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An Immersive Visuo-Haptic VR Environment with Pseudo-Haptic Effects on Perceived Stiffness

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Abstract. In this presentation, we describe an immersive visuo-tactile VR system which presents tunable subjective hardness of virtual objects by employing the pseudo-haptic effects. Our system supposes that users put on an HMD and a glove which contains a mechanical structure that presents constraining force to his or her fingers in pinching virtual objects. The system visually displays a re-rendered virtual hand pinching deformed objects with its finger flexion magnified or suppressed graphically, for arousing the pseudo-haptic effect. We expect this method to be effective in creating mobile wearable tactile systems that are correlated to personal VR systems in home applications.

Keywords: pseudo-haptics, immersive VR

1 Introduction

Researches on immersive VR have become more active than ever since the advent of well-calibrated HMDs such as Oculus rift (Oculus VR, LLC.) [1], which offer a practical platform for personal use with a considerably compact setting. The HMD-based immersive VR is expected to make good applications combined with haptic devices because the view HMD displays is free from visual interference caused by haptic devices.

In this research we aim to construct a personal system which allows mainly home users to experience an immersive VR contents accompanying haptic feedback expressing perceived stiffness of virtually rendered objects. We suppose that the system would not constrain free body movements of users and not be bulky with the aim of its prevalent casual use in future. To this end we exploit the pseudo-haptic effects, which enhance or soften subjective haptic experiences by simultaneously displaying correlated non-haptic (such as video or sound) information to users with haptic stimuli, instead of electrically generating actual external force on users' bodies.

There have been several studies on the pseudo haptic effects, mainly handling the visuo-haptic correlations. By modifying the visual feedback to users according to the expected pseudo haptic effects, users can feel the virtual objects they are in contact with vary in its reacting force [2], shape [3] or mass [4] although there is no actual change in physical interaction in real world. Furthermore, there has been a study reporting that the experimental subjects' perceived hardness of a virtual object presented with active force display is enhanced by simultaneously displaying visual deformation that was visually exaggerated [5]. In our research, we present force sensation passively to users by using the device which only consists of mechanical structures that do not require electric power consumption.

In relation to these examples, we focus on presenting hardness of a virtual object by displaying a re-rendered virtual hand of the user's own holding an elastic virtual object with its finger flexion exaggerated or suppressed. We demonstrate a fabricated system and is currently investigating the condition in displaying a set of stimuli that would elicit the anticipated pseudo-haptics at its best.

2 System Overview and Implementation

Fig.1 shows a whole picture of the fabricated system consisting of HMD, a hand motion sensor and a force-displaying glove. Users see a virtual object and re-rendered his or her own hand via HMD they wear. The position and posture of their hand are captured by the sensor with stereo IR camera (Leap Motion by Leap Motion, Inc.). The users put on the glove implemented with piano wires that constrain finger movements, making users feel reaction force of the virtual object (Fig.2). Note that no active electrical components are embedded in the wire and hence the actual reaction force is uncontrollable. The displayed object deforms as the users move their fingers. As stated above, the displayed flexions of users' fingers are processed and the object deformation is directly affected accordingly (Fig.3). A vibrator is installed on the glove for displaying clicking vibrations representing virtual creaking of the deformed objects.

Fig. 1. Whole Picture of the fabricated System

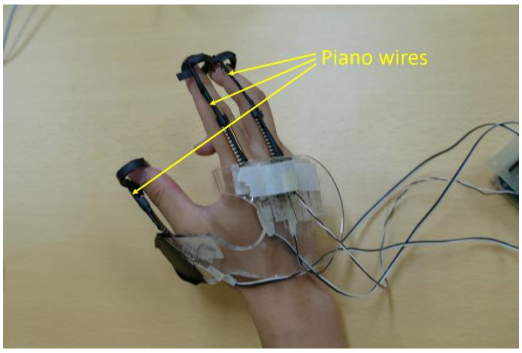

Fig. 2. Picture of the glove users put on to feel reaction force of the virtual objects

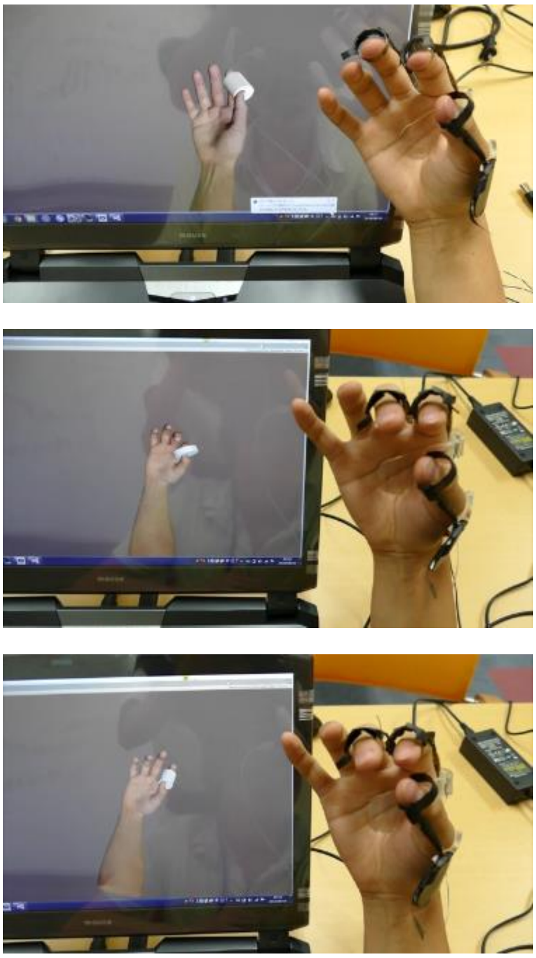

Fig.3. Picture of re-rendered virtual hand displayed with its finger flexion unchanged(top), magnified(middle) and suppressed(bottom).

3 Conclusion And Future Works

We expect that the fabricated system can virtually tune subjective hardness of a virtual object held by the users in an immersive VR environment by adjusting displayed virtual images while keeping actual reaction force presented to his or her fingers unchanged. We empirically have found that pinching virtual objects with the device we provided would offer users a haptic experience that is more realistic and conforming to visual feedback than with the bare hands.

In the future, we will evaluate the effect of pseudo-haptics in this system and will investigate a method increasing it.

Acknowledgement

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