ShareHaptics: A Modular Haptic Feedback System using Shape Memory Alloy for Mixed Reality Shared Space Applications

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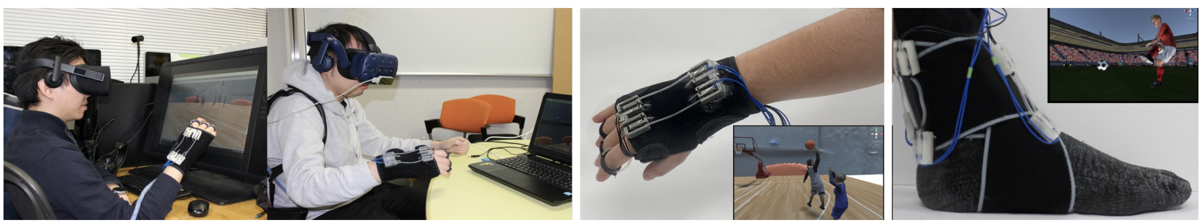

Figure 1: Two particip ants using ShareHaptics, which renders a shared mixed reality environment (left), while using a wearable haptic glove (middle) or haptic ankle braces (right) for haptic jack-in

ABSTRACT

We present ShareHaptics, a novel modular system to provide tactile and pressure feedback in mixed reality applications using a novel actuator: shape memory alloy (SMA). We apply it to fingers, wrist and foot ankle. Although it can be used for haptic feedback in a diverse set of use cases, we specifically focus on collaborative applications: ShareHaptics allows to haptically jack-in to a remote environment via a custom glove and ankle braces. We demonstrate a wide range of applications: watching sports, gaming, and collaborative discussions and skill transfer.

CCS CONCEPTS

• **Computer systems organization** → **Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability.

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KEYWORDS

Haptics, Sharing, Collaborative, Mixed Reality, Tactile, Shape Memory Alloy

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1 INTRODUCTION

Latest Mixed Reality (MR) systems have become so sophisticated that they can make us believe in perceiving virtual objects, avatars or environments [Tachi 2015]. We can transmit these virtual scenes over far distances to enable collaborative tele-presence. Yet, as soon as we try to touch parts of those scenes, the illusion breaks down, as haptic feedback is still not as advanced and cannot easily be transmitted.Therefore, a major research effort in VR/AR/MX focuses on haptic/tactile actuation [Chernyshov et al. 2018; Leithinger et al. 2014]. We are exploring novel haptic feedback methods using Shape Memory Alloy (SMA) [Chernyshov et al. 2018]. We propose ShareHaptics, a system that combines the haptic feedback from the SMA with Mixed Reality visuals for collaborative applications creating a shared space between participants. We introduce the concept of haptic jack-in, which is the ability "feel what a character is feeling" via subtle actuation on the wrist and/or ankle depending on the application. We "haptically" transmit a movement or the "intent" of a movement from one particpant to another. The contributions of this work are as follows: (1) we explore SMA as a novel actuator for collaborative MR applications (especially exploring how to transmit the "intent" of one participant to the other), (2) we present a modular system to actuate fingers, wrist as well as ankle, (3) we show and implement a couple of application cases for ShareHaptics.

2 RELATED WORK

There are a lot of haptic interfaces for MR/AR/VR content[Azmandian et al. 2016; Choi et al. 2018]. For example, Lopes et al. used electrical muscle stimulation to stimulate the muscle for a sense of haptic feedback[Lopes et al. 2017] . Additionally, they couple this with appropriate visual feedback in VR specifically for EMS for an enhanced experience. However, the use of EMS requires long setup times for each user and does not scale well (2 electrodes for one muscle).Another related work is achieved by Benbelkacem et al.[Benbelkacem et al. 2018] where he developed a low cost haptic suit using vibrators for collaborative scenarios. However, vibrators tend to be heavier, noisier, and more difficult to simulate actuation from pressure. The use of SMA for haptics solves these issues, as stated by Chernyshov et al. [Chernyshov et al. 2018], who explored the use of SMA for finger-based progressive haptic feedback. Looking at virtual reality (VR) content, it was found that mixed reality (MR), which uses both information from the physical and virtual world, was appropriate for information transfer and spectating [Pai et al. 2018]. However, no haptic interface was developed, which could benefit from additional information an insight in the activity being performed. Unlike previous works, ShareHaptics uses SMA to give subtle feedback about a remote user's motion. SMA for actuation is silent, fast, affordable and subtle, making it suitable for a variety of applications. To demonstrate this, we further developed two haptic modules using SMA; glove module (hand and finger actuation) and ankle braces module (feet actuation) which will be elaborated in the following section.

3 SYSTEM OVERVIEW

Our system is divided into two main feedback modalities: visual and haptic. The novelty of the work is in the haptic actuation, yet as we are trageting collaborative MR environments, the visual component is an important addtion. To facilitate the perception of a shared physical space, the host scans his/her physical space by HTC vive Pro and rebuilds it in the virtual environment to be shared for other participants who join. The view point is fully customizable and scalable, where the content itself can be rendered according to the participants preference. For the haptic modality, we introduce the concept of haptic jack-in, where participants of the MR may choose to jack-in into different elements present in the environment. For example, for spectating sports with friends, participants may jack into players to directly feel the player's movement. For collaborative learning environments, participants may perform remote haptic jack-in to another participant. To achieve this, we created two wearable devices to facilitate a range of motion feedback. The haptic glove is meant to provide a subtle flexing sensation to the wrist (wrist dorsiflexion) and finger Similarly, the haptic ankle braces actuates the ankle towards the knee (ankle dorsiflexion). The actuation itself is achieved using SMA that is wired through a custom 3D-printed part. The haptic glove is comprised of a pair of SMA wires at the back of the hand, as well as one SMA wire for the index, middle and ring finger respectively (7 wires per glove). The ankle braces is equipped with 4 pairs of SMA wires to provide enough force to actuate the ankle.

4 EXPERIENCE

Users can pick their preferred activity where the physical space is directly scanned and imported into the virtual world. The interaction will either be hand-based or feet-based via the glove or ankle braces module respectively, to suit the scanned environment.We believe this can be a crucial technology for haptic skill transfer

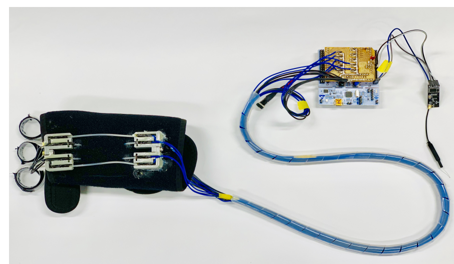

Figure 2: The glove ShareHaptics prototype: Shape Memory Alloy for actuation connected to an STM32 Nucleo-64 board.

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