醫學影像儲傳系統超音波影像擷像功能之設計
A Design of Ultrasound Image Acquisition for Picture Archiving and Communication System

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摘 要

臺中榮民總醫院自民國 82 年開始建構第一套中文環境、全院規模之醫學影像儲傳系統，並採用高效益且操作方便的個人電腦作為影像處理工作站。本文將探討其超音波影像擷像子系統：我們利用截像卡擷取超音波影像，並與醫院資訊系統上的病患資料做整合，以提供臨床使用。本系統穩定可靠，其影像品質亦可被臨床醫師所接受。

關鍵字：醫學影像儲傳系統，超音波影像擷像系統，截像卡

Abstract

Taichung Veterans General Hospital began to setup its hospital-wide PACS since 1993, and it is the first large-scale PACS in the Chinese environment. The system employs personal computers as its image stations to make it more cost-effective and user friendly. The Ultrasound Image Acquisition System (UIAS), being a part of our PACS, was developed in 1994 to provide the ultrasound images for clinical reference. The images are obtained from the grabbing board and integrated with Chinese demographic data, which are transferred from our hospital information system automatically. The performance of UIAS is stable and reliable, and its image quality is also acceptable by the clinical doctors.

Key words: picture archiving and communication system (PACS), ultrasound image acquisition system (UIAS), image grabbing board

1. Introduction

We started to design the primitive picture archieving and communication system (PACS) in Taichung Veterans General Hospital (TCVGH) in May 1993 [1]. The image capturing and communication system (ICCS) for emergency computed tomography (CT) was the first successful implanted system for clinical application [2]. This system integrates CT scanners, personal computers (PCs), network systems, an IBM API gateway, and an IBM mainframe platform (Fig. 1). The ICCS has been on-line service in the emergency unit (EU) since August 1994, and had received considerable support from the doctors, nurses, and staff of the TCVGH emergency unit with great interests in ICCS, since it allowed physicians in the EU to observe patients' images on image-viewing stations immediately after the patients were scanned by CT. It also made remote consultation possible between EU doctors and radiologists through a hot line. This saved a great deal of time and physical energy used for unnecessary trips between the EU and Department of Radiology during consultation [3,4]. This ICCS is the first successful PACS implemented in Taiwan, and further improvements have been continually added to make it more cost-effective and user-friendly. A Fuji computed radiography (FCR) system was installed in the emergency unit in October 1995, and plain film was implanted in this ICCS after modification of the software and display monitors. A basic structure and test environment for the development of PACS is currently under review, and a large-scale PACS in a Chinese environment has been developed to obtain the images from all the image modalities in the TCVGH (Fig. 2) [5]. Our PACS was connected with the hospital information system [6,7] through which we also successfully transferred the Chinese demographic data into non-Chinese medical imaging devices to print films with patients' Chinese names [8].

The ultrasound image acquisition system (UIAS), being a part of this large-scale PACS, was developed in 1994 after the ICCS was installed in the emergency unit. By extending the ICCS to the inpatient service, we further provide ultrasound images for clinical reference. Ultrasound and CT were the first images chosen for PACS, because these images do not have strict specifications, and hence less storage expense, for the display monitors.

2. Materials

The UIAS was built on the PC local area network (LAN). After the ultrasound images were captured, patient's demographic data were obtained in advance from the hospital information system (HIS) on the IBM main-frame automatically through the system gateway. We used a PDI Tecon image grabbing board (Redmond, WA) to digitize the ultrasound images (Fig. 3), because the ultrasound manufactures could not support any network interface on the old-fashioned ultrasound scanners. However, most of the newly-purchased advance CT, MR, and digital fluoroscopy units are equipped with the standard DICOM interface. We insisted on a PC-based policy to reduce cost, and PCs were used as the image server, main frame gateway, and acquisition and viewing station [9-10]. The main components of the image acquisition station (Fig. 4,5) and the image grabbing board (Fig. 3) are listed in table 1 and table 2, respectively. The image grabbing user interface was built on the Windows 3.1 operation system designed by a local computer company in Taiwan. An Intel Pentium 100 PC was used as the image capture station. It has 64 MB RAM to be used as a buffer for prompting image access, and a 1.0 GB hard disk drive to store the captured images and image processing software. Images were captured from an ultrasound scanner by an ultrasonographer and then stored in the image server and synchronously displayed on a 17-inch Multisync color monitor. The text data outputs, such as patient's demographic data and control procedure data, were displayed on the same monitor.

There was a 200 GB array disk for on-line image storage and retrieval (about 2-month capacity for the ICCS), and a 100-piece CD ROM jukebox was used as an image backup system after the large-scale PACS was set up in 1997. The image viewing stations were installed in the reporting room of the Department of Radiology, clinical department offices, and the inpatient nursing stations.

The UIAS was connected to 2 ultrasound scanners in the inpatient service room - i.e. an ATL Ultramark 9 HDI (Bothell, WA) (Fig. 4) and a Diasonics SPA 1000 (Milpitas, CA); and a ultrasound scanner in EU - i.e. an ALOKA SSD 650 (Tokyo, Japan) (Fig. 5). Hence, there were 3 UIASs in total. Another 3 ultrasound scanners will be installed with UIAS and connected to the network after this study to service the outpatient and physical check-up units.

Table 1: Specifications of the image acquisition station

CPU	Intel Pentium 100
RAM	64 Mbytes
Hard disk	1.0 Gbytes (SCSI hard disk)
VGA card	S3 windows accelerator card
display monitor	17-inch multisync color monitor

Table 2: Specifications of the image grabbing board

input signal	NTSC, PAL, CCIR, RS-170/330/343 VESA2
video frequency	3.75 to 45 MHz
resolution	max. 2048 x 2048 x 8 bits

3. Methods

The TCVGH's PACS was developed in a Chinese environment [4,8]. The image acquisition station of the UIAS was installed near the ultrasound scanner (Fig. 4,5). The ultrasonographer input the sequence number of each requisition order into the image acquisition station; then, the patient's Chinese demographic data were retrieved from the file server (these data had been entered into the hospital information system when the patient first visited the hospital), and then waited for the images to link (Fig. 6).

The images were obtained from the grabbing board connecting to the multi-format camera signal output port, or directly to the ultrasound video signal cable with a T-connector from the ultrasound scanner. To reduce the image acquisition procedure and processing time, we integrated the image grabbing hot key with the exposure foot pedal of the multi-format camera (Fig. 4). The image was captured by the UIAS simultaneously whenever it was frozen and taken by the multi-format camera. Then it was sent to the file server at the Information Center after the captured images were automatically linked with patient's demographic data. The image capture software installed in the UIAS supported the function of adjusting the output image quality to the optimal digital ultrasound image as well.

A local image buffer in the hard disk of each UIAS was designed to avoid the network system shutting down. The gateway alarm system was also developed to check any disorder in the acquisition station and to notify the on-duty engineer immediately when surveillance was not available.

4. Results

The video signal of the images was digitized by the image grabber board at high speed. It took no more than 3 seconds to transfer a frozen image to the server. The transmission was almost finished at the same time as the ultrasonographer made a hard copy by stepping the pedal exposure switch without interrupting the regular examination process. The image quality, with 740 x 580 spatial resolution of the 8-bit gray level, was acceptable for the doctors. This UIAS could be used to connect not only with an ultrasound scanner, but also with other medical imaging modalities without additional networking devices supported by the manufacturers [3,4]. At the viewing station of this PACS, no additional dedicated monitor was needed to display ultrasound, CT, and/or MR images for diagnosis (Fig. 7,8).

The patient's demographic data was catalogued by the sequence number on each request order, to avoid reentry by the sonographer on each examination. Because the image signal was provided by the ultrasound scanner and was optimized by the sonographer, the digitized image quality was good enough for viewing and diagnosis without further adjusting image contrast or brightness.

The combination of hard copy exposure and digital image capture on the same switch that enables image exposure and digitization at the same time provided an efficient working environment and optimal image quality.

Image transfer did not interfere with the examination procedure even in busy periods. The memory size for each ultrasound image was no more than 430 KB, and it took 2 seconds on average to transfer it to the storage system.

This UIAS is user-friendly. Besides the above functions, there were some special features to fit our demands. The patient's demographic data could be retrieved not only by sequence number, but also by record number, name, and date of application. The captured images could be viewed as soon as the examination was finished, and the displayed images could be added or deleted, if they were not satisfactory.

5. Conclusion

After an 8-month trial, the performance of this UIAS was stable and reliable. There was no complaint from the technologists or doctors who were working with or using the captured images. The image quality was quite acceptable for the doctors using a 14-inch high resolution color monitor for diagnosis. In recent years, the American College of Radiology and National Electronics Manufactures Association (ACR-NEMA) has been working hard to set a standard for communicating medical imaging information [11,12]. Many ultrasound manufactures have announced they will provide a DICOM 3 image management and networking function in the near future. At that time, digital ultrasound images might be obtained and transferred to the PACS directly without such a UIAS.

However, for the extension of the current PACS to a large-scale hospital-wide PACS, there are some problems need to be solved. For example, 1. a pre-fetching technique is required to make an average of one 2K X-ray image per second; 2. The image quality of the current monitor is not good enough to display plain X-ray or fluoroscopy images; and 3. a cinematic display for real-time ultrasound images should be considered in the future.

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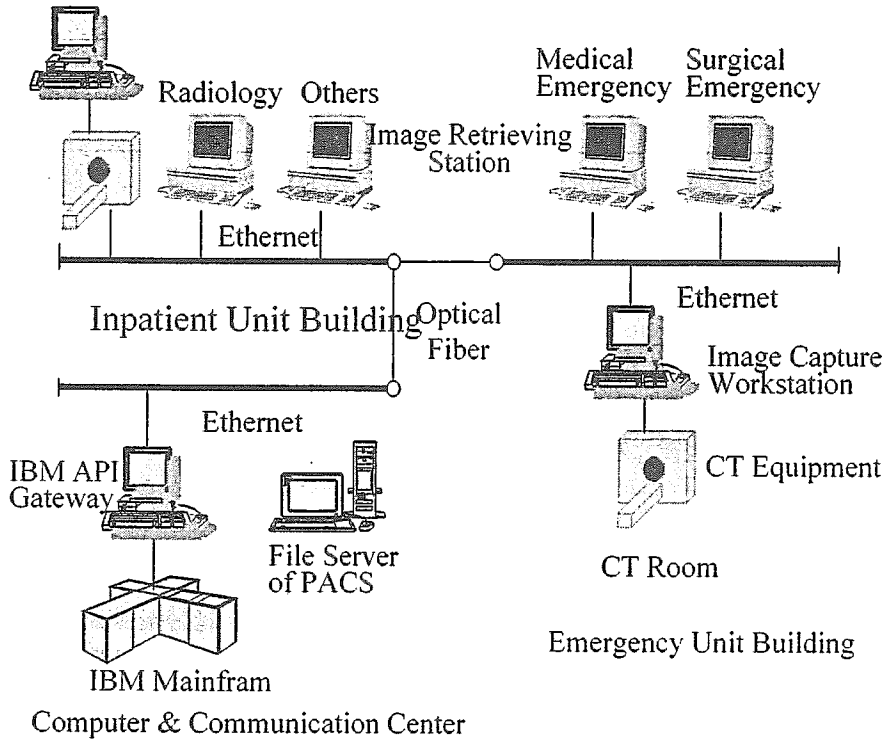

Figure 1: Infrastructure of emergency computed tomography ICCS in TCVGH.

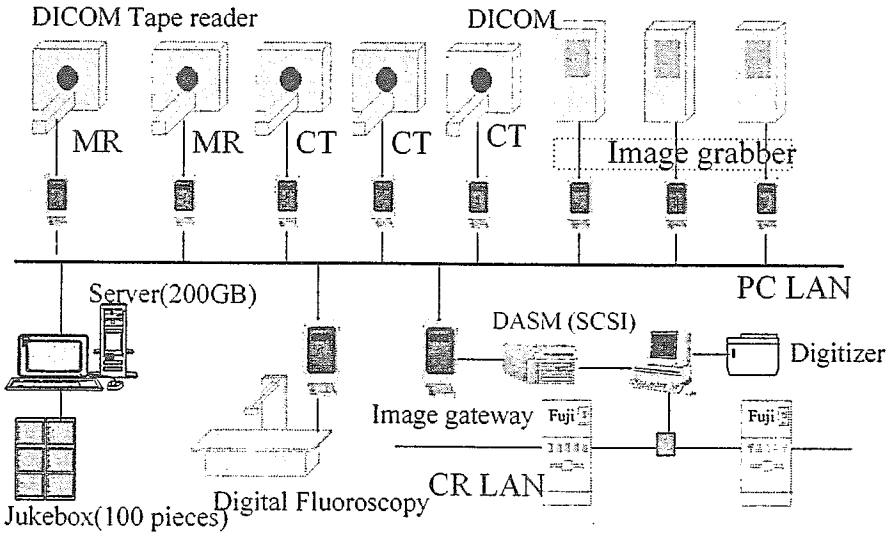

Figure 2: Infrastructure of the networking of the image modalities in the Department of Radiology, TCVGH.

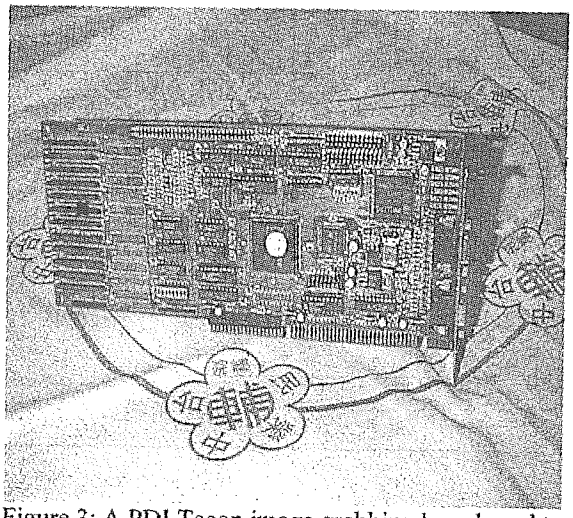

Figure 3: A PDI Tecon image grabbing board used to digitize the ultrasound images.

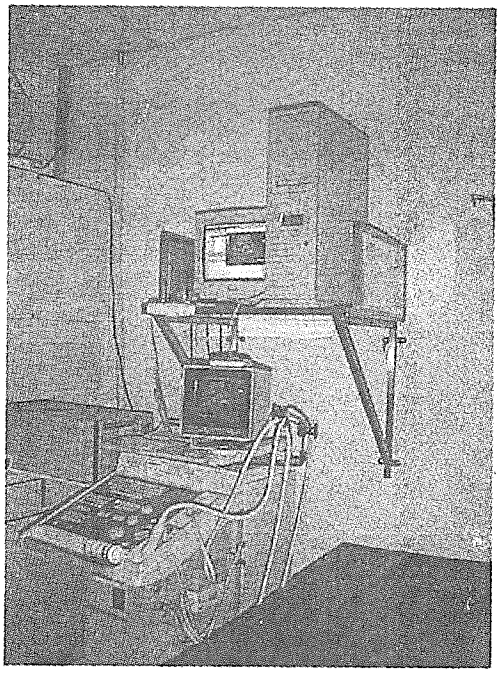

Figure 5: The image acquisition station of the UIAS (arrow) for the emergency ultrasound scanner.

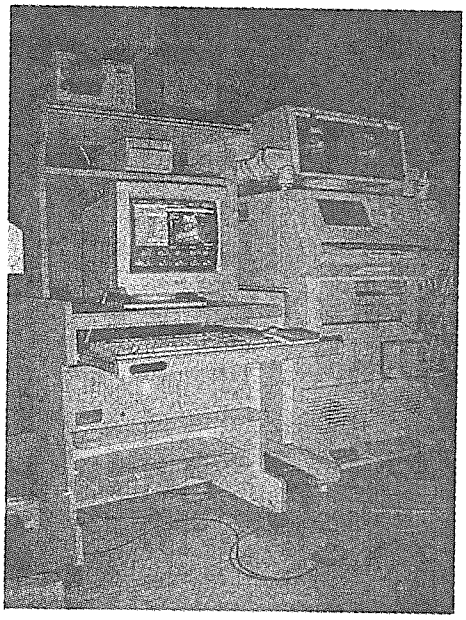

Figure 4: The image acquisition station of the UIAS (arrow) for inpatient ultrasound scanner, with a pedal switching plate (small arrow) for image capturing and multi-format camera exposure.

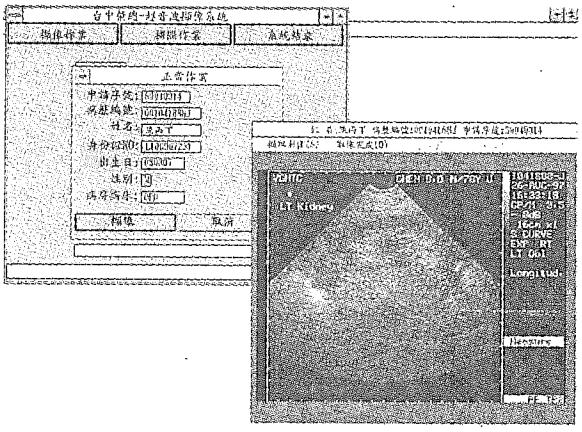

Figure 6: A screen display showing the operation of ultrasound image capturing and its connection to the demographic data.

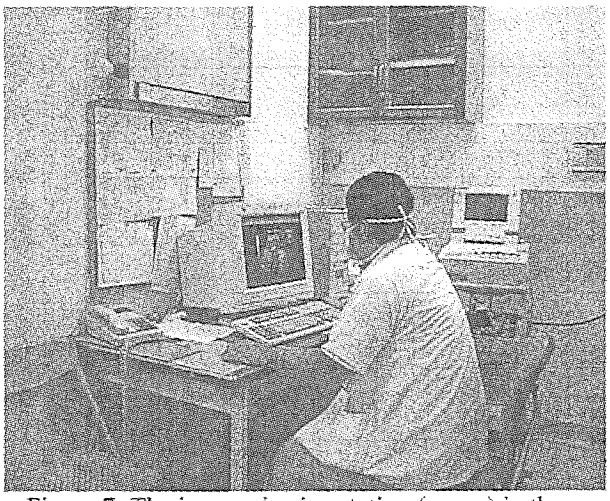

Figure 7: The image viewing station (arrow) in the emergency consultation room.

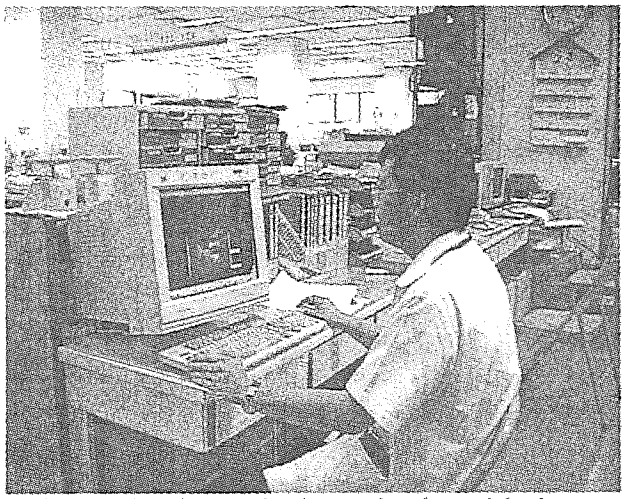

Figure 8: The image viewing station (arrow) in the inpatient nursing station.