Using Juggling as a Controller for Computer-Generated Music: an Overview of the Creation of an Interactive System Between Juggling and Electronic Music

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Abstract: This work presents aspects that concern the relationship between juggling, music and programming, in the creation of an interactive system for generating and controlling electronic music through a juggling routine. Developing an interactive system between these areas suggests new paradigms in the creation of a juggling routine, as well in the creation of a music composition. In this work it will be discussed these paradigms and how the creation of this "New Interface for Musical Expression" (NIME) design affected my ways on thinking about juggling and music.

Key-words: Interactive systems. Juggling. Computer-generated music. NIME.

Usando Malabares Como Controladores de Música Gerada Por Computador: Uma Visão Global Da Criação De Um Sistema Interativo Entre Malabares e Música Eletrônica

Resumo: Este trabalho apresenta aspectos que dizem respeito à relação entre malabares, música e programação, na criação de um sistema interativo para gerar e controlar música eletrônica através de uma sequência de malabares. Desenvolver um sistema interativo entre essas áreas sugere novos paradigmas na criação de uma sequência de malabares, assim como na criação de uma composição musical. Neste trabalho serão discutidos estes paradigmas, assim como a criação desta "nova interface para expressão musical" (NIME, do termo em inglês) afetou a minha maneira de pensar sobre música e malabares.

Palavras-chave: Sistemas interativos. Malabares. Música gerada por computador. NIME.

1. Introduction

This paper is part of a research that became my undergrad thesis in 2014. This research started some years after starting studying music technology and having juggling as a hobby. This hobby started while working as a composer in a circus group, and through my juggling practice and chats with other jugglers I developed the interest on creating a system that would map juggling movements – a routine – into music in real time. This system would bring together the different qualities of juggling and music. But, before starting talking about the system, what is the concept of juggling?

> Juggling is the art of keeping objects in the air by throwing them from hand to hand in a controlled, rhythmical way. A very plain definition of juggling might be "keeping more objects in the air than you have hands. (AUSTIN apud WAGENAAR, 2009: pg. 5)

There are several types of juggling devices, like balls, rings, clubs, etc., but this work focuses only on juggling balls. A juggling ball has a uniform size and movement in the air, and it doesn't spin like a club. So, because of that, it suits well the motion tracking strategy presented further in the text, being the juggling ball a good juggling device for being transformed in a music controller.

2. Building an Interactive System

Several features of interactive music systems are appealing and interesting to me, for instance: what an instrument can do, how are the systems built, and how gestures and sound are mapped.

> Interactive music systems are used in many different contexts including installations, networked music ensembles, new instrument designs and collaborations with robotic performers (Eigenfeldt and Kapur 2008). These systems do not define a specific style – that is, the same interactive model can be applied to very different musical contexts. (DRUMMOND, 2009: pg. 125)

As Drummond says, it is hard to define exactly what an interactive system is. Rowe (1993), in his book *Interactive Music Systems*, defines it as:

> Interactive computer music systems are those whose behaviour changes in response to musical input. Such responsiveness allows these systems to participate in live performances, of both notated and improvised music. (ROWE apud DRUMMOND: 2009, pg. 125)

Drummond (2009) mentions that the definition in Rowe's book focuses on the responsiveness of the system, where the system listens to the performer and generates the music. In Rowe's concept the influence of the music on the performer is secondary.

Alternatively, my juggling/music system suits the *Interactive Composing* concept, made by Chadabe (1997).

> These instruments were interactive in the same sense that performer and instrument were mutually influential. The performer was influenced by the music produced by the instrument, and the instrument was influenced by the performer's controls. (CHADABE apud DRUMMOND, 2009: pg. 125)

An important concept of this work is the requirement of having the interactive system using juggling and music in a way that one is influenced by the other. A working hypothesis is that the interaction would bring new possibilities in the creation of a juggling routine. This said, unusual gestures and throws, that might not be so interesting in a regular routine, can become more interesting with an interactive juggling and music system.

> Critical investigation of interactive works requires extensive cross-disciplinary knowledge in a diverse range of fields including software programming, hard- ware design, instrument design, composition techniques, sound synthesis and music theory. (DRUMMOND, 2009: pg. 125)

In order to design an interactive system between juggling and music, as mentioned by Drummond, one needs to have a cross-disciplinary knowledge in a diverse of fields. Gathering

knowledge on juggling, music, and programming allowed me to trace parallels not only between juggling and music, but also to integrate them with a computer program.

3. The Software

One of my first concerns was on how I would translate the balls' action into computer data. I decided to use the software Max[1], from Clycling '74, for this purpose. Max offers real-time audio and video capabilities, making it the ideal programming environment, for me, for building my software.

After choosing Max to be the interface between juggling and music, I had to decide how the music would be synthetized. Although all the system could be done in Max, I decided to work with another software too, called Live[2], from the company Ableton. Live is a great digital audio workstation that allows one to easily work with loops and effects. Live also includes a tool called Max for Live (M4L), which bridges Max and Live. M4L allowed me to make things that I only could do on Max, but with the flexibility of Live.
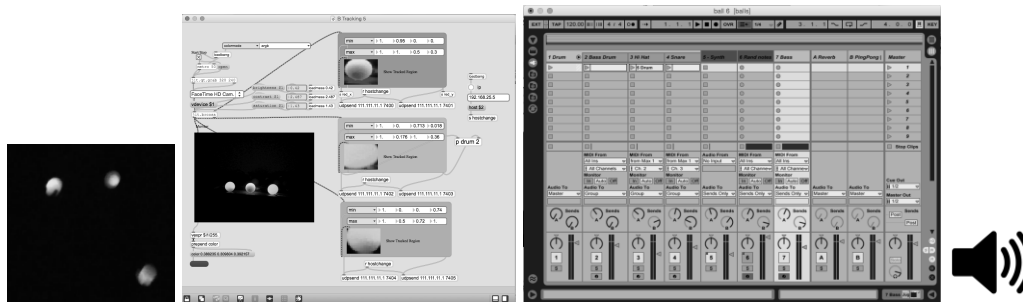

Figure 1. How the system flows: Juggling routine ‑ Motion Tracking inside Max ‑ Music generation inside M4L and Live ‑ Speakers. The details of each part will be discussed later on.

4. The Hardware

The hardware design starts by selecting the sensor technologies to track the balls' motion. Some of the options were camera, laser sensors, and contact microphones on the juggler's hands. I chose to use the camera, as it would allow me to continuously track each of the balls individually, instead of a discrete tracking provided by the other methods. Others advantages in using a camera are: it allows one to track several parameters at the same time in a juggler's routine, depending on how many balls are used; most of laptops have a built in camera, making it easier to other people to use the software. However, a camera has one disadvantage, on most computers it can't be controlled manually, it adjusts its parameters automatically, by default. To solve this

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problem a third party software had to be used. To have the control upon the built in webcam I used the software "Webcam Settings", which allows one to control parameters such as: exposure time, brightness, hue, contrast, etc. This way, a configuration in the camera can be done, accordingly to the environment situation.

The type of ball was chosen taking into account how the motion tracking works. To track each ball separately it is needed that each one has a different color. The motion tracking works on tracking specifically colors, so, for this purpose, glowing balls showed to be the most reliable devices. Just having glowing balls in the dark, without a background or other colors that might be tracked by mistake, makes a safer way to work with the motion tracking system.

In the next chapters it will be discussed some techniques and concepts used to build the software, the music issues involving in developing the interactive system and the hardware used.

5. An Overview of the Interactive System

The Max patch is responsible for three things: tracking the balls' positions in the air, mapping it to numbers, and sending it to Live. Then, these are used as musical parameters.
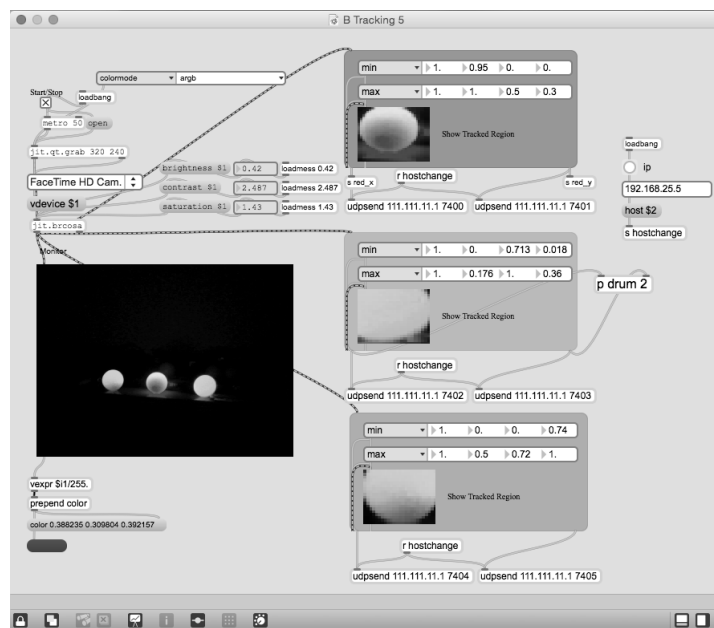

Figure 2. The main window of the Max patch. In the left it can be seen the camera's monitoring and in the right three boxes, each one monitoring each ball separately.

The balls' positions are tracked continuously and mapped into numbers. Then, those numbers are sent to different modules, each module being responsible for creating one layer in the overall sound, like one musician in a band. Each module has one different algorithm, which makes it to generate certain notes and rhythms. My intention was to create "virtual musicians" that would

play with me, each one with its own characteristics, where their musical decisions would be done related to my juggling movements. There are four modules, which can be used one with each ball: The "Drummer", for percussive sounds, the "Basser", for the bass sounds, the "Melodizer", which creates melodies, and the "Theremizer", that works and sounds similar to a Theremin.

6. Mapping Juggling Into Music

To map juggling into music, the first step was transforming the balls' position into data. I decided to collect three different parameters from each tracked object: position in the Y and X-axis and the speed. In order to that, I used an object from the Jitter library, from Max, called "jit.findbounds". It looks for a range of alpha, red, green and blue values on the screen, which is decided by the user. For example, in order to track the color red, one has to type the minimum and maximum of red, green and blue, for the desired hue, in a range from 0-1. Once the range is told, it will look on the screen where those pixels are located and it will create a quadrilateral around the area that they are present. The object "jit.findbounds" will give the position of each bound of this quadrilateral. With a ball, the quadrilateral will be a square, and the center of this square, will be the center of the ball. Through some calculation it can be found the exact center of the ball, having its Y and X position. Subtracting the value of the position of the ball in a moment, with its value some milliseconds later, will give its speed, so, the faster the movement, the bigger will be the difference.

A motion tracking system could be used for a variety of applications, but how it could be optimized for juggling? In order to create a system that would be more idiomatic for juggling I focused on mapping certain juggling gestures into certain analogue music gestures, based on personal opinion.

A feature that was added in the latest version of the software was the "mapping" one. It allows the user to map the Y, X, or speed data, to any mappable device in Ableton Live. For example, I can map the X position of a ball to a lowpass filter in a drum loop, the Y position to its "Q" and the speed to a distortion dry/wet.

One of the modules, the "Melodizer", creates melody lines like in a continuous improvise. This module has several parameters which can be mapped by on ball data, such as rhythmic division, pitch range, note length, etc. So, an option that worked well for me was mapping the Y position to the pitch, so as higher the ball is, the higher are the pitches of the notes.

One thing that is very "idiomatic" in juggling is throwing the balls in different heights.

The software has a feature that sends a midi note each time that the ball reaches a certain height. With that, the user adjusts the height threshold, so, every time the ball is thrown above it, a midi note will be triggered, like a "cymbal", for example.

With the "mapping" feature several kinds of mappings can be made. For me, the pitch is related to the height, but for another user, it can be the Y-axis, it's really a matter of taste, what suits better your music and juggling style.

7. Concerns About Creating a Juggling/Music NIME

Creating a system to track the ball's motion was the easier part to do, however, translating this information into an aesthetically interesting juggling/music routine turned to be the more difficult. There will be always three values for each ball, the X and Y position in a 320x240 pixels space, and the speed. But, what to do with these values? Before deciding the overall sound, tone, style of music that I would like to have, many tests were made. I created different modules, each module being responsible for creating a different layer in the final musical result. At first, I did some simple synths that could work as "melody layers". The first one was a sine wave, with another sine wave controlling its phase, which, later on, became the "Theremizer". The Y-axis controls the pitch in the range [20, 1000] Hz, from bottom to top. The phase is controlled by the X-axis, ranging from 0 Hz to 30 Hz, from left to right. Also, the X position controls the panning. This way, using this synth in the interactive system can be a clear way to show that the synth is being controlled by the balls' motion. This module was interesting on using in one or two balls at time, however, when adding a third one, the result was not as good as before. While doing a Cascade[3] trick, with three balls, for example, the balls' movement are continuous, with ups and downs, making the system to generate continuous up and down *glissandi*, leading to a sound that I didn't wanted

The sound of three balls doing *glissandi* doesn't work well for what I want, but juggling is not restricted to three or more juggling devices. At this point in my research, I realized that I was too attached to what I knew as juggling tricks and decided to go some steps back in my juggling technique, experimenting with just one or two balls. For my work, building an interactive system between juggling and music is not just related to tracking a juggling routine and mapping it to music. It is, indeed, the creation of a NIME (New Interface For Musical Expression), requiring the discussion of the intersections between music and juggling, opening possibilities for changes on my music and juggling practice. Keeping that in mind, I tried to use the juggling balls as they were

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[3] The Cascade trick is one of the most basic juggling tricks. The Cascade consists in throwing each ball to the other hand always in the same height.

equally important as juggling device and as music instrument, discovering the peculiarities that this NIME would bring to my music and to my juggling routine.

8. Conclusion

These paradigms brought by the NIME's creation reveals the need for a new kind of performer: the "musician juggler" or the "juggler musician". This performer will, probably, be closer to one of the practices only. But, one will need to have both qualities for making a good routine with this device. Good musical qualities will not guarantee good visuals, as well as good juggling qualities will not guarantee good music. Therefore, a juggler would need to know music, as well as a musician would need to know how to juggle. Throughout the years, most of the jugglers that I have met had a very strong musicality. Some of the jugglers were musicians before they started to juggle, like me. For several reasons, juggling is closely related to music, due to its very rhythmically patterns, that can easy be related to music, for example. This relation can motivate musicians to learn how to juggle and jugglers to learn how to make music. So, building a device that is both juggling and music instrument seems to be a good idea for those that work with both arts.

Building a software may be an endless task. Each time that I work with it I find a new possibility, or even a new bug, things that make me want to continue to develop the software. The software is continually being updated and can be downloaded in my website. http://www.gustavosilveira.net/#!-----/c6qh

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