AUDIOVISUAL DRUM PAD WITH LEAP MOTION

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ABSTRACT

In this study, we built a Leap Motion controlled drum pad that visualized the performer's hand and drum pads in order to test whether this visual feedback improved the performer's accuracy and usability. Also, we made the loudness of the drum pads dependent on the speed at which the performer hits them in order to test whether this would encourage the performer to use bigger and more varied gestures while performing. Our informal tests with the digital drum pad were successful in both of these areas. We found that multimodal feedback is an important consideration in digital instruments, and found that there is a need for more digital music instruments that encourage gestural performance.

1. INTRODUCTION

In prior lab work with the Leap Motion, we noticed that we had a hard time using it without being able to see where our hand was positioned relative to the sensor. We thought that we could improve upon this by adding visual feedback of your hands. We also thought that when performing, some sort of gesture should be applied to aid in the expression of digital music performance. We then, seeking to combine the two, brainstormed some ways to implement this idea. Our broad idea was to make an all-in-one instrument with Pure Data that would be able to generate and manipulate different sounds. As the project proceeded, we narrowed it down to a drum pad with different sounds that could be programmed in Pure Data, and visuals developed in Unity that would give visual recognition of what is being played as well as predicted hand location.

Our interest for this project was sparked by our experience using Leap Motion along side Pure Data, and brought to life by our interest in attending live music shows. Nowadays many big name artists just sit behind a computer and punch a couple buttons, click and drag a bit, turn some knobs and then the performance is over. We thought that we could make something that would allow the artist have a bit more interaction with the audience, and provide the audience with some feedback as well. The lack of instruments in such performances eliminates a vital part of what live music has always been about: interacting with the fans. Our project looks to bridge this gap, allowing Dj's and beat producers to become closer to an orchestra conductor in the way they can express emotion through gestures.

2. BACKGROUND

The leap motion controller offers music performers a new way to manipulate digital audio, and its uses in this field is growing. In the music field, Han & Gold have researched the practicality, drawbacks, and latencies experienced when using leap motion as an instrument. In their study, they created a virtual keyboard and virtual drum pad. They found that using the leap motion controller with a drum pad layout was significantly better than a piano keyboard layout, because there is better gesture recognition with the naturally large swings of hitting a drum and with greater target area spacing [2]. Han & Gold's study did not include visual feedback, however.

According to Plemmons & Mandel, using visual, auditory, and haptic feedback with the leap motion enables complex actions to become intuitive [4]. We wanted to explore this topic, and found that more research is needed concerning the effectiveness visual feedback in musical performance with the leap motion.

Some in-depth research has been done on gestures used in musical performance. In a performance, observers are able to recognize the expressive and emotional intent from musicians' movements [1]. This phenomena has encouraged traditional instrument performers to use expressive

gestures while performing on stage. With modern digital music performance however, often only micro-gestures are needed, such as mouse clicks and knob turns. The quest for more efficient interfaces for music production has minimized the physical interactions needed to produce music, and this has led to a lack of expressive or emotive gestures in digital music performance. There is a need for new digital music instruments that enable more broad gestures, and another goal of our application is to encourage these broad gestures, in order to improve the performance qualities of the tool.

3. METHOD

3.1 Approach

To create a music tool that would meet our goals, we chose a combination of Leap Motion to recognize gestures, Pure Data to create and manipulate sounds, and Unity to provide visual feedback.

The drum pad was designed as a virtual box that you could reach into with your hands, and it allows you to hit 4 drum pads on the bottom of the box to create sounds (see Figure 1). At the top of the back wall of the box, a metronome visualization moves from left to right, showing the duration of the loop.

When the player's hand hits a pad on the bottom, the sound is emitted, as well as visual feedback in the form of a flash of color on the pad and a colored dot that appears on the metronome visualization. Visual feedback is also constantly present from the virtual hand that follows the performer's physical hand, allowing the performer to properly judge how close or far away their hand is from one of the four drum pads.

The back wall also includes a grid that activates a phaser effect (see Figure 2). When the performer puts their hand into the grid and moves around in the grid plane, the phaser effect alters the sounds that are being played back in the loop.

We attempted to create an 'efficient' instrument that can produce a wide variety of sounds from a limited and easily learnable set of possible inputs. This was inspired by Jordà's paper on efficiency and apprenticeship in digital instruments [5].

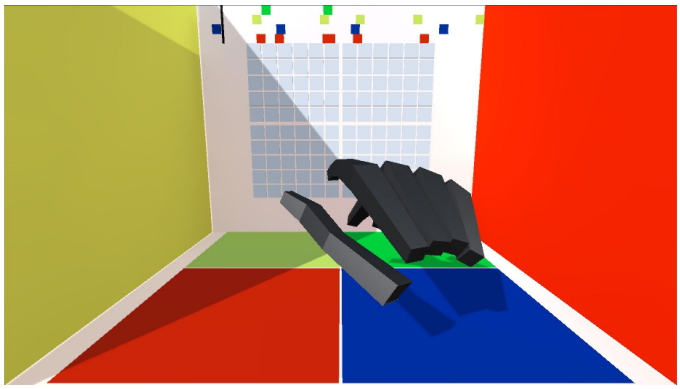

Figure 1. Visual representation of beatpad and performer's hand

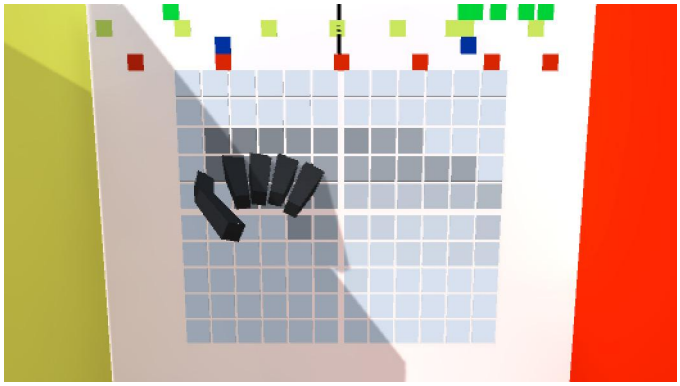

Figure 2. Performer's hand being dragged along the back wall, creating a phaser effect

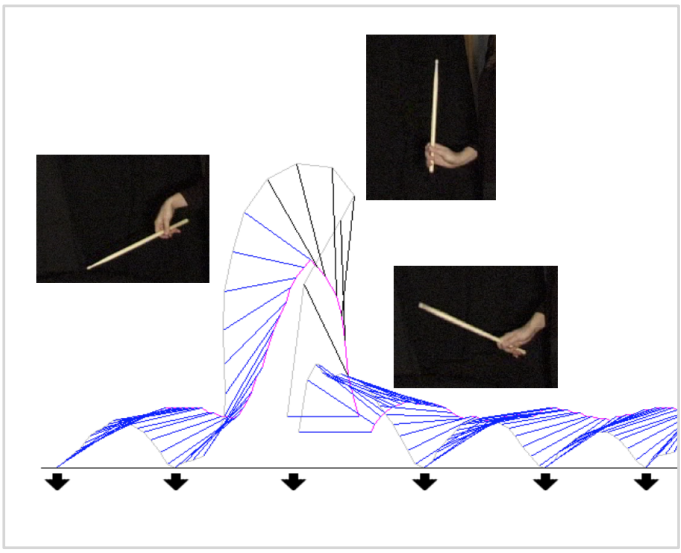

Figure 3. Stick movements for accented and unaccented drum strokes [1]

3.2 **Program Architecture**

Due to limitations and time constraints, our program was essentially two different programs running in Pure Data and Unity simultaneously. Most of the functionality of our project was built in Pure Data, and we replicated the gesture recognition in Unity and added a simple and clean user interface.

We used Pure Data for all of the audio processing that is going on in the background when you are running the final product. Using the Leap Motion Patch we were able to read the values fed through to create “barriers” at certain xyz positions that we used to activate the different drum pads as they were banged. While playing with the Leap Motion we noticed that the finger position values were highly variable depending on your hand orientation. In order to combat this we used the palm position as well as the position of each finger when detecting the bangs to get more accurate feedback. We started off by just creating one wall that could play one sound when your hand passed that X-value and incrementally added more features as we thought of them and researched more. We decided to stick with one hand since in the past we had many problems getting both hands to be consistently detected. Each barrier that you see in Unity corresponds to a specific position value in Pure Data where if your hand passes through that value, one of the sounds that is programmed to it will be played. Along with that we decided that to make the sounds more expressive for the performer, we would use the velocity of the hand as it approached the drum pad to set the volume of the sound. The faster your hand hits the drum, the louder the sound. This is inspired by real stick movements that occur in traditional drumming (see Figure 3). Along with the drum pad at the bottom we added in a high hat synthesizer if your hand is raised a quarter meter or so.

We had come to the point where we had created all the sounds and we could play all of them but only one by one. We had done what we were seeking to but it still felt incomplete. It was at this point that we thought about making the looper. We could then make beat clips as we describe them. This would allow us to have a sound that we could manipulate using effects as we initially wanted. The looper works by recording 2 seconds at a time and adding new sounds to a Pure Data array, then playing back the array, which includes all of the previous loops. With this we could now use the tools in PD to create a phaser effect that was altered using the back wall of the box. Based on the x and y position of your hand along the back wall, the phaser speed and depth were controlled, respectively.

In Unity, the same gesture recognition method used in Pure Data was replicated in C#. Additional code was added to activate color flashes on the drum pads, create a metronome/loop visualizer, and to create colored dots whenever a drum pad was hit. A simple visualization of the drum pad interface was also modeled in 3d within Unity.

3.3 **Testing**

During development we continually tested how easy it was to use the drum pad and how much improvement was made to visual feedback and gestural performance. We made revisions to the program based on our informal tests. Some other things we tested were: how accurate the gesture recognition was, whether or not the gestures felt natural, how much gestural movement was required to play the instrument, and whether or not the player could tell where the loop starts and ends.

Some major revisions we made were: recognizing drum hits using finger positions in order to increase accuracy; moving some of the drum pads from the side walls of the box to the bottom because of poor finger recognition when the hand is sideways; and adding a metronome visualization to help the performer understand the loop timing.

4. **RESULTS**

From our informal analysis of the instrument, we found that:

- visual feedback from seeing your hand and seeing drum hits improves accuracy and usability
- using hand velocity to affect loudness of drum beats is an effective way to encourage gestural playing

The most noticeable improvement came from the player being able to see their hand in relation to the drum pads. This greatly improved accuracy of drum hits, and gave the player more confidence in hitting the pad they intended to hit. Visual feedback from the color flashes on drum pads

added mostly to usability, but did not improve accuracy.

Using hand velocity to affect loudness led the player using faster and more exaggerated arm swings, but this feature needs more fine-tuning in order to be more effective. Also this feature only has auditory feedback, and might also benefit from visual feedback representing fast/slow arm swings and soft/loud drum hits.

These results are based on our informal observations of playing the instrument ourselves, but a next step for the project will be to perform formal tests to confirm these hypotheses.

5. DISCUSSION

Our visual feedback result fits with Silva et al.'s finding that their use of visual and tactile feedback was enjoyable for the player and helped them understand the piano key positions [3]. Our result also fits with Plemmons & Mandel's statement that adding multimodal feedback increases intuitiveness of leap motion applications.

The performance gesture result also fits with current research. By encouraging the player to perform a natural arm swing gesture to hit the drum, the performer actually performs that sound-facilitating gesture, which results in a visual gesture that is perceived by the audience [1]. The audience perceives emotion and expressiveness from the performer's gesture, and responds to it, adding to the feedback loop between the performer, instrument, and audience [6].

A key limitation we experienced with our system was the Leap Motion's accuracy. A performer can have accurate physical movements but the Leap Motion may not properly recognize them, and this can break the flow of the performance. Another negative influence on our testing was that some of the sounds we created in Pure Data sounded harsh on the ears, and the phaser effect was adding extra noise even when it wasn't in use. We revised the sounds in order to make the performance more pleasing, but haven't tested the new version yet.

In order to improve our audiovisual drum pad, we would consider adding tactile feedback in the future. Our drum pad included visual feedback, but according to the Leap Motion Developers article [4] and the "Crystal Piano" built by Silva et al. [3], our instrument could benefit even more from tactile feedback. To improve the gestural performance, ideally we would engage both hands, especially since this is the natural way to play drums. Finally, a new device like the leap motion might be better suited to different kinds of gestures than drum hits. It would be worthwhile finding out which gestures feel the most natural with Leap Motion and which ones are most accurately read by it.

6. CONCLUSIONS

In this study, we built a Leap Motion controlled drum pad that visualized the drummer's hand and drum pads to improve accuracy and usability through visual feedback, and made the loudness of the drum dependent on the speed at which the drummer hits a pad in order to encourage a more gestural performance. From our informal tests, these hypotheses were validated by the drum pad we created.

More rigorous testing is needed to confirm these correlations, and we feel that these are promising topics to explore in future research. There is a lot of room for new digital instruments that encourage gestural performance, and this could fill a gap in the current state of on-stage digital music performances. Also for creators who are making new digital instruments, the sound that's produced is the primary concern, but providing multimodal feedback is also an important consideration to improve accuracy and usability.

7. REFERENCES

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