Joseph Malloch & D. Andrew Stewart

Project Description

We are requesting a renewal of funding from CIRMMT in order to continue development of our new digital musical instrument (DMI). Specifically, the continuation of this project will involve advances in several areas:

1. Refinement of the sensing platform:
   - 1.1 Additional sensing modalities (strain, bending, ultrasound distance-sensing, microphone, breath pressure)
   - 1.2 Performing sensor signal processing on-board the instrument
   - 1.3 Completing a wireless version of the instrument to increase portability, freedom of movement
   - 1.4 Developing a mature version of the hardware design
   - 1.5 Creation of smaller (and larger) models of the controller (an instrument family)
   - 1.6 Testing advantages of higher spatial-resolution capacitive sensing (> 48 channels)
2. Continued exploration of mapping possibilities
   - 2.1 Perhaps incorporating spatialization (use to control existing implementations)
3. Continued exploration of approaches to performance-practice using the instrument
   - 3.1 Development of a codified version; pedagogy
4. Continued exploration of notation issues
   - 4.1 Development of a mature, codified approach
5. Find/form a pool of musicians familiar with the instrument for future performances
6. Compose a new piece for more than one pipe (multiple performers) to be presented at a DCS concert in 2006

All of the above advances will be driven by formal and informal user-testing. Improvements will be made based on the results of - and comments from - musicians practising and performing with the DMI. Work will be carried out in the Input Devices and Music Interaction Laboratory (IDMIL), under the supervision of Marcelo Wanderley, and the Digital Composition Studio (DCS) under the supervision of Sean Ferguson.

The initial development of this instrument took place over the 2005-2006 academic year with the support of a CIRMMT student award and the CIRMMT Director's Interdisciplinary Excellence Award. A description of the aims of the project and of work already completed is found in the "Research Report" section below.

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Interdisciplinary Nature of the Project

The process of creating new digital musical instruments is by its nature interdisciplinary, since it involves important issues of both aesthetics and technology. While we have each approached these issues individually, one of us is a composer exploring music technology, and the other is a music technologist interested in composition. We each bring different experience to this project, which will positively influence the end product - an instrument that is robust both technically and aesthetically. Together, we possess the knowledge and experience necessary to successfully bring this project to fruition.

Through our studies at McGill and independent research, we have a comprehensive understanding of previous and ongoing DMI research and design. Through our supervisors, and our positions as McGill students, we have access to lab spaces for electronics and software development, gesture-analysis, and digital composition. We have experience using various types of sensing technologies and products, and not least, we have hands-on experience using these sensors to utilize human movement in musical ways.

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Research Report

This report outlines the initial stages of the DMI project and our progress. While this project has not yet resulted in any academic papers, we have both recently submitted papers for related projects to the NIME2006 conference. Once the initial stages of the project are completed (spring 2006), we intend to report our work and conclusions in a paper submission to NIME or another conference.

Papers we have recently submitted (individually):

[1] J. Malloch, E. Sinyor, D. Birnbaum, and M. M. Wanderley. Towards a new framework for DMI conceptualization. *Submitted for publication*. 2006.
[2] M. M. Wanderley, D. Birnbaum, J. Malloch, E. Sinyor, and J. Boissinot. SensorWiki.org: A Collaborative Resource on Transducers for Researchers and Interface Designers. *Submitted for publication*. 2006.
[3] D. Lebel and J. Malloch. The G-Spring Controller. *Submitted for publication*. 2006.
[4] D. A. Stewart. SonicJumper composer. *Submitted for publication*. 2006

Prototype Construction and Testing

Two versions of the pipe prototype will be completed in early March, 2006. They are cylindrical objects, with a 5-centimetre diameter, and measuring approximately 1.2 and 0.8 meters in length respectively. One side of the pipe's surface is covered with 48 capacitive touch sensors (or 32 touch sensors for the smaller version), which differs from standard position-sensing in that it is completely multi-touch (a touch at every position can be sensed simultaneously). The other side of the pipe contains 2 long continuous pressure sensors, designed and built by Rodolphe Koehly. Internally, the pipe contains a piezoelectric contact microphone to acoustically detect jarring, and two 3-axis accelerometers (one at each end) to sense tilt and acceleration of the device. Signals from the capacitive sensing are time-multiplexed using a microcontroller, which also provides analog-to-digital conversion for the accelerometer and pressure sensor outputs. The instrument interfaces with a computer using the USB, and output data can be read into Max/MSP using the [hi] object. Future implementations will use the [serial] object instead, since this method allows faster data throughput than is possible using the HID standard, improving the "responsiveness" of the controller.

The entire instrument is enclosed in a protective, smooth layer of shrink tubing to make it strong and durable. On the surface are small fret-like protrusions, between the positions of capacitive sensors, to allow tactile navigation of the sensing surface. Some frets will be colour-coded for quick visual navigation, similar to the way harps use red and blue strings for the pitch-classes C and F.

The output of the sensors is being mapped to higher-level representations of the instrument's state and of the interaction taking place. The signal processing necessary to extract this information forms part of an "intermediate mapping layer," intended to aid the development of new synthesis engines for the physical interface. The brief list below shows some of the information that can be extracted from the raw sensor outputs, and mapped to musical parameters:

1. raw audio from piezo microphone
    - 1.1 velocity of hit
    - 1.2 precise timing of hits
    - 1.3 pitch of hit (tap vs. thump)
2. raw output from accelerometers
    - 2.1 tilt (posture) x, y, z
        - 2.1.1 delta tilt
        - 2.1.1 difference between 2 ends of the instrument = rotation
    - 2.2 shaking x, y, z
    - 2.3 shaking "energy" (with leaky integrator)
    - 2.4 thumping on floor
3. states of capacitive sensors
    - 3.1 discrete fingerings (multi-touch)
    - 3.2 difference between touching with finger and hand (area)
        - 3.2.1 "damping"
    - 3.3 tapping position
    - 3.4 tapping timing
    - 3.5 brushing/bowing speed
    - 3.6 brushing/bowing "energy" (with leaky integrator)
    - 3.7 whether instrument is being held
4. raw output from continuous pressure sensors
    - 4.1 whether/which end instrument is being held
    - 4.2 "damping"

The pipe's synthesis engine is being developed in parallel with the physical construction of the instrument. The voice of the pipe is generated using Max/MSP. Mappings within the application have already been established to accommodate the manipulation of the instrument, as described in the examples above. Audio sample playback, passed through granular synthesis objects, is at the core of the synthesis engine; however, intricate and exhaustive audio mixing techniques are used to create source files for audio sampling. That is to say, the procedure of sample playback entails accessing a buffer object (in Max/MSP), which contains a "hybrid" audio file. This audio file was created by sampling and mixing together several different genres of music. The objective is to have numerous hybrid audio files that can be swiftly loaded into a [buffer] object in real-time. This is akin to changing the string on which a musician plays; or it can be seen as changing to a larger or smaller instrument, within the same family (i.e. alto clarinet to bass clarinet). Currently, both physical modelling synthesis and dynamic filtering are being implemented.

Performer Training

We are presently involved in a Special Projects Seminar taught by Professors Wanderley and Ferguson. The seminar has offered us a forum for testing our instrument with real musicians. In turn, performer input has shaped our approach to performer interaction, training, and pedagogy. Interacting with musicians has helped us to refine the playing technique of the pipe. To date, we have developed three possible modes of performing on the pipe.

1. Percussive Mode:
   - 1.1 hold horizontally at shoulder height with thumbs towards the performer (i.e. frame-drum)
   - 1.2 hold vertically (i.e. violoncello, chime)
   - 1.3 strike, brush, tap on both sides of pipe using thumb and index fingers
   - 1.4 thump on floor
   - 1.5 use other hand to "dampen" the sound
2. Continuously Excited Mode:
   - 2.1 sitting, hold pipe vertically like a violoncello. Use right hand to excite sound by brushing, tapping; use left hand for manipulation or selection of musical parameters (i.e. pitch)
   - 2.2 rotate and swing the instrument (i.e. Japanese bo)
3. Discrete Control Mode:
   - 3.1 place instrument horizontally on lap or a stand; play with two hands on surface of pipe (i.e. piano)
   - 3.2 hold vertically (like a bassoon) and precisely finger touch sensors

Naturally, many of these interaction modes require drastically different mapping approaches. As the instrument (and our experience with it) gains maturity, a single mode/mapping, or a related set of them, will likely emerge as the favourite.

Composition of Study and Original Work

An instrumental study is currently being conceived for a concert in Thomson House, on April 10, 2006. The piece explores problems of physiological, technica, and musical difficulty, which requires of the player not only mechanical application but proper study and correct interpretation as well.

In the fall of 2006, a more comprehensive piece will be composed, with themes exploring the notion of a "talking stick" as an extension of human interaction. The instrument's physical appearance lends itself to the "stick" concept, evoking numerous images in the mind of the audience member. Some might see a tool or weapon; others may see the instrument as having some connection to cylindrical instruments (i.e. flute or recorder, bassoon, didgeridoo). Also, these images evoke the social activities associated with the "stick": manual labour; combat or conflict. Primarily, the composition will address how the instrument can act as an extension of the human body, much in the same way Escrima sticks (used in a Filipino martial art) are considered extensions of one's attack or how wind instruments are extensions of the human singing voice.

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