MusicGrip: A Writing Instrument for Music Control

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Abstract

In this project, we have developed a real-time writing instrument for music control. The controller, MusicGrip, can capture the subtle dynamics of the user's grip while writing or drawing and map this to musical control signals and sonic outputs. This paper discusses this conversion of the common motor motion of handwriting into an innovative form of music expression. The presented example instrument can be used to integrate the composing aspect of music with painting and writing, creating a new art form from the resultant aural and visual representation of the collaborative performing process.

Keywords: Interactive music control, writing instrument, pen controller, MIDI, group performing activity.

1. Introduction

For many traditional musical instruments, the most complicated and difficult part for performers is the training of the reflex motor motion of one's fingers. It is common for people to spend much of their time while learning to work with a new instrument, on adjusting and adapting the finger movements for the scales, positions, and affordances specific to the instrument. Finding better ways to learn new physical motions and techniques for musical expression has always been an important aspect in the development of new music interfaces and instruments [1].

While these systems provide an easy way to get some sort of sonic output, the motion and gesture for playing those instruments expressively and creatively still needs substantial practice. It is also often quite difficult to repeat the gesture, limiting the use of these types of interfaces for composition.

Handwriting and drawing movements are skills that contain unique expression for every individual. It is both a personality representation through graphic marks and a means to communicate, capture, and clarify ideas with

other people. It differs from person to person yet it's easy for everyone to repeat the same general motion easily. Our writing/drawing pattern, the way we hold a pen and the resultant handwriting can even be used as a method of identifying different individuals. Therefore, we have developed a music controller which takes advantage of the uniqueness of this motion as a means of expressive real-time music control and also takes advantage of the familiarity of writing for communication and the capture of ideas as a means for collaborative composition.

In this paper, we describe the development and implementation of MusicGrip, a system that creates electronic music in real time based on the writing and drawing motion. Pressure sensors are attached to a conventional pencil grip (Figure 1) and signals are collected through three different pressure sensors, one on each face of the triangular shape grip. The sensors provide three different channels of sensing allowing the dynamic interaction between composing and drawing. By augmenting a palette of several pens in this way, the MusicGrip system can be used as a real-time, multi-user performance instrument.
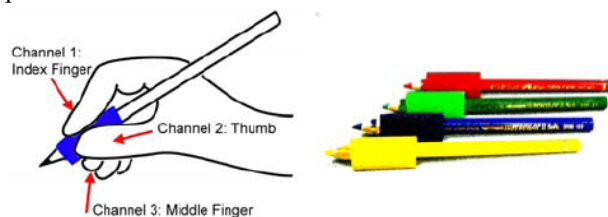

Figure 1. Illustration of input channels and the design of the triangular pencil grips.

2. Pen as a Music Instrument

Various research projects have sought to use pens in musical applications, often for editing music notes and composing with a tablet input [5-7]. Some efforts have used commercial digital pens and tablets as musical instruments. For example, researchers at Center of New Music and Audio Technology (CNMAT) at UC Berkeley have over a decade of research employing tablet-based musical interfaces [2-3] – also of note is the use of tablets as performance instruments by Arfib and collaborators [4]. The x-y pen-tip coordinate data captured by the electronic tablets in these examples are analyzed to attain features or commands that can be used to control or provide input to a

musical system. However, the detailed variations of one's finger movements on the writing implement and the overall motion of the hand beyond the location of the pen tip can hardly be captured.

To capture the nuanced expressions from movements of handwriting and drawing, we looked at the components that make up a person's unique grip on the pen and how the gripping pressures change throughout the writing session. In our design, force sensing resistors are placed on each of the three main finger contact points on the writing implement by use of a triangular shaped pencil grip (Figure 2a).

Although some electronic batons have been implemented with multipoint pressure sensors that respond to dynamic grip [8], these were designed as free-gesture interfaces for the entire hand. A music controller that uses the vector finger pressure variances from the writing or drawing motion against a surface is novel in many ways. First, unlike the conventional input methods that require a specific type of pen with the electronic tablet, a pencil grip can be attached to any writing instruments. Besides the flexibility of the writing implement, it also allows writing on different surfaces. The same writing motion can have unlimited musical expressions through assorted combinations of pens and papers, as these specifics affect the pressures and the angles of the grip. In Figure 2b, the red brush gives greater pressure sensitivity then the green pencil, whereas the green pencil needs more force to create similar graphics.
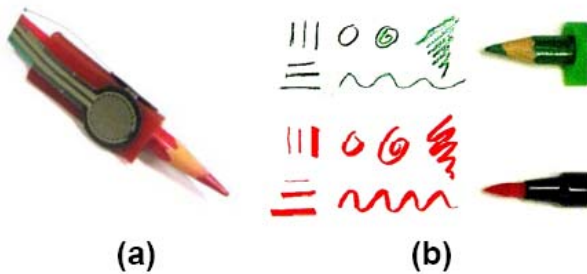

Figure 2. (a) Pencil grip with pressure sensors on each side. (b) Drawings from the same person with different writing instruments indicating different pressure and angle sensitivities from the tip.

Since these different types of pen will generate different dynamic values from the sensors, they can provide different sonic output. This can be likened to differences in traditional musical instruments such as the type of wood used for the body or the materials for strings. A palette of various writing instruments can be provided, each mapped to different sonic output or compositional method, allowing the composer to pick different tones and mappings the same way a painter picks up a different color or texture. In the music composing aspect, different from traditional music notes and instruments' representation, the composing process is documented from the drawing and writing and can be played back and analyzed through the optic input from the extension of MusicGrip which will be discussed later on.

3. System Overview

The prototype consists of three pressure sensors attached to a pencil grip, serving as input signals. The signals are converted to MIDI by an Atmega168 microcontroller and a 6N139 Optocoupler. The output signals are connected to a MIDI-USB converter through a MIDI adapter and transmit to a PC. The sensor data is processed in real time and mapped to specific MIDI messages. In the first version of the design we use Reason, a digital music synthesizer platform, to generate sound and create a mapping to trigger and modify these sounds with the pen sensor data. The major components of the system are shown in Figure 4b.
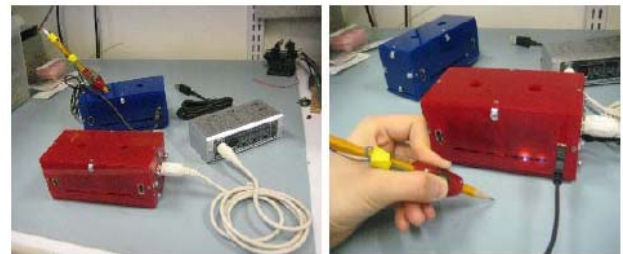

Figure 4. Components of the prototype: palette racks and the MIDI converter.

First, the input device is a pencil grip with three pressure sensors attached to a pen. The sensor signals are transmitted through a USB cable. Second, the palette rack (the red and blue boxes) that contain the electronics to convert the input sensor signals to MIDI outputs and also provide a space to keep the various input pens ready for use. There are currently two inputs in one unit which consist of six channels. Six LEDs are included (three for each pen), which serve as indicators and light up with their brightness in proportion to the pressure input. The last component is the MIDI-USB interface which takes MIDI signals and connects the inputs to a PC. Here, we use an EDIROL 3 in/3 out USB MIDI interface from Roland.

4. Mapping Strategies

4.1 Multiple Users

The pressure sensors for each pen for the three major fingers, index finger, middle finger, and thumb are mapped to parametric MIDI control signals. The user can change the mapping completely by rotating the pen and switching which finger controls which parameter. Since people generally write with only one hand at a time, the selection of which parameter to control with a particular sensor on a particular pen is done with multi-user collaboration in

mind. An example of a multiple user collaborative performance mapping is shown in Figure 5 and described as follows.
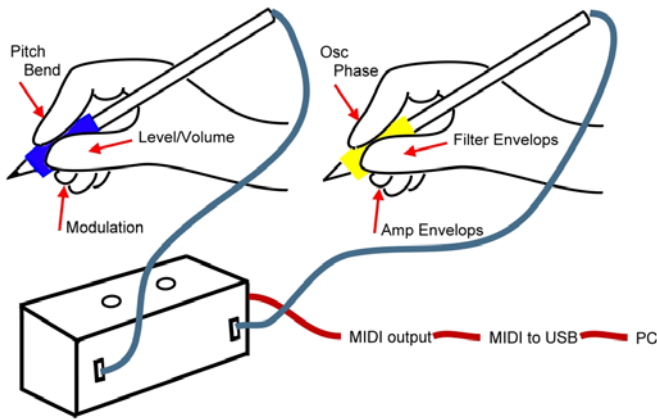

Figure 5. Mapping for collaborative performance from two users.

One of the users will be responsible for the melody of the music by selecting notes, adding modulation, and controlling the dynamic level of the sound. The index finger is mapped to the pitch bend, the thumb to the level/volume, and the middle finger to the modulation. The other user will be responsible for the control of different effects from the synthesizer (in other words the timbre). The index finger is mapped to the phase of one oscillator, the thumb to the filter envelope, and the middle finger to the amplifier envelope. For more complicated group collaboration, the texture and color of the pen will serve as an indication of the mapped tones and effects of that particular pen, just as an artiest picks up a unique pigment from a palette in the painting process, e.g. warmer color for warmer tone.

4.2 Single User

Another way to map the signal input is to coordinate the input pressure with note pitch (Figure 6). The most controllable and dynamic movement of the three channels is the one associated with the index finger. Thus, in the single user mapping, we use this channel to control the pitch. The second most manageable channel is the thumb and it is used for level control. The third channel can be assigned to a user-selectable tone control or effect.

Primarily for the single user mapping, but also usable by a group, we have built a standalone version that can run and perform without a computer. For this version we have added three speakers and three amplifiers to the electronics contained in the palette rack, and have created a small tone synthesizer that works directly from the analog signals from the sensors.
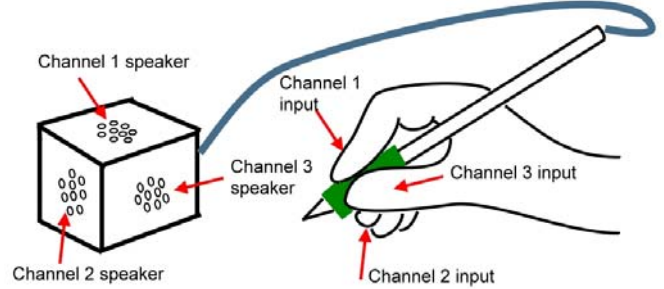

Figure 6. Illustration of an alternative mapping strategy for single user.

5. Group Evaluation/Collaborative Performance

The first user study and collaborative performance was conducted during the final project presentation of MAS.963 — Principles of Electronic Musical Controllers at the Media Laboratory, MIT. Four people were asked to start drawing/writing on the same piece of paper without practicing beforehand. For this test, shown in Figure 7a, two of the input instruments were mapped to the pitch control of separate synthesizer instruments, and the other two were mapped to the control of rhythm and effects. From the written artifact shown in Figure 7b, we can clearly observe the different roles in this performance. The two pitch controlling solo instruments are the yellow and blue lines. The drawings have less repeated pattern and are more free form in shapes. On the contrary, the rhythm section shown by the red and green lines has distinct repetition.
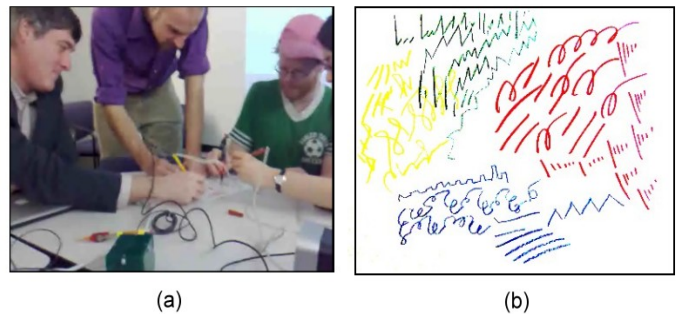

Figure 7. (a) Participants in the collaborative performance. (b) Results from the performance, indicating different roles in the composition process.

Thanks to the familiarity with the use of a pen, the users were able to collaboratively create cohesive audio moments after picking up the instruments. The users were able to recreate similar sound patterns by recreating the same written patterns, allowing iteration and developing of musical parts.

6. Ongoing Extensions of MusicGrip

MusicGrip's functionality can be extended by adding additional input sensors, for example, illuminated photodiodes and microphones. A small extension board is being designed to attach near the bottom of MusicGrip.

The photodiodes collect reflected red, green and blue light from a small region near where the pen tip contacts the writing surface (an onboard white light source can uniformly illuminate the paper beneath) that can be used to trace and scan written marks from previous performances or already existing printed material. In addition, the photodiodes can provide information about the current activity, such as the presence, color, and lightness of the marks as they are drawn. The data from the photodiodes can be mapped to musical outputs in order to create compositions directly from written marks. It can also be included in the mapping alongside the MusicGrip pressure sensors as an additional real-time parametric channel.

A contact microphone or piezo element mounted against the pen can capture the sounds created from the writing implement contacting and moving across the writing surface. This sound will vary according to the specific pen and paper used as well as with the user's specific gestures, providing information regarding texture variations of the contact surface. The collected audio from the microphones can be modified by a variety of digital effects (e.g., real-time convolution against a stored sample [9]) or in conjunction with the sound generated from the MusicGrip sensors (e.g., the writing sound amplitude could gate and/or filter the synthesized audio). These techniques greatly increase the compositional styles and methods that the MusicGrip can support by including the use of live sounds created from the endless supply of writing surfaces. Accelerometers and/or gyros can also provide useful gestural input from pen tilt, twist, ad dynamics.

7. Conclusions and Future Work

We have presented the MusicGrip, a music control interface utilizing the input from the different pressures and angles of associated writing/drawing motions. It helps performers to relate past experiences in writing and drawing with musical control and expression. The MIDI output can be mapped into various instrument and effects which provides innumerable possibilities for the creation of music. In addition to the musical output, the performers create a written or visual artifact as additional creative output or as notation of the composition.

To sum up, MusicGrip provides a new platform for collaborative musical experimentation and integrates two forms of art— painting and music, into a single realm of artistic expression.

In addition to the modifications suggested in the last section (and perhaps making the system wireless), we plan to test MusicGrip extensively with professional musicians and people lacking musical background to evolve a corpus of appropriate mappings.

8. Acknowledgments

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