PERFORMING ARTICULATION AND EXPRESSION THROUGH A HAPTIC INTERFACE

Lauren Hayes
University of Edinburgh
Department of Music, Edinburgh, UK
laurensarahhayes@gmail.com

ABSTRACT

While digital technologies offer a host of new sonic possibilities, we are no longer dealing with the physical vibrations of strings, tubes and solid bodies as the sound source, but rather with the impalpable numerical streams of digital signal processing (DSP). As a result, when we perform with digital musical instruments (DMIs), we can no longer make use of haptic feedback provided through the body of the instrument itself. Furthermore, many DMIs are derived from interfaces designed for effortlessly smooth human-computer interaction. Here, however, the struggle afforded by the resistance and physical forces of acoustic instruments, which I will argue is integral to musical performance, is all but lost.

This paper discusses the musical outcomes of an exploration into the use of a haptic interface as an instrument for the performance of digital music. I will argue that it is the introduction of these tangible forces that is crucial for the articulation and effectuation of sonic ideas. In particular, the instrument will be discussed in relation to Rebelo and Coyne’s quote: “artwork Running Backwards, Uphill [10], aimed at making the incorporation of haptic technology into DMIs both inexpensive and easy to programme. The toolkit offers a series of basic force-feedback profiles for the Falcon, including virtual walls and springs. Used and adapted in combination with various DSP techniques, new instrument prototypes start to emerge. The Falcon ball grip can be moved within a 3D space, approximating a cube of side around 11 centimetres. How- ever, depending on design choices, a virtual space of infinite size could be traversed. The haptic technology can provide the experience of palpable (but virtual) objects, surfaces, and indeed textures. Thus possibilities for designing interactions based on a host of different gestures arise, where we can imagine not only bumpy or smooth, but also being able to move through different atmospheres, at various speeds, depending on the viscosity employed6. Furthermore, interactions that defy

loops that lead to the diversity of achievable musical expression. However, the audio-tactile link has been largely missing in systems of digital music. Instruments can no longer be described as such only those resonating bodies of physical constructs; indeed the sound sources of DMIs cannot usually be linked to real-world vibrating objects. Emmerson writes that, as performers, we “sense this loss of tactile location”[4]. MIDI controllers are often modelled on the studio paradigm, consisting of knobs and faders, and tend not to offer the types of interaction that make use of physical forces such as pressure, friction, collision, resistance, and so on. Even instrument-based MIDI controllers not only fail to communicate the whole picture in terms of the performer’s gestural information, but do not go far enough in allowing the virtually unharmonious types of engagement to manifest between performer and instrument, as hinted at by Rebelo and Coyne’s quote.

As research into tangible computing develops, the importance of how we engage with the digital world through our physical interactions is being increasingly highlighted. The incorporation of haptic feedback into mobile phones, and more recently tablet computers, is one such example. Developments in the field of haptic technology directly related to music are steadily increasing. These include ways of using our tacit knowledge of how we interact with physical objects as a means of mapping input gesture to digital audio parameters [8]. Other work specifically uses the already acquired motor-skills of a musician as the basis for haptic instrument design [2]. In related research, I have attempted to reintroduce the tactile sensation of sound to the performer by incorporating vibrotactile feedback within the performer-instrument coupling [6]. In what follows I will attempt to argue the case for employing tangible forces as a means to enhance the potential for sophisticated expression and articulation of performed digital music. I will propose that:

1. Diverse musical expression is achieved through constant multimodal negotiation between performer and instrument.
2. Exploring the resistance of an instrument, either physically or virtually, can help to craft a performance.
3. Haptic technology can help to create shared participation between performer, instrument and performance space.

2. SOUND SCULPTING WITH A HAPTIC CONTROLLER

During his keynote address at the International Computer Music Conference, 2011, University of Huddersfield, Simon Emmerson suggested that the idea of sculpting sound was now “a metaphor that could be made ‘real’ through suitable haptic interfaces and three dimensional representations” [6]. What follows will offer a modest step towards a realisation of this idea, where digital audio can indeed be moulded and articulated through three-dimensional (3D) tangible interactions.

In this way, not only do we rely on auditory feedback to navigate between sounds, but we are also guided by ongoing tangible exchanges with the instrument.

2.1. Repurposing a Commercial Game Controller

The Novint Falcon is an affordable1 commercial 3D game controller, providing up to 9 newtons of resistive force-feedback to the user [1]. While this is of a much lower bandwidth than, for example, Claude Cadoz’s Modular Feedback Keyboard [5], one of the first haptic musical instruments, or “gestural force-feedback transducers”, it is nonetheless receiving attention as a low-cost solution to designing haptic DMIs. The Haptics Lab2, at CCRMA, Stanford University, is an audio-performance workshop specifically based around the Falcon.

Open source software is available from Nonpolyno- mial Labs3, enabling the Falcon to operate within musical programming environments such as Max/MSP + Pure Data4. Edgar Berdahl, at CCRMA, developed HSP, “a simple platform for implementing haptic musical instru- ments” [1], aimed at making the incorporation of hap- tics into DMIs both inexpensive and easy to programme. The toolkit offers a series of basic force-feedback profiles for the Falcon, including virtual walls and springs. Used and adapted in combination with various DSP techniques, new instrument prototypes start to emerge.

The Falcon ball grip can be moved within a 3D space, approximating a cube of side around 11 centimetres. However, depending on design choices, a virtual space of infinite size could be traversed. The haptic technology can provide the experience of palpable (but virtual) objects, surfaces, and indeed textures. Thus possibilities for designing interactions based on a host of different gestures arise, where we can imagine not only bumpy or smooth, but also being able to move through different atmospheres, at various speeds, depending on the viscosity employed. Furthermore, interactions that defy

real-world physical relationships can be created through the HSP’s interface. For example, a simple wall model could disintegrate after being hit with a particular velocity, and reform once the user has passed through to the other side. Of course, meaningful relationships between such interactions and their effect on the musical outcomes must be considered.

2.2. Performance Potential

On trying out the device for the first time, it feels, peculiarly, both new, yet familiar. After initial experimentation within this environment, the possibilities for prototyping new haptic-based musical instruments become obviously clear. The three degrees of freedom gives potential not only for macro-movements of the hand, but for further engage- ment from more of the body. Thus larger gestural movements can be transduced into parametric information, while still allowing for finely focussed articulations. Rebelo refers to performances as a “multimodal participatory space”, somewhere where the performer employs “negotiation of subtlety and the recognition of threshold conditions” [9]. I would argue that by introducing haptic devices, we also increase the potential for this type of engagement.

Emmerson’s idea of sound sculpting suggests that 3D manipulations would enable us to mould multiple aspects of the sound simultaneously. The very nature of the Fal- con affords this type of interaction, given that any move- ment will produce a minimum of three data streams. Thus, the potential for multi-mapping is inherent. The expres- sive potential of acoustic instruments can, in part, be at- tributed to the multiple and ongoing negotiations between performer and instrument. For example, playing fast stac- cato scales on a piano requires continuous assessment by the performer about kinaesthetic and haptic information, such as the bounce of the fingers against the keys, and the speed or acceleration of the hand. Thus, simply by nature

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Figure 1. Performance of Running Backwards, Uphill, Reid Hall, Edinburgh, 2011.
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of its design, the Falcon already goes some way in offering the qualities necessary to make a convincing instrument.

2.3. Development of an Instrument

After testing the various physical models given within the HSP examples, the virtual wall was used most extensively as a starting point, as the action of striking a surface with different objects and forces could be considered to be one of the most primitive sound-producing gestures. I implemented a visual rendering of a ball bouncing on the wall using JavaScript within Max/MSP, which was initially useful for providing additional visual feedback while developing the system. However, since much of my practice within computer music aims to remove the need to look at a laptop screen while performing (through engagement either with haptic interfaces, or augmented instruments) [7] [6], this quickly became redundant.

One of the most interesting aspects of the instrument was that depending on the different force profiles used, it could rapidly change between allowing wild gestures, to very restricted, even secure, environment where moving through detailed nuances of a sound could be explored. The four buttons on the small ball grip of the Falcon allow rapid switching between different forces profiles and parameter mappings, within a single performance.

3. RUNNING BACKWARDS, UPHILL

This section describes the implementation of the Falcon as a performance instrument within a compositional framework.

Running Backwards. Uphill (2011) [3] for violin, cello, piano and live electronics, attempts to explore the relationships between touch, gesture and timbre by examining the sonic qualities of the acoustic instruments, and furthering these through the use of electronics. The performers are directed to lurch and fall off the keys; or, to create the most delicate airy bowed sound. Extended techniques are combined with sound analysis methods, resulting in an informed integration between the two sonic worlds.

3.1. Articulation and Expression

One of the challenges with this composition was to develop a method for articulating the electronic part that could evoke the same expressive qualities within the music as would be expected of the professional ensemble. The musical language of the piece itself is very gestural (see Figures 2 and 3), and thus it was important that the electronic part should also be performed in such a way as to reflect this.

The boundaries of any instrument can be where the most expressive moments emerge, from an unstable clarinet multiphonics, to the point at which a digitally generated pulse turns into pitch. But for instruments within the class of resonating bodies, these boundaries are intrinsically coupled with physical resistance. As Aden Evens explains:

For his part, the musician resists the resistance, which is to say, he employs technique...technique is designed to place the instrument's resistance in contact with the musician, to allow him to feel the many dynamics it offers of force and sound.[5]

Thus, by working with the haptic device, I could successfully couple physical resistance with these virtual boundary areas, in which turn allowed for a greater range of potential expression in which the performer could employ technique.

In the first part of the score (see Figure 2), the Falcon is used to play short segments of samples of a prepared piano. With the added resistance of the controller, I was able to make micro-movements along the domains of both start and end points of the sample, as well as the speed of playback of the samples themselves. Without the force to play off, the result would have sounded jerky and ill-crafted, whereas pushing through the resistance allowed smooth transitions through the various parameters, producing a legato effect.

In this section, the string instruments play long tremolo lines in which both the speed of the tremolo, and pitch transition continuously. The dynamics also ebb and flow gradually until the entrance of the piano. I wanted the electronic part to reflect these characteristics by transitioning gradually both in timbre, dynamic and pitch. The haptic device gave the performer a sensation, or feeling of moving through the sound, increasing the amount of information available for negotiating the performance.

4. RESULTS AND DEVELOPMENT

The purpose of this paper was not to detail the technical capabilities of the Novint Falcon, as these are thoroughly described elsewhere [1], but rather to describe how employing a haptic device can manifest imagined musical ideas and expressive nuances. Not only through practice, but also by considering the crucial negotiations and feedback loops that take place between performer and instrument, it becomes evident how employing haptic technology can solve some of the problems associated with the performance of live electronic music.

Implementations of different force profiles, combined with visous damping, allow the performer to feel their way through different aspects of digital audio, and sculpt the sound accordingly. In the work described, using resistant forces designed with very simple physical manipulations allowed vastly different types of engagement to be employed within the piece. Through the use of haptics, as a performer, I could more easily position myself within the shared participatory performance space. I will conclude by suggesting that this is a place that we, as composers of digital music, need to more deeply explore.

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