Stick'n Roll: A Playful Stick Interface for Curved Display

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ABSTRACT

We present a projection system called Stick'n Roll in which users manipulate a set of sticks (or batons) on a series of curved display. The system relies on the use of unique movement of sticks rolling on convex surfaces. We regard the touching of sticks to the surfaces as input to the display that also functions as a multi-touch input device. We develop a variety of applications such as balloon popping, a music game, a virtual keyboard, and a draw tool that make effective use of the rolling of this stick interface. Since the silhouette of the pair of surfaces resembles a huge opened "picture book", we put some applications together in that virtual book and enabled transferring from one application to the other by turning over the virtual pages. Then, the new experience users can have when they control the sticks and manage the world in the picture book is what we want to share as "kiddy dream in VR", the theme of ReVolution 2015.

Categories and Subject Descriptors

B.4.2 [Input/Output and Data Communications]: Input/Output Devices - Image display

H.5.2 [Information Interfaces and Presentation]: User Interfaces - Input devices and strategies

General Terms

Performance, Design, Human Factors.

Keywords

Curved display, Sticks, Rolling, Interface, Projection, Music game.

1. INTRODUCTION

Recently, research and development on curved display has advanced significantly, especially for smartphones, large-screen TVs, and digital signage. However, advantage of such displays is rather focused on the quality of images and the interfaces are limited to existing ones such as a mouse and a keyboard, a remote

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Figure 1. Play with Stick'n Roll.

controller, a multi-touch device using fingers, and so forth. As such, little is known on input methods and interfaces that make effective use of the curved surfaces.

We propose a projection system called Stick'n Roll (Figure 1) that makes effective and playful use of sticks rolled on a series of convex surfaces. The system relies on the unique movement of sticks rolling on such surfaces that are recently developed by one of the authors [1]. In our system, we "electrify" this system by making the sticks as interface, the curved surfaces as display upward, and touching of sticks to the surfaces as input to the system. For implementation, we cover the curved surfaces with sensor sheets based on electromagnetic induction. Then, the surfaces work not only as multi-touch input devices but also as display. The sticks are coated with the aluminum tape for obtaining the touching information on the sensor sheets. These data are sent to the computer and used for each of the applications. The generated images are transformed to fit to the surfaces and finally sent to the projector set above the display. We note that the system can be played not only by a single user but also by several users collaboratively or in rivalry using all sides of the surfaces.

We have developed a variety of applications, such as balloon popping, a music game, a virtual keyboard, and a draw tool that make effective and playful use of rolling sticks. For ReVolution 2015, we regard the pair of surfaces as a huge opened "picture book" and put some of the applications together in the book, where one can move from one application to the other in the book by virtually turning over the pages. Through demonstration, we show that Stick'n Roll offers a new playful and kinetic interaction with curved display and it can be used in a broad range of applications, including gaming, music, sports, and performing arts.

2. VISUAL INSTRUMENTS

Generally, we call such instruments as musical instruments that a player skillfully manipulates to make musical and auditory expressions. Analogously, we call such instruments as *visual instruments* that a player skillfully manipulates to make certain visual expressions. Then, existing instruments such as the pommel horse, hoops, rings, ribbons for gymnastic and rhythmic gymnastic and yoyos, balls, clubs, rings, and trapeze for play and performing arts could fall in this category. Furthermore, one of the authors has developed several new types of visual instruments based on object rolling [1-3]. In Figure 2, we show the visual instruments developed in [3], where the set of sticks (or batons) are rolled on the series of convex surfaces to make a variety of tempo-spatial patterns. The locus of the end point of the stick is shown two-dimensionally in Figure 2, Right.

Figure 2. Left: rolling of sticks on curved surfaces. Right: its two-dimensional visualization.

We notice that this instrument is suitable to be electrified as digital devices by the following reasons.

- The surfaces can be regarded and used as display facing upward.
- The sticks roll and touch the surfaces at one point every moment (theoretically), so it can be used as input to the surfaces.
- When multiple sticks and surfaces are used at a time, various input patterns (multi-touching, synchronous and asynchronous input, etc.) are possible, which allows users to implement a variety of applications on the system.
- Rolling of sticks is visually appealing and the manipulation of sticks is quite playful in its own right.

Based on these observations, we electrify the instrument as a digital entertainment system that admits a reasonable range of applications.

3. SYSTEM DESCRIPTION

3.1 System Overview

The overview of the system is shown in Figure 3. The system consists of the following devices: The curved surfaces on which pressure sensor sheets and white screens are spread; multiple sticks used as interfaces; the computer; and the projector. When sticks are rolled on the surfaces, the sensor sheets on the surfaces recognize the touching information of the sticks and send this data to the computer. The computer detects how the sticks move on the surfaces and makes application-specific processing. After transforming the images to be mapped on the surfaces properly, they are sent to the projector and projected onto the surfaces. The overview of the system is shown in Figure 4.

Figure 3. Rolling of sticks on curved surfaces.

Figure 4. The whole system.

In the succeeding sections, we illustrate some details of the system.

3.2 Surfaces and Sticks

The surfaces are made of PVC sheets and fixed to the wooden frame of size 600x450 [mm] in the convexly arched form as shown in Figure 5, Left. The surfaces are covered with sensor sheets and the white screen. The sticks that roll on the surfaces are coated with aluminum tape as shown in Figure 5, Right, to detect the touching information with the sensors. The sticks have the same length with that of the surfaces (of about 600 [mm]) and they have some weight on both ends to make them roll smoothly and continuously on the surfaces.

Figure 5. Left: curved surfaces covered with sensor sheets and screen. Right: stick interface coated with aluminum tape.

3.3 Sensor Sheets

To detect the touching of sticks on the surfaces, we use the sensor sheets based on electromagnetic induction, called the LL sensor developed by Xiroku Inc. [4]. When metal approaches the sheet, cells closer to the metal have higher electromagnetic coupling coefficients. The sheet is originally flat and is used mainly for detecting the pressure of objects acted on it. We use specially ordered laminated and bendable ones to fit to the curved surfaces as shown in Figure 6. The size of the sheet is 600x600[mm] and it consists of 60x60 cells of size 10x10[mm], each of which has a sensing point. The sampling rate of the sensor is 100Hz. Since the velocity of the stick on the surfaces can be up to around 1.0-2.0[m/sec], touching point of the stick can be detected every time it moves for 1-2 cm. The sticks are coated with aluminum tape to get large values of electromagnetic coupling coefficients that range from 0 to 2^{16} . All of the coefficients are sent to the computer as arrayed integer data. Thus, the surfaces work as multi-touch input devices as well as display.

Figure 6. The sensor sheet spread on the surface.

3.4 Processing of the Computer

The computer receives the arrayed data of the sensor sheets and makes several types of processing such as data preprocessing, application-specific processing, and the image transformation for projecting to the surfaces properly. The computer programs are written with C++ on Windows 7 incorporating OpenGL. We illustrate some details of each of the procedures.

3.4.1 Data preprocessing

Since the array data sent from the sensor sheet contain noise ranging from around 0 to 200, we set the threshold 2000 to see whether the stick touches the surfaces. Then the data are used for detecting at which points the stick touch on the surfaces. Here we note that since the coefficients of the touching information are obtained over all the grid points on the surfaces, the moving paths of several sticks can be detected simultaneously real time.

3.4.2 Application-specific processing

Once the points the stick touches on the surfaces are detected, they are used for each of the applications. In many applications, image and sound data are used and updated at each frame. We briefly illustrate the general method for update of images using the example of balloon popping. Balloon popping is a mini game in which a player rolls a set of sticks and hits the floating balloons as shown in Figure 7. Update of images occurs when it is necessary to change the status of objects in the display at the next frame, for example, when balloons in the display change their shapes or locations. At each frame, all the image segments are composed with the background image at appropriate locations.

Figure 7. An image of balloon popping.

Figure 8. Flow of the computer processing.

Since the new image is still flat and not suitable for the curved surfaces, it is modified to fit to the surfaces as explained below.

3.4.3 Image transformation for projecting to surfaces

The flat and rectangle images are modified to fit to the surfaces in the following way. We first make the 3D model of the surface. By attaching the images on this model, we obtain the image with contour that is appropriate to project onto the surfaces. We summarize the flow of the processing in Figure 8.

4. APPLICATIONS

We developed applications that make effective use of the stick manipulation on the surfaces, such as balloon popping, a music game, a virtual keyboard, and a draw tool. We explain each of the applications.

4.1 Balloon Popping

The first application is the balloon popping already shown in Figure 7. In the application, a player rolls the sticks to hit the balloons aiming at high scores. Rolling of sticks has an advantage for such an application that requires hitting objects in precise timing and control. In balloon popping, such requirements appear in sweeping balloons in a line, avoiding some balloons, and manipulating several sticks using two hands. Furthermore, two players can enjoy the application by standing at both sides and passing the sticks as shown in Figure 9.

Figure 9. Passing sticks between two players.

Since the whole silhouette of the surfaces resembles a huge “picture book” that is opened, we put some of the applications together in the book and enable to transfer from one application to the other by virtually turning over the pages.

4.2 Music Game

Next is the music game in which a player rolls the sticks and hits the stars in appropriate timing to sound musical notes. Rolling of sticks is effectively used in the game, for example, in hitting several stars in a sequence in the appropriate timing to sound the corresponding notes continuously as shown in Figure 10, Left, and in hitting two or more stars simultaneously using multiple sticks to make a musical chord as shown in Figure 10, Right. The application accepts input of music in the MIDI format and automatically allocates stars in random locations.

Figure 10. Left: rolling sticks to hit two stars. Right: rolling two sticks to make a musical chord.

4.3 Virtual Keyboard

We have implemented a virtual keyboard with 12 notes of one octave plus one more note of the higher C as shown in Figure 11, where the seven notes of the white keys (C to B) are allocated in the left-hand side of the surfaces and the 5 notes of the black keys plus the higher C are allocated in the right-hand side. Though the number of allocated keys is rather small at present due to the area limitation, we can manipulate a pair of sticks and play music within the limited keys.

Figure 11. Virtual keyboard.

4.4 Draw Tool

Finally, we show the draw tool for the surfaces in Figure 12. As with the usual draw tool, a user chooses a color from the color pallet and draws using the sticks. The most common way to draw is to use the top or the end of the stick like a pen for the tablet. This tool has also another unique way of drawing with the side of the stick coated with aluminum tape. The other special function of the tool is to lock and unlock changing colors using the buttons with the key images in the left-hand side of the surfaces. The reason for introducing them is that when users manipulate the sticks on the surfaces, the sticks often point the color buttons unintentionally and change colors. These key buttons enable the users to use the colors stably even after mishitting.

Figure 12. Draw tool.

5. CONCLUDING REMARKS

We developed a projection system called Stick’n Roll in which users roll stick-like interfaces on curved surfaces. We also developed some applications for the system that make use of the rolling motion of sticks. We have made demonstration of the system at some exhibitions such as CEDEC2014 and TokyoTawachika Lab 2015 and confirmed that the system can be played and highly evaluated by users ranging from junior high school students to the older adults (actually, we were awarded the first place at the interactive session at CEDEC 2014). Thus, we could say the system provides a new kind of playful interaction using stick interface and curved display. The future work lies in refining the applications, making quantitative evaluation on the system, and simplifying and downsizing the system in the physical sense.

6. ACKNOWLEDGMENTS

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