A Development of a Medical Information Transmisson System in Moving Picture Form(MedMpeg)

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ABSTRACT

With the rapid development of communication technology and widespread uses of internet service, utilization of internet-based medical information systems which transmitts moving pictures of medical objects is becoming a common practice. The internet-based medical information service prvovides richer information than conventional services such as touch-tone telephone, personal computers e-mails, or pagers, because "a picture is worth a thousand words". However, the systems passively transmits moving pictures of the medical objects to the users, and thus the system cannot intelligently adjust itself to provide better service. As the tradeoff exists between transmission speed and quality of the image, there is a need that moving pictures be analyzed to adjust the trnasmission speed and image quality. When very little difference between consecutive images are detected, the system can automatically increase the size of the image files, thus enhancing the quality of image. In contrast, the system should increase the number of images to send more pictorial information by sacrificing the quality of each individual image, when a significant difference is detected. In this paper an adaptive filtering technique is introduced which adjusts the quality of image and transmission speed according to a clinical situation in hospital.

1. Introduction

With the rapid development of information and communication technology, devices of medical information transmission has gone through

drastic changes: from analog film form to digitized picture form, and possibly in near future from the wired internet-based moving pictures to wireless PDA carrying moving picture form. The moving picture of medical scenes/objects is providing much richer information than conventional devices such as touch-tone telephones, pagers, and wired computer communications. Because of the convenience of the PACS devices, many medical organization recently begin to install the systems and provide the services.

Currently, the network-based PACS service is limited to wired one. In off-line modes the doctors cannot obtain real-time medical information outside medical facilities. This is because current wireless communication devices cannot provide bandwidth sufficient to transmit moving picture data in real-time mode. However, with the rapid progresses made in hand-held PDA(Personal Digital Accessory) technology and auto-PC, off-line service of medical information is becoming a reality. Even though wireless internet service are available in some PDA products, the service is limited to text information or still image data. However, we believe that wireless on-line internet service for transmitting moving picture will be available soon.

This research addresses how to provide better service to the medical doctors and staffs with a limited bandwidth and transmission speed. The main idea is to increase transmission speed when significant changes are detected in the traffic scene data. To the contrary, the system decreases transmission speed but provide enhanced service in the quality of the image, when the motion of an object is slowed. For the system to determine the service parameters, an analysis module for determining speed of file transmission is needed.

This paper consists of three more chapters. In the following chapter, the architecture of MedMpeg system, an internet-based PACS service system, is introduced. In section three, the basic principles of MedMpeg image compression technique and traffic volume analysis module are described. Then, final conclusion and future research are reserved for the final section.

2. MedMpeg Architecture

MedMpeg(Medical Moving Picture) system consists of image data compression/decompression module and traffic situation analysis module. To provide a stream of moving pictures captured at medical laboratories or clinics, operations rooms, the system is required to compress large sized

image data of into a tiny concise image data so that the communication channel with narrow bandwidths can handle multiple pieces of images in a unit time. For the reason, the system needs high ratio compression algorithm. Currently, many PACS service providers use hardware-based solution. But, the approach employed in this research relies solely on software solution. The images are compressed into a tiny module and then sent to the other party through the network, local area network or internet based wide area network, using softwares installed at each client terminal. Decompression module provides the reverse operations of the compression module, located at the opposite side of the server's encoding module.

Also, traffic analysis module is needed to adjust the transmission speed and quality of the image, depending on the situation. When a significant difference is not detected between consecutive images, high speed transmission is not required. The slow speed transmission is compensated by the high quality image transmitted to make a full use of the bandwidths. To the contrary, when significant differences are detected between consecutive images, i.e., very fast movement of the medical objects, high speed transmission with low quality of image can be justified. Adjustment of the transmission speed and quality of image is conducted by the network traffic analysis module.
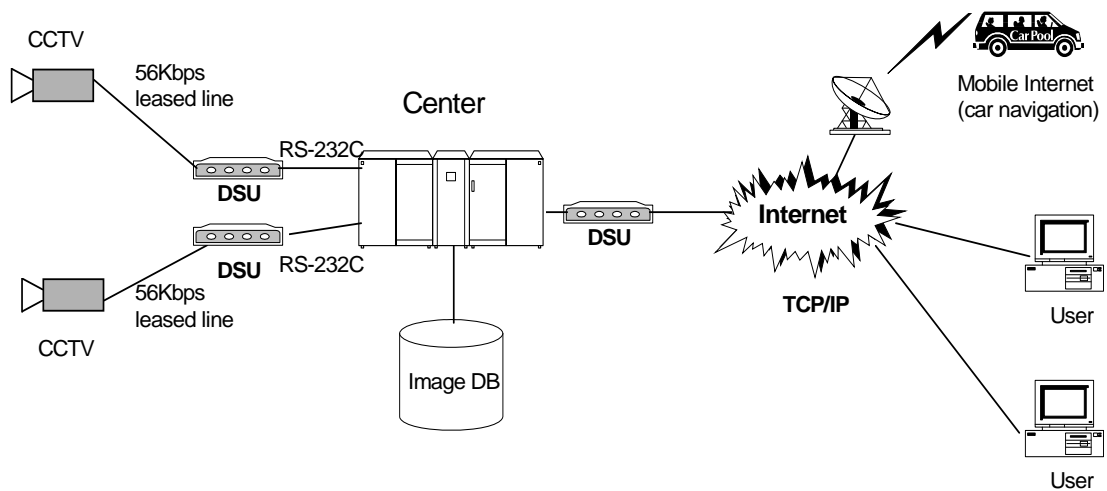
[Figure 1]   MedMpeg System Layout
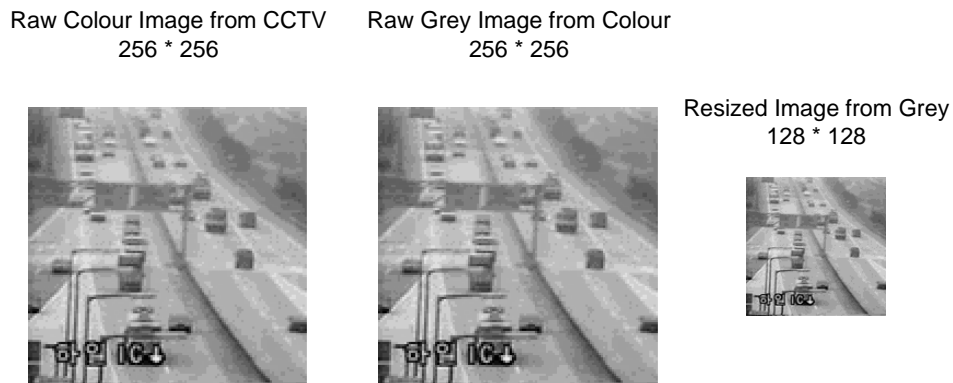
2-1. Image Representation

Suppose that the size of input image in a freeway CCTV is 256 by 256 size with 256 color. In that case, as the color image is basically composed of three components (red, green, blue : RGB), three 256*256 array is

needed to calculate Discrete Cosine Transform (DCT) algorithm.

Because human being's perception is more sensitive to brightness rather than to any chrominance information, a more suitable coding is needed to distinguish between luminance and chrominance. This means that, instead of separating colors, one can separate the brightness information (luminance Y) from color information (two chrominance channels U and V). The component division for YUV signal is defined as follows [Steinmetz and Nahrstedt, 1995] :

$$Y = 0.30R + 0.59G + 0.11B$$
$$U = (B - Y) * 0.493$$
$$V = (R - Y) * 0.877$$
$$Where, \ R : Red, \ G : Green, \ B : Blue$$

We resize original image to $128 * 128$ by a simple sampling method. The result figures are as follows:

Raw Colour Image from CCTV   Raw Grey Image from Colour
256 * 256   256 * 256

Resized Image from Grey
128 * 128

[Figure -2] Transmission of Medical Images

2-2. DCT Based Data Compression

Image compression techniques clearly play a crucial role in digital

 multimedia applications. Multimedia systems requires data compression algorithm because of the large storage requirements of multimedia data and network bandwidth that does not allow real-time data transmission.
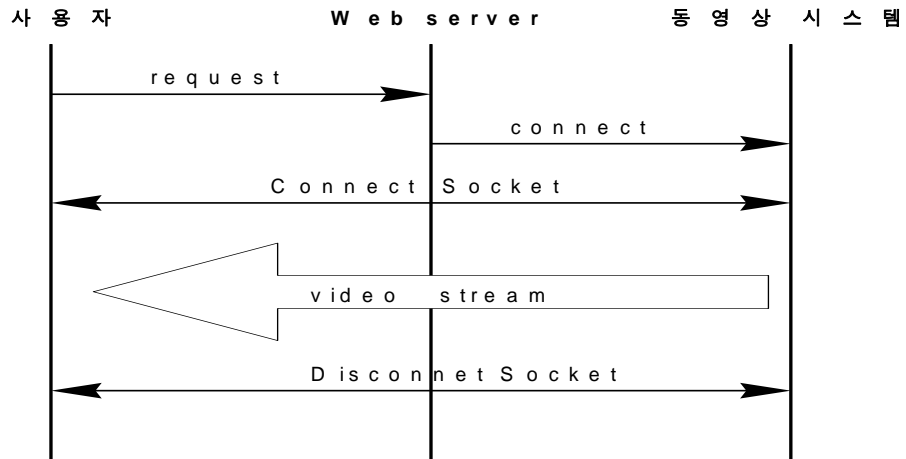
[Figure -3] Transmission of Video Data

The flow diagram of image compression method is follows:
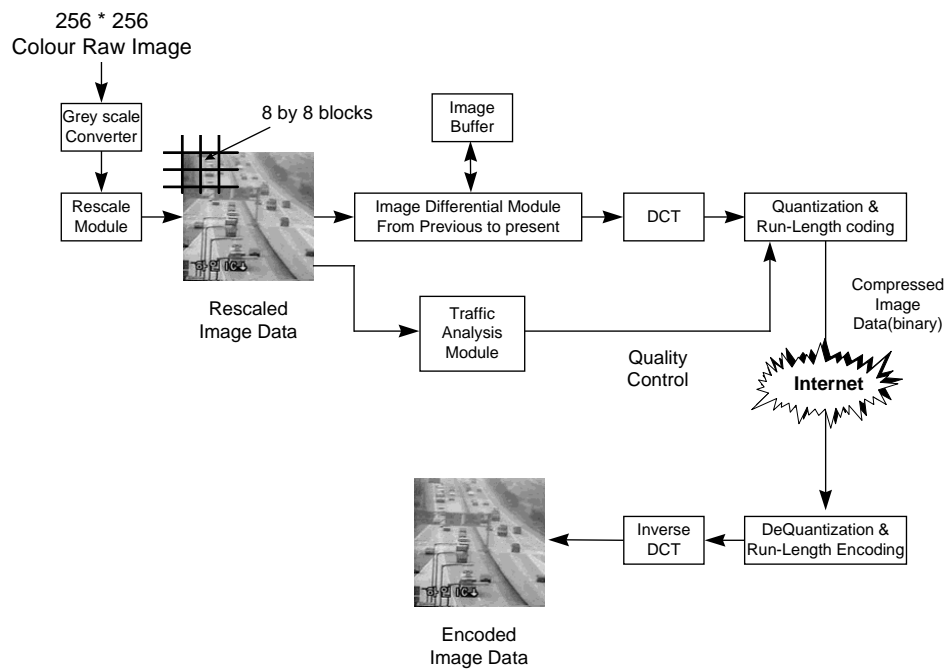
[Figure - 4] Data Transmission Diagram

3. Compression and Adjustment

3-1. Discrete Cosine Transform (DCT)

The MedMpeg system employs sequential Discrete Cosine Transform(DCT) technique which encodes each image component in a single left-to-right and top-to-bottom scan. In the application of DCT algorithm low frequency domain has different interpretation from high-frequency domain. When DCT operations are conducted on the image, correlation in the image is reduced and energy is converged into the low frequency domain. It indicates that unnecessary information in high frequency domain can be significantly reduced.

Low frequency domain obtained in DCT conversion includes more information than high frequency, and thus can reduce correlations between pixels so that the system eliminates spatial redundancies. The DCT algorithm is as follows [Nelson and Gailly, 1996] :

$$DCT(i,j) = \frac{1}{\sqrt{2N}} C(i)C(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} pixel(x,y) \cos\left[\frac{(2x+1)i\pi}{2N}\right] \cos\left[\frac{(2y+1)j\pi}{2N}\right]$$

Where, $C(x) = \frac{1}{\sqrt{2}}$ *if x is* 0, *else* 1 *if x* > 0

[The Discrete Cosine Transform]

$$pixel(i,j) = \frac{1}{\sqrt{2N}} C(i)C(j) DCT(i,j) \cos\left[\frac{(2x+1)i\pi}{2N}\right] \cos\left[\frac{(2y+1)j\pi}{2N}\right]$$

*Where,* $C(x) = \frac{1}{\sqrt{2}}$ *if x is* 0, *else* 1 *if x* > 0

[The Inverse Discrete Cosine Transform]

3-2. Quantization Matrix and Network Traffic Analysis

Clearly an enormous number of schemes could be used to define values in the quantization matrix. Generally, we get excellent compression ratios with large quantization step, but poor image quality. Contrary, when the quantization step size is small, the compression ratio is not so high, but quality of the images can be good. That is why International Standard Organization(ISO) has developed a standard set of quantization values for

using JPEG code.

MedMpeg system does not use a single quantization matrix or fixed quantization table, but employs flexible quantization mechanism: adjusts quantization parameters to modify the quantization matrix according to the traffic volume. The adjustment begins with differentiation of image at *t* and *t-1*. The analysis of the image frequency distribution makes it possible to estimate the traffic volume and changes in the traffic volume.
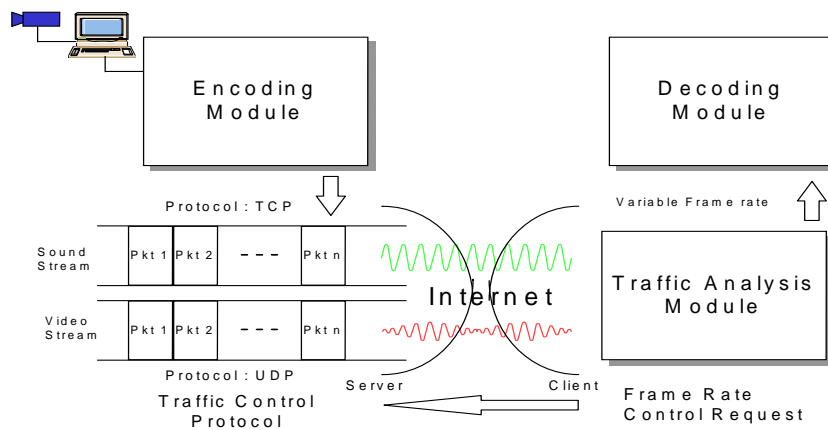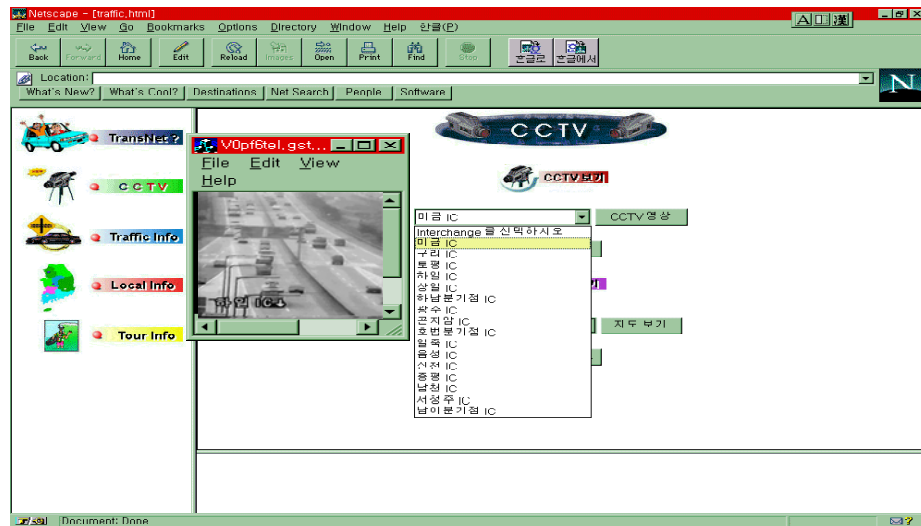
[Figure -5] Traffic Analysis Module

MedMpeg employs two dimensional fast Fourier Transformation (2D-FFT) to analyze the frequency distributions with consideration of transmission speed [Sid-Ahmed, 1995]. 2D-FFT is defined as followings:

$$H(n_1, n_2) \ = \ \sum_{k_1=0}^{N-1} \sum_{k_2=0}^{N-1} h(k_1, k_2) e^{(-j2\pi/N \cdot (n_1 k_1 + n_2 k_2))} \ = \ DFT\{h(k_1, k_2)\}$$

$$Where, \ n_1 \ = \ 0,1,2,\cdots,N-1$$
$$n_2 \ = \ 0,1,2,\cdots,N-1$$

3.3 Image Transmission Viewer

[Figure -6] MedMpeg Viewer for RealTime Transmission

An image viewer was developed for viewing image data of MedMpeg. As shown in Figure-6, the viewer provides service of real-time view of medical objects or locations. The user can select the locations or employees which he/she wants to talk by clicking the menu button. The screen menu can be enlarged.

4. CONCLUSION

In this research suggested is a technique which adjusts the quantization step size based on network traffic analysis to achieve high-quality image transmission and simultaneously maximizing the bandwidth efficiency. The technique is employed in transmitting moving pictures of the medical objects installed at clinics, laboratories, or operating rooms, under the environment of computer network, high-speed local area network or low-speed wide area network. In the technique, the transmitted images are generated by frame unit and image differentiation is used to estimate the network traffic situation. When the differentiation result is large, the frequency distribution is in the high-frequency domain. However, as the

change of image differentiation is within a small value when the no

significant motion of the objects is detected, the frequency distribution is in the low frequency domain. The characteristics of frequency distribution are utilized in developing network traffic analysis module. The improvement of DCT-based compression algorithm should be done with development of quality step controlling module.

Reference

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