HapTONE: Haptic Instrument for Enriched Musical Play

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

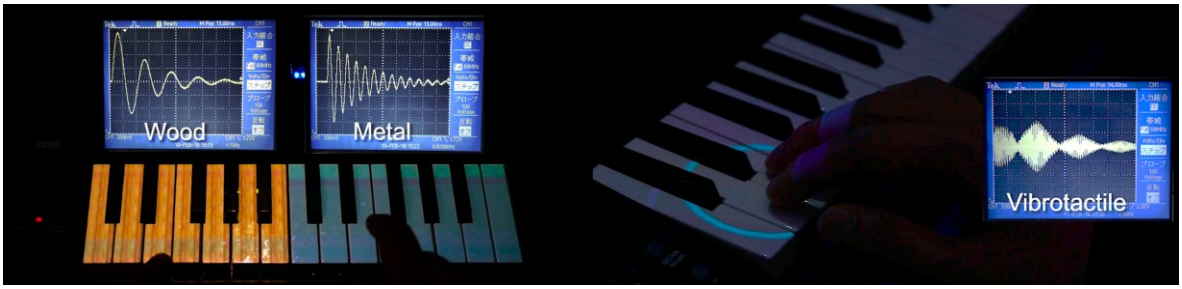


Figure 1: *Overview of applications, (left) accurate reproduction of percussion instrument (xylophone and glockenspiel) and (right) synchronized vibration with animation.*

Abstract

This paper describes a novel music entertainment system that draws on auditory, tactile and visual senses. HapTONE presents players with high-fidelity vibrotactile sensations, not only after pressing the keyboard but also during the pressing operation itself. We developed keyboard type instrument that composed of key unit which is structured a vibrator and a distance sensor. This instrument reproduces the touch sensation of a keyboard, stringed, wind, percussion or non-musical instrument. We describe three applications of HapTONE that include: 1) the accurate replication of percussion instruments; 2) playing of pseudo-stringed instruments, and 3) synchronized vibration with animation. HapTONE is a musical entertainment system for players themselves using auditory, tactile and visual senses.

Keywords: musical instrument, haptic, vibrotactile

Concepts: • **Human-centered computing ~ Interaction devices;** *Haptic devices;*

1 Introduction

Playing musical instruments is one way in which humans have entertained themselves from the earliest of times. Recent advances in electronic technology have enabled people to play a variety of instruments using one interface such as a synthesizer, which produces auditory output. However, haptics are not typically used. When you press the keyboard of an electronic piano, the sound of a xylophone or violin is produced, but the touch sensation remains that of a plastic keyboard.

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

SIGGRAPH '16 Emerging Technologies, July 24-28, 2016, Anaheim, CA, ACM 978-1-4503-4372-5/16/07.
http://dx.doi.org/10.1145/2929464.2929477

There are several studies of haptic feedback linked to music, many of which aim to enhance the listening experience [Baijal et al. 2012]. In terms of the playing experience, Marshall and Wanderley [2006] added vibrotactile sensations to electronic instruments. For keyboard instruments, Lewiston [2008] added tactile sensations to a piano to create a learning system, and Oboe and De Poli [2002] reproduced the touch sensation of keyboard instruments such as the piano or organ. To date, researchers have not superimposed the tactile sensation associated with completely different instruments when playing the keyboard or non-musical instruments.

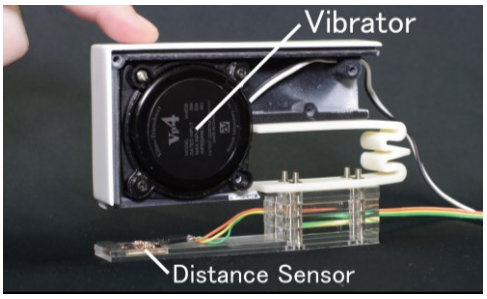
We developed a system called HapTONE that modulates the touch sensations of a keyboard. HapTONE presents the player with different vibrotactile sensations, not only after pressing the keyboard but also during the pressing operation itself. This is done by using optical distance sensors and vibrators placed in a keyboard. This system reproduces the touch sensation of a keyboard, stringed, percussion or non-musical instrument. HapTONE is designed as a musical entertainment system for players themselves.

2 Designing HapTONE

The HapTONE system is composed of the key unit and a microcontroller (mbed NXP LPC1768) to control each units, and a PC for audio-visual feedback. A key unit is structured a vibrator (Vp408, Acouve Laboratory) and an optical distance sensor (Figure 2(upper)). Stroke distance measurement and vibration corresponding to the distance and velocity are controlled by the microcontroller with a feedback loop of faster than 1kHz. The vibrator is driven by an audio amplifier (SSM3302, Analog Devices), ranging from 30Hz to 1000Hz. The unit resonates at 50Hz (2.84G), 90Hz (5.05G) and 110Hz (4.00G) (Figure 2 (lower)). The distance sensor is composed of photo-reflector (TPR-105F, GENIXTEK), calibrated to measure up to 16mm with 4% maximum error. Data obtained by the sensor is converted into MIDI data and sent back to PC for audio-visual feedback.

HapTONE presents the auditory and vibrotactile sensation not only after pressing the key but also during the stroke operation, which gives the sensation of continuous vibration associated with stringed instruments such as the violin. Stroke distance data is also used for visual expression. The auditory sensation is presented via PC, but the vibration waveform is stored in the microcontroller beforehand, and replayed by changing some parameters during pressing the key. This structure greatly reduces latency between the users' action and

haptic feedback, enabling users to feel not only simple vibration, but also physical properties of contact object.



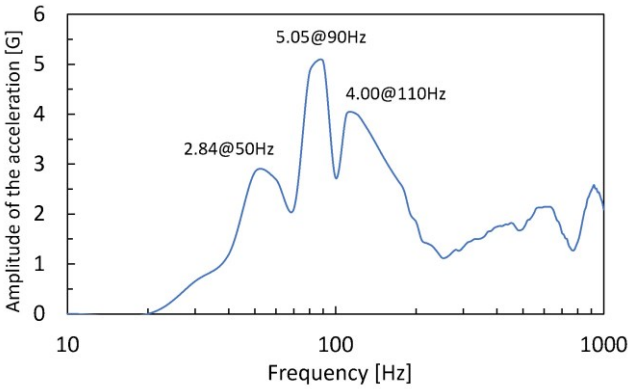


Figure 2: (Upper) Key unit of HapTONE, (lower) frequency of vibration response of a key unit.

3 Applications

We designed three applications using HapTONE: 1) accurate reproduction of percussion instruments; 2) playing of pseudo-stringed instruments, and 3) synchronized vibration with animation. These applications enhance the music playing experience.

Accurate Reproduction of Percussion Instruments. The property of materials can be clearly felt by presenting decaying sinusoidal vibration [Okamura et al. 2001]. HapTONE creates the impression of playing percussion instruments, such as a xylophone or glockenspiel, using this model that lets players feel the wood or metal (Figure 1(left)). Players can also feel any unmolded vibration of the instrument such as drums by recording and playing back vibration data (Figure 3).

Figure 3: Playing back vibration of drums.

Playing of Pseudo-Stringed Instruments. One of the features of HapTONE is that it can present vibration during stroke operation. Continuous vibration that imitates strings gives the impression of a stringed instrument to the player. For example, by presenting the sound and vibration of a violin that corresponds to the velocity of the stroke in real time, HapTONE let players play a pseudo-violin with sound and haptic feeling.

Synchronized vibration with Animation. Interactive projection mapping with haptic feedback is achieved using keystroke data, presenting synchronized vibration and animation in accordance with real time stroke distance. An example is shown in Figure 1(right), where animation helps to teach the melodies of 'frog song'. The system presents jumping and singing animation and vibration of the croaking frogs. These projections enrich the learning experience and pleasure of playing the piano.

Vibrotactile sensation, carefully selected to match visual contents leads to a synergistic animation. HapTONE is a high quality music entertainment system using auditory, tactile and visual senses.

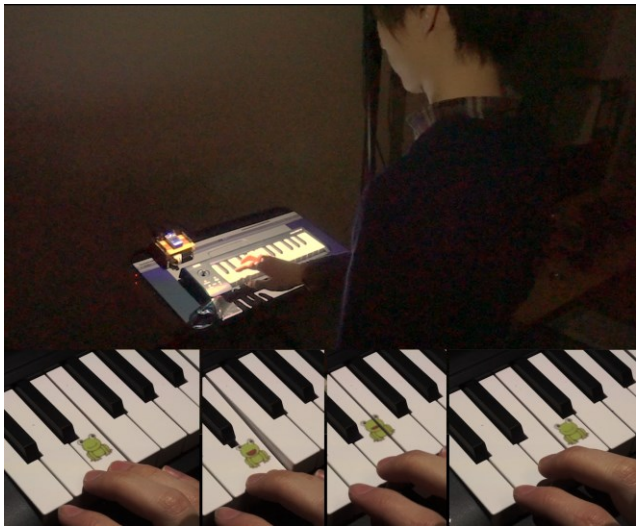


Figure 4: Animation helps to teach the melodies of 'frog song'.

Acknowledgement

This research is supported by the JST-ACCEL Embodied Media Project.

References

BAIJAL, A., KIM, J., BRANJE, C., RUSSO, F. AND FELS, D.I., 2012. Composing Vibrotactile Music: A Multi-Sensory Experience with the Emoti-Chair. *Proceedings of IEEE Conference on Haptic Symposium (HAPTICS)*, 509–515.

LEWISTON, C., 2008. MAGKEYS: *A Haptic Guidance Keyboard System for Facilitating Sensorimotor Training and Rehabilitation*. PhD thesis, Massachusetts Institute of Technology.

MARSHALL, M. T. AND WANDERLEY, M.M., 2006. Vibrotactile Feedback in Digital Musical Instruments. *Proceedings of New Interfaces for Musical Expression (NIME06)*, 226–229.

OBOE, R., AND DE POLI, G, 2002. Multi-instrument virtual keyboard – The MIKEY project. *Proceedings of New Instruments for Musical Expression (NIME02)*, 1–6.

OKAMURA, A. M., CUTKOSKY, M.R. AND DENNERLEIN, J.T., 2001. Reality Based Models for Vibration Feedback in Virtual Environments. *IEEE/ASME Trans. on Mechatronics*, 6, 245–252.