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Real Time Drum Augmentation with Physical Modeling

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1. Abstract

Whilst digital drum kits have become ubiquitous across the performing and recording realms of the music industry over the past few years, research into extending real drum performance and sounds is still in its early stages. As digital drums have become more common on the world's stages and recording studios, the way that sounds are triggered using piezo based triggers and the sounds themselves, generated from samples, has changed very little. This project looks at how acoustic drums and percussion can be augmented using physical models of acoustic instruments and how new performances and sounds can be created.

2. Introduction

The sounds generated by physical modeling can be recreations of existing instruments, a particularly proportioned snare drum for example, or completely new instruments that might be difficult or impossible to create in the real world such as a 20–foot long kick drum.

Using the acoustic sound of a drum as an exciter to the physical model, new sounds can be played using real drum kits and percussion. This hybrid approach creates dynamic performances and sounds that could be used in many different scenarios, from reinforcing the live sound of a rock band's kick drum to the development of new sounds for avant-garde composition.

Existing digital drum approaches rely on the triggering of fairly static digital samples with little variation built into the performance other than velocity information that is sent from the drum pad to the drum brain. The digitally augmented approach allows performers to use the dynamics and sound of their existing instrument as a starting point to the creation of new sounds. Importantly their playing technique remains unchanged, whereas digital drums require pads which have none of the expression and dynamism of real drums.

3. Physical Modeling and Drum Augmentation

Aimi's PhD thesis 'Hybrid Percussion: Extending Physical Instruments Using Sampled Acoustics' [1] explores the idea of digital drums and covers in detail some of the various digital drum kit models. It goes some way to explore their flaws – i.e. that they do not behave in the same way as real acoustic drums. They convert velocity into timbre changes for instance, but do not differentiate between brushes or sticks to change the sound. There is also no haptic response from the virtual drum skin back to the musician.

In their thesis they use convolution to process a sampled drum sound :

> 'In this work, the continuous acoustic output of a struck physical object is processed to add the resonance of a sampled instrument. This is achieved by employing existing low–latency convolution algorithms which have been extended to give the player control over features such as damping, spectral flattening, nonlinear effects, and pitch.'

This results in a closer relationship between the drummer and the sound being played back.

Figure 1: Simplified Convolution Instrument (figure based on Aimi's)

Aimi also brings a good quote in the form of his musical vision for the project:

> 'The core musical vision for this work is to make a system that gets out of the way of great players and lets then do what they do best: explore the range of sounds possible, expand the timbres available, find new and surprising ways to play, and get good at playing it. All through acoustic interaction with physical objects.'

It is arguable whether this system is actually acoustically driven as the piezo is a form of pressure transducer and is not reliant on air pressure generated by the drum itself, rather the body of the instrument in contact with the piezo microphone. Factors such as microphone placement, microphone type and more subtly nuanced acoustic sounds will not be picked up by the piezo microphone.

The idea of the percussion instrument being something that can be explored and that timbres and new ways of playing are there for the taking by the musician is very appealing. Percussion lends itself to sonic exploration with the player using different beaters, techniques and patterns to create different textures and sounds, often combining two sounds together or using various stick techniques such as flamming. A digital extension of this where the player can control timbres and explore the textures they create directly is something worth researching further.

Aimi uses convolution to change the sound of the drum, another idea would be instead to augment the drum spectral processing. In the paper 'The Augmented Drum Kit: An Intuitive Approach To Live Electronic Percussion Performance' by Michalakos [2] this approach is taken. He uses spectral processing, acoustic feedback and samples to augment his very personalised drum kit. This works extremely well as can by his demonstration videos, performances and experimental album 'Frrriction' [3]

However this approach has a number of problems. Namely that the kit and individual instruments it comprises of are heavily customized to Christos' playing and would not suit another percussionist. Therefore there would be a steep learning curve for someone to learn how to play the kit. Although there is GUI for the kit it is again designed with one user in mind and not useful for general distribution of the software:

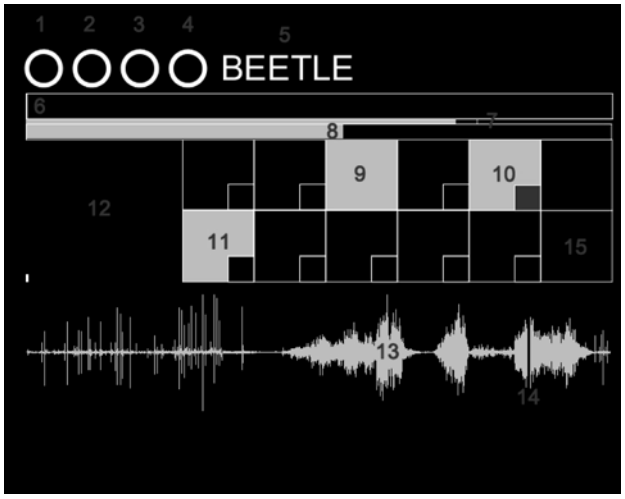

Figure 2: Michalakos' Performance Graphical User Interface

Michalakos' work is interesting, and although taking a very personal and customized approach it does go some way to demonstrating what is possible with digitally augmented percussion.

In another paper, yet another approach is taken. Adam Tindale's [3] focus is to use physical modeling, instead of samples, to recreate the sound of the drums. The interesting part of this method is that he uses a timbre recognition and strike location algorithm to modify the parameters of the physical model of the drum.
Thus the drummer can modify the drum model using a paradigm that the musician is already familiar with i.e. hitting the drums in different ways and with different implements. Something that is important when creating augmented instruments to be played by others, as opposed to personalised instrument augmentation.

In this way the resonator is the only physical modeled part of the system, with the drumhead and stick being real objects. This allows the musician to use familiar implements as opposed to striking unfamiliar rubber pads used in most digital drum kits. The rubber pads of older digital drums are usually quite unforgiving and have been associated with RSI, although this has been improved with the likes of the Roland TD20 mesh head system. Also Tindale's system will allow the musician to use any drum or percussion instrument to create an impulse signal for the physical model.

The drum then becomes both the instrument, responsible for creating the initial impulse which then in turn reacts with the physical model, and also the controller – modifying the signal depending on how the drum is struck.

Waveguide modeling is used to create model of a tube which then has a number of adjustable parameters including length of the tube, dampening of the tube and timbre. In this way many different drum sounds could be generated quickly with a relatively simple interface.
This method is relatively CPU efficient and also results in many different sounds, from boxy to bell like. It also allows a low latency, important for live performance.

It is worth noting that both Native Instrument's Machine software and FXPansion's drum plugin BFD3 have both made use of physical modeling to enhance the sound of sampled drums in their software. The original samples are processed using adjustable physical models allowing the user to edit such parameters as drum dimension, head tension and drum materials.

3.1. The Dronebox Physical Model

Oli Larkin's Dronebox is a physical modeled VST plugin effect based on modal synthesis. It consists of a bank of 6 tunable comb filters. A comb filter can be

thought of as a resonator. When you walk in an alleyway or underpass the resonance you hear is a comb filtering effect that occurs because the sound waves bounce between the walls very quickly. This resonance is similar to the physical vibration of a string, which is why comb filters are used in physical modeling synthesis and why Dronebox can be used to emulate the resonant strings of a sitar or piano etc.

3.2. Triptych, a piece for Snare, Rototom and Physically Modeled Strings

As a proof of concept a piece of music was created that explores the potential of working with live percussion and physical modeling in real time. The piece uses the timbres and textures that can be generated using a simple percussion set consisting of a snare drum and two roto–toms feeding into a physical modeled set of strings running as a VST plugin (created by Oliver Larkin, University of York). Research follows on from work by Christos Michalakos[1] who devised a physical modeling system for augmented drum kit at Edinburgh University.

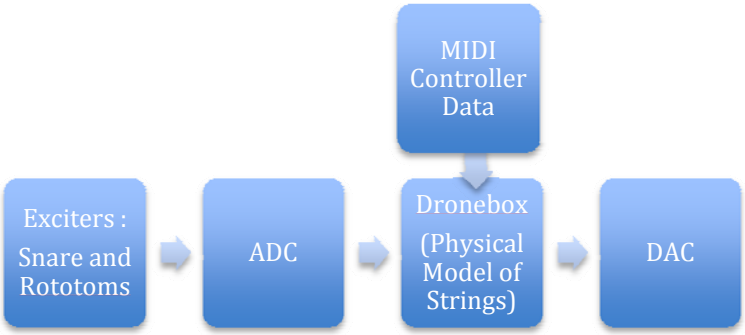

Figure 3 : Signal Flow for the Triptych Piece

The percussionist plays the piece using a variety of extended techniques to excite the string model. The model is controlled in real time using a standard MIDI controller to change various parameters of the model.
it demonstrates the benefits of the strong interaction between the physicality of the performer's gestures and the changing textures of the electronic sounds produced. Sonically it is extremely engaging as it explores the range of sounds generated from the extended percussion techniques exciting the physical model. The performer reported a deeper, more intuitive relationship with the sound when compared to a standard digital drum kit.

Dronebox contains a huge range of adjustable parameters including pitch, LFO rate and shapes, audio effects including delays and reverbs and a number of different pitching modes.

In the piece ‘Triptych’ we used two strings of the possible eight to add drones, sound effects and melodies to the percussion kit. After a long period of improvising with Martin the key parameters we were commonly using were mapped permanently to MIDI controls to allow quick, intuitive control of the plugin.

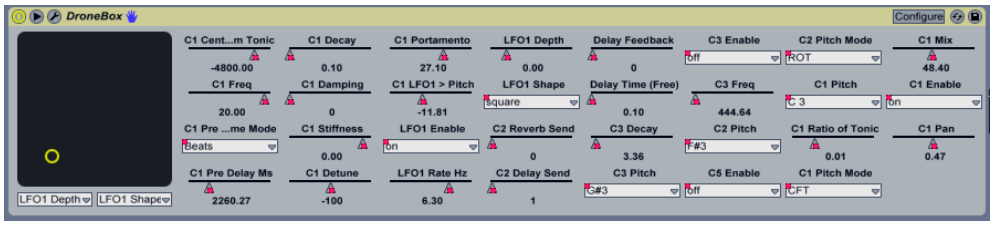

Figure 3: Screen–grab of mapped Dronebox parameters for ‘Triptych’

4. Transcript of an Interview with Martin Schureger, co–composer and percussionist

1. What was the composition process for Triptych?

Ben and I started by collectively improvising with me playing a small selection of percussion instruments: roto–toms, snare drum and bongos. As rehearsal sessions progressed, we refined the selection of instruments to just snare drum and two roto–toms and a large selection of traditional and non–traditional beaters.

By recording sessions we were able to listen back and filter out the better sections and build on those as rehearsals progressed. With quite long improvisations, sometimes just one idea came out, but this process allowed the later versions of the piece to be far more distilled. Once we had a good idea of what did and didn't work, we went through a similar process with structure, deciding on a loose order of events.

The piece is vary variable and will be very different in every performance, nevertheless we both have an idea of what we can achieve, so it is much more developed than an initial improvisation would be.

2. How did this alter to your usual process (if at all)?

This process of devising a piece through improvising and discussing was relatively new to me. I have done this before, but usually in a situation in which another musician takes on more of the 'composer' role and usually starting from a more fixed idea. Here, we were both inputting equally, although the idea of the piece – a work for solo percussionist and this specific patch – was Ben's.

3. How do you differ your playing technique when performing with the system?

Playing with this system, I felt the more varied the sounds were I put in, the more Ben would have to work with and the more interesting the end result would be. As such, I used a lot of non–traditional and extended techniques on the drums, as well as using a wide variety of sticks and playing with my hands. I was also aware of the positioning of the microphones, so the playing area would change depending on how much I wanted to be picked up: for example, really quiet sounds work well very close to the microphone.

4. What sounds do you like out of the system? How do you think this could be used by percussionists and composers?

All of the sounds have a lot of possibilities for both percussionists and composers. The nature of the system lends itself well to having an element of improvisation, as it is not entirely predictable: this is a great thing though. It could form part of any musician's toolkit of sounds for live shows or could form part of a more through–composed work. I don't think it is limited to any style of music, as you can get such different sounds from it.

5. Limitations of the system?

The limits of the system could be seen as the unpredictability of it; however, this is really a limitation that gives more creative possibilities. One issue is the huge array of sounds possible, and the need to know exactly what you want before starting, or make sure you have enough time to experiment and find what works. It's not a system that would work for a musician or composer who wanted a quick solution to something, it has instead to be learned like any instrument. (The same could be said for learning to compose and perform with any instrument or type of music...)

6. Future developments, what would you like to see?

This could work really well as a system which the player operates themselves. By assigning parameters to midi controllers (pedals, trigger pads, etc), this could form a natural extension to a percussion or drum kit setup, or indeed to any instrument. Making the parameters which are being controlled really understandable in a musical way would help too: i.e. a pedal which increases the amount of bass

frequencies, or something controlling the 'franticness' of the sounds. The more understandable it is in musical and sonic terms, the quicker and easier a musician could get on with using it.

5. Conclusion

There are many ways to approach the problem of augmenting percussion with physical modeling. However the approach I am taking currently with string models results in interesting and useable sounds suitable for composition and improvisation. Future work will involve the development of my own drum models to extend the range of the instrument with more realistic percussion sounds and a suitable interface with which to control the output of the model whilst playing drums. I am looking into using facial recognition and the Microsoft Kinect as possible options as a means of control by the musician. Further work will include more pieces and compositions and the development of a full plugin that can be used in hosts such as Ableton Live.

References

[1] Roberto Mario Aimi: Hybrid Percussion: Extending Physical Instruments Using Sampled Acoustics, Massachusetts Institute of Technology (2007)

[2] Michalakos, Christos: The Augmented Drum Kit: An Intuitive Approach To Live Electronic Percussion Performance
The Proceedings of the 2012 international Computer Music Conference (ICMC 2012), Ljubljan, 9–14 (September 2012)

[3] http://reidid.bandcamp.com/track/frrriction-i (accessed 7/7/13)

[4] Tindale, Adam R.: A Hybrid Method for Extended Percussive Gesture' Proceedings of the 2007 Conference on New Interfaces for Musical Expression (NIME07), New York, NY, USA, June 6th – 10th 2007