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Study on communication system between haptic-device for medical operation training system

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***Abstract*:** Recent years, advances in medical technology are remarkable and the amount of study required to medical students increases year by year. But it is not easy for them to acquire medical operation technique and as a result inexperience in medical operation is feared. But it is difficult to obtain the opportunity of operation practice. The physician has empirically acquired medical technologies through observing medical operation performed by experienced physician in actual condition, but the malpractice really happens occasionally, To solve these problems, it is necessary to give them the same feeling as an experienced doctor feels when he performs a real medical operation. For the purpose, it is needed to give all medical information felt by the experienced doctor to them through a network.

Keywords: PHANTOM**,** Haptic-feedback device, Communication, Education

I. INTRODUCTION

The aim of this research is to have a learner acquire the skill on medical operation by giving him the same visual and haptic sensation as an experienced physician who is conducting operation. As the first step, this research aims at building communication system which synchronously sends/receives simultaneous medical information to distant places.

II. SYSTEM STRUCTURE

Fig.1 shows configuration of this system structure. PHANTOM and PC are connected by particularized lines. Tests using three kinds of communication methods UDP, TCP and Skype communication are conducted. OpenGL draws a virtual organ operated by a skilled person making use of a virtual scalpel controlled with PHANTOM. The purpose of this research's is to compare the quality of each communication method.

1. PHANTOM

Fig.2 shows two PHANTOMs; (a) is Premium 1.5 and (b) is Premium1.0. The basic function is almost the same, but there is considerable differenc e in the movement range.

PHANTOM is a three dimensional haptic feedback device. It has positional sensors from three to six degree of freedom to enable detailed operation.

PHANTOM can give force to an operator. Force is assumed to be force of the spring. The force ca n be changed by providing contact of spring k according

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to Hooke's law.

2. UDP communication

The feature of the UDP communication is enumer ated as follows.[1]

· This System can transmit data to two or more other parties at the same time.

· It is real time and much higher than TCP communication because it does not have a sending again system and congestion control.

· The enhanced feature is not equipped.

· The Diagram of the network is not concealed.

· The connection need not be established before data are exchanged.

· The source PC does not concerned whether data reached the destination PC or not. So data may be broken or lost.

3. TCP communication

The feature of the TCP communication is enumerated as follows.

· It has the function to maintain the data adjustment.

-The sent data is calculated, forwarded, checked with checksum by a destination PC. The data broke n during transmission is omitted and is recognized as the un-received data. So the data is resent from the source PC to the destination PC.

· The flow control is equipped.

-This means the receiving PC can control the se nding PC, that is, the receiving PC sends the number of bytes the sending PC can transmit when the response puts out.

· It is necessary to establish the connection to send or receive data.

4. Skype communication

Skype is internet telephone service and uses P2P technique.[2][3] It assures a stable call even on a law line or inside firewall. Generally, Skype is used by telephone service and messenger used**.** An advantage to exploit Skype is to encipher the data and to distinguish the connected status with a companion.

In this research, we use it for a data communication.

5. Open GL

Open GL is programming interface for three – dimensional graphics. It is possible to draw three-dimensional highly accurate image at the very high speed.

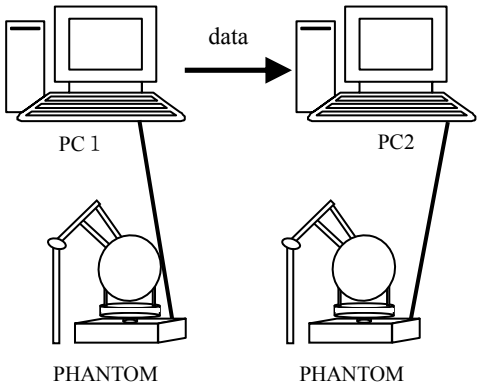
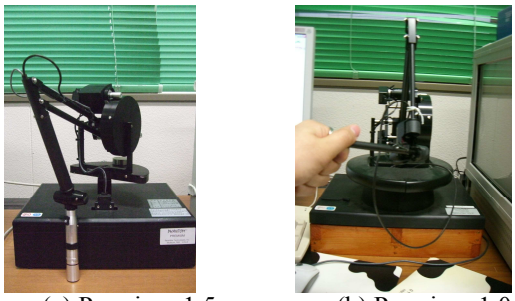


Fig.1 System structure



(a) Premium 1.5 (b) Premium 1.0

Fig.2 PHANTOM

III. INTERPOLATION

Data may be lost in UDP communication. So the received PC must interpolate missing data. As methods of interpolation, Lagrange's interpolation and Newton's interpolation are well known. In this case, we have used Newton's interpolation because it is easy to interpolate missing data even when the number of them increases. The dimension will change based on the number of objects in Newton's interpolation. In this research, we develop three expressions- the second, the third, and the fourth dimensions.

Fig.2 shows interpolation. If the data are lost at 2, 6 and 9 when a receiving PC took the data, it prepares an expression and performs interpolation.

It interpolates that individual data before and behind the loss coordinates is used when the number of objects is two, two data ahead of the loss coordinates and the following one coordinates are used when the

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number of objects is three, and two data before and behind the loss coordinates is used when the number of objects is four. The expressions show (1), (2) and (3).

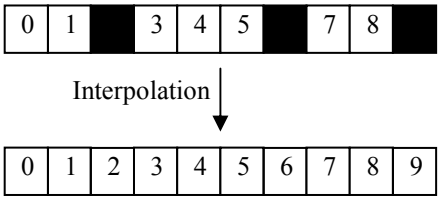


Fig.2 Interpolation

$$f(x) = c_0 + c_1(x - x_0)$$
$$c_0 = y_0, c_1 = \frac{y_1 - y_0}{x_1 - x_0} \quad (1)$$

$$f(x) = c_0 + c_1(x - x_0) + c_2(x - x_0)(x - x_1)$$
$$c_0 = y_0, c_1 = \frac{y_1 - y_0}{x_1 - x_0}, c_2 = \frac{1}{x_2 - x_1}\left(\frac{y_2 - y_0}{x_2 - x_0} + \frac{y_1 - y_0}{x_1 - x_0}\right) \quad (2)$$

$$f(x) = c_0 + c_1(x - x_0) + c_2(x - x_0)(x - x_1) + c_3(x - x_0)(x - x_1)(x - x_2)$$
$$c_0 = y_0, c_1 = \frac{y_1 - y_0}{x_1 - x_0}, c_2 = \frac{1}{x_2 - x_1}\left(\frac{y_2 - y_0}{x_2 - x_0} + \frac{y_1 - y_0}{x_1 - x_0}\right) \quad (3)$$
$$c_3 = \frac{1}{x_3 - x_2}\left(\frac{y_3 - y_0}{(x_3 - x_0)(x_3 - x_1)} + \frac{c_1}{x_3 - x_1} + c_2\right)$$

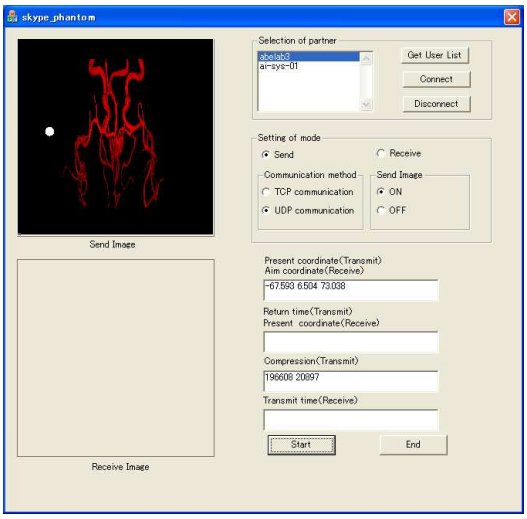
IV. Verification

We examined what influence will occur when a method of interpolation or a method of communication method is changed. To make the measurement precise as far as possible, the average value is calculated by repeating several times interpolation. This time, the data to be sent is limited to PHANTOM coordinates-x, y and z.

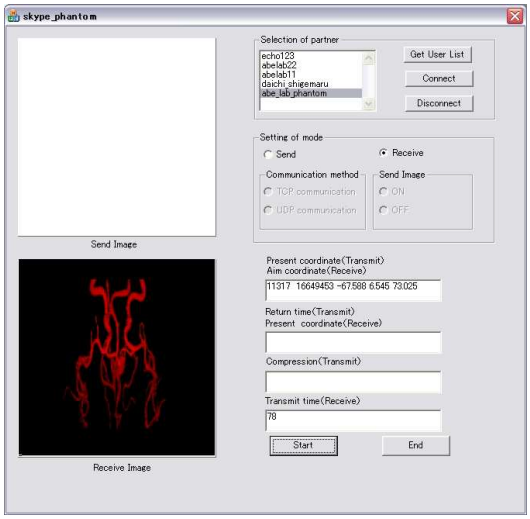
V. RESULTS

1. Operation Screen

Fig.3 shows the display window used in communication test[4][5]. The upper and bottom window which are rendered with Open GL correspond to a sending window and receiving one, respectively. The black point corresponds to the PHANTOM point, and the coordinate values are shown in the right side.



(a) Operation Screen of send PC



(b) Operation Screen of send PC

Fig.3. Operation screen

2. Result

Comparison between UDP and TCP is shown in Table 1, the lack of data has been caused at UDP communication, but it has not been caused at TCP communication. Communication time by TCP is much more than that by UDP.

Table 1 Time-lag between UDP to TCP

	UDP	TCP
Time-lag(ms)	3.24	111.86

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Table.2 shows the error rate calculated based on the difference between the original data and the data restored by interpolation. The table shows how the error rate decreases according to the dimension of the method used when five data are lost during communication.

Table 2 Error average by the number object

point	Two	Three	Four
Error Average	0.003	0.002	0

The above data are obtained form the experiment in which both sending and receiving PC are connected with LAN in our laboratory. To get the result when 2 PCs are connected with WAN, the experiment between our laboratory and Wakayama University has been conducted. In this experiment, image data are also sent.

In this case, there was the apparent difference between the sending and receiving images, and it seemed that movement of Phantom point does not accord with the image. This is due to the difference in computational capability of PCs used, and this is solved by preparing PCs with the same performance. Another way to solve the problem is to thin out image data when the data is sent out. In this case, the number of data eliminated must be determined not to make people feel sense of incongruity. Finding a appropriate number needs further experiment.

VI. CONCLUSION

In this research, we develop communication system using the haptic-feedback device PHANTOM, OpenGL and Microsoft Visual C++ 6.0.

It is confirmed that haptic data are successfully sent 1000 times a second through network, but it is difficult to send image data thirty frames a second. This means that the synchronization between haptic data and image data may not always attained. It is necessary to examine if the haptic data synchronized with image data sent out are successfully restored at the destination or not.

ACKNOWLEDGMENT

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