Pen de Touch

Sho Kamuro[*1]
The University of Tokyo

Kouta Minamizawa[*2]
The University of Tokyo

Naoki Kawakami[*3]
The University of Tokyo

Susumu Tachi[*4]
Keio University

Figure 1: Proposed device "Pen de Touch"

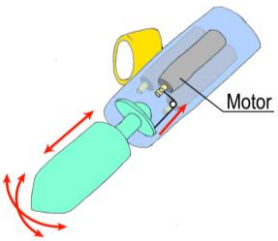

Figure 2: Internal structure

Figure 3: Prototype system

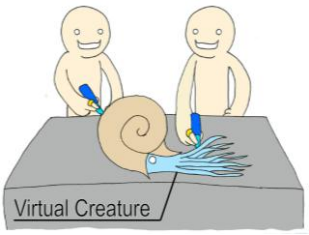

Figure 4: Use of Pen de Touch in a museum

We propose a pen-shaped handheld haptic display that allows haptic interactions with virtual environments by generating kinesthetic sensations on the user's fingers; the user's movements are not restricted since the device does not have mechanical linkages. Unlike conventional haptic displays that provide vibrations, which are not representative of tactile sensation, our proposed device, named "Pen de Touch" (Figure 1), provides kinesthetic sensations to the muscles in the user's fingers.

1. Introduction

Various handheld haptic displays have been developed, which are more easy to use than wearable haptic displays because the user needs to merely grasp the device to enjoy the haptic interactions. Human haptic sensations include cutaneous sensations of the skin and kinesthetic sensations produced at the joints of fingers and arms. PHANToM [SensAble Technologies Inc.] is an example of a typical handheld haptic display, which enables a user to perceive kinesthetic sensations with the help of mechanical linkages, which are driven by multiple motors. However, this device requires to be grounded, restricting the user's movements within the range of the mechanical linkages. Recently developed portable handheld haptic displays such as wUbi-Pen [Kyung and Lee 2008] and Senstylus [Fiorentino et al. 2005] can provide haptic sensations without mechanical linkages. Although such ungrounded devices do not impose restrictions on the motion performed by users, they can provide only cutaneous sensations or periodic kinesthetic sensation. The wUbi-Pen requires the use of physical contacts with the screen surface and does not function if it is moved in mid-air; on the other hand, Senstylus can provide only vibrations, which do not satisfactorily represent the realistic feeling of touch. The development of an ungrounded haptic display that can provide continual kinesthetic sensations has not been reported thus far.

2. Method

Our proposed haptic device is pen-shaped so that the user can hold the device in the same way as he or she would hold a writing pen. In order to downsize the device, we developed our device on the basis of the hypothesis that the kinesthetic sensations on fingers alone are sufficient to represent the sensations of touch. An ungrounded device can not apply an external force to the user's hand; therefore, the point of support and the point of application of force must be located within the hand itself. We fixed the supporting point as a point on the base of the index finger and applied forces to the fingertips by changing the length of the pen-shaped device. Therefore, we developed a haptic display for haptic augmentation, which the user could use and freely move his or her hands in mid-air without any restrictions that could be introduced by the use of mechanical linkages. Figure 2 shows the mechanism of working of our proposed device. The device consists of a part from where the pen is held (grip part) and a base part. When the device is held in a user's hand, the base part is fixed to the base of the user's index finger, which is inserted in a ring attached to the base part; the user grasps the grip part by tip of the index finger, the middle finger, and the thumb. The motion of the device is measured by using an optical motion capture system. When the tip of the device touches a virtual object, the grip part is pulled back toward the base part with the help of the motors, thereby generating the kinesthetic sensations on the skin and muscles of the user's fingers. Inside of the base part, three motors and strings are fixed, which pull each connecting point in the grip part and control the 3-DOF motion of the grip part, as shown in Figure 2. The motion parallel to the central axis generates "pushing" or "pecking" sensations on the fingers, and the motion perpendicular to the central axis generates the sensation of friction or the sensation of touching an object by the side of the pen.

3. Application

Pen de Touch is a simple device, which can be easily applied to various types of conventional virtual reality environments that are not haptically augmented. Figure 3 shows a prototype haptic interaction system interacting with a computer graphics character. Our haptic display device provides the kinesthetic sensations to the users depending on the contacts between the pen tip and the virtual character. The virtual character then moves according to the contacts from the user, thereby making the virtual reality system interactive. As a result, the user experiences the feeling of communicating with the character, as it were actually existing in the real world. The easy accessibility and good representational ability of our proposed haptic device has encouraged us to further develop this device for use in practical systems; as the next step in this direction, we plan to construct a haptic interaction system for multiple users, which can be used in a public domain such as a museum (Figure 4).

References

Kyung, K. and Lee, J. 2008. wUbi-Pen: windows graphical user interface interacting with haptic feedback stylus, *ACM SIGGRAPH 2008 New Tech Demos*.

Fiorentino, M., Uva, A. and Monno, G. 2005. The Senstylus: a novel rumble-feedback pen device for CAD application in Virtual Reality. In *Proceedings of WSCG 2005*.

[*1] e-mail: sho_kamuro@ipc.i.u-tokyo.ac.jp
[*2] e-mail: kouta_minamizawa@ipc.i.u-tokyo.ac.jp
[*3] e-mail: naoki_kawakami@ipc.i.u-tokyo.ac.jp
[*4] e-mail: tachi@tachilab.org

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