

# HapticAid: Wearable Haptic Augmentation System for Enhanced, Enchanted and Empathised Haptic Experiences

Tomosuke Maeda<sup>1,\*</sup>, Roshan Peiris<sup>1</sup>, Nakatani Masashi<sup>1</sup>, Yoshihiro Tanaka<sup>2,3</sup>, Kouta Minamizawa<sup>1</sup>

<sup>1</sup>Keio University Graduate School of Media Design

<sup>2</sup>Nagoya Institute of Technology

<sup>3</sup>JST PRESTO



**Figure 1:** *Enhancing Haptic Experiences with HapticAid. (A) HapticAid System. (B) Enhancing the haptic experience. (C) Enchanting haptic experiences in passive objects. (D) Empathising haptic information through communication*

## Abstract

We present HapticAid, a wearable system that enhances haptic sensations. The system consists of a wearable skin vibration sensor that is placed at the middle phalanx of a finger, a processor that processes haptic information, and a wrist-worn haptic actuator that provides haptic feedback. We envision three application areas with the HapticAid system: enhance, i.e., amplify and enhance haptic sensations; enchant, i.e., experience new haptic feedback when interacting with passive objects; and empathise, i.e., communication of haptic experiences that allows connecting and empathising with others' haptic sensations.

**Keywords:** Haptics · Augmented haptics · Wearable device

**Concepts:** •Human-centered computing → Haptic devices;

## 1 Introduction

Technological advances can enhance human ability. Aids such as eyeglasses and hearing aids allow us to support and enhance our visual and auditory senses. Similarly, haptic augmentation has been designed proposed to increase human touch capability.

In this study, we demonstrate that by augmenting the haptic perception, we aim can enhance human touch experiences by sensing the haptic details of touched surfaces, and then provide real-time haptic feedback onto the user's wrist. In a previous study, Tactile Contact Lens [Kikuuwe et al. 2004] uses the principle of leverage, thereby enhancing the perception of irregularities on the surface. Similarly, Tanaka et al. [Tanaka et al. 2014] developed a system for system for performing a laparoscopic surgery, which detects lumps

\*email:t.maeda@kmd.keio.ac.jp

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s). © 2016 Copyright held by the owner/author(s).

SA '16, December 05-08, 2016, , Macao

ISBN: 978-1-4503-4539-2/16/12

DOI: <http://dx.doi.org/10.1145/2988240.2988253>

and provides real-time feedback using a tactile display. However, in these studies, bare fingers cannot be used. In another study, a fingernail display [Ando et al. 2007], which consists of a vibrator on the nail and a photo detector, is used for haptics augmentation for virtual reality. In other approaches, white noise is represented on the hand or wrist. [Lakshminarayanan et al. 2015]. This haptic information is not skin vibration.

In this paper, we propose the HapticAid which is wearable haptic augmentation system using haptic information from skin vibration sensor, and describe in detail, the system configuration, the preliminary result of haptic enhancement effects, user experiences in our daily lives.

## 2 HapticAid System

We propose a system that obtains haptic feedback signal from the fingertip and processes it onto the wrist. To augment the haptic sensation at the finger, the HapticAid System consists of three main components: a sensor that acquires the signal of haptic information from the fingertip directly as skin vibration (Haptic Sensor); a frequency filter for haptic augmentation and enhancement (Signal Processor); and a wrist-worn haptic actuator (Augmented Haptic Wristband) to apply the enhanced haptic sensation, as shown in Figure 1 (A).

*Haptic Sensor:* For the finger-worn haptic sensor, we utilise a wearable skin vibration sensor using a PVDF (polyvinylidene fluoride) film [Tanaka et al. 2015]. This is worn on the middle phalanx of a finger. The placement of the sensor at the middle phalanx (and not at the fingertip) avoids any interference between the finger and the object being touched by the user. The sensor receives the haptic information through the skin vibrations propagating from the fingertip.

*Signal Processor:* The measured signal can be output as voltage change, similar to a sound signal with frequency components less than 1000 Hz [Tanaka et al. 2015]. This signal is amplified through the TECHTILE toolkit [Minamizawa et al. 2012] to drive the haptic actuator on the wristband. We modulate the haptic signal detected by the sensor with a frequency filter. We use various high pass and band pass filter configurations to enhance the haptic signal with a

low cut-off frequency of approximately 250 Hz due to the sensing characteristics of the sensor and skin vibration propagation [Tanaka et al. 2015]. The voltage of 250-1000 Hz is enhanced with the frequency filter.

*Augmented Haptic Wristband:* To compose the wearable system, as shown in Figure 1 (A), a voice coil vibrator (ALPS ELECTRIC CO., LTD. Hybrid Forcereactor) is installed in a wristband prepared by the 3D printer (Stratasys uPrint). The Augmented Haptic Wristband can render modulated haptic sensations onto the wrist. It should be noted that the haptic actuation on the wrist affects the sensed signal at the fingertip. As Figure 1 (A) shows, the haptic actuation on the wrist is attenuated before reaching the finger-worn sensor.

### 3 Preliminary Results

We conducted an experiment to evaluate HapticAid. The objective of this experiment was to detect an uneven test tip placed under a felt sheet. Because the test tip could barely be detected by the participant without the use of any device, we hypothesize that HapticAid can enhance and augment haptic sensations, only if the tip can be detected at a better rate when using it.

To assess the augmentation effect of the system, we tested it under the three conditions. Null condition: the participant was not equipped with HapticAid. White noise condition: the participant was equipped with HapticAid which was provided white noise without the sensor. Augmented condition: the system provided an augmented haptic feedback on the wrist with this system.

Figure 2 shows the bar graph of the detection rate averaged for ten participants. One-way repeated measures ANOVA was used for averages in each condition in the experiment. The analysis showed a significant difference ( $F(2, 18) = 8.21, p = 0.0029$ ). We conducted the multiple comparison paired t-test using Holm-correction. The analysis showed a significant difference between null condition and white noise condition ( $p < 0.05$ ). Similarly, the analysis indicated significant difference between the values of the null condition and augmented conditions ( $p < 0.05$ ).

From preliminary results, we obtained that participants' haptic sensations were significantly enhanced in both white noise and augmented conditions. Therefore, the HapticAid system which provides the feedback from the haptic sensor, can enhance the haptic sensations and interact with objects while touching them.

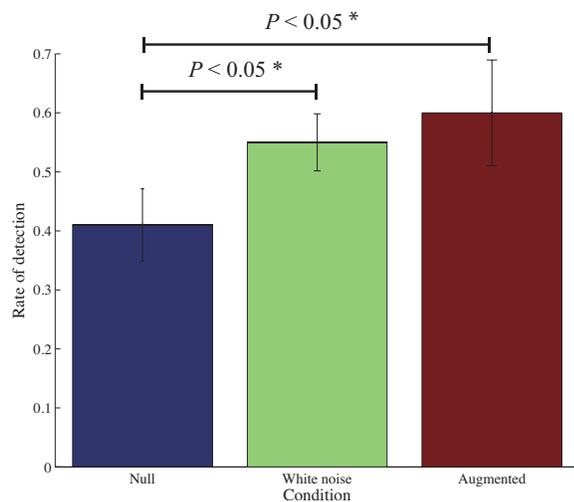


Figure 2: Detection rate

## 4 User Experiences

The HapticAid system experience will focus on three key areas: Haptic Enhancement, Haptic Enchantment, and Haptic Empathy. The participants will be able to wear the system and experience these new haptic sensations through three sections of demonstration.

*Enhancement:* The participants will be able to experience the enhancement of touched objects. Here, the touch is enhanced and provided as feedback on the wrist. Moreover, the goal is to experience enhanced or amplified haptic sensations in our daily life. For example, participants can experience the actual (amplified) roughness when touching a sheet of paper, and experience enhanced touch sensations using a bare finger.

*Enchantment:* In this section, the participants will be able to experience new haptic feedback as they interact with passive objects. The goal is to perceive how our interactions with passive objects can be embedded with haptic information. For example, playing a computer game using a keyboard and pen can be experienced with haptic feedback. Likewise, participants can experience different sensations while bouncing a ball on a table tennis racket.

*Empathy:* Here, the aim is communicating haptic experiences. The goal of this segment is to experience what others experience. For example, haptic sensations that are previously recorded are played back for experiencing haptic sensations that another participant was sensing. In addition, participants exchange visual sensation using HMD and haptic sensation with another person, communicating haptic experiences.

### Acknowledgements

This work is supported by a JST ACCEL Embodied Media Project and JSPS KAKENHI Grant Number 26700018.

### References

- ANDO, H., WATANABE, J., INAMI, M., SUGIMITO, M., AND MAEDA, T. 2007. A fingernail-mounted tactile display for augmented reality systems. *Electronics and Communications in Japan (Part II: Electronics)* 90, 4, 56–65.
- KIKUWE, R., SANO, A., MOCHIYAMA, H., TAKESUE, N., TSUNEKAWA, K., SUZUKI, S., AND FUJIMOTO, H. 2004. The tactile contact lens. In *Sensors, 2004. Proceedings of IEEE*, IEEE, 535–538.
- LAKSHMINARAYANAN, K., LAUER, A. W., RAMAKRISHNAN, V., WEBSTER, J. G., AND SEO, N. J. 2015. Application of vibration to wrist and hand skin affects fingertip tactile sensation. *Physiological reports* 3, 7, e12465.
- MINAMIZAWA, K., KAKEHI, Y., NAKATANI, M., MIHARA, S., AND TACHI, S. 2012. Techtile toolkit: a prototyping tool for designing haptic media. In *ACM SIGGRAPH 2012 Emerging Technologies*, ACM, 22.
- TANAKA, Y., NAGAI, T., FUJIWARA, M., AND SANO, A. 2014. Lump detection with tactile sensing system including haptic bidirectionality. In *World Automation Congress (WAC), 2014*, IEEE, 77–82.
- TANAKA, Y., NGUYEN, D. P., FUKUDA, T., AND SANO, A. 2015. Wearable skin vibration sensor using a pvdf film. In *World Haptics Conference (WHC), 2015 IEEE*, IEEE, 146–151.