Stretchable Transducers for Kinesthetic Interactions in Virtual Reality

Extended Abstract

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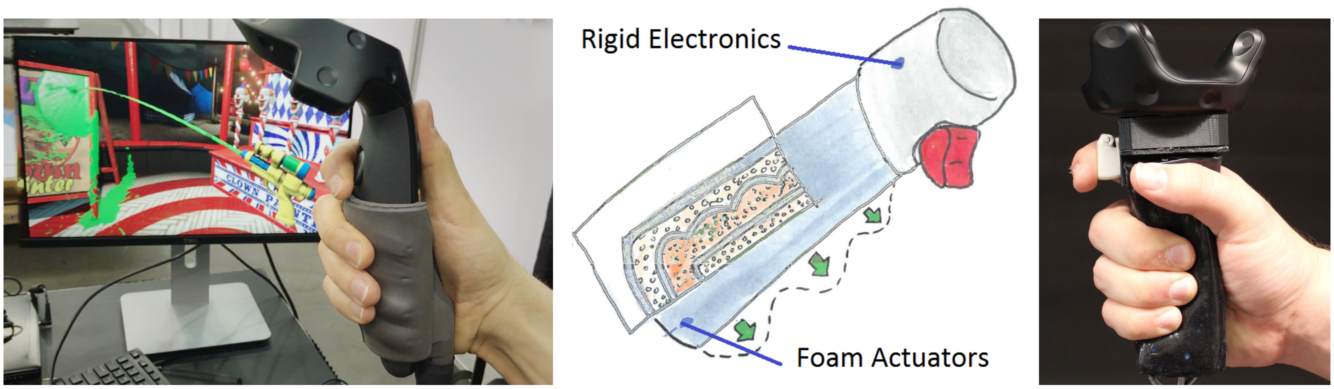

Figure 1: The tools of soft robotics enable immersive kinesthetic experiences in augmented and virtual reality while remaining safe to use. Left: Using fluidic elastomer actuators (FEAs), we demonstrate a soft skin that can provide force feedback to a motion tracked controller integrated with the VR Funhouse application. Middle and Right: A soft controller uses the variable compliance of soft structures to simulate different textures and materials.

CCS CONCEPTS

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

KEYWORDS

Human Computer Interaction, Haptics, Virtual Reality

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OVERVIEW

Commercial virtual reality devices such as the Oculus Rift and HTC Vive enable experience designers to emulate a number of human sensory inputs with computer simulations. Commercial experiences have demonstrated plausibly realistic audiovisual sensory input, but somatosensory feedback has been more limited in scope. Most successful attempts in providing feedback to the human Kinesthetic system were considered power-demanding, expensive and potentially harmful to users, therefore somatosensory input has largely been addressed by vibration-based devices, like Linear Resonant Actuators and Eccentric Rotating Mass actuators, aimed at stimulating receptors near the surface of the skin. This method is widely accepted as a proxy in lieu of resisting to muscle tension, but it is not considered a path to realistic input.

Stemming from advances in materials science, the field of soft robotics constructs stretchable actuators, sensors and displays [Li et al. 2016; Mac Murray et al. 2015; Zhao et al. 2016] using structures and materials that can be deformed at forces exerted by human muscles. To date, most demonstrations of soft robotics have focused on mobile robots, compliant grippers, and biomedical applications. Here we present the use of these technologies for kinesthetic feedback in virtual reality. The materials used to build these devices (e.g silicon) have mechanical properties similar to that of human tissue and are well-suited for applications that require direct and prolonged contact with human skin. Additionally, these systems are well-suited for commercial applications due to the low material cost and compatibility with scalable manufacturing techniques.

We provide two key demonstrations to highlight the use of fluidic elastomer actuators to provide haptic feedback. These demos allow users to progress through a series of brief experiences where the hand-held controller adjusts its form and behavior to match that of the virtual object used in each demo. The objects held in the demo include a goo gun, pistol and mallet.

PNEUMATIC SKIN

First, we have developed a thin (3mm) pneumatic skin to cover an HTC Vive controller. This pneumatic skin has 12 individually inflatable chambers placed in contact points similar to those of objects used in the game play of NVIDIA's VR Funhouse [NVIDIA 2016]. By sending impulses to the user based on actions in the game, the flow of gas into the chambers enhases the gameplay of VR Funhouse. For instance, pneumatic chambers along the bottom of the controller inflate to simulate the recoil of a revolver or the chambers undulate to simulate fluid moving through a water gun.

FOAM CONTROLLER

Our second demonstration is a rubber foam controller that changes stiffness and texture to represent a variety of objects from NVIDIA's VR Funhouse. The controller is composed of co-mingled blocks of foam that we selectively pressurize to provide force feedback upon gripping by the user. The combinations of stiffening different foam modules can represent a large number of Funhouse objects. For instance, the absence of pressurized blocks can simulate the palm area of a boxing glove, while a highly pressurized controller (all blocks pressurized) can mimic the stiff wooden handle of a mallet.

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