Explorations in Digital Control of MIDI-enabled Pipe Organs

Johnty Wang
Input Devices and Music
Interaction Laboratory/CIRMMT
McGill University
johnty.wang@mail.mcgill.ca

Robert Pritchard
School of Music
University of British Columbia
bob@mail.ubc.ca

Bryn Nixon
Ryerson United Church
Vancouver, Canada
brynnixon@icloud.com

Marcelo M. Wanderley
Input Devices and Music
Interaction Laboratory/CIRMMT
McGill University
marcelo.wanderley@mcgill.ca

ABSTRACT

This paper describes the use of a MIDI-enabled pipe organ console at Ryerson United Church in Vancouver for music service during worship, as well as a custom built dedicated librarian and performance software that opens up possibilities for exploration in alternative control of the instrument via various gestural interfaces. The latter provides new possibilities for expression and extended performance practice including dance and interactive installations. Future work on both the artistic use of the system as well as technical development of the interfacing system is presented.

1. INTRODUCTION

The pipe organ, unlike most other acoustic instruments, allows modification of its *mapping* [1]. In other words, it is possible to change the behaviour of the instrument through stops and couplers, affecting the sound produced when the keyboard manuals and pedals are played. Most modern organs are controlled with electronic systems that provide faster and more scalable performance [2]. However, in addition to technical improvements, digital systems also allow easy addition of external interfaces such as MIDI, which support extended control techniques using other devices. A MIDI enabled pipe organ's console can be used as an interface that allows performer input to be recorded or transmitted to other sound generators, and the sound producing mechanism of the instrument effectively becomes a synthesizer that can be controlled with compatible signals. In this paper, we describe the use of a MIDI-enabled pipe organ console for use in worship service as well as explorations in alternative control.

2. RELATED WORK

The Yamaha Disklavier [1] is an example of a MIDI-enabled instrument that can be controlled externally as a synthesizer. In the case of the pipe organ, the spatial arrangement of the pipes and wide spectral range provide additional possibilities over the single array of strings of the piano.

The Organ Augmented Reality project [3] extends the output of a pipe organ through real-time projection mapping of audio visualizations as well as sound processing and spatialization.

Chris Vik's "Carpe Zythum" [4] is a composition that makes use of a Microsoft Kinect sensor to provide gestural control on a similar organ console. The work described in this paper, in contrast, makes use of the MIDI functionality for musical service at the church, as well as the construction of a platform to support new performances.

3. RYERSON UNITED CHURCH ORGAN

Ryerson United Church, in addition to being a place of worship, hosts a large number of musical events including the "Sundays at 3" concert series, the Pnuema Children's Choir, Dunbar Ryerson Voices Choir (a large community choir that performs 2 oratorios each year with orchestra), and a number of concerts by various professional and amateur choirs in the community.

The organ is, shown in Figure 1 is 4 manual instrument built by the Canadian builder Casavant Frères in 1964. The modern control system is installed by Steve Miller of Solid State Organ Systems [2]. In 2005 the organ was rebuilt and part of the process included the addition of a MIDI-capable controller. In 2012 the actual MIDI interface was physically exposed, providing an externally accessible interface of the control system. The built-in features of the current console include a sequencer that can store and playback recordings on a USB stick, and extended capabilities include connection with a tablet application [3] that can be

[1] http://www.disklavier.com/
[2] http://www.ssosystems.com/
[3] http://www.ssosystems.com/pages/palette.html

Figure 1. The Organ at Ryerson United Church.

used to control various settings of the instrument. The MIDI output port of the console will emit messages pertaining to keyboard and pedal action using note messages, as well as system changes representing the state of the couplers and stops via System Exclusive (SysEx) commands. The MIDI input provides reciprocal features of the output and allows note and system state control from external sources using the same protocol.

4. USE OF MIDI CONSOLE IN MUSIC SERVICE

In this section, we document some of the ways that the MIDI system has been employed by performers in the music service as well as concert and rehearsal settings.

4.1 Rehearsal/Audition Aid

The basic use of the MIDI system with a sequencer has proven to be an invaluable learning tool for all of the organists who practice and perform at Ryerson, since it allows them to record various ways of performing a piece and then play those back in order to hear their registrations, tempi, phrasing etc. as it sounds from the audience's perspective.

4.2 Playback

Since the playback of a MIDI sequence would result in the exact sound produced by a live performance, it is possible to playback recordings to provide background music in the church *as if* it was performed live, far more realistic than any audio reproduction technique. While this is by no means intended to substitute live performance, this feature greatly increases the versatility of the church space.

4.3 Accompaniment

There has been some experimentation with performing Sunday service 'postludes' using the sequencing features of the MIDI, click track and live piano, with performances of Bach, Halley, and Hymn 'preludes'.

A number of choral anthems were performed using the MIDI sequencer, such as the Duruflé Requiem mvts 1 and 2, Bach choral movements from Cantatas. Orchestral parts can be entered into a MIDI sequencer with wind and string parts represented on different divisions or manuals which presents the music as it was written and in a way that cannot be performed by a live player through a transcription of the score.

4.4 Tuning Aid

Finally, due to the large distance between the pipes and the console, the tuning process of a church organ can be quite cumbersome. In the traditional process, a particular stop is activated and either an assistant in the form of a real person (or a device such as a pencil) is used to depress and hold a key on the manual to sound the pipe while another person performs the tuning of the pipe. With this interface, it is possible to use a wireless controller and activate any stop or key remotely, thereby making the process much easier with a single person.

5. EXPLORATIONS IN ALTERNATIVE CONTROL

To provide an entry point in exploring alternative control of the instrument, we first built an interface patch to expose access of the internal configuration of the console. The keyboard/pedal and swell controls are done with standard MIDI note and volume messages which are directly accessible in most programming environments for digital media, but the internal state of the active stops can only be accessed via System Exclusive (SysEx) messages. We have implemented a Max/MSP driver patch to translate between the internal protocol used by the instrument and the user interface. From there, additional user applications performing various mapping between gestural signal input, mapping patches and/or external signals can then communicate locally within *send* and *receive* objects, or via network protocols such as Open Sound Control (OSC) [5].

5.1 Overview of Max/MSP Interface Patch

While the Ryerson organ uses MIDI SysEx protocol and can accept MIDI messages, the low speed of MIDI communication can preclude the use of the MIDI transmission speed on such a complex instrument. Instead, the core transport medium is packet-based Ethernet. The organ console is scanned at approximately 500 Hz and a packet containing the complete state of the organ is sent whenever a change is detected. Thus, the complete state of the organ can be changed with one packet. To accommodate the MIDI protocol, 8k transmission buffers are used. However, with no pacing on the interrupt-driven transmission buffer, care must be taken to avoid flooding the system with data.

The full configuration of the organ's stops and couplers is represented by a 22 byte SysEx message, as shown in Figure 2. The first two bytes contain the header and manufacturer ID. Then 3 bytes are used to select the bank or group of the configuration. Following are 16 bytes of configuration data appended by the single byte corresponding to the terminating SysEx footer.

Each stop is associated with a specific bit in the 16 bytes for a given bank, so activating and deactivating a stop con-

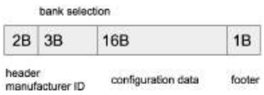

Figure 2. SysEx message format

sists of setting a specific bit to be on or off. When any stop is toggled on or off, its bit value is added to or subtracted from the current status of all stops. This change is immediately read and transmitted as a packet containing the complete state of the organ.

Presets can be created by storing a packet of the organ's current state. When the packet is retrieved and passed to the organ, it automatically updates the state of all stops and combinations. The packet is also passed to the Max/MSP patch which converts the data to bit values and configures the GUI to reflect the organ's state. Any incremental changes can be performed using bitmasking operations so only the stop of interest is affected.

Control of the organ stops was effected through the creation of a Max/MSP organ stop bpatcher, as shown in Figure 3. Each stop bpatcher displays the Casavant Frères stop ID number in the upper left, the name of the stop (Trompette, Bourdon, etc.), and the length of the stop (4, 8, etc.) in the lower centre. Clicking on the blue button toggles the stop on and off, sending a message with the stop's identifying bit turned on or off. This bpatcher also provides visual indication of the status of each stop that may be triggered via the organ console itself.

Figure 3. The stop bpatcher

5.2 Modes of Operation

While the Max/MSP software was designed to work specifically with the Casavant organ at Vancouver's Ryerson United Church, it was coded with an eye/ear towards being useable with similar organs and systems. To that end, the software has learning and performance modes.

In Learning Mode the user arms a particular GUI stop by clicking on its green toggle button. The red LED begins flashing, indicating that the stop is active and ready. The user then pulls the appropriate stop on the organ console. Activating the console stop sends the stop's unique SysEx message to the Max/MSP patch, where the packet is stored in a buffer. The user then clicks on the blue button in the GUI stop, and the packet is saved to a buffer using a *coll* object. The green toggle then turns off, and the red LED stops flashing. Going through this for each stop allows the user to build up the entire stop library, thereby having access to the entire sound capabilities of the instrument.

In Performance mode, the organist plays as per usual, and the status of the organ is reflected in the GUI as the stops are engaged and disengaged. However, external MIDI control is also possible by having a MIDI controller send note-on, note-off, volume, sustain, etc. messages. By sending messages external controllers are also able to turn individual stops on and off, or activate entire combinations of stops.

A screenshot of the main Max/MSP patch is shown in Figure 4. In our explorations thus far we have used OSC endpoints via the *udpreceive* object with manual message routing for external control from user patches and external sensors. This allows us to trigger both note and stop change messages from any device on the network.

5.3 Mapping Examples

We have created a number of preliminary mapping demonstrations with the system [4] , which serve to show the potential for building new performances and interactive installations with the system:

Hand Gesture Control: Using a variety of interfaces such as the Leap Motion [5] , a wrist-worn fitness tracker with motion sensors and mobile phones, we have demonstrated preliminary methods of mapping hand motion to note actuations on the instrument. Simple hand-location to note frequency mappings were done, but since sensors provide a wealth of other information (e.g. finger joint position, rates of rotation, drawing gestures on a touch screen, etc.), there are many further possibilities.

Dance: One area of particular interest to us is the ability to use Kinect hardware and custom-written software to track one or two dancers, and use the resulting data to control the organ. The Kinect software, Kinect Controlled Artistic Sensing System (KiCASS) is being developed at the University of British Columbia in capstone projects carried out by undergraduate Engineering students collaborating with the School of Music digital performance ensemble Sonic UBC Laptop Sounds and Sensors [6] . KiCASS runs on a Surface Pro II and can track up to 25 points on each of two dancers. Using a local router it broadcasts the tracking data in OSC format, allowing multiple computers to access the data for use in performance. For dance with the Ryerson organ, a dancer is tracked using the KiCASS system, the resulting OSC data is acquired by a laptop running Max/MSP, and the data is mapped to various performance parameters and sent to the organ through a hardwired MIDI interface. With limb motion, posture, and location the dancer is able to control the generation of MIDI note data and stop configurations.

Prenatal Musical Instrument: A brief experimentation was performed during the development of a prenatal instrument [6] where fetal movements, detected via pressure sensors attached to the belly of the mother, was mapped to trigger notes on the organ.

All of these examples are relatively rudimentary mappings that provide an entry point to more interesting possibilities afforded by the system.

[4] https://www.youtube.com/watch?v=4TuJ5PlTIA0
[5] https://www.leapmotion.com/
[6] https://ubcsubclass2016.wordpress.com

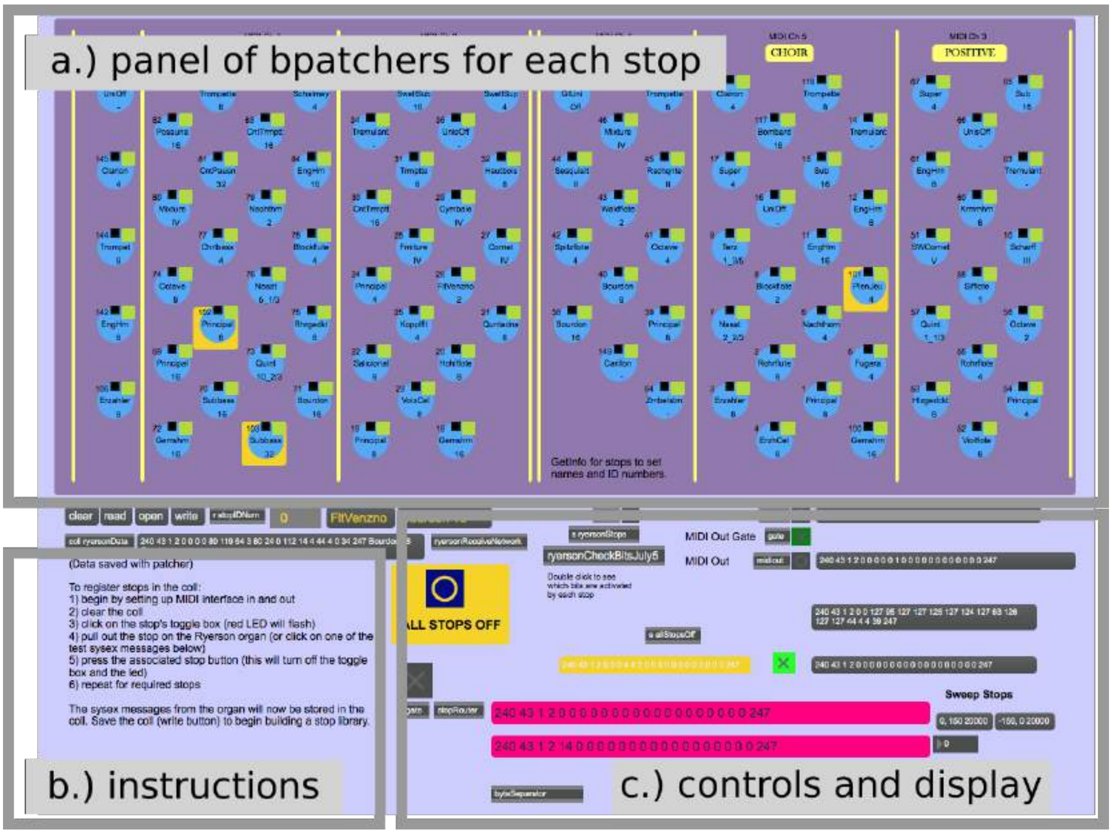

Figure 4. The Max/MSP Interface Patch showing a.) the panel of bpatchers for each stop, b.)basic usage instructions and c.) miscilleneous controls and status output

5.4 Towards a unified control and mapping framework

The distributed nature of the components of the pipe organ spread across the church building, coupled with the potential for new control input as described above, lends naturally to distributed mapping and control schemes. The Max/MSP patch that was implemented can be seen as a configurable driver application that provides a single point of access to control to the instrument and provides an interface between user input and the lower level SysEx control messages. While it is possible to use end-to-end protocols like OSC to communicate as we have done so far in the examples, explicitly defining connections can quickly become cumbersome in a collaborative setting where multiple sensing devices are spread across multiple machines. A potential platform to work with is the libmapper [7] library, which builds self discovery and dynamic mapping between devices on top of end-to-end protocols like Open Sound Control. Libmapper provides mapping tools that allow simultaneous and potentially different visualization and editing tools of the mapping between devices on the network.

6. FUTURE WORK

For the music service at Ryerson, we intend to continue working pieces that can utilize the orchestral playback and accompaniment features provided by the MIDI system including standard organ repertoire, orchestral and chamber music, and choruses.

One current limitation of the sequence based accompaniment is that they are following the fixed tempo of a recording, and synchronization between the conductor and other instrumentalists and the sequencer are done through click tracks. While it is possible to apply tempo changes as implemented by the“tempo map” feature in many sequencer software, once set it cannot adapt to live performance variations. By employing sequencing software that allows adaptable real-time tempo tracking via gestural input such as NoteAbilityPro [8], it would be possible to provide more flexible accompaniment options during live performance. For the click tracks it may be possible to use haptic instead of audio channels such as the VibroPixel system [9], or the SoundBrenner [7] which eliminate the need for musicians to wear headphones during performance.

Continuing work with the existing Kinect system we are currently working on an interactive dance piece that will be incorporated into a church service. Associating visual gestures in the choreography with sounds emitted by an instrument that is familiar to the congregation provides novel and engaging ways to explore themes presented in the scripture.

Thus far, all of the mapping demonstrations using new controllers have been focused on activating notes. As the large number of different pipes of the organ and their mixtures provide an immensely rich tonal palette, the control of registration (combination of different sets of pipes) is

[7] http://www.soundbrenner.com/

a natural feature of any interactive system involving this instrument.

In terms of software development, our long term goal is to provide an easy to use mapping system that allows artists to access the sonic capabilities of the instrument. By creating and exposing a standard protocol for access along with support with mapping libraries such as libmapper facilitates the use of the system by composers, musicians, and digital media artists.

Since many other organs are equipped with similar control systems, it would be possible to implement the same system in more than one location as well, and provide further possibilities such as teleperformance. In these situations, the self learning feature of the driver patch, extended with the ability to define the number and name of the stops, would be very useful to automatically capture the different stop configuration in other Solid State Organ consoles employing the same SysEx format.

7. CONCLUSION

In this paper we have presented the use and initial explorations in alternative control of a MIDI enabled pipe organ in a church. Ways that this additional piece of technology has extended the existing musical service has been described, along with the technical developments and demonstrations of the system using additional gestural sensing technology showing the potential for creating new performances and interactive installations. Finally, we present our plans for the continued use of the system in service as well as new compositions as well as technical developments to scale up the usability of the system. From a cultural perspective, the work documented in this paper presents a method of utilizing technology and music to foster new forms of dialogue between the religious communities where these instruments have been used traditionally and wider society.

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