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Peak Signal-to-Noise Ratio Evaluation of Server Display Monitors and Client Display Monitors in a Digital Subtraction Angiography Devices

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Abstract

This study evaluated PSNR of server display monitor and client display monitor of DSA system. The signal is acquired and imaged during the surgery and stored in the PACS server. After that, distortion of the original signal is an important problem in the process of observation on the client monitor. There are many problems such as noise generated during compression and image storage/transmission in PACS, information loss during image storage and transmission, and deterioration in image quality when outputting medical images from a monitor. The equipment used for the experiment in this study was P's DSA. We used two types of monitors in our experiment, one is P's company resolution 1280×1024 pixel monitor, and the other is W's company resolution 1536×2048 pixel monitor.

The PACS Program used MARO-view, and for the experiment, a PSNR measurement program using Visual C++ was implemented and used for the experiment. As a result of the experiment, the PSNR value of the kidney angiography image was 26.958dB, the PSNR value of the lung angiography image was 28.9174 dB, the PSNR value of the heart angiography image was 22.8315dB, and the PSNR value of the neck angiography image was 37.0319 dB, and the knee blood vessels image showed a PSNR value of 43.2052 dB, respectively. In conclusion, it can be seen that there is almost no signal distortion in the process of acquiring, storing, and transmitting images in PACS. However, it suggests that the image signal may be distorted depending on the resolution and performance of each monitor. Therefore, it will be necessary to evaluate the performance of the monitor and to maintain the performance.

Keyword : DSA system, Display monitor, Compression, PACS, PSNR

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I. Introduction

With the development of digital technology, the medical field is also rapidly digitizing. The development of the fourth industry is expected to accelerate the digitalization of the medical industry[1]. The vast amount of digital medical images generated in medical institutions are stored in PACS (Picture Archiving and Communication System) servers to become big data. Such big data is the foundation for the development of artificial intelligence technology[2]. When transmitting medical images in PACS, noise may occur on the network. The image is compressed, stored, and transmitted to improve these limitations and to ensure smooth server operation and seamless medical treatment[3]. In order to use the compressed medical image for treatment, it must be completely restoration. In the case of compression and restoration, even a small loss of information affects treatment, which increases the rate of false diagnosis[4]. A high-resolution image without loss must be output from a reading monitor and a medical monitor, and an image without noise and distortion of the image must be output on a general monitor. In order to improve these problems, an objective and reliable evaluation should be made. However, until now, the quality evaluation part of medical images is limited to display devices[5]. Distortion of image signals can occur in signal acquisition and display, compression storage and transmission, restoration and display exaggeration[6]. In this paper, by evaluating the PSNR of the server display monitor and the client display monitor of the DSA system, we propose an evaluation method for noise and image quality deterioration occurring in the process from acquiring the server display signal to the client display monitor.

II. PSNR evaluation of digital medical images

PSNR is most easily defined via the mean squared error (MSE)[7]. Given a noise-free $m \times n$ monochrome image I and its noisy approximation K, MSE is defined as:

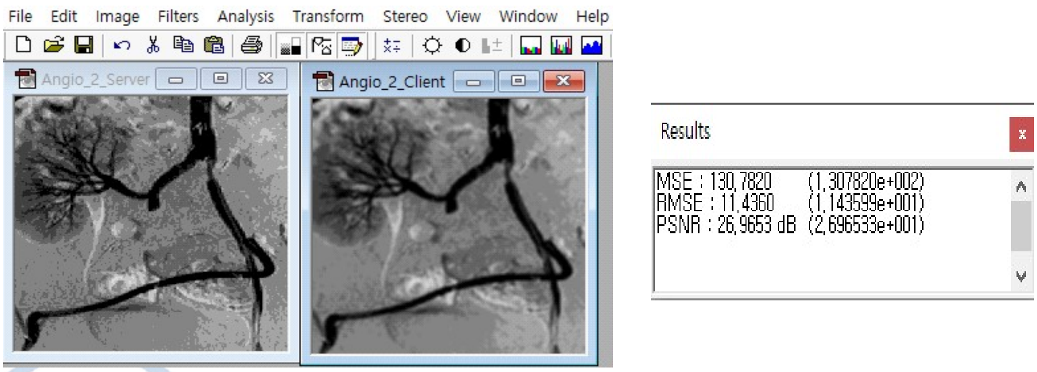
$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The PSNR (in dB) is defined as:

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$

Here, MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with B bits per sample, MAX_I is 2^B-1. If the two images are the same without any difference in quality loss, the MSE is 0 and the PSNR is infinite more than 50dB. In the case of lossless image, the MSE is 0, and the PSNR is not defined. 50dB is regarded as the original image, and if the difference is more than 11dB, it is viewed as a similar image[8]. In particular, since medical images are images dealing with human life, serious misdiagnosis can occur even with small loss of image quality. Therefore, the quality level should be over 30dB [9]. The standard deviation tells us how far the observations are from the mean. Currently, image evaluation by PSNR is widely used for image quality evaluation of various images, and occupies a very important weight. Specifically, it is widely used for evaluation of compression codes such as deterioration of image quality and noise generation of compressed images during image compression. Compression is a type of coding, and coding refers to both encoding that changes arbitrary data for a specific purpose and decoding that restores the changed data to its original state.

Lossless compression is also referred to as reversible compression, and when decompressing a compressed image, original information can be restored without loss, and has a lower compression rate than loss compression. Representatively, Huffman Coding is used. Loss compression is also referred to as irreversible compression, and is a compression method that does not match the original data before compression because some data is lost when compressed data is restored again. Image compression generally uses image conversion that removes redundancy between pixels of an image, reducing the size of the original data and storing it. A loss compression has a high compression rate instead of corrupting information and not recovering it again. Representatively, Cosine Transform Coding is used. A lossless compression method is widely used to prevent loss of information and deterioration of image quality that occur when compressing an image. At this time, PSNR is used to measure the quality between the original image and the compressed image and to evaluate the compression codec.[10].



(a) Input of experimental images (b) PSNR experimental result

Figure 1. Execution of image processing program written in C++

III. Materials and methods

Digital subtraction angiography (DSA) digitizes the analog electrical signal obtained from a fluorescence multiplier and a camera by an AD converter, and then subtracts the blood vessel image and the mask image in the image processing process to obtain a blood vessel image. In other words, it is a method in which the density of the image is digitally digitalized to remove the overlapping part, thereby erasing bone and soft tissue, and displaying only the blood vessel image[11].

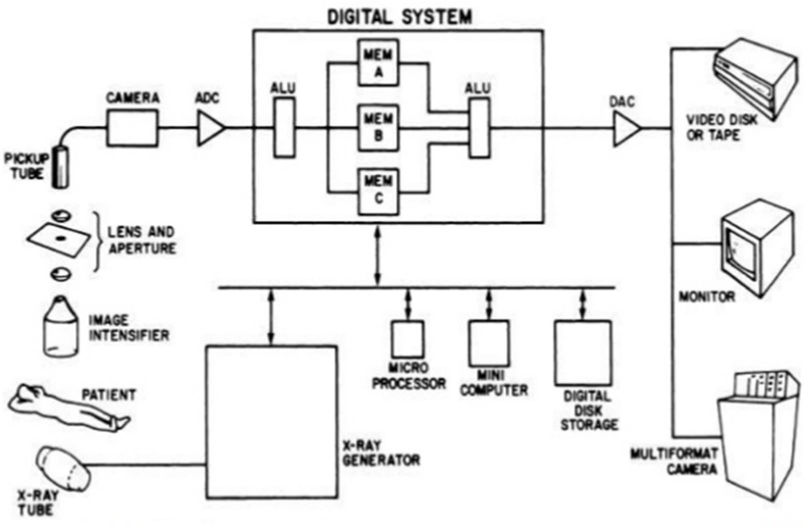


Figure 2. Structure of DSA system

DSA has better reproducibility than film angiography, which was mainly used in the past, and can freely change the contrast, so that even with a small amount of contrast agent, images of a certain contrast can be obtained. In addition, it is possible to change the image through real-time shooting, image storage, and post-processing. DAS requires an analog/digital converter that converts analog signals into digital signals, an image processor that processes and changes images, an image memory device and storage device that stores and stores images, and an image monitor [11].

1. Experimental equipment

The equipment used in the experiment was DSA system from P company. There are two monitors used for the experiment by displaying angiographic images: P company's resolution 1280×1024 pixel monitor and W company's resolution 1536×2048 pixel monitor. MARO-viewer was used for PACS, and analysis was performed by programming with Visual C++.

2. Experiment method

In the experiment, the quality of the sever image and the quality deterioration of the compressed and stored client image were compared, and the image quality of the monitor expressing the image was compared with the original. The evaluation image was used in the experiment using the DSA image acquired in the process of angiography.

3. Experimental procedure

In the experimental procedure, an angiography interventional procedure was performed, and the server image displayed on the monitor was acquired. And the same image was acquired by displaying it on the doctor's monitor. The two acquired images were programmed with Visual C++ to perform MSE and PSNR analysis.

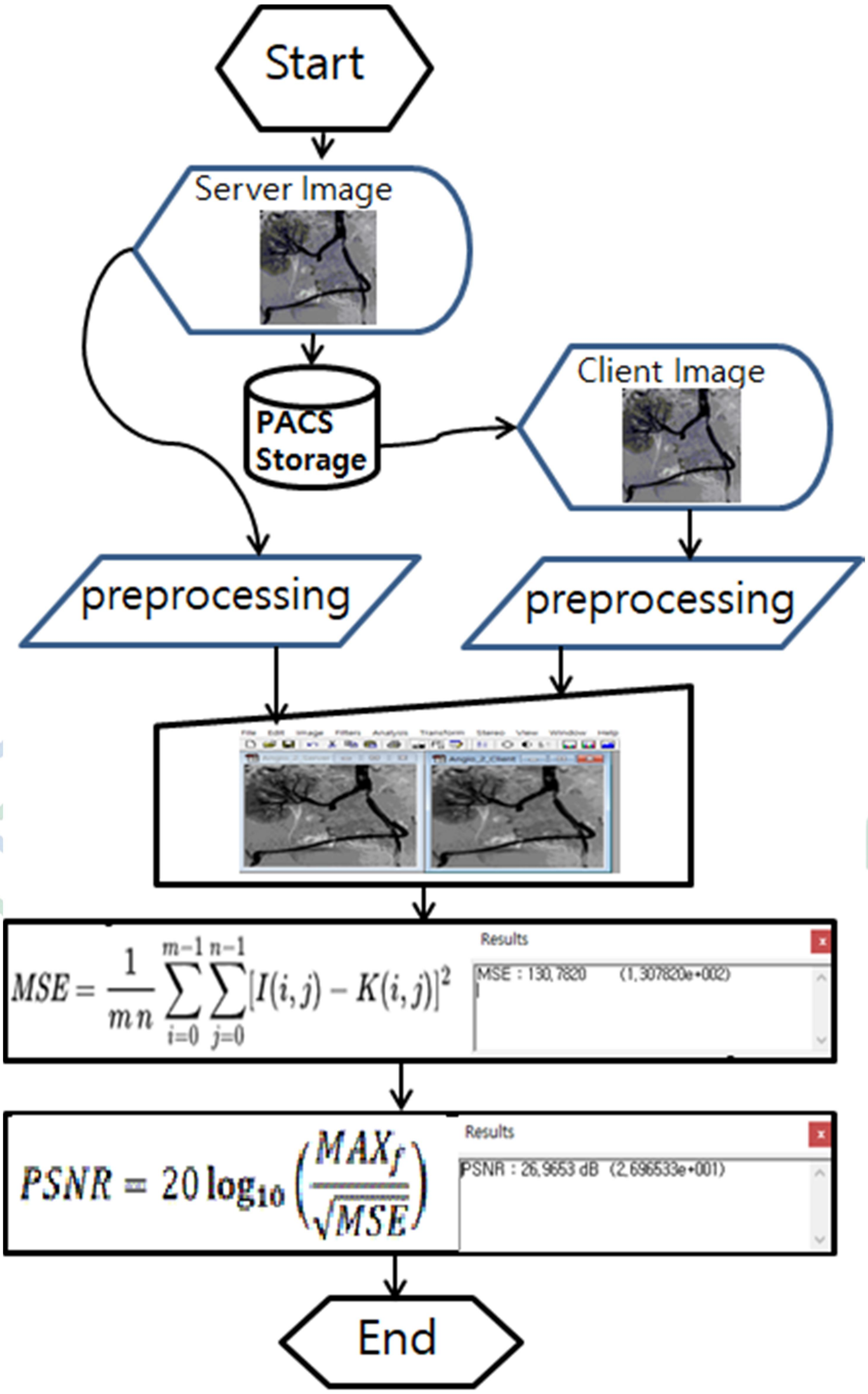


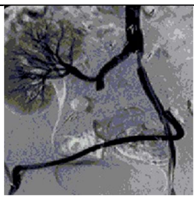
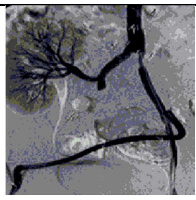
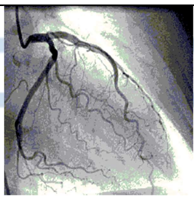
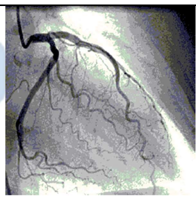
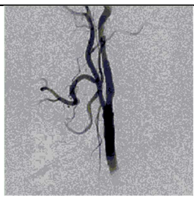
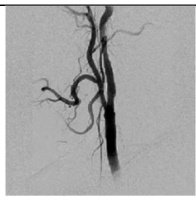
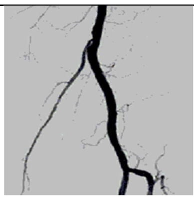
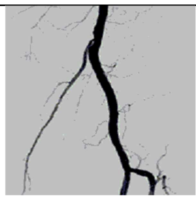
Figure 3. Experimental process

3.1. An experiment images

For the experiment, we acquired the server image in the process of interventional angiography image. The monitor used at this time was a 1280×1024 pixel monitor from P's company. And then, the image stored in the PACS server in the form of

*.dcm was displayed on the PC of the doctor to obtain a client image. The monitor used at this time was a 1536×2048 pixel monitor from W's company. The acquired experimental images were Kidney angiography image, Lung angiography image, Heart angiography image, Neck angiography image, and Knee angiography image. The obtained experimental images are shown in Table 1.

Table 1. Experimental images

No	Server image	Client image
1 Kidney angiography		
2 Lung angiography		
3 Heart angiography		
4 Neck angiography		
5 Knee angiography		

3.2. The Result of experiment

The experiment was carried out by the procedure shown in Figure 3 by executing the experiment program. Table 2 shows the difference between the server image and the client. Table 3 shows the MSE and PSNR values obtained through the experiment.

Table 2. Difference between server image and client image

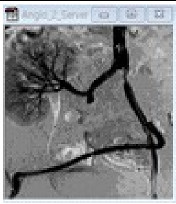
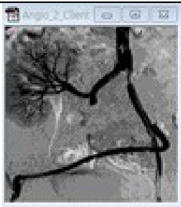
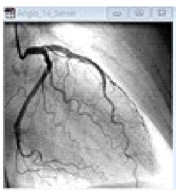
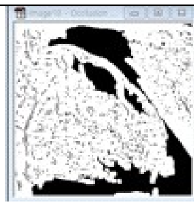
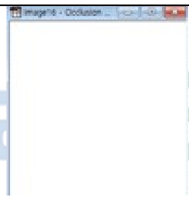
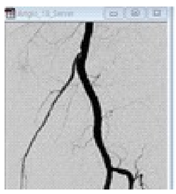
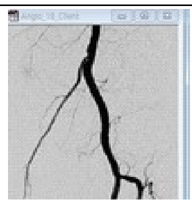
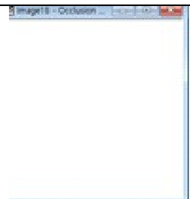
No	Server image	Client image	Difference image
1			
2			
3			
4			
5			

Table 3 shows the MSE and PSNR values of the server and client images used in this study.

Table 3. Result of experiment

No	MSE(Mean Square Error)	PSNR(Peak Signal–to-Noise Ratio)
1	130.7820	26.9553 [dB]
2	83.4332	28.9174 [dB]
3	338.7914	22.8315 [dB]
4	12.8791	37.0319 [dB]
5	3.1086	43.2052 [dB]

IV. Results and discussion

Looking at the difference between the two images shown in Table 2, there was a difference between the two images in images 1 to 3 in the body side, but no difference was found in images 4 and 5 in the neck and limb images. It can be seen that the MSE and PSNR values in Table 3 are also correlated with the difference between the two images.

The kidney angiography image of Table 3 number 1 showed a MSE value of 130.7820 and a PSNR value of 26.958 dB. The lung angiography image of Table 3 number 2 showed a MSE value of 83.4332 and a PSNR value of 28.9174 dB. The heart angiography image of Table 3 number 3 showed a MSE value of 338.7914 and a PSNR value of 22.8315 dB. The neck angiography image of Table 3 number 4 showed a MSE value of 12.8719 and a PSNR value of 37.0319 dB. The knee angiography image of Table 3 number 5 showed a MSE value of 3.1086 and a PSNR value of 43.2052 dB.

Changes in PSNR values of server and client images are considered to be a problem in resolution and management of server and client monitors, not in PACS image acquisition, storage, and transmission[12][13].

V. Conclusion

In this study, PSNR analysis was performed on two images to evaluate the difference in the quality of images displayed on the server monitor and the client monitor in digital subtraction angiography.

The experiment tested the following 5 cases:

1. Kidney angiography image,
2. Lung angiography image,
3. Heart angiography image,
4. neck angiography image,
5. knee blood vessels image

As a result of the experiment, the PSNR value of the kidney angiography image was 26.958dB, the PSNR value of the lung angiography image was 28.9174 dB, the PSNR value of the heart angiography image was 22.8315dB, and the PSNR value of the neck angiography image was 37.0319 dB, and the knee blood vessels image showed a PSNR value of 43.2052 dB, respectively.

In conclusion, it can be seen that there is almost no signal distortion in the process of acquiring, storing, and transmitting images in PACS. However, it suggests that the image signal may be distorted depending on the resolution and performance of each monitor. Therefore, it will be necessary to evaluate the performance of the monitor and to maintain the performance.

Competing interests
The authors declare that there is no conflict of interest regarding the publication of this paper

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