Physically Colliding with Music: Full-body Interactions with an Audio-only Virtual Reality Interface

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Abstract
A Very Real Looper (AVRL) is an audio-only virtual reality (VR) interface inside of which a performer triggers and controls music through full-body movement. Contrary to how musical interfaces in VR are normally used, a performer using *AVRL* is not disconnected from their surrounding environment through immersion, nor is their body restrained by a head-mounted display. Rather, *AVRL* utilizes two VR sensors and the Unity game engine to map virtual musical sounds onto physical objects in the real world. These objects help the performer locate the sounds. Using two handheld VR controllers, these sounds can be triggered, looped, acoustically affected, or repositioned in space. *AVRL* thus combines the affordances of the physical world and a VR system with the reconfigurability of a game engine. This integration results in an expansive and augmented performance environment that facilitates full-body musical interactions.

Author Keywords
Audio-only virtual reality; full-body interactions; augmented musical performance; virtual musical interfaces; new interfaces for musical expression.

Figure 1 – A standard use of a VR system: an immersed user wears a head-mounted display and interacts with a visually simulated environment using handheld controllers. Photo by Raul Altosaar, ©2018.

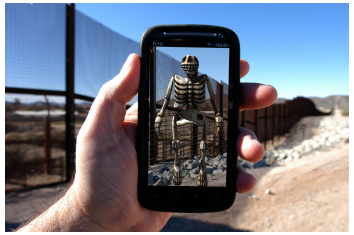

Figure 2 - A standard use of an AR system: a visual interface overlays computer-generated imagery on top of real-world imagery. "Border Memorial" by John Craig Freeman is licensed under CC BY-SA 3.0.

CCS Concepts

• **Human-centered computing~Virtual reality;** auditory feedback; gestural input;
• **Applied computing~Sound and music computing;** performing arts;

Conference Themes

AVRL responds to the following conference themes:

- Performances (e.g. dance, physical performance, music) that explore or utilize hybrid systems
- Hybrid assemblies that combine digital, physical, biological, and/or social systems
- Novel interactions realized through traditional crafts or unconventional materials, professional artistry, craft or musicianship

Introduction

When considered in the context of musical performance, current VR systems are alienating because they inhibit the immersed performer from developing a connection to the audience and surrounding space. These systems are also awkward because they rely on a head-mounted display (see Figure 1) that impedes expressive, full-body musical interactions.

Augmented reality (AR) systems suffer from similar problems. Much research in this field is concentrated on predominantly visual interfaces that may neglect other sensory modalities [1] and their expressive affordances. These interfaces are also small and exist either on smartphone screens (see Figure 2) or in head-mounted displays. By design, these interfaces encourage specific types of interaction in which users remain relatively immobile and utilize the interface from a fixed viewpoint.

In the context of musical performance these are undesirable interaction paradigms that hinder full-body musical interactions that build upon a performer's understanding of and connection to the everyday world, their own bodies, the surrounding environment, and other people [2].

However, there is reason to continue investigating the application of VR and AR systems for musical performance. First, these systems provide inexpensive, real-time motion tracking that can be leveraged to design novel musical interactions. Second, VR and AR systems allow virtual data to be overlaid on top of the real world, thus enabling a musical performance to be spatially and acoustically augmented. Furthermore, when building VR and AR musical interfaces inside of a game engine, digital assets such as sound files and MIDI sequences become highly reconfigurable. This makes rapid-prototyping and musical ideation possible without additional material or hardware costs.

We hypothesized that the affordances of a VR system can mitigate its hindrances in the context of musical performance.

Related work

Gibson's *Opto-Photo-Kinesia* is an audio-visual performance in which infrared trackers are worn by a performer and used to control audio effects, trigger musical sounds, and effect lighting changes [4]. Similarly to how the handheld VR controllers function in *AVRL,* these infrared trackers track user position and velocity in 3D space. This enables the performer to interface with musical elements through bodily movement. Mäki-Patola, et. al describe four musical instruments developed to assess VR technology in the

Figure 3 – A performer holds the VR controllers used to trigger and control music inside *AVRL.* These controllers are motion tracked in real-time using infrared light emitted by the HTC Vive base stations. Using this motion tracking data, 3D models of the controllers are animated inside of a virtual environment in the Unity game engine. This animation corresponds to the exact position, speed, and rotation of the controllers that are held and moved by the performer. The controllers can then be used to collide into 3D models (see Figure 5) which have been overlaid onto physical objects in the real world (see Figure 4). These collisions trigger various musical sounds at low latencies. Photo by Raul Altosaar, ©2018.

context of musical instrument design [5]. Although their instruments primarily relied on visual simulation and user immersion in a way that *AVRL* does not, their discussion about the kinds of musical interfaces suited for VR is relevant. Some of the earliest musical experiments with VR were conducted by Bolas & Stone in 1989. They noted that the flexibility of design and musical interaction enabled by VR technology is nearly infinite [7]. Also pertinent is Mulder's description of a virtual musical instrument as a real-time gestural interface through which a performer can interact with the nearly unlimited capabilities of a sound synthesis system [8]. Finally, *AVRL* echoes Wessel and Wright's central metaphor for musical control by physically enabling the performer to fly about in a space of musical processes [6].

A Very Real Looper (AVRL)

AVRL is an audio-only VR interface built inside of the Unity game engine for the HTC Vive VR system. The size of this interface is determined by the distance between the Vive's two VR sensors, also known as base stations. *AVRL* is extra-large in the sense that it usually comprises a medium-sized room but can be set up to have a maximum tracking volume of roughly 3600 cubic feet [3].

First, Unity and the Vive's base stations are used in conjunction to overlay virtual, three-dimensional (3D) models onto physical objects in the real world. These physical objects visually represent the locations of the 3D models to the performer. These 3D models have been programmed to detect collisions between themselves and the handheld Vive controllers (see Figure 3) that are being animated in real-time using motion tracking data received from the base stations.

After detecting a collision, the 3D models trigger a musical sample, a MIDI sequence, or a specific MIDI note or chord. Thus, inside of *AVRL* the performer is physically colliding with music. These musical sounds and sequences are triggered only once by default, but can be looped by pressing a button on the controllers. To assist the performer with pinpointing the exact location of the 3D models, strong haptic feedback is provided by the controllers whenever a collision is detected.

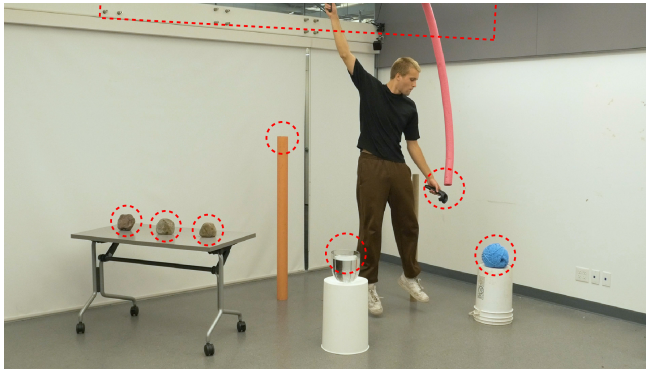

Figure 4 – A performer triggers musical sounds that have been overlaid as 3D models (see Figure 5) onto physical objects inside the performance space. The objects act as visual markers that represent the location of the musical sounds to the performer. Image by Raul Altosaar, ©2018.

Each 3D model contained by *AVRL* can be repositioned using the Vive controllers into new locations within the performance space that is delineated by the placement of the two base stations. This allows the performer to create novel sets of full-body musical interactions by mapping the 3D models into different locations before performing. For example, a 3D model could be overlaid onto a physical rock located on the ground. This would

force the performer to crouch down to trigger the sound contained by that specific model. Another 3D model could be moved high above the performer's head and overlaid onto a light fixture, thus forcing the performer to jump up or toss a Vive controller into the air to trigger that sound.

The Vive controllers also provide a wide range of easily accessible, numerical motion tracking data that includes current movement speed, rotation, and position in 3D space. Inside of *AVRL*, these data are used to control audio parameters and effects in real-time. For example, a MIDI sequence is first looped by the performer and the intensity of an audio effect affecting that sequence is then altered by moving the controller either higher or lower in space.

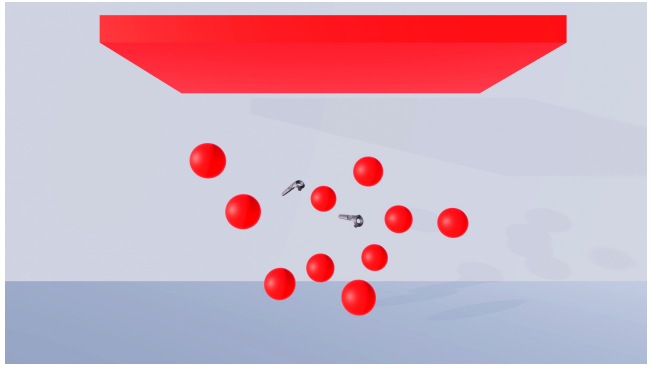

Figure 5 - A virtual view of *AVRL* captured in the Unity game engine depicts the 3D models (in red) and Vive controllers (in black). Image by Raul Altosaar, ©2018.

Conclusion

AVRL is an audio-only VR interface that generates a large, highly reconfigurable musical performance environment that is spatially and acoustically augmented. While using *AVRL* a performer is not obstructed by a head-mounted display, immobilized by a static visual interface, or separated from their surroundings through immersion. Rather, inside of *AVRL* an unrestrained body moving through physical space is the primary conduit for musical expression. During a musical performance, *AVRL* enables the performer to develop a relationship to the audience and surrounding space while triggering and controlling musical sounds through full-body movement. *AVRL* thus harnesses the affordances of the physical world, a VR system, and a game engine to enable expressive and embodied musical interactions.

Acknowledgments

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Documentation

A short technical breakdown of *AVRL* can be viewed here: https://vimeo.com/288778622**.** An early performance with *AVRL* can be viewed here: https://vimeo.com/294810067**.**

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