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INTEGRATING MUSIC AND MARTIAL ARTS

An Interactive Qualifying Project Report

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by

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2. music
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Abstract

The integration of music and martial arts was accomplished using electronic sensors, computer software, and synthesizers. The sensors detected body movement, the software translated the readings into MIDI information, and the synthesizer produced the final music. The project emphasized how to use the computer software to interpret the sensor readings. Two methods of creating the music were studied and compared.

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Introduction

Musicians have been experimenting with digital music and synthesizers for over fifty years now. A recent interest has been in developing new digital music instruments to be used in live performances. One development is that of hyperinstruments, which enhance common instruments like guitars, keyboards, and cellos. Another area of research is designing systems that allow a person to manipulate sounds and music by using sensors which detect movement and gestures. This would allow a performer to move freely while producing music.

I am interested in how I can use the current technology to produce music. However, since I am not a musician, my performance will be an abnormal one. Having studied martial arts for the past seven years, I have developed a great love for live martial arts performances, including competitions, skits, and demonstrations. A special interest of mine is choreographing a series of techniques into a kata and synchronizing it with music. In these performances, I have taken an already created piece of music and placed techniques in correspondence to the music. In this project, I have done the opposite. As I performed techniques, the sensors detected my movements, and then the resulting signals were mapped to digital music. This resulted in a martial arts kata being synchronized to music, a similar result to what I had before.

In order to test whether I have been able to successfully generate music through my movements, the performance has been video taped. A successful performance will result in a well-performed martial arts kata accompanied by a rhythmical music piece. An additional goal is for the music to mirror the kata in style, feel, and emotion.

There are two methods to be tested in the creation of the music from the martial arts techniques. The primary method is to have each signal from the sensors directly mapped to one specific sound. Thus the series of movements combine to create a series of notes and ultimately the music. The other method is to allow the movements to generate their own music based upon when and how I move. Each movement still creates its own sound, but the sound heard is dependent upon sensor values. I hope to discover which method is more effective for me to produce a quality performance.

Background

An electronic musician uses an electronic device to create music. More common devices resemble normal instruments like guitars, keyboards, and violins. It does not always resemble a common instrument, but the body is often made into the instrument. The musician's gestures can be determined by mechanisms reading body locations and movements. These gestures and movements have various ways to be translated into musical impressions.

One such tool is called the MidiDancer and was developed for the Troika Ranch dance theatre company. They desired to give the dancers more control of the visual and sonic elements of the performance. Their goal was to create a more direct connection from stage performances and the media accompanying it (Coniglio).

The MidiDancer used eight joint sensors that measure the degree a joint is bent. A dancer wears a wireless encoder and transmitter, which relays MIDI messages to a receiver. From there, the data is verified and passed onto a MIDI controller. The MIDI controller translates the data into prerecorded samples, volume control, and/or video signals (Coniglio).

The Troika Ranch dance theatre company has been performing since 1993. Their first performance with the MidiDancer was an eleven minute production in 1994 called "In Plane." The MidiDancer was used to recall video images of the dancer, as well as generate music and control theatrical lighting. In one part of

"In Plane," the dancer controls a six part rhythmic counterpoint, volume of each part being controlled by a limb. If she stands in a neutral position, almost no sound is heard. But as she moves and bends her limbs, the music becomes more noticeable (Coniglio).

The BodySynth is a wireless MIDI controller used to trigger music and lighting effects. It uses at least four muscle tension detectors (EMG) which are worn on the dancer's body. Signals from the EMG are collected in a small body unit before being passed over a wireless transmission system. The signals from the EMGs and other inputs are translated into MIDI messages, such as note on, pitch bend, panning, and other continuous controllers. Laurie Anderson, Pamela Z, and the Cyberbeat Brothers (Chris Van Raalte and John Zane-Cheong) have performed with the BodySynth (Marrin).

The first attempt by a large company to produce wearable musical devices was made by Yamaha. They created the Miburi, which was a stretchy cotton shirt with bend/flex sensors, two handgrip units, and a belt unit. The handgrip units consist of two velocity sensitive buttons on each index, middle, ring, and pinky fingers, and a see-saw key on each thumb. The combined effort of simultaneously moving a joint and pressing a button generates the musical notes (Marrin).

Chris Janney designed a musical system that amplifies and sonifies the natural electrical impulses that stimulate the heart to beat. A solo dance, which is a combination of choreographed and improvised monements, is performed.

Musical text, jazz scat, and classical music pieces are laid over the amplified heartbeat sounds. A recent performance has done by Mikhail Baryshikov, entitled "HearBeat:mb." (Marrin)

Laetitia Sonami performs with a device called the Lady's Glove, which is two gloves made of thin Lycra mesh and containing switches, sensors, and resistive strips. Laetitia's performances resemble South Asian mudra and sign language and use samples, frequency modulation, and additive synthesis (Marrin).

Integration

I have attempted to broaden the realm of interactive music to include martial arts performances. The music heard during my performance is a direct result of the movements I make.

The artistic side of martial arts is demonstrated in forms (called hyungs or katas in some styles). Traditional forms are taught to students in order to practice specific movements in a pattern replicating an actual fight. Forms were designed so that the student could practice their techniques without needing another individual. In order to advance in rank, a student is typically asked to perform the forms he knows as an example of his skill. In addition, forms are often used in competitions where individuals perform a form of their choice and they are judged on the accuracy of the form and the quality of the techniques. Another competitive event allows students to perform traditional or creative forms that are set to music. For creative forms, the competitor picks a musical piece and then will often choreograph techniques to match the music. The combination of physical and musical movements creates an entertaining piece of art.

The style with which I have the most experience and which I use in this project is TaeKwonDo. General Choe created this Korean martial art in the 1940s. Since then it has grown to be one of the most practiced style in the world.

Powerful discrete movements, especially with kicks and aerials, characterize TaeKwonDo. Using sensors to detect the movements is made easier because the movements are powerful and discrete. A softer style, such as gong fu, may have difficulties in detecting movements.

Initially, I chose to integrate a traditional TaeKwonDo kata with music. A longer form that contains a variety of movements and looks good in a demonstration should be used first. For this reason I started working with a form called Gwang-gae. It is the first form a student learns after achieving black belt, and thus it contains more variation than earlier learned forms and its greater complexity makes it a good demonstration piece. Gwang-gae contains thirty-nine movements, including punches, kicks, and numerous kinds of blocks.

From this point, I needed to compose a musical piece to be produced by the movements. My primary goal in the composition was to mirror Gwang-gae with the music. I did this by creating a note for each limb that was moving, and thus a chord if a movement involved more than one limb being used. The time it takes to make the movement was also considered in the composition. Later, loudness, pitch bends, and panning were added to enhance the sound.

Now that the artistic ends were covered, the technology needed to be dealt with. The first side of the technology was the hardware, an I-CubeX System by Infusion Systems. The I-CubeX digitizer receives signals from sensors. The sensors react to some sort of stimulus, whether it is light, touch, rotation, or linear movement, and the digitizer translates the data from the sensors into MIDI signals. The sensors used in the project are called GForce. They are small (2.25" x 1.5" x 0.75") devices that sense acceleration and deceleration. The single wire running from it connects to the I-CubeX digitizer.

A computer program called Max then interprets the signals from the I-CubeX. Max uses a graphical object-oriented programming language. It has numerous capabilities, especially being able to send and receive MIDI signals. In addition, it is capable of computations and logic. Each program is created in what is called a patch. An I-cube object in the patch allows the program to interact with the I-CubeX digitizer. The MIDI signals from the digitizer can be read as outputs from the I-Cube object. These values can then be sent through a series of other objects and messages, arranged in an algorithmic design that creates the desired result.

The first few patches I created were simple and were geared more towards getting the I-Cube to work with the software and trying to understand the behavior of the sensors. One early issue I dealt with was the timing of events. I did not want everything happening at once and creating just a steady stream of notes being produced. I limited the length of each note to 50 milliseconds and decreased the interval at which the digitizer read from the signals to 200 milliseconds. A metro object was also used to limit at regular intervals when outputs from the I-cube object are passed onto computations. Another timing issue was when signals from more than one sensor tried to pass through the same objects at the same or close to the same time. This often caused at least one sensor to not have its data translated. A simple resolution was to have each output from the I-cube object be translated by its own algorithm. This became very important later on.

I was now ready to begin to take the results from the sensors and translate them into the music that I had composed. In order to do this, I created a table that shows each limb, its movement, and when it is done. This table can be seen in Appendix A.

Next, a method to follow a score was needed. Each time a distinguished movement has been detected, the software would play the next note in the composition. Each output of the I-cube object must have its own score following process; so as to not lose data as was discussed earlier. Since the score following algorithm takes up a lot of space, and it needs to be used by more than one output, I created a subpatch for each output. The subpatch behaves just as a normal patch; it's just a subroutine of the master patch. It conserves space and allows for simple reuse.

To do the score following, I used a counter and a series of gates. The counter is incremented each time a movement is detected. Once the counter is adjusted, the new value is sent to the gates. Gates allow inputted data to pass only to the specified output, and which output is determined by the value of the counter. Each output of the gate causes a note to be played. This note will continue to play until just before the next note is played.

The final adjustment was to modify what qualifies as a distinguished movement. The sensors will read 64 when at a perfect stillness. My original design had all readings above 85 qualifying as a movement. Unfortunately, this did not account for movements in the other direction that cause the reading to decrease. I added all readings below 22 to also be included. These readings worked most of the time but not always. When I made a movement but no note was played, it was found to be distracting to an audience member. I decided to lower the threshold values to 75 and 35. Unwanted note calls result from the lower threshold, but this is believed to be more pleasing to the audience than missed calls.

The second method I used for creating the music did not rely upon a previously composed musical piece. Instead, the musical composition was unique to each performance because the sounds generated were based upon mathematical computations done with the sensor values. Synthesizer sounds were also changing throughout the performance, and never did two performances use the same sounds.

The numerical value resulting from each sensor's movement was the basis of all the computations used to create each sound. First, each time a sensor value passed a threshold (threshold values were similar to those used in the first piece), a counter was incremented by one tenth. This counter was used to iterate through the sixteen channels on the synthesizer, each of which had its own patch (A patch is a synthesizer sound used to replicate a real or unreal sound).

Second, sixty-four was subtracted from the sensor value, which is between 0 and 127. The absolute value of this result was used as the velocity at which the note would go on. Lastly, seventy-five was subtracted from the sensor value, and the absolute value of this result was the note value. If this value was less than 46, the volume was increased to maximum, 127; otherwise the volume remained at 64. This was done to compensate for lower pitch sounds not being as loud. The final effect I made on this was to have all sounds from the sensor on my left hand by panned to the left speaker, and vice versa.

The resulting performances from these two pieces were rather unique. The first one was often difficult to follow because it seldom worked completely. Notes were not always happening when they were intended, and it lost much of its original intentions. The second piece, however, was more successful. Even though the kata was very basic and repetitive, the constantly changing synthesizer sounds kept the audience intrigued. Additionally, since no notes could misfire, there could be no compositional mistakes. The only problem occurred when I chose synthesizer sounds that had a long sustain. These sounds would continue to play and often drown out any newer notes played. When good sounds were chosen the randomness of the music worked well and created an interesting interactive musical piece.

Conclusion

The project should clearly have an effect upon the interactive music society. Since no previous work with martial arts is found, my studies broaden the number of ways to perform live electronic music. Dancing is often used as an instrument for control of the live media, but this project shows that martial arts can also be used. Other forms of physical expression could also be used.

In addition, I have also shown possibilities in how to map the physical gestures to the music. This leads to implications of my project that extend beyond the music realm. I have mapped my movements to music, but the resulting effect could be used to control almost any type of machinery or electronics. Perhaps a fighter pilot could use it to control the jet or its weaponry. Another possibility is for use by the handicap. A wheelchair bound person could use it to control direction and speed of the chair. Or a bed bound person could use it to change the channel on the TV or call for help. Higher accuracy will be needed if this is to be used in everyday use or in high-risk situations. But the possibilities are endless.

Bibliography

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Appendix A

The table shows the number of the movement, which limb performs it, the name of the movement, and the MIDI note value associated with it.

	Left Hand	Right Hand	Left Foot	Right Foot
1	ready 69	ready 76	ready 83	
2	64	upset punch 71		
3	upset punch 74	77		
4		hooking block 69		
5	low knife hand guarding block 69	76		
6	hooking block 76			
7	69	low knife hand guarding block 76		
8	knife hand guarding block 71	77		
9	72	knife hand guarding block 79		
10	upward palm pressing block 69			
11		upward palm pressing block 72		
12	71	low inward block with knifehand 77		
13			middle side piercing kick 64	
14			high side	

			piercing kick 64	
15	64	inward knifehand 77		
16	downward hammer fist 71			
17				middle side piercing kick 64
18				high side piercing kick 64
19	inward knife hand strike 64	77		
20		downward hammer fist 71		
21	upward palm pressing block 69	downward palm pressing block 79		
22	downward palm pressing block 65	upward palm pressing block 76		
23		back fist 64		heel stomp 64
24	64	forearm guarding block 77		
25	low block 71			
26		spear hand 67		
27		back fist 64		heel stomp 64
28	64	forearm guarding block 77		
29	low block 71			
30		spear hand 67		

31	inward punch 69	inward punch 76		
32	upset punch 67	upset punch 74		
33				front kick 71
34		knife hand forearm block 67		
35	inward punch 67	inward punch 74		
36	upset punch 69	upset punch 76		
37				front kick 71
38	knife hand forearm block 69			
39		high front punch 60		