HaCHIStick: Simulating Haptic Sensation on Tablet PC for Musical Instruments Application

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ABSTRACT

In this paper, we propose a novel stick-type interface, the "HaCHIStick," for musical performance on a tablet PC. The HaCHIStick is composed of a stick with an embedded vibrotactile actuator, a visual display, and an elastic sheet on the display. By combining the kinesthetic sensation induced by striking the elastic sheet with vibrotactile sensation, the system provides natural haptic cues that enable the user to feel what they strike with the stick, such as steel or wood. This haptic interaction would enrich the user's experience when playing the instruments. The interface is regarded as a type of haptic augmented reality (AR) system, with a relatively simple setup.

ACM Classification: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Haptic I/O, Input devices and strategies, User-centered design.

General terms: Design, Human Factors.

Keywords: Haptic augmented reality, musical instrument, stick-type interface, tablet PC, vibrotactile sensation.

INTRODUCTION

Musical instrument applications are considered to be one of the killer applications for tablet PCs. They enable users to interact directly with the display, perform parallel tasks (i.e. multi-touch) to produce multiple sounds, and play various instruments by simply changing the software. However, common touch panels for the tablet PC do not provide haptic feedback when tapped. For example, when playing guitar on a tablet PC, haptically-speaking the user just feels a glass plate.

Many works have provided haptic sensation to the user's fingers by using surface vibrations [1] or controlling friction [2]. However, musical instruments are not only played with the fingers (e.g. piano, guitar, harp), but also with sticks (e.g. xylophone, glockenspiel, drums).

The aim of this paper is thus to propose a stick-type interface, the "HaCHIStick" (haptic computer-human interaction with stick; the author's family name is also embedded) for musical instruments on the tablet PC, which provides haptic sensation as a result of striking the instruments.

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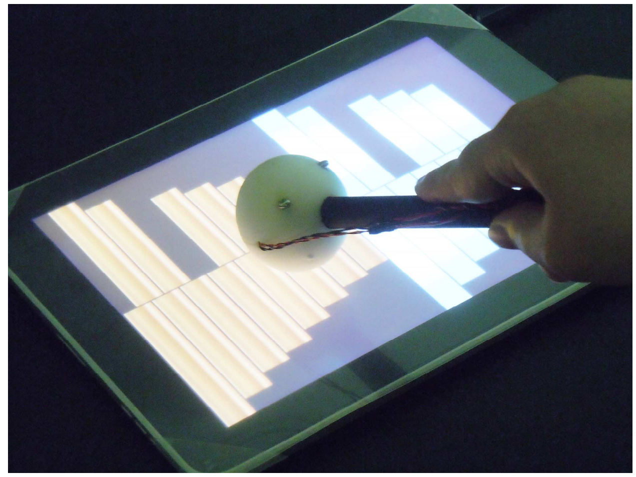

Figure 1: The HaCHIStick, which enables haptic interaction with musical instruments on a tablet PC

RELATED WORKS

When tapping the surface of a hard object with a stick, we can discern the material using haptic cues, and without visual and audio cues. This haptic cue consists of kinesthetic sensation (i.e. reactive force) and vibrotactile sensation (i.e. cutaneous mechanical deformations and vibrations).

There have been numerous proposals for stick-type haptic devices that provided both kinesthetic and vibrotactile sensation.

Wellman et al. proposed the mounting of a vibrator on an active force feedback device [9]. They used a decaying sinusoid model to simulate the vibrations that result from tapping. They showed that users could discern the material using the vibrotactile cues. Okamura et al. also proposed a similar method [8]. However, these methods both require a high cost force feedback device, which is impractical for our purposes.

We proposed a technique using pseudo-haptic feedback to provide the kinesthetic sensation instead of the active force feedback device [3]. Pseudo-haptic feedback is a haptic illusion, where visual cues create haptic sensation without physical haptic stimulus. However, full substitution of kinesthetic sensation by other means is still not possible.

The Haptic Pen [6], and the Ubi-Pen [5] are both stylus type devices with embedded vibrators and tactile actuators. In this case, the kinesthetic sensation is naturally presented by real contact, while the vibrotactile sensation is added to present the geometrical properties on the touch panel.

PROPOSED METHOD

Unlike the previous stylus type devices, our target motion is "striking". Therefore, if we simply "add" vibrotactile sensation, users still feel a hard glass surface material from the innate vibration caused by real collisions.

Our idea is to "subtract" the real vibrotactile sensation, simply by using an elastic sheet, and then to present the intended vibration through a vibrotactile actuator embedded in the stick (Figure 1).

SYSTEM STRUCTURE

System configuration

Our proposed device is implemented using a system consisting of a tablet PC, a HaCHIStick, an elastic sheet and an audio amplifier, as shown in Figure 2.

The elastic sheet on the tablet PC is used to cancel the vibration that results from the HaCHIStick striking the surface of the tablet. A voice-coil embedded in the HaCHIStick is controlled by an audio signal from the tablet PC through its audio output and the audio amplifier.

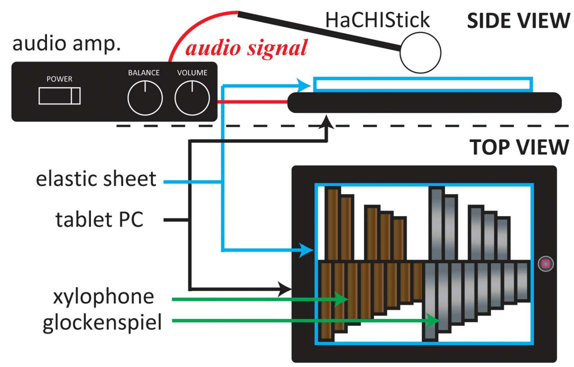

Figure 2: System configuration

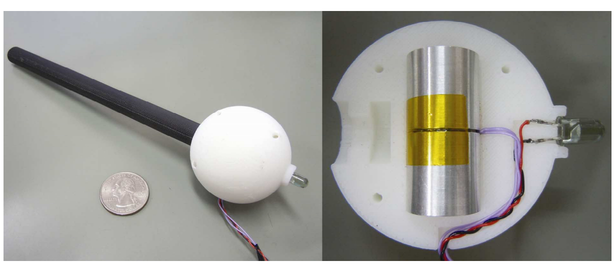

Figure 3: The prototype of the HaCHIStick: The left image shows the exterior, and the right shows the internal configuration. The voice-coil type actuator is embedded.

HaCHIStick

The HaCHIStick and its internal configuration are shown in Figure 3. The current prototype is made from acrylonitrile butadiene styrene (ABS) resin and has an embedded voice-coil type vibrotactile actuator (Tactile Labs Inc., Haptuator [10]). The actuator can output a high-bandwidth vibrotactile stimulus controlled by the audio signal, and can achieve sophisticated levels of vibration. The length and weight of the stick are 200 mm and 80 g, respectively.

CONCLUSION

In this paper, we proposed a stick-type interface, the "HaCHIStick," that provides haptic feedback when it is used to strike virtual musical instruments on a tablet PC. By combining the kinesthetic sensation induced by striking the elastic sheet with vibrotactile sensation, it provides natural haptic cues that enable the user to feel what they strike with the stick. This haptic interaction is intended to enrich the user's experience when playing the virtual instruments. The work is regarded as a type of haptic augmented reality (AR) system [4, 7], and has a relatively simple setup.

As our work is still at a preliminary stage, there is considerable future work to be done. This includes optimization of the elastic sheet design, because, in addition to subtracting vibrotactile sensation, its viscous properties also mean that it affects kinesthetic sensation.

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