Hé(和):Calligraphy as a Musical Interface

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ABSTRACT
The project Hé(和, harmony) is a sound installation that enables a user to play music by writing calligraphy. We developed a system where calligraphic symbols can be detected and converted to a sound composed of pitch, pitch length, and volume though MIDI and serial communication. The Hé sound installation involves a micro-controller, photocells, and multiplexers. A DC motor controls the speed of a spooled paper roll that is capable of setting the music tempo. This paper presents the design concept and implementation of Hé. We discuss the major research issues such as using photocells for detecting components of calligraphy like thickness and location. Hardware and software details are also discussed. Finally, we explore the potential for further extending musical and visual experience through this project's applications and outcomes.

Figure 1. Hé(和)

Keywords
Interactive music interface, calligraphy, graphical music composing, sonification

1. INTRODUCTION
Throughout history, engineers and artists among others, have tried to demonstrate the relationship between sound and vision in diverse area, including art and science. More recently, studies in sound sonification that convert visual images to sound have been a subject of increasing interest. In addition, the practice of Chinese calligraphy shares a lot of characteristic with music composing. The beauty of Chinese calligraphy is the line art, which are composed of the varied strokes. The technique of calligraphy possesses the same principle as in the serious study of a musical instrument. In this paper, we describe Hé, a novel sound installation that converts many features of Chinese calligraphy to musical notes. The installation has a motor that rolls the paper that is marked by calligraphy. On the top of the installation, there is a circuit board containing 15 photocells detecting the calligraphy features - like thickness, length, and positioning - by means of analyzing the amount of light. In addition, we used a serial connection to send out measurement data to a computer. Received at the computer, the data was processed by a Processing program script to analyze binary inputs and reformat them into Music Instrument Digital Interface (MIDI) messages. As MIDI messages, they were then outputted to a MIDI synthesizer program such as Garageband, Cuebase.

2. MAPPING CALLIGRAPHY FACTORS TO MUSIC
Music is art of precision and practice. Musical notes are a set of instructions that allows the practice of music. This project is meant to explore the territory where this set of instruction is replaced by another art form's expression and precise instruction. In this part, we discuss the relationship between Chinese calligraphy and music, and how this relationship is applied to our project. In addition, we introduce our approach to mapping calligraphy images to sound.

Essential questions we addressed:

* What characteristics of calligraphy would be interesting as input?
* How can the characteristics of calligraphy be detected by microcontroller?
* How should inputs be mapped to music output?

2.1 CHARATERISTICS OF CALLIGRAPHY
Music performance is similar to the practice of calligraphy. The wrong stroke of a word is equivalent to a discordant note. Chinese calligraphy is an art of precision, practice, emotion, and style. The practice of Chinese calligraphy shares a lot of characteristics with musical composition. Music is a language that utilizes the basics of Chinese calligraphic expression:

unrestrained, mature, feminine or masculine, graceful, serious, youthful, well-knit, prolix, rich, exuberant, and classic (Figure 2).

The following table will explain the similarities between calligraphy and music:

Table 1. The Art Beauty of Chinese Calligraphy, Shen Peifang [2]

Music	Calligraphy
tone color	writing nature
acoustic quality	quality of line
intonation	accurate writing skill
volume	writing intensity
tone range	the comparison of writing changes
tempo	pause and transition when writing
rhythm	partial or entire arrangement of calligraphy work
artistic conception	artistic conception

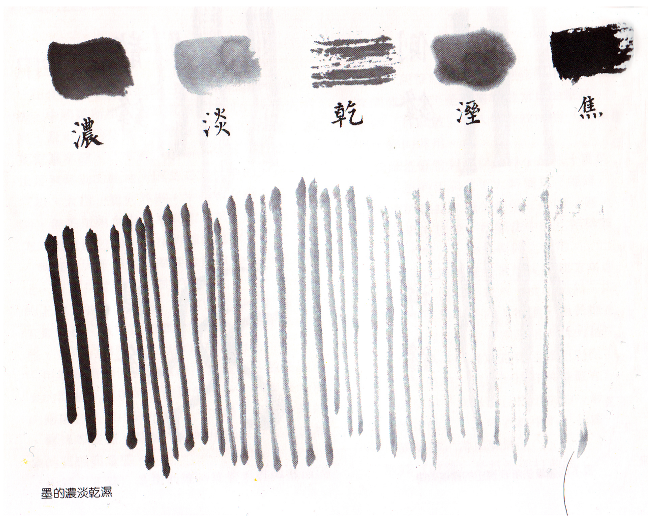

Figure 2. Chinese calligraphy ink pressure: thick, light, dry, wet, charred

Based on the expression of the word, can musical notation become an art creation in itself? What if musical score goes beyond representation, and become a presentation. The calligraphy of the musical note becomes a part of the art creation. Location, length, direction and pressure become parameters that also contribute to the composition of music. The precision of the music creation will be retained, but the perception of sounds and visuals can be enriched. The relationship among note and music and composer are now more powerful, emotional and personal. So in the case of calligraphy music, the musical score becomes a brush stroke. The stroke location, length, direction and pressure become the physical parameter to compose music.

2.2 CALLIGRAPHY AS SOUND INPUT PARAMETERS

In this project, we consider three factors of calligraphy: location, length, and thickness. Then, we map them to three basic musical components: notes, note length, volume of notes. We also consider tempo of music by using a motor to decide the speed of the paper that is spooling up into a roll. In order to detect and control these musical components, we use fifteen photocells, a motor, push switches and a light bulb. The technical ideas are described in Chapter 3.

Table 2. Calligraphy as sound input parameters

Painting Component	Music Component
The location of painting	Pitch
The length of painting	Pitch length
The depth of painting	Sound volume
The speed of the motor	Tempo

Since 'Hé' runs with MIDI and a virtual music instrument in Garageband, we match these sound components to MIDI messages.

Table 3. Converting musical components to MIDI messages

Music Components	MIDI Message
Pitch	Note On
Rest	Note Off
Pitch length	Delay time
Volume	Key Pressure

2.3 SOUND MAPPING

The sound generated from 'Hé' required a relationship with its characteristics or mood. Since our project is related to Chinese Calligraphy, we use the Chinese pentatonic scale which has five different notes called Gung (宫), Shang (商), Jiao (角), Zheng (徵), Yu (羽) that match to C, D, E, G, A in the western scale. In our project, using fifteen photocells, we can play three octaves of this scale.

Figure 3. Chinese pentatonic scale, Gung (宫), Shang (商), Jiao (角), Zheng (徵), Yu (羽)

3. TECHNICAL IDEA

As we described above, our technical challenge was detecting location, thickness, and length of calligraphy, and developing the controlling motor. Figure 4 illustrates the basic technical idea of 'Hé'.

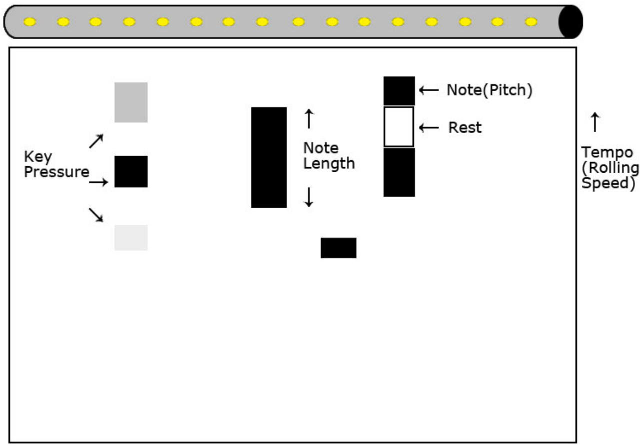

Figure 4.The basic technical idea of 'Hé'

The attached motor rolls up the calligraphy paper. There are fifteen photocells on the top of the installation that can detect the quantity of black ink written on the paper. Detected values are transmitted through Serial communication and converted into the following MIDI message format:

NoteOn[0x90, note, velocity]

3.1 SENSING THICKNESS OF CALLIGRAPHY

Since paper can be transparent and black ink blocks the penetration of light, we could get different values from photocells according to varying levels of black ink (Figure 5). On the test, we used basic rice paper (0,001 mm, non glossy) and a standard photocell (3 k ohm, 100 mW).

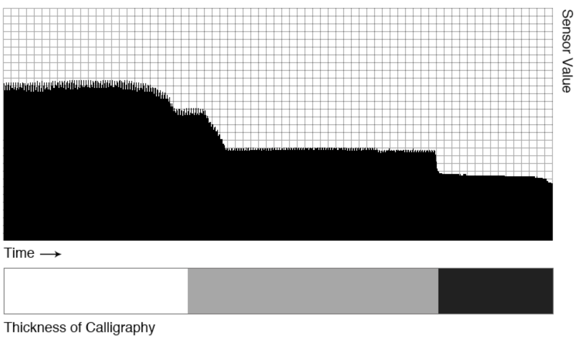

Figure 5. Photocell values according to varying levels of black ink

Moreover, since the amount of light can be changed by space, time or weather, we created a program that gets five initial values for five seconds when it turns on. It calculates the difference between the present and initial values, which makes it possible to detect the distinction of thickness of black ink stably. Finally, fifteen LEDs installed on the opposite side of each of the photocells visualize the values of photocells, which help the user to understand which notes are playing.

3.2 SENSING LOCATION AND LENGTH OF CALLIGRAPHY

The device's horizontal axis denotes the pitch of sound and the vertical axis represents time, which is the same as a 90-degree rotation of traditional notation. It sends the following midi note number to Garageband, virtual MIDI synthesis program.

(60,62,64,67,69,72,74,76,79,81,84,86,88,91,93)

Figure 6 shows the relationship between notes and the location of sensors

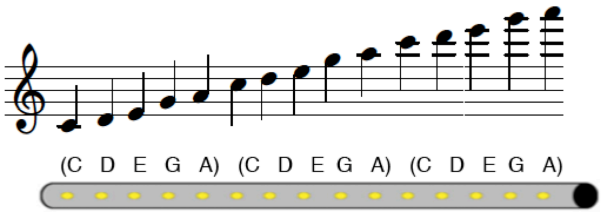

Figure 6. Mapping location and length of calligraphy to notes

4. RELATED WORK

Even though we could not find a specific musical instrument or installation using calligraphy, Hé is related to other projects dealing with graphical sonification or composing. SoundPaint (Jurgen Reuter, 2005)[1] is a program for creating sound based on transforming image data into audio data. It analyzes pixels of images and generates sounds depending on its color. The user can define the color-to-sound components such as waveform, duty cycle, effect and vibrato. UPIC (Xenakis, 1978) is a digitizing tablet link to a computer, which has a vector display. In the UPIC system, the user can draw waveforms and its volume, which are rendered by computer. Then, the program analyzes line drawings, with each graphical line being converted into a melody line. Makesound (Burrell, 2001)[9] also uses pixel-based conversion like SoundPaint. Burrell used the following mapping for sound synthesis, where some mappings are similar to Hé.

Table 4. Mapping strategy of Makesound

x - axis	phase shift
y - axis	time
hue	frequency
saturation	clarity (noise content)
luminosity	intensity (amplitude)

5. IMPLICATIONS AND DISCUSSION

We conducted three user tests for different types of groups: musician, calligraphist and the average person. First, after a brief explanation about how it works, we asked the musician to draw what she wanted to compose through calligraphy. Figure 7 shows the comparison between what she intended to compose and what she draw at the result.

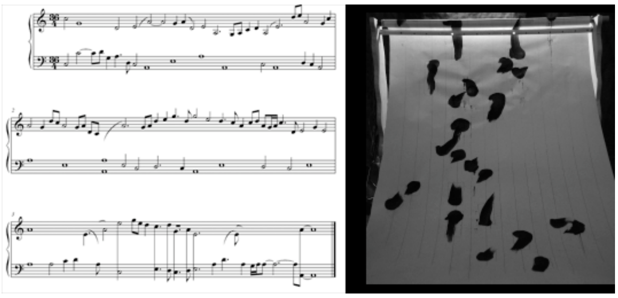

Figure 7. The Score and calligraphy from the musician, Songhee Jung

Although it was difficult to control tempo and the length of a note, the musician could make the almost identical music through calligraphy as she intended to compose. Moreover, we could expect the extension of musical expression through making experimental music by means of the practice of calligraphy. Second, we asked a calligraphist to write some characters, and showed her its conversion to music. The calligraphist was not only amazed to see how her calligraphy converted to music, but also tried to make a different shape of calligraphy that could produce harmonized music. These experimental trials also can give opportunities for calligraphists to expand their means of expressions.

Figure 8. Hé as an expression tool for calligraphists

Finally, we also tested it for the users who do not have much knowledge about music or calligraphy. We asked them to write some calligraphies or shapes after brief explanation of how it works. Some people tried to make intentional shapes in hopes of producing what they intended to hear, whereas others focused on the shape of calligraphy and were curious about what music their calligraphy generated. Since our project used harmonized notes, Chinese pentatonic scale, people could listen to well-assorted music with Chinese calligraphy even if they are not good musicians. Since many people enjoyed its interesting future, we also can expect the various types of arts participation. The video of 'Hé' is accessible on the website: http://www.itp.nyu.edu/~lk1068/he

6. CONCLUSION AND FUTURE WORK

We propose a new type of musical instrument in which people can draw calligraphy and listen to how it converts to sound. From the user testing, we found that the users were very curious about what sounds can be generated from their calligraphy, and actively participated in drawing calligraphy. Also, since our project converts basic visual components to musical components, Hé(和) will help people to understand the relationship between vision and sound.

However, we can only use Hé(和) for a limited time because the paper should be replaced when people paint on it (the paper serves as a one-time use). We expect Hé(和) to improve as a better musical instrument when we can use longer paper or build the system that can refill its paper supply automatically upon usage.

7. REFERENCE

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