World Wide Microscope : New Concept of Internet Telepathology Microscope and Implementation of the Prototype

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Abstract

We defined a new concept of microscope system for telepathology, named World Wide Microscope (WWM), and implemented its prototype. WWM is constructed by the following three units; (1) microscope unit, (2) control unit, and (3) internet unit. The microscope unit is a conventional light microscope equipped with a motor drive X-Y stage and an objective lens revolver, auto focus and auto iris functions, and a CCD camera. The internet unit is a World Wide Web homepage in which a Java applet and a communication server are installed. The applet is implemented several methods that realize to make a PC client on the Internet as a telepathology terminal. The control unit relays request commands generated from the applet to the microscope unit, and captures the microscopic images. We think WWM will probably become the all round telepathology tool of the next generation.

Keyword

Telepathology; Internet; Java; Applet; World Wide Web

Introduction

The original concept of conventional telepathology system was proposed by Weinstein et al. in 1987, and the development of the systems based on their concept has been continuing over the world. The essentials of the system they defined were the following three; (1)a remote controlled light microscope attached to a high-resolution video camera; (2) a pathologist workstation incorporating controls and a high- resolution video monitor; and (3) a telecommunications linkage. The most successful implementation of this requirements can be found in the efforts made in Norway where pathologists of University hospital of Tromso developed a practical telepathology system for supplying pathological services to a rural hospital apart from 400 kilo meters away. In Japan, clinical pathologists of Kyoto Prefectural University of Medicine with engineers of Olympus Optical Corporation developed a unique telepathology system that uses still images only but enables to control remote microscope completely and interactively. They started telepathology services between a local hospital located in the northern area of the prefecture and have been obtaining good results on telediagnosis of cancer frozen sections.

However, those conventional systems have following economical weak points; (a) the prices of the systems are usually too high for many hospitals, especially local and rural hospitals whose financial basis are generally very weak; (b) the communication costs are also too high because most systems need to use exclusive line, or ISDN line whose cost depends on distance between terminals; (c)because there is no standard of the system, compatibility among different systems are very poor.

We will introduce here the concept of World Wide Microscope (WWM) that would be overcome those economical problems. It is not a concept of telepathology system but is a concept of microscope system that realize internet telepathology. As its name, WWM is a microscope situated on the Internet and enables to be controlled via the World Wide Web by any clients anywhere over the Net. It is a robotic microscope holding a URL and a WWW server with special CGI, communication server, digital image capturing method, and a Java applet for clients. The applet has several functions to control the microscope via the Net and receive and display images created from it. The client of the WWM doesn't need any special terminal, hardware, or even software. Only he must prepare is a personal computer connected to the Internet. We think the WWM will probably become the all round telepathology tool of next generation.

Concept and basic design of WWM

As mentioned above, WWM is a robotic microscope implemented with several internet technology. The conceptual diagram of the WWM is shown in Figure 1. It is divided into following three units; (1) microscope unit; (2) control unit; and (3) internet unit. The microscope unit consists of a conventional microscope with a computer controllable X-Y stage and a objective lens revolver, and a CCD camera. In the microscope, auto focus and auto iris mechanisms are built in. The control unit manages movements of the X-Y stage and the revolver, and captures images generated from the CCD camera. The internet unit is a WWW homepage that has in which a communication server and a Java applet are installed.

All the components are integrated systematically. Suppose that a prepared specimen is set on the X-Y stage. First, a user situating over the Net accesses the homepage from his client machine
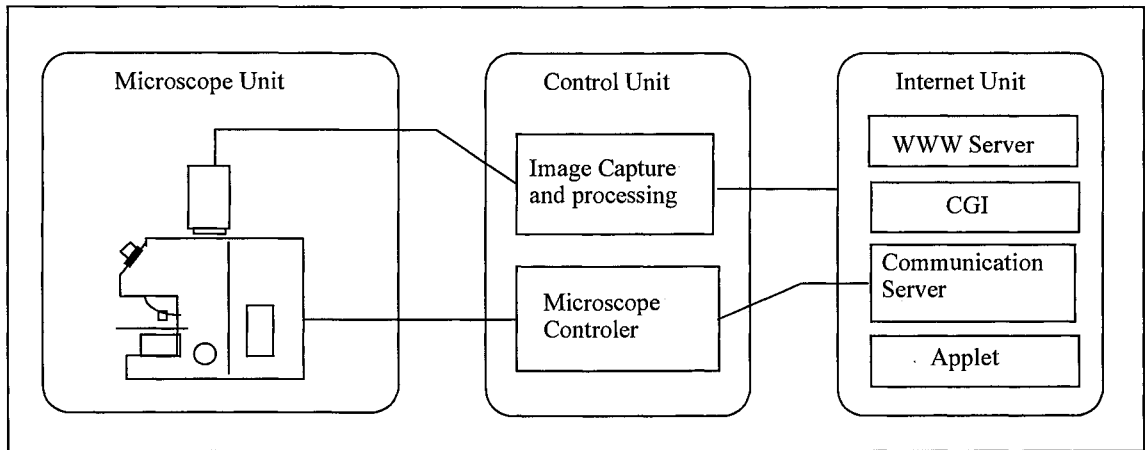
Figure 1 - Conceptual Diagram of World Wide Microscope

by using a internet browser. Then the applet is downloaded into the browser and executed automatically.

The applet has a method to connect to the communication server via the Net by using TCP/IP socket protocol. Also it can request to the communication server to control the microscope, capture images, and set them at a specific directory on the homepage. When the requests arrive, the communication server transfer them to the microscope manager in the control unit. It generates control commands to the microscope. The X-Y stage and the revolver are driven, the auto focus and auto iris work spontaneously, and the microscopic images are captured. Then the images are transferred to the clients and displayed by the applet.

Figure 2 shows how to use the WWM for telepathology. The WWM permits multiclient. When two or more clients get access to the WWM, the communication server starts to relay the control commands generated by a client to the others. Also microscopic images are transferred to all the clients. So, more than two pathologists over the Internet can observe and discuss

on the same specimen at once. Figure 3 shows the operating protocol of interactive collaboration among clients and the units of the WWM.

Prototype design and implementation

Ideally, WWM should be able to use high quality motion picture, but the Internet infrastructure doesn't admit it. So, we designed a prototype system that use only still images. How to control the microscope under still image condition is the following : (1) capture the entire image of prepared specimen by using low power objective lens, (2) mark a point on it where you want to see in large and select the lens, (3) the microscope is controlled and the image you request is captured and transferred. By repeating the cycle, pathologists possibly observe remote specimen interactively. The prototype system was developed by using OLYMPUS AX-80 microscope and Windows 95 personal computers. A color CCD camera that had NTSC resolution was equipped on the microscope. The WWW server we
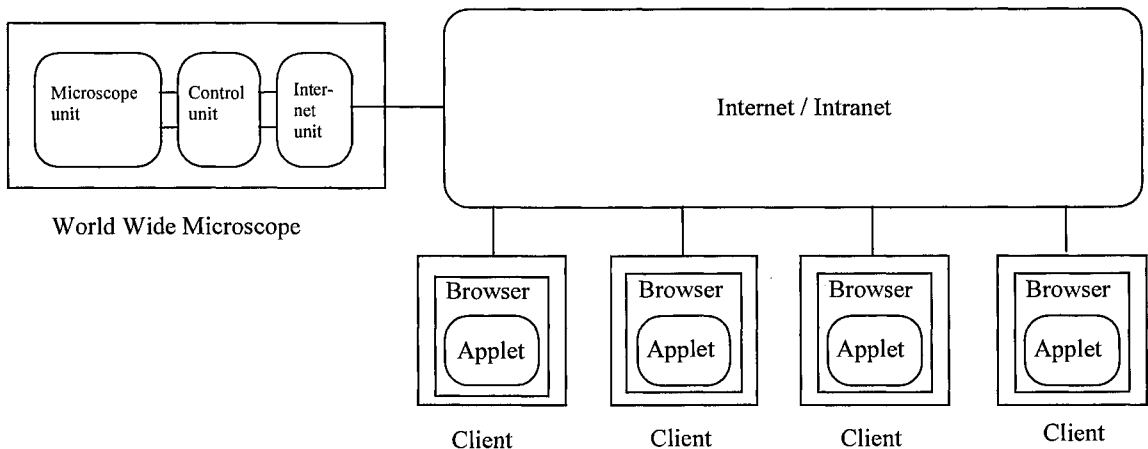

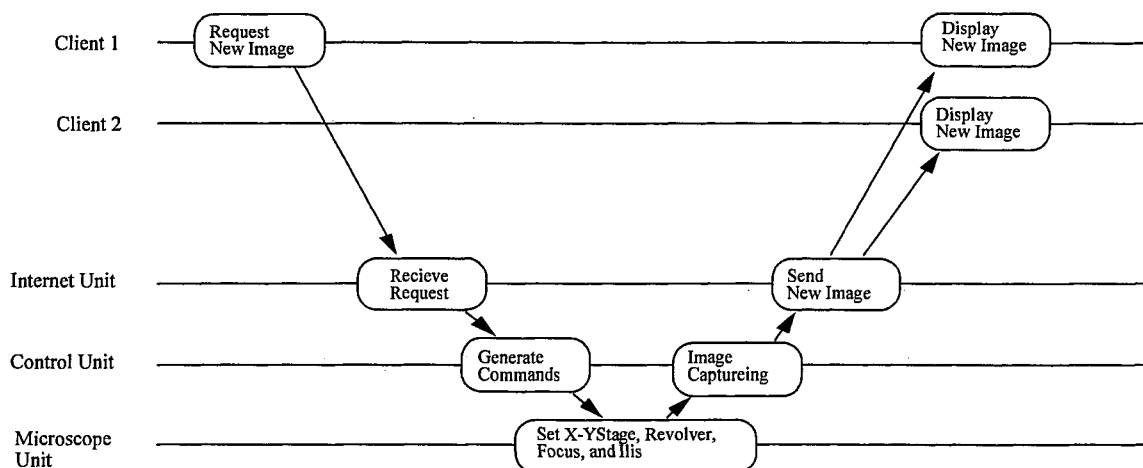*Figure 2 - World Wide Web Microscope on the Internet/Intranet*

Figure 3 - Operation protocol of World Wide Microscope

used was WebSite. The applet and the communication server were implemented by Java programming language. The other software was developed by C language.

Tests and results of the prototype

We tested the prototype under intranet condition in our laboratory. The WWM was set up on the 10 base LAN. A specific network address was given to it and the WWW server was started. A prepared specimen was set on the X-Y stage. Then a PC client (we call it Client-1) was made access to the homepage by using Microsoft Internet Explorer. The applet was downloaded and executed in the browser automatically. First, we ordered the WWM to capture the whole sample image by using lowest power objective lens. The objective lens revolver was driven in accordance with the order, the auto focus and auto iris worked, the microscopic image was captured, compressed into JPEG format, set in the homepage, transferred to the client and the applet displayed it. Then, on the image we marked a point where we wanted to observe in detail and specified an objective lens. The X-Y stage was moved to the point, the objective lens was changed, and the microscopic image was captured and then transferred to the client immediately. This cycle needed less than 10 seconds.

Nest, we made another PC client (Client-2) access to the WWM to test multiclient telepathology. Interactive remote collaboration between the two clients was succeeded completely. Voice communication between them was established by using CU-seeMe.

Discussions

In this study, we produced an idea of internet microscope system for telepathology and developed its prototype. Also we indicated that the prototype worked very well over the intranet. Though the field test over the Net is not carried out yet, we expect that it will establish internet telepathology diagnosis.

WWM should be relatively cheep than the other remote controllable telepathology systems, because it doesn't need any special terminal for pathologist. The most expensive unit to construct the prototype was the microscope, about 50,000 dollars. With a motor drive X-Y stage, CCD camera, video capture board, and a PC, the total cost of the prototype amounted to about 70,000 dollars. However, if it use a standard microscope with a manual X-Y stage, the controls of them must be done by an operator, the cost of the system may be down around 10,000 to 20,000 dollars.

WWM doesn't require wide band width line as the communication linkage. Most of regions except several big cities in the most developed countries in the world cannot use super highway networks. The narrow ISDN (64Kbps) is the only high speed telecommunication linkage in the areas. However, WWM enables to transmit the microscopic still images in practical time via the ISDN. It is estimated that it spends only 10 seconds per an image transmission.

Moreover, there is no compatibility problem on WWM. Most of all personal computers installed no special hardware or software enables to be used as the clients of WWM. Also telepathology diagnosis with interactive remote collaboration between two clients is established easily by using WWM.

We think World Wide Microscope will be the most practical and economic solution for international telepathology in the near future. Now, we are planning field tests of the system over the Internet.

References

[1] Weinstein RS, Bloom KJ, and Rozek LS. Telepathology and the Networking of Pathology Diagnostic Services. Arch Pathol Lab Med 1987; 111; pp. 646-652

[2] Nprdrum I, Engum B, Rinde E, et al. Remote frozen section service: A telepathology project in northern Norway. Human Pathol 1991; 22; pp. 514-518

[3] Tsuchihashi Y, Mazaki T, Murata S, et al. ISDN Dependent Telepathology using an Automicroscope in Kyoto,

Japan, to Support Regional Medicine. Human Pathol (in press)

[4] Arnold K, and Gosling J. The Java™ Programming Language. Addison Wesley 1996

[5] Gosling J, Yellin F, and The Java Team. The Java™ Application Programming Interface, Volume1 and 2. Addison Wesley 1996

[6] December J and Ginsburg M. HTML 3.2 and CGI Professional Reference Edition. Sams net 1996: Part 2 and Part 3

[7] Nagata H and Mizushima H. NCC_image: New remote collaboration telemedicine system over the Internet by using Java. The 3rd Int.Conf.Telemedicine 1997: pp. 180

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