A Study for Watermark Methods Appropriate to Medical Images

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The network system, including the picture archiving and communication system (PACS), is essential in hospital and medical imaging fields these days. Many medical images are accessed and processed on the web, as well as in PACS. Therefore, any possible accidents caused by the illegal modification of medical images must be prevented. Digital image watermark techniques have been proposed as a method to protect against illegal copying or modification of copyrighted material. Invisible signatures made by a digital image watermarking technique can be a solution to these problems. However, medical images have some different characteristics from normal digital images in that one must not corrupt the information contained in the original medical images. In this study, we suggest modified watermark methods appropriate for medical image processing and communication system that prevent clinically important data contained in original images from being corrupted. Copyright © 2001 by W.B. Saunders Company

THE USE of perceptually invisible watermarks is one form of image authentication that has been proposed as a method to protect against illegal copying or modification of copyrighted material.¹ A watermarking algorithm consists of three parts: (1) watermarking, (2) making an algorithm, and (3) verifying the algorithm.

In the watermarking algorithm, watermark embedding can be done either in the spatial domain or in the transformed domain.² We applied the watermark methods to medical images, and then adjusted it appropriately in those two domains. First, in the spatial domain, we added the watermark to the background of the image. In this method, we computed checksum and added it into the background using the modified M-sequence method. Because the background of medical images is meaningless, we could prevent damage of important information. Second, in the transformed domain, we used discrete cosine transform (DCT)

Fig 1. Frequency domain watermark embedding scheme.

coefficients of the image by using a one-dimensional watermark, W . We applied this method by adjusting the scale factor used in transform domain in order not to damage the important information such as a lesion. The resulting images were verified by medical doctors.

Fig 2. Frequency domain watermark extraction.

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Fig 3. (A) Original image, (B) watermarked image, and (C) corrupted image.

In the frequency domain method, the overall procedure of the proposed watermark embedding procedure is depicted in Fig 1. A frequency-based method spreads the watermark over the whole spatial extent (frequency content) of the image, and is therefore less likely to be affected by geometric distortions.³ However, it can damage important information, such as a lesion in the medical images, so one must choose the spread frequency region not to corrupt the important information.

We created a watermark that consists of a sequence of real numbers, $X = \{x_1, x_2, \dots, x_n\}$, where each value was chosen so that it was normally distributed with $N(0,1)$. The original image was divided into 8×8 blocks, and the DCT of each block was computed. After DCT, we chose appropriate components in the coefficients of the transform matrix, except the DC component. The selected sequences were $V = \{v_1, v_2, \dots, v_n\}$. To get watermarked coefficient sequences V' , we used $v'_i = v_i (1 + \alpha x_i)$, where α was a scaling factor.

Extraction of the embedded watermark is an inverse process of the embedding watermark

scheme.^{4,5} To extract the embedded watermark, we needed the original image. First, we needed to know the location of the embedded watermark. Second, we extracted the AC component from the watermarked image. Afterward, we used correlation to evaluate the similarity between the original image and the corrupted image. The overall extraction scheme is illustrated Fig 2.

RESULTS

We used 256×256 head magnetic resonance image (MRI) in the experiments. We were able to apply the watermark method appropriately to the medical image and find the appropriate value of the scaling factor, which was tolerable for the medical imaging applications. Also, we could evaluate the similarity between the original watermarked image and the corrupted images.

Figure 3A is the original image, Fig 3B is the watermarked image, and Fig 3C is the corrupted image of which some portion is replaced with another image. Figures 4A-C are the results of the similarity evaluation between the watermarked image and the others. Figure 4C shows that the corrupted image has little similarity to the original watermarked image.

CONCLUSION

The spatial watermark method had the advantage that it did not damage the important information if the watermark was embedded in the background of images. Even though it was easy to eliminate the watermark from the watermarked image, it was hard to determine how much information was corrupted where the watermark was not supposed to be, such as in a nonbackground region. However, we could estimate the corruption to the full region of the image such as the intentional noise. The frequency domain method had an advantage of robustness for illegal modifications, but some of information contained in the original images underwent mild changes.

Fig 4. Results of images in Fig 3A-C.

Medical images have some different characteristics from other digital images. Despite of the modified watermark method we suggested in this study, the point in question is open to

further discussion. We must develop a more appropriate watermark method that minimizes the damage of information and has robustness for change.

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