Virtual Pottery: An Interactive Audio-Visual Installation

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ABSTRACT

Virtual Pottery is an interactive audiovisual piece that uses hand gesture to create 3D pottery objects and sound shape. Using the OptiTrack motion capture (Rigid Body) system at TransLab in UCSB, performers can take a glove with attached trackers, move the hand in x, y, and z axis and create their own sound pieces. Performers can also manipulate their pottery pieces in real time and change arrangement on the musical score interface in order to create a continuous musical composition. In this paper we address the relationship between body, sound and 3D shapes. We also describe the origin of Virtual Pottery, its design process, discuss its aesthetic value and musical sound synthesis system, and evaluate the overall experience.

Keywords

Virtual Pottery, virtual musical instrument, sound synthesis, motion and gesture, pottery, motion perception, interactive sound installation.

1. INTRODUCTION

Virtual musical instruments based on mathematical acoustics have been successful for recent years in the computer music research community. Performers who don't have any background in music can benefit from virtual instruments because they are usually easier to play than real instruments [1] Moreover, there are no complicated and required sound skills and time consuming installation in virtual music environment. Computer and portable virtual device can bring enjoyable and powerful musical experience to anyone who wants to play music. New technology and media have been combined with traditional musical instruments, and it has expanded the boundary of real and virtual experience to performers. Thus, today's virtual musical instruments are becoming more powerful while our awareness of them as technology is shrinking.

The most significant part in the development of virtual musical instruments is the investigation of human body movement and gesture. As new technology has been evolved, new interactions may cause problems in understanding the performers' communication with the new interface and contents. The ideal solution to allow the performers to perform digital and virtual musical instruments is to use natural body movement and hand gesture in the same manner as they do in the real world. Thus, the reuse of natural hand gesture should be addressed in virtual environment for the better performance. Especially, natural hand gestures originated from pottery art are simple and intuitive ways to create 3D objects. Furthermore, 3D pottery shapes can be converted to dynamic visual forms and sound spectrum because of its dynamic 3D data.

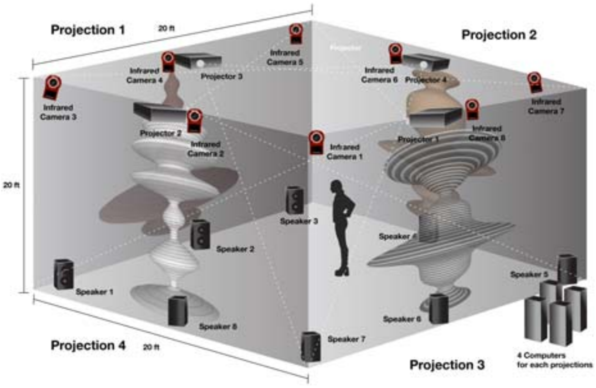

Figure 1. Overall structure of Virtual Pottery.

While considering the new musical interface in virtual environment, we have been designing and implementing Virtual Pottery, an interactive audiovisual installation. The natural hand gesture from original pottery is used for the fundamental interaction. A performer should be in motion-capture environment called OptiTrack motion-capture based on Rigid Body toolkit [2], and wear a glove attached with trackers. Although the performer should be in specific arranged environment (motion-track system), he/she is free to use the hand and move the body. Furthermore, 3D shapes along with harmony can enhance immersive audiovisual experience.

2. RELATED WORKS

There are already existing interactive systems that control music or sound based on human body movement [3-6]. For example, Hyperbow Controller [3] provided a solution to extending the limit of traditional musical expressions. The sound produced can be altered by bow position, pressure on the bow stick and acceleration of the bow. Another example is Sound Sculpting [4], which proposed a new approach to mapping hand movements to sound through shapes of a virtual input device controlled by both hands. The attributes of the virtual object are translated into new parameters for real time sound editing on MAX/FTS application.

As regards the methods of virtual objects expression, especially in pottery and clay arts, L'Artisan Electronique [5] showed a good example that implies the creation of pottery by hand gesture to virtual space and 3D printing techniques. This work shows how the virtual pottery pieces can be converted to 3D pieces in real time, which is the very clear and direct

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instruction to audience. CHINA [6], a hands-on interface, supports 3D object creation and ceramic arts in a virtual environment. Dynamic hand gestures create virtual objects stereoscopically that are presented through LCD shutter glasses. The glasses and glove connected with computer in a small space limit performers to share their creation of pottery pieces to other people. Virtual Pottery has a similar interaction with these works mentioned above in terms of visualization, pottery theme and hand gesture. However, the musical composition and flexible space arrangement used in Virtual Pottery highlight the huge difference. The additional function, music sequencer interface, can be powerful strength of our project.

In contrast to aforementioned examples, we highly focus on 3D shapes with sound spectrum by simple natural hand gesture with a metaphor of pottery method so that audience can easily be aware of frequency-domain spectrum and simple arrangement of sequencers.

3. VIRTUAL POTTERY

This section describes Virtual Pottery. First, concept and scenario are presented. Next, we depict how to capture motion from human gesture, how to translate acquired motion data into sound synthesis parameters, and how to visualize data. Fig. 1 shows the overall structure and installation plan of Virtual Pottery.

3.1 Concept and Scenario

The concept for Virtual Pottery began with a casual question: "*Can we design 3D pottery shape and sound together by hand gesture in real time?*" In real pottery, various materials, equipment and huge amount of time and effort to achieve professional skills are required. On the other hand, if there is a virtual environment where we can realize 3D virtual sculpting, a lot of physical problems appeared in real pottery creation can be solved. Fig. 1 shows the overall structure and installation plan of Virtual Pottery. In order to realize Virtual Pottery installation as shown in fig. 1, an appropriate environment, where hand gesture can be detected without complicated equipment installation and other following physical fabrication, is needed for Virtual Pottery implementation. In section 5, we describe diverse aspects of the implementation and detailed technical information about the installation space and environment.

The ideal equipment and space for Virtual Pottery must consist of motion-tracking system with infra-red cameras and opti-trackers for human gesture recognition. In the space, four projectors on the ceiling present four or more pieces of pottery that contain various musical harmonies, and continuously play all sequentially in real time via multi-channel speaker system. The performance is happened when a performer enters the space, and stands in front of the first projection. Once the performer understand how to create and manipulate the design of pottery piece, he/she can save the pottery file by choosing "save" button on the screen, and move on the other pieces of pottery in order to compose musical structure. The performer can control the arrangement and speed of sequencing pieces of pottery by changing hand gesture.

3.2 Visualization of Virtual Pottery

Overall, the design of pottery pieces simulates the real clay pottery works in terms of shape, symmetry, texture, and color. If you look fig. 2, the results show not only the representation of appearance of real pottery artworks but also frequency domain graphs or sound spectrum. The dramatic change of radius of certain y axis results in the creation of various design of pottery shapes. Performers can enjoy, play and challenge by altering the shapes of pottery along with sound spectrum. It's

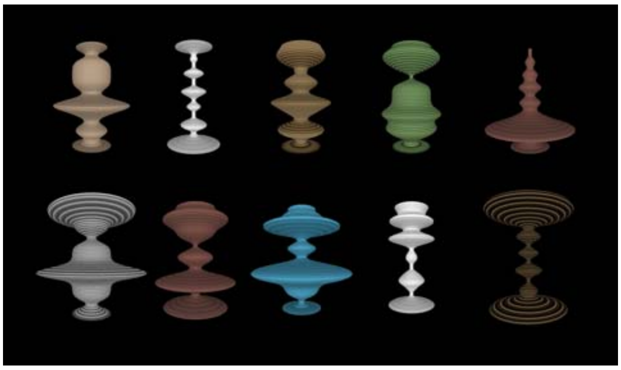

Figure 2. Various design created on Virtual Pottery system.

very intuitive way for performers to recognize the harmony and visual shape of pottery all together. Furthermore, if the performer flips the hand and changes four values of quaternion, the color and texture of pottery pieces are changed. For example, different glaze material can be applied in certain part of the piece, so that the variations of sound spectrum deliver powerful result in composition. The beautiful aesthetics of various pottery pieces are enjoyable for performers Music, shape and color are correlated each other, and all the aspects in Virtual Pottery harmonize together in real time music performance.

3.3 Sound Synthesis

In Virtual Pottery, the creation of pottery actually means a process of sound synthesis. The most significant feature in Virtual Pottery is a translation from hand gestures and materials of traditional clay art into sound synthesis process in a virtual space. To bridge two different concepts, the creation of pottery and sound perception, we set up the rules that making a clay body is transformed into 3D sound magnitude spectrum, and applying glaze materials is applied to change audio filter and effect. Those two functions are the most primary steps for the creation of pottery in Virtual Pottery. In conclusion, we need two major translations: i) vertical contour, which is formed by making clay body can be translated into shaping frequency spectrum, and; ii) glaze material on pottery surface, which can be represented by audio filter system in our system.

3.3.1 Clay Body Shape to Magnitude Spectrum

One of the major two translations, the vertical contour, is obtained by mapping a clay body shape to a curve. In our work, we regarded this curve as a magnitude spectrum of a periodic sound snippet. A magnitude spectrum consists of frequency and its power magnitude information. Virtual Pottery transforms the height of pottery into frequency as: the contour on lower part of clay body describes low frequency component of sound, whereas; the upper part of clay body describes high frequency component of sound. Meanwhile, frequency range in translation can be limited to audible frequency. In our work we limited the translation between 20Hz and 1,000Hz, because performers usually want to describe sound within voice frequency band range. On the other hand, the shortest distance between a point on axis of rotation and curve is regarded as magnitude information. Finally, a sound snippet is synthesized by composing the above frequency and magnitude information. Fig. 3 depicts how to synthesize a sound from a shape of virtual pottery.

3.3.2 Glaze Material to Audio Filter and Effect

The other translation deals with glaze materials on the pottery surface to apply audio filter representation. In real pottery creation, ceramist enamels a partial or entire clay body to

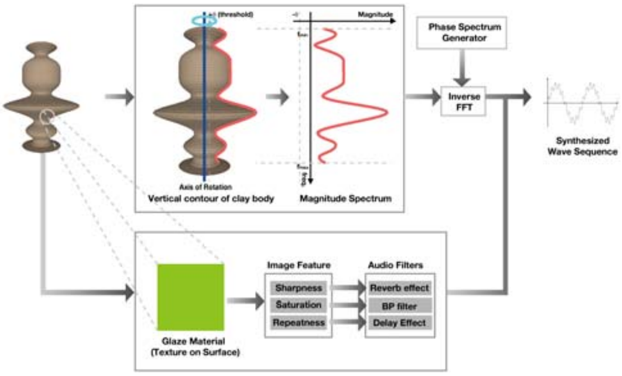

Figure 3. Sound synthesis from a creation of virtual pottery.

characterize the surface of a piece. As like the glazing step in real pottery creation, we focused on applying texture on the virtual pottery surface. In glazing step, performers can fill out different texture on the entire surface, which can be examined by the texture type of the pottery piece. As aforementioned, every position on the height of pottery represents every frequency value. Thus, the height of glazed area can be regarded as the frequency range to apply audio filter. On the other hand, texture can be translated into diverse audio filters by pre-determined rule. In Virtual Pottery, we set up the rules as sharpness, saturation, and period of texture pattern of glaze image, and employed band-pass(BP) filter and reverb/delay effects. In detail, we translated sharpness of glaze image into reverb effect, a saturation range of glaze image into a frequency range of BP filter, and period of texture pattern into delay time. Fig. 3 depicts the process of image feature extraction from texture on the surface of virtual pottery and translation of extracted feature into audio filters, which will be applied to lastly synthesized sound.

4. SOUND SEQUENCER

As explained in section 3.2, performers can change the values of x, y, and z axis to modify the shape of pottery pieces and sound spectrum. After the single piece of pottery is created, performers can arrange it in four different projection walls and compose the harmony sequences by using the same hand gestures. As we briefly mentioned before, the process to save design is to move hand toward a “Save” button on the screen, and activate it by changing y value. And the performer moves on to create another new piece of pottery in the front of second screen while the previous design is kept playing on the first screen. So after the performer creates all the four designs on each projection wall, all the four pieces of pottery are played in certain time interval. Every design take turns playing their sounds one after another just as the performer has laid them out. The performer can create various compositions by laying out the other pre-saved pottery pieces. In real time, diverse musical performance can be possibly created by basic hand gesture. This real time performance is observed by not only the performer but also the other audiences in the room.

5. IMPLEMENTATION

It is needed to consider diverse aspects in order to implement our novel interface, Virtual Pottery. In this section, we present our idea to implement Virtual Pottery from diverse viewpoints.

5.1 Installation Space Requirements

As mentioned in section 3.1, Virtual Pottery needs an appropriate space for satisfying the installation plan shown in fig. 1. For satisfying overall requirements, we selected TransLab in UCSB, which are furnished with diverse equipment such as four projectors with projection walls, motion

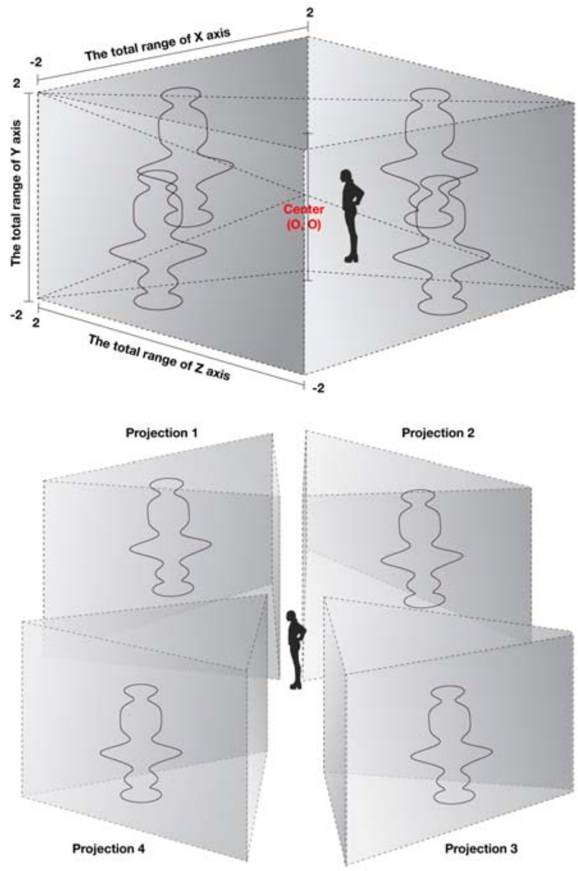

Figure 4. Spatial range configuration for motion gesture recognition functionality in Virtual Pottery.

capture system, and multi-channel speaker system. The size of TransLab room is about 20ft (width) x 20ft (height) x 20ft (depth), which is perfectly enough to have a performer and certain number of audiences. In this space, the performer should wear a glove with attached trackers and perform the hand gesture in x, y, and z axis. Finally the motion capture system receives and processes the gestural information.

5.2 Hardware and Software Requirements

The hardware of Virtual Pottery consists of interactive controller, audiovisual equipment, and computer systems.

We first considered a wireless interactive control system for maximizing performer’s activity and minimizing physical obstruction in performance. A solution, the OptiTrack motion capture system, a part of Rigid Body system [2] and is prepared at TransLab in UCSB, satisfied all the requirements. OptiTrack contains a glove with three attached trackers and enables UDP-based data transfers via wireless network communication.

Our work required low-latency network to deliver performer’s action quickly; hence we had to consider high performance computer system. Since visualization task could clog sound synthesis task and vice versa under computer system with low number of CPU cores, we did not assign multiple functionalities to one computer system. Thus, we limited only one visualization task and one sound synthesis task to one computer system, because most our computer systems contained two or more number of CPU cores. Exceptionally, one of the systems carried out additional sound sequence task, which controls audio playback of each system via local network, and the task just needed extremely smaller amount of process resource than ones of other tasks.

On the other hand, the software implementation is mainly based on Processing [8], which is an open source Java language-based development environment for easily implementing audiovisual objects. In order to extend functionalities in Processing-based development environment, we additionally employed following extension libraries: UDP processing library [7] for wireless communication between devices and Minim [9] for sound synthesis.

5.3 Motion Gesture Analysis

When the values of x, y, and z axis are acquired in Processing-based application, one triangular boundary surrounded by positions of the three values is created in the Rigid Body software, which enables to track the position of the performer's hand. The performer should choose one projection among total four projections, and enter the spatial range of selected projection space. The way of creating a piece of pottery is the same in any projection. If the performer moves the hand vertically to change the value of y axis, it represents the selection of a specific frequency domain to change the magnitude. In order to expand/reduce certain radius of 3D string and to increase/decrease the magnitude of certain frequency, the performer should move the hand forward to screen and enter to "Active mode/ON." The boundary between "Active mode/ON" and "Inactive mode/OFF" is in the middle of spatial range. And then, the performer can move the hand horizontally and vertically to adjust the shape and sound of the pottery.

6. DEMO PERFORMANCE

We had a demo performance in TransLab on January, 2012. One performer continuously created four pottery pieces and arranged it in four projection walls. There were some audiences who observed the overall process and performer's live performance. The audience interestingly observed how the performer quickly noticed the way of composing good harmonies by keeping altering radii of 3D virtual pottery pieces. Once the performer learned the simple synthesis and composition skills, the subtle musical composition was possibly conducted, and mostly the visual strength delivered the enjoyable experience to both audience and the performer. However, as the performer got exhausted by consistently running into the other projection in order to modify the shape of the pottery, the speed of music variation has been slower than the one at starting point. However, the other performer switched the turn, and soon the problem was resolved. The other problem was also the degraded networking performance between Processing-based application and OptiTrack system. Since Processing needs to prepare and optimize additional library to communicate with other heterogeneous systems, it was hard to integrate Processing-based application with interfaces implemented on other platforms. Hence, this problem could cause data transmission performance degradation in local network system, for example, the delayed response bothered smooth performance. It should be the prior part to figure out for the next version of Virtual Pottery.

7. CONCLUSION

The creation of Virtual Pottery was an experiment to craft a virtual audiovisual installation that is a novel interactive sound synthesis and sequence interface. It combines physical metaphors of a pottery clay art with the virtual elements of a drawing and musical instrument. Even though the first demo performance has been positive on the whole, we still have much to learn from the rich data it provides about how performers learn and relate to the experience. We have plans to work on some further enhancements and assessments of the system as follows: developing a method to stabilize the networking

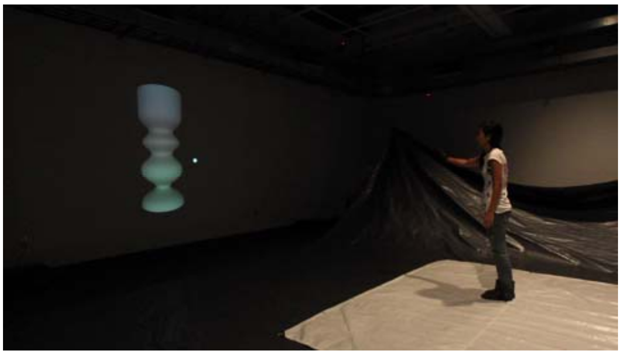

Figure 5. Demonstration and test installation in TransLab.

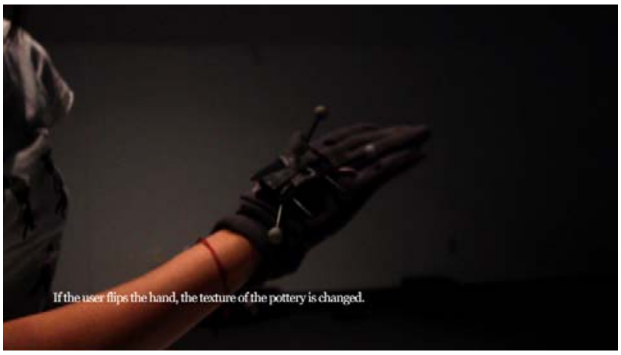

Figure 6. Three trackers on a glove.

communication, investigating a system for the advanced sound sequencer, supporting real time 3D printing with Virtual Pottery making, and experimenting possibility of its application to the ceramic art or music education. We would like to investigate the usefulness and effectiveness of this installation through these activities.

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