Multiple Texture Button by Adding Haptic Vibration and Displacement Sensing to the Physical Button

Daichi Ogawa[1], Vibol Yem[1], Taku Hachisu[2], Hiroyuki Kajimoto[1]
[1] The University of Electro-Communications, Japan [2] University of Tsukuba, Japan

1 Introduction

A physical button that is mounted in a mouse, a keyboard, or a shutter of a camera, provides both force and tactile feedback when a user presses it. It is certainly that users can recognize the press and input through the sensation of "click" vibrations. Many mechanical mechanisms for presenting a click sensation in a physical button have been proposed, however the click sensation can be generally presented in only one for one physical button. On the other hand, the virtual button on a touchscreen lacks haptic feedback such as a click sensation because there is no mechanical mechanism. To solve these issues, approach to reproduce and present a click sensation has been proposed by presenting the haptic vibration for the press of the virtual buttons [Fukumoto et al., 2001][Tashiro et at., 2009][Kim et at., 2013].

In our study, we designed Multiple Texture Button that presents a variety of sensations by combining the actual physical buttons and vibration. To implement a video game application, touch sensation of the button can be presented and changed in real time to be suitable for the context of the content. We developed a Multiple Texture Button for presenting the click sensation by providing decaying sinusoidal vibration and sampled vibration waveform at the moment of press.

2 Related Work

Haptic cue consists of kinesthetic sensation (i.e. reactive force) and vibrotactile sensation (i.e. cutaneous mechanical deformations). The physical button pressing involves these two sensations. When a user presses the button with a finger, the reactive force of the spring is generated on a fingertip. In addition, cutaneous sensation is also generated when there is a vibration of the collision of the button.

[1]e-mail: {ogawa, yem, kajimoto}@kaji-lab.jp
[2]e-mail: hachisu@ai.iit.tsukuba.ac.jp

*CHERRY Corporation
http://www.cherrycorp.com/english/switches/key/mx.htm.

SA'15 Workshop on HMCD, November 02 – 06, 2015, Kobe, Japan.
ACM 978-1-4503-3932-2/15/11.
http://dx.doi.org/10.1145/2818384.2818394

For example, various types of buttons manufactured by CHERRY Corp*. consists of pressure spring to present reactive force sensation and plate spring to present vibrotactile sensation. Using the high stiffness of pressure and plate spring, the button respectively, becomes heavy in pressing and is able to generate high frequency of vibration. MX Switch Brown which is one of lineup is adapted soft leaf spring, a small amplitude vibration is generated when user presses it. It is also possible to adjust the stiffness of the button to be suitable for user's preferences by replacing the pressure spring.

A single physical button is considered to present various click sensations by replacing the stiffness of the pressure or plate spring. However, it is dynamically impossible to change touch sensation in real time during using an application. The purpose of our study, therefore, to present various click sensations by presenting haptic vibration of vibrator mounted on a physical button. It also can be possible to change touch sensation of existing keyboard and mouse to make it suitable for user's preference.

On the other hand, there are many studies to reproduce or present the click sensation for virtual buttons pressing on the touchscreen. Fukumoto et al. [Fukumoto et al., 2001] used the vibrator and Tashiro et al. [Tashiro et al., 2009] used the ultrasonic vibrator to vibrate touchscreen to present click sensation of virtual button. Kim et al. [Kim et al., 2013] analyzed the press force and button displacement, and designed haptic feedback of virtual button which is closed to the real physical button by presenting vibration based on the force applied to the touchscreen. These studies have shown that even if virtual button lacks haptic feedback such reactive force or press force, it is possible to reproduce various click sensations by presenting haptic vibration.

3 Designing Multiple Texture Button

The button is composed of two parts, the operating part (in red) which is pressed by a finger and the case part (in blue) which is to support the operating unit (Figure 1). Exterior of the button is made of Acrylonitrile Butadiene Styrene (ABS) resin. Operating part is incorporated with a vibrator (Vp408, Acouve Laboratory Inc.), and connected to the case part with a pressure spring (spring constant k=0.889[N/mm], natural length 43mm). This button is able to presents a reaction force up to 8.89N, which produced by pressure spring of maximum displacement 10mm.

Infrared (IR) Photo-transistor and IR LED were set up on the bottom of case part and operating part, respectively. They were used to measure the displacement of operating part by the light intensity (Photo Sensing Unit). The microcontroller (mbed NXP LPC1768, Semiconductors NV) was also used to measure the displacement with 20,000 samples per second. The output of an analog signal from the PC or the microcontroller was amplified by the audio amplifier (TA7252AP, TOSHIBA Corp.) to drive the vibrator(Figure 2).

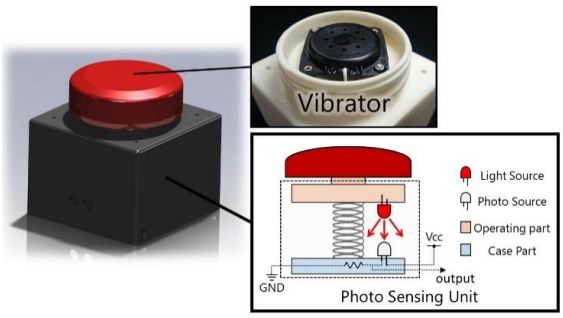

Figure 1: *Structure of the Multiple Texture Button*

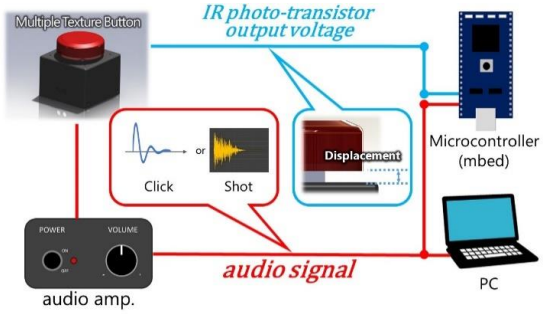

Figure 2: *Overview of system*

Vibration presentation method. The button presents the click sensation by presenting an exponentially decaying sinusoidal waveform (Eq. (1)) [Okamura et al., 2001] at the time of pressing.

$$Q(t) = A(v)e^{-Bt}\sin(2\pi ft) \qquad (1)$$

Where Q is the acceleration of the vibration generated by the impact, t is the time elapsed of the impact, v is the impact velocity, A is the initial amplitude (a function of v), B is the decay rate, and f is the vibration frequency. The exponentially decaying sinusoidal waveform has been used to reproduce the vibration or haptic sensation for the material [Hachisu et al., 2011] when hitting the object or presenting click sensation [Kurihara et al., 2013]. In the previous study [Okamura et al., 2001], we preliminarily confirmed that it is able to present a variety of click sensation by adjusting three parameters of A, B and f.

It is also able to present an audio signal that recorded in advance. Our button can be used for some applications such as games. For example, the vibration at the time of shooting of the gun is recorded in advance, and it is replayed when a user play the game to shot the bullet by pressing the button. User's experience is expected to enhance the contents by presenting this recorded vibration at the moment of button pressing.

4 Applications

We proposed two kinds of application designs for our button by using three advantages, 1) high-speed sensing for displacement, 2) haptic vibration presentation corresponding to displacement, and 3) vibration with changeable parameters.

Reproduction of click sensations. Such as buttons developed by Cherry Corp. or a tact switch, the physical buttons can present various types of click sensations. On the other hands, Kim et al. were able to present click sensation on a touch screen, which is similar to the sensation of physical button by taking account of the pressing displacement. As with their studies, we proposed the presenting of various click sensation by presenting a different vibration waveform which depends on the pressing displacement. For example, it is possible to exaggerate the collision vibration of the button by presenting a decaying sinusoidal waveform as shown in Eq. (1) at the end point of the press operation part of the button. In addition, it is considered that the subjective stiffness of the button changes according to the change of the frequency of vibration. It is also possible to present the half-press sensation like a shutter button of the camera by presenting a click sensation at the middle point of its operation. The user is able to perceive clearly the displacement by presenting the different waveforms at the middle and the end point of its displacement.

Haptic vibration presentation that matches the contents. There are many methods for enhancing an immersive experience by presenting vibration stimulation to users during the experience of movie, music or games [Israr et al., 2012][Cassinelli et al., 2012]. In these studies there are also the cases to present the tactile feedback onto the button input during playing the video game, but most of them are symbolic vibration presenting. We aim to enhance the immersive sense by presenting the vibration that acceptably matches the context of contents. Specifically, users would be presented a vibration of shots, hits or heart beats if they play the shooting game, the action game or the love-game. We consider that, to enhance the immersive sense, the design of haptic stimulation such as auditory and visually stimulation, which convey the users are necessary. For the future work, we plan to establish the design requirement of the haptic feedback of button input for contents such as video games.

References

Fukumoto. M., Sugimura, T. Active Click Tactile Feedback for Touch Panels, Proceedings of ACM Symposium on Human Factors in Computing Systems (CHI) 2001, pp.121-122.2001

Tashiro, K., Shiokawa, Y., Aono and T., Maeno, T: Realization of Button Click Feeling by Use of Ultrasonic Vibration and Force Feedback. Proceedings of Third Joint EuroHaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator System, pp.1-6, 2009.

Kim, S. and Lee, G.: Haptic Feedback Design for a Virtual Button Along Force-Displacement Curves. Proceedings of ACM Symposium on User Interface Software and Technology (UIST) 2013, pp. 91-96, 2013.

Okamura, A.M., Cutkosky, M.R., and Dennerlein, J.T.: Reality-Based Models for Vibration Feedback in Virtual Environments. IEEE/ASME Transaction on Mechatronics, 6(3), pp.245-252, 2001.

Hachisu, T., Sato, M., Fukushima, S. and Kajimoto, H.: HaCHIStick: Simulating Haptic Sensation on Tablet PC for Musical Instruments Application, Proceedings of ACM Symposium on User Interface Software and Technology (UIST) 2011, pp.73-74, 2011.

Kurihara, K., Hachisu, T., Sato, M, Fukushima, S., Kajimoto, H.: Periodic Tactile Feedback for Accelerator Pedal Control, Proceedings of IEEE World Haptics Conference 2013, pp.187-192, 2013.

Israr, A., Kim, S., Poupyrev, I. and Stec, J.: Surround haptics: Tactile Feedback for Immersive Gaming Experiences, Proceedings of ACM Symposium on Human Factors in Computing Systems (CHI) 2012, Interactivity Presentation, pp.1087-1090, 2012,

Cassinelli, A., Angesleva, J., Watanabe, Y., Frasca, G. and Ishikawa, M.: Skin Games, Proceedings of ACM Symposium on Interactive Tabletops and Surfaces (ITS) 2012, pp.323-326, 2012