
Mediated Musical Interactions in Virtual Environments

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Abstract

Musical interactions performed within virtual spaces are mediated by the rules and realities inherent to each environment itself. Control interactions in virtual spaces pass through a layer of influence dictated by the environment – as well as any actors or processes existing within – before being mapped to parameters of sonic and musical creation and control. Such mediation layers are intrinsic attributes of musical works built within game and virtual environments and play significant roles in the sonic and musical experiences realized in such spaces. These *mediated musical interactions* and the interfaces that support them should be considered and approached as a distinct form of musical interaction with their own performance practices, approaches and taxonomies.

Author Keywords

virtual reality; procedural music; gaming.

ACM Classification Keywords

H.5.5 [Sound and Music Computing]: Methodologies and techniques

Introduction

For as long as computers have been purposed as real-time generators and controllers of musical sound, composers and performers have researched methods and mappings

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Figure 1: Performers on stage controlling the *Carillon*.



Figure 2: Hand gestures in *Carillon* are mapped to the virtual hands of player avatars.



Figure 3: *Carillon* being performed collaboratively by visitors during a gallery presentation.

through which performative gesture can intuitively drive computer-based instruments and procedures [5]. Traditional instrumental performance practices, developed over centuries of musical evolution, have by their very nature been based in the physical control of physical interactive systems. While the introduction of digital music systems have freed musical generation and control from the necessary constraints of physical interaction, there exists a strong desire amongst contemporary composers, performers and researchers to develop idiomatic performance mappings linking musicians' physical gestures to computer-generated music systems. Borrowing from traditional physical musical control systems, the mapping schemata utilised to connect performative gesture or motion to sound generating or manipulative process in a great number of HCI driven musical interactions is direct or nearly direct, meaning the control of musical systems is carried out without influence from external entities or processes.

With the advent of immersive environments, both "virtual" spaces viewed with head-mounted displays as well as game spaces rendered on two-dimensional displays, control of digital interactions can now occur within rich autonomous ecosystems complete with rules and realities capable of influencing user interactions. Influences such as simulated forces like gravity, artificially intelligent agents or networked third-party controlled avatars can modify or intercept a desired motion or action, essentially *mediating* the intended control interaction.

As composers and performers further explore the use of immersive environments for musical composition and performance, there exists a need and an opportunity to further our understandings of these mediated musical interactions alongside discussions of traditional musical interactions as well as common HCI paradigms and practices.

Mediated Musical Interactions

While a great deal of research in computer-based musical systems has focused on interaction models that couple performative gesture to sound - with special import given to the particular mapping strategies used to translate data from one paradigm to another - the role of the environment itself as a mediating force should not be ignored or discounted. Wanderley describes a digital musical instrument as the sum of three constituent parts: "the gestural controller, the synthesis algorithm and the mapping strategies between them" [8]. In works within which a rendered environment, potentially replete with autonomous agents, third-party actors and inherent rules governing object behavior play a mediating role, there potentially exists a fourth constituent part, namely the environment's own internal ecology of rules and actions.

Rendered Realities

Virtual environments and the ecosystems of action and reaction developed to function within such environments are equally capable of creating realistic simulations of existing physical location and modes of interaction or fantastical interpretations of space and a user's interaction with that space. Virtual instruments controlled by player/performers can procedurally drive musical systems and modeled instruments [3, 7, 9]. Collaborative performance spaces allow virtual ensembles to perform virtual instruments together, though performers may be geographically dispersed [6]. Or rendered space can exist as a telematic performance and listening environment for sound and music created in the physical world [4].

Sample Works

A selection of projects and musical works created within rendered spaces are discussed in this section.

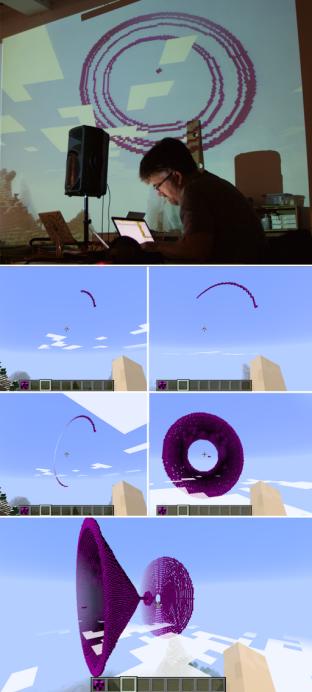


Figure 4: Minecraft structures are generated algorithmically in *OscCraft*.



Figure 5: An *OscCraft* marimba generates OSC messages when struck by player avatars.

CARILLON

Carillon (2015) [1] is a live performance work for 1-3 soloists and laptop orchestra. Built using the Unreal Engine 4, *Carillon* consists of a massive virtual machine/instrument controlled via a system of gears and levers. Performers wearing head-mounted displays and Leap Motion hand-tracking units select gears from the structure and set them into motion using hand gestures (see Figures 1 and 2). The instrument is designed to be collaborative, as each performer connects to a central server, allowing the entire performing ensemble to affect the motion of the same virtual structure.

The performance practice exhibited in *Carillon* is somewhat unorthodox in that while the performers on stage are clearly visible to the audience, there can at times seem to be little to no direct correlation between their hand gestures and discernible foreground sonic events. The motion of each gear in *Carillon* drives a continually-triggered modified Risset additive synthesis bell model in Pure Data. Performer hand-gestures control changing bell parameters that, to the listening audience, sometimes are perceived primarily as musical background structures. The procedural sonification of gear motion and the indistinct role of performers' gestures can result in the audience's attention being primarily focused on the motion of the rendered gears rather than the performers themselves.

In this model, the collaborative nature of the instrument adds an element of potential conflict, as multiple performers can simultaneously be trying to manipulate any single gear. This conflict acts as a mediation layer for each performer's intention, as the amount of control and the audible response their gesture ultimately controls can vary widely.

OSCCRAFT

OscCraft [2] is a modification to the popular Minecraft game environment that embeds a bi-directional Open Sound Con-

trol library within the game itself. Real-time player and environment data mediated by the changing game space itself is extracted from Minecraft and streamed out of the environment over UDP. Bi-directional communication between audio server and game server allows for the coding and control of mediated interactions including the generation or destruction of blocks both as a driver for and as a response to real-time musical events. Data streams representing continuous as well as discrete events from the game are read within audio programming languages such as Chuck and SuperCollider and used as control parameters for physically-modeled instruments, synthesis processes and algorithmic musical systems.

As sound-generating events in *OscCraft* can be tied to both features of the environment (block creation, destruction and collision) and to features of the player avatar (motion, rotation, speed, action), events that modify the topography of the environment as well as actions that alter the intended motion and action of the performer act as mediation layers. *OscCraft* allows the real-time creation and destruction of blocks via OSC input, a feature that has been utilised in performance to alter the landscape around a performer while simultaneously generating sonic events.

ECHO::CANYON

ECHO::Canyon (2013) is an interactive musical performance piece built using UDKOSC [3]. *ECHO::Canyon* features a reactive musical environment within which the idiomatic gestures and motions of avatar flight and physiological motion are mapped to procedural musical sound-producing processes.

In *ECHO::Canyon* performers control actors flying through a rendered landscape using a computer keyboard and mouse or commercial game-pad. Actor location and rotation in game-space, distance from objects as well as other param-



Figure 6: The motion and action of flying avatars is sonified in real-time in *ECHO::Canyon*.

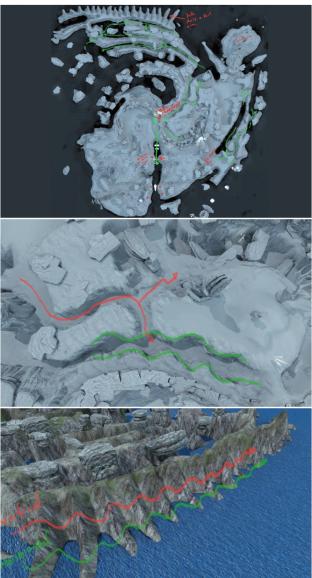


Figure 7: Environment topographies mediate musical interactions in *ECHO::Canyon*. Avatars move through composed pathways to procedurally generate sound and music.

eters describing their interactions with the environment are streamed in real-time to sound-servers using OSC. Individual bones that comprise each avatar skeleton are tracked, transforming every twist and turn, wing flap and arm reach into musical controllers. The environment itself is sculpted in such a way as to allow performers the freedom to perform musical interactions by moving above, around and through the topography. In this way the process of environment design takes on the role of composition, with sections of virtual hills, canyons and valleys acting as musical pathways through the environment.

In *ECHO::Canyon* sound generated by avatar motion and relationship to the composed topography is mediated by environmental parameters such as gravity, AI controlled agents and the sculpted contours in the environment itself. While the performer has subtle control over avatar gesture and motion and subsequently over the generated sound of the system, that control is mediated by these effectors, creating a performance dynamic in which the performer is constantly reassessing and adjusting to the space's internal ecology.

Conclusions

Interactions carried out in virtual spaces can be affected by forces either generated by rules of the environment itself or through the action of disparate agents operating within the space. Musical interactions in such spaces are mediated by forces which can interrupt and affect direct mapping schemata linking performer control systems and musical generation. Based on the potentially unique characteristics of musical interactions occurring within virtual and rendered spaces, mediated musical interactions should be considered and evaluated as a distinct form of musical interaction with their own performance practices, approaches and taxonomies.

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