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Pneumatic Actuated Haptic Glove to Interact with the Virtual Human

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Abstract. Realistic haptic feedback of virtual human avatars would make the virtual world more alive. In the direction of this goal, we focused on making pneumatic actuated haptic glove to augment the perception of human skin response. We have designed a pneumatic controlled actuation with silicone-made cavities (end-effectors), which are situated at the fingertips and the center of the palm embedded within the glove. Various positive air pressure is used to inflate the chambers to perceive soft skins with different shape, stiffness, and homogeneity. The palm actuator is to provide feedback for a grasping interaction, whereas the fingertip actuators are used to generate finger-based touch, e.g., pinching with two fingers. The VR environment with the HMD is designed to improve the immersive experience. Altogether, the system is controlled wirelessly. In this work, we will demonstrate the various scenario of human body parts in which the user can interact with and touch the human to perceive the natural haptic feedback from the skin.

Keywords: Pneumatic glove· Soft haptics · Skin display · Augmented reality · Wearable interfaces.

1 Introduction

The natural kinesthetic and tactile feedback perception through the interaction with a virtual human body could open the new dimension in several industries, such as medical, education, and entertainment. However, creating realistic human touch responses are complex in nature due to significant reasons: 1) inhomogeneous structure of human body, 2) area-based nature of contact for better realism.

Our solution in this paper is to utilize the concept of haptic augmented reality, i.e., mixing virtual and real haptic sensation. For instance, the most important factor for realistic skin feeling is the feeling of very gentle and smooth distribution of pressure that surrounds the whole fingertip or palm area. Generating this kind of feedback using currently available haptic device is very challenging since they usually provide point-based and tool-mediated feedback. Our approach is to

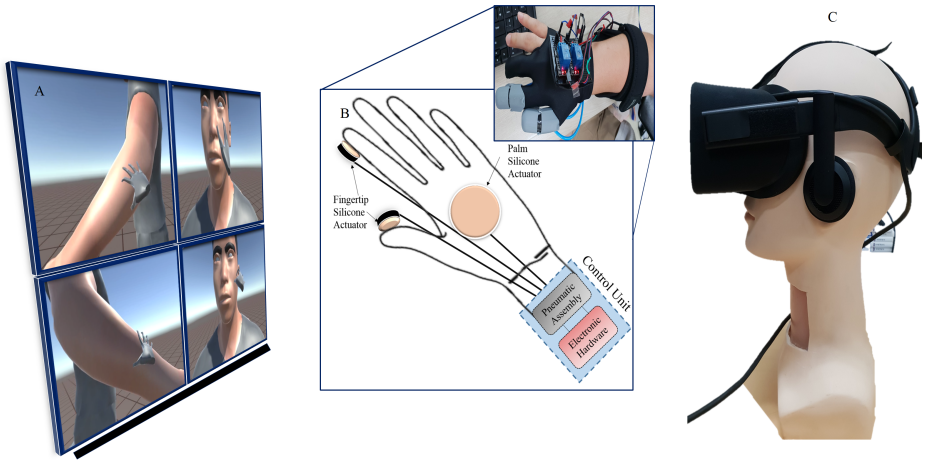

Fig. 1. Illustration of Wi-Fi enabled system architecture: (A) VR scenes (B) Haptic glove assembly (C) HMD.

completely replace the contactor or end-effector of the haptic device with skin-like material that exhibits very similar deformation characteristics as real skin, and make it only in contact with human skin when needed as a glove type. In addition, the haptic properties of the skin-like end-effector can be controllable, where we can flexibly provide different stiffness based on the internal contact dynamics simulation.

To change the haptic property of the end-effector and to control the contact force to the finger, our implementation uses pneumatic actuation with a silicone-based bladders. We also combined this actuation setup with a glove. This haptic glove is, to our best knowledge, the first attempt that is specialized for the interaction with soft skin.

2 Methodology

The most haptic gloves (including commercial) for the VR environment uses actuation techniques such as electromagnetic [1] and DC motor [2]. However, such actuation techniques may lead to unrealistic tissue-like haptic response. In the previous work [5, 4], it has proven that silicone-made bladder with pneumatic actuation is capable of providing tissue like haptic feedback with realism and high-fidelity. Also, the advantages of pneumatic actuation in haptics domain are summarized in [3]. Therefore, in this project, we have designed and developed the small size, and silicone-made actuators to produce a soft response like natural skin feeling. These actuators can be embedded at the fingertips of the hand-glove to characterize the touch, palpation, and pinch. In addition, an actuator is placed at the center of the palm to represent the grasp on the human body (such as a wrist grip).

With the capability of controlling the size of the pores with variable pneumatic pressure, the system can produce soft and stiff body conditions. Moreover, the inclusion of VR scene with a head-mounted display (HMD) that is similar real human body would improve the immersiveness to the human skin touch.

2.1 System Architecture

To achieve control mentioned above, we have designed and developed a preliminary system comprising a pneumatic actuated haptic glove, a standard pneumatic and electronic hardware assembly, VR scene, and a HMD. The system is operated wirelessly. The overall components of the system are shown in Fig. 1.

3 Demonstration

Currently, the haptic glove consists of only three actuators. One is in the middle of the palm and two are at the thumb and an index finger. VR environment is created using Unity 5 and Oculus HMD. In the demonstration, we provide the real and classified skin scenarios (such as different body parts) with normal and abnormal skin conditions. The participants would able to experience immersive human touch at the various human site with the capability to perceive the natural kinesthetic and tactile feedback.

4 Future work

In this paper, we are intended to demonstrate the preliminary system to augment the human touch using mixed reality. In the near future, we will improve the effectiveness of kin touch with precise tissue feedback such as different muscles, and stiffness like a bone. Moreover, we will characterize the system.

5 Acknowledgement

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