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Object Manipulation System by Cooperative Work with Haptic in Shared Virtual Environment

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1 Introduction

In recent years, virtual reality (VR) has become a subject of a great deal of research. The VR is the technology to create environment by computers where users can feel and act as if they are in the real world. The VR technology is rapidly improved with the speed-up of the computer and the network performances. Extensive research has been dedicated to share the same virtual reality environment in difference places. Such VR technologies are expected to be utilized in various field such as the medical treatment and education. A cooperative virtual reality with haptic sense is current most hot research topic, where users in distinct places can share the same virtual environment, and collaborate with each other feeling haptic sense. For example, several doctors can perform the virtual operation sharing image, voice and haptic infomation. In such a shared virtual reality environment, it is necessary to allow each user to manipulate virtual object without the sense of incompatibility.

However, there is a problem that should be solved when haptic infomation is transmitted over the network. That is the update cycle of the force feed-back mechanism of the haptic device is very fast and about 1kHz; therefore, the feed-back force must be calclated faster than the update cycle. However, in the IP network, the communication delay varies from a few seconds to 100 milliseconds. Therefore, transmition of a steady force feed-back is difficult, when the force feed-back is processed over the network.

This research aims at construction of the system that operates the object on one virtual environment shared by several users with haptic devices.

In this research, we propose a method to control the network connected virtual enviroment. In our method, the force feed-back is separated from the network and calclated in user side to cope with the problem of the communication delay. Moreover, cooperative work system with realistic haptic sense is achived by calculating the movement of virtual objects with actual physical system in very high-speed.

2 Communication on network of force feed-back

In this research, we use the PHANToM as a haptic device that provides the user with the force feed-back. First, we examine the influence of the force feedback when the haptic device is used over the network. The system is configured as a server-client model, and manages the state of the virtual reality environment at the server. The Spring-Damper model is used to caluclate the force feed-back presented to the user to achieve high calculation speed. We constructed the prototype system which manages all communications of the force and virtual environments with the server. It is confirmed that even if the communication cycle of the force feedback becomes high-speed, the operativeness of the user is not always improved. Furthermore, the operation became unstable oppositely. In the case with the communication delay, we confirmed not becoming of high speed the stabilization of the operation at the update cycle of the force feed-back.

3 High-speed physical model

The update cycle of the haptic device is about 1kHz, which is very fast compared with, and the that of display,i.e. about 60Hz. Therefore, a high-speed physical calculation is necessary for the force feedback. The force feedback when the user operates a virtual object is calculated by the Spring-Damper model. Another computing model is requied to calculate the motion of the virtual reality environment. There are various calculation methods for simulating a physical phenomenon of the virtual reality environment. We employ the penalty method to calculate the physics. The penalty method is a calculation technique based on the amount of the infiltration and the speed of a virtual object. The penalty method calculates the spring instead of solving the restraint type of a virtual object. As a result, a physical phenomenon can calculate at high speed.

4 Object manipulation system by cooperative work in shared virtual environment

We propose a method to control the networked virtual environment; that is, client is responsible for calculation of force feedback, which is usually done in server side. This will achieve calculation of force feedback in high update cycle. Information communicated between server and clients are those on the cooperative virtual reality environment shared several clients, and cursor position of PHANToM in each client. The update cycle of those information can be the same as that of of the graphics at user side (about 15Hz-60Hz) because those information are used to know the state of the virtual environment. It is verified that the proposed control method can provide stable operation rather than calculating force in server side.

5 Conclusion

In this thesis, we proposed the object manipulation system in the shared virtual reality environment with haptic to which the operation was steady compared with a past system.

We examine the system that uses the network of a past technique for calculating the force feedback with the server. We examined the relation at an update cycle of force feedback of a virtual object necessary to operate it and the necessary update cycle between the server and the client. We examined the update cycle of the force feedback of a virtual object to operate it, and we examined the relation at the update cycle between the server and the client similarly. Next, we examine a high-speed physical simulation to update a virtual environment, and we used the technique for updating the virtual reality environment by using the technique of penalty method. In this system, it was clarified to generate steady force feed-back to the user's object manipulation with changing the management method of the system, and to obtain the object manipulation system by the cooperative work with a haptic in the shared virtual reality environment with few senses of incompatibility.