Hapballoon: Wearable Haptic Balloon-Based Feedback Device

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Figure 1: (a) Overview of the device, (b) reaction force presentation via balloons, (c) & (d) application examples

ABSTRACT

We developed The "Hapballoon", a novel device that is worn on the fingertips. The device can present three types of sensations: force, warmth, and vibration. Force sensations are presented when the inflated balloons on individual devices contact one another. The device is easy to attach on the finger, and does not obstruct common optical finger tracking methods that track the back side of the hand in virtual reality (VR) and augmented reality (AR) applications. Each module weights approximately 6 grams, and the balloons are inflated via an air tube connected to a device on the user’s arm. This wearable haptic presentation device may improve the realism of various VR and AR applications.

CCS CONCEPTS
• Human-centered computing → Haptic devices.

KEYWORDS
Balloons, Force sensation, Human interface, Virtual reality

ACM Reference Format:

1 INTRODUCTION

Manipulation of objects using one’s hands is a common type of interaction in virtual reality (VR) space. However, currently available hand-held VR controllers (such as Oculus Rift, and HTC Vive) must be held firmly in the palm of the hand, and finger movement is limited. Furthermore, it is difficult to present precise kinesthetic feedback because the feedback is implemented with a general vibration function. Therefore, existing technologies are limited in terms of accurate manipulation and positioning of objects in VR space.

Gripping an object is one of the most important movements during an interaction with an object in VR space. This is because tool use often involves a gripping motion. Several studies have examined methods for executing gripping motion in VR space [Bouzit et al. 2002] [Choi et al. 2017] [HaptX 2019] [Hinchet et al. 2018]. However, the proposed devices are often relatively heavy or have a complicated structure, and some cannot be used with a common optical hand tracking system because they cannot be used while wearing gloves.

We developed the Hapballoon to address these issues. The Hapballoon modules are composed of light-weight balloons positioned on multiple fingers, and can be used to present the sensation of gripping at the fingertips and the palm (Figure 1). The Hapballoon weighs about 6 g and is easy to wear. It can present force, thermal, and vibration sensations. Furthermore, it is compatible with common optical hand tracking systems such as Leap Motion when tracking the back side of the hand.

2 SYSTEM DESCRIPTION

We used pneumatic actuators to create a module that is relatively light and small. When the modules are attached to the fingertips of multiple fingers, the inflated balloons can contact one another, thus presenting a tactile sensation to the fingertips. The balloons...
can be inflated to a height of 30 mm. A peltier device (tefc1-03112, NIPPON TECMO) is installed in the part of the module that contacts the finger pad, and this can be used to present changes in temperature. Linear resonant actuators (LRAs) (LD14-002, Nidec Copal Corporation) and photo reflectors (TPR-105F, GENIXTEK CORP) are installed inside the module. LRAs can present vibrations to the finger at a drive frequency of 150 Hz, and the photo reflectors sense the height of the balloon from the inside to enable control of the balloon size. Air pressure sensors, which are connected to a tube, measure the force between balloons that are in contact. These systems make it possible to present three components of haptics: force, warmth, and vibration.

The system overview is shown in Figure 3. The modules are connected to a computer via USB. The air tubes are connected to an air pump (SC 3710 PML, SEJOO MOTION). The VR world was created using the 3D game engine Unity, and a head mounted display such as Windows MR was used to display the scene. Finger motion was tracked by Leap Motion.

![Figure 2: Haptic force presentation](image1)

![Figure 3: System overview](image2)

## 3 USER EXPERIENCE

The device can be used to present pinch and grip sensations, which can be used in VR scenes, especially those involving gripping and holding objects.

We conducted a demonstration in which various objects were presented in VR space for a user to handle (Figure 4). When the user held a spherical object or pinched a bar-like object, realism was improved by combining the sense of reaction force, heat and cold, and vibration to imply collision.

![Figure 4: Hapballoon applications in VR space](image3)

## 4 CONCLUSION AND FUTURE WORK

The Hapballoon is a light wearable device that can be used to present various haptic sensations. It is possible to present force feedback, especially with respect to pinching and gripping of objects, as well as temperature and vibration information to enhance the material feeling of the VR world.

The device may have both VR and AR applications. For example, when a user attempts to grip an object in the real world, the size, softness, and material of the object can be modulated by inflation of the balloons (Figure 5). In the future, we plan to evaluate the use of this device in VR and AR applications.

![Figure 5: Hapballoon applications in AR space](image4)

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## REFERENCES


