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Adaptive Lossless Medical Image Watermarking Algorithm Based on DCT & DWT

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Abstract

This paper, presents a robust, secure and lossless digital image watermarking based on DWT and DCT. The combined DWT-DCT algorithm embedded watermarks in original medical image. It embeds watermark like patient's name, disease's name, hospital's name, and doctor's signature into original medical image. This watermarking algorithm provides privacy of patient. Many performance factors are considered to evaluate the performance parameters of the proposed scheme. The performance evolution factors include PSNR, and measuring their correlation with degradation of the whole image.

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Keywords; Watermarking; Discrete Wavelet Transform(DWT); Discrete Cosine Transform(DCT); Mean Square Error(MSE); Peak Signal to Noise Ratio(PSNR); Correlation.

1. Introduction

In the present era, Digitalization of information has been promoted in many fields like telemedicine, banking, shopping, office work, broadcasting etc; rapid growth of internet in these fields leads to the availability of person's data in the public. Telemedicine is the field which provides health care through electronic information technologies when patients are far from the doctor[1]. Digitalization of medical information provides the storage and transmission

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of medical information over internet. Patient's medical records are always been an important issue for privacy protection. Most hospitals and health care centers have bulk of patient's data storage and transmission, such as images related to patient's personal information, and disease report. Among these data, the patient's medical images (like X-ray, CT scan, MRI) and personal information are very sensitive and need to be protected against any type of attacks [2]. To preserve the privacy, patient data can be embedded into the medical images. This patient information can be used as a watermark. The basic idea of digital watermarking[3] is to embed watermark in original image; after watermarking the output image and the original image should be similar, so that doctors can retrieve the hidden data from the digital image to perform proper treatment when it necessary. Embedding of additional data as watermark within the medical images requires extreme care because the watermark must not affect the image quality. The bad quality image may cause a misdiagnosis in the treatment and lead to human causality and financial losses. In today's digital era, the telemedicine applications play important role in our lives[1] but this medical images data can easily access by any unauthorized person and do unofficial modifications and manipulation. This may also lead to human lives losses so there is necessary need to secure these digital data.

In this paper, a new secure lossless watermarking technique is proposed based on DCT & DWT for medical images. The combined DCT-DWT transform could compensate the drawbacks of each other and this leads to the result of effective algorithm for watermarking. This digital watermarking method is fragile when any attacker applies attacks in this image then watermark is distorted and the patient's information is saved from attack. The proposed watermarking is done in two steps. The first step is embedding the watermark in original medical image. In the second step extracted the watermark using semi blind techniques form the watermarked image.

This paper is organized in the following manner. Section 2 discusses literature review based on medical image watermarking; Section 3 represents proposed watermarking technique based on DWT and DCT; Section 4 describes performance metric of propose work; Section 5 shows experimental results and finally in section 6 concludes this paper.

2. Literature Review

At present, the research in digital watermarking can be categorized into two classes: spatial-domain and frequency-domain. Spatial domain embedded the watermark inside the original image by changing the pixel values of the original image[4, 5]. Least significant bit is one of example of spatial domain techniques. Frequency domain embedded the watermark by changing coefficient values in transform domain. Frequency domain techniques include Discrete Wavelet Transform (DWT) [6, 7, 8], Discrete Cosine Transform (DCT) [8] and Discrete Fourier Transform (DFT) [8].

A. Z. Abdullah [9] has been presented an adaptive medical image watermarking technique is based on wavelet transform and property of human visual system in order to maintain the authentication of medical image. Watermark embedding process is carried out by transform the medical image into wavelet domain and hide the watermark in the image coefficients. But these process two level DWT transform use so data payload capacity are reduced and size of watermark is very small.

The scheme proposed by Giakoumaki et al. [10] is based on wavelet transform. This watermarking scheme embeds multiple watermarks in medical image. The scheme provides medical confidentiality and record integrity, but the perceptual quality is degraded due to the use of multiple watermarks.

Al-Haj[11] has proposed a watermarking scheme utilizing both DWT-DCT transform based digital image watermarking algorithm. Watermarking is carried out through the embed of the watermark in the first and the second level DWT. Sub-bands of the host image sub-sequenced by the application of DCT on the selected DWT sub-bands. In this technique two levels DWT use so less payload capacity.

C. S. Woo [12] proposed a multiple watermarking method. In this method Encrypted patient data is embedded as annotation watermark for achieving the privacy control and a tiled binary pattern embedded as fragile watermark for tamper localization. Two different watermarks are used for achieving privacy and authenticity causing extra payload and less visual fidelity of watermark image.

To improve the visual quality of watermarked image Nisar Ahmed Memon [13] has divided the medical image into two parts Region of interest (ROI) and Region of non-interest (RONI). The author propose a hybrid watermarking method which embeds a robust watermark in the RONI for achieving security and privacy, while honesty control is achieved by inserting a fragile watermark into the ROI. Propose a technique which assures the integrity of ROI. The proposed method remove distortion produced in ROI by undoing the watermark embedding process after the authentication process deems the image as authentic. But in this technique segmentation is big problem, if segmentation are not proper then these embedding process distorted the medical image. ROI region is short then payload capacity is reduced and watermark quality also reduced. In this technique more complexity and more computation power required.

Classical Medical Image watermarking is a tradeoff between payload visual fidelity and complexity. As we increase payload distortion increase and results in less visual fidelity. To improve the visual fidelity and to protect the medical information lies in image, it has been divided into two parts ROI and RONI but this result in increased complexity and less payload. Reversible watermarking has an edge over other two watermarking scheme due to less complexity and more payload capacity. Watermarking scheme must be adaptable and lossless for the better visual fidelity of recovered image.

3. Proposed Watermarking Technique

A new image watermarking technique is proposed based on DWT-DCT to embedded the watermark into the medical images in such a way that it is imperceptible by the human visual system. The adaptive method is employed to determine appropriate coefficients for hiding watermark by decomposing the medical image into different regions and select the regions which are low sensitive to the HVS. The HVS is sensitive to changes in the lower frequencies as it represents more significant characteristics of the image. The higher frequencies gives the less significant details of the image and changes in these frequencies, are not easily noticeable by HVS. This digital watermarking method is fragile when any attacker applies attacks in this image then watermark is distorted and the patient's information is saved from attack. The proposed watermarking is done in two steps. The first step is embedding the watermark in original medical image. In the second step extracted the watermark using semi blind techniques form the watermarked image. In semi blind watermarking process for extraction of time we required the original image for recovering the watermark from the watermarked image.

3.1 Watermark Embedding Process

The aim of this process is to insert the watermark data into a medical image. This process consists of five steps. The first step involves applying DWT to the medical image which is provide four sub band of original medical image, these are LL, LH, HL, HH. In second step, apply DCT in high frequency component (HH). The third step determines scaling coefficients with the help of original image. In fourth step, insert the watermark in the medical image. At the last step, performs the inverse DCT and DWT to construct the watermarked medical image.

1. Discrete Wavelet Transform: In first step of watermarking be apply DWT in original image. The first level of DWT produces four sub-bands, termed as LL, LH, HL and HH. The LL is a low resolution version of the medical image and LH for horizontal, HL for vertical and HH for diagonal direction are the detailed sub-images.
2. Discrete Cosine Transform: In second step of watermarking apply DCT in high frequency component HH, which is provide DCT coefficient values of image.
3. Computation of Adaptive Scaling Factor: For computing the adaptive scaling factor applying DCT block base transform in original image, and which provide block in matrix form each matrix first component in DC value of matrix. After these process find mean of these DC value which is scaling factor. This scaling factor is multiplied with watermark coefficient values and made a new watermark coefficient.
4. Watermark Hiding Process: In watermark hiding process, new watermark coefficient is add with DCT confident values. After adding watermark in host image provide a new transform coefficient of image.
5. Inverse Transform: Complete this process applying inverse transform in new coefficient value. First apply Inverse DCT (IDCT) in new coefficient value that provide high frequency component (HH) of DWT. At the last apply inverse DWT (IDWT) which create watermarked image.

3.1.1 Proposed Watermarking Embedding Algorithm

Step 1: Apply DWT to decompose the original image into four non – overlapping multi resolutions sub-bands: LL, LH, HL, and HH.
Step 2: After the decomposition of high frequency sub-band HH, apply DCT.
Step 3: In third step find the adaptive scaling factor.
Step 4: Embeds the watermark in the DCT of HH.
Step 5: Apply the IDCT and IDWT and construct the watermarked image. Figure 1 shown block diagram for embedding algorithm.

3.2 Watermark Extracting Process

In extracting process both watermarked and original image are required to extract the watermark. This process consists of four steps. In first step applying DWT in both watermarked and original image which is provide the four sub bands. In second step applying DCT in both high frequency of watermarked and original image. In third step find the scaling factor. And in last step subtract the DCT coefficients of watermarked to original image and multiple these coefficients to scaling factor.

1. Discrete Wavelet Transform: In first step of extracting be apply DWT in original image and watermarked image. The first level of DWT produces four sub-bands, termed LLo, LHo, HLo and HHo for original image and LLw, LHw, HLw and HHw for watermarked image.

2. Discrete Cosine Transform: In second step of extracting apply DCT in high frequency component HH for both image, which is provide DCT coefficient values of original and watermarked image.

3. Computation of Adaptive Scaling Factor: For computing the adaptive scaling factor applying DCT block base transform in original image, and which provide block in matrix form each matrix first component in DC value of matrix. After these process find mean of these DC value which is scaling factor. This scaling factor is multiplied with watermark coefficient values and makes a new watermark coefficient.

4. Watermark Extracting Process: In watermark extracting process subtracted the DCT coefficients of watermarked image to original image and multiplied these coefficients to adaptive scaling factor which create watermark image.

3.2.1 Proposed Watermarking Extracting Algorithm

Step 1: Apply DWT to decompose original image and watermarked image into the four multi-resolution sub-bands: LL, LH, HL, and HH.
Step 2: After the decomposition of high frequency sub-band HH, apply DCT in both image.
Step 3: In third step find the adaptive scaling factor.
Step 4: Extracted the watermark using subtraction of DCT value of both image HH sub-band, and multiplied the adaptive scaling factor to DCT value of coefficient. Figure 2 shown block diagram for extracting algorithm.

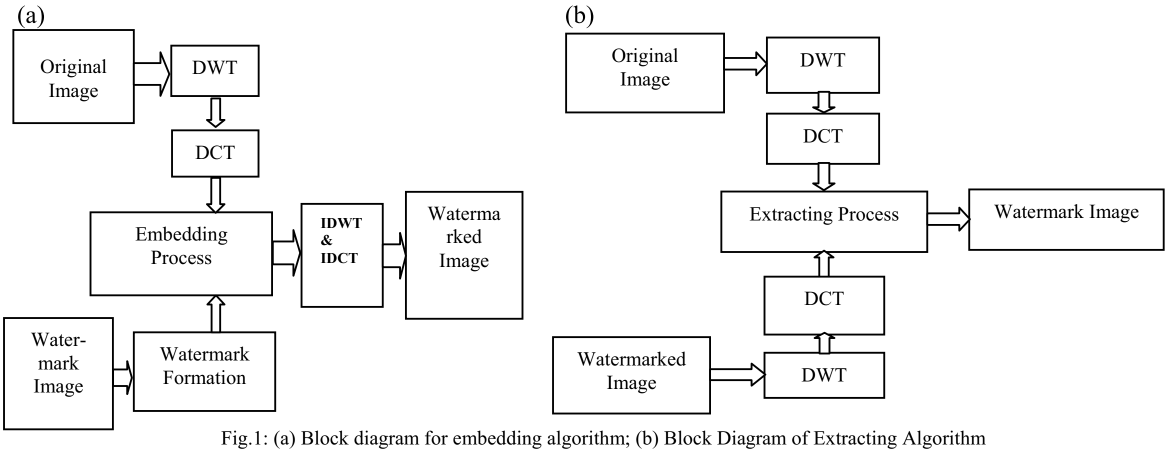

Fig.1: (a) Block diagram for embedding algorithm; (b) Block Diagram of Extracting Algorithm

4. Performance Parameters

This paper considers performance metrics to calculate the performance of watermarked image. The performance metrics are Peak Signal to Noise Ratio (PSNR) [14], Mean Squared Error (MSE) [14] and Correlation.

5. Experimental Results

The experiment has been performed with the software MATLAB R2013a version. Experiments have been performed with a 512×512 "X-Ray", "CT Scan", "MRI" as the gray scale original medical image, and patient personal data is converted into image form and used as watermark. In this experiment different embedding factor 0.5α, α and 2α use to find better results and α provide the better result as compared to 0.5α and 2α. The original images, watermark image, watermarked image and recovered watermark image quality show by figures. Figure 2 shows X-ray watermarked result images. Figure 3 shows CT scan watermarked result images. Figure 4 shows MRI watermarked result image.

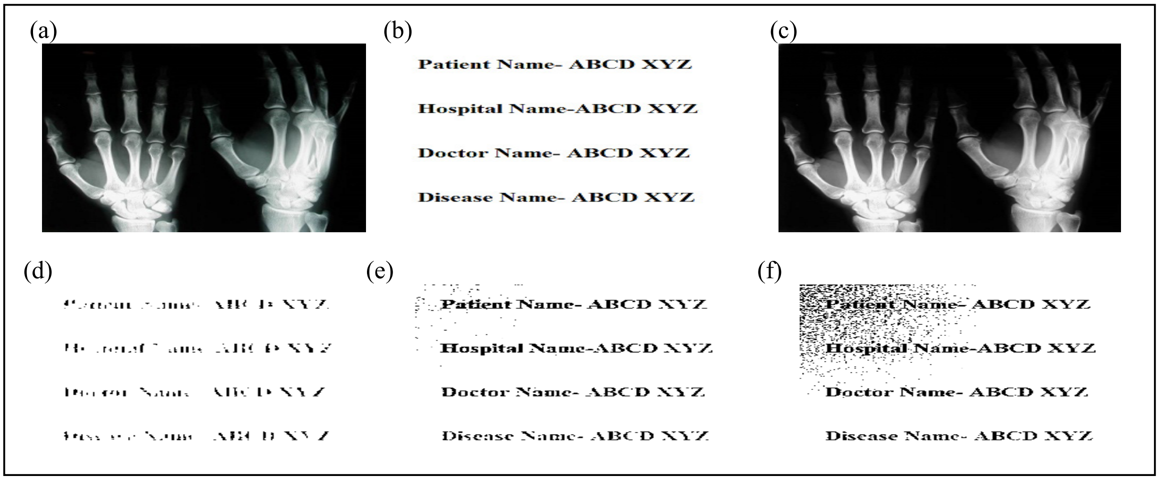

Fig. 2: X-ray watermarked result images (a) Original Image; (b) Watermark Image; (c) Watermarked Image; (d) Recovered Image for 0.5α; (e) Recovered Image for α and (f) Recovered Image for 2α.

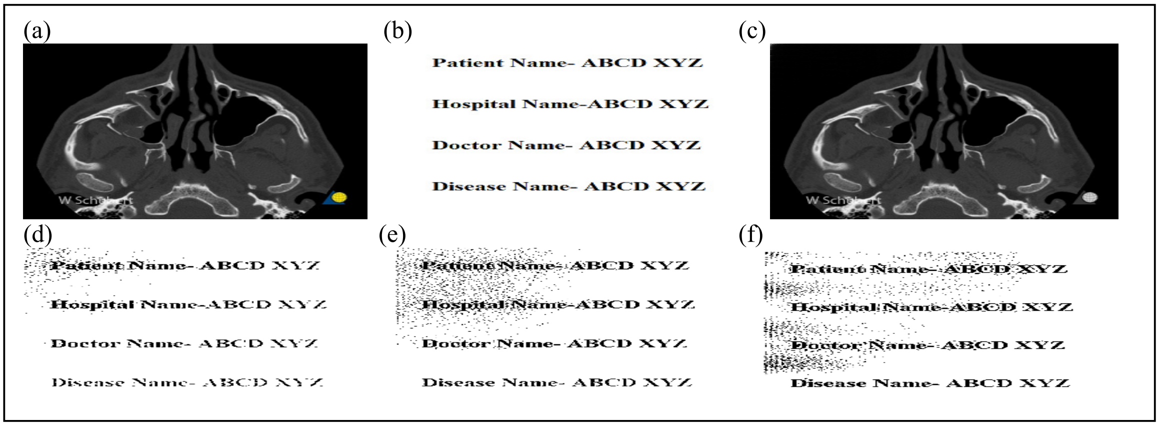

Fig. 3: CT scan watermarked result images (a) Original Image; (b) Watermark Image; (c) Watermarked Image; (d) Recovered Image for 0.5α; (e) Recovered Image for α and (f) Recovered Image for 2α.

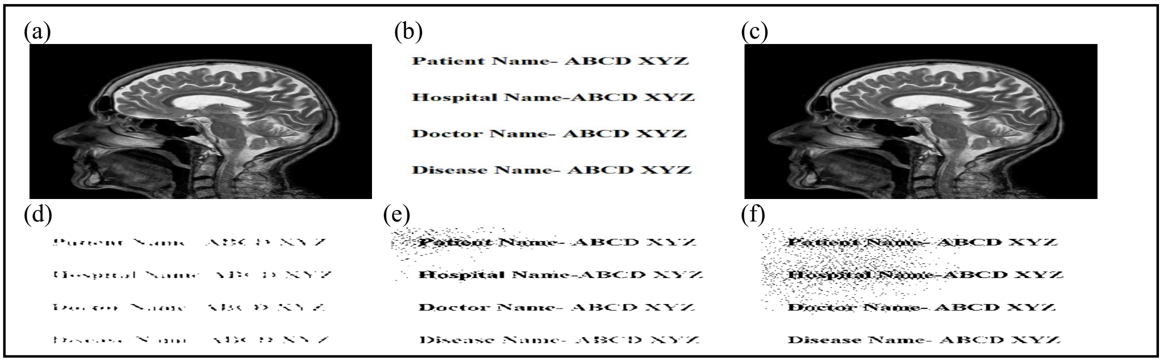

Fig. 4: MRI watermarked result images (a) Original Image; (b) Watermark Image; (c) Watermarked Image; (d) Recovered Image for 0.5α; (e) Recovered Image for α and (f) Recovered Image for 2α.

Figure 2, 3 and 4 show the results of watermarked image and recovered watermark with different embedding factor 0.5α, α and 2α. When using embedding factor 0.5α recovered watermark is distorted and information not proper visible but when using embedding factor α quality of recovered watermark increased and information of watermark is proper visible than 2α. So values of embedding factor α is good for watermarking process and provide better results as compared to 0.5α and 2α.

Table 1.The parameter values of X-ray watermarked images

Embedding Factor	0.5α		α		2α	
Watermarked Image	Correlation	PSNR	Correlation	PSNR	Correlation	PSNR
Image 1	1.0000	51.2618	0.9999	45.8936	0.9997	42.1269
Image 2	0.9999	47.2152	0.9996	42.7627	0.9991	38.7446
Image 3	0.9997	44.6871	0.9993	40.9331	0.9983	36.9066
Image 4	0.9999	48.5346	0.9998	44.7422	0.9993	39.9103
Image 5	1.0000	51.3470	0.9999	45.9591	0.9997	42.1799

Table 2.The parameter values of CT scan watermarked images

Embedding Factor	0.5α		α		2α	
Watermarked Image	Correlation	PSNR	Correlation	PSNR	Correlation	PSNR
Image 1	0.9993	43.6153	0.9982	39.4691	0.9955	35.4783
Image 2	0.9997	44.8320	0.9992	40.5158	0.9980	36.7341
Image 3	0.9995	44.8005	0.9987	41.0259	0.9965	36.6699
Image 4	0.9998	45.9857	0.9996	42.2091	0.9990	38.0833
Image 5	0.9998	48.5317	0.9996	45.9348	0.9987	40.9634

Table 3.The parameter values of MRI watermarked images

Embedding Factor	0.5α		α		2α	
Watermarked Image	Correlation	PSNR	Correlation	PSNR	Correlation	PSNR
Image 1	0.9997	48.2848	0.9993	44.3518	0.9983	40.6076
Image 2	0.9999	48.5840	0.9997	44.8224	0.9992	40.5040
Image 3	0.9999	51.2592	0.9997	45.8345	0.9993	42.0177
Image 4	0.9998	45.9359	0.9994	41.5449	0.9985	37.6678
Image 5	0.9997	45.7869	0.9991	41.3596	0.9975	36.8669

Above tables 1, 2 & 3 show results of watermarked image in form of PSNR and Correlation. The PSNR uses as the indicator to reflect the distortion introduced by the embedding algorithm usually the acceptable degradation level is 40 dB [15]. Watermarked image PSNR value in greater than 40 for good imperceptibility, and correlation is approximate 1 for lossless watermarking. Table 1 shows the results of X-ray images; table 2 shows the results of CT scan images and table 3 shows the results of MRI images with use of different value of α . Where α is embedding factor. Three different value of α is 0.5α, α and 2α are use in algorithm to find out the best result of parameters. When use the 0.5α as a embedding factor correlation and PSNR values are good but recovered watermark is distorted, but embedding factor value is α correlation and PSNR value are approximately same and recovered watermark quality is good and embedding factor value change to 2α recovered watermark distortion also increase. So α provide the batter result as compare to 0.5α and 2α.

6. Conclusion

The Proposed Algorithm of Medical Image watermarking is provided lossless medical image watermarking procedure; with embedding and extraction of the watermark which is basically patient information. The experimental results indicate the efficiency of the proposed scheme. The high value of PSNR represent that the image quality is not degraded and provide good visualization; the value of PSNR for proposed work of watermarked image with original image is 40 to 45 dB which is high enough to visualized the image data and it shows that propose algorithm provide imperceptibility and security of patient information.

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