Experiment of Handwritten Tele-communication System between Hawaii and Toyohashi

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***Abstract*--This paper describes the tele-control system for Deaf-Blind people. Our proposed tele-control system consists of the client devices, the motion server, and the Internet connection. The client device transmits the operator's force to the motion server, the motion server calculates the device motion, and the client device positions its self to the commanded position. The stability of this system is proved in the international experiment between Hawaii and Toyohashi.**

I. INTRODUCTION

Deaf-Blind (DB) person has impairment of both vision and hearing. They are difficulty to gather information visually and audibly, and different tactile and haptic communication (e.g., tentacle talk and braille) are used in according to individual background. However, the diversity of the communication method makes it difficult for the DB to communicate with each other. Also, Visual and hearing impairments increase with age. Today, DB people are expected to communicate via the Internet in order to participate in society. Research and development of new communication technology for DB people is ongoing [1]. However, most systems require braille, which is difficult to learn after becoming DB. Here, we propose a method for simulating handwritten characters to communicate by writing characters on the palm with a finger. With handwritten characters, it is considered that communication would be possible without special training. Our image of telecommunication system is shown in Fig. 1.

This system can be realized by multilateral tele-control. Multilateral control that exchanges information bi-directionally is an extension of bilateral control that exchanges information bi-directionally, one to one. The purpose of this study is to develop a handwritten communication system that DB people can use to communicate via the Internet.

II. CONSTRUCTION OF TELE-CONTROL SYSTEM

A. Multilateral tele-control system

The proposed multilateral tele-control system is shown in Fig. 2. In this system, n clients are connected to the motion server through the network and the scattering matrix. They then interact dynamically with each other. The topology of the multilateral tele-control system is a star type, with the server/client system normally used in a network. Therefore, it is easy to expand the number of connections.

In Fig.2, $G_{mx}(s)$ is the client model, $G_{sx}(s)$ is the server model, $W_m(s)$ and $W_s(s)$ are a phase control filter, $G_{cs}(s)$ is a phase lead compensator, $G_{cm}(s)$ is a phase delay compensator, T_{ui} and T_{di} are communication time delay, f_{mxi} is the force added by the operator, f_{sxi} is the force received at the server, x_{si} is the position of the device calculated at the server, and x_{mi} is the position received at the master.

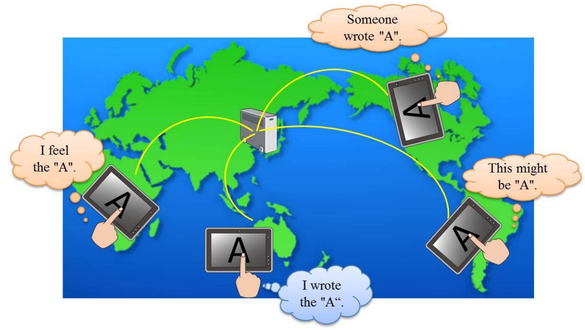


Fig. 1. Image of telecommunication system for Deaf-Blind people.

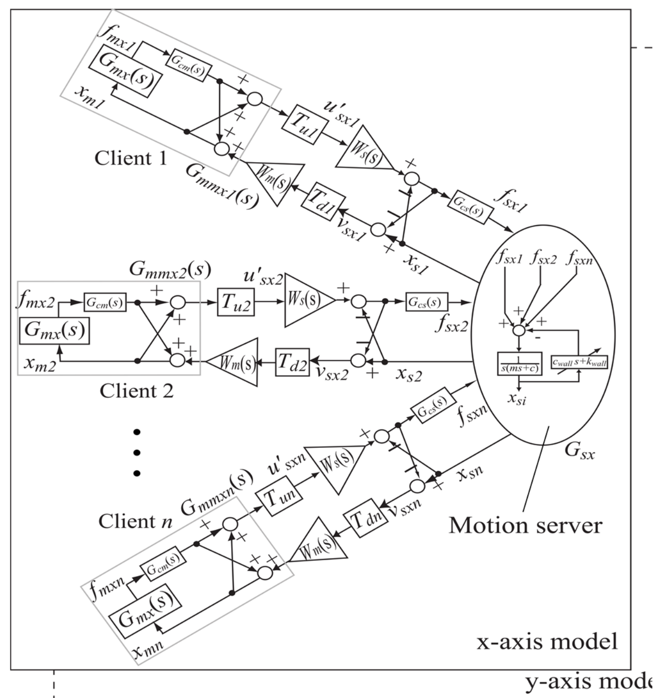
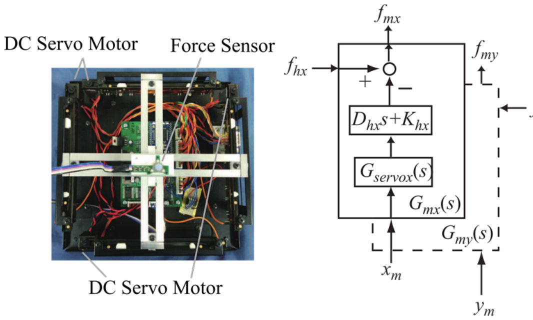


Fig. 2. Block diagram of shared haptic mouse with multilateral control system

The scattering matrix is the cross section of Fig. 2. The scattering matrix was first introduced into tele-control by Spong[2] , It was developed by Miyoshi as a method to stabilize the bilateral control system of non-passive linear systems against $G_{mx}(s), G_{sx}(s)$[3]. Stability of a server/client multilateral control system using scattering matrix was also proposed by Ogawa[4].



(a) Photograph (b) Physical model

Fig. 3. Photograph and block diagram of model of client device.

B. Client model

The models of the clients $G_{mx}(s)$ are admittance-control systems. As shown in Fig. 3(a), the haptic device of clients assumed that the xy sliders could be positioned by the servomotor, and the force sensor was equipped to detect the operating force. The operator can transmit operating force f_{hx} to the haptic device and feel the position x_m by the xy slider, which is moved by position control and sensor. The transfer function $G_{mx}(s)$ is given by expression Eq.(1).

$$G_{mx}(s) \simeq D_{hx}s + K_{hx} \qquad (1)$$

C. Motion server

Every forces from each client are gathered to the server, and are integrated in order to calculate the each position of the client. The transfer function of dynamic model in the server is given by

$$G_{sxi}(s) = 1/\{s(ms + c)\} \qquad (2)$$

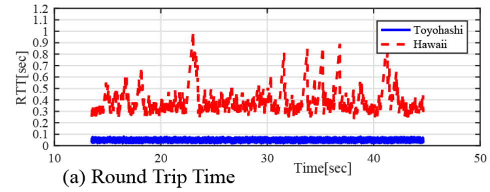
as shown in Fig. 2. The commanded position, which is determined by upper equation, is transmitted to the client side as the position x_{si}.

III. Experimental Results

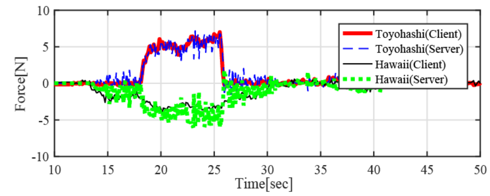
The experiments of the tele-control between Hawaii and Japan were carried out. Two clients is set up at the Honolulu city and Toyohashi city, and the motion server is set up as the cloud server on Amazon Web Service. The purpose of this experiment is to prove the stability of our proposed control algorithm regardless of the communication delay. The protocol of the experiment is similar with Tug-of-War, that is, two operators apply their force each other. Figure 4 shows the experimental results. The top figure demonstrates the Round Trip Time(RTT) both between Hawaii and the cloud server, and between Toyohashi and the cloud server. The former maximum RTT exceeds 1[s] and the average RTT is almost 400[ms], because the communication between Hawaii and Japan goes through United States mainland. While, the latter RTT is only 50[ms], because the cloud server is set up in somewhere in Japan.

The middle figure shows the forces of each operator. First, the operator in Hawaii applied his force toward the left direction in 2[N] from 13[s] to 18[s]. Next, another operator in Toyohashi applied his force toward the opposite side in 5[N] from 18[s] to 26[s]. Then, the operator in Hawaii tried to maintain his power from 13[s] to 30[s].

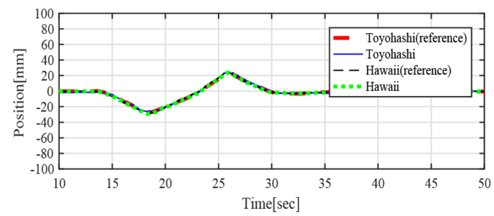
The bottom figure illustrates the motion of each client. Both



(a) Round Trip Time
between Hawaii - server and Toyohashi - server



(b) Applied force in Hawaii and Toyohashi



(c) Position of device in Hawaii and Toyohashi

Fig. 4. Experimental results between Hawaii and Japan

devices moved toward left direction from 13[s] to 18[s] due to Hawaii's force. However, from 18[s] to 26[s], both devices shifted the right direction, because Toyohashi force was stronger than that of Hawaii. After that, they were pulled back due to maintained Hawaii's force.

During this experiment, the system could be stabilized and any vibration was not observed in spite of more than 400[ms] time delay. Therefore, the stability of our proposed system was proved in the actual international experiment.

IV. Conclusion

In this paper, the experimental results of the tele-control between Hawaii and Japan were described. Since they were carried out successfully, the stability of our proposed control system was validated.

Acknowledgment

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Examples of Reference

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