

Trois Machins de la Grâce Aimante: a Virtual Reality String Quartet

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Figure 1. Performers for *Trois Machins de la Grâce Aimante* sit in traditional string quartet order [l to r: violin I, violin II, viola, cello] but face outward towards their tracking towers. In networked space, projected behind, each performer retains the same position but faces inward to see one another's communicative gesture. (Photo: Andreas Pirchner, 2018)

ABSTRACT

Composing electronic and electroacoustic music in the twenty-first century already requires artists to reconcile their own future-facing creative intents within a context of historical performance practice and precedent. The use of virtual reality environments as spaces for musical performance, creation and content dissemination adds an additional layer of complexity and possibility. This paper describes the technical and compositional processes and observed problematics devised and discovered during the creation of *Trois Machins de la Grâce Aimante*, the first virtual reality string quartet composed for Coretet, a virtual stringed instrument and networked performance application.

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1. INTRODUCTION

Trois Machins de la Grâce Aimante is a composition intended to explore twenty-first century technological and musical paradigms. At its heart *Trois Machins de la Grâce Aimante* is a string quartet descended from a tradition that spans back to the 18th century. As such, the work primarily explores timbral material based around the sound of a bowed string, in this case realized using a set of physically modeled bowed strings driven by Coretet [9], a virtual reality string instrument and networked performance environment. The composition is for four performers (see Figure 1) and takes the form of three distinct movements, each exploring different capabilities of the instrument itself and requiring different forms of communication and collaboration between each member of the ‘coretet’. For each movement a different method of notation and scoring is used: a fully-improvisational percussive performance, a graphical reference score, and an interactive visual in-engine scoring solution.

2. PRIOR WORK

Trois Machins de la Grâce Aimante and Coretet leverage infrastructures (such as a networked client/server model), hardware (Oculus Rift HMDs and Touch controllers) and software (Unreal Engine 4) commonly found in computer gaming systems. The combination of game-based technologies, presentations, and interaction modalities with musical form and function have over the last few decades started to become more prevalent. As part of a 1993 exhibit on virtual reality at the Guggenheim Museum in New York, Thomas Dolby presented The Virtual String Quartet, a pre-recorded and non-real time animated performance of Mozart's String Quartet no. 18 in A Major viewable through head-mounted displays and spatialized by tracking audience members' positions in a gallery space [4].

Ensemble performance works that utilize networked software environments have a long history ranging from early work by The Hub [5], to laptop orchestra performance [13, 14], to musical works based upon existing/hacked video games [1, 6]. As commodity VR devices have become both readily available and more affordable and the computing hardware necessary to run such equipment has become faster and cheaper, it has become significantly easier for artists to leverage virtual reality as a platform for musical performance [7]. And the use of game engines to create enactive and interactive VR and rendered musical environments has been explored as well [2, 8, 12].

3. CORETET

Coretet is a real-time VR instrument modeling basic bow and string interactions and performance practices idiomatic to stringed instruments such as violins, violas and cellos. Commissioned by the GAPPP project [10] at the IEM in Graz, Austria, Coretet and Trois Machins de la Grâce Aimante showcase commodity technologies such as Oculus Rift¹ head-mounted displays and the Unreal Engine 4² augmented with Open Sound Control (OSC) [15] and a Pure Data (PD) [11] audio engine driving a physical model of a bowed string from the Synthesis Toolkit (STK) [3].

Fundamentally Coretet is a single instrument which can be shaped and scaled by performers into different configurations (see Figure 2). Parameters such as neck length, body size, and number of strings can be manipulated in real-time to either recreate traditional stringed instruments such as violin, viola or cello or to create new and physically impossible instruments. For ease of use during performance, parameter presets for violin, viola and cello can be chosen and recalled instantly as can an experimental spherical instrument configuration known as the orb.



Figure 2. Coretet can be played using four different instrument configurations. From left to right: orb, violin, viola, cello and the Coretet bow

4. COMPOSITIONAL STRUCTURE

Trois Machins de la Grâce Aimante was composed alongside the development of the Coretet instrument, and as such explicitly explores the performance practices and ensemble strategies made possible by Coretet. Commissioned as part of the GAPPP project in 2018, Trois Machins de la Grâce Aimante consists of three distinct movements, each combining improvisational and pre-composed materials in fundamentally different manners. At the time of this publication, only Movement II of the composition had been performed in concert, with two performances by the same ensemble in Gratz, Austria, one performance by a quartet in Mexico City, and one performance by a quartet in Porto Allegre, Brazil. Videos of performances as well as additional material about the composition and the Coretet instrument are available online³.

4.1 Movement I

Movement I serves as an introduction to the performance, with performers first engaging Coretet using its orb configuration. The structure of Movement I is improvisational and rhythmic with a metronomic pulse being established by the ensemble. Notes on the orb are triggered by the collision of the avatar's skeletal mesh and the surface of the orb generating pitched percussive sounds. Performers move from performing rhythmic hand strikes to bowing the orb, creating a single pitch similar to that of a bowed steel plate or saw. The movement concludes as each performer bows the orb, resolving to a static four-note chord across the ensemble.

4.2 Movement II

Movement II explores a function of Coretet that allows finger positions activated along each instrument's neck to be quantized to a variety of modes and scales. To denote each selected mode or scale fret markings similar to those found on a viola da gamba or guitar are made visible along the instrument's neck.

¹ www.oculus.com/rift/

² www.unrealengine.com

³ www.coretet.io

These modes and scales include:

- Octave: the neck is divided into two regions
- Triad: major triad built on a string's root pitch
- Pentatonic: a five note scale
- Whole-tone: a six note whole tone scale
- Chromatic: a single octave chromatic scale
- Quantized: the full range of the instrument with pitches quantized to the nearest note in a chromatic diatonic scale
- Free: the full continuous range of the instrument without quantization

A composed improvisation within each selected mode is performed by the ensemble for movement II and focuses on different rhythmic, harmonic and melodic ensemble performance practices. A traditional graphic score (see Figure 3) was prepared for Movement II and used by the composer and ensemble outside of the virtual environment for the preparation of concert performances.

4.3 Movement III

Whereas the first two movements of *Trois Machins de la Grâce Aimante* are largely improvisatory in nature, Movement III was composed using traditional notation practices and focuses on vertical harmonic structure and rhythmic synchronicity. Within a virtual reality environment where performers wearing head-mounted

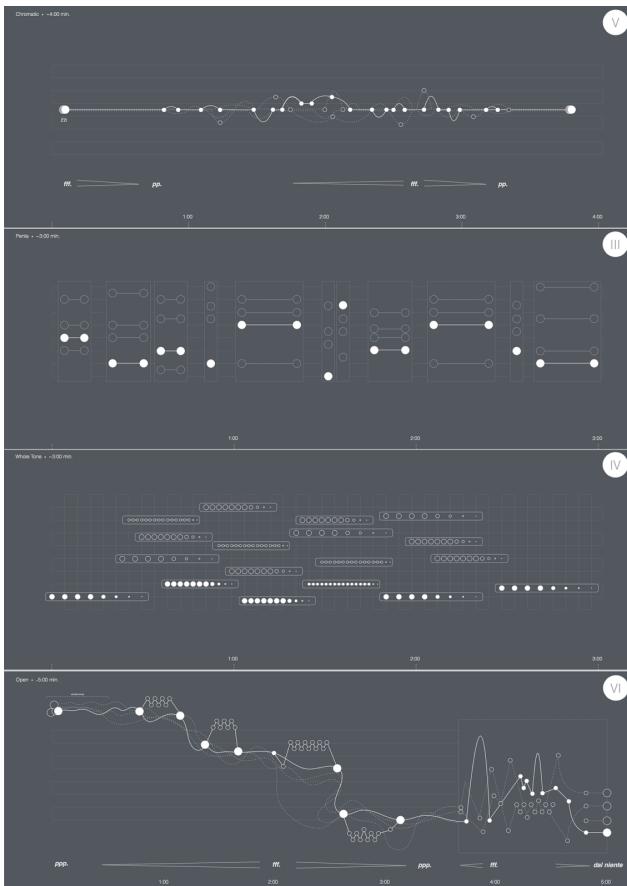


Figure 3. Four pages from the reference score for Movement II, each representing a different mode/scale setting.

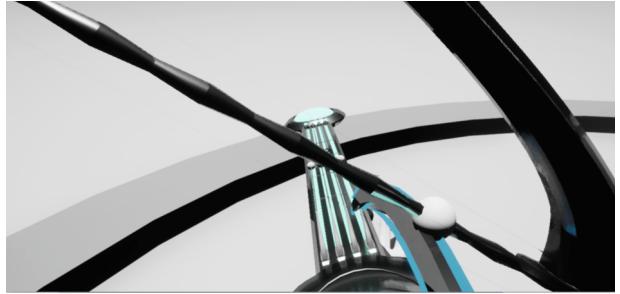


Figure 4. Notes are sounded when strings are activated and the bow collides with the bowing bar.

displays are unable to view notated scores in a traditional manner, Coretet instead displays notes from a musical score in real-time as glowing blue pitch location indicators along the instrument's neck. Scores are synchronized across each of the clients and read individual MIDI tracks exported from a parent score using standard music notation software.

5. PERFORMANCE PRACTICE

Performers in *Trois Machins de la Grâce Aimante* control a virtual bow (see Figure 2) modeled after a traditional cello bow to activate the set of bowed string physical models when the bow comes into contact with a specific bowing bar on the instrument. Figure 4 shows a blue outline around the bowing bar indicating a collision between bow and bar, for which a tracking marker indicating the collision is represented as a white sphere.

Bow pressure is controlled by calculating position along the bowing bar with one end representative of a high level of bow pressure and the other end representative of a low level of bow pressure. Bow speed is calculated by windowing bow position deltas.

By pressing buttons on the left hand Oculus Touch controller, performers choose which string will be activated. By moving their left hand along the instrument's neck and pressing each string's associated button, performers change the pitch of the current sounding note. String positions activated by button presses are marked in real-time by dark-grey oval markers. For *Trois Machins de la Grâce Aimante* each string of Coretet is tuned to the same base fundamental frequency as the corresponding string on the violin, viola and cello in concert A 440 Hz tuning.

In concert performance such as is utilised for *Trois Machins de la Grâce Aimante* a game server hosts each Coretet client instance (representing each performer) connecting across a local ethernet network. Performers in Coretet see each others' head, bow and instrument in real-time within the virtual concert space (see Figure 5), allowing for the use of communicative visual gesture both of the head and of the instrument and bow. In live concert situations, a view into the networked space is presented to audiences from the game server. In a manner similar to e-Sports broadcasts of networked games, a series of virtual cameras on the server are projected in 2D for viewing by audiences seated in traditional concert halls.

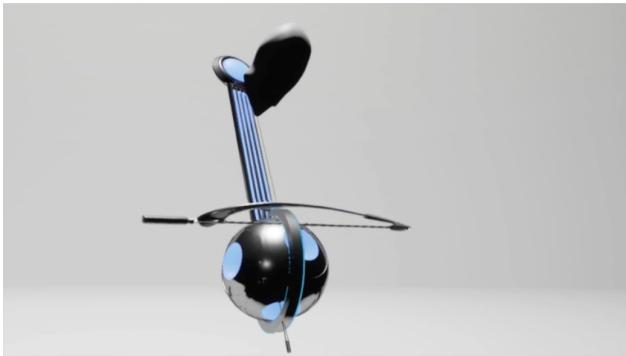


Figure 5. One client playing the Coretet cello as seen from a second client or from the server.

6. PRODUCTION CONSIDERATIONS

In its current state, the production of a performance of *Trois Machins de la Grâce Aimante* is a challenge requiring a significant allocation of resources. To place four performers in a shared virtual reality space, four full virtual reality setups are required, each consisting of an Oculus Rift head-mounted display, two Oculus Touch hand controllers, two Oculus tracking stations, and a laptop with the cpu, memory and video card speed capable of running Coretet at high consistent framerates on the Rift headsets. Each laptop is connected via ethernet to a network switch, which is also connected to a server computer, also running the Coretet software. The server hosts all four game clients and displays camera views within the virtual environment - selected by an engineer in real-time using keys on the computer keyboard mapped to individual cameras or camera sequences - to a projector or display in the concert space. A separate laptop also connected to the network switch runs a four-channel Pure Data audio server for Coretet.

While complex technology requirements for computer music performance works are by no means new or novel, a goal of both *Trois Machins de la Grâce Aimante* and Coretet has been to create a system that could practically and reliably used in live concert performance by musicians around the world. While commodity virtual reality headsets like the Oculus Rift are now priced at a relatively affordable level, they are by no means ubiquitous amongst consumers, either gamers or musicians. As such it is not reasonable to assume or require that musicians purchase or gain access to the necessary computing power to perform the piece.

In that light, performances of *Trois Machins de la Grâce Aimante* have only taken place with the composer not only present, but also providing all equipment necessary to run Coretet and perform the piece. Similarly performers can currently only rehearse both the instrument and also the composition itself when the composer is in attendance. Indeed, for all four performances of *Trois Machins de la Grâce Aimante* to date, ensembles have only had between four and five days to first acquaint themselves with the Coretet instruments, and then, as an ensemble, learn the piece.

7. DISCUSSION

From the time of its inception, *Trois Machins de la Grâce Aimante* was intended to exist as a composition firmly descended from traditional ensemble instrumental performance practices with a goal of exploring how virtual implementations of musical instruments could leverage learned expert behaviors of highly skilled musicians. While the work's grounding in traditional performance practice and the inherent limitations of the Coretet instrument have helped focus and constrain potential sonic and gestural exploration, as with any musical work composed for a novel musical interface, instrument or system there was a significant up-front investment of time and resources necessary to both design, create and then explore the physical and virtual affordances made available by Coretet.

The development of Coretet was strongly influenced by the first generation of hardware on which it was to run, namely the Oculus Rift "consumer version" head-mounted display, Oculus Touch controllers and external tracking towers. As such, there are certain performance aspects of Coretet and transitively of *Trois Machins de la Grâce* that are limited by the constraints of that hardware platform.

7.1 Single Position Hand-Tracking

Tracking of Coretet performers' left hands along the length of the instrument neck happens simultaneously for all four strings, meaning the concept of "hand-positions" and the ability to use finger displacement to play intervals from the same position is not currently supported in Coretet. This is a significant limitation of the current version of the instrument.

7.2 Lack of Tactile Feedback

As with any virtual reality system, the virtualization of a physical control system is typically lacking the same haptic and tactile feedback offered by the original. In Coretet, when quantization of frequency is not selected, it is difficult to articulate specific notes without any fluctuation, as the performer's hand is held in mid-air without any tangible surface on which to rest. While the Oculus Touch controllers do offer the ability to send haptic pulses and buzzes in response to events generated in software, the lack of a physical object with which to interact requires new contextualization for performer gesture and for the types of music that can be composed for the instrument.

7.3 Occlusion of Non-Virtual Space

Most current VR systems are differentiated from Augmented Reality (AR) systems by the focus on rendered spaces as a context within which presence is focused (VR) as opposed to the augmentation of physical spaces with digital construct and information (AR). The occlusion of performers' vision when wearing the current generation of Oculus VR head-mounted display prohibits the use of many traditional methods of musical scoring,

performance, and communication that trained musicians have spent significant time and effort perfecting.

8. CONCLUSIONS

To date, successful performances of Trois Machins de la Grâce Aimante in Europe, South America and the United States suggest that the modes of networked virtual reality instrumental performance afforded by the composition and by the Coretet instrument could be a viable form of musical performance. While the production considerations in staging a performance of Trois Machins de la Grâce Aimante are considerable, they are not so far out of reach that such a project could only be performed once, by one ensemble in one fixed location. In contrast, the staging of Trois Machins de la Grâce Aimante in multiple countries around the globe by multiple performance ensembles suggests that we've crossed a technological and financial inflection point, after which the production and performance of such works can only get easier.

Moving forward, development of Coretet is currently focused on improving the user experience, bug fixing and implementing interface layers sufficient to submit the application to online software stores available for download by end users. Performers and funding to stage the full performance of all three movements of Trois Machins de la Grâce Aimante are currently being sought with a goal of resolving a full performance of the work in Spring of 2020.

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