行政院國家科學委員會補助專題研究計畫成果報告

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計畫類別：■個別型計畫　　□整合型計畫
計畫編號：NSC　89－2314－B－002－268－M08
執行期間：　89 年　8 月　　1 日至　90 年　7 月　31 日

計畫主持人：蘇誠道
共同主持人：陳世杰、荊宇泰
協同主持人：李文正

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- □赴國外出差或研習心得報告一份
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- □出席國際學術會議心得報告及發表之論文各一份
- □國際合作研究計畫國外研究報告書一份

執行單位：台大醫學院放射線科

中　華　民　國　90 年　10 月　24 日

行政院國家科學委員會專題研究計畫成果報告

以網際網路為基礎的遠距無線緊急影像醫學照會系統

Web-Based Emergent Radiological Consultation – Wireless Teleradiology

計畫編號：NSC 89-2314-B-002-268-M08
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一、中文摘要

整合封包無線電服務（GPRS）採用分封交換技術，大幅提升網路和空中頻道資源的使用效率。本計畫嘗試利用筆記型電腦及 GPRS 手機建立一套無限遠距影像醫學照會系統。本計畫使用具有 13.3 吋螢幕、解析度為 1024x768 的筆記型電腦來接收及看醫學影像，並使用具有 GPRS 功能的手機將筆記型電腦連上網際網路 (Internet)。透過無線傳輸下載放置在我們實驗用主機中的醫學影像。經過傳送的影像品質足夠臨床參考價值。如果善加利用此系統，將能照會未在醫院值班的放射線科醫師。本研究證實利用現有的技術可以建立一套實際可行的遠距無線緊急影像醫學照會系統。

關鍵詞：專題計畫、報告格式、國科會

Abstract

The General Packet Radio Service (GPRS) is a new nonvoice service that allows information to be sent and received across a mobile telephone network. The purpose of this study is to build a wireless teleradiology consultation system based on a notebook computer and a cellular phone using GPRS technology. A notebook computer equipped with a 13.3" TFT LCD monitor and 1024x768 XGA resolution digital display was used for receiving and viewing images. A GPRS terminal was used as a wireless modem to connect the notebook computer to the Internet. Radiographic images were downloaded from our web server via wireless Internet transmission. The transmitted images were acceptable for consultation and may save hospital visits by radiologists. This study demonstrated that a useful remote teleradiology consultation link could be built with readily available technology.

Keywords: Teleradiology, GPRS

二、Introdoction

Teleradiology is the electronic transmission of radiological images from one location to another for the purposes of interpretation and/or consultation. Users in different locations can view images simultaneously. More timely interpretation and consultation can be achieved with the use of teleradiology system. Radiological consultation can also be done in medical facilities without on-site radiological support.

However, current development in teleradiology required a fixed line for data transmission. Specialized software and hardware may be necessary for sending and viewing the images. Consultation cannot be made when the specialist do not have access to the teleradiology terminals.

Recent development of digital wireless networks, such as GSM (Global System for Mobile communication) makes it possible to transmit both voice and data to a portable terminal. The General Packet Radio Service (GPRS) is a new nonvoice service that allows information to be sent and received across a mobile telephone network more efficiently. With GPRS, the information is spilt into separate “packets” before being transmitted and reassembled at the receiving end. The theoretical maximum speed is 171.2 kilobits per second (kbps) using all eight timeslots. GPRS fully enables mobile Internet functionality by allowing internetworking between the existing Internet and the new GPRS network. Any service that is used over fixed Internet today will be as available over the mobile network.

The purpose of this study is to build a wireless teleradiology consultation system based on a notebook computer and a GSM cellular phone using GPRS technology.

三、Materials and Methods

Radiographic images including plain film, CT and MRI were captured using a digital camera (CoolPix 990, Nikon, Japan). This camera can digitized radiographic images into three different resolution settings, VGA (640 x 480) and XGA (1024 x 768) up to the full size of 2048 x 1536. All of these image sizes also offer three JPEG (Joint Photographers Expert Group) quality levels (Fine, Normal and Basic) plus an uncompressed TIFF (Tagged Image File Format) mode (Hi) at 2048 x 1536.

Selected images were uploaded into an Internet FTP server in our radiology department for further evaluation.

The cellular phone Timeport P7389i (Motorola, US) was selected for trial. This device is the only cellular phone with GPRS capability in Taiwan at present. Data transmission with the computer can be done through built-in infrared port at the rate of 14.4 kbps. A software driver is required to be loaded into computer to properly interface the computer with the mobile phone. KGTelecom, Inc. provides GPRS connection with the Internet.

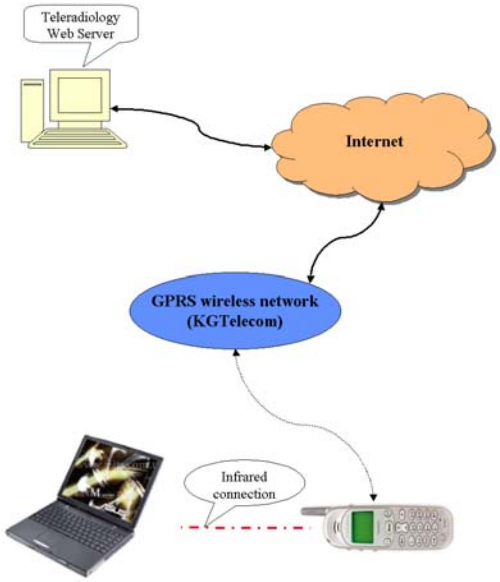

Fig 1 The technical configuration of the wireless image consultation chain.

A notebook computer equipped with a 13.3" TFT LCD monitor and 1024x768 XGA resolution digital display was used for receiving and viewing images (M8300, ASUS, Taiwan]. The configuration of the wireless teleradiology consultation system is shown in Figure 1.

Windows 98 (Microsoft Corp., Seattle, WA, USA) was used as the operating system. Images were viewed with a shareware program (ACDsee, ACD Systems, USA).

四、Results

A preliminary test was performed to assess the overall performance of this system. Setting up the communication for the mobile phone and notebook computer requires about 20 seconds. It takes about 13 minutes to download a test file with the size of one megabyte into notebook computer using GPRS connection. The average transmission rate is about 10kps. KGTelecom, Inc. charges network usage by the amount of data transmitted. It costs NTD $0.05 per 200 bytes.

Table 1. Estimated file size, transmission rate and cost for one image in different camera settings.

Resolution	JPEG quality	Compression ratio	File size (Bytes)	Transmission time	Cost (NTD)
2048X1536	Hi (TIFF)	1:1	9326K	~125 min	$2387
2048X1536	Fine	1:4	~820K	~11 min	~$200
2048X1536	Normal	1:8	~550K	~7 min	~$140
2048X1536	Basic	1:16	~310K	~4 min	~$80
1024X768	Fine	1:4	~220K	~3 min	~$60
1024X768	Normal	1:8	~140K	~2 min	~$35
1024X768	Basic	1:16	~90K	~1 min 10 sec	~$23
640X480	Fine	1:4	~100K	~1 min 20 sec	~$25
640X480	Normal	1:8	~60K	~50 sec	~$15
640X480	Basic	1:16	~50K	~40 sec	~$13

The relationship of file size, expected transmission time and cost versus camera settings is summarized in table 1. Because of the limited transmission bandwidth of current GPRS mobile phone, the resolution setting of 2048X1536 is not suitable for wireless application. The comparison with image quality and camera setting is shown in Figure 2. A camera setting of 640X480 resolution and basic JPEG compression quality is acceptable for clinical consultation. With this setting, we can obtain one image within one minute with relative low cost. Thus wireless teleradiology system may be useful in clinical practice.

五、Discussion

Teleradiology has long been used for remote consultation [1]. Yamamoto first reported the idea of using wireless communication and portable computers for radiological consultation [2]. In a recent study, Yamamoto demonstrated a prototype of wireless CT teleradiology for neurosurgical consultation in the united state using CDPD (cellular digital packet data) transmission protocol [3]. The theoretical data transmission speed for CDPD in the US is 19.2 kbps. The actual bandwidth in Yamamoto’s study is about 5~8 kbps.

Reponen J, et al. in Finland tested a prototype wireless system using a GSM telephone, PCMCIA digital cellular data card and a notebook computer for emergent CT consultation [4]. Transmission time via GSM for a single CT image was 1 min. The transmitted images were acceptable for final diagnosis in 72% of the cases and the wireless link saved a hospital visit by the senior radiologist in 24% of the cases.

The data transmission speed for current GSM system in Taiwan is only 9.6 kbps. GPRS offers a major improvement in spectrum efficiency, capability and functionality. The theoretical maximum speed for GPRS is 171.2 kbps, which is faster than both CDPD and current GSM network. Achieving the maximum speed of 171.2 kbps would require a single user taking over all eight timeslots without any error protection. Because there are only limited radio resources that can be allocated to all users, it is unlikely that a network operator will allow all timeslots to be used by a single user. The Motorola Timport P7389i only support one time slot for upload and two time slots for download, which also severely limited the bandwidth. A bandwidth of about 5~10 kbps is obtained in this study.

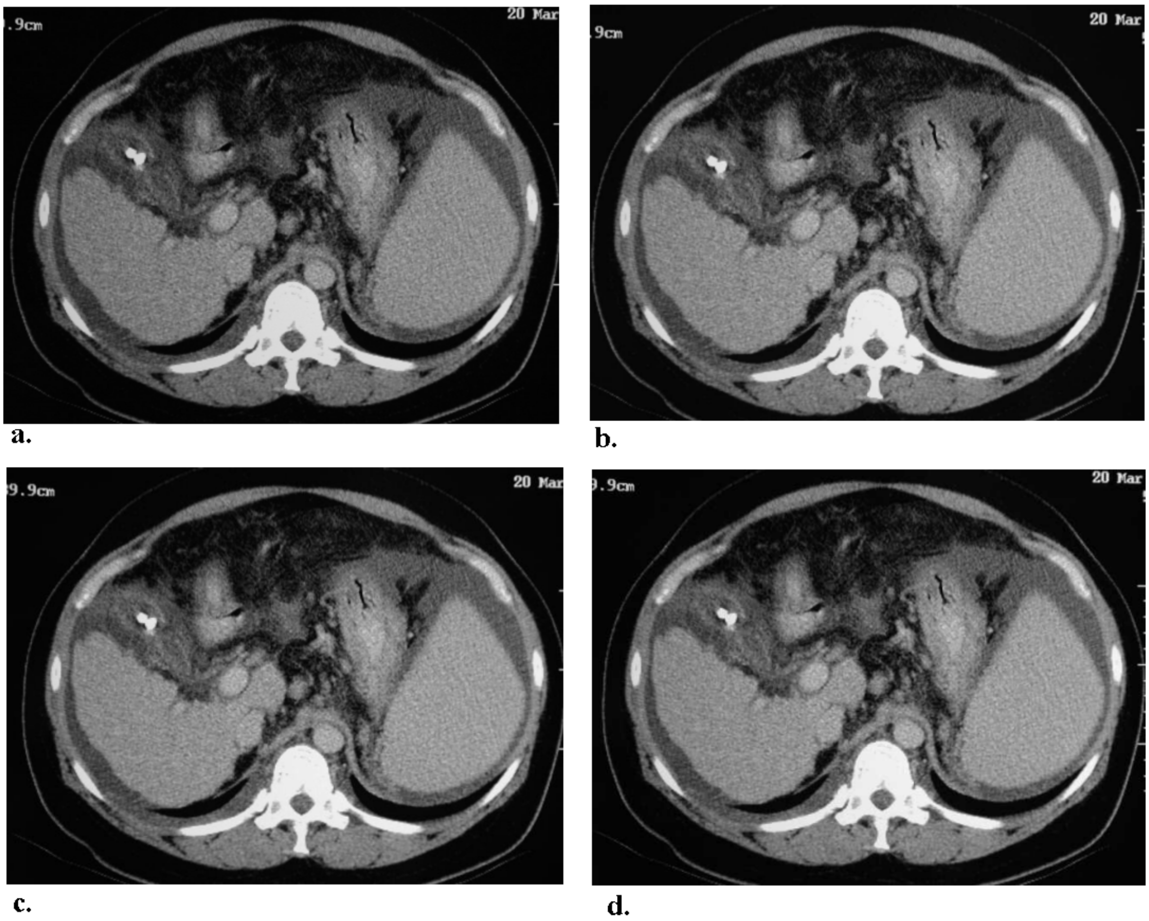

Fig 2. Comparison of image quality in different camera settings. **(a)** 1024 X 768 (XGA) with normal JPEG quality factor. **(b)** 1024 X 728 with basic JPEG quality factor. **(c)** 640 X 480 (VGA) with normal JPEG quality factor. **(d)** 640 X 480 with basic JPEG quality factor.

In 2002, GPRS networks are expected to allow speeds of 57.6 kbps. Global data roaming using GPRS is operational. Third generation mobile phone technology UMTS (Universal Mobile Telephone System) with wireless data rates up to 2 Mbps is expected to become commercially available in 2003.

To reduce the required bandwidth for radiological consultation, image compression is required. It has been shows that a JPEG compression ratio of 1:10 to 1:15 dose not affects the diagnostic quality of radiological images [5].

In summary, GPRS facilitates instant Internet connection whereby information can be sent or received immediately. The transmitted images were acceptable for diagnosis and may save hospital visits by radiologists. A useful remote teleradiology consultation link can be built with readily available technology.

六、參考文獻

1. Jutras A. Teleroentgen diagnosis by means of video-tape recording. AJR 1959;82:1099-1102.Yamamoto LG. Wireless teleradiology and fax using cellular phones and notebook PCs for instant access to consultants. Am J Emerg Med 1995;13:184-197.
3. Yamamoto LG, Williams DR. A demonstration of instant pocket wireless CT teleradiology to facilitate stat neurosurgical consultation and future telemedicine implications. Am J Emerg Med 2000;18:423-416.
4. Reponen J, et al. Digital wireless radiology consultations with a portable computer. J Telemedicine and Telecare 1998;4:201-205.

5. MacMahon H, et al. Data compression: effect on diagnostic accuracy in digital chest radiography. Radiology 1991;178:175-179.