During the Fall 2004 semester I took my sabbatical leave to complete a prototype for a real-time computer music gestural control system. I had previously designed the hardware following research that I conducted as part of a study grant awarded in the Summer of 2003. I was able to complete two prototypes of the gloves during my sabbatical and I was able to make use of these prototypes for several concert performances as well as one new composition. I wrote a paper based on this research that was submitted and accepted to the national computer music conference run by the Society for Electro-Acoustic Music in the United States (SEAMUS).

To accommodate upcoming performances I altered my timeline initially to allow me to build a prototype glove earlier than my proposal indicated. I spent much of September researching gloves and construction materials as well as constructing a right-handed glove for use with flute. I used this glove for performances of my real-time flute and computer piece *Catalyst*. These performances were held in Portland and San Diego at the New West Electro-Acoustic Music Organization international music festival September 25 and October 2, 2004. I was also able to use this prototype for a lecture-recital at Eastfield Community College on February 16, 2005.

In October I began building the two-hand version of the gloves. I also began refining the software portion of the interface to allow for motion tracking, sample playback, looping and granular synthesis. I was able to compose a piece with the new prototype titled *Plastique*. I performed this composition as part of a solo recital that I put on at the Center for Experimental Music and Intermedia, which is part of the University of North Texas’ College of Music on October 25, 2004. I also gave a lecture (one of two) earlier that same day to composition majors about the design and construction of the data gloves. All of the elements of the prototypes hardware and software were working; however, the demands on the computer’s CPU were so great that I had to be selective about how many simultaneous tasks were to be performed. For instance, it was impossible to run granular synthesis routines at the same time as multiple sample playback. In addition, I found it necessary to use two-dimensional rather than three-dimensional motion tracking for this same reason. I have included the recital program information following this summary (pages 3 ~ 4).

Following the UNT recital I prepared a paper based on this research, which I submitted for consideration to the 2005 SEAMUS conference organizers. This paper, as well as my eight-channel composition, *Cognitive Dissonance*, was accepted for inclusion on the conference, however, due to an illness I was unable to present my paper at the conference in April 2005. Fortunately, my composition was performed in my absence. I plan to resubmit the paper for consideration at the 2006 conference. A copy of this paper follows this sabbatical summary (pages 5 ~ 9).

In early November I attended the International Computer Music Conference where my eight-channel composition *Clique* was being performed. I was able to attend many paper sessions and computer music concerts throughout the weeklong conference that contributed to my knowledge of real-time interfaces for gestural control of computer music.

Following the conference, I continued to refine elements of the data gloves and accompanying software while I also began researching hardware and materials for an interactive installation. This project titled *Alloys and Echoes* would be a collaborative venture involving sculpture and computer controlled solenoids, lights and computer music that would run in the end of January in THE ARTS Gallery on the Spring Creek Campus. Art students under the direction of CCCCD professor Luke Sides would provide the sculpture while I would design, program and construct the interactive elements. The show ran successfully from January 18 through February 11, 2005.

Lastly, during the first two weeks of December I began designing and programming a distributed processing algorithm for rendering 3D animation across a lab of computers. This project involved...
researching and learning the AppleScript programming language as well as learning the UNIX implementation of the POV-Ray animation environment. After two weeks I was able to successively render animations on several machines greatly improving the rendering speed. This algorithm will prove extremely valuable for future animations since it can take advantage of idle computers in the MIDI/Synthesis lab on the Spring Creek Campus.

In conclusion, I am very appreciative of the opportunity to apply for and make use of the sabbatical leave at Collin County Community College. I feel I was able to make productive use of the time and I hope that my efforts will bring further exposure to CCCCDD as a place of serious academic research.
Program

<table>
<thead>
<tr>
<th>Title</th>
<th>Description</th>
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</tr>
<tr>
<td>Cognitive Dissonance</td>
<td>eight-channel computer music</td>
<td>12.5</td>
</tr>
<tr>
<td>Inside the Box</td>
<td>animation with computer music</td>
<td>8</td>
</tr>
<tr>
<td>Swan Song</td>
<td>eight-channel computer music</td>
<td>7.5</td>
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<tr>
<td>Self-Ex</td>
<td>video</td>
<td>8</td>
</tr>
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<td>Total Duration</td>
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Notes

*Plastique* (2004) is a real-time multi-channel work featuring samples of plastic bottles. I have always thought that plastic bottles were an interesting combination of a percussive attack with a resonator so for this piece I recorded over 240 samples of various bounces, slides and spins. These samples are loaded into MAX/MSP and processed in real-time using sound file granulation and spatialization software.

*Cognitive Dissonance* (2004) is a multi-channel piece composed with recordings of everyday household sounds which were chosen for their rhythmic qualities. While some of the samples were processed with granular synthesis techniques, many were left unaltered and assembled into rhythmic textures. The piece and title were inspired by psychology where the expression refers to the anxiety felt when new ideas challenge long-held beliefs. It is part of a natural process of learning in which the individual is forced to resolve this "dissonance."

*Inside the Box* (2004) is my attempt to develop a causal relationship between animation and music. For this piece I modeled boxes containing bouncing balls in the script-based freeware 3D modeling program *POV-Ray*. Whenever a ball strikes the side of the box, a note message is generated for later rendering in Csound. Programs for the camera trajectory and box placement were written in MAX while the final assembly of the video was handled in Final Cut Pro. Though I have worked on this piece more than any other I can recall, it is a work in progress.

*Swan Song* (2004) is a composition based on *The Silver Swan* - a madrigal with words and music by Orlando Gibbons. It was first published in 1612 and I have always thought this madrigal one of the most beautiful pieces ever written. In my composition I have attempted to revisit and dwell on some of that beauty. The source recording was taken from a rehearsal of the *CCCD Chamber Singers* under the direction of Katherine Morgan in the spring of 2004.

*The Silver Swan*

The Silver Swan who living had no note
When death approached unlocked her silent throat.
Leaning her breast against the reedy shore,
Thus sung her first and last, and sung no more.
Farewell all joys; O death, come close mine eyes;
More geese than swans now live, more fools than wise.
Self-Ex (2004) is a work for video that uses a unique experience in my childhood to illustrate some reflections about art and society. The experience involved events surrounding my stay in the hospital after letting my curiosity with fire get the best of me. But the video is actually intended to be self-referential and is ultimately “about” how we as artists question where we look for our content.

Catalyst 101001 (October 10, 2001) is a multi-channel composition made up entirely from sounds generated by the live instrumentalist (for this performance, flute) and which are processed in real-time by the computer using various digital signal processing algorithms. These algorithms were programmed in MAX/MSP and they include effects such as delay, reverb, ring modulation, filtering, granular synthesis and pitch shifting. Some of the synthesis parameters are modulated in real-time by the software but some aspects of the piece (such as recording loops) are controlled by the performer. There are four distinct sections of the piece: an opening section of glissandos, a middle percussive section, a section featuring long delays resulting in a quasi imitative polyphone texture and a final homophonic section. The title has two meanings. The first is the fact that there are no pre-recorded sounds for this piece – the flute ‘catalyses’ the sound potential of the computer. The second is my adaptation of the theory of entropy: that complexity (or a high degree of organization) eventually turns to chaos. The complexity of life (and especially the growing complexity of human life) appears to run counter to this principle even though it is well known that humans cause much more entropy than organization when they make something of any complexity (such as building a house or even forming thoughts). Thus, in my view, life, as wonderful as it is, is ultimately and simply a catalyst for entropy. Catalyst was recently revised and performed in Portland and San Diego as part of the New West Electro-Acoustic Organization (NWEAMO) International Festival.

About the Composer

Christopher R. Morgan is an instructor at Collin County Community College where he directs the New Music Ensemble and teaches courses in music composition and technology including MIDI, synthesis and audio for video. He received his Ph.D. in composition from the University of North Texas with a dissertation to design, program and compose for an eight-channel sound spatialization system. Chris composes primarily electro-acoustic music such as solo multi-channel musique concrète pieces, video, as well as real-time interactive works for a performer with computerized sound, lights and graphics. His papers and music have been presented both nationally and internationally at events such as the Society for Electro-Acoustic Music in the U.S. (SEAMUS) and International Computer Music Association (ICMA) conferences in addition to the many concerts and educational workshops sponsored by the Texas Computer Musicians Network of which Chris is the current president. Chris is also active as a jazz pianist and serves on the Board of Directors of the Texas Conservatory for Young Artists. In January 2005, Chris’ work will be featured in an interactive sculpture installation highlighting sculptures that can be “played” by visitors using keyboards and computer-controlled electromagnets (solenoids). The installation Alloys and Echoes will run for approximately two weeks beginning January 18th, 2005 at THE ARTS Gallery at Collin County Community College. For more information about this and other upcoming performances please visit http://iws.ccccd.edu/cmorgan
Custom Glove Controller Construction for Real-Time Interactive Music

Overview

In this paper I will discuss the design and construction of a pair of glove controllers with accompanying software. Much research has centered on creating glove controllers for use with interactive computer music. Many of these gloves contain sensors that provide continuous values such as flex and force resistors. These continuous control signals are often mapped to synthesis parameters and used to control music. However, there are sometimes too many parameters to control and expanding the number of sensors leads to a problem of cognitive overload of the user. One possible solution is to create presets of multiple synthesis parameter values and ‘morph’ between these presets.

For this project I designed gloves that could be used for this purpose. The gloves provide the ability to choose presets as well as to move between presets. Each glove contains thirteen switches and an LED. Software developed includes MAX/MSP “abstractions” for creating presets of synthesis parameters as well as assigning and localizing those presets to locations in a virtual 3D space. With a third party video program, the 3D location of the LED on each hand is tracked and used for morphing between presets. The switches on the glove are connected to a third party card that generates MIDI note-on messages which can be mapped to almost any purpose such as switching between presets or providing on/off control over synthesis parameters. At the same time the 3D hand location can also be used to provide continuous control over three parameters per hand. This lecture will conclude with a demonstration of musical excerpts from a recent interactive composition employing the gloves and software.

Glove Construction

After several attempts at finding consumer gloves suitable for the purposes of this project I decided to build the gloves from scratch. The types of gloves tested included golf, racquetball and batting gloves. One of the most successful prototypes made use of evening gloves but while these were very lightweight and thin, they did not offer enough support for the wires. It was at this point that I decided the only way to get the right materials and structure together was to build the glove myself.

Thirteen contacts are attached to the glove in between the knuckles of each hand. These function as electrical contacts for use with the Doepfer CTM64 card that looks for a closed circuit to generate a MIDI note-on message. In this case I attached a ground wire to the tip of the thumb and 13 positive connectors to the other parts of the hand. All of the contacts were made of a flexible wire mesh with single conductor wires soldered to them. A 25-conductor computer cable was used with D-sub connecters soldered to one end to allow for easy attachment to the box contacting the Doepfer card. Whenever the thumb touches one of these positive connectors on the other parts of the hand, a note-on message is produced. The gloves are lightweight and the user is able to maintain some use of the hands for such tasks as typing, using a mouse, etc.

For one prototype, intended for use by a flutist, I left the ends open, exposing the fingertips and attached connectors to the backs of the fingers. The flutist was able to play unencumbered and still use the switches to choose different DSP effects. This functionality could have easily been achieved by using MIDI foot pedals or even a computer keyboard but the unobtrusive nature of the gloves made their use inconspicuous and took little away from the performance.
Software Design

Once the computer receives the note-on messages they can be remapped to control functions. To accomplish this I built a simple MAX abstraction call *GloveIn* that takes two arguments: the MIDI note number to match and a second argument which determines whether or not the note is held until the contact is broken and a note-off message is sent. If *hold* is off, then only the note-on message is used.

Example 1: The *gloven* abstraction

Below is an example of a patch using both keyboard and glove control to route audio to different processing algorithms.
Example 2: *GloveIn* used to choose audio routes.

Each glove also contains an LED: red for the right hand and blue for the left. Using the video processing software *SoftVNS*, the user is able to track the motion of the LED attached to each hand. These XY (one camera) or XYZ (two cameras) coordinates are then used in MAX to determine how close a hand is to the virtual location of a preset.

Example 3: Two-dimensional version of *pset*.

Example 4: The *param* abstraction.
The *pset* (preset) abstraction takes three (or four) arguments: preset number, x, y (and z) coordinates. Presets are programmed by means of another abstraction *Param* that also takes three arguments: parameter identification number, minimum and maximum value.

The presets are programmed in the following way. An initial message is sent to one of the presets whose number matches the preset the user wishes to program. At this point, the preset is set to “listen” to all incoming parameter values from each of the *param* abstractions. These can be sent all at once or one at a time. Once editing the preset is complete, another message tells the preset to stop listening. This procedure is repeated for as many presets as the user wishes to use. Lastly, the user can use the gloves to navigate the 3D space and move closer or farther away from a preset. Below is an example of a 2D version.

Example 5: A sample patch using *pset* and *param*.

For a real-time composition, a user attaches a *param* abstraction to each synthesis parameter and assigns minimum and maximum ranges. Next, a *pset* abstraction is created to assign each of the parameter values to a location in virtual space. Lastly, the user morphs between each of the presets by navigating the space. This can be done on the screen with a mouse or with video motion tracking software such as softVNS. Below is a portion of a patch with several *param* objects attached to granular synthesis parameters. This patch is an adaptation of the parameters used to control Nobuyasu Sakodna’s granular synthesis patch.
Example 6: A sample with *params* attached to synthesis parameters.

The gloves and software were successfully utilized in performance of the real-time interactive piece *Plastique*. The piece utilizes dozens of samples of plastic bottles. For a portion of the piece the contacts on the glove are used to trigger samples and toggle looping on or off. The LEDs are used as continuous controllers yielding values for reverb decay time, reverb depth and sample transposition. In another section of the piece, two samples (one each for the left and right hands) are run through two separate granulators with the hands morphing between the presets assigned to each sample.

**Future Research**

I plan to continue refining the glove controller both in the hardware design as well as its accompanying software. One shortcoming of the current motion tracking method is the need for high contrast between the LEDs and any images behind the user. As a result, the gloves are best used in dim lighting in front of a dark background which includes the user's clothing. To offer more flexibility in terms of performer attire and stage lighting, I will investigate other motion tracking options such as ultrasonic, infrared and radio frequency transducers. One consumer virtual reality glove (Essential Reality P5) uses infrared and works within a three to four foot range. It could be possible to retrofit this consumer glove with a number of switches.

If the user is able to wear both the transmitting and detection transducers, then it will be possible to incorporate a wireless MIDI transmitter so that the user is not tethered to one location. Another direction of research involves finding low profile switches that offer some tactile feedback. Lastly, the design of this glove does not preclude the use of other continuous control signals such as flex resistors. I intend to incorporate these as well while making allowances for the fact that one cannot close the switches of the contacts without simultaneously flexing the fingers.