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Title

Force Sensation of the Human Finger when Using a Multi-Fingered Haptic Interface

Speaker

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Abstract

Haptic interfaces that present force and tactile feelings have been utilized in the areas of telemanipulation, interaction with micro-nanoscale phenomena, medical training and evaluation, and others. A multifingered haptic interface (MHI) has greater potential for effectiveness in these applications than does a single-point haptic interface. In particular, telemanipulation is necessary when using a humanoid hand robot. When a human manipulates an object by using his or her hand, the human receives a tactile sensation through a contact plane between the finger surface and the object surface as a result of the grasping force, vibration and heat. However, when a human manipulates an object in a virtual environment or telemanipulates a humanoid hand robot, he or she uses an MHI and receives a tactile sensation through a finger holder, which connects the human fingertip and the haptic finger of the MHI. This means that the tactile sensation is derived from all of the contact surfaces between the human fingertip and finger holder. Therefore, for the MHI to be further developed, it is necessary to clarify the human tactile sensation that occurs under these conditions.

The characteristics of the force sensation of the human finger have been reported in several papers. In most of these studies, the force sensation was evaluated upon performance of the flexion/extension motion. Humans feel the force sensation during the adduct/abduct motion and the moment sensation, which often occurs with the grasping of a corner of a long object. These characteristics have not been previously evaluated.

Our group has developed a multi-fingered haptic interface called HIRO III[1], as shown in Figure 1. HIRO III consists of an interface arm with 6 degrees of freedom (dof), a haptic hand with five haptic fingers, and a controller. Each finger has three joints allowing 3 dof. The first joint, relative to the hand base, allows abduction/adduction. The second and third joints allow flexion/extension. A three-axis force sensor is mounted in a tip link of each haptic finger. To manipulate the haptic interface, the operator has to wear a finger holder on his/her fingertips.

The finger holder contains an iron sphere, which is attached to the permanent magnet at the force sensor tip to form a passive spherical joint. This passive spherical joint makes adjustments between the human and haptic finger orientations and ensures safety if the MHI malfunctions. When the operator moves his/her hand, the haptic interface follows the motion of the operator's fingertips and presents a sensation of force. We have evaluated the characteristics of the following force sensations experimentally using the HIRO III:

1) Ability to recognize the direction and magnitude of a three-dimensional force;
2) Ability to recognize the direction and magnitude of the friction moment.

The experimental results showed that the ability to recognize the force varied according to the displayed force direction. Moreover, the ability to recognize the frictional moment was not affected by the roughness of the object surface or the angle between the fingertip and object surface.

Finally, a small device that presents the frictional moment, which was developed based on the experiment results for the force and moment sensations, and a virtual object handling system which can present the normal force and the friction force, are presented.

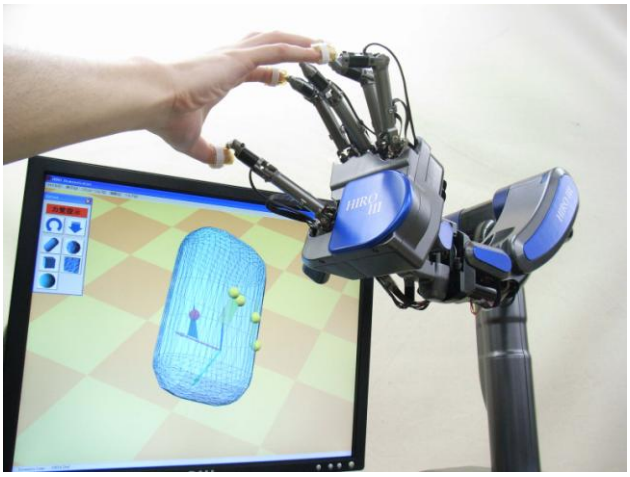

Fig 1. Multi-fingered haptic interface HIRO III

Reference

1) T. Endo, H. Kawasaki, T. Mouri, Y. Doi, T. Yoshida, Y. Ishigure, H. Shimomura, M. Matsumura, and K. Koketsu, Five-Fingered Haptic Interface Robot: HIRO III, Proc. of WorldHaptics 2009, pp.458-463, 2009