[DRAFT]Encounter-type Haptic Feedback System Using an Acoustically Manipulated Floating Object

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Abstract. This paper proposes a novel encounter-type haptic feedback system for virtual reality (VR) utilizing a balloon that can move around in three dimensional space. By locating a balloon at a position corresponding to that of virtual object, the user wearing a head mounted display feels a contact sensation when his or her hand touches a virtual object. The balloon is remotely actuated by applying acoustic radiation pressure. The users can touch a VR object directly by their hands or via controllers or rods. We constructed a prototype system and conducted a preliminary experiment.

Keywords: Encounter-type Haptic Feedback, Airborne Ultrasound, Floating Object, Virtual Reality.

1 Introduction

A contact sensation is indispensable for virtual reality (VR) for its users to naturally interact with its contents. Many approaches have been proposed to achieve a natural contact sensation.

Encounter-type haptic feedback [1-3] is one approach to present a natural contact sensation of an object in a virtual world or in a remote place. Encounter-type device presents a contact sensation by controlling a real proxy object so that it touches the user only when he or she touches a virtual object. Conventionally, a proxy object is controlled by a robot arm [1,2] or is implemented in an exoskeleton [3].

In this paper, we propose a novel encounter-type haptic feedback system utilizing a balloon whose position is synchronized with the position of a virtual object (Fig. 1). The balloon is manipulated in three dimensional space using airborne ultrasound. Therefore, the proposed system can present a contact sensation anywhere in three dimensional space without mechanical actuation.

The feature of the system is that it does not require users to wear special haptic devices. This allows a user to move their hands in a wide range. In comparison with midair haptics using ultrasound [4,5,6] or air flow [7], the proposed system requires only several small devices to cover a large workspace.

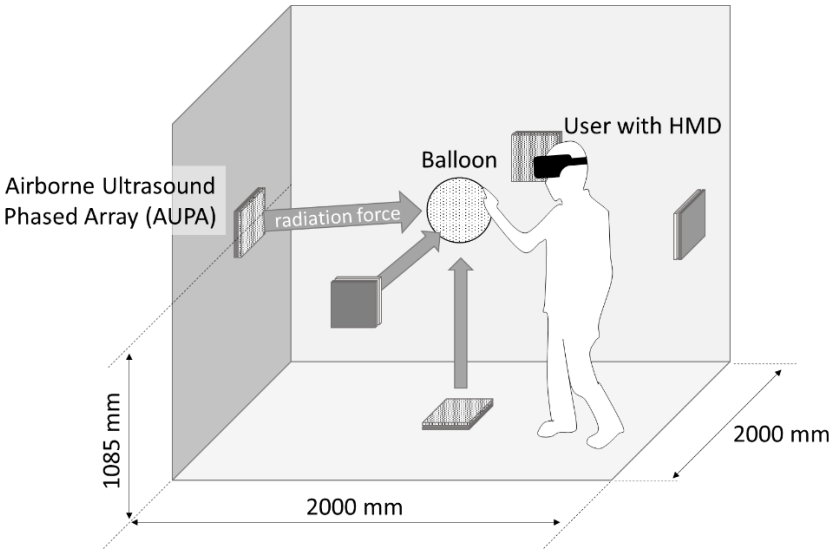

Fig. 1. System overview.

2 System Configuration

The proposed system presents a contact sensation consistent with VR image by controlling a position of a balloon to the corresponding position of the virtual object. The proposed system consists of two subsystems: a VR image output subsystem and a floating object position control subsystem (Fig. 2). The VR image output subsystem renders a virtual world and user's virtual hands using Unity and Leap Motion, and displays the virtual world to the users through a head mounded display (HMD). The floating object control subsystem deliver the balloon to the position corresponding to that of the virtual object. It actuates the balloon using acoustic radiation pressure generated by airborne ultrasound phased array devices [4]. The balloon is stabilized by a PID feedback controller based on its position observed by Kinect v2. To synchronize a balloon and a virtual object, the position of the virtual object is transformed from VR space coordinates to real space coordinates and is send to the position control subsystem in real time. Through the above process, a user gets a contact sensation from a floating object when he or she touches a virtual object image displayed by the HMD at an arbitrary 3D position.

We constructed a prototype and conducted a preliminary experiment (Fig. 3). In the experiment, a user interacted with a spherical object in VR space. This figure demonstrates that the user encountered a balloon when he approached to the virtual sphere.

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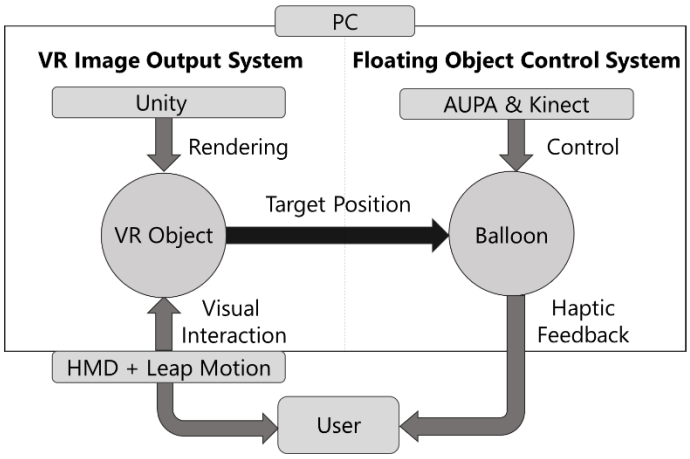

Fig. 2. System configuration.

Fig. 3. Haptic feedback by the proposed system.

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