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햅틱 피드백을 갖는 가상현실 응용 사례

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Virtual Reality Applications with Haptic Feedback

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Virtual reality (VR) opened the possibility of moving beyond the 2-D world of conventional desktop systems to an immersive, multi-sensory environment generated by computer graphics. Haptic feedback (Haptics) is now starting to get recognition and use in intensive applications for manipulation, while smell and taste feedback are at the stage of early research. This paper reviews some current works on increased haptic feedback augmentation in virtual reality applications.

Keywords : virtual reality(VR), haptics, force feedback, graphic animation

1. Introduction

Virtual reality (VR) opened the possibility of moving beyond the 2-D world of conventional desktop systems to an immersive, multi-sensory environment generated by computer graphics. The interaction component of this user interface involves multi-sensory channels, such as the visual, auditory, haptic, smell, and taste ones. The majority of today's VR simulations use the visual (3-D stereo displays) and auditory (interactive or 3-D sound) modalities. Haptic feedback (Haptics) is now starting to get recognition and use in intensive applications for manipulation, while smell and taste feedback are at the stage of early research.

Haptic feedback has been gaining much attention as an important sensorial channel that enhances virtual reality interactions. The word haptic refers to something "of or relating to the sense of touch" [1]. Now, haptics (or haptic feedback) is a crucial sensorial modality in virtual reality interaction. Haptic feedback groups the modalities of force feedback, tactile feedback, and the proprioceptive feedback [2]. Force feedback integrated in a VR simulation provides data on a virtual object hardness, weight, and inertia (object hardness, weight, mechanical compliance, motion constraints and inertia). Tactile feedback is used to give the user a feel of the virtual object surface contact geometry, smoothness, slippage, and temperature (surface contact geometry, rugosity of virtual surfaces, edges, smoothness, slippage, and temperature). Proprioceptive feedback in the sensing of the user's body position, or posture. Especially, unlike tactile feedback, force feedback can actively prevent a user from moving into a restricted simulation space, and thus has been widely used in current VR applications. As such, haptics is a recent enhancement to virtual environments allowing users to "touch" and "feel" the simulated objects they interact with. This sensorial channel complements the visual and auditory feedback modalities used in current VR simulations [2]. The resulting complex system is more expensive than present PCs, but simulations with haptics are more realistic and more useful. Applications of haptics went beyond teleoperation into the more general and expansive field of data exploration and manipulation. Current commercial interfaces give users the ability to touch and feel virtual objects.

This paper reviews the current works on increased haptics augmentation in virtual reality applications. Section 2 introduces and describes several haptic displays widely integrated with VR applications. Section 3 presents some VR application ssytems integrated with haptic feedback, and followed by conclusions.

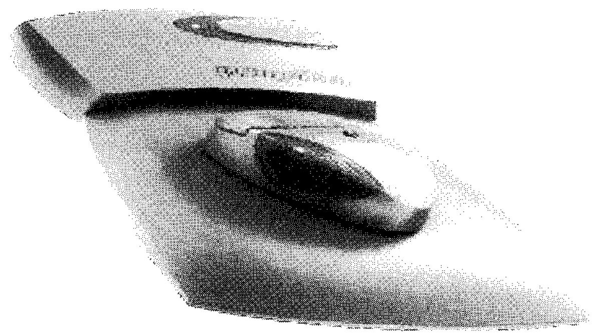
2. Haptic display

A device configured to provide haptic information to a human is called a haptic display. Just as a video display allows the user to see a computer generated scene, a haptic display permits the user to "feel" it. The size, shape, and function of these devices are as varied as the human receptors which they target.

Tactile displays, a subclass of haptic displays, target the vibration and pressure sensing elements of touch. Other haptic displays generate larger motions and forces which are sensed through both touch and kinesthesia. These are typically called force display (in most cases, this means haptic display, rather tactile display). This display includes hand controllers or manipulanda, and can resemble joysticks or robotic manipulators. Sometimes, extending haptics to large-volume virtual environments is very desirable due to the new generation displays.

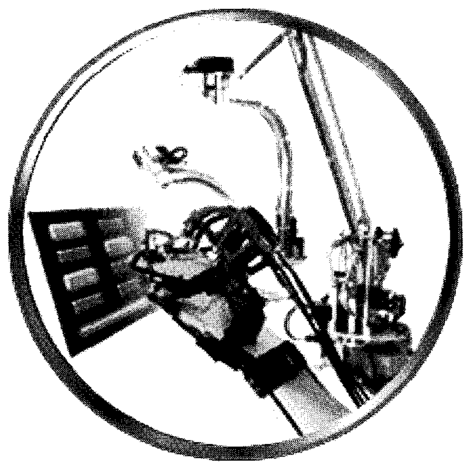
There are many ways to classify a haptic interface depending on the type of actuators used, the application area, or the grounding arrangement. In order to resist the user's actions, these interfaces need to be grounded to either the desk, a wall or ceiling, or on the user's body. Typically, grounded haptic displays are divided into two categories : desktop and wearable display. WingMan (Fig. 1) by Immersion Corp. and PHANToM (Fig. 2) by Sensable Technology Inc. are widely-used desktop haptic displays, while Cyberglove (Fig. 3) by Immersion Inc. is one of well-known wearable haptic displays.

3. Virtual Reality Applications



<Figure 1> WingMan by Logitech
(http : //www.logitech.com/)

<Figure 2> PHANToM by SensAble Technology Inc.
(http : //www.sensable.com/)



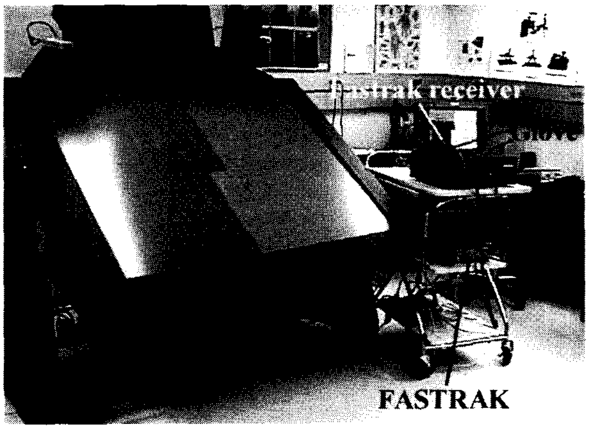
<Figure 3> Cyberglove by Immersion Corp.
(http : //www.immersion.com/)

Main purpose of VR applications augmented with haptic feedback is training and education. This covers from the application of general purpose such as CAD model for prototype design and assembly to special purpose such as military, medicine, and space. Improved technology including wearable computers, novel actuators, and haptic toolkits will increase the use of force and tactile feedback in foreseeable VR application.

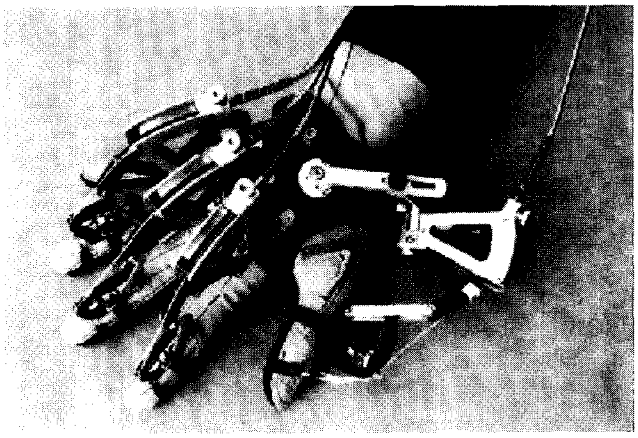
VR application with haptic feedback in early stage was the project GROPE at the University of North Carolina [3],[4]. The project explored the use of force feedback for scientific visualization. The field of haptics moved further into virtual reality with Margaret Minsky's Sandpaper system [5]. A two degree-of-freedom force feedback joystick communicated with a computer generated virtual environment to simulate haptic primitives such as masses, springs, dampers, and texture. At the University of Tsukuba in Japan, Hiroo Iwata developed a nine degree-of-freedom device which applied forces to the operator's hand to simulate grasping of complex virtual objects [6].

Figure 4 shows a typical large-volume virtual environment with haptics, which was developed at the Human-Machine Interface Laboratory, Rutgers University. With this system, he/she, who may be in front of a the large 3-D stereo display and wearing active glasses, could manipulate virtual balls of varying compliance using a haptic glove. The user could feel the hardness of the balls and was able to sort them accordingly, into "soft," "medium," or "hard" bins [7].

One haptic interface that gives the user more freedom of motion is the CyberPack produced by Virtual figure 5. With this system the user can walk in front of a large display, or in a CAVE, grasp and feel the compliance of virtual objects. Virtual Technologies (now Immersion Inc.) has recently introduced the CyberForce arm which can be combined with the CyberGrasp glove to provide more realistic haptics simulations [8]. As shown in Figure 3, the CyberForce attaches to the back of the palm and produces both translating forces and torques to the wrist. As such the user can feel both object mechanical compliance (produced by the haptic glove), and the object weight and inertia (produced by the CyberForce arm). The system is aimed at desktop usage, like CAD/CAM design or service training tasks, thus it is not applicable to large-volume haptics. Of course, there are other force feedback arms that can be attached at the user's wrist, such as the PHANToM Premium (Fig 2), or the Sarcos Master hands [9].



<Figure 4> Large Volume Displays with Force Feedback by Rutgers Univ. (http : //www.caip.rutgers.edu/)



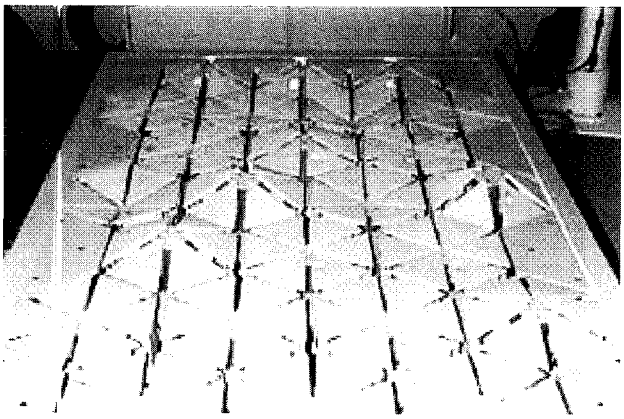
<Figure 5> CyberGlove of CyberGrasp

One of remarkable trends of virtual applications with haptic feedback is that the virtual applications have been shifted to large systems, in which user is immersed. Unlike small systems based on desktop virtual applications which have been done by many researches, virtual applications supporting locomotion to users as shown in Fig. 6 have been developed to enhance/maximize users' reality.

With those applications, user can feel as if he/she is immersed into real environment : in the middle of mountain or building, beyond simple object touch by desktop based applications such as glove and mouse.

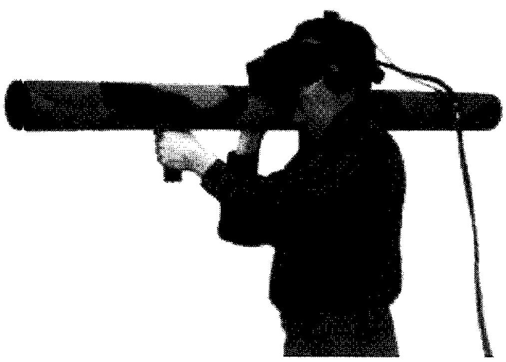
Another way to create large-volume simulations with haptics is to use a treadmill that tilts. Recently, Japanese researchers have proposed the replacement of the treadmill with an active floor. As shown in Figure 7, the floor is composed of modular actuator tiles which can change slope to replicate a moderately curved 3-D surface [10].

<Figure 6> Locomotion Interface by Univ. of Utah and Sacros Inc. (http : //www.cs.utah.edu/)



Close-up view of the ALF platform, showing the triangle plates grouped into hexagonal drive units

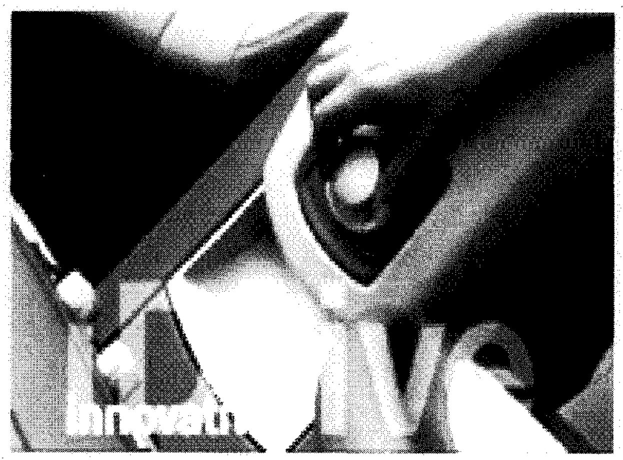
<Figure 7> Active floor at ATR in Japan (http : //www.mic.atr.co.jp/)



<Figure 8> The VR application for the training of anti-tank (http : //www.5DT.com)

Besides the applications mentioned in above, lots of researches has been conducted in many researchers for either the general purpose or special purpose in the world. For example, there exist many VR applications with haptics for the special purpose such as a military training for the anti-tank shown in the Fig. 8, a medical/surgical simulator for continuous medical education (CME) (Fig. 9), a haptic button/knob in a car for driver (Fig. 10), and so on.

<Figure 9> Reachin Laparoscopic Trainer : fully implemented VR with haptics for medical/surgical laparo-scopic procedure education (http : //www.reachin.se/)



<Figure 10> The iDrive System by BMW and Immersion featuring a single control dial mounted on the center console (http : //www.immersion.com/)

4. Conclusions

Some of current works on increased haptic feedback augmentation in virtual reality applications are reviewed in this paper. Virtual reality (VR) applications have been rapidly disseminated in our daily training and education for either general purpose or special purpose such as military, medicine and space. The bottom line is the increased haptic feedback with those VR application systems to support more realistic and natural environment like real world to trainees no matter what the purpose is.

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