M-Hair: Extended Reality by Stimulating the Body Hair

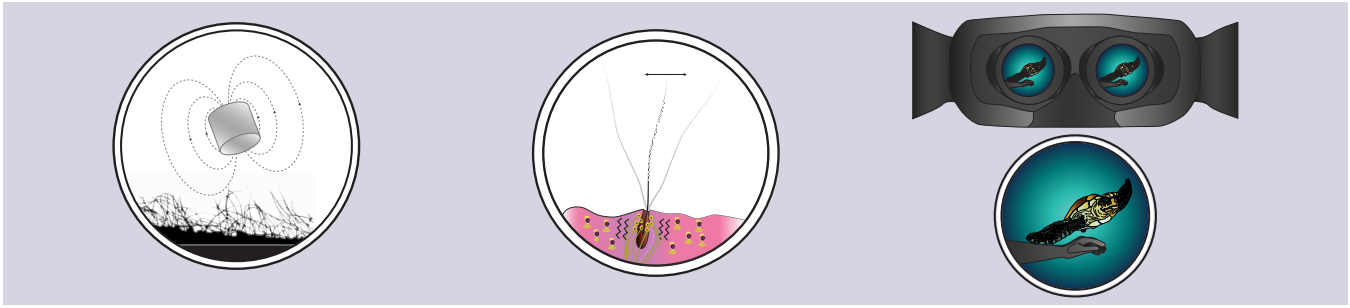
Roger Boldu
Augmented Human Lab, ABI
The University of Auckland
rboldu@ahlab.org

Sambhav Jain
Augmented Human Lab, ABI
The University of Auckland
sambhav@ahlab.org

Juan Pablo Forero Cortés
Augmented Human Lab, ABI
The University of Auckland
juan@ahlab.org

Haimo Zhang
Augmented Human Lab, ABI
The University of Auckland
haimo@ahlab.org

Suranga Nanayakkara
Augmented Human Lab, ABI
The University of Auckland
suranga@ahlab.org



ABSTRACT

M-Hair is a novel method for providing tactile feedback by stimulating only body hair. By applying passive magnetic materials to the body hair, these ones responsive to external magnetic forces/fields, creating a new opportunity for interactions, such as enriching media experiences, emotional touch, or even relieving pain.

CCS CONCEPTS

• **Hardware** → **Haptic devices**; • **Human-centered computing** → *Virtual reality*.

KEYWORDS

Hair; Hair interfaces; Tactile, Non-contact Tactile Stimulation.

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1 INTRODUCTION

Human hair, apart from warmth and protection, also has a significant role as a sensory organ, extending the sense of touch beyond the skin's surface. It detects minute contacts caused by e.g., air flow or insects, providing uniquely subtle sensations. In fact, rich in C tactile (CT) neurons, a highly sensitive type of mechanoreceptor [Li et al. 2011] previously related them to pleasant and emotional touch [Halata 1993; Lechner and Lewin 2013] or even reducing pain [Liljencrantz et al. [n.d.]]. Contrarily, human glabrous skin (hairless skin) is innervated by mechanoreceptors sensitive to deformation, vibration, and slip.

Despite large volumes of previous research on haptic interfaces, most existing work on haptic feedback in virtual reality (VR) has focused on presenting shapes, weight, or force of virtual objects. The main reason is that most techniques rely on physical contact between the actuator and the skin, which prevents any distinction between hair and skin stimulation. Furthermore, these techniques are often intrusive, requiring the attachment of electronics onto the human body [Culbertson et al. 2018]. There is limited research addressing the intrusiveness of haptic displays with non-contact stimulation [Tsalamlal et al. [n.d.]]. Two of the most developed and explored techniques that apply non-contact haptic stimulation are air [Sodhi et al. 2013] and acoustic [Carter et al. [n.d.]]. However, these techniques still do not differentiate between hair and skin, and so stimulate skin, generating sensations such as pressure, temperature change, etc.

M-Hair is a novel technique for creating tactile feedback by only stimulating body hair. The hair is augmented by mixing and applying hair products, such as hair gel, with magnetically responsive particles, such as iron. Then, the augmented hair is stimulated with an external magnetic fields, which can be generated through electromagnets or permanent magnets. The movement or change of the magnetic field strength would induce varying sensations on the hair. M-Hair generates a subtle tactile sensation without physical contact. We have developed a system to stimulate the hair and investigated these in the context of virtual reality applications.

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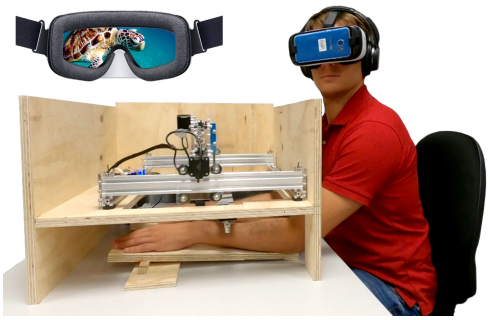

Figure 1: Setup of the experiment where participants experienced VR with and without M-Hair stimulation.

Multiple user studies were performed to understand the unique sensation generated by the stimulation, and its effect in virtual reality immersive experience. The results insinuate a unique sensation which has been described as "unique" and "subtle" sensation and graded as a "felt real" in the VR evaluation.

2 M-HAIR EVALUATION

We conducted a user study to under how the sensation of M-Hair would augment VR experiences. We modified a 2D laser engraver[1], by replacing the header of the engraver with a rare earth permanent magnet. To augment the body hair with magnetic properties, we mix magnetic particles and a carrier that affixes the particles to the hair. Although we developed custom and more efficient recipes, for safety-compliant purposes, we used commercially available cosmetic products. For the magnetic particles, we chose a face mask[2] that contains a high concentration of iron particles. For the carrier, we used a hair wax[3]. The ingredients were then mixed in a centrifugal mixer[4]. The participants (6 of them aged between 25 and 29) were asked to place their both arms under the laser engraver (see Figure 1) and experience 2 VR contents (Scuba Diving & Roller Coaster) in two different conditions (With& Without stimulation). After experiencing each condition, the participant completed a questionnaire (Figure 2).

2.1 Immersion Results

Within each condition for scuba diving, no significant difference ($t(7)$=2.36, p=.052) was found for immersion between tactile feedback (M=4, SD=0.78) and no tactile feedback (M=3.54, SD=0.67). For the roller coaster, a significant deeper immersion ($t(7)$=2.36, p=.006) was found for tactile feedback (M=3.79, SD=0.51) over no tactile feedback (M=3.22, SD=0.59). Looking at the responses (Figure 2), while on-hair tactile feedback seems to contribute to immersion in terms of awareness (question 6) and attention (question 3) in the virtual world, it does not reduce the sense of space and time in the real world (questions 4 & 5). This may be due to the limitation of the form factor of the study instrument, which restrained the participants' arms movement. Another interesting observation is that participants were more aware of their surroundings in the VR world with feedback (question 6), especially in the scuba diving

[1]http://wiki.eleksmaker.com/doku.php?id=elekslaser_a3_pro
[2]https://www.drbrandtskincare.com/products/magnetight
[3]https://www.gatsbyglobal.com/en/product/moving-rubber/index.html#grunge-mat
[4]http://www.thinkymixer.net/products/item-all/ce-certified-model/are-250ce.html

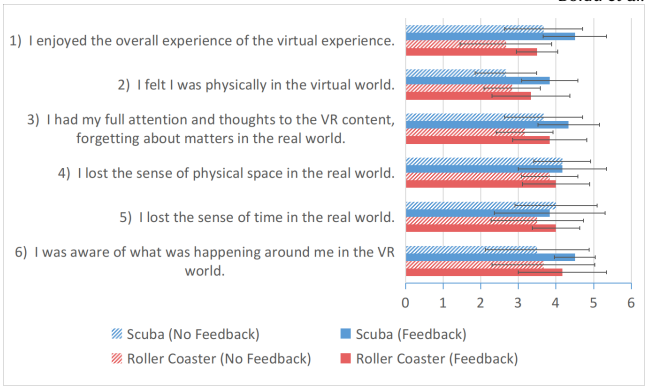

Figure 2: Responses for the two contents with and without feedback by M-Hair

content, where we designed the feedback to synchronize with the events in the content, such as bubbles and approaching fish.

2.2 Participant Comments

The participants reported to further enjoy the immersion experience with the on-hair tactile feedback. Participants 1 and 2 had a deep immersion with the diving experience: "*the haptic feedback made it feel like currents/fish/plants physically touching*", "*it felt like real*". Without on-hair tactile feedback, a number of participants reportedly felt more disconnected: "*lack of physical awareness in the real world*", "*I did not feel the water*", "*It was significantly less immersive than the previous, as I couldn't feel any movement, just see and hear it*". Participants provided insights regarding the video quality and type of content. Most participants preferred the scuba diving content due to the *random surprises* (in the surroundings) and *minor stimulation*. One participant mentioned that it would be difficult to increase the realism of the roller coaster content without a full-body kinesthetic feedback. These comments suggest that the utility of the on-hair feedback needs to consider the context in which it is used. In terms of the location of stimulation, one participant also suggested that legs could be another appropriate option.

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