Altered Touch: Miniature Haptic Display with Force, Thermal and Tactile Feedback for Augmented Haptics

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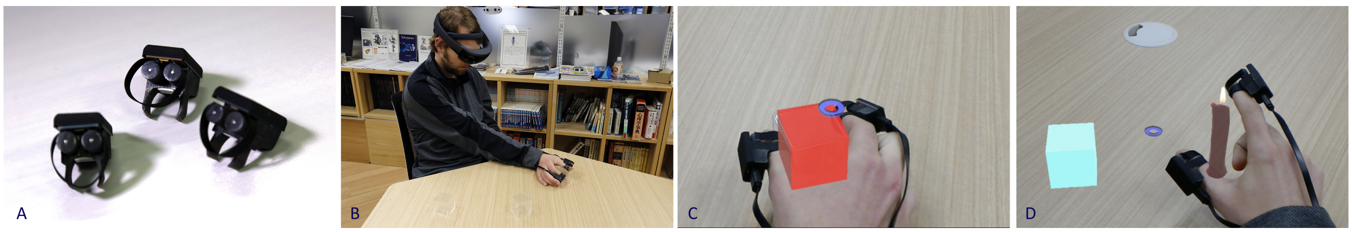

Figure 1: (a) Augmented Haptics Display, (b, c) Touching a haptic augmented clear cube, (d) Augmented thermal cues

ABSTRACT

In this paper, (1) we developed a fingertip haptic display with integrated force, tactile and thermal feedback in a miniature form-factor such that it can be worn easily and used with augmented reality applications without affecting the existing tracking technologies. (2) we propose the concept of "Altered Touch", where the integrated fingertip haptic display stated in (1) was used to alter the haptic properties of real objects by rendering projected visual and haptic feedback. The system consists of our own force display Gravity Grabber mechanism[Minamizawa et al. 2007] to render vertical, shearing forces, high frequency tactile vibrations, and a peltier module for thermal display. The integrated haptic display module weighs less than 50g, can be easily interfaced to a PC with just one micro USB cable, and works standalone from any other additional hardware. In this paper we use this wearable haptic actuator in several augmented reality applications to alter the softness/hardness and hot/cold sensation and several use cases have been discussed. Furthermore, the haptic display could be expanded to design a haptic glove that can interact with both virtual and augmented worlds.

CCS CONCEPTS

•Human-centered computing → Haptic devices;

KEYWORDS

Augmented Haptics, Force Sensation, Thermal Sensation, Tactile Sensation

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1 INTRODUCTION

Grounded and ungrounded integrated haptic displays have been used in many virtual reality applications. However, these devices [Fernando et al. 2012; Perez et al. 2016] are not suited for wearable augmented reality applications due to their complexity and bulky nature and thus mainly used in master-slave manipulation in robotics. Several augmented reality applications[Narumi et al. 2010] use pseudo haptic sensations, but they do not use active haptic rendering techniques.

In this paper first, we developed a fingertip haptic display with integrated force, tactile and thermal feedback in a miniature form-factor such that it can be worn easily and used with augmented reality applications without affecting the existing tracking technologies. As shown in Figure 1(a) the haptic display is very compact and could be connected to a PC with just a single micro USB connection. The integrated haptic display module weighs less than 50g and fits into average fingertip width of 20mm. Thus, wearing multiple displays in a single hand does not limit the finger movements and could use the existing gesture tracking APIs such as Leap Motion, Microsoft Kinect or HoloLens without having to rely on alternate methods of gesture tracking.

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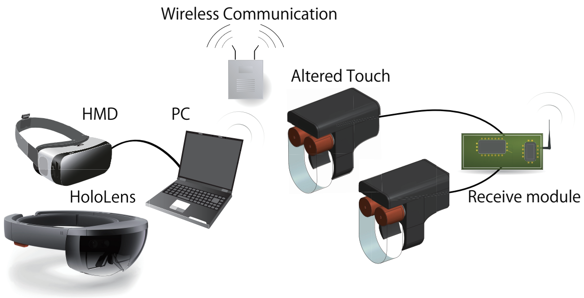

Figure 2: System Overview

Secondly, we propose the concept of "Altered Touch", where the integrated fingertip haptic display stated in (1) is used to alter the haptic properties of real objects by rendering projected visual and haptic feedback.

2 SYSTEM DESCRIPTION

As shown in Figure 2, the integrated haptic display module can be connected to a wearable PC with just a USB connection and embedded into wearables. Depending on the application, you can use it with one finger or you can use multiple fingers such as a thumb and index finger combination. By using multiple, it becomes possible to pick and pinch. The system was built on top of the Unity Game Engine so that it could be used with virtual reality headsets such as Oculus CV1 or Optical See Thru HMD's such as HoloLens.

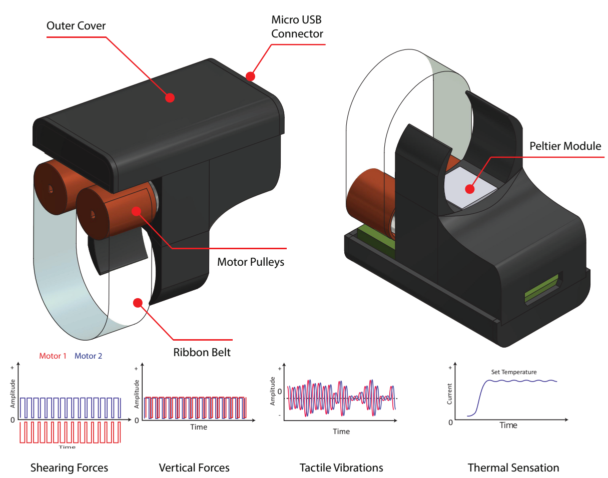

Figure 3: System Description

As shown in Figure 3, the haptic module consists of two Miniature DC motors and a belt attached to the motors to create vertical and shearing forces in a similar manner to the Gravity Grabber[Minamizawa et al. 2007] device. By rotating the motor clockwise and counterclockwise, it is possible to move it vertically on the belt. This outputs vertical pressure to the fingertip. Furthermore, by making it possible for both motors to rotate clockwise and counterclockwise independently, it is possible to move the belt in the horizontal direction. This can slide the belt, and outputs a shearing force to the fingertip. A peltier module is placed underneath the motors that touches the user's nail and the skin above. In accordance with a command received from the wearable PC, by controlling the current flowing through the Peltier module, it outputs either warm or coldness. It outputs texture by outputting audio signal of texture to motor together with pressure and shearing force. The above apparatus can render vertical forces by pulling the belt, shearing forces by sliding the belt, textures by converting the textural audio signals into DC motor PWM[Yem et al. 2016] and thermal sensations with the peltier module. These control signals are received from the connected wearable PC, and a microcomputer incorporated in the integrated tactile display module controls the two motors and the Peltier module.

3 USER EXPERIENCE

The integrated haptic device can be used in many virtual and augmented reality applications. We developed Altered Texture applications as shown in Figure 1(b-c) where the user can see an augmented texture projected onto a transparent cube using HoloLens. The user can feel the softness or hardness with the aid of vertical and shearing forces when he tries to grab the physical block and different textures with the aid of high frequency vibrations on the same transparent cube.

4 CONCLUSION AND FUTURE WORK

We developed a fingertip haptic display with integrated force, tactile and thermal feedback in a miniature form-factor such that it can be worn easily and used with augmented reality applications without affecting the existing tracking technologies. By using the force display, we proposed the concept of "Altered Touch", that can be used to alter the haptic properties of real objects by rendering projected visual, and haptic feedbacks. The system has its limitations such that the projected virtual objects cannot be tracked in free space. Furthermore the gesture tracking is very limited and thus the target applications become limited. This haptic display could be expanded to design a haptic glove that can alter the haptics in reality, and we could feel the touch as we would always want to.

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