wUbi-Pen : Windows Graphical User Interface Interacting with Haptic Feedback Stylus

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Abstract

In this work, we designed stylus type haptic interfaces interacting with a touch screen. There are two kinds of haptic styli termed wUbi-Pen. The type I has functions of providing vibration, impact, texture and sound and it is a stand alone system including own battery and wireless communication module. The type II does not include the texture display module and it is a miniaturized version. We present a new interaction scheme on the Windows graphical user interface based on pointer movement haptic feedback events such as clicking, drag, drop, moving and etc. In addition, a simple interactive digital sketchbook has been implemented, which is providing haptic and auditory feedback while drawing and touching objects. We also introduce a tactile image display method on a touch screen with the wUbi-Pen and a simple fitting puzzle utilizing haptic feedback events.

CR Categories: H.5.1 [Information Interface and Presentation]: User Interfaces; H.1.2 [Models and Principles]: User/Machine Systems

Keywords: haptic, pen, stylus, GUI, windows, image, tactile

1. Introduction & Research Objective

Touch screen has been widely adopted for the purpose of visual display and input device of mobile devices, kiosks and etc. Application of touch screen reduces additional input devices or interfaces of a system. However, the most common complaint of users when they manipulate user interface on a touch screen is uncertainty. Fore example, they are not sure whether they pressed a button or not although there was a visual feedback.

In order to make up this uncertainty, there have been efforts providing haptic feedback in the use of touch screen. A tactile display for handheld devices "TouchEngine" was suggested [Poupyrev et al. 2002]. It creates instantaneous force when a user operates button. However, it could be applied to only small screen device since magnitude of the force was not enough. There was another trial to provide tactile feedback for a mobile device [Luk et al. 2006]. Array of shear stimulator conveys pattern information to users. However, it requires considerable amount efforts to electronics to be applied to a mobile device. More practically, tactile feedback actuators were installed at the corners between touch panel and display screen [Immersion Corporation]. When we install actuators inside the device, actuator usually requires strong output power to create recognizable haptic response. If we increase power of actuators, electronics problem should be solved for mobile devices. If we decrease power of actuators, a system does not provide available haptic feedback.

The styli are most commonly adopted input interface of a touch screen in these days. There have been researches for separated haptic input interfaces in the form of stylus. Lee et al. [2004] achieved initial work for a haptic stylus. They installed a pressure sensor at the tip and a solenoid inside the body of the pen. It provides button clicking and buzzing sense. Recently, another approach adopted a similar device for a different application [Lee et al. 2007]. More recently, a pen-like haptic interface providing vibrotactile feedback and texture feedback was suggested [Kyung & Lee. 2008]. All researches shows haptic styli are useful for manipulation of graphical user interface. However, miniaturization of their mechanism and electronics is required for realizing an interface of mobile devices.

Our work has been focused on a mobile and wireless stylus termed wUbi-Pen providing various combinations of haptic stimuli. It provides vibration, bilateral impacts and sound feedback in accordance with manipulation events. We introduce a windows graphical user interface interacting with haptic feedback stylus. The interaction deals with buttons, pick up, drop, drag, scroll, size control and menu movement/selection. We suggest a simple interactive digital sketchbook has been implemented, which is providing haptic and auditory feedback while drawing and touching objects. We also introduce a tactile image display method on a touch screen with the wUbi-Pen. In addition, a simple fitting puzzle utilizing haptic feedback events will be introduced for the performance evaluation of proposed scheme.

2. wUbi-Pen

2.1 Type I

Fig. 1 shows an implemented version of the wUbi-Pen type I. As shown in Fig. 2, we installed a vibrator, an impact generator, speaker and a texture display module in the stylus. When we use the stylus as a pointing device on a touch screen, events occurred in computing device are transmitted to the stylus through Bluetooth wireless communication.

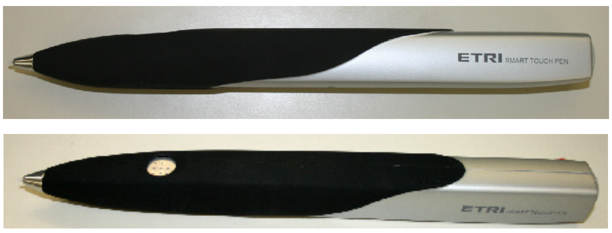

Figure 1. wUbi-Pen Type I

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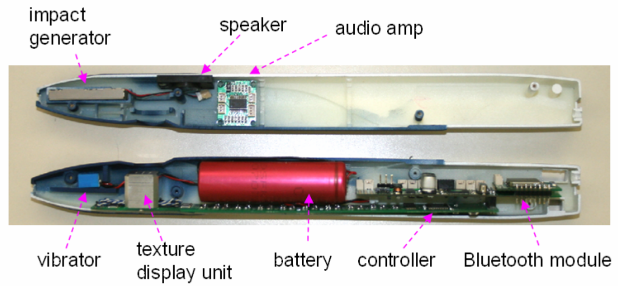

Figure 2. Internal Structure of the wUbi-Pen Type I

The vibrator generates vibration. The impact generator is a linear vibrator which produces a click-like sensation with bilateral collision of a mass. The generator is arranged along a longitudinal axis of the stylus housing. The texture display unit is composed of 3x3 pin array. Each pin creates indentation on the skin and combination of pins' movements represents tactile patterns. Battery and Bluetooth module enable the stylus to operate as a stand-alone system. Two profiles of serial protocol and headset have been installed in a Bluetooth module.

2.2 Type II

As shown in Fig. 3 and Fig. 4 wUbi-Pen type II is a miniaturized version of type I. The texture display unit has been removed and the space has been replaced by a microphone. Since power consumption of the type II is less than 20% of type I, its battery is smaller version. The size of the type II will be a scale of pencil if it is customized. Our target is to insert the haptic stylus in the computing device such as PDA, mobile phone and etc.

Figure 3. wUbi-Pen Type II

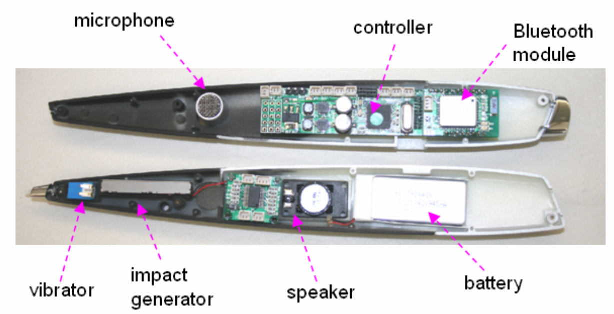

Figure 4. Internal Structure of the wUbi-Pen Type II

3. Windows Interfaced based on Haptic Feedback

We designed a new windows interface interacting with haptic stylus. When we use a touch screen device, precise manipulations are very strictly limited. Although touch screen decreases complexity of input interfaces, it also decreases usability. The loss of tactile feedback disturbs user's confidence in manipulations such as button pressing, menu selection, object/window selection/movement, scrolling and size control. As shown in Fig. 5, we implemented a Windows graphical user interface interacting with haptic feedback stylus. Manipulation events such as button pressing/releasing, pop-up or menu change are monitored and each event is matched with one or combination of varying vibration, short term vibration, falling down impact, rising up impact and continuous or gradual vibration.

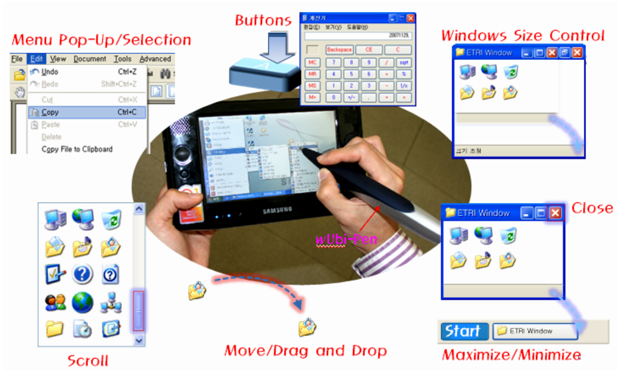

Figure 5. Windows GUI Interacting with the wUbi-Pen

Button Clicking: The button clicking stimulation is composed of falling-down impact and rising-up impact for button pressing and releasing respectively.

Menu Selection: When a menu is changed a short term vibration or impact is created. When the pointer moves on inactivated menu, tactile feedback is not provided.

Object Selection/Movement: When we select an object or a window, clicking-like stimulation is generated. When we move the selected object, instantaneous tactile bit is generated according to the movement.

Scroll & Window Size Control: In order to guide a precise control of scrolling and enlarging window, tactile bit is generated in accordance with every event.

Close, Maximize & Minimize: There is short term vibration or varying vibration to indicate execution of command.

4. Interactive Drawings

4.1 Interactive Digital Sketchbook

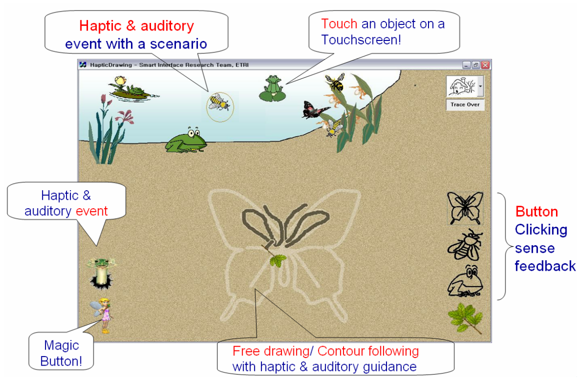

Figure 6. Example of the Interactive Digital Sketchbook

Fig. 6 shows an example of digital interactive sketchbook. In these days, digital book has become new education or entertainment system for children. We add interactive functions to the digital book. The developed system provides following functions. Fig. 7 shows a young boy drawing a frog using the wUbi-Pen.

Free Drawing: There is vibration feedback and sound feedback when a user draws on a touch screen. Vibration and sound intensities varies in accordance with drawing velocity.

Contour Drawing: When a user draw contour exactly, there is a soft beating feedback. However, when the pointer deviates from the line, there is an instant vibration to guide the contour.

Touching Object: There are objects, materials and animals in the screen. A user touches them with haptic feedback.

Figure 7. Scene of the User Test

4.2 Tactile Image Display

The Ubi-pen mouse enables tactile pattern display on a touch screen. In a previous work, we suggest a methodology to display a texture with the Ubi-Pen [Kyung & Lee, 2008].This program provides a symbolic pointer in the shape of a square, with a size of 15x15 pixels. A user can load any grayscale image. As shown in Fig. 8, when the user touches an image on the touch screen with the wUbi-Pen type II, the area of the cursor is divided into 9(=3x3) sub-cells and the average gray value of each cell is calculated. Then, this averaged gray value is converted to the intensity of the stimuli displayed on each pin of the tactile display.

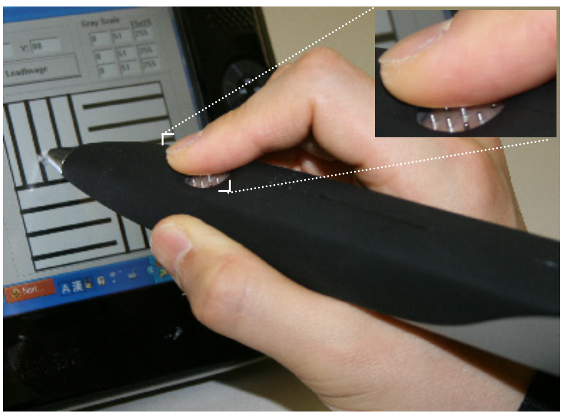

Figure 8. Tactile Image Display

5. Fitting Puzzle

One of examples to verify performance of haptic styli and touch based graphical user interface, we designed a puzzle game. If we control objects precisely on a touch screen with a stylus, it will spread practical application area of touch screen devices. As shown Fig. 9, we specially designed a puzzle game. When we select, move, rotate and resize a polygon, tactile cues help to control precisely. In order to measure performance of touch based user interface, we measure task completion time and duration of each task.

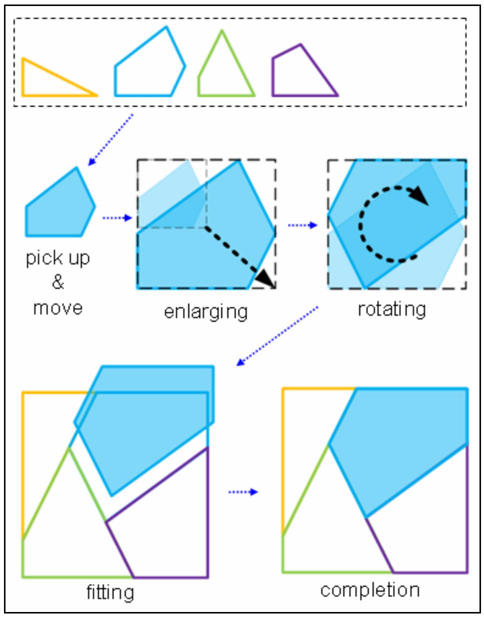

Figure 9. Procedure of Fitting Puzzle

6. Conclusion

In this work, we introduce stylus type haptic interfaces interacting with a touch screen and their applications. The styli provide tactile cues including vibration, impact, distributed pressure and sound. The haptic styli improve usability of touch screen devices. They are applied to touch based Windows user interface and interactive drawings on touch screen devices. The styli will be miniaturized to be inserted into mobile devices.

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