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研究室で撮影した本人のスナップ写真、及び発表論文のコピーを添付

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研究テーマ Evaluation of a PC-Based Video-Teleconference System on Chest Radiographs

2．本年度の研究業績

(1) 学会・研究会等においての口頭発表 ㊒・無 (学会名・内容)

1. 第37回日本エム・イ学会 市販テレビ会議システムについての画像評価-肺癌症例を用いての検討-
2. MedInfo98 Telemedicine Videoconferencing with Still and Moving Images using ISDN64
3. 日本エム・イ学会東海支部学術大会 胸部X線画像に関する市販遠隔テレビ会議システムの評価
4. 第18回日本医療情報学連合大会 市販テレビ会議システムについての画像評価

(2) 学会誌等に発表した論文 ㊒・無 (雑誌名・論文名)

Journal of the Telemedicine and Telecare(掲載予定)
Evaluation of a PC-Based Video-Teleconference System on Chest Radiographs

3．今後の研究計画

遠隔医療効率向上のために、医用静止画像及び動画像の伝送、画質の改善を目的として、下記のa, b, cの研究を予定している。

a. 静止画像

比較的快適な環境でかなり高い信頼性をもって診断支援を可能とするための画像のデジタル化条件、デジタル画像の表示条件等を探究したい。また静止画像のサイズは伝送時間と直線関係がある。パソコンテレビ会議システムを用い場合、経済性と使い勝手を考慮して、パソコンテレビ会議システムにどのくらい解像度の静止画像が診断支援として的確かつ、経済性が満足であるかを研究したい。

b. 動画像

ISDN64電話回線３本で用いて、UCG、CAGのビデオ画像伝送を行いたい。また画像再生スピードを変えて、その画像を評価したい。

c. さらにケーブルテレビネットワークを用いて、医用動画像及び静止画像の伝送を行いたい。

d. 中国における都市部及び農村部における遠隔医療の必要性の調査を行う。

４．研究指導者の意見

徐君は名古屋大学医学部医療情報部大学院生として、病院管理学、心電図自動解析、医療情報システム、特に遠隔医療システムの研究をし、当部はその指導的役割を果たしてきた。徐君は中国上海第二医科大学卒業した医師であり、中国における医療状況を熟知し、遠隔医療必要性を感じている大学院生である。従って、当部での遠隔医療研究を熱心に行い、肺がん診断についてのテレビ会議システムの研究に高い成果を上げ、さらにシステム発展に努力している。この技術と知識を中国における、医療システムの改善に応用したいとの希望が大である。

研究指導者氏名　山内一信　印

５．研究報告

別紙形式を参考に、報告本文4000字以上で報告して下さい（枚数自由・ワープロ使用）

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研究成果の発表予定がある場合は発表原稿・抄録集等を添付して下さい。

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Evaluation of a PC-Based Video-Teleconference System on Chest Radiographs

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Summary

Chest radiographs of 50 patients, including 25 with lung cancer were digitized at 100 dpi resolution and saved in the JPEG format at a low compression rate. Four respiratory specialists observed these images on a video-teleconference system display with 800×600 pixels resolution. After one month, they observed original chest radiographs. ROC analysis was performed of the answers based on a 5-point confidence scale. The observer-specific Az index values for the video-teleconference system ranged from 0.803 to 0.944, and the corresponding Az values for the conventional radiographs from 0.926 to 0.957. No differences were found between the video-teleconference system image and original images, showing that a video-teleconference system will be useful as a supplement to a diagnosis of chest X-ray films.

Introduction

Most of the many clinics in Japan are staffed by general practitioners. These clinics often need the real-time input of medical specialists such as radiologists, pathologists and so on for the improvement of diagnosis and treatment. Until quite recently, it was difficult to obtain this kind of specialized help. The real-time transmission of medical images to medical specialists and discussions with them have long been sought by medical practitioners. Now the rapid development of digital radiograph systems, digital data networks and video-teleconference softwares has put such help within their reach. Medical specialists can also offer real-time radiological support and other assistance to medical practitioners using this new equipment. Such collaboration may lead to improved patient care and avoidance of unnecessary patient transfers.

The world's first medical-image transmission system was developed some thirty years ago, using TV cameras and TV signal transmission[1]. In early trials, the image quality was not good enough, and the diagnostic accuracy of the transferred images was lower than expected. Now the transmission of medical images is possible via any of 6 modes: (1) Internet, (2) Integrated Service Digital Network (ISDN) narrow and broad band, (3) public telephone lines, (4) cable TV networks, (5) communication satellites and (6) mobile phones[2]. The rapid development of modern communication technology provides medical diagnosis and treatment with new opportunities[3]. Now, on video-teleconference systems are available at low cost to small and outlying hospitals.

Considering its cost-effectiveness and ease of operation, we decided on a low-cost video-teleconference system which is able to transfer both still images and moving medical images through ISDN 64, and to allow collaboration with those using personal computers. This system is extremely versatile and very easy to operate.

Although a large number of studies have been done on the diagnostic performance of digitized soft-copy images on a CRT display, most of them dealt with very expensive, specially equipped high-performance workstations. Therefore, we intend to apply the PC-based low-cost video-teleconference system to the teleradiology system, especially in this study, and we have evaluated this video-teleconference system for the detection and diagnosis of lung cancer on chest radiographs, using of receiver operating characteristic (ROC) analysis.

Methods

Video-Teleconference System

The video-teleconference system used in this study was composed of personal computers (OKI, if station 5133), a scanner (EPSON GT-8500 scanner), and speakerphone. The PC-based video-teleconference software, PictureTelPCSlive50, was installed, and it was connected to the ISDN network at 128 kbit/s. The personal computer systems used an IBM compatible one with 32 MB RAM, 1 GB hard disk, and a 17-inch color monitor, with a resolution of 800×600 pixels, and was able to display 16,700 different of colors.

Case Selection

Fifty chest radiographs were selected for the study by an experienced physician who did not participate in the observer performance studies; 25 of these radiographs featured lung cancers of varying subtlety, including metastatic lung cancers, while the other 25 were either normal or had some lesions other than lung cancer. These radiographs were obtained from patients hospitalized from1995 to 1996 in the First Department of the Internal Medicine or Thoracic Surgery of the Nagoya University Hospital.

Digitization and Display of Chest Radiographs

The chest radiographs were separated into the left and right sides, and were digitized and stored separately on the hard disk. This was because the maximum size up to which the scanner can scan the image for digitization was 210×297 mm. We used a resolution of 100 dpi to digitize the complete chest radiograph in order to adapt the image for display on a 17-inch cathode-ray tube (CRT) monitor (Fig 1). When the radiographs were digitized, a specialist with no involvement in the present study controlled image contrast, brightness etc. to keep the image quality at its maximum. Then, the digitized images were compressed in the JPEG format at a low compression rate, and saved on the hard disk. The average size of the stored image was 55 Kbytes, and its range was 6-86 Kbytes.

The digitized chest radiographs were transferred by the application share mode (a function of video-teleconference software) to the monitor for image reading and analysis (Fig 2). Between the initially digitized and transferred images, there were no significant differences in image quality[4]. In according to this, separate two location observe the same quality image are thought.

Observer Performance Studies

Four respiratory specialists, each with more than 10 years of clinical experience, participated in the observer performance studies. For each observer, we previewed the image reading test composed of two reading sessions; in one session, the hard-copy screen-film images were interpreted using a conventional view box, and in the other session, the soft-copy images on the 17-inch CRT monitor in video-teleconference system were interpreted. In the latter session, the observers were permitted to use the various functions with which the system is. There was a one-month interval between the two image reading sessions.

Although the observers were informed that the chest images might contain lung cancer, they were not informed of the purpose of this study, and were blind to individual clinical information. They were asked to indicate the presence or absence of lung cancer on the following discrete five-point scale: 1 = definitely not present, 2 = probably not present, 3 = cannot be decided, 4 = probably present, 5 = definitely present. Reading time was not limited.

To evaluate the observers' performance, the binormal ROC curves were estimated for each observer by means of the maximum likelihood method. The area under the ROC curve (A_Z) was used as an index of performance. A_Z together with the slope and the intercept parameters of the binormal ROC curve when plotted on normal deviate axes were calculated for each estimated curve. The statistical significance of the difference between each pair of reading conditions was analyzed by applying a Student *t* test for paired data to A_Z values. Here, a value of $P < 0.05$ was taken to be significant. For each reading session, the overall performance of the observers as a group was summarized with a pooled ROC curve obtained by averaging the slope and intercept parameters of individual observer's ROC curves.

Results

The reading time of the chest radiography on the CRT display and light box was less than 30 seconds for each case. Fig 3 shows the four observer-averaged ROC curves obtained in the two reading sessions. The observer-specific A_Z index values for the video-teleconference system ranged from 0.803 to 0.944, and the corresponding A_Z values for the conventional radiographs were from 0.926 to 0.957 (Table 1). The performance for the video-teleconference system from 3 observers was lower than that for the conventional radiographs, but the opposite for the remaining observer. However there were no clearly significant differences between the video-teleconference system and the conventional radiographs ($P = 0.07$). Every observer was satisfied with the use of the PC-based video-conference system.

Discussion

In any teleradiology system, the quality of the soft-copy image on the CRT monitor is important. This image quality is determined by: the spatial and contrast resolution of the display device; background luminance level and luminance range of the display system; brightness uniformity; extraneous light in the reading room; displayed field size; viewing distance; image motion and monitor flickering; signal-to-noise ratio of the displayed image; magnification functions; and the user interface[5].

The higher the resolution of the image on the CRT display is, the better the radiologists diagnostic performance will be. Slasky et al. reported that the difference between a high-resolution workstation CRT display image and a conventional film images was often small[6]. However, it is known that the radiologists diagnostic performance is not improved by improvements in the resolution power when the resolution is higher than 0.1mm pixel size (254 dpi)[7]. It is important in displaying radiography film that the minimum requirements be set at a 0.2 mm sampling pitch (127 dpi), 10 bit density sampling resolution for digitizing, and 1000×1000 resolution degree, and 8 bit resolution in the density direction. However, the above-mentioned factors[5] make it difficult to define the exact requirements for image quality, Physicians who practice telemedicine should be aware of these differences in image quality and adapt their practice accordingly. A physician is as liable for a diagnosis based on transmitted X-rays as he or she is for one by normal X-rays. Moreover, the complete chest image digitized at 127 dpi cannot be shown on a 800×600 pixels CRT display of the kind usually used. Therefore, it is necessary to select the spatial resolution appropriate for the PC-based video-teleconference system.

In a system built around a personal computer, the resolution of most CRT monitors is 800×600 or 1024×768 pixels. We scanned conventional radiographs with a resolution of 100 dpi, and displayed them on the 800×600 CRT display in a PC-based system, and found that the quality of these soft-copy images was slight inferior to that of conventional radiographs. In fact, the performance of three observers of the video-teleconference system was lower than that when judging conventional radiographs, although there was no statistically significant difference between the CRT images and the conventional film reading session.

System based on the personal computer in this study is not expensive, so it will be readily affordable by clinic offices of general physicians or in the outlying hospitals. Further more, it is reported that interactive, low-resolution telemedicine is valuable for consultations between generalists and subspecialists[8]. In the present study, every observer was able to indicate the site of the lung cancers, and to describe their sizes and shapes. All observers read each image within 30 seconds.

In telemedicine, the time for image-file transmission should also be considered. The transmission of high-resolution digital images required a longer time compared with low-resolution images. As the time of a transmission image is important for collaboration, the shorter the time needed for image-file transmission the better. In our previous study, we found a close relationship between transmission time and the size of digital images[9], and that the time for a transmission image of 800×600 pixels was 110 seconds by using ISDN 64. If the chest radiographs are digitized at 100 dpi and then compressed in JPEG format, the range of file size was from 6 to 86 Kbytes, with an average size of 55 Kbytes. Even the maximum file (86 Kbytes) was transferred within 43 seconds, a tolerable time for a PC-based video-conference system. Thus, in terms of diagnostic performance and transmission time, the PC-based video-teleconference system will be acceptable for the consultation between generalists and subspecialists.

Conclusions

We evaluated the diagnostic performance of a PC-based video-teleconference system in the detection diagnosis of lung cancer on chest radiography. There was no significant difference between the results of a PC-based video-teleconference system and the conventional radiographs, suggesting that the diagnostic performance and transmission time in a PC-based video-teleconference system would be acceptable for consultation between generalists and subspecialists.

Acknowledgements

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Captions for Illustrations

Fig 1

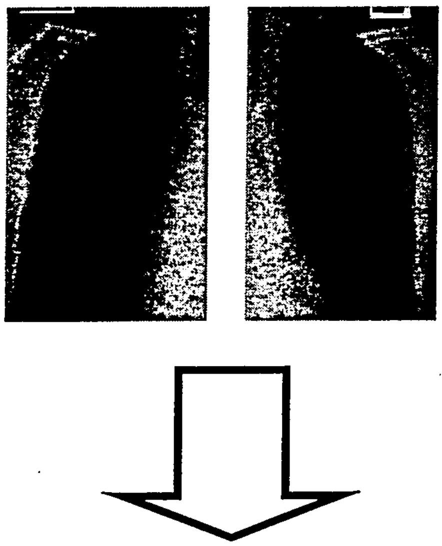
The present video-conference system, and presentation of chest radiographs on the CRT display.

Fig 2

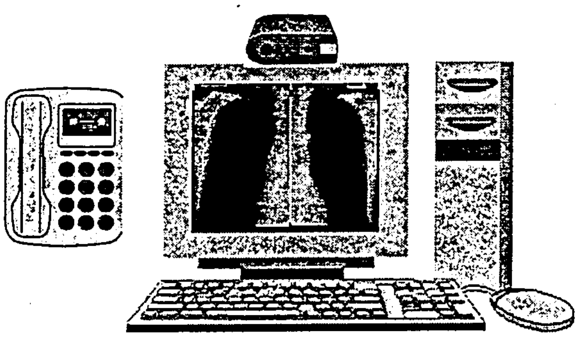
The observer was reading the soft-copy images on the 17-inch CRT monitor in video-teleconference system.

Fig 3

The combined ROC curves of the CRT display image and the conventional film.



The chest radiographs were separately scanned into the computer in the left and right side by side at 100 dpi



The digitized left and right chest images were displayed side by side on the 17-inch CRT display

The present video-teleconference system:

1. **OKI If station 5133 PC**
2. **EPSON GT – 8500 scanner**
3. **The speakerphone**
4. **The CCD camera**

Fig 1 The present video-conference system, and presentation of chest radiographs on the CRT display.

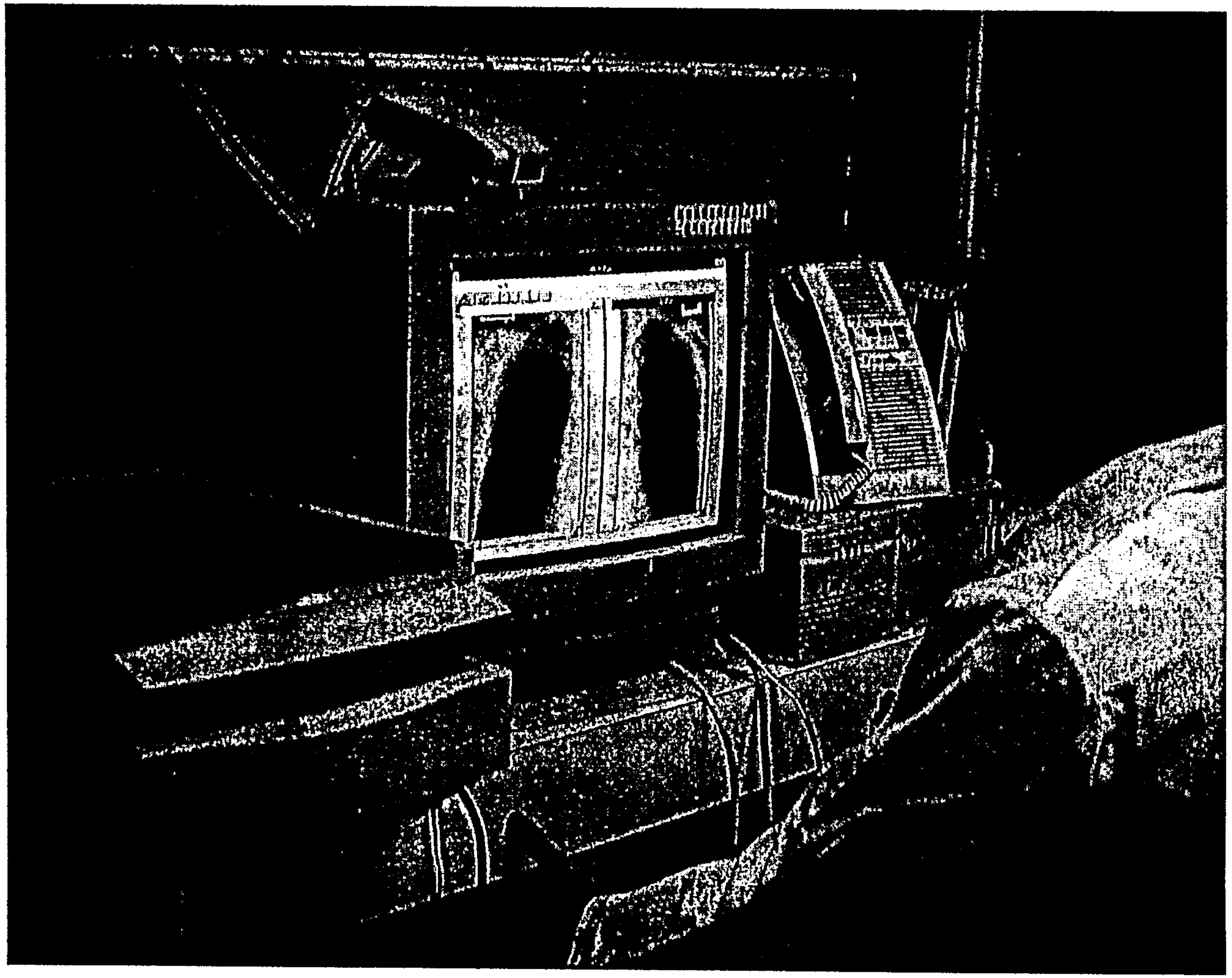


Fig 2 The observer was reading the soft-copy images on the 17-inch CRT monitor in video-teleconference system.

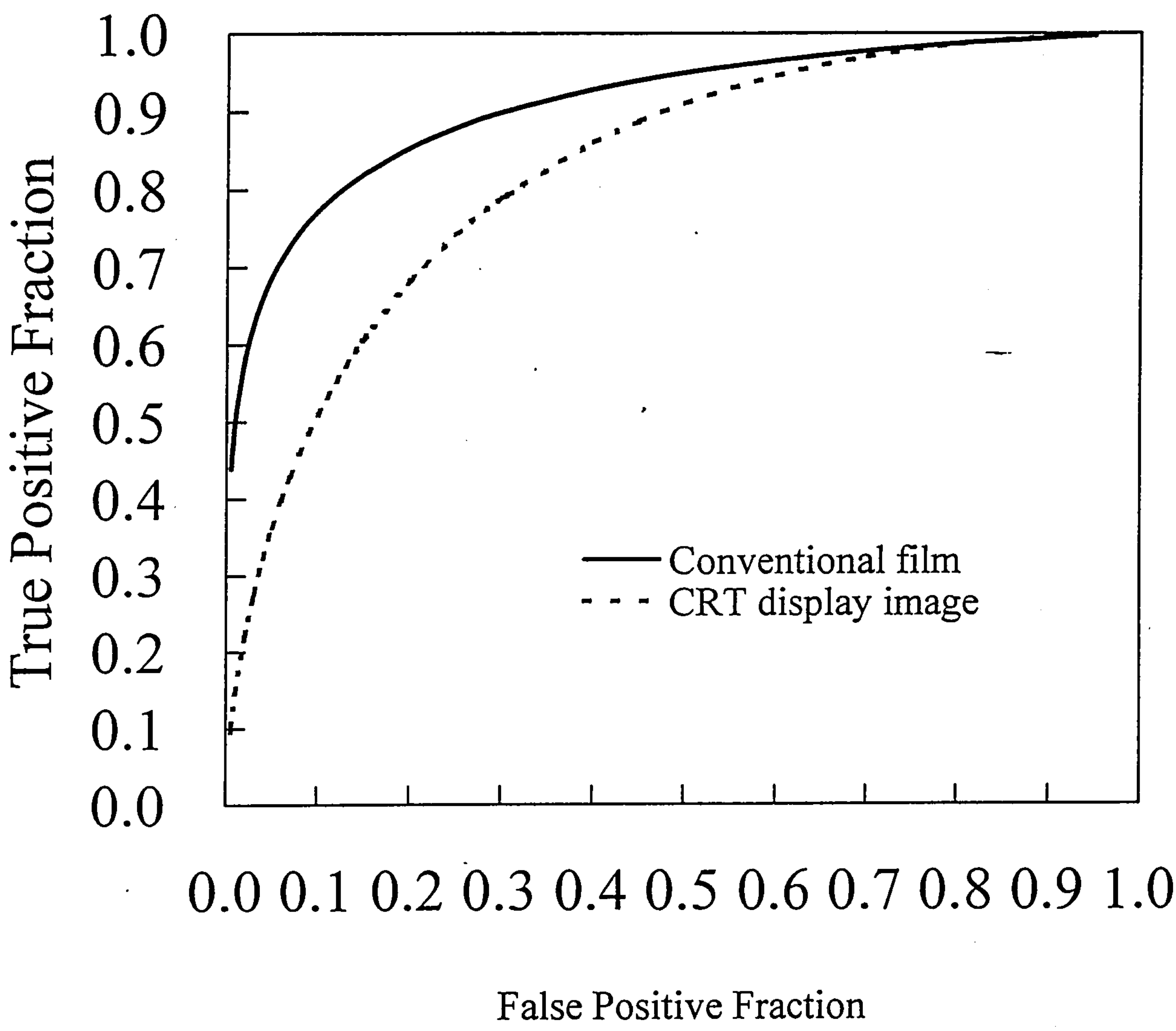


Fig 3 The combined ROC curves of the CRT display image and the conventional film

Table 1 Area under the ROC curve derived from the analysis of lung cancer by 4 specialist

	Conventional film	Images on CRT display
Observer 1	0.9255 ± 0.0427	0.8030 ± 0.0641
Observer 2	0.9414 ± 0.0357	0.9444 ± 0.0449
Observer 3	0.9343 ± 0.0415	0.8446 ± 0.0618
Observer 4	0.9570 ± 0.0289	0.8010 ± 0.0648