Physically Colliding with Music: Expressive and Embodied Interactions with a Non-visual Virtual Reality Instrument

Raul Altosaar
Integrated Media
OCAD University
Toronto, ON M5T 1W1 Canada
3148968@student.ocadu.ca

Adam Tindale
Associate Professor
Digital Futures
OCAD University
Toronto, ON M5T 1W1 Canada
atindale@faculty.ocadu.ca

Judith Doyle
Associate Professor
Integrated Media
Co-Director, SMACLab
OCAD University
Toronto, ON M5T 1W1 Canada
jdoyle@faculty.ocadu.ca

Abstract
A Very Real Looper (AVRL) is a non-visual virtual reality instrument inside of which a performer controls musical sounds and sequences through gesture and bodily movement. Contrary to how virtual reality (VR) is normally utilized, a performer playing *AVRL* is not disconnected from their surrounding environment through visual immersion, nor is their body restrained by a head-mounted display. Rather, *AVRL* uses VR sensors in conjunction with a game engine to map musical sounds and sequences onto physical objects and spaces. These sounds are then by triggered by a performer simply wielding two controllers. *AVRL* thus combines the affordances of the physical world with the modularity of a game engine, consequently activating the expressive potential of the body inside of a large, highly reconfigurable, and musically augmented environment.

Author Keywords
Virtual reality; new musical interfaces; expressive interactions; embodiment; multi-modal experiences; virtual environments.


Figure 1 – A standard use of a virtual reality system: a user wears a head-mounted display and interacts with a visually simulated environment using two controllers. Photo by Raul Altosaar, ©2017.

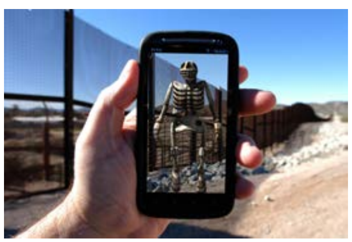
Figure 2 - A standard use of an augmented reality system: a visual interface that overlays computer-generated imagery on top of real-world imagery. “Border Memorial” by John Craig Freeman is licensed under CC BY-SA 3.0.

ACM Classification Keywords
H.5.1 Multimedia Information Systems: Artificial, augmented, and virtual realities; J.5. Computer Applications: Arts and Humanities: Performing Arts; H.5.2 User Interfaces: Input devices and strategies.

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 virtual reality (VR) systems are alienating because they inhibit the immersed performer from developing a connection to the surrounding space and audience. These systems are also awkward because they rely on a head-mounted display (see Figure 1) that impedes expressive and embodied musical interactions.

Augmented reality (AR) systems suffer from similar problems. Much research in this field is concentrated on predominantly visual interfaces that may neglect the expressive affordances provided by other sensory modalities [1]. These interfaces are also small and exist either on smartphone screens or in head-mounted displays (see Figure 2). 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 expressive and embodied musical interactions that build upon a performer’s understanding and connection to the everyday world, their own bodies, the surrounding environment, and other people [2].

However, there is reason to continue investigating the intersection between VR/AR systems and musical performance. First, VR/AR systems provide inexpensive, real-time motion tracking which can be leveraged to design novel musical interactions. Second, VR/AR systems allows virtual data to be overlaid onto the real world, thus allowing a musical performance to be simultaneously augmented both spatially and acoustically. Furthermore, when building VR/AR tools or experiences inside of a game engine, digital assets such as sound files and MIDI sequences become modular and highly reconfigurable, thus making rapid-prototyping and ideation possible without additional material or hardware costs.

We hypothesized that the affordances of VR/AR technology can mitigate its hindrances in the context of musical performance.

Related work
Gibson’s *Opto-Photo-Kinesia (OPK)* 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 VR controllers function in *AVRL,* these infrared trackers are used to track user position and velocity in 3D space, thus enabling the performer

Figure 3 – A performer holds the virtual reality controllers used to play *AVRL.* These controllers are motion tracked in real-time using infrared light emitted by the HTC Vive base stations. Using this motion tracking data, three-dimensional (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 physically held and moved by the performer. The virtual models of the controllers can then be used to physically collide into 3D models (see Figure 5) which have been overlaid onto the real world (see Figure 4). These collisions trigger various musical sounds and sequences with extremely low latency. Photo by Raul Altosaar, ©2017.

to use gesture and bodily movement to interface with musical elements. Mäki-Patola, et. al describe four VR instruments developed to assess VR technology in the context of instrument design [5]. Although their instruments primarily relied on visual simulation and performer immersion in a way that *AVRL* does not, their discussion about the kinds of musical interfaces VR is suited for is relevant. Some of the earliest musical experiments with VR were conducted by Bolas & Stone who noted that the flexibility of design that VR technology affords is nearly infinite [7]. Also pertinent is Mulder's description of virtual musical instruments as real-time gestural interfaces through which a performer might access the nearly unlimited capabilities of sound synthesis systems [8]. Finally, *AVRL* echoes Wessel and Wright's central metaphor for musical control by quite literally enabling the performer to physically fly about in a space of musical processes [6].

A Very Real Looper (AVRL)

AVRL is a non-visual VR instrument built inside of the Unity game engine for the HTC Vive system. The size of this instrument is determined by the distance between the Vive base stations. This instrument 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 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 Vive controllers (see Figure 3) which are being animated in real-time using motion tracking data. 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 further assist the performer with non-visually pinpointing the location of the 3D models, strong haptic feedback is provided by the controllers whenever a collision is detected.

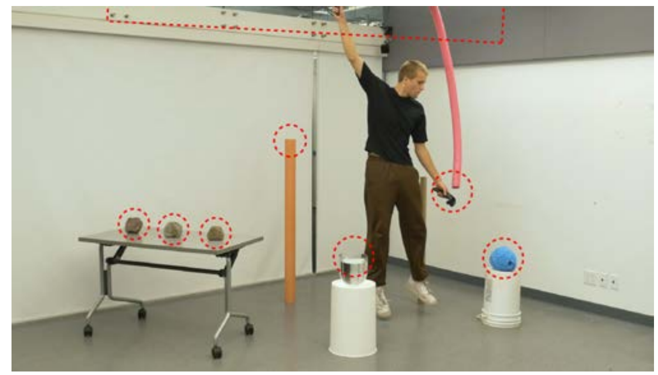

Figure 4 – A diagram depicting a performer colliding into musical sounds and sequences which have been overlaid as 3D models (see Figure 5) onto physical objects and locations inside the performance space. The objects act as visual markers that represent the location of the musical sounds or sequences to the performer.

Each 3D model contained by *AVRL* can be repositioned at any time to a new location within the performance space. This allows the performer to create novel sets of bodily interactions by mapping the 3D models into different locations before performing. For example, a virtual 3D model could be overlaid onto a physical granite rock, thus forcing the performer to crouch down to trigger a sound. 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 controller into the air to trigger a sound.

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

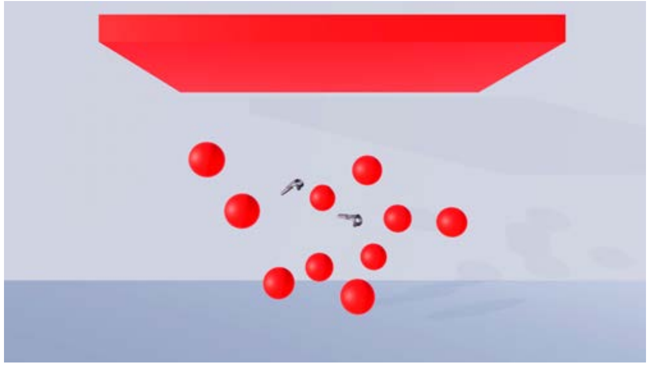

Figure 5 - A virtual view of *AVRL* captured in the Unity game engine which depicts the 3D models (in red) and Vive controllers (in black).

Conclusion

A Very Real Looper (AVRL) is an expansive, non-visual VR instrument that generates a highly reconfigurable musical performance environment that is at once spatially and acoustically augmented. While playing *AVRL* a performer's body is not obstructed by a head-mounted display or immobilized by a static interface. Rather, inside of *AVRL* an unfettered body moving through physical space is the primary conduit for musical interaction and expression. During a musical performance, *AVRL* enables the performer to develop a relationship to the surrounding space and audience while controlling music through gesture and movement. Thus, *AVRL* successfully harnesses the affordances of the physical world, VR technology, and a virtual game engine to enable expressive and embodied musical interactions.

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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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