Harmonic Paper: Interactive Music Interface for Drawing

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Abstract
This paper describes the project ‘Harmonic Paper’, an interactive interface that converts a user’s drawing into music. By means of a microcontroller and series of photocells, the installation can detect diverse features (location, thickness) of physical drawing in a letter-size paper, and convert them into musical components (note, volume, tempo) with visual feedback (color light). We also provide a custom-designed software that allows users to virtually practice this hardware installation. This set of software and hardware helps user to explore new musical and visual expression through an understanding of audio-visual relationship.

Author Keywords
Music interface; drawing; sonification; visualization

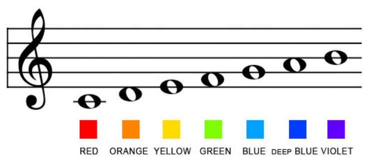
ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. See:

Introduction
The project ‘Harmonic Paper’ is a stand-alone interactive interface that helps users explore the relationship between music and drawing. By means of a microcontroller, MIDI codec IC and series of photocells, the interface detects the thickness and location of drawing in a letter-size paper(8.5 in x 10.5 in), and

converts them into music note and sound volume. As shown in Figure 1, a user can insert a piece of drawing on the top of the interface(1) and crank the handle(2) in order to roll down the paper. While the paper passes the sensor box(3) that includes 15 photocells, it generates the sounds on real-time according to ink's location and thickness with color LED light feedback. The color of the lights are mapped by the order of corresponding sound frequency(i.e. C, D, E, F, G, A, B convert to Red, Orange, Yellow, Green, Blue, Dark Blue, Violet). The software interface is also provided in which users can virtually practice the functions of this hardware. Such combination of software and hardware allows users to create both musically-composed drawings and visually-created music.

The motivation of this project is to explore the question: how technology can help people to feel the sense of 'synesthesia?' Synesthesia generally refers to the phenomenon that one sensory stimulate additional sensory at the same time. Kandinsky's abstract paintings including Composition series can be a good example of the synesthesia that is possible by his ability of synesthesia[6]. Although such concept has been discussed since more than 200 years[1] ago as well as introduced in diverse area including art and science, it is still considered as unfamiliar and magical ability that ordinary people rarely understand and experience.

With the aid of modern technology, however, this concept becomes more accessible to understand. Especially in the field of Human Computer Interaction, many types of novel interfaces have been introduced for helping users to explore the relation of visual and sound, which ultimately supports a better understanding of synesthesia. Jo's Drawsound[2] utilizes a multi-touch screen with custom-designed electrical pan in order to explore how drawing and its action can be converted to sound. Li's Music Box[3] utilized a camera and computer to recognized the drawing in the paper. Huang et al.'s MelodicBrush focuses on detecting Chinese Calligraphy practice by means of screen and camera. The project 'He'[4], one of authors of this paper was participated, converts Chinese calligraphy into Chinese pentatonic scale by means of photocells and serial communication with MIDI program on the computer. However, all of these interfaces require professional setting like sensitive location of camera, lighting or installed software on computer, which makes difficult for novice users to enjoy and explore. In addition, those related projects have lack of visual feedback of drawing practice that can give more playful interaction.



The LED colors are mapped in the the order of sound frequency in one octave to Newton's prism spectrum, then repeats in the second octave.

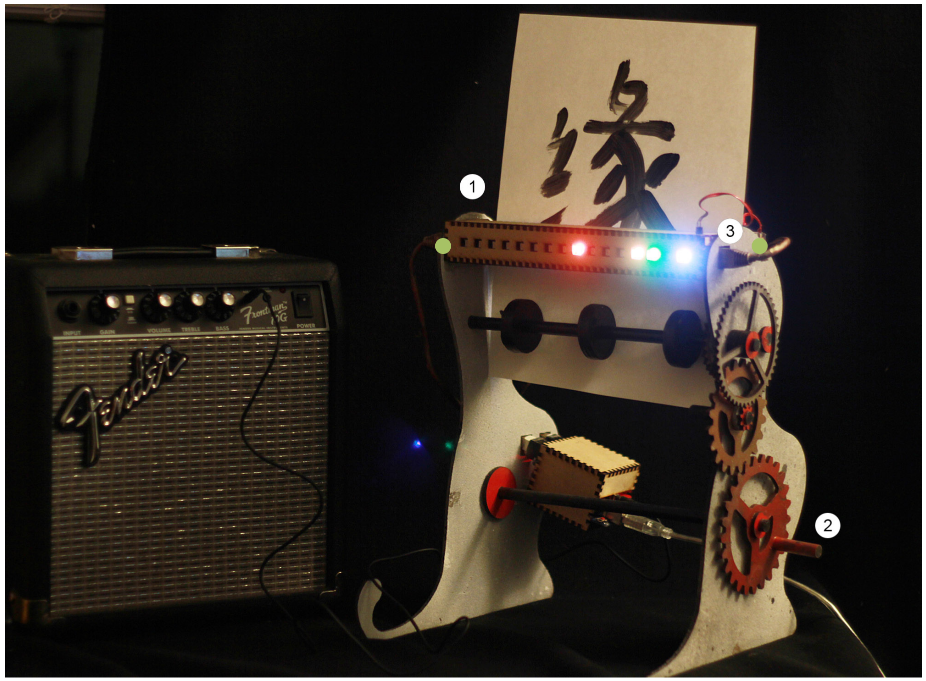
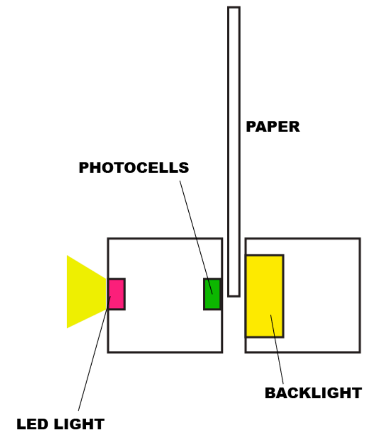


Figure 1. Harmonic Paper Interface.



While the paper passes the sensor box that includes 15 photocells, it recognizes ink's location and thickness. Behind the sensor box, there is backlight that allow stable ink detection.

Approach

As we discussed above, we identify several limitations on the existing interfaces about drawing and sound, and set up the following design goals. First, the new interface would be more accessible for novice that doesn't require complicated setting. To do this, we designed a stand-alone device that only need 12v DC power that runs without a computer. Second, the interface would provide a familiar drawing setting to for more people. Although increasing numbers of people draw something in screen-based devices like iPad, the combination of paper and pen are still intuitive to more people including children and old people. For this, our interface is designed for using a letter-size paper and normal ink pen, which are easily found in our everyday life. Third, the interface would provide colorful feedback, which draws user's attention as well as help understand the color-sound relationship. In addition, we also wanted to design the software that has the same function as the hardware interface, which allows user to practice the interface virtually. Therefore, users are expected to be able to compose the music not in traditional notation way, but in 'drawable' way, which push the boundary of musical and visual expression.

Drawing to Sound

The interface detects three following factors of drawing: location, length and thickness. Such factors are converted into notes, note length and the volume of the sound. A user can decide the tempo of the sound by rotating the crank. For example, a user can make fast tempo music by rotating the crank faster by which a paper roll down faster as well. These sound factors are also digitalized as MIDI signals and sent to MIDI IC. Table 1 shows how drawing maps to MIDI signals. According to the location, 2 octaves of C scales are supposed to trigger. Figure 2 how MIDI notes trigger based on the drawing's location.

Drawing Factors	Sound Components	MIDI Signals
Location (Left to Right)	Note (Low to High)	Note On and Off
Length (Up to Down)	Note Length (Short to Long)	Delay Time
Thickness (Bright to Dark)	Volume (Low to High)	Key Pressure
Paper Rolling Speed	Tempo	None

Table 1. How to convert drawing to MIDI signal in the project.

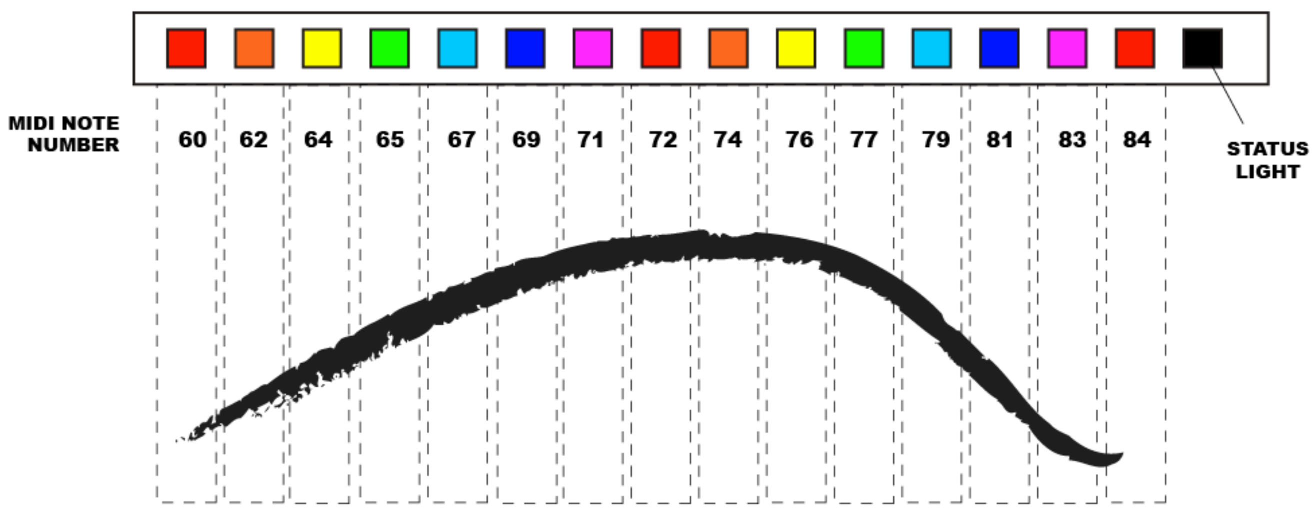


Figure 2. The relationship of drawing and MIDI note in the hardware interface.

Sound to Color

The interface also includes the series of RGB led that gives visual feedback of triggered sound. Both acoustic sound and visible light can be analyzed in the wave frequency domain. For example acoustic sound is located in the range from 20Hz to 20,000Hz that maps low pitch to high pitch. On the other hand, the frequency range of visible light lies on 430 trillion Hz ~ 750 trillion Hz that maps red(4 x 10^14 Hz) to violet(8x10^14 Hz). In our project, we simply map the order of sound frequency in one octave to Newton's prism spectrum, then repeats in the second octave. For example, C, D, E, F, G, A, B convert to Red, Orange, Yellow, Green, Blue, Dark Blue, and Violet.

Technical Details

Hardware

The interface uses 15 photocells to detect the location and thickness of drawing. There is also a led light box behind the series of photocells. A paper is supposed to be inserted between this backlight and photocells. When the thickness of ink that drew on the paper block the backlight, the photocells measures the amount of the light it can get based on its locations. This information is interpreted by Arduino Microcontroller and sent to MIDI IC, and therefore generates the corresponding sound through speakers.

Software

The user interface of the software is as shown in Figure 3. Basically, a user can choose three options in thickness (light, medium, hard) and three options in length (short, medium, long). After these two selections, the corresponding box will follow the mouse cursor, and then a user can drop the box where he or she wants to draw. After finishing the drawing, they can click the "play" button to listen to the drawing that they composed.

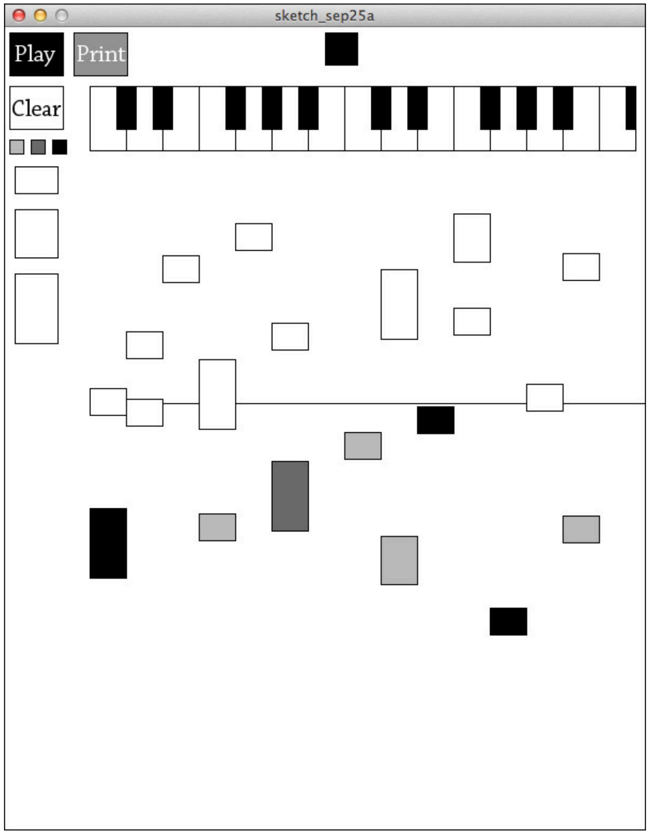


Figure 3. Software interface of Harmonic Paper. User can virtually practice the hardware.

User also can delete what they designed by clicking 'Clear' button. Once it starts playing, the "Timeline" indicator goes down from the top to the bottom of the drawing to detect the thickness and location of the boxes. Detected boxes make corresponding music notes and become blank while the timeline is passing by. There is also 'Print' function that allows to save the drawing into PDF file and print it into a letter-size paper. This paper also can be used in the hardware interface as shown in Figure 3. The software is implemented by Processing, a JAVA based open source language platform, and MIDIbus library.

Conclusion and Future Work

The project 'Harmonic Paper' is an interactive interface that allows users to listen to the music from their drawings on the paper. Among other projects converting drawing to music, this interface provides following advantages: easy-setting, physical drawing conversion, and color LED feedback. We expect these advantages would help people to enjoy and understand the concept of sonification, music visualization and synesthesia. In order to prove such goals, following user test will be required in the future works. In addition, from internal user tests by our colleagues, we identified several limitations on our project that we have to leave as our future works in this paper. First, the system only detects the thickness of drawing without recognizing its colors. If the system becomes color detectable, it would help better visual expression of drawing. Second, the current system doesn't detect the continuous line of drawing; it divides 15 sections of the paper from left to right. Although the purpose of this project is not to convert drawing to sound exactly(not sure whether it is even possible), but gives more room to explore the relationship between music and drawing easier and enjoyable way, we still would like to explore other possible ways by improving the issue that we mentioned above.

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