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MULTIMEDIA NETWORK SYSTEM

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Abstracts Based on the technical innovation of the recent communication system technologies, systems are linked by the world wide network. We introduce some examples of the multimedia network systems. Especially, we introduce our recent attempt to realize the multimedia tele-surgery system using high speed optical fiber network. At first, we shows the technical problems of the multimedia tele-surgery. We applied this idea to the intravascular neurosurgery. System configuration for the prototype experiments and experimental results are shown.

Keywords Multimedia network robotics, ATM, Teleoperation, Virtual environment, Medical application

1. INTRODUCTION

Technical innovation of the recent communication system technologies, such as multimedia, networking, and down sizing technology is remarkable. So, common ownership and distribution of information resources are widely spread all over the world. Communication style became interactive, and we can exchange multimedia information freely, such as image, sound, text data in real time. These world wide phenomena are based on the development of network communication system and electronics technologies, improvement of computer processing time and storage capacity, and infrastructure of the broad band aspect of high speed communication networks. By linking the world wide networks with the multimedia communication technology, we can realize smooth and real time communication, and rise above the time and space limitation. This will bring us improvement of social and working environment in our near future.

On the other hand, robotics technologies are improved so much to realize high speed, high precision, intelligent, low cost system based on advancement of the electronics and computer technologies. Most of the application field of robots was manufacturing process in industry. Recent application fields of robots are expanding to the medical, welfare, construction, and hazard maintenance fields. In the case of manufacturing process, we can design the process so that we can easily model the working environment and tasks for the robots. So, it is relatively easy to realize automation using the robots. However, in the case of field works in construction site or medical care services, there are so many unknown factors, and safety is very important factor for the system evaluation. In such cases, due to the difficulty of full automation we relay on the human operator to control the robotic system. When we need to consider interaction between robots and human, multimedia information and remote control are very important. Thus, we need to study on the multimedia network robotics. The followings are the research topics of the multimedia network robotics.

(1) Teleoperation technology from distant place
(2) Network technology to unite distributed robots
(3) Human-robot symbiosis through the network

There are many application fields of multimedia network robotics.

For example, in the construction site, human operator controls the construction machine, such as crane and truck. Working environment of the operator is not always comfortable and safe enough. So, teleoperation of such machines from the safe place is demanded. Here, multimedia and communication technologies have a great important role to realize smooth, comfortable, and real time teleoperation of the system.

These technologies are also useful to realize a global manufacturing system. We can unite several working machines including robots which are distributed all over the world. Each robots and subsystems are linked together. Figure 1 shows the concept of the distribution and integration of the agents by the multimedia networks. Based on this architecture, remote maintenance is also possible through the network.

Moreover, multimedia and communication technologies can be used for the medical field. Now a days, medical field is diversified and the number of the specialized medical doctors is decreasing. If we exchange multimedia information in real time, it will help and promote collaborative works between the medical doctors. This idea is proposed as the multimedia tele-medicine.

In such ways, systems are linked by the world wide network. It has great advantage. As an example of the multimedia network systems, next we introduce the

multimedia tele-surgery using high speed optical fiber network. At first, we shows the technical problems of the multimedia tele-surgery. We applied this idea to the intravascular neurosurgery. System configuration for the prototype experiments and experimental results are shown.

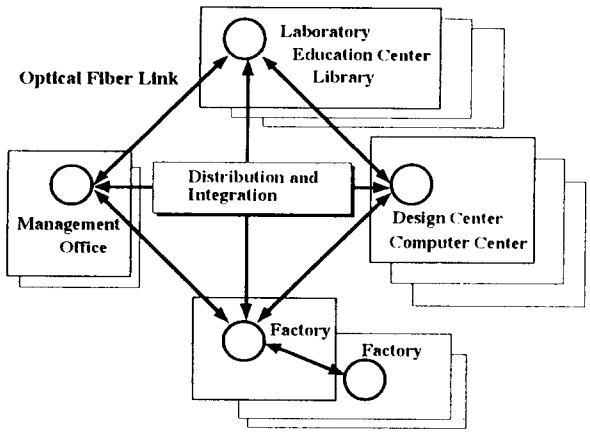

Fig. 1 Distribution and Integration of Agents by Multimedia Network

2. BACKGROUND OF TELE-MEDICINE

In recent years, medical diagnostic systems have been developed such as a X-ray CT (Computed Tomography) and a MRI (Magnetic Resonance Imaging) /1/. These medical devices enable us to build 3D models of the human body. Based on the analysis, diagnoses of the patients and planning for the medical operations are conducted. Moreover, minimum invasive surgery using intravascular surgical tools has great attention in the medical field. This technique allows us to reduce physical pain from the patient /2-5/. For example, a catheter is one of the medical tool for endovascular surgery /3-5/. In these days, the catheter is frequently used for the nurosurgical operations. It can be navigated far deep into the brain from the outside through the blood vessel.

Now a days, medical field is diversified and so the number of the specialized medical doctors is decreasing. It is important to assist doctors diagnosing and operating the intravascular surgical tools such as the catheter. To solve this problem, we propose a method of the multimedia tele-surgery for training, diagnosis, and assistance in surgery. There have been reported many research works on the teleoperation/7-11/. Recently, the teleoperation is being considered for medical purpose. Research interests are focused on the telepresence/8/, user interface/6,9/, time delay/10/, low-cost and widely available interface/11/ and so on. To implement this innovative technology,

(1) high speed communication,
(2) useful user interface, and
(3) improvement of teleoperation capability

are very important. High speed and real time communication is indispensable especially for the medical application to realize reliable diagnosis and appropriate treatment. There are quite few research works on implementation of the teleoperation tasks in the high speed network aiming at dynamic operation with real time color image. So, we use the high speed/ wide band optical fiber network and ATM (Asynchronous Transfer Mode), which give the basis of the networked robotics. ATM has excellent features such as bandwidth allocation, which is suitable for multimedia communication on computer networks. We designed a new teleoperation system based on ATM which is different from the conventional one based on Ethernet.

There are few research works on design methods of a useful user interface applying the multimedia technology for the teleoperation. Generally, we should consider the following points.

(a) Stability of the control system
(b) Quality of service(QoS) in the network
(c) User assistance (with learning and adaptation property)
(d) Augmentation of reality

In this paper, we focus on the user assistance methods for the teleoperation under the new information infrastructure.

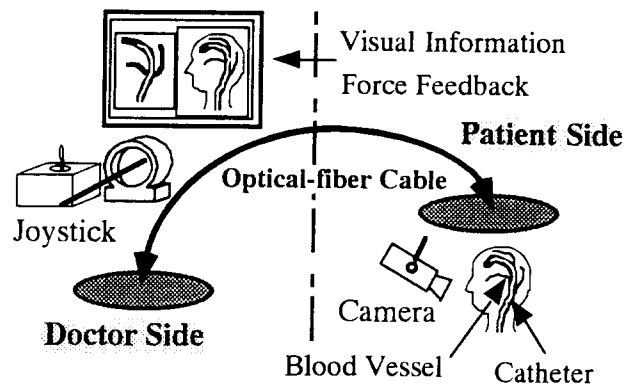

Fig. 2 Concept of Multimedia Tele-surgery

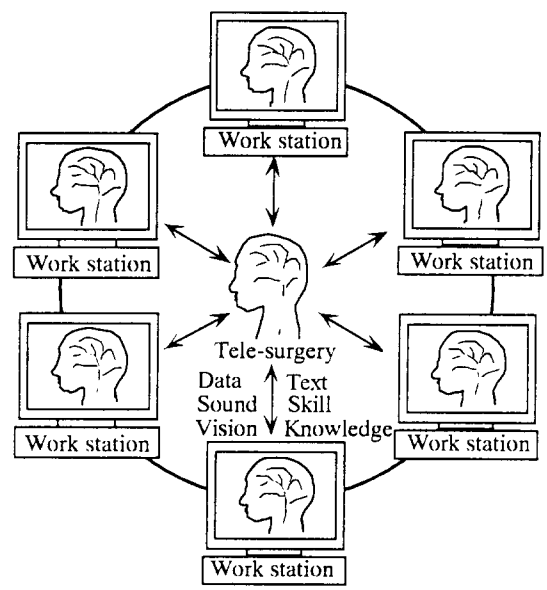

Fig. 3 Concept of Multimedia Based Medical Network

3. CONCEPT OF MULTIMEDIA TELE-SURGERY

Multimedia technology can integrate several different media, such as, high quality image, real time color image, sound, text data, control signal and so on. With the high speed communication technology, we can realize interactive communication between the different places. Figure 2 shows the concept of the multimedia tele-surgery. Operator can get several information through the high speed optical fiber linkage. The number of the specialized doctors tends to decrease. By using the multimedia network, we can exchange the information about the patients. The virtual environment will support collaborative work between several doctors in the different places. The idea of the distributed virtual environment for concurrent engineering has been proposed before/12/. The distributed virtual environment can be applied for the medical matters. This idea will leads to the world wide education system, and proper decision making will be possible based on the global communication. Figure 3 shows the concept of the multimedia based medical network to realize a tele-pathology and tele-surgery (tele-medicine).

4. APPLICATION TO THE INTRAVASCULAR NEUROSURGERY

4.1 Construction of Virtual Environment/6, 13/

Surface of the blood vessel is very sensitive. Handling skill of maneuvering the catheter as well as reduction of handling time is quite important to reduce a pain from a patient. A medical simulator for the intravascular neurosurgery is important for training medical doctors. We modeled 3D virtual environment of a human blood vessel in a graphics workstation and developed a medical training simulator for the intravascular neurosurgery. Figure 4 shows outline of the simulator.

4.2 Force Displays/13/

In the previous research works, we have developed an active catheter that has multiple degrees of freedom /4/. The basic component of it has two degrees of freedom. Orientation of the catheter's tip can be controlled. So we have designed a joystick(Fig. 4, left side) which has 2 DOF, and used it as the controller of the active catheter. This joystick has two DC motors. Each motors connects with an optical encoder. The operator can input the polar coordinates' values according to the measurement of the encoders. The DC motors can apply feedback force to the operator based on the force acting on the catheter. So, it can be used as a force display. Normally, catheter is inserted by the medical doctor. In case of the tele-surgery, position and orientation control of the catheter head is required. So, we have developed a master slave device which can insert and rotate the catheter. The master device and slave device is the same. One of them is shown in Fig. 4 (right side). Force information is very important especially if the visual information is insufficient/6/.

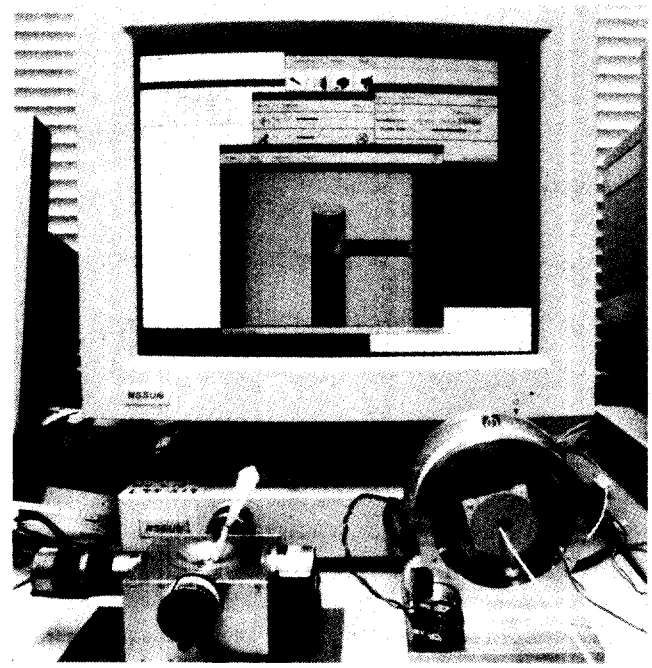

Fig. 4 Outline of the Simulator

5. VISUAL ASSISTANCE

It is difficult to set a vision sensor at the tip of the catheter, if it becomes extremely thin. Normally, we get a real time 2D X-ray image for the real time operation by the medical doctors. However, the 2D image is one representation of the 3D object, so view point selection becomes very important depending on the task. Moreover, selections of the coordinate systems of the catheter and the blood vessel model are also important. If they are not set properly, the operation task becomes difficult.

To discuss these matters, we propose how to set the coordinate systems of the blood vessel for the catheter operation. Here, the blood vessel is approximated by the cylinder. We assume the direction of the blood vessel can be represented by the cylinder axis. If there is a branch, the coordinate system of the blood vessel before the branch is set as {n-1}, and the direction of this vessel is set as the Z_{n-1} axis. Next, coordinate system of the blood vessel in the proceeding direction is set as {n}, and the direction of this vessel is set as the Z_n axis. Then, plane P_n is made by these Z_{n-1} and Z_n axes. We set the view point on the normal line of this plane P_n. This normal direction is set as the Y_n axis. Finally, the X_n axis is decided according to the right hand system. We can select the view direction in this way. Figure 5 shows the coordinate system of the blood vessel and the view point.

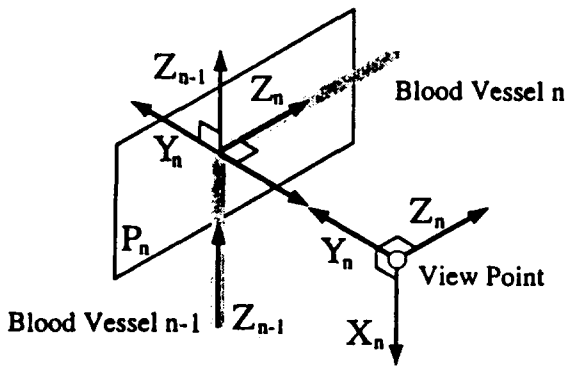

Fig. 5 Coordinate System and View Point Selection

6. MULTIMEDIA TELEOPERATION EXPERIMENTS

We performed multimedia teleoperation experiments between Nagoya and Tokyo. Nagoya is located about 350 km far from Tokyo. We used ATM and shared high speed optical fiber network of 156 Mbps between Nagoya and Tokyo. The operator works in Tokyo. The catheter simulator is set in Nagoya. The operator uses the joystick in Tokyo to control the catheter in Nagoya. Time delay of the catheter control system was 11.79 ms (σ=0.12). He can communicate with the people beside the catheter simulator in Nagoya. They can exchange the real time color moving pictures (24 bit color, 640 by 480 pixels). The operator in Tokyo can feel the force reflection when the catheter contacts and pushes the blood vessel wall in Nagoya.

The operator can navigate the catheter to the target position by the tele-communication using the multimedia technology. The motion of the catheter is stable and the communication time delay was not significant for the catheter operation. Proposed visual assistance is very effective for catheter operation. Based on this simple experiment, we can confirm the effectiveness of the proposed system.

7. CONCLUSIONS

We introduced some examples of the multimedia network systems. Especially, we introduced our recent attempt to realize the multimedia tele-surgery system for training, diagnosis, and surgery using the high speed/ wide band optical fiber network and ATM. ATM has excellent features such as bandwidth allocation, which is suitable for multimedia communication on computer networks. We designed a new teleoperation system based on ATM which is different from the conventional one based on Ethernet. We built a prototype tele-surgery simulator for the intravascular surgery and proposed operational assistance methods. Teleoperation experiment between Nagoya and Tokyo was successful. Based on our attempt, we hope we can integrate the doctors staying in the different places so that they can cooperate each other by exchanging information.

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