On Realization Medical Imaging Viewer based on DICOM Standard

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Abstract - PACS is an integrated communication network system which is consists of image acquisition devices, storage archiving units, display stations, computer processors, and database management systems. In medical industry, they have been introduced the medical equipments through PACS systems based on the DICOM standard. In this paper, we have reviewed the performance of JPEG and JPEG2000 used as medical image compression and realized the transmission mode on DICOM standard.

Keywords: PACS, DICOM, JPEG, JPEG2000.

1 Introduction

Picture Archiving and Communication Systems (PACS) departs at step that exchange pictures in hospital through communication network owing in brilliant IT development currently. And its technology has been developed in direction that achieves high functions such as remote diagnosis, 3D stereopsis, and functions of moving picture. PACS is a concept perceived in the early 1980s by the radiology community as a future method of practicing radiology. PACS consists of image acquisition devices, storage archiving units, display stations, computer processors, and database management systems. These components are integrated by a communications network system.

In the image compression, JPEG and JPEG2000 are international standard for lossy, lossless, and nearly lossless compression of continuous-tone still image and is the primary compression technology supported in DICOM. In addition, the image transmission is highly considerable for time and efforts of doctors. Based on JPEG standard, there are typical transmission modes which are sequential and progressive. To explore the transmission performance, the transmitted images were decoded and evaluated in terms of peak signal-to-noise ratio (PSNR).

Interest of latest PACS trend is focusing on remote image diagnostic (teleradiology). Patients wait for hours before hearing physician's results from an MRI, CT or ultrasound test because radiologists are not always in residence to view the data. In order to avoid the inconvenience, the new web-based teleradiography system uses network access and allows images from an MRI, CT or ultrasound test to be viewed by a radiologist from another location as long as there is Internet access [1].

Figure 1 shows the overall full PACS system [2]. It describes that PACS captures X-ray, MR, CT and ultrasound images in a digital format and allows these images to be accessed by physicians via computer for immediate diagnosis. PACS consists of image acquisition devices, storage archiving units, display stations, computer processors, and database management systems. These components are integrated by a communication network system. In addition, the PACS realize the communication based on medical image standard which is a DICOM [3]. In general, DICOM specifies that image information represents an Information Object which is defined in Information Object Definition (IOD), and commanding word is relating to Service Class which is defined in DICOM Message Service Element (DIMSE). IOD specify information for medical image where is corresponding to patient's name, examination type, date and it looks like a format dealing with standardized medical information. With these items, if there are real values on each item, it is called Information Object instance [4].

In this paper, in what follows we will first introduce the concept of the realization for image compression and transmission on medical application are presented. In section 3, experimental results are presented and we conclude in Section 4 with discussions and future work.

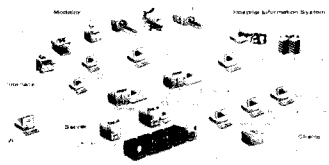


Figure 1. A schematic for full PACS.

2 Principle of Image Communications

A medical image requires very high quality unlike an image that is used usually. For example, a chest image that is acquired in CR amounts one image size to 7 ~ 8 MB. Like this, when an image acquiring from various equipments is deciphered by interpretation doctor or stores for conservation to long term storage device etc., it should be compressed in extent that do not influence on next interpretation. Therefore, compression and transmission technology should be considered in PACS.

In DICOM standard, the compression technology specify in lossy or lossless methods such as JPEG, run-length encoding, or JPEG-LS. Currently, JPEG2000 in [5] is added in new standard of DICOM image compression. Another considerable point of PACS could be a transmission of scanned image. Unlike the high transmission environment, it is necessary to consider the transmission component such as bit rate or number of scans. In the following subsection, we introduce the basic technology in terms of bit-rate compression performance and transmission schemes.

2.1 Image compression

The JPEG [6][7] standard for image compression is comprised of a toolkit that has three distinct components: baseline lossy, extended lossy, and lossless. Baseline lossy JPEG, the most widely implemented of the three, utilizes the discrete cosine transform (DCT) to decompose an image into sets of spatial frequency coefficients.

JPEG2000 [8][9] characteristic can embody lossy and lossless compression at the same time in one encoded bit stream, and is shown quality of more excellently eminent image than existent JPEG in high compressibility. In addition, JPEG2000 in a sense of ROI (region of interest) coding [10] is possible, and can be applied to technique of watermarking, labeling etc. for security of image. Also, it has various bit-depth to 1bit through 16bits in compression and supports compression of motion image. The strength of JPEG2000 is that it is capable of tiling unlike JPEG. Since JPEG processes 8x8 subimage tiling and DCT (discrete cosine transform), it is tended to block-shape artifact in high compression ratio. On the other hand, JPEG2000 is advantage that can enhance quality of image or reduce use of memory controlling by tiling of image random. Also, DCT in JPEG changes an image to characteristic of frequency, but JPEG2000 is scalable to an image by scale or resolution because DWT (discrete wavelet transform) [11].

2.2 Image transmission

The aim of this section is to realize the visual data transmission under the medical environment with JPEG transmission schemes. The data transmission in medical applications, they still requested the lossless data to ensure the detection of patient's disease. Compression methods for incremental transmission enable progressive transmission of the whole image starting with low-resolution, and then gradually increasing the resolution. This capability is important when a user does not know a priori which part(s) of an image are of interest, and such determination needs to be done by visual examination of the whole image. In many practical situations (i.e., large images transmitted over low-speed connections), it is not feasible to transmit the whole image at the high resolution, hence the need for incremental transmission. In this paper, we introduce the sequential and progressive transmission schemes [7].

3 Experimental Results

In a transmission application, compression has always to be performed prior to data transmission. In this experiment, we tested the performance of data compression a point of view and realized the image transmission. In the transmission, the doctor has been waited the study film to diagnose the patient. In order to avoid the waiting time, they can diagnose the data by transmitting study image sequentially or progressively.

3.1 Experimental data and compression

The tested images of 256x256x8bpp abdominal, 256x256x8bpp side brain for the compression performance analysis and 512x512x8bpp brain for the transmission analysis are utilized in the work. Figure 4 and 5 shows the image comparison based on JPEG and JPEG2000 as described in previous section. In particular, Figure 4 shows the lossless operation with ratio 2:1. As shown in Figure 4, we can expect the no difference for the case of lossless operation. For the better understanding, the high compressed image shows the blocking effect as we expected in Figure 5.

On the purpose of comparison of an image quality, a general evaluation tool, PSNR (Peak Signal to Noise Ratio), has been adopted. The PSNR can be written by following.

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right)[dB] \quad (1)$$

where, *MSE* is a mean square error between the original and reconstructed images. The PSNR comparison curves are shown in Figure 6.

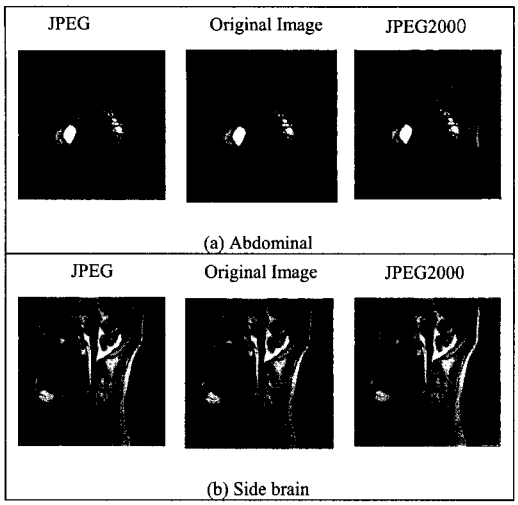
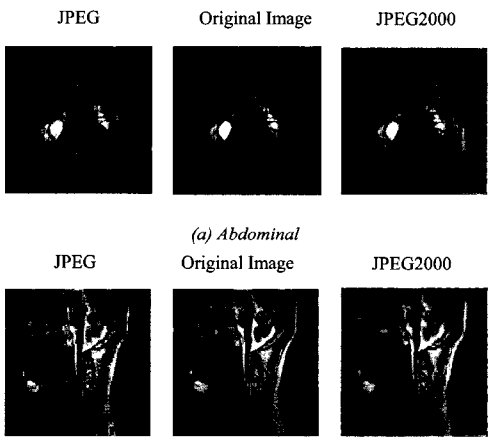


Figure 4. Result of image compression ratio 2:1.

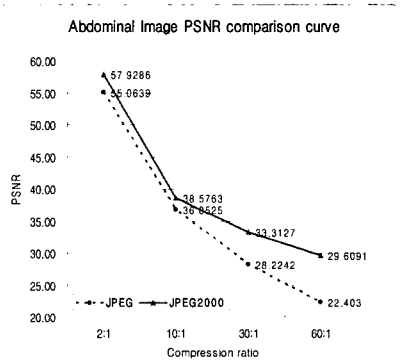


(b) Side brain

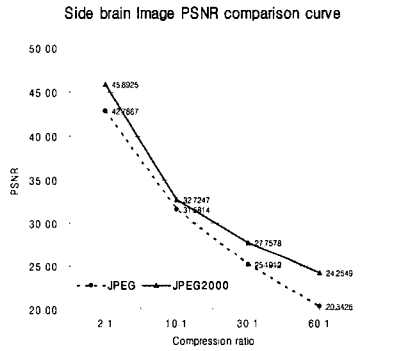
Figure 5. Result of image compression ratio 60:1.

3.2 Image transport

For the transmission of study image, the tested image of 512x512x8bpp was utilized. As shown in Figure 7, the brain image was processed by blocks sequentially. Figure 8 described the progressive process using spectral selection of DC and AC components. In the medical area, the diagnosis radiologist can expect and figure out the fundamental information for the emergency case what is transmitted.



(a) Abdominal



(b) Side brain

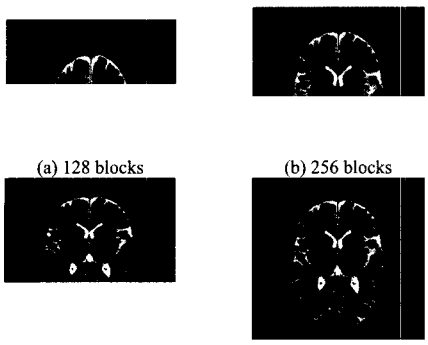
Figure 6. PSNR comparison curve.

3.3 Development of DICOM viewer

The new development of medical image viewer based on standard is an essential indispensable element and in addition a convenient viewer development can pursuit a lot of growths and gains in medical industry. Even though the developed viewer system has very limited properties on comparing the commercial software, the developed medical imaging viewer has the following properties:

1. Read a DICOM standard formatted image
2. Read the patient/study information
3. Provide the JPEG sequential and progressive process of decoding stage
4. Support the JPEG/JPEG2000 encoding/decoding

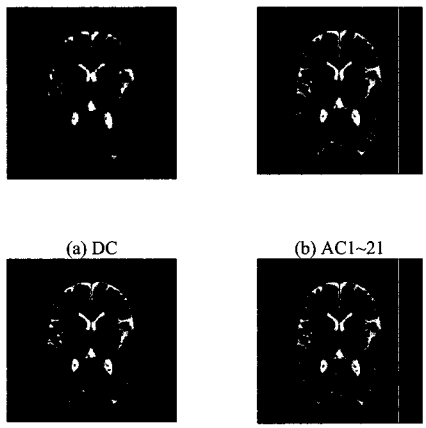
Figure 9 shows a snapshot of the imaging viewer with above properties and depicts the test brain image and Tag information with patient and study. The right side explains the example of JPEG sequential and progressive process



(a) 128 blocks (b) 256 blocks

(c) 384 blocks (d) 512 blocks

Figure 7. Sequential mode brain image.



(a) DC (b) AC1~21

(c) AC21~42 (d) AC43~63

Figure 8. Progressive mode brain image.

4 Conclusions

In this paper, we reviewed the JPEG and JPEG2000 standard algorithm for utilizing medical image application. The purpose of this work is, in particular, to explore that the realized medical image viewer is suitable to a DICOM standard from the raw image format to JPEG2000 by comparing the compression performance of JPEG and JPEG2000. In future, according to network construction necessity between medical institutions, gradually, web-PACS debecomes accelerated. Therefore, patient image possession or interpretation is expected to become possible from outside hospital. Even if patient private life and security problems are raised, web- PACS is shown signs to be spread gradually on the mobile terminals such as tablet PC and PDA based on wireless LAN. In addition, the mobile PACS will apply the medical industry to provide the quality of service.

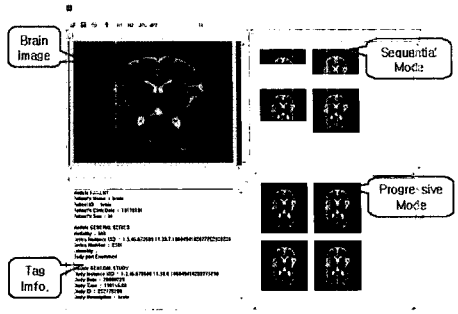


Figure 9. A snapshot of DICOM viewer.

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