StickMusic: Using haptic feedback with a phase vocoder

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ABSTRACT
StickMusic is an instrument comprised of two haptic devices, a joystick and a mouse, which control a phase vocoder in real time. The purpose is to experiment with ideas of how to apply haptic feedback when controlling synthesis algorithms that have no direct analogy to methods of generating sound in the physical world.

Keywords
haptic feedback, gestural control, performance, joystick, mouse

1. INTRODUCTION
Digital synthesis has freed instrument design from being tied to the physical method of generating sound. Thus any arbitrary interface can be mapped to any given synthesis algorithm; indeed the mapping can also be designed to suit the goals of the designer[1]. Adding haptic feedback brings back this feedback loop that is an fundamental aspect of playing traditional instruments[2]. Haptic interfaces have thus far mostly been used to control synthesis methods that have direct analogies to the physical world[3][4][5]. Scanned synthesis, designed with haptics in mind, relies on metaphors from the physical world[6] to synthesize sound.

Digital synthesis has opened vast realms, allowing the creation of a wide range of sounds that could not previously be generated. The combination of a digital interface controlling digital synthesis opens the door to new approaches to creating sound and interacting with the instrument itself. Just as the computer has freed the interface and the mapping from being tied to the physical methods of generating sound, haptic feedback need not be limited to interfaces controlling synthesis algorithms with analogues to the physical world.

2. IMPLEMENTATION
StickMusic was programmed using Pd[11] on Debian GNU/Linux. The phase vocoder was taken from an included Pd patch by Miller Puckette. A number of external objects are used, including: *ff*[13] for joystick feedback control; *ifeel*[12] to control the pulse generator in the mouse, and the *linuxevent*[12] to get the data from the joystick and the mouse.

3. INTERFACE
In building this instrument, I reviewed many possible interfaces from knobs to The Plank[7] to tablets. I chose the combination of the joystick and the mouse because they offered enough dimensions of control while providing haptic feedback. I did not want to start with building my own hardware because the issue that I am currently most interested in exploring is how to use haptic feedback to represent more abstract ideas. By using off-the-shelf haptic controllers, I could quickly start working with these ideas. A phase vocoder is used because it can generate a broad range of timbres with the ability to use real-time sampling for source material.

I chose a Saitek Force joystick and a Logitech iFeel mouse. While limited as musical controllers, using them allowed me to rapidly ramp up and test ideas about how I can apply haptic feedback when controlling a phase vocoder. The joystick offers many different types of feedback, from forces to friction to vibration. The mouse has a motor which can create pulses that are perceived as individual events, a stream of pulses, or an audible vibration, depending on their rate.

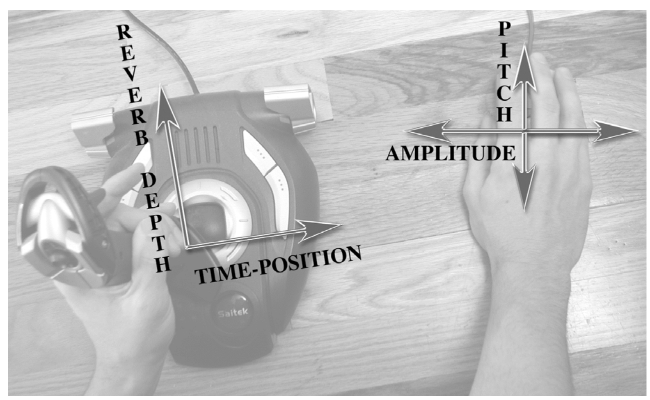

Figure 1. The basic mapping of StickMusic

4. MAPPING
4.1 Control
The joystick/mouse mapping is similar to a bowed string instrument in that large bowing gestures are performed with the right hand, while the left hand does more restricted selection gestures. The joystick's X axis is mapped to the time-position of a Hanning-windowed segment in the current sample, which is then analyzed using FFT. The analysis of that segment is used to generate the base timbre using an inverse FFT. This provides control over a palette of timbres. Since I intended timbre to be the main means of expression, it makes sense to map it to the X-axis, which is the most natural dimension of a joystick for the arm to control. The Y-axis is mapped to reverb, giving the sound a

feeling of distance relative to the amount the Y-axis is pushed forward. The twist controls the stereo position of the sound source. The velocity of the mouse's X-axis is mapped to the amplitude, bringing about a bowing motion like the Cymatic[5]. Velocity-based control also provides a more engaging experience as compared to a position-based control[1]. The mouse's Y-axis is directly mapped to the transposition of the phase vocoder, thereby controlling the pitch. Personally, I miss the physical activity of playing traditional instruments, so I intended the mouse to inspire large gestures.

4.2 Feedback

A constant force is applied to each joystick axis to give the musician feedback as to how far along that axis the joystick is pushed. These forces push the joystick’s origin to its lower left corner. A fixed-frequency vibration is generated in both the mouse and the joystick relative to the mouse's X-axis velocity. A system of "detents" (pulses) is used to mark the passing of octaves in the transposition, with one pulse representing the top of the lowest octave, and five pulses representing the bottom of the highest octave. If the mouse goes out of the six octave range, a constant high frequency vibration is triggered until it is brought back into range.

5. EVALUATION

I have been playing StickMusic with various musicians in a series of free form sessions called Frylab (a.k.a. NIME2)[8]. I also played a solo set with Gideon D'Arcangelo's NIME course[9] at Tonic, a experimental music club in New York City. The first impression of playing StickMusic is that it feels lively. The vibration triggered by the mouse "bowing" felt in the hands reminded me of a trumpet mouthpiece buzzing on my lips, while the forces on the joystick made it feel like I was controlling something physical. The most noticeable weakness is the mapping of pitch to a relative axis, the mouse's Y-axis. Since the mouse axes do not have absolute positions, it is relatively easy to get lost when controlling pitch through dramatic changes in timbre or large, quick gestures. The detents make a notable difference in the level of pitch control. While the instrument was designed to use timbre as the central means for expression, the pitch mapping limited overall control. The X-axis of the mouse controlling amplitude did not suffer the same problems as the pitch control because the velocity used is always relative to the given position. The haptic feedback is key to playing the instrument and aids greatly in dealing with this. This was especially evident when the haptic feedback stopped functioning due to software troubles.

Making a few changes to the haptic feedback would enhance the experience. Instead of a fixed-frequency, a vibration relative to aspects of the synthesized sound would provide more information: for the mouse, the vibration frequency could be relative to the pitch; for the joystick, the vibration could be relative to the average amplitude of the current window of the sample, which is used to generate the timbre. The forces on the joystick, while helpful, did not provide the level of detailed information for precise control of the timbre. Also, the mouse itself holds strong associations; the mouse hand easily fell into the old habit of small, more discrete gestures normal for its traditional use rather than the broad gestures intended.

6. FUTURE WORK

The next step towards understanding whether the haptic feedback provides broadly useful information is to do formal user testing of StickMusic. I plan on testing the instrument with both experienced musicians and novices to see how they respond to it. Also, changes in the mapping could provide for a more expressive and intuitive interface. Since a basic level of haptic feedback has proven useful in my instrument, enhancing it should directly aid the pitch control. Other force "effects" like "spring" or "inertia"[10] might provide more useful information on the joystick axes. In the long run, the game controllers lack the level of precision needed for a musical instrument, so better hardware would need to be developed. Specifically, a joystick with a greater range of motion would make for more precise control, a mouse that did not feel like a mouse would break the standard mouse associations, and feedback motors with faster response times would allow for quicker gestures.

7. ACKNOWLEDGMENTS

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