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MULTILAYER SECURITY BASED ROBUST WATERMARKING TECHNIQUE FOR MEDICAL IMAGES IN DWT-DCT DOMAIN

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Abstract: This paper provides strongly robust digital image watermarking scheme for medical images using DWT-DCT domains. Security levels are increased by using different pn sequences, threshold values, summation of pn sequences, Arnold periodicity, Arnold scrambling, DWT and DCT domains. The medical images of 512x512 size used as cover images and grey scale hospital logo of 64x64 size is used as watermark and results are tested for 11 different values of flexing factor with middle and high frequencies then analysed and compared. The scheme gives PSNR up to 42.8846 and NC 0.9451 for high frequency sub band. The robustness with different noise and filtering attacks are tested and presented. Simple, symmetric, orthogonal 'Haar' wavelet is used for decomposition and direct flexing factor is used.

Keywords: Orthogonal, DWT-DCT, PSNR, Arnold, Transmission.

INTRODUCTION

Creations, copy, distribution and transmission of multimedia data have become common needs. Digital Image Watermarking provides copyright protection to digital images by hiding important information in original image to declare ownership. Perceptual transparency and robustness, capacity and blind watermarking are main features those determine quality of watermarking scheme [6]. Perceptual transparency means perceived quality of image should not be destroyed by presence of watermark. Robustness indicates resistance to different attacks like compression, scaling, rotation, cropping, noise attacks, sharpening, contrast adjustment etc. Perceptual transparency and robustness are two contrast measures. Hence, researchers strive for strongly robust with better perceptual transparency in watermarking schemes. The watermarking can be achieved either in spatial domain or in frequency domain. In spatial domain, watermark is embedded by directly modifying pixel values of cover image. These algorithms are simple in implementation. But problems with such algorithms are: Low watermark information hiding capacity, Less PSNR, Less Correlation between original and extracted watermark and less security, hence anybody can detect such algorithms. The Frequency domain the watermark is inserted into transformed coefficients of image giving more information hiding capacity and more robustness against watermarking attacks because information can be spread out to entire image [1]. In this paper a combined DWT-DCT based watermarking method is proposed providing multilayer security and robustness.

SURVEY

LSB based watermarking in spatial domain is the straightforward method, but once algorithm is discovered, watermark will be no more secured[3]. An improvement on LSB substitution is to use pseudo random generator to determine pixels to be used for embedding, based on given seed or key. Security of the method is improved but algorithm is not still completely secured[3]. In CWT, Calculating wavelet coefficients at every possible scale is huge amount of work, and it generates a lot of data. There is highly redundant information as per as the reconstruction of the signal is concerned. Due to the attractive features of Discrete Wavelet Transform, researches have been focused on DWT [15].Wang

Hongjun, Li Na have proposed a DWT based method [14] in which watermark was embedded in middle frequency coefficient using :

$$F'(u,v) = F(u,v) + \alpha W(u,v) \quad (1)$$

where, F(u, v) is wavelet coefficient, W is randomized binary watermarking, α is flexing factor with $\alpha = \beta\ |m|$,where m is mean value of all coefficients watermarking embedded. But this method doesn't provide enough security. The method proposed in [14] using DWT was extended in [15] to enhance security of algorithm by using Arnold's Transform pretreatment for watermark. As given in [16] two phase watermark embedding process was carried out using DWT. Phase 1: Visible watermark logo embedding, Phase 2: Feature extracted watermark logo embedding. The algorithm was based on Texture Based Watermarking. In 2008, as given in [17] using DWT, host image is decomposed into 3 levels recursively. In level one we get 4 sub bands. In level 2, each subband of level 1 is divided to 4 sub bands to give total 16 sub bands. Finally, each subband of level 2 is again divided into 4 sub bands each to give total 64 sub bands. Then' Generic algorithm' was applied to find the best subband for watermark embedding to provide perceptual transparency and robustness. But the process is too lengthy and time consuming. Some frequency based watermarking techniques are based on only Discrete Cosine Transform. But common problem with only DCT based watermarking is block based scaling of watermark image changes scaling factors block by block and results in visual discontinuity.[1][6][23][25].As given in [13], J. Cox et. al had presented 'Spread spectrum based watermarking schemes', Chris Shoemaker has developed CDMA based Spread spectrum watermarking with one scale DWT and got PSNR between 35-40 db for various attacks [26]. As given in [10], Harsh Varma et. al tested CDMA based watermarking scheme with spatial domain and frequency domain with DCT as well as DWT. But these algorithms have low information hiding capacity. Almost all CDMA based methods have low watermark information hiding capacity [24].

FOUNDATIONS OF OUR METHODOLOGY

A. DISCRETE WAVELET TRANSFORM (DWT)

ISO has developed and generalized still image compression standard JPEG2000 which substitutes DWT for DCT. DWT offers muti resolution representation of image and DWT gives perfect reconstruction of decomposed image. Discrete wavelet can be represented as

$$\psi_{j,k}(t) = a_0^{-j/2}\psi\,(a_0^{-j}t - k\,b_0) \qquad (2)$$

For dyadic wavelets a_0=2 and b_0=1, Hence we have,

$$\psi_{j,k}(t) = 2^{-j/2}\psi\,(2^{-j}t - k\,) \qquad j, k \in Z \qquad (3)$$

When image is passed through series of low pass and high pass filters, DWT decomposes the image into sub bands of different resolutions [6][18][19][20]. Decompositions can be done at different DWT levels.

LL1	HL1
LH1	HH1

Figure 1: One Level Image Decomposition

At level 1, DWT decomposes image into four nonoverlapping multiresolution sub bands: LL1 (Approximate sub band), HL1 (Horizontal sub band),LH1 (Vertical sub band) and HH1 (Diagonal Sub band). Here, LL1 is low frequency component whereas HL1, LH1 and HH1 are high frequency (detail) components [7][8][9]. Embedding watermark in low frequency coefficients can increase robustness significantly but maximum energy of most of the natural images is concentrated in approximate (LL) sub band. Hence modification in this low frequency sub band will cause severe and unacceptable image degradation. Hence watermark is not embedded in LL sub band. The good areas for watermark embedding are high frequency sub bands (HL, LH and HH), because human naked eyes are not sensitive to these sub bands.

B.DISCRETE COSINE TRANSFORM (DCT)

The discrete cosine transform (DCT) represents an image as a sum of sinusoids of varying magnitudes and frequencies. The DCT has special property that most of the visually significant information of the image is concentrated in just a few coefficients of the DCT [21]. It's referred as 'Energy compaction Property'. The DCT for image A with M x N size is given by:

$DCT_{pq} =$

αpαqm=0M−1n=0N−1Amn cos*π2m+1p2M*

$$\cos\left(\frac{\pi(2n+1)q}{2N}\right) \qquad (4)$$

Where,

$$0 \le p \le M-1 \text{ , and } 0 \le q \le N-1 \qquad (5)$$

$$\alpha_p = \begin{cases} 1/\sqrt{M}, & p = 0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases} \qquad (6)$$

$$\alpha_q = \begin{cases} 1/\sqrt{N}, & q = 0 \\ \sqrt{2/N}, & 1 \le q \le N-1 \end{cases} \qquad (7)$$

As DCT is having good energy compaction property, many DCT based Digital image watermarking algorithms are developed. It's already proved that DWT-DCT combined approach can significantly improve PSNR with compared to only DCT based watermarking methods.

C. ARNOLD TRANSFORM

Arnold Transform has special property that given image comes to it's original state after specific number of iterations. These specific number of iterations termed as 'Arnold Periodicity'. Hence Arnold Transform is used as efficient technique for increasing security in watermarking schemes [6]. The Arnold Transform of image is

$$\begin{pmatrix} x_n \\ y_n \end{pmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{pmatrix} x \\ y \end{pmatrix} (mod\ N) \qquad (8)$$

Where, (x, y) ={0,1,.....N} are pixel coordinates from original image. (x_n , y_n) are corresponding results after Arnold Transform. The periodicity of Arnold Transform (P), is dependent on size of given image. From equation: 11 we have,

x_n=x+y (9)

y_n=x+2*y (10)

If (mod (x_n, N) ==1 && mod (y_n, N) ==1)
then P=N (11)

OUR METHODOLOGY

The Watermark Embedding and Extraction Process for HL sub band is given below. Same procedure can be applied for HH and LH sub bands.

A) WATERMARK EMBEDDING

Step 1: Read Cover Image of 512x512 size and apply one level DWT. Consider HL1 sub band.
Step 2. Read grey scale watermark of 64x64 size.
Step 3: Depending upon Key K1, generate pn sequence for given watermark and calculate sum say SUM, which is summation of all elements in generated pn sequence
Step 4. Determine Arnold Periodicity P for given watermark.
Step 5: If SUM > T, where T is some predefined threshold value, then perform watermark scrambling by Key K2= P+ Count, else perform watermark scrambling by Key K3= P+ Count, where count is programmer defined counter. Here, we get 'Scrambled Watermark' by Arnold Transform.
Step 6: Generate two pn sequences: pn_sequence_0 and pn_sequence_1, depending upon sum of all elements of mid band used for DCT transformation.
Step 7: Perform watermark embedding using following equations:
If Watermark bit is 0, then

$$D' = D + K * pn\_sequence\_0 \qquad (12)$$

If Watermark bit is 1, then

$$D' = D + K * pn\_sequence\_0 \qquad (13)$$

Where D is matrix of mid band coefficients of DCT Transformed block and D' is Watermarked DCT block.
Step 8: Apply Inverse DWT and then apply Inverse DCT to get 'Watermarked_Image'.

B. WATERMARK EXTRACTION

Step 1: Read 'Watermarked_Image' and apply one level DWT to retrieve HL1 sub band.

Step 2: Use 4x4 size for DCT blocks. Generate two pn sequences: pn_sequence_0 and pn_sequence_1, depending Security levels are increased by using different pn sequences, threshold values, summation of pn sequences, Arnold periodicity, Arnold scrambling, DWT and DCT domains. 'Perceptual Transparency' is measured in terms of 'Peak Signal to Noise Ratio' which is given by:
embedding process, rand('state', 15) is used, then, same process is to repeated here.

Step 3: Extract mid band elements from DCT block and find correlation between 'extracted mid band coefficients and pn_sequence_0' as well as 'extracted mid band coefficients and pn_sequence_1'.

Step 4 Determine watermark bits as follows:
If correlation between 'extracted mid band coefficients and pn_sequence_0' is greater than 'extracted mid band coefficients and pn_sequence_1', then record watermark bit as 0 else record watermark bit as 1. Here we get 'Intermediate watermark'.

Step 5: Apply Arnold Scrambling to Intermediate watermark' to give final recovered watermark'

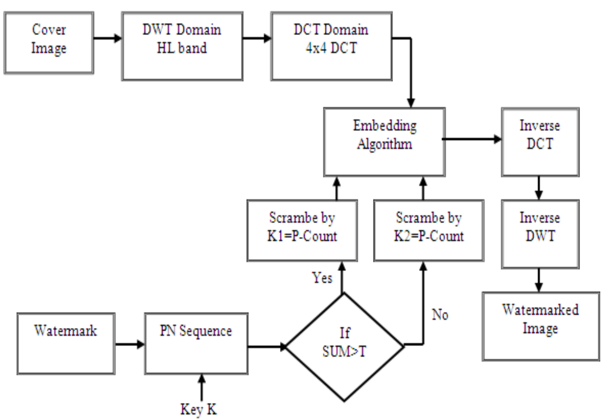


Figure 2: Block diagram for Watermark Embedding Process

EXPERIMENTAL RESULTS

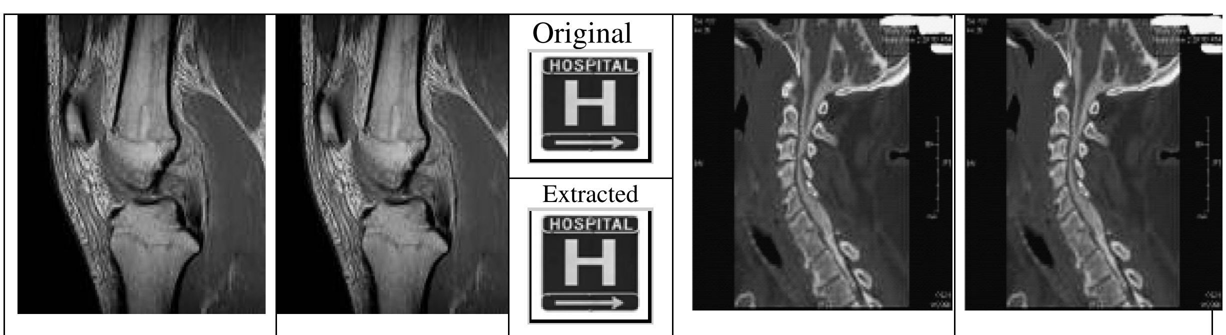
This paper is implemented in Matlab. The medical images of 512x512 size used as cover image and grey scale hospital logo of size 64x64 size is used as watermark. The scheme is also tested for middle and high frequency sub bands with different attacks like Noise addition, filtering etc. The performance is measured by: 'Perceptual Transparency' and 'Robustness'. The Perceptual Transparency' is measured by PSNR which is given by:

$$PSNR(db) = 10log_{10} \frac{(Max_I)^2}{\frac{1}{M*N}\sum_{i=1}^{M}\sum_{j=1}^{N}[f(i,j)-f'(i,j)]^2} \qquad (14)$$

Where, f (i, j) is pixel of original image. f '(i, j) is pixel values of watermarked image. Max_I is the maximum pixel value of image. Robustness is measure of immunity of watermark against attempts to remove or destroy it by image modification and manipulation like compression, filtering, rotation, scaling, collision attacks, resizing, cropping etc. Robustness is measured in terms of Normalized Correlation (NC). The correlation factor (Normalized Correlation) measures the similarity and difference between original 'watermark and extracted watermark[22] . The NC is given by:

$$NC = \frac{\sum_{i=1}^{N} w_i\, w_i{'}}{\sqrt{\sum_{i=1}^{N} w_i}\sqrt{\sum_{i=1}^{N} w_i{'}}} \qquad (15)$$

Where, N is number of pixels in watermark, wi is original watermark, wi' is extracted watermark. Experimental results show that scheme gives better PSNR 42.8846 and NC 0.9451for high frequency sub band. The test results for 11 different values of flexing factor at HL,LH and HH sub bands are presented and analysis is done. The results are shown in Table 1 and Figure 3, Figure 4 and Figure 5.



A) Original Cover Ortho_image	B) Watermarked Ortho_image	C)Water-marks	D)Original Cover Spinal Image	E) Watermarked Spinal Image

Figure 3: Experimental results for Medical Images with size 512x512 and Watermark of size 64x64

Table:1 PSNR and NC for different values of flexing factor in HL,LH and HH bands

Flexing Factor(K)	HL Sub band		LH Sub band		HH Sub band	
	PSNR	NC	PSNR	NC	PSNR	NC
5	42.8846	0.8627	42.8846	0.8732	42.8846	0.9439
6	41.3010	0.8770	41.3010	0.8945	41.3010	0.9439
7	39.9620	0.8920	39.9620	0.9058	39.9620	0.9451
8	38.8022	0.8955	38.8022	0.9125	38.8022	0.9451
9	37.7791	0.9061	37.7791	0.9214	37.7791	0.9451
10	36.8640	0.9107	36.8640	0.9230	36.8640	0.9451
11	36.0361	0.9168	36.0361	0.9248	36.0361	0.9451
12	35.2804	0.9193	35.2804	0.9308	35.2804	0.9451
13	34.5851	0.9252	34.5851	0.9325	34.5851	0.9451
14	33.9414	0.9252	33.9414	0.9340	33.9414	0.9451
15	33.3422	0.9282	33.3422	0.9365	33.3422	0.9451

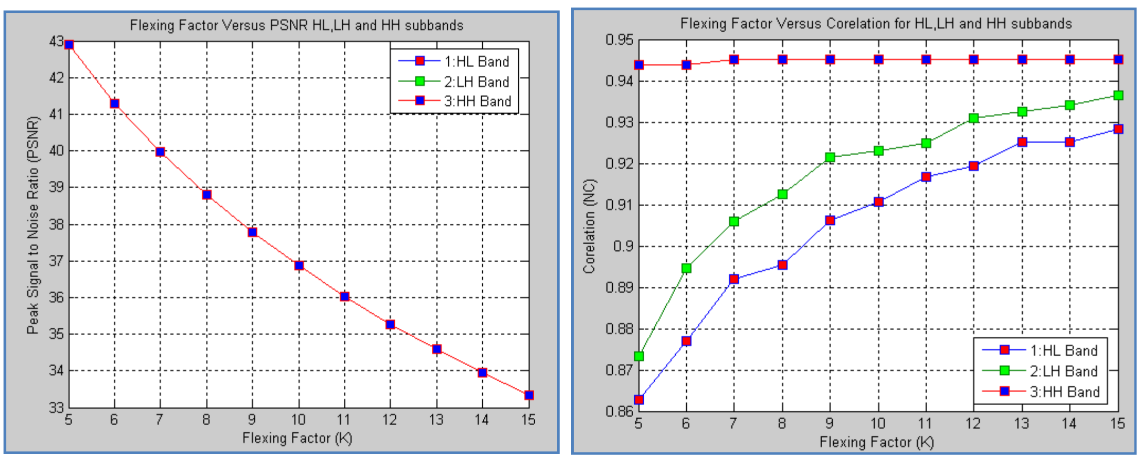


Figure:4 PSNR Versus Flexing factor and Correlation Versus Flexing Factor for HL, LH and HH sub band

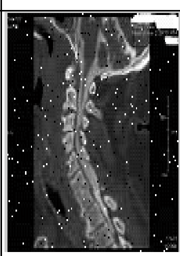
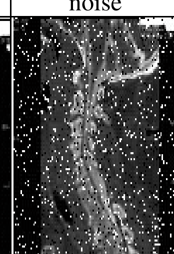
Attack Details	Salt and pepper 0.02 noise	Median Filtering	Salt and pepper 0.06 noise	Median Filtering	Salt and pepper 0.12 noise	Median Filtering
Water-marked Image						
PSNR	35.5976 : after filtering		35.013 :after filtering		33.738: after filtering	

Figure 5: Results of different Noise and filtering attacks on watermarked image in HL band for k=13

CONCLUSION

Experimental results show that our scheme provides multilayer security with DWT-DCT domain for medical images. The different pn sequences, threshold values, summation of pn sequences, Arnold transform, DWT and DCT domains are used for providing high security. The complete analysis of watermark embedding in middle and high frequency is provided. It is found that DCT –DWT based method provides good results with compared to only DCT based methods. We are getting maximum NC up to 0.9451 proving that extracted watermark is has much better quality.

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