Feel it: Using Proprioceptive and Haptic Feedback for Interaction with Virtual Embodiment

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ABSTRACT

Virtual embodiment has become popular for enhancing virtual interaction in terms of sharing object information. A user can control a character or object in a virtual environment to provide immersive interactive experience. However, one of the limitations for the virtual interactions was the incapability to receive feedback apart from visual hints. In this demonstration, we present using servo motor and Galvanic Vestibular Stimulation to provide feedback from a virtual interaction. Our technique transforms information of the virtual objects (e.g.: weight) into haptic and proprioceptive feedback that stimulates different sensations to a user. We present the user experience to the attendees of SIGGRAPH 2020 through a live demonstration in a virtual environment controlled using a virtual robotic arm.

CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Interaction devices; Haptic devices.

KEYWORDS

Human Augmentation, Haptic Feedback, Proprioceptive feedback

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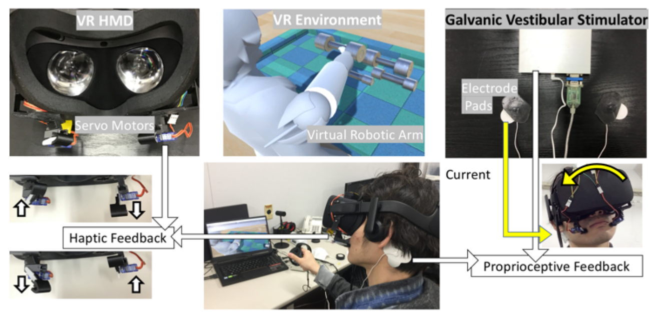

Figure 1: System design overview with virtual interaction translated into haptic and proprioceptive stimulations.

1 INTRODUCTION

Virtual interaction techniques are becoming more common as the virtual reality (VR) becomes popular. A user can view or stimulate an immersive experience by seeing or interacting with virtual objects. Usually, this is achieved by reaching and grabbing at the virtual object using a VR controller accompanied with a vibration to provide physical sensation as if they are touching with their own hands. However, this can only provide limited information especially when the user needs to understand more information about the respective virtual object.

To overcome such limitations, receiving feedback via another channel has become a common solution. A user could see visual feedback in the form of written text or visual cues for understanding object information (Bi et al. 2018). Apart from that, using haptic feedback (Moriyama et al. 2019) or proprioceptive feedback (Sra et al. 2019) is also a popular option for sending stimulation-based information. This provides an immersive experience that does not only improve accuracy, but also enhances user performance for task solving (Kaul and Rohs 2016). However, applying them for a virtual embodiment is still a new area of research.

Our research focuses on providing stimulation-based feedback in a virtual interaction in order to enhance task performance and improve social presence. While using feedback can also improve accuracy and awareness of one's surroundings, it is sometimes challenging to transform certain nonverbal information of a virtual object such as *mass* into a stimulation. In this demonstration, we introduce the use of servo motors and Galvanic Vestibular Stimulation (GVS) as techniques to provide immersive feedback to a user in a virtual environment. We transform the servo motors into haptic feedback that can push a user's head towards a particular direction. We also use GVS to send low current through electrode pads to stimulate proprioceptive feedback in different directions and at different strengths according to the virtual object information

2 SYSTEM DESIGN

A user wears a VR HMD (Oculus Rift CV1) to immerse into a virtual environment with interactive objects at the surroundings. Furthermore, there is a 3D avatar with a robotic arm that extends from the right shoulder of the user for interaction with the virtual scene. The user can use a VR controller (Oculus Controller) to control the robotic arm to interact with different virtual objects. However, the position movement is restricted in order to reduce complexity while focus is placed on the virtual embodiment experience. Based on the information, the user may receive haptic feedback or proprioceptive feedback that is stimulated via the haptic device or the GVS.

2.1 Galvanic Vestibular Stimulation

The GVS can provide proprioceptive feedback by attaching two electrode pads at both sides of the vestibular sensory area behind the ears. Each of the electrode pads can send and receive low current (below 2.5mA) that induces head motion rotation for the user. When a current is sent to one side of the electrode pad, this triggers a visual motion as if their view was rotated towards the direction where the current was induced. This stimulation is caused by ocular torsion that directly influences the brain perception (Nagaya et al. 2005). As a result, the user will passively bend his/her head towards a direction according to the sensation driven by the stimulation. Furthermore, adjusting the current (between 0.1mA to 2.5mA) will alter the strength of the stimulation. In the demonstration, this is represented by the mass of the virtual object.

2.2 Haptic Design

The haptic feedback is stimulated through two servo motors coated with a haptic pad attached on the VR HMD (See Figure 1). This allows the devices to be placed and rest on both sides of user's face near the mouth when it is mounted. While connected, each of the servo motors will be moving in an omni direction. This stimulates a physical sensation on the skin as it is pushed upwards or downwards when mounted vertically.

For simulating left and right rotations, two servo motors move in an opposite direction that guides the user to bend their head towards left or right. Similarly, servo motors can operate at different speed with a different angle for a variety of strength. In terms of the communication and system implementation between the software and hardware, we used an Arduino Uno that transforms virtual object information into digital signals.

3 USER EXPERIENCE

With haptic and proprioceptive stimulation on a user's head, the concept can be used in different areas such as providing an immersive VR experience, human-robot augmentation, or remote collaboration. At SIGGRAPH 2020, we will showcase an example of a virtual embodiment experience where attendees can experience different feedback stimulation by interacting with different virtual objects through a robotic arm in a virtual environment. Concurrently, a representative acting as a local-to-the task partner will be demonstrating and providing explanations to the participant.

4 CONCLUSION

In this demonstration we present an example of virtual embodiment techniques using haptic and proprioceptive feedback. A user can receive somatosensory information from a virtual or remote object as if interacting via a virtual robotic arm. Our demonstration uses servo motors to push at the user's skin in different directions and GVS that transmits low current using electrode pads to the vestibular system which transforms digital information into sensations. Furthermore, the technique could also be applied in remote collaboration.

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