A Compact Pseudo-Force Glove Using Shape Memory Alloys

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Abstract

We propose a pseudo-force glove using SMAs(SMA: Shape Memory Alloy), which can present a sensation of grasping a virtual object. SMAs stimulate a fingertip and finger's joints to induce cutaneous and proprioceptive sensations, respectively. Downsizing and large force were achieved by setting the fulcrum of SMAs wire at finger's joints. The developed system enabled to present a sensation of grasping a virtual object.

Keywords: Pseudo-force, Shape memory alloy, Proprioceptive sensation

1 Introduction

MR(Mixed Reality), which integrates real and virtual spaces, is intensively studied. The wearable haptic devices that can be operated in a wide space draw the attention of MR researches. As a haptic device operable in a wide space, a pseudo-haptic display is noted[1], because the pseudo-haptic display is compact and lightweight. The pseudo-force presents original or different stimuli to stimulate a part of mechanoreceptors or proprioceptors effectively with a compact and lightwight device. Foregoing studies stimulate only finger mechanoreceptors[2]. We propose a pseudo-force glove using SMAs(SMA: Shape Memory Alloy), which can present a sensation of grasping a virtual object. SMAs stimulate a fingertip and finger's joints to induce cutaneous and proprioceptive sensations, respectively.

2 Device configuration

A pseudo-force device is composed of four parts per finger. Fingertip part is presented cutaneous sensations by compressing fingertips. Proprioceptive sensations are presented by stretching distal interphalangeal(DIP) joint, proximal interphalangeal(PIP) joint, and metacarpophalangeal(MP) joint parts to provide the joint torque.

SMAs shrinks by only 5% of full length. Therefore, if the length of SMAs changes when the finger is flexed, it can not get enough displacement to give the torque. In this study, in the DIP and PIP joints, the fulcrum is placed in the center of rotation of the fingers, passing through the fulcrum in SMAs, to reduce the change of SMAs length due to the finger flexion and to generate the torque effectively.

Assuming that the force $\vec{f}$ is applied to the fingertip, joint torque $\vec{\tau}$ is given by the formula (1).

$$\vec{\tau} = J^T \vec{f} \tag{1}$$

where $J = \dfrac{\partial \vec{r}}{\partial \vec{\theta}}$ is Jacobian matrix, $\vec{r}$ is position vector, and $\vec{\theta}$ is joint angle vector.

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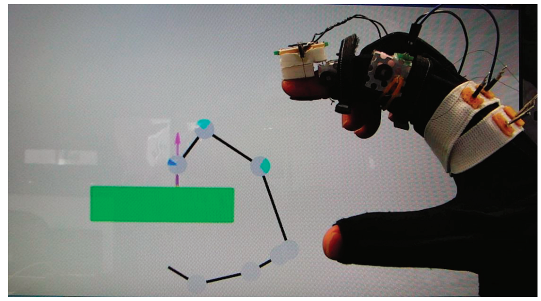

Figure 1: Prototype device.

Table 1: Specification of the prototype device.

Name	Value
Size (figertip)	15[mm] × 20[mm] × 20[mm]
Size (DIP joint)	15[mm] × 20[mm] × 10[mm]
Size (PIP joint)	15[mm] × 25[mm] × 15[mm]
Mass (per finger)	12[g]

3 System

The system was equipped with Intel CPU(Core i5 2.26GHz), 4GB main meory, Intel HD graphics board, and the data glove 5DT 14 Ultra by Fifth Dimension Technologies. Specification of the prototype device is shown in Table1. Fig.1 shows a prototype of the pseudo-force gloves in this study. Joint angles and positions of the finger were measured using the data glove. Finger forces and finger joint torques were calculated from the penetration of the finger to the virtual object. Displacements of the SMAs were determined from the joint torque. As a result, the force sensation of grasping a virtual object was presented to the user.

4 Conclusion

A pseudo-force glove which stimulated a fingertip and finger's joints to induce cutaneous and proprioceptive sensations, respectively was developed. The result showed that the developed system enabled to present a sensation of grasping a virtual object with the lightweight device.

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References

[1] Y. Kuroda, M. Nakatani, S. Hasegawa, K. Fujita: Research Trend of Display and Calculation of Pseudo-Force Induced by Physical Stimuli, Transactions of the Virtual Reality Society of Japan, Vol. 16, No. 3, pp. 379-390, 2011 (in Japanese).

[2] K. Minamizawa, S. Fukamachi, H. Kajimoto, N. Kawakami, S. Tachi: Wearable Haptic Display to Present Mass and Internal Dynamics of Virtual Objects, Transactions of the Virtual Reality Society of Japan, Vol. 13, No. 1, pp. 15-24, 2008 (in Japanese).

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