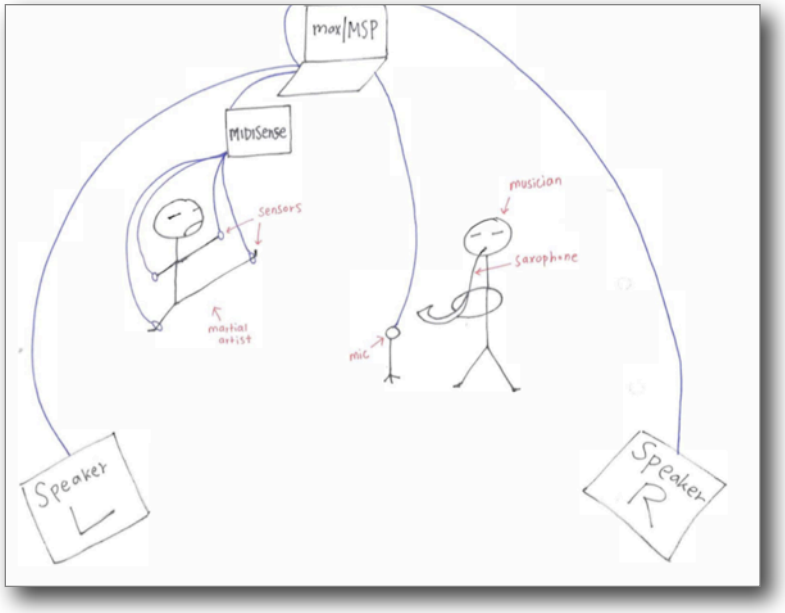
ACCELEROMETER-MIDI INTERFACE

FOR DANCERS OR MARTIAL ARTISTS AND MUSICIANS



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• Motivation

Since every composer has different interests and ideas about what music should be composed and sound, there can be no axiom for contemporary music. However, regardless of the composer's stylistic taste, the process of musical composition involves intentional or unintentional control[1] of various musical parameters, which include frequency (pitch), amplitude (dynamics), speed (tempo), and sound color (timbre). More importantly, but from a less technical perspective, music may also encompass one's cultural background, emotions, knowledge, social and political stance, and personality among many other things. Thus, all aesthetic discussions which will be made should only be accepted as personal statements.

I, as a composer, am very interested in keeping high energy and momentum throughout the duration of the piece. In the process of making music with high level of energy, I discovered that some basic laws of physics can be applied to musical parameters. For example, frequency acts like gravity. High pitches seem to have more energy than relatively lower pitches, and a sustained high pitch stores energy - just as an object held in high altitude has potential energy - which creates an agitation for the listeners. If the high pitch falls rapidly, it creates kinetic energy just like a falling object. Also, faster passages, louder dynamics, and dissonance generally have more energy than their counterparts. Furthermore, if a passage maintains a constant high energy, it accumulates energy, which then transfers to a local or global climatic state. However, when any kind of constant state persists for a certain period of time, regardless of its energy level, a dissipation of energy may occur, which can translate into boredom, or more positively, a quiet state of mind. How much energy is accumulated or dissipated depends on such musical parameters and their associated energy levels, how their are coupled with each other, whether changes have been made gradually or abruptly, what kind of expectations preceding passages created, and whether the composer follows or contradicts the expectations. This is a rather complicated subject since there exists many variables and their couplings that can make difference. This is an area which all musicians and listeners are aware of at least on a subconscious level, but has not been studied in any detail.

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[1] Even John Cage ended up controlling all musical parameters from his non-intention.

I was fascinated by the idea of mapping actual physical energy with musical energy, some of whose relationship exists only conceptually - such as the relationship between gravity and frequency. Thus,from my aesthetic standpoint, taking the actual physical quantities such as acceleration and using them as the tool for changing musical energy was a very intriguing topic.

On the other hand, the relationship between music and dance - or any kind of physical movement for that matter - throughout the human history is indisputable. The inspiration, however, does not come from the well-known historical fact. Rather, I was fascinated by the instances where these two closed-related but disjoint entities, music and dance, conjoin to become one. For example, when a tab dancer dances, her shoes play a role as percussion instruments, creating movements that are not only visible but also audible. A less obvious example would be performance practices where the gesture of musicians change the way audience perceive the sounds. I wanted to take this idea further and to create music that translate the physical movement into music, in order to create a dance we can hear, and a sound we can see.

• Construction

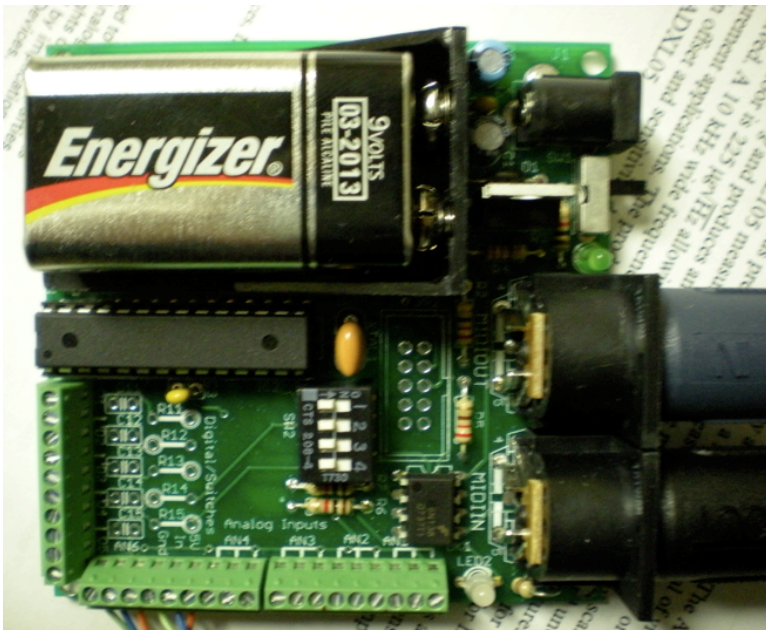
Live sound processing and MIDI interface construction are the areas that are well explored. However, like most other fields where two areas combine, some problem persists. The people who are capable of making such interface are engineers with high interest but limited knowledge about music, and the professional musicians who are interested in electronic music simply do not have sufficient background to understand how such device works. Thus, the purpose of developing the accelerometer-MIDI interface is to gain some basic understandings about the construction so that I can create a versatile devise for multiple purposes and compose electronic music that is artistic and meaningful.

1) Interface

The starting point was to purchase a kit to make a MIDI interface. Since any kind of circuit design was out of my league, I resorted to a ready-to-be-assembled kit made by Limor Fried[2], which came with a

[2] Visit the website http://www.ladyada.net to find out more about Limor Fried and MIDIsense. This is one of the many interesting project done by Ms. Fried, and she has very detailed explanations about all her projects.

printed circuit board, capacitors, resisters, a programmed micro-controller, and all necessary parts which can be soldered and used. This interface simply takes some variable voltages from the sensors attached to it and sends them out as CC (Continuous Controller) values in the MIDI signal. The interface takes up to 11 sensor values at once and each of them can be assigned different CC numbers. Once I can get the sensor values as a form of digitized signal, I can easily have them control whatever musical parameters I wish in Max/MSP[3]. The only problem I had was the software Limor Fried designed to calibrate and assign CC numbers for the sensors was not updated for current Mac. The latest version only existed for PC and she simply had no time to develop one for mac any time soon. After a short trial and error period, I soon found a temporary solution. The interface can be used in Macs after being calibrated using a PC.

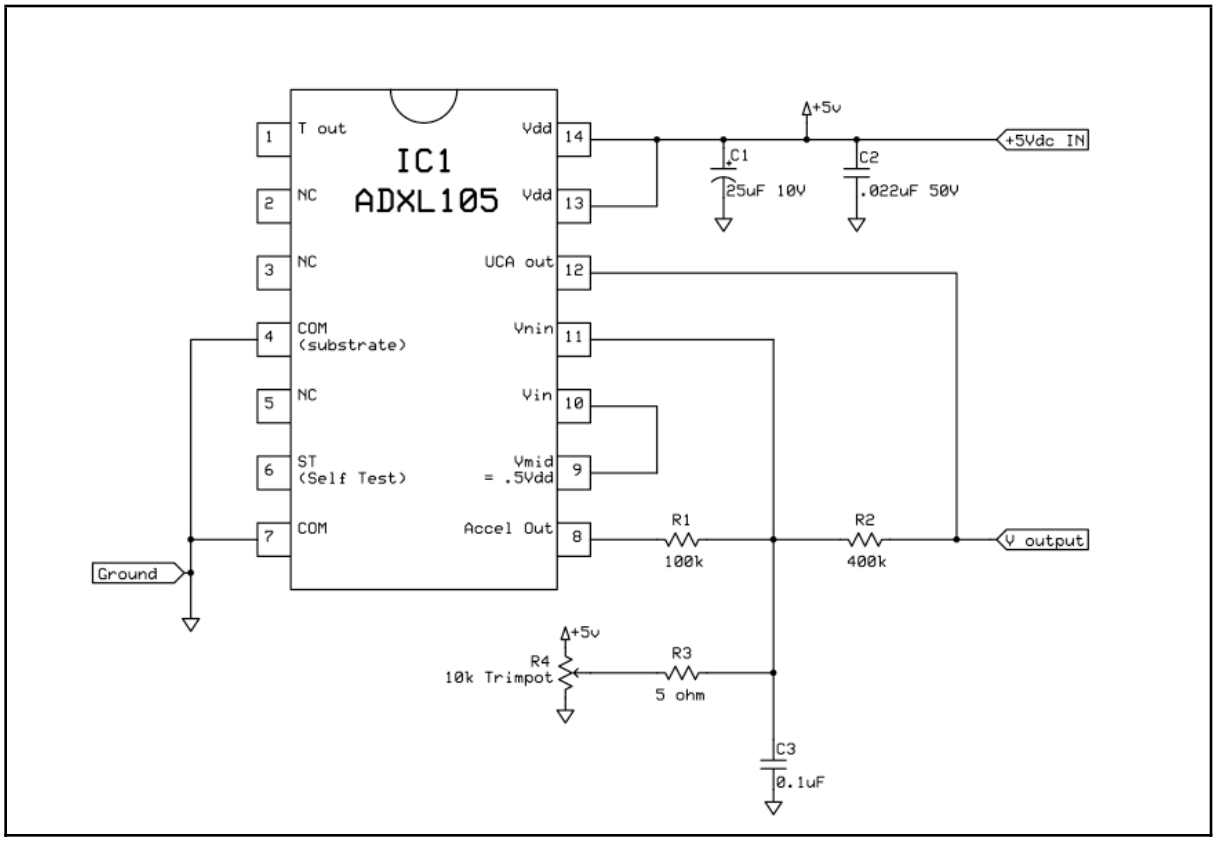


[Figure 1] MIDIsense Adio kit assembled

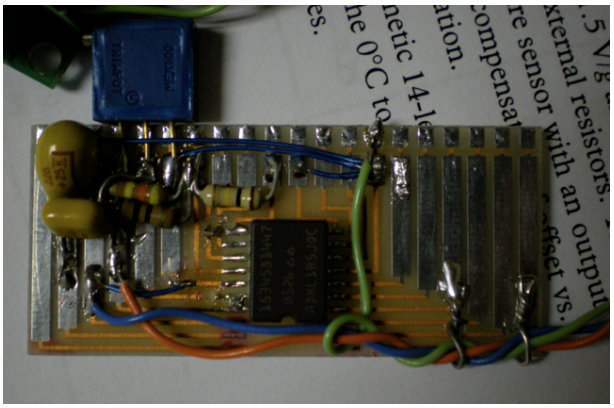
2) Sensors

There exists numerous kinds of sensors that can be used with the MIDIsense interface. I have only tested it with potentiometers and accelerometers, but according to the designer, some types of distance sensors, ribbon controllers, temperature sensors etc. can be used. Since I was interested in translating kinetic and potential energy of physical movement into music, accelerometers were the best choice for me. It turns out there are so many kinds of accelerometers that figuring out what works well with my purposes was not a simple task. I referred to Texas Instrument Accelerometer guide to learn the basics about

[3] This software is developed by Miller Puckette and is a commonly used among musicians for live and studio sound processing. For more information, visit http://www.cycling74.com.



[Figure 2] Accelerometer Schematic



[Figure 3] ADXL105 assembled

[Figure 4] E-mu MIDI-usb connector

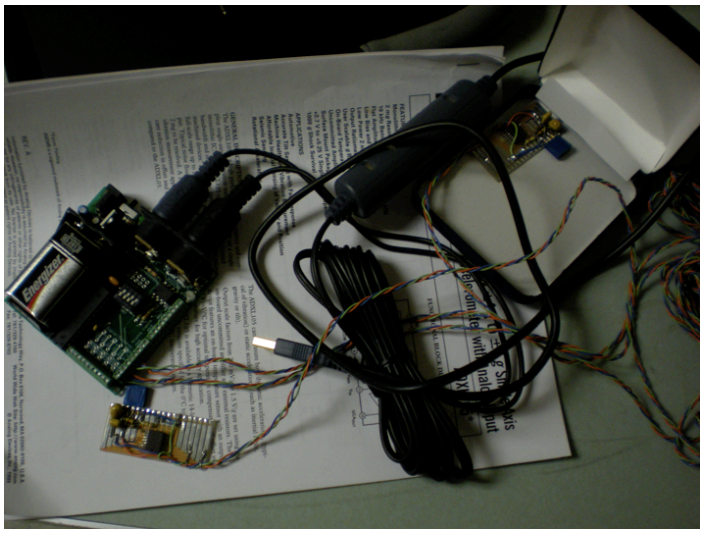
accelerometers.[4] Then, professor Errede from physics department from the choice of accelerometer to the circuit design. See figure 2 for accelerometer schematics.[5] ADXL105 is a single axis accelerometer which responds to both static and dynamic accelerations. The sensitivity can be calibrated from ±1g to ±5g, which was a more than enough range for any kind of human movements I would be using. It is low powered (2.7-5.25V), which made it work with MIDIsense which accepts variable voltages up to 5V.

[4] TI accelerometer guide can be found here. http://www2.usfirst.org/2005comp/Manuals/Acceler1.pdf, http://www.dimensionengineering.com/accelerometers.htm is good as well.

[5] Steve Errede, Alan Carter, Rev. 1.0, 4/14/2009

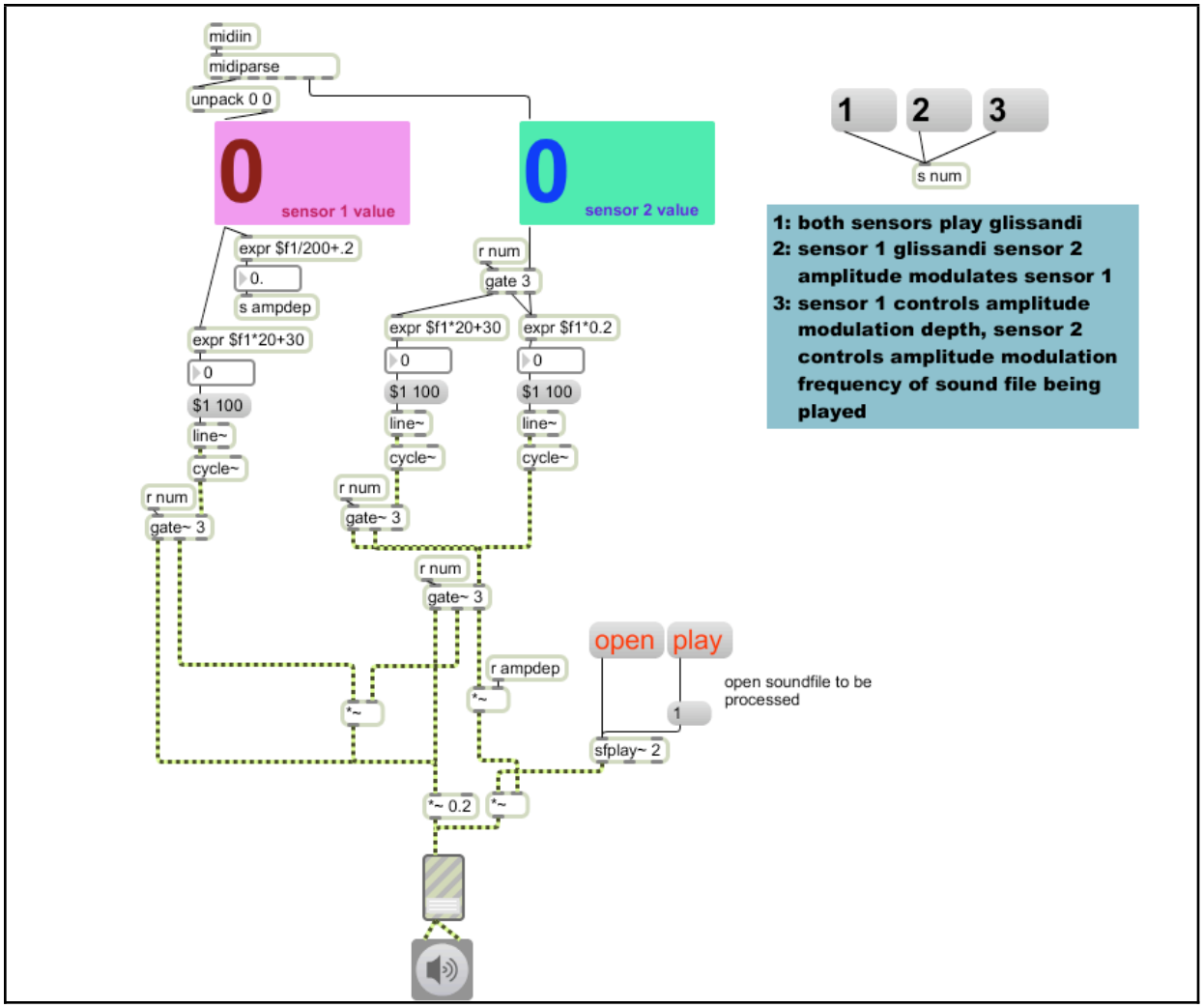
3) Connector

Last step was to purchase a MIDI to USB cable since most laptop computers do not have any MIDI-in/out port. One of the cheapest ones that also works is E-mu Xmidi 1X1 USB MIDI interface which I bought for $30.[6]



[Figure 5] Accelerometer-MIDI interface

4) MaxMSP demo



[Figure 6] MaxMSP Demo

[6] http://www.emu.com/products/welcome.asp?category=610

With the interface and sensors connected to USB, I can accept the sensor values as a digitized signal in MaxMSP. In this case, the sensor values from two connected sensors send Continuous Controller values in the MIDI signal to two separate channels. [Figure 6] shows a simple MaxMSP patch that has three presets. For preset 1, both sensors control the frequency of sine waves such that moving sensors will create two-part polyphony of glissandi[7]. Preset 2 has the sensor 2 assigned to amplitude modulate sensor 1 when sensor 1 still plays sine wave glissandi. Last preset is set up so that any sound files can be opened and controlled by the sensors; sensor 1 controls amplitude depth, and sensor 2 controls the frequency of the modulator.

• Composition

The continuous controller values will be used in two different ways: to generate their own sound and to control the sound played by the musician. The accelerometer-MIDI interface is versatile and can be used for any instruments and with many different types of sensors. However, the actual musical composition should utilize any possibilities inherent in the choice of instrument, the sensors, and software.

For this particular project, I am working with percussion instruments and accelerometers. Non-pitched percussion instruments generally have rich inharmonic contents that can be amplitude-modulated and filtered to create interesting sounds. Also, many pitched percussion instruments can be bowed to create long notes so that slow processes by tilting of accelerometer can be implemented. Also, any sounds with sharp attacks with short resonances are good source material for delay process with feedback.

The first part of the piece is played just by the dancer. Each of the sensors will control frequency of the resulting signals and every movement will create a series of glissandi. Since we have two sensors, each of them will have different values creating two-part polyphony - as preset 1 in the demo program. Although the actual waveform will be predetermined in the software, the resulting sound will be similar to that of a theramin.

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[7] 'sliding' of pitches by gradually changing frequency. Musical term for pitch bend.

After a short opening passage by the dancer is introduced, the musician *sneaks in* by playing some long bowed notes that are similar to what the dancer had been playing. At this point, the dancer, instead of producing her own sounds, starts to control the sound made by the musician. The main processes to be used are amplitude modulation and equalizer. The slow processes in the beginning will gradually get faster as the dancer increases the speed of her movement and the musician decreases the duration of notes and increase the density of events.

In the last part, the sharp attacks generated by the musician will create a series of feedback delay, whose feedback level and frequency will be controlled by the dancer. At this point, multiple processes can be coupled with the sensor values to lead to some kind of climax, after which the first part returns with some distortion and changes.

• Project Direction

The most important step to be followed is to make the interface and sensor board less fragile to allow more aggressive movements. Then the actual musical composition with effective processing software, and performance should follow. Once the accelerometer, percussion, and dancer coupling is proven effective, I would like to try the MIDIsense with other sensors, instruments, and martial artists. Furthermore, this interface can be attached to the musician directly so that the musician can play both the sound and movement.

• Acknowledgments

I would like to express my gratitude to Professor Steven Errede for lots of help and suggestions. Since I am mainly a musician with a very limited knowledge about electronics, all circuit design and schematics were done by the *real* scientists. This project would never have been possible without these people. Thank you to Limor Fried for Midisense design, and to Steven Errede for accelerometer schematics.

- Useful links

Limor Fried website
http://www.ladyada.net

MaxMSP
http://www.cycling74.com

Texas Instrument Accelerometer Guide
http://www2.usfirst.org/2005comp/Manuals/Acceler1.pdf

MIDI-USB connectors
http://www.emu.com/products/welcome.asp?category=610

ADXL105 Specifications
http://www.analog.com/en/mems-and-sensors/imems-accelerometers/adxl105/products/product.html