Untethered Pneumatic Haptic Glove for Realistic Haptic Feedback in Virtual Reality*

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***Abstract*— An untethered pneumatic haptic glove (HaptGlove) is developed for realistic haptic feedback in Virtual Reality (VR). HaptGlove accurately monitors finger movements using microfluidic strain sensors and provides kinesthetic and cutaneous feedback to the user's five fingers. This enables "physical" touching of virtual objects to realistically feel the shape, size and stiffness. HaptGlove can be implemented in VR gaming to improve gaming immersion and also has the potential to create a more realistic and effective VR medical training program.**

I. Introduction

Haptic devices that provide realistic haptics sensations with imperceptible latency, good wearability and a fully untethered form factor are needed to bring Virtual Reality (VR) immersion and applications to a new level [1]. One limitation of current VR is the lack of realistic haptic feedback, which is critical for not only immersive gaming but also medical education where meaningful information can be conveyed through touch, such as via palpation. However, most current haptic gloves share the same limitations of being bulky and heavy or unable to provide realistic haptic feedback [2]. Here, we developed a patent pending untethered, lightweight pneumatic haptic glove for realistic touch sensation in VR.

II. Method

Finger tracking is achieved using ultrathin PDMS microtubes injected with eGaIn as the sensing element [3]. The electrical resistance of the sensors increases when user flexes their fingers. Next, finger sensation is achieved using two kinds of haptic feedback modules integrated inside HaptGlove - Pneumatic Clutch (PneuClutch) and Pneumatic Indenter (PneuIndenter). PneuClutch is a passive module mounted on the back of the hand for variable stiffness kinesthetic feedback. PneuIndenter is an active module placed beneath the fingertips for cutaneous stimuli of variable force through skin indentation. Each HaptGlove integrates five pairs of independently controlled haptic modules for five fingers with a total weight of only 283g (Figure 1a).

When touching virtual objects, a deterministic amount of pressurized air will be delivered to the haptic feedback modules. PneuClutch will be engaged, providing users with feelings of shape and softness by restricting finger movement. At the same time, the soft top surface of PneuIndenter will expand, providing tactile force feedback. By regulating the actuation pressure, the rotation stiffness of PneuClutch and the tactile force from PneuIndenter can be controlled to provide soft and hard perception. By controlling the actuation frequency, a vibrating pulse sensation will be delivered.

We developed a VR archery game that used HaptGlove to shoot arrows (Figure 1b) where the string tension and the sudden tension release can be felt. Significant improvements in realism and immersion against two other modalities (no hpatic feedback and vibtration feedback) were observed through user studies and questionnaires, including 19 participants. In addition, a palpable virtual patient was developed using HaptGlove for medical training (Figure 1c). Tissue stiffness, organ sizes and pulses can be felt by trainees. Importantly, those palpable signs can be easily reconfigured for different training purposes.

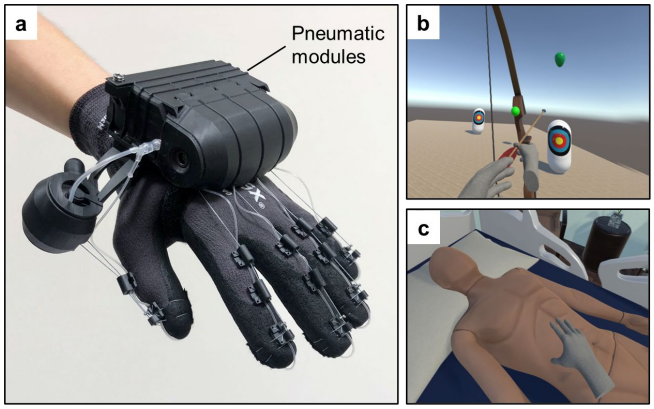

Figure 1. HaptGlove implementation and applications. (a) HaptGlove wore on the hand. (b) Gaming application, using HaptGlove to play a archery game. (c) Medical training application, using HaptGlove to perform palpation training on a virtual patient.

III. Conclusion and Future Work

Our untethered and lightweight HaptGlove allows users to interact with virtual objects naturally and realistically, which has great potential to facilitate more immersive gaming experiences and more effective medical training programs. More in-depth user studies and analysis need to be done to quantatitively evaluate the effectiveness of HaptGlove in VR.

References

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