Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 14 (14): 1638-1642, 2014
ISSN 1812-5654 / DOI: 10.3923/jas.2014.1638.1642

Study on Medical Image Watermarking Techniques

S. Priya, B. Santhi and P. Swaminathan
School of Computing, SASTRA University, 613401, Tamil Nadu, India

Abstract: Security of medical image is possible by using digital watermarking techniques. The significant information is embedded within a host medical image in order to provide integrity, consistency and authentication in healthcare information system. Authentication is done by embedding significant information in spatial as well as in transformed domains. This study proposes a reversible invisible watermarking technique to embed significant information within a Computed Tomography host medical image by using different transformed domains. Watermarked image is evaluated by verifying peak signal to noise ratio (PSNR) value and Structural Similarity Index Measures (SSIM). In the analysis, wavelet transform based watermarking technique PSNR value is high and SSIM value is nearly equal to 1 states that for medical image wavelet transform gives best reversible watermarking compare with other watermarking techniques.

Key words: Reversible watermarking, FFT (fast fourier transform), DCT (discrete cosine transform), DWT (discrete wavelet transform), CT (computed tomography), medical image

INTRODUCTION

In medical environment, the different types of medical images are transferred in order to get suggestion from remote location physician to diagnose and also are used for archival based applications. Medical image is transferred through internet using different multimedia techniques. Concentration is needed to protect medical (cover) image from external attack.

Different types of information security technique are available like cryptography (Schneier, 2007), steganography (Amirtharajan and Rayappan, 2012a, b, c, d, Amirtharajan *et al*., 2012; Padmaa *et al*., 2011; Rajagopalan *et al*., 2012; Thenmozhi *et al*., 2012; Janakiraman *et al*., 2012a, b) and Watermarking. Watermarking is used to protect medical image during transmission. It is a process of embedding significant information over a host medical image to provide authentication, information hiding, tamper proof data, etc., (Coatrieux *et al*., 2009). Confidentiality, authenticity and reliability are considered as main factor for watermarking process. Watermarking process is mainly classified into visible and invisible watermarking. Invisible watermarking is a robust technique for watermarking attacks (Priya *et al*., 2012).

In medical image watermarking the significant information is hidden within a cover medical image and that information should not be detected and retrieved or modified by the unauthorized user. It is mainly used in one-to-many communication system where as steganography is used in one-to-one system (Sharma and Gupta, 2012). Medical image watermarking is classified as ROI (Region Of Interest) and reversible technique (Sonika and Inamdar, 2012). In health information system robust and reversible watermarking is needed for diagnosis purpose. The reversible watermarking technique provides the original medical image at the recovery side without any loss. If there is any loss in the extracted medical image, it will give the wrong result (Coatrieux *et al*., 2006; Rohini and Bairagi, 2010).

Medical image watermarking is done by both spatial and transformed domain. Several types of medical images are there such as Magnetic Resonance Image (MRI), CT, Ultra Sound (US), Positron Emission Tomography (PET), etc. There is no common watermarking technique applicable for all types of medical images because property for each type is different from others. This study mainly deals about CT image invisible watermarking in different transformed domain.

In spatial domain, the watermark is embedded within original medical image (Wang *et al*., 2009). Many techniques are used to embed watermark such as LSB (Least Significant Bit) substitution technique, Pixel alteration and bit shifting, etc. The spatial domain watermarking technique is very easy and simple with less complexity. It is not robust to common attack. The attackers easily attack the watermarked medical image and extract the watermark data. Fragile watermarking technique is implemented in spatial domain (Dharwadkar *et al*., 2010).

The spatial host medical image is converted into transform domain and watermark is embedded into the transformed host image by changing its transformed

Corresponding Author: S. Priya, School of Computing, SASTRA University, 613401, Tamil Nadu, India

coefficients. Compare to spatial domain, transform domain is robust to watermarking attacks (Asatryan and Asatryan, 2009). Different types of transform domains are there such as Discrete cosine Transform (DCT), Fast Fourier Transform (FFT) and Discrete wavelet Transform (DWT).

FFT produces a frequency domain image for spatial medical image. It is the fundamental and basic watermarking technique. One main advantage compared with spatial domain is transformation invariant and resistant against rotation (He and Sun, 2005; Kang *et al*., 2010). This method provides good robustness against geometric and stir mark attacks (Poljicak *et al*., 2011) but it degrades the image quality due to round of error (Raja *et al*., 2005).

In image processing, DCT is a commonly used transform function. It converts spatial image to frequency transform domain image. The DCT is a very trendy transform function used in image processing. In DCT domain watermarking, by considering the Multiple Descriptions Coding (MDC) and Quantization Index Modulation (QIM) of an image will give more robust to local and global attacks (Chandra and Srinivas, 2009). It allows good energy compression and implementation part, also feasible and simple compared to DFT (Khayam, 2003).

In signal processing application, wavelet plays a major role. Reversible robust watermark research work mainly concentrate on wavelet domain. Wavelet has special features than that of DCT and FFT. Based on HVS (Human Visual System) characteristics, this technique focuses on small changes in edges and textures of the medical image (Mistry, 2010). Image decomposition is done by integer wavelet and watermark is embedded by considering the threshold value (Golpira and Danyali, 2009). Fragile watermarking is done by embedding two watermarks in the interest and non interest region of medical image by using IWT (Integer Wavelet Transform) (Memon *et al*., 2009).

MATERIALS AND METHODS

In this study, watermark information is embedded within a cover image using Zigzag scanning for both spatial and transform (FFT, DCT, DWT) as shown in Fig. 1. The watermark is embedded by considering the alternate coefficient value of cover image during zigzag scanning process.

Proposed algorithm: In this study, transformed domain technique is introduced for CT medical image. The proposed algorithm is as follows:

- Read the host CT medical image
- Preprocess the host image [resizing enhancement]
- Read the watermark image
- Preprocess the watermark image
- Select transform
- Apply transform
- Embed watermark into transformed domain
- Reconstruct the watermark
- Analyze the performance

The proposed watermarking model for CT medical host image is shown in Fig. 2.

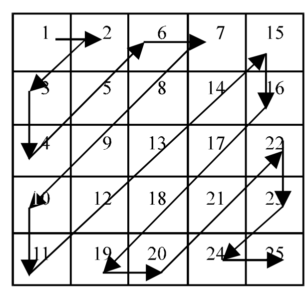

Fig. 1: Zigzag scan procedure

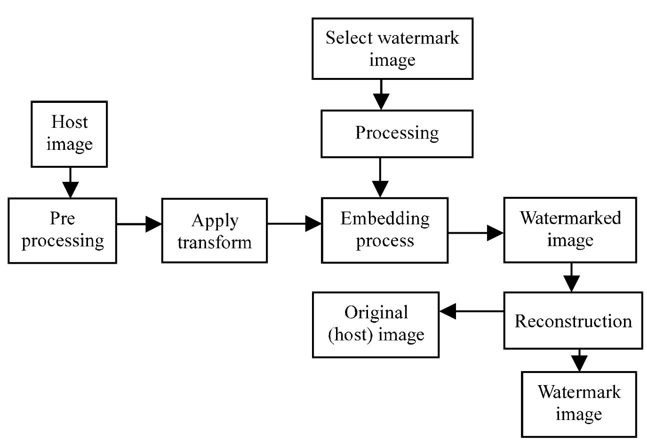

Fig. 2: Proposed watermarking process

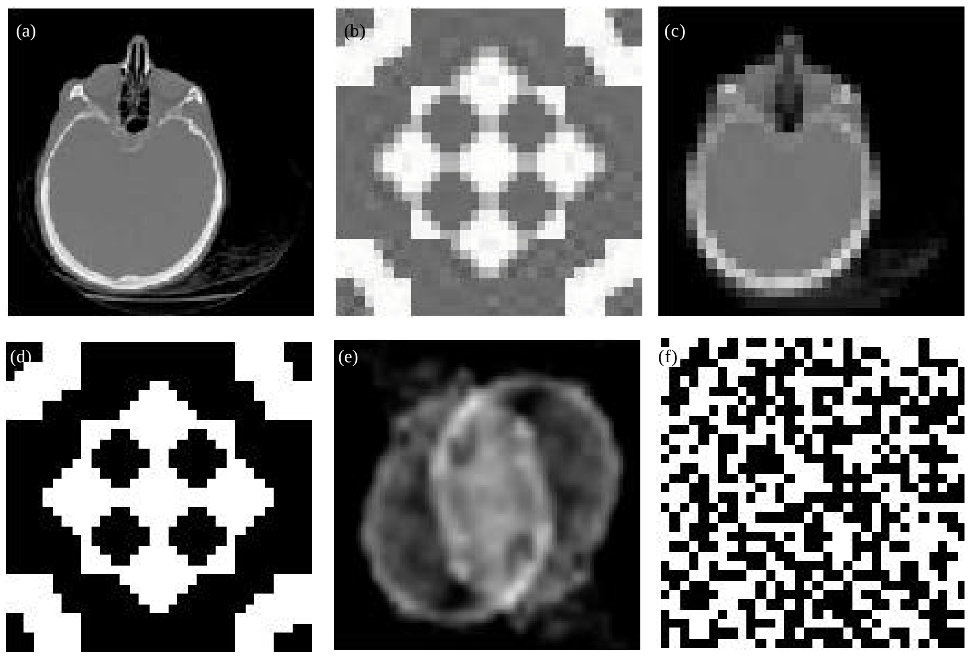

Fig. 3(a-f): Outputs of CT image watermarking, (a) Original CT image, (b) Original watermark, (c) Spatial domain recovered image, (d) Spatial domain extracted watermark, (e) FFT recovered image and (f) FFT extracted watermark

The host medical image is generated. Then preprocessing technique is applied to host CT image. It converts RGB image to gray level image and reshapes the given host CT image. Select the suitable transform and applied to preprocessed host CT image. The transformed image is read in zigzag manner. Preprocessed watermark image is embedded within a transformed coefficient to produce a watermarked image. At the receiver side the watermark is extracted from watermarked by applying reverse of embedding algorithm. Different watermarking techniques are implemented and its output images are shown in Fig. 3.

RESULTS AND DISCUSSION

This study concentrates on invisible medical image watermarking techniques. The watermark image is embedded in a 204X204 host CT medical image. This work compares the four different approaches. This can be analyzed through the performance measures PSNR and SSIM. The experimental results are shown in Table 1.

PSNR is a full referenced quality metric used to calculate a noise level between original watermark and extracted watermark image. From Table 1, DWT technique has the highest PSNR value compared with other techniques. SSIM is another quality metric and it will compare the original and watermarked image to measure the image quality. The value of the measure SSIM nearly equal to one depicts that the extraction is lossless. DWT watermarking technique has the highest SSIM value that is nearly equal to 1. By the study, DWT is identified as the best technique for medical CT image watermarking (Fig. 4-5).

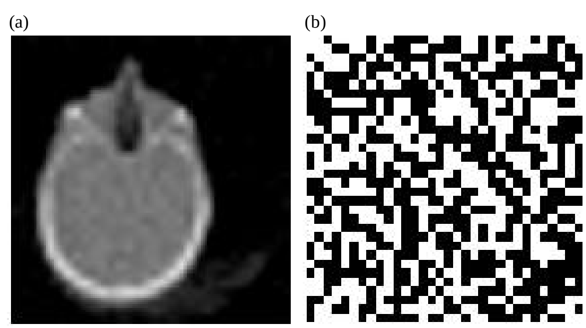

Fig. 4(a-b): (a) DCT recovered image and (b) DCT extracted watermark

Table 1: PSNR and SSIM values of watermarked image

Domain/measures	Spatial	FFT	DCT	DWT
PSNR	9.2995	4.7543	4.7907	259.6402
SSIM	0.7592	0.3475	0.6613	0.9999

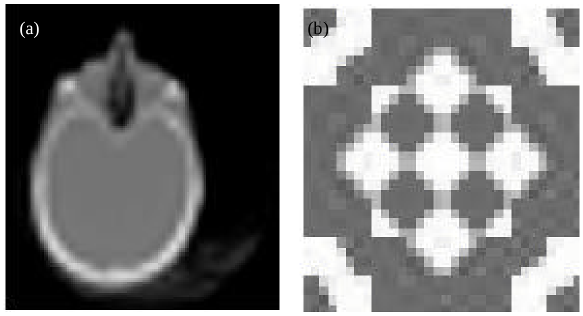

Fig. 5(a-b): (a) DWT recovered image and (b) DWT extracted watermark

CONCLUSION

The watermarking techniques for medical images in transformed domain (FFT, DCT and DWT) are compared with spatial domain in this study. For medical images, reversible watermarking is needed for better analysis. These techniques are suitable for CT medical images. There is no common watermarking technique suitable for all the types of medical images. In this study, watermark image is embedded within a CT medical image to produce watermarked image using different transformation. From the experimental results, DWT provide the best reversible watermarking technique for CT medical image. DWT gives high SSIM value and it also equals with HVS.

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