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Functional Evaluation of Telemedicine with Super High Definition Images and B-ISDN

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Abstract

In order to determine whether a super high definition (SHD) image running at a series of 2048 resolution x 2048 line x 60 frame/sec was capable of telemedcine, we established a filing system for medical images and two experiments for transmission of high quality images were performed. All images of various types, produced from one case of ischemic heart disease were digitized and registered into the filing system. Images consisted of plain chest x-ray, electrocardiogram, ultrasound cardiogram, cardiac scintigram, coronary angiogram, left ventriculogram and so on. All images were animated and totaled a number of 243. We prepared a graphic user interface (GUI) for image retrieval based on the medical events and modalities. Twenty one cardiac specialists evaluated quality of the SHD images to be somewhat poor compared to the original pictures but sufficient for making diagnoses, and effective as a tool for teaching and case study purposes. The system capability of simultaneously displaying several animated images was especially deemed effective in grasping comprehension of diagnosis. Efficient input methods and creating capacity of filing all produced images are future issue. Using B-ISDN network, the SHD file was prefetched to the servers at Kyoto University Hospital and BBCC (Bradband ISDN Businness chance & Culture Creation) laboratory as an telemedicine experiment. Simultaneous video conference system, the control of image retrieval and pointing function made the teleconfernce successful in terms of high quality of medical images, quick response time and interactive data exchange.

Keywords

Super High Definition Image; Image Filing System; Telemedicine; Broadband-ISDN

Introduction

In recent years, the importance of medical images transmission in clinical diagnoses and research, as well as medical education continues to grow [1]. However, there still exist some problems on archive, communication and display of high quality images from various modalities.

In this study, a "super high definition (SHD) image" technology (2048 pixels x 2048 lines x 60 frame/sec. [2]) was implemented as a high quality integrated image filing system which meets the needs for clinical practice, education and research. Then, the filed medical images were transmitted among local sites to elucidate the potentiality for telemedicine. At the first experiment (Experiment 1), the SHD image filing system was tested to acquire and archive various images of medical modalities and to verify the clinical usefulness for the stand alone filing system. We generated a case file of ischemic heart disease patient which contained all types of medical images, and twenty-one physicians evaluated whether the system architecture and image quality fulfilled the clinical needs. In the second experiment (Experiment 2), the transmission of SHD image quality and the operability of the filing system were studied with broadband integrated services digital network (B-ISDN)environment.

Outline of the SHD filing system

In order to archive and communicate high quality medical images, the SHD images were adopted and the filing system was developed in this study in cooperation with Nara Research Center of the Telecommunication Advancement Organization of Japan. The filing system is structured as four components of data acquisition, data processing and storage, display and communication as shown in Figure 1.

Data acquisition

The film scanner (Leafscan45, Leaf Systems) and the digital still camera (Leaf Digital Studio Camera, Leaf Systems) are connected to the personal computer (MAC 8100/80). The film digitizer (LD-4500, Konica) and the color printer (Fujix Pictograph 3000, Fuji Photo) are linked to the workstation (Sun SS20). The film digitizer and the digital camera which allow flexible input have spatial resolution of more than 3000 pixels x 2000 lines at more than 12 bits depth. After the input image data are processed on the computers, connected to the input device, they are then transferred to the SHD image server via LAN.

Data processing and storage

The image server (SHD-1000, Mitsubishi Electric) and an image database management system are installed. The server is able to contain 256 SHD images on local RAM that corresponds to 3 Gigabytes data volume. The SHD image data for each RGB

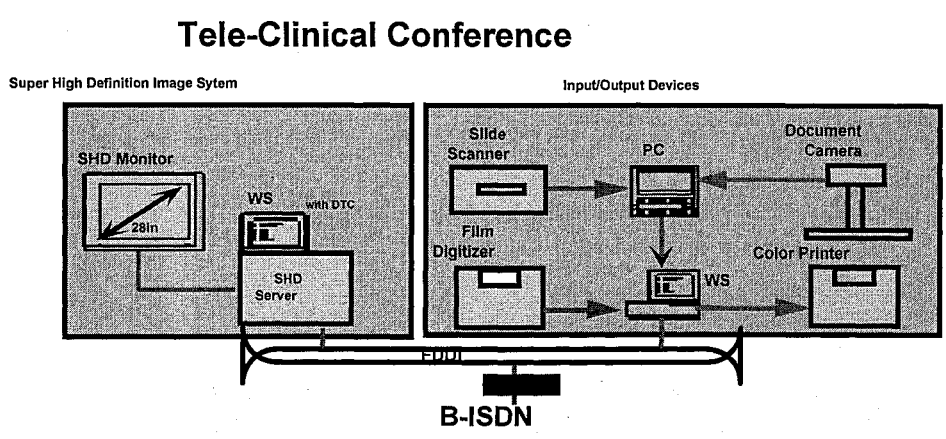

Figure 1 - Hardware configuration of the SHD filing system

signal channel are transmitted through 8 Gbps display bus, and converted to analog output with the rate of 357 mega-samples per second. Frame rate is achieved as progressive 60 frames per second. A video board for NTSC television conference can also be connected to this server to digitize NTSC video signals. The video signals input into the video board are used as a device to input non SHD images with low resolution.

Display

The SHD monitor (DDM2801, SONY) is used for the display which is able to demonstrate 2048 pixels x 2048 lines and temporal resolution is up to 60 frames per sec with non-interlace RGB 8 bits image.

Communication

The SHD system provides an environment for multipoint SHD conference. The three sets of the local system are connected via B-ISDN. The pictures in the system are transferred to another sites beforehand and can be controlled from remote points. An electronic television conversation system is also installed in the control unit of the workstation to communicate among the sites.

Multi-image Filing and Operation

In constructing an image filing system which archives a variety of medical images, a cardiovascular disease case was selected as an example. Since the patient underwent twice PTCA (percutaneous transluminal coronary angioplasty) because of restenosis of the artery, her clinical history can be divided into 4 phases (before and after the first and the second PTCA). In the filing system, we stored the pictures of case summary, electronic cardiogram (EC), chest roentgenogram (CX), ultrasonic cardiogram (movie)(US), myocardial scintigram (MS), coronary angiogram (movie) (CA) and left ventriculogram

(movie)(LV) in each clinical phase. This system accumulated a total of 248 SHD images, 243 medical images and 5 text images of the explanation of the history of the case. The content is described in Table 1. In order to improve retrieval operability, a GUI (Graphic User Interface) displaying a matrix was developed. The vertical axis indicates the types of medical modalities and the horizontal axis, the time course. By clicking a button on the matrix, users can retrieve and instantly display the chosen modality image from the SHD image frame memory.

Experiment 1: SHD image filing

Materials and Methods

This system has made centralized and instantaneous retrieval possible for a variety of high resolution medical images by combining a SHD input and output device with an effective GUI. In order to gain a medical perspective regarding this system, with cooperation from the First Department of Internal Medicine at Osaka, University Medical School, had twenty-one doctors from its medical staff evaluate its operability of GUI for the retrieval system,quality of the images and possibility of medical use. An evaluation sheet in the form of a questionnaire was used. After operating the system, each evaluator filled out the sheet in a format asking them to evaluate the system in three areas: modality-specific operability, image quality, and its practical usefulness. The three areas then consisted of several more questions pertaining to certain details.

In evaluating operability of GUI for the image retrieval system, evaluators were also asked to grade the operability when choosing a screen, response time of screen display, operability when comparing several images, and functionality of displaying animated images. For each item a five scale evaluation choice was given and evaluators. In evaluating the quality of this system, evaluators were first asked to grade the image resolution, brightness of image, and contrast of image in comparison to the resolution of other systems. Evaluation remarks were selected from a four point scale. Four, the highest was labeled as "equivalent" to the original images. Finally, regarding the first three questions, the evaluators were asked to give a grade between one to five for an overall evaluation of the operability and quality of the system.

The third part regarding evaluation was concerning about the practical use of the system. Evaluators were asked to grade the possibility of use as an teaching system, effectiveness in case conferences, and use as a database for clinical research.

Table 1 - Number of SHD images in modality type and clinical period

Image Modality	Primary Hospitalization	Post Primary PTCS	Reconstriction	Post Secondary PTCA
Plain Chest X-ray	1	0	1	0
Rest ECG	1	1	1	2
Exercise loaded ECG	3	3	0	3
UScardiogram		6.0(animated)		
Myocardial Scintigram	2	6	1	6
Coronary angiogram	90(animated)	3	3	6
Left Ventriculogram		50(animated)		

Results of evaluation

These results were obtained using the CCIR method taking the following steps. Each question had a selection of five (or four) grades. Each grade was scored from 1 to 5 (1 to 4) points. Scores given by all twenty-one evaluators were then added and an average point in each section was calculated. As the detail of the result was already reported [3], brief evaluations are as follows.

The operability was graded as "rather good" for RE, EE and LV, and "average" for others. As for image quality in comparison with other systems, resolution was graded "equivalent" for CX, EC, CA, LV, and "rather poor" for US and MS. For the sufficiency of image quality in making diagnoses, EC and LV was graded "possible", CX, US, MS as "almost possible". The comprehensive evaluation regarding the operability and image quality indicated that LV was evaluated as "good", EC, US and CA as "rather good", and "average" for MS.

The results of evaluation for practical use showed that usage in education system and study groups were evaluated as "can be used" and use as clinical research database was evaluated as "can mostly be used."

Experiment 2: SHD image transmission with B-ISDN

Materials and Methods

An preliminary teleconference network among Osaka University Hospital, Kyoto University Hospital and BBCC laboratory were connected via B-ISDN (Figure 2). The same cardiovascular patient file was used in the experiment Since the amount of the SHD image file was so huge that the file was arranged to prefetch. The control signal for retrieving SHD images, pointing data and moving image data and voice data for the interactive video conference were communicated. Physicians at each local site evaluated the quality of image and the operability of the system at telemedical environment.

Results

The total amount of the SHD image file was about 3 GB and it took two hours to transfer all the pictures beforehand. Owing to the prefetch procedure, we could retrieve the picture quickly by means of user friendly interface tool which also controlled the remote system simultaneously. The system also showed pointer

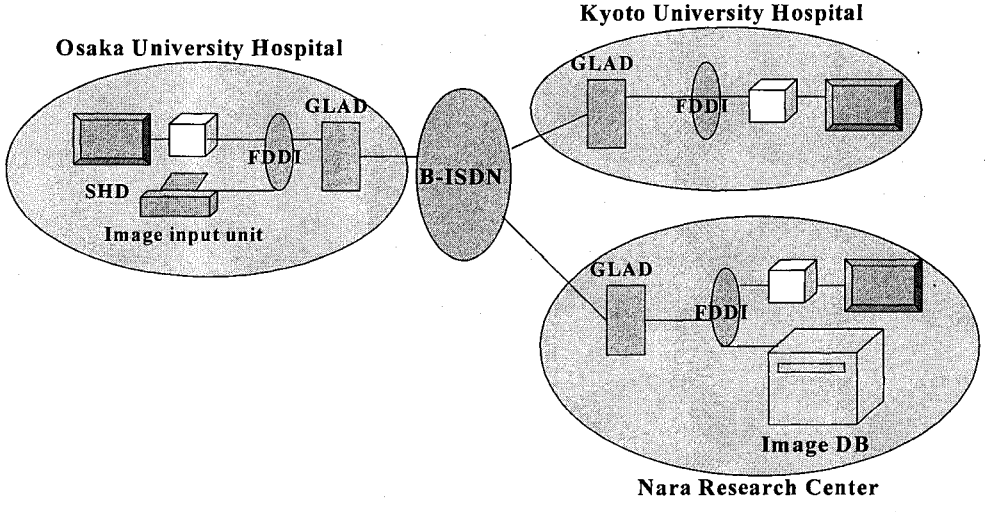

Figure 2 - Network configuration of the Experiment 2

function not only in static picture but also in movie. When we stopped the movie, we could see the same frame in both side. The conference finished without any trouble as though it held in the same room. The successful inter-action demonstrated that super high definition system and B-ISDN based system is enough specification to deal the high quality-oriented telemedicine.

Discussion

The experiment 1 examined whether a SHD image system enabled various types of medical images to be integrated and utilized. A medical image filing system with the SHD format was constructed and all types of images produced during treatment of one example of coronary heart disease case were registered. Furthermore, the system was evaluated focusing on simplicity of search monitoring and image quality. All images are stored in frame memory and waiting time for the image to be displayed is extremely short. The interface which presents seven types of images in a matrix of four phases helps the user have command of the orientation of several images and easily select the desired image. The system is also capable of displaying animated images without losing its high quality. Doctors highly evaluated the system on the above points. When evaluating therapeutic effectiveness for patient care, physicians' need to compare two or more images of different phases on the same screen surfaces. Out of US and other images which are generally poor in quality, two or more selected images with different phases were simultaneously displayed on one screen. Its convenience in observation was graded highly by specialists.

As for resolution, CX, CA, LV received high evaluation and US and MS received low evaluation. Original images of US and MS have poor resolution to begin with and there may be a problem in the images' input methods. On the other hand, original images of CX, CA, LV have high resolution. Therefore, the fact that these were evaluated highly indicate that display of these images are possible by SHD format. Among the images used in this experiment CA required the most detailed distinction, but was evaluated to be sufficient enough for diagnosis on this system image. The above suggests that the SHD image format is sufficient in terms of resolution at least for the types of images handled in this experiment. Furthermore, we have exemplified that the search GUI was extremely effective in this image filing system.

In the Experiment 2, the huge SHD image file was pre-fetched in order to assure the quick response time for the retrieval of the image data. Since the quality of the images and the response time are major factors for success of tele-medicine, we have chosen the preftech. Simultaneous use with video conference system, pointer and the SHD filing system provide the basis for clinical use such as tele-consultation as well as clinical education and training. Although quantitative assessment has not made yet, we have demonstrated the potentiality of the SHD image via B-ISDN transmission for the high quality oriented tele-medicine

Conclusion

Telemedicine and electronic patient record system are one of the major goals in the clinical information system. Telemdicine is widely developed in the field of home care to distance learning. The high quality image oriented tele-medicine has some hurdles to be overcome. As an practical example of telemedice, we have deployed a medical image filing system which utilizes the super high definition image format, and transmission systemwith broadband integrated services for digital network for SHD image based teleconference system. In the experiments, we have illustrated that upon integrating various types of medical images including animated ones, the SHD image structure was sufficient and capable of establishing a useful medical image filing system. In another experiment, we assessed broadband digital network for remote operation of the SHD system and video conference. The prefetch of the SHD image file was considered as one of the solution for telemedicine of high quality images. The advancement of the information processing and communication technology will make telemedicine more comfortable, more effective and less cost.

Acknowledgement

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