimentation to staged presentations.

Advances in VR and AI now make this possible. VR provides a spatial medium where musical elements can be manipulated as objects, while AI models can generate and transform material in real time. Our system combines object-based interaction in VR, AI-assisted instruments, and real-time multiplayer collaboration to support these new modes of music making.

2 System Design

Effortless combines XR interaction in Unity/Meta Quest, AI-assisted generation via Lyria RT(3) and Magenta models in ONNX/Sentis(4; 5), sound synthesis and effects in Csound(6), and serverless multiplayer networking with ZeroTier(7) and Mirror(8). BlockadeLabs Skybox(9) environments map to palettes, movements, and full compositions along a timeline.

2.1 Sound as Object

Musical elements appear as manipulable objects. Users can grab and move objects to spatialize them, stretch to modify dynamics, or throw to introduce motion. Gesture mappings allow expressive control, making musical manipulation physical and intuitive.

2.2 AI-Assisted Instruments

AI-driven instruments allow users to generate sounds from text prompts, with synthesis powered by the Lyria RT API. These instruments can be moved and stretched in space to blend more or less into the overall mix. The system also supports MIDI clip generation, where existing material can be transformed into new clips or sessions, similar to workflows in Ableton Live. This is achieved by converting Magenta's GrooVAE(10) and MusicVAE(11) models into ONNX and executing them in Unity using Sentis.

Csound serves as the primary engine for sound synthesis, spatialization, generative algorithms, and modular effects processing. It also supports the integration and reinterpretation of classic Csound works, allowing historically significant compositions to be adapted for immersive and collaborative performance contexts. AI-generated and user-generated instruments can be routed through Csound FX chains, enabling flexible hybrid workflows and expressive performance control.

2.3 Virtual Worlds

Virtual worlds are AI-generated using BlockadeLabs Skybox. Each world can be saved with instruments, spatial layout, and parameter states as a movement. Movements can then be arranged along a composition timeline, allowing the environment itself to function as a musical structuring device. Transitions between worlds can signal sectional changes, shifts in mood, or narrative progression, and in mixed reality mode these worlds blend with the physical surroundings. This enables performances that move fluidly between immersive, imaginative spaces and the performer's real environment, supporting both studio-style composition and live cinematic performance.

2.4 Hierarchical Organization

- Palettes: collections of similar sounds that can be switched on the fly.
- Movements: groups of instruments within a world, including spatial positions and parameter settings.
- Compositions: arrangements of movements and environments along a timeline, similar to a film editor.

This structure enables compositions to integrate instruments, virtual worlds, and textual elements such as titles for movements or chapters, supporting narrative-driven organization. Compositions are saved and loadable, enabling replay, experimentation, and staged performance.

3 Interaction and Collaboration

Effortless supports real-time multiplayer collaboration, enabling participants to co-compose and co-perform in shared VR/MR environments by manipulating sound objects and instruments together. Networking is handled via ZeroTier and Mirror, providing LAN-style connectivity without dedicated servers. The system also supports audience participation, allowing listeners to join as observers in virtual or mixed reality. The platform has been tested with up to ten concurrent headsets and demonstrated in live performances at ICSC 2024(12)(13)(14) and ICMC 2025(15)(16).

4 Discussion and Implications

The system supports both novice and expert workflows and enables collaborative and performative uses of AI in music. Limitations include ONNX model size constraints on standalone headsets and latency when using network-based synthesis. Addressing these will require model compression and hybrid compute strategies.

5 Conclusion and Future Work

We plan to expand Effortless AI-assisted instruments with real-time audio input and conduct user studies. We envision community-driven VR music worlds where AI-augmented creativity is shared globally, alongside new immersive approaches to teaching and learning composition.

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