Feasibility Study of a Rotational Haptic Display – Rotational action and measuring the rotational moment at the wrist –

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ABSTRACT
We are developing a wearable exoskeleton rotational haptic interface that will fit the human body. First, we developed a force sensor to measure the rotational moment of rotational tasks at the wrist and measured the rotational moment of important tasks. Then, we tried to develop a prototype of the exoskeleton rotational haptic interface.

Index Terms: H.5.2 [User Interfaces]: Haptic I/O —; H.1.2 [User/Machine Systems]: Human information processing—Human factors

1 INTRODUCTION
Haptic information is important for interactive manipulation of virtual objects and enhancing the presence of virtual environments. A number of haptic interface devices [4], which exhibit reaction force or tactile sense by touching objects have been studied. Grounded-type haptic devices, such as Phantom [11], Spidar [10], and Haptic Master [3], have also been applied in numerous types of virtual reality systems. However, these devices required to be fixed within their environment, e.g., the floor, and the working space is limited by the structure. To improve system portability, non-grounded or body-grounded devices have also been developed. One had a wearable joystick [5] allowing the user to set up the acting point from their forearm, while the other variant was the HapticGear [7], in which the actuator was at the back of the user. Forces were transferred to the finger through a string, which was actuated by a motor. For realizing the wide range of haptic area, we selected a wearable haptic display that set force acting points on the body. Therefore, much research has to be done on exoskeleton-type haptic displays [6, 1, 9, 2] in which the outer frames fit the body, and joint jaw moments are generated by the haptic interface. The selection of the exoskeleton type [8, 12] to fit the joint jaw depends on the angle of the joint.

Since there was no research conducted on analysing the rotational moment of the hand; therefore, in this study, we focussed on devising methods for measuring the rotational moment of the hand, and we developed a prototype of a haptic interface that could represent rotational moment.

2 SENSOR OF MEASURING THE ROTATIONAL MOMENT
Figure 1 shows a schematic of the rotational moment sensor. We designed a double shell structure such that the sensing parts were located between the shells. Four sensing parts with homogenized strain were used. In our sensor, we set the strain gauge opposite two sensing parts, while the other two sensing parts were dummies. We set four strain gauges at these sensing parts and connected them to a bridge box, amplifier, and A/D converter; then, we measured the rotational moment using a personal computer.

2.1 Rotational moment measurement results
The rotational work consisted of the following:
(1) Rotation of a door knob.
(2) Opening a valve.
(3) Turning a key.
Figure 2 shows the measurement results of the rotational moment for rotation of the door knob.

![Graph showing measurement results of rotational moment](image)

Figure 2: Measurement result of rotational moment (rotation door knob)

2.1.1 Developing the prototype of interface

Figure 3 shows the prototype of rotational moment haptic display system. We used an exoskeleton mechanism. A part was built at each joint jaw, and these parts were connected to a motor. This drive mechanism had several flaws and required improvement. We used double shell structures at the wrist, and the rotational moment was generated by the motor. This motor was set up outside the parts, and rotational moment was generated inside the parts using a belt. In this case, the motor generates the opposite rotational moment required for the corresponding task.

![Prototype system of rotational moment haptic display](image)

Figure 3: Prototype system of rotational moment haptic display

3 CONCLUSION

We considered basic elements of a new haptic interface for rotational wrist tasks. First, we developed a force sensor to measure the rotational moment, and then measured the rotational moment of some important human tasks. Then, we considered a prototype system of a rotational haptic interface. We are now trying to verify its rotational haptic functionality through experiments. This interface currently suits only rotational tasks. We will improve it by including another functional movement, thereby building a more flexible exoskeleton haptic display.

4 DEMONSTRATION

New rotational moment sensor and measurement experiments are presented by personal computer video.

REFERENCES


