**Sound Pointage: Creation of Music by Accumulating Minimal Elements of Digital Information**

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**Abstract**

*Sound Pointage* is a type of artwork that demonstrates a new method of creating digital sound. It compiles minimal elements of digital information to build sound. In this approach, artists can control all aspects of sound rather than simply allocating abstract musical concepts such as notes. *Sound Pointage* was implemented with a high-performance computer mouse and was open to the public for two weeks. Visitors freely interacted with the work, and their actions were accumulated as a seamless waveform, eventually being converted into a hi-fi sound.

**Keywords:** Sound creation method, Pointage, Drawing sound

**Motivation**

Before anything else, music is the art of sound, and sound is the vibration of the air medium that is transferred to the eardrums of listeners. The eardrum resonating with the medium then sends a corresponding electrical signal to the brain, causing a time-varying effect on the listener’s soul. Musicians have desired to understand this mysterious phenomenon and have continued their creations based on different technologies. At this point, a single technology is not only a simple method but it represents a single philosophical perspective of one’s understanding on music. Hence, it is not surprising that sometimes a new method of creating sound leads to the birth of a new genre of music [1, 2].

This work began with a question about conventional methods of creating music. I desired to escape from the existing framework of making music, which conceptualizes sound as a composition of several types of meta-information, such as pitch or duration. On the other hand, I imagined the smallest material of digital sound, which is going to be continuously stacked to make what can be termed *architectural sound*. This approach is possible because all digital information has its own smallest data packet given its discretized nature of signal representation. In the case of sound, the time and amplitude domain is divided into finite numbers of samples, which are determined by the sampling rate and bit depth of quantization. After this division, the time-amplitude space becomes a uniform grid, and its smallest element is surrounded by a unit of the quantization step with a unit of the sampling interval. I could assume this element to be the smallest difference that a listener can recognize, as nearly all recorded music is now distributed in a standard digital format (44100Hz, 16 bit). In my work, this element will be accumulated gradually to build sound. Through this process, music more closely matches the musician’s intention, which is more integrated than any other form of music before. This work is like an abstract painting grounded on deconstructivism and supporting the musician’s intentions with the highest degree of freedom.

There have been several previous works in which drawing was considered a metaphor for a means of creating music [3, 4, 5, 6]. However, these works only undertook mapping between the drawing action and the resulting sound, assuming several abstract features as well in the visual domain. This represents merely a repeated philosophy in a different sensory domain. Hence, the method presented here is very different from these earlier works.

**Technical Issues**

In this section, I discuss the technical issues to overcome in order to implement the system. As any digital sound is simple two-dimensional data with varying time and amplitude domains, my implementation offers a surface consisting of uniformly distributed markable points for musicians. The number of points is determined by the sampling frequency and bit resolution of interest.

Here, the target sound quality corresponds to that of standard CD-quality sound (44100kHz, 16 bit). Hence, I need 44100×65536 dots to create one second of sound. This number is quite large, given that 705 high-resolution monitors were required (Mac Cinema Display, 2560×1600) to make all of the dots visible at a glance. Therefore, a very sensitive sensor is required to capture the intent of the musician successfully over this broad area of dots. In this case, a CCD sensor embedded in a high-performance camera (Canon 5D Mark 2, 5616×3744) could be a candidate, but musicians still need to take 100 pictures of a hand-drawn waveform, which also requires additional image-processing algorithms to extract the lines from the background noise. Hence, it is too challenging and unrealistic.

When considering A4-size paper as an appropriate area over which a hand can move freely, the computer mouse is the only device with which it is possible to process hand movements in sufficient resolution so as to represent an audio signal. The computer mouse has a fixed-body coordinate system and is intended to capture delicate movements of a human hand in a small space. The mouse has evolved continuously since the graphical user interface (GUI) of the personal computer became popular. A mouse commonly measures about 1000 samples per inch of movement (1000 counts per inch, CPI). However, recent developments in the gaming industry have allowed a more powerful mouse that measures about 6400 samples in an inch of movement [7].

With this high-performance mouse, I can now sample 64000 times during 25.4cm of movement in both the time and amplitude domain, which is sufficient for creating high-resolution audible sound from hand movements. Furthermore, the sensor of the computer mouse experiences relatively little noise and is easily transferred onto a personal computer to visualize the entire procedure in real time on a display. Hence, I decided to use this mouse for further implementations.
Implementation
The computer mouse detects two-dimensional (2D) motion with respect to its supporting surface. These measured signals were reported as dx and dy values with respect to its body-fixed coordinate system. However, it is challenging to capture raw data passing through the operating system of a laptop. Therefore, I built an interface composed of an Arduino microprocessor and a universal serial bus (USB) shield to capture the raw data coming from the computer mouse. The interface then transfers the data to a laptop using a serial port. The java application installed in the laptop uses a projector to render the real-time generation of the waveform. Also, when any new waveform is added, the entire waveform is played through a pair of electric speakers to give feedback to the artist.

This system was installed in a gallery (Fig. 1) with the mouse located on the top of a white cubic box. Visitors can freely manipulate the mouse over the surface to create sound elements. Only left-click-and-drag actions were allowed, which generated white strokes on a black wall. This is similar to a pen function using a drawing application, while the strokes represent the waveform of the sound in my installation. In this case, the vertical and horizontal axes of the wall were mapped onto the time and amplitude domain of the waveform, respectively.

The projector was installed at an angle such that it could selectively visualize the beginning of the waveform on the floor. The beginning point was fixed at that location, and the strokes were generated from that point to be sequentially carved on the black wall behind it. However, only a small part of the waveform was shown on the wall due to the limitation in the resolution of the projector (1920×1080 pixels). Nearly 1400 projectors are needed for a full visualization of the area, which is impossible at this stage.

The signal from the mouse was used to generate strokes in a manner similar to that of a drawing application. However, the strokes were only added in the upward direction, as a unit-sampling interval for the firing of a dy event. This setup guarantees that a sufficient length of the final waveform is retained during an exhibition period. However, this is not mandatory for general use. Lastly, the raw dx signal was simply added to the amplitude of the waveform.

Once a left-click-and-drag action of a visitor is finished, the entire waveform including the history was instantly transferred into a wave file (44100Hz, 16 bit), which was played through a pair of electric speakers. Visitors can change their drawing strategy based on this inspection. Lastly, the exhibition continued for two weeks, recording all of actions performed by each of the visitors.

Resulting Sound
Many people visited the gallery during the exhibition period and manipulated the mouse using varying strategies. As a result, about one second of length of sound was created, containing approximately 44100 sampled points. Some people enjoyed very intensive strokes, which resulted in a high frequency with large amplitude of sound. Others enjoyed more relaxed strokes to make a low and quiet sound, as shown in Fig. 2. However, it was commonly difficult for people to draw a straight line using the mouse, which is an ergonomic problem pertaining to the hardware itself [8]. Thus, it is still important for artists to have time to learn the technology, while the proposed method is very intuitive and minimal. Musicians who make music in this way for a long time will likely find it easier to express their intentions.

Some people tried to relate the images in their movements to the drawn sound directly. Is there really a semantic difference in the resulting sound between the movement, i.e. between annoyance and pleasure? It would be more interesting to attach the mouse sensor onto different body locations to transfer a dancer’s movement into hi-fi sound. I want to conduct more research in the future from this perspective.

The resulting waveform sounds new to our ear, as it cannot be generated by a typical synthesizer or with acoustic musical instruments. It does not sound like noise, although abstract musical concepts are not apparent in the sound. Furthermore, listeners were more immersed in the sound, as it was not in the lo-fi format but was presented in standard CD quality. All of the listeners agreed that no patterned sound familiar to our ears was found. This sound can be used as a solo music track or synthesized to augment conventional electronic music, eventually heralding a new type of music.

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References and Notes