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ROBOTIC TELE-DIAGNOSIS SYSTEM OF ECHOGRAPHY And Wireless Experiment for Mobile Telemedicine

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Abstract-**We have experimented a tele-diagnosis system of echography to control the echographic diagnosis robot (EDR) which was developed in our laboratory. The examiner controlled it apart from the patient and obtained echogram of internal organs with the patient status image. The places of the examiner and the patient are connected by wireless network. Remote diagnosis of echogram was possible with sufficient image quality after a skilled examiner got used to control the robot. The robot was stable to slight body movement. The adult patient never felt any discomfort to the robot. Since required bandwidth of this system was at most 1Mbps, we confirmed the ability of this system for mobile robotic telemedicine.**
Keywords **- tele-echography, medical robot, wireless network, mobile robotic telemedicine**

I. INTRODUCTION

Nowadays many researches and trials of telemedicine are reported in biomedical engineering society. Almost of them include data exchange like tele-conference or image transfer but exclude physical action. Despite physical contact is necessary in ordinary medical diagnosis as touching by hands or some tools, it is not popular in telemedicine area.

We have developed a tele-diagnosis system of echography (tele-echography) to control the medical robot [1,2] which moves an ultrasound probe on the body surface of a patient. The robot was carefully designed to be put on abdomen and not to make discomfort to patient. The robot moves 6 degrees of freedom and detects contact force on the body with being carefully considered safety and manufactured to move probe on human abdomen in three dimensionally.

We applied the tele-echography system by connecting two points by wireless network. Wireless connection is very useful for tele-medicine especially in Japan because of geographical features consist of high mountains and isolated islands. Though present accessible distance is several kilometers at longest, international connection might be possible in the future.

In this paper we express an experiment of wireless tele-echography by controlling the madical robot and discuss the possibility for mobile robotic telemedicine.

II. EXPERIMENTAL SETUP

A. Overview

Fig.1 shows the concept of mobile robotic tele-echography system. The patient may be carried by the ambulance to go to a hospital. It saves time for pre-diagnosis until arriving at the hospital. The examiner controls the robot put on abdomen of the patient from the hospital. Medical robot moves as the examiner likes to move. The patient status images and echograms are transferred back to the examiner. Conversation is also possible.

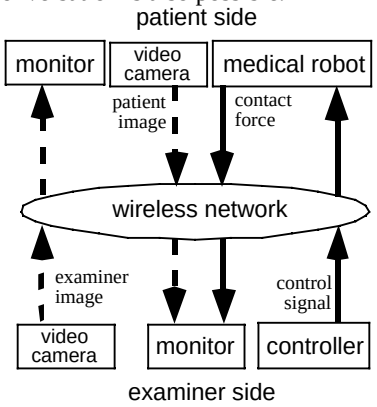

Fig.1 Signal diagram of tele-echography.

Here the medical robot should be simple to be carried on narrow space and stable against slight body movement of patient in a moving vehicle. We think that echography is available for mobile image diagnosis of internal organ because of its feasibility compared to CT or MRI.

B. Patient Side Situation

We have developed the echographic diagnosis robot to realize 6 DOF motion of three dimensional rotation and translation. The robot is put on the abdomen of patient. Total weight is 3.3kg but it did not let adult feel heavy [1,2]. Since whole mechanisms are put on the abdomen of patient [3], this robot is stable to slight movement of body and bed.

Fig.2 shows the patient side situation. Image streaming server (PCS-1600, Sony Co. Ltd.) is on the monitor beside the patient. It terminates not only two patient status images from two video cameras but also echogram captured by echography.

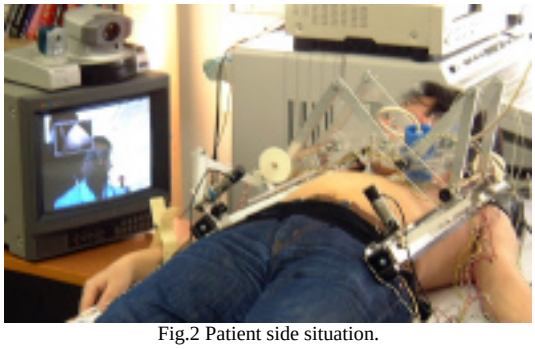

Fig.2 Patient side situation.

C. Examiner Side Situation

Fig.3 shows the scene of the examiner side situation. A medical doctor controls remote robot by the two-axis

joystick. Control interface was designed for the examiner in the way of observing the patient from his legs direction. Angle of the right stick is completely corresponded to the angle of probe. Left stick is used for translation. The examiner is looking at echogram and patient status image simultaneously on the PC monitor as shown in Fig.4.

Fig.3 Examiner side situation.

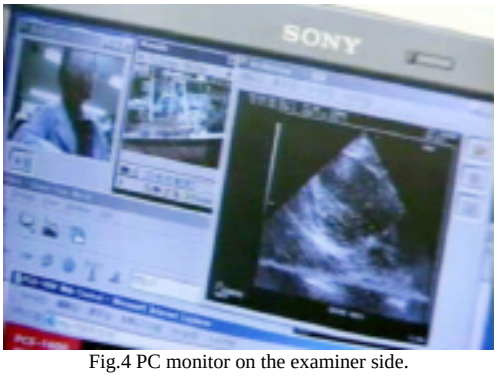

Fig.4 PC monitor on the examiner side.

D. HORB technique for remote control

To control the robot via network, we applied HORB[4] technique which is derived from ORB (Object Request Broker) technique in distributed object system for network computing. It is suitable for fast control system and enables crucially higher performance than Java RMI, Voyager and CORBA [5]. We developed it under C++ and Java platforms.

III. Results of Experiment

We used two wireless LAN bridges SB-1100 (ICOM Co.Ltd.) to connect Ehime University and temporal examination room that locates 1.4km apart from the hospital at 10Mbps. Line speed was sufficient to communicate at most 6Mbps bandwidth. The robot followed the command from the examiner and closely touched on the surface of abdomen. We adopted ITU T.120 standard data protocols that enabled high quality conference with real time moving echogram. Time delay was less than 1sec when image size was CIF 352x288 pixel for echogram by 512Kbps. It was much more comfortable than our previous experiment [1,2] using motion-JPEG encoding.

The examiner got used to operate after a few minutes practice. Quality of echogram was sufficient to diagnose. The examiner instructed the patient to stop and to resume breathing easily in case of observing heart.

The adult patient did not feel any discomfort to the robot put on abdomen even more than one-hour experiment. However, we are not sure this style is suitable for a pregnant woman or an infant. Thus several types of construction of robot should be prepared for actual clinical use.

Fig.5 shows variation of packet number and bit rate passed through wireless antenna during the experiment. Total bit rate was at most 1Mbps so that social infrastructure of this application is already available. Present progress of mobile communication enables high-speed transform that makes easy to apply to mobile robotic tele-echography.

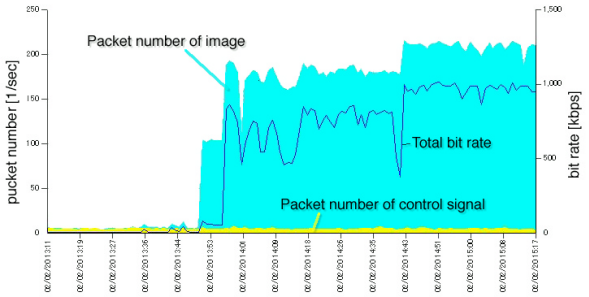

Fig.5 Time variation of packet number and bit rate during the experiment.

IV. Conclusion

We have experimented the tele-echography to control the echographic diagnosis robot by connecting two points with wireless network. The robot never made the patient dangerous and was stable to slight body movement of patient. We confirmed the ability of mobile robotic tele-echography as a part of telemedicine. We propose this system to a diagnosis in emergency between hospital and ambulance or helicopter in order to gain time for critical patient to transport. We hope our system would become an enlightenment to develop robotic telemedicine.

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