Journal of Theoretical and Applied Information Technology
30th November 2015. Vol.81. No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A HYBRID ROI-EMBEDDING BASED WATERMARKING TECHNIQUE USING DWT AND DCT TRANSFORMS

[1]Osama Hosam, [2] Nadhir Ben Halima

[1]Asstt Prof., The City for Scientific Research and Technology Applications, IRI, Alexandria, Egypt

[2] Asstt Prof., Faculty of Computer Science and Engineering, TAIBAH UNIVERSITY, Saudi Arabia.

E-mail: [1]mohandesosama@yahoo.com, [2]nbenhalima@taibahu.edu.sa

ABSTRACT

Digital image watermarking is mainly used in copyright protection. We propose block based approach for watermarking images with their own ROI. The algorithm divides the image into 8x8 blocks. DWT transform is applied on each block. The extracted LL of the computed DWT is obtained and DCT is applied on LL to obtain LL-DCT coefficients. The watermark is embedded by changing the sign of LL-DCT coefficients of each block. In this paper we study the block perturbation properties, we found that the block embedding index is inversely proportional to watermark robustness; in addition we found that single 8x8 block can optimally hold single bit by changing the sign of the medium LL-DCT coefficient.

Keywords: *Image Watermarking, Discrete Cosine Transform, Discrete Wavelet Transform, Region of Interest, Embedding, Extraction, Human Visual System.*

1. INTRODUCTION

Watermarking is the art of hiding data into digital carriers. Watermarking is used mainly in copy right protection. The watermark is embedded into the digital carrier to make it robust to different types of attacks. Even if the watermark is visible to some algorithms, it must be robust to the degree that makes it impossible for the attacker to use the digital carrier after successfully removing the watermark.

Watermarking research started in 1990 [1], watermarking is mainly used for copyright protection such as protecting governmental documents [2]. The massive production of communication technologies and the insecurity of transferring digital data in digital channels made it urgent to find a method to protect digital media and secure digital communication.

Generally, any watermarking technique must have the following properties:

- Imperceptibility: This means embedding the secure information into the digital channel without detection from Human Visual System (HVS) or statistical methods.
- Robustness: This means the watermarking scheme must be robust mainly to affine transforms such as rotation, translation and scaling. In addition, it must be robust to geometrical attacks such as compression and noise addition.

Spatial domain watermarking techniques such as Least Significant Bit (LSB) are easily detected by Steganalysis tools [3]. Extensive approaches in literature concentrate on embedding the watermark in the frequency domain. Li and Wang [4] presented watermarking approach that modifies the quantization table of JPEG compression and inserts the secure data into the middle frequency coefficients.

Region of Interest (ROI) based watermarking is the art of hiding part of the image into the image itself for image content preserving. Generally, there are two different trends in ROI watermarking; the first trend which is frequently used in medical images [5] protects the medical image lesion zone. In this paper we refer it as ROI-BE or ROI Based Embedding. The embedding is done by ignoring ROI in watermarking; the ROI of the medical image refers to the area of lesion that contains the most important pathological information. If ROI is used in embedding, this may cause an erroneous diagnosis. The second trend is to use ROI as the watermark, and embed the watermark in all regions of the image with no intension to embed the watermark into specific image regions. We refer to this trend as ROI-E or ROI Embedding. ROI-E has many applications, such as protecting ROI such that

Journal of Theoretical and Applied Information Technology
30th November 2015. Vol.81. No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

it can be retrieved even after attacking the watermarked image. The authors in [6] proposed ROI-E watermarking approach to recover ROI after intentional and non-intentional image attacks. In ROI-BE the algorithm can be broadly depend on ignoring visual attention area in the watermark embedding process. The Visual Attention Model (VMA) [7] is calculated and ignored in image watermarking. DWT based watermarking approach with VMA ignorance is developed in [8]. In this paper we proposed ROI-E approach to embed ROI into the image. The algorithm embeds the watermark into the median values of LL-DCT by changing its sign. The main contributions of this paper are:

- Developing ROI-E approach by combining DCT and DWT.
- Exploring the effect of changing the sign of LL-DCT coefficient and its value too. In the results section we proposed Trade off parameter that can control the trade-off between the watermarking quality and robustness.
- Exploring the effect of using the low, medium and high LL-DCT coefficients for embedding, and developing a relationship between "embedding index" and robustness.

The remaining of this paper is organized as follows, first, DCT transforms is explored and an extensive background about DCT watermarking approaches is introduced. A short survey about the related work is then presented, and finally the proposed algorithm is introduced with the results and discussion.

2. TRANSFORM DOMAIN WATERMARKING

Transform domain techniques embeds the watermark into the frequency coefficients of the image. The watermark is spread all over the image, thus making the watermark more robust to image manipulation attacks than spatial domain approaches. In addition frequency domain watermarking techniques are compatible with existing compression techniques in particular the JPEG standard, such types of watermarking ensures high performance when the watermarked image is subject to lossy compression. Compressions are mostly important in internet browsing and image transformation on the internet and mobile networks. Referring to JPEG compression standard, the watermark is embedded in the quantization step of JPEG compression. an example of this presented in Li and Wang [9] approach. The authors presented watermarking approach that modifies the quantization table of JPEG compression and inserts the secure data into the middle frequency coefficients. Their new version of quantization table provides 36 coefficients in each 8x8 block. Watermarking based on DCT (Discrete Cosine Transform) of JPEG compression contains several stages, JPEG compression is shown in Figure 1. Watermarking is done in the quantization step to avoid losing the secure data.

Figure 1. JPEG compression stages. Watermarking is done in the quantization step of JPEG compression.

To embed a watermark in the frequency domain, the transformation is applied on the original image then the transform coefficients are perturbed to embed the watermark. Two common transformation are frequently used, namely DCT and DWT [10], we are going to investigate DCT approach in detail.

The transform domain watermarking general outline is presented in Figure 2. The image is transformed by using either DCT or DWT, and then the transformed image is used to embed the watermark by perturbing the transform coefficients. The watermarked image is obtained by taking the inverse transform of the perturbed transformed image. The watermark extraction is the inverse process of watermark embedding as illustrated in Figure 3.

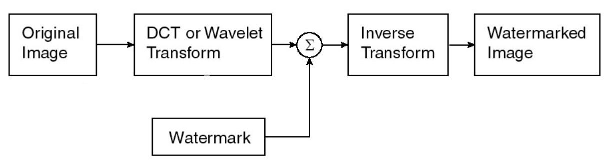

Figure 2. Block diagram of the watermark insertion process

The watermarked image is transformed either by using DCT and DWT then we have two types of watermark extraction

- Non-blind watermarking: in which the original image is used in the extraction process. So the transformed image is compared with the transform of the original image. From the difference between both transformed images the watermark can be extracted.
- Blind watermarking: In which the original image is not used in watermark extraction. As

Journal of Theoretical and Applied Information Technology
30th November 2015. Vol.81. No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

an example of such techniques is proposed by Osama [11].

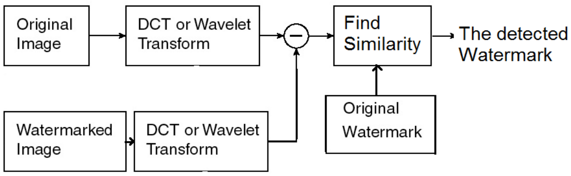

Figure 3: Block diagram of the transform domain detection process in non-blind watermarking techniques.

Discrete Cosine Transform Watermarking

In DCT the image can be represented by a collection of sinusoids of different magnitude and frequency. DCT transforms the image domain from spatial domain to frequency domain. According to Human Visual System (HVS) capability, the human eyes can detect the change in low frequency components of an image. Most DCT based watermarking approaches embed the watermark either in the middle frequency bands or high frequency bands [11]. DCT has relatively high performance compared to other transforms. It has been used in JPEG standard for image compression.

The DCT definition of a 1-D sequence of length N is :

$$C(u) = \alpha(u) \sum_{x=0}^{N-1} f(x) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \quad (1)$$

for $u = 0,1,2,\dots,N-1$. Similarly, the inverse transform is defined as:

$$F(x) = \sum_{u=0}^{N-1} \alpha(u) C(u) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \quad (2)$$

for x= 0,1,2,…,N− 1 . In (1) and (2) α(u) is defined as:

$$\alpha(u) = \begin{cases} \sqrt{1/N}, & u = 0 \\ \sqrt{2/N}, & u \neq 0 \end{cases} \quad (3)$$

The 2-D DCT is a direct extension of the 1-D sequence. 2-D DCT is defined as:

$$C(u,v) = \alpha(u)\alpha(v) * \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right], \quad (4)$$

Where $C(u,v)$ is the resulting DCT coefficient at the coordinates (u,v), $\alpha(u,v)$ is same in Equation(3), C is the two dimensional square array of size $N \times N$, and $u, v = 0,1,2,\dots,N-1$.
The inverse DCT transform is defined as:

$$f(x,y) = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} \alpha(u)\alpha(v) C(u,v) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right], \quad (5)$$

Where: $x, y = 0,1,2,\dots,N-1$.
The first transform coefficient in the block is the average value of the sample so at location (0,0). In the two dimensional $N \times N$ block, the value for $\alpha(u,v)$ is $\sqrt{1/N}$, this value is referred to as the DC coefficient. All other transform coefficients are called AC coefficients and have $\alpha(u,v)$ equal to $\sqrt{2/N}$ [12]. The DCT transformed image is basically divided into non-overlapping blocks. each block is 8x8 components. The DCT coefficients are depicted in Figure 4.

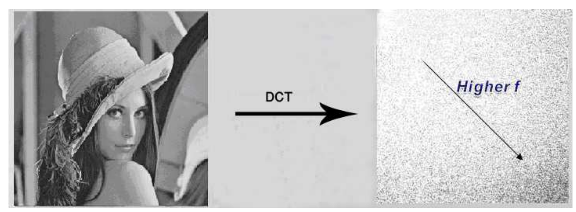

Figure 4. The DCT transform of the Lena image showing the absolute values of the coefficients corresponding to the low frequencies are higher and appear in the up-left corner of the square, while high frequency coefficients appear in down-right with lower absolute values.

The low frequency components have higher coefficient values and appear at the upper left corner of the image. The first component at the upper left corner is the DC value and the remaining components are referred as AC components. The high frequency components appear at the lower right corner of the image and represents lower coefficient values. The energy of the natural image is concentrated in the lower frequency bands of the transformed image. If the watermark is embedded in the lower frequency bands it may be removed after compression. It is better to select range of middle frequency components for watermark embedding [13].

DCT based watermarking is more robust than tradition spatial domain watermarking techniques [14]. DCT watermarking techniques are robust against simple image processing procedures such as compression, low pass filters, high pass filters, and band-pass filters; and also robust to noise additions such as salt and pepper, white noise and Gaussian noise. They are more complex in implementation

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

and computationally expensive. DCT watermarking can be classified into Spread Spectrum DCT watermarking and Block based DCT watermarking [15]. In spread spectrum watermarking [16], the main idea is to spread the watermark over many frequency values so it has little effect on the image energy at that value, and hence will not be detectable.

In Block based DCT watermarking, as an example of this type can be found in [17]. The algorithm is divided into two parts: a part for watermark embedding, and a part for watermark detection. In watermark embedding, the image is initially divided into 8×8 blocks and is converted into the frequency domain using 2D DCT. Two pseudo-randomly selected positions in each of the 8×8 blocks are initially determined to carry the watermark data. In the watermark recovery, the watermarked image is divided again into 8×8 blocks and converted to the frequency domain using 2D DCT. The same two pseudo-randomly selected positions in the embedding process are used.

We proposed watermarking approach with combining both DWT and DCT. Depending on the fact that changing the sing of the obtained LL-DCT coefficients is not affecting the watermarked image quality. After attacking the watermarked image, LL-DCT values can be changed but the signs are not changed.

3. RELATED WORK

Tung et. al. [18] proposed ROI based watermarking algorithm by embedding ROI into Region of Background (ROB) of the same image. ROI watermark is coded into binary sequence using DPCM (Differential Pulse Code Modulation) and ECC (Error Correct Code) technique. The Torus automorphism technique is applied to add more security layer by adding both diffusion and confusion properties to the watermarking technique. The original image is decomposed into L-Levels Wavelet coefficients. The sub-bands of ROB is selected and used for embedding by perturbing their coefficients. Their approach is not robust to attacks, they have an average PSNR=27 dB of the watermarked image after attack. In addition, after embedding without attack they obtained an average PSNR=30 dB of the watermarked image.

Ali [19] proposed combined DWT and DCT watermarking. The watermarking is done by carefully selecting DWT sub-bands for embedding followed by DCT transform on the selected sub-band. DWT is applied on the cover image to extract LL1, HL1, LH1, HH1 sub-bands. DWT is applied again on HL1 only to extract LL2, HL2, LH2, HH2. HL2 is then selected for embedding by dividing it to 4 x 4 blocks. DCT is applied on each 4 x 4 HL2 blocks. The coefficients are sorted in descending order; the mid-band coefficient is used for embedding single bit of the watermark. The difference between our proposed method and mentioned method in [19] is that the author divides HL2 into blocks, but in our proposed method we introduce the blocking to the host image.

In [20, 21] a similar approach has been introduced by both authors. In their approach, the watermark is extracted from the image as ROI. DWT is applied on ROI to obtain LLr,HLr, HHr, LHr, LLr,LLr is then used as the watermark. The carrier image is divided into 8 x8 non-overlapping blocks. DWT is applied on each block to obtain LLs,HLs,HHs, LHs. LLs is used as the watermark carrier for each block. Each block's LLs carried single value of ROI's LLr. r and s is used here to differentiate between wavelet coefficients of the ROI and The block respectively. The criteria of changing block's LLs with a single value of ROI's LLr is to find the nearest coefficient in LLs that has the minimum difference with the current value of ROI's LLr.

Osama [11] proposed an efficient and fast method is proposed for embedding the watermark into the highest DCT coefficient values. The author didn't propose block based approach; instead DCT transform is applied on the whole image. In [5] the authors proposed new watermarking approach for protecting medical images with multiple watermarks. The algorithm avoids the tedious selection of ROI in most medical image watermarking approaches. They provided the algorithm with robustness to image attacks but still they ignored the quality of the watermarked images which is around 20, PSNR=20 dB. In their algorithm, DCT is applied to the whole image and high value coefficients are selected for embedding a sequence of binary bits. The embedding is done by changing the coefficient sign. The algorithm depends on the fact that embedding in higher value coefficients is more robust to noise attacks than lower value coefficients. An extensive study will be introduced in this paper to view the above fact from different angles.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4. THE PROPOSED WATERMARKING APPROACH

We have implemented combined DWT-DCT watermarking technique for embedding the region of interest for an image into the image itself. DWT is applied onto the image and then DCT is applied onto the lower bands LL of DWT, so we refer to the proposed algorithm as LL-DCT based embedding. With the same analogy, the inverse LL-DCT means applying DCT inverse then DWT inverse. ROI is the fundamental portion of an image it can completely identify an image. The algorithm has two phases, watermark embedding and watermark extraction. The watermark embedding procedure mainly focuses in embedding into the middle frequency band of the LL-DCT coefficients. The embedding is done by changing the sign of the corresponding coefficient. LL-DCT coefficients with high values represent zero frequency values or DC values; on the other hand, LL-DCT coefficients with low values construct the high frequency bands of the image. Embedding in both ranges will be noticeable by HVS. We embed the watermark into the medium frequency bands. The algorithm is not applied on the whole image; instead the image is divided into 8 x 8 blocks, LL-DCT transform is applied on each block separately, the median value of each block will be perturbed by changing its sign to embed the desired watermark.

4.1 LL-DCT Watermark embedding

The embedding procedure extracts ROI manually; user can select any region in the image to embed it into the carrier image as a watermark. The carrier image is divided into non-overlapping 8 x8 blocks. LL-DCT is calculated for each block the values are sorted in ascending order. The median value is calculated for each blocks' LL-DCT coefficients; the median values will be the carrier coefficients; In parallel; ROI will be converted to a vector W. The watermark value is embedded then the watermarked block is returned back by taking the inverse LL-DCT transform. the proposed watermark embedding procedure is shown in Figure 5.

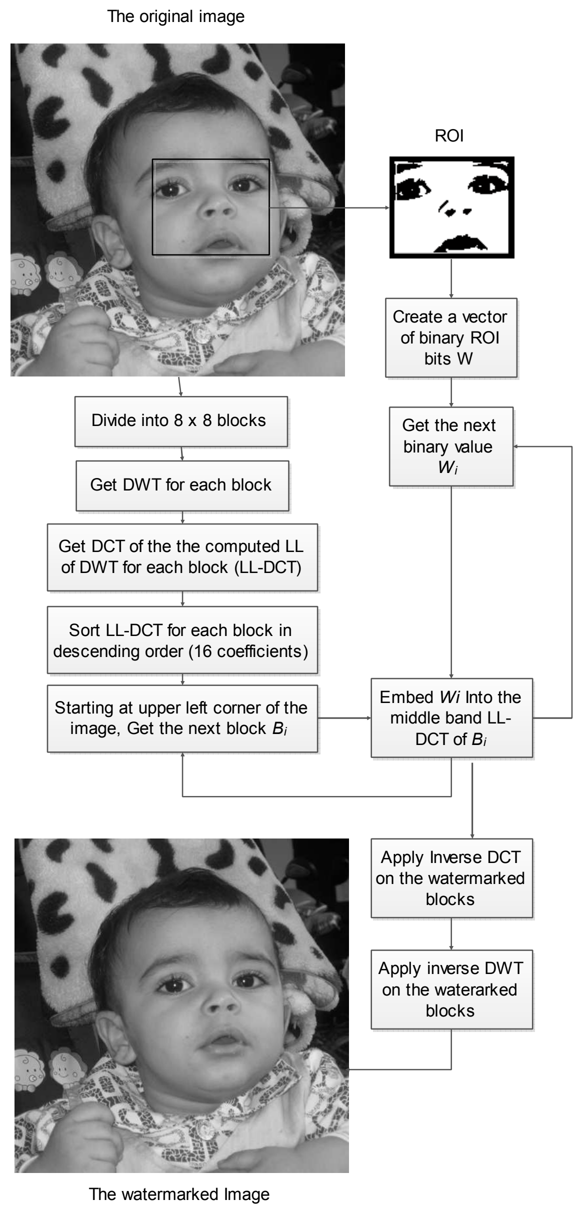

Figure 5. The Proposed Watermark Embedding Procedure

The watermarking process contains the following steps.

Step 1: Extract the region of interest (ROI) from the original image by manually selecting the portion of the image which best describes the whole image. The extracted ROI is depicted by R and its size is r x c the selected ROI is better selected as square region (r=c) so processing can be handled easily.

Step 2: Apply gray-scale to binary transform with best threshold to get ROI binary image R_t.

Step 3: Convert R_t to a vector W which contains the watermark values to be embedded. Hold the next value to be embedded into W_i.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Step 4: Divide the image *I* of size *n x m* into *8 x 8* non-overlapping blocks. The block size S_b can be decided according to the watermark length L. So the number of blocks $N_b >= L$. We can use equation (2) to decide the best S_b.

$$f = \sqrt{\frac{mxn}{N_b}} \qquad S_b = \left\lfloor \frac{f}{2} \right\rfloor \times 2 \qquad (6)$$

Step 5: Get the next block *B(b,d)*, where *b, d* are the indices of B's first pixel located at the upper left corner of B. *b, d* is incremented by 8 in each iteration.
Step 6: Apply LL-DCT transform on B to obtain B_t with 4 x 4 size.
Step 7: Convert B_t to vector *V*.
Step 8: Get the median value of V. When V length is odd the formula is:

$$x_m = x_{\frac{n+1}{2}} \qquad (7)$$

When V length is even the formula is:

$$x_m = \frac{x_{\frac{n}{2}} + x_{\frac{n+2}{2}}}{2} \qquad (8)$$

Step 9: Go to step 3 to get the next W_i.

Step 10: Change the sign of the median value (*M* value) at position x_m according to W_i value using the following formula

$$M = \begin{cases} -T_{doff} \times |M| & W_i = 0 \\ T_{doff} \times |M| & W_i = 1 \end{cases} \qquad (9)$$

where T_{doff} is user specified parameter.
Step 11: Repeat Step 9 and Step 10 until *i= L*. Get the inverse LL-DCT of all blocks after changing their median values.

4.2 DCT Watermark extraction

The extraction is similar to the procedure of embedding as shown in Figure 6; the original image is divided into 8 x 8 non-overlapping blocks. DWT transform will be applied on each block then DCT is calculated for LL sub-bands. The median value of the transformed blocks will be obtained and put into a vector M. The sign of M values will be used to restore back the watermark bits and rearrange them from vector to matrix. The following procedure is used in the extraction process.
Step 1: Divide the image I_s *(the watermarked image)* of size *n x m* into *8 x 8* non-overlapping blocks. The block size S_b can be decided according to the watermark length L. So the number of blocks $N_b >= L$. use equation (6) if a block size other than 8 x 8 is selected in the embedding procedure.

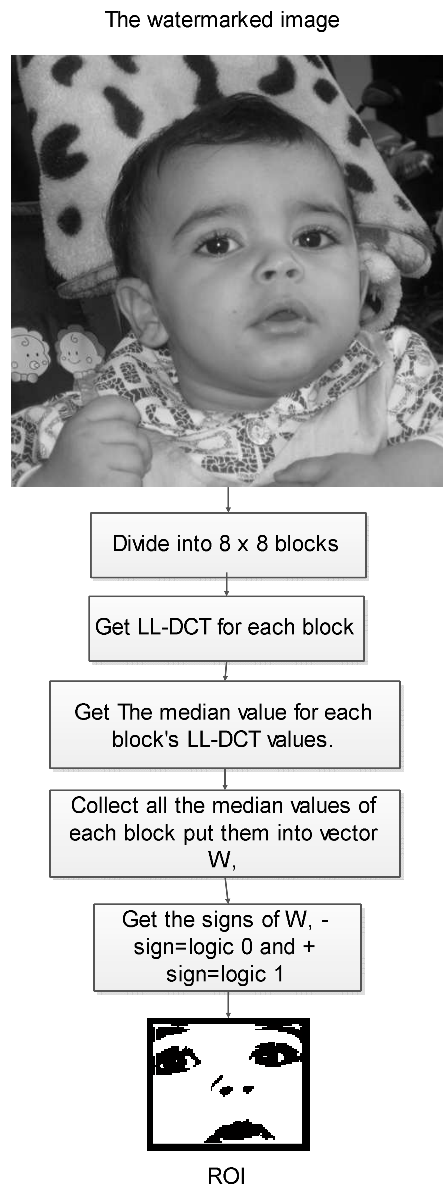

Figure 6. The Proposed Watermark Extraction Procedure

Step 2: Get the next block *B(b,d)*, where *b, d* are the indices of *B*'s first pixel located at the upper left corner of *B*. *b, d* is incremented by 8 in each iteration.
Step 3: Apply LL-DCT transform on B to obtain B_t its size is 4x4
Step 4: Convert B_t to vector *V*.
Step 5: Get the median value of *V*. use equations (7) , (8).

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Step 6 : Go to Step 2, iterate number of steps = N_b, when finished put all the median values into single vector *M*. Note that *M* length is N_b

Step 7: The signs of *M* is representing the binary values. *W* vector can be obtained using the following equation

$$W_i = \begin{cases} 0 & if\ M_i is\ negative \\ 1 & if\ M_i\ is\ positive \end{cases} \quad (10)$$

W vector must be reshaped to square matrix of size *r x c* by using the following formula

$$r = c = \sqrt{L} \quad (11)$$

The resulting *W* matrix is ROI.

5. QUALITY MEASURES

The evaluation of the watermarking process is done according to the quality of the extracted watermark and the watermarked image. Using the quality measures, robustness of the watermarking procedure can be evaluated especially when the watermarked image is attacked. The attack can differ from adding noise to trying to remove the watermark from the watermarked image. The main objective is to make sure that the quality of the image after watermarking is still acceptable. To evaluate the quality of the watermarked image we introduced MSE, PSNR, SF and SSIM [22]

We are introducing here the most common measures used in comparing the quality of images in watermarking approaches; namely the Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR). MSE defines the image as collection of numbers contained in a matrix and calculates the accumulated average of squared error measured between the original image and the watermarked image. PSNR is a measure of the peak error. MSE gives estimation of the difference between both images. MSE of 0 means no difference between the original image and the distorted image. Given an image *I (i, j)* and an image *K (i , j)* of equal dimensions, the MSE is defined to be:

$$MSE = \frac{1}{m*n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \quad (12)$$

where M and N are the dimensions of the image. MSE is often used as a measure between two images because it measures the energy of the difference between both images which simplifies calculations of typical MSE since image processing transforms are typically energy preserving.[23]

Another common performance measure is used frequently in image processing is PSNR. it measure the ratio between the maximum possible power of the signal and the possible percentage perturbation of the signal or the added noise. The quality of the original image *I(i,j)* with *NxM* pixels and the watermarked images *K(i,j)* with *NxM* pixels are calculated using the following formula:

$$PSNR = 10 * log_{10}(\frac{MAX_I^2}{MSE}) \quad (13)$$

where MAX_I is the maximum intensity value of the image pixels.

MSE and PSNR have an inverse relationship, i.e large values of PSNR means high quality of embedding and high similarity between the compared images. While large values of MSE means lower similarity and high degradation of the watermarked image compared to the original image. This comes from the fact that PSNR measure a ratio between the signal and noise or S/N where S is the signal and N is the noise. So large values of S means large value of the ratio and small values of Noise leads also to large values of the ratio. PSNR is measured in units of decibels (dB). PSNR of value 40 dB means the watermarked image and original image are indistinguishable by Human Visual System, typically most watermark approaches get embedding quality ranges from 30 to 40 dB's. To evaluate the watermarking technique the following equation is used

$$SNR = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} I^2(i,j)}{\sum_{i=1}^{M} \sum_{j=1}^{N} [I(i,j) - I_w(i,j)]^2} \quad (14)$$

OR,

$$SNR_{dB} = 10 * \log_{10} \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} I^2(i,j)}{\sum_{i=1}^{M} \sum_{j=1}^{N} [I(i,j) - I_w(i,j)]^2} \quad (15)$$

where I , I_W are original image and watermarked image respectively.

The Structural SIMilarity (SSIM) [24] index is a method for measuring the similarity between two images. For calculating SSIM, the quality measure is considered between two images assuming one of them in perfect condition. SSIM proposed extracting the luminance from the scene since it doesn't affect the object structure in the image. The difference between SSIM and other approaches such as MSE and PSNR is that these approaches concentrate on calculating the perceived error; but SSIM considers the error as the perceived degradation in the structural information of the objects in the scene. Structural information is considering the inter-dependence of pixels inside the image which carry very important information about the structure of the object in the visual scene. SSIM is measured using the following formula:

$$SSIM(x,y) = \frac{(2\mu x\mu y + c1)(2\sigma xy + c2)}{(\mu_x^2 + \mu_y^2 + c1)(\sigma_x^2 + \sigma_y^2 + c2)} \quad (16)$$

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

where μ_x the average of x, μ_y the average of y, σ^2_x the variance of x, σ^2_y the variance of y, σ_{xy} the covariance of x and y, $c1=(k_1L)^2$, $c2=(k_2L)^2$ are two variables to stabilize the division with weak denominator, L the dynamic range of the pixel-values (typically this is $2^{\#bits\ per\ pixel}-1$) and $k1=0.01$ and $k2=0.03$ by default.

6. RESULTS AND DISCUSSION

In this section, the results of embedding 8-bits in each block are introduced with analysis of the results. The results of embedding single bit in each block are then introduced with a comparison of the proposed 8-bits embedding with respect to watermarked image quality and watermark robustness.

6.1 Embedding 8 bits in each block

The original image is divided into 8x8 blocks. DWT of each block is obtained then the DCT of the obtained DWT LL sub-band is obtained. So we have DCT of LL or LL-DCT. If LL-DCT for each block is sorted in descending order, the smallest coefficients can be considered as the watermark carrier coefficients. As shown in Table1. The smallest coefficients for Block 1 are -8.7500 -5.9384 4.2702 -3.8018 3.4482 -2.0000 1.6203 -1.6060. The sign of the LL-DCT coefficient can be considered as the watermark logic. So Block one can embed -1 -1 1 -1 1 -1 1 -1 or 0 0 1 0 1 0 1 0 if -1 sign is considered as logic 0 and +1 sign is considered as logic 1. For embedding ROI with 8-bits depth color or gray scale with 2^8 levels, in this case pixel intensities range from 0 to 255 values. Single pixel value (8 bits) can be embedded into the smallest coefficients or the high frequency bands of each block. This can be done by changing the sign of the corresponding low coefficients. As an example, to embed gray intensity with value 6, the binary equivalent is obtained which is 0 0 0 0 0 1 1 0, then the signs of smallest LL-DCT is changed considering the smallest coefficient carries the LSB this logic is embedded into Block9 Table 1.

Changing the high frequency bands is not affecting the quality of the watermarked image. The algorithm is applied on 'lena' image with an objective to find the effect of changing the signs of the LL-DCT lowest coefficients. Lena image is 512x512 grays image with 8 bits color depth. The image is divided into 8x8 blocks to obtain 64x64 blocks or 4096 blocks. ROI is selected toward lena's mouth with 60 pixels width and 60 pixels height. So, ROI of 60x60=3600 pixels will be embedded into the carrier image. 3600 blocks only will be needed for embedding the entire ROI. In each block the sign of lowest LL-DCT coefficients will be changed. Upper part of Figure 7 shows the original Image and the Watermarked image after embedding ROI of 3600 pixels.

Table 1: Sorted LL-DCT For 9 Blocks Of "Lena" Image.

Block 1	Block 2	Block 3	Block 4	Block 5	Block 6	Block 7	Block 8	Block 9
878.7500	1.1181	1.2345	1.6764	1.1426	1.0417	1.0461	1.0652	1.2560
149.3632	0.0480	0.0483	-0.1041	-0.1144	-0.0476	-0.0463	0.0252	0.0320
-59.0000	0.0182	0.0395	-0.0799	0.0249	0.0279	-0.0179	0.0928	0.0100
57.4967	-0.0050	0.0211	-0.0153	0.0216	-0.0112	-0.0164	0.0264	-0.0095
-44.5202	0.0044	0.0161	0.0138	-0.0089	0.0085	0.0153	-0.0218	-0.0048
19.5817	0.0043	-0.0130	0.0088	0.0077	-0.0083	0.0070	-0.0165	-0.0030
13.6765	0.0032	-0.0062	-0.0084	-0.0074	-0.0070	0.0054	-0.0101	-0.0029
11.0701	-0.0032	-0.0056	0.0074	-0.0059	0.0051	0.0049	0.0073	0.0026
-8.7500	***-0.0031***	***-0.0052***	***0.0069***	***-0.0057***	***0.0047***	***0.0043***	***-0.0065***	***-0.0018***
-5.9384	***-0.0023***	***0.0045***	***-0.0055***	***0.0045***	***0.0046***	***0.0036***	***0.0058***	***-0.0013***
4.2702	***-0.0019***	***-0.0031***	***0.0045***	***-0.0036***	***0.0039***	***0.0035***	***0.0045***	***-0.0012***
-3.8018	***-0.0014***	***-0.0026***	***0.0022***	***-0.0035***	***-0.0035***	***0.0033***	***0.0029***	***-0.0011***
3.4482	***-0.0009***	***0.0017***	***-0.0019***	***0.0021***	***-0.0034***	***0.0029***	***0.0020***	***-0.0008***
-2.0000	***0.0008***	***0.0013***	***-0.0019***	***0.0013***	***-0.0025***	***0.0027***	***-0.0020***	***0.0005***
1.6203	***-0.0005***	***-0.0008***	***-0.0015***	***0.0009***	***-0.0014***	***0.0027***	***-0.0018***	***0.0003***
-1.6060	***0.0002***	***0.0003***	***0.0010***	***-0.0005***	***0.0000***	***-0.0023***	***-0.0005***	***-0.0001***

Journal of Theoretical and Applied Information Technology
30th November 2015. Vol.81. No.3

ISSN: **1992-8645** www.jatit.org E-ISSN: **1817-3195**

Instead of only changing the sign of the lowest coefficients, we tried to change the value too. We multiplied each coefficient with a parameter, we call it T_{doff} parameter, T_{doff} parameter is analogous to gain factor α [2]. So the coefficient sign will be changed and the new value is equal to T_{doff} parameter with the required sign. Lower part of Figure 7 shows the extracted watermark when embedding with different values of T_{doff}parameter. The original watermark or ROI is shown at the left side, the remaining images from left to right shows the extracted watermark after embedding ROI with different T_{doff} parameters ranges from 1 to 4. The experiment results are shown in Table 2. The lower part of Figure 7 shows the first 4 rows of Table 2. Table 2 shows that when using T_{doff}<= 2 there is noise encountered when extracting the watermark, this can be shown by examining SSIM values for each corresponding T_{doff}. ForT_{doff} values greater than 2 the extracted watermark is noiseless. The noise is encountered due to the sensitivity of the lowest LL-DCT coefficients to any change transform application. When the value of the coefficients increased, the coefficient values will be more robust to transform application.

Table 2: The Effect Of Tdoff Parameter On The Embedding Quality.

T_{doff}	PSNR	MSE	SSIM
1	40.4420	5.4216	0.2796
2	40.1751	5.7652	0.9995
3	39.7627	6.3395	1
4	39.2443	7.1432	1
5	38.6595	8.1729	1
6	38.0429	9.4196	1
7	37.4155	10.883	1
8	36.7781	12.604	1
9	36.1565	14.543	1
10	35.5590	16.688	1

From Table 2 it is shown that when increasing T_{doff}value the quality of the image decreases (PSNR decreases) and the error increases (MSE Increases). However increasing T_{doff} means more strength in extracting the embedded watermark (SSIM is stable for T_{doff}> 2). So we have tradeoff between image quality and watermark extraction strength. This is the reason of the T_{doff} name of that parameter. Since

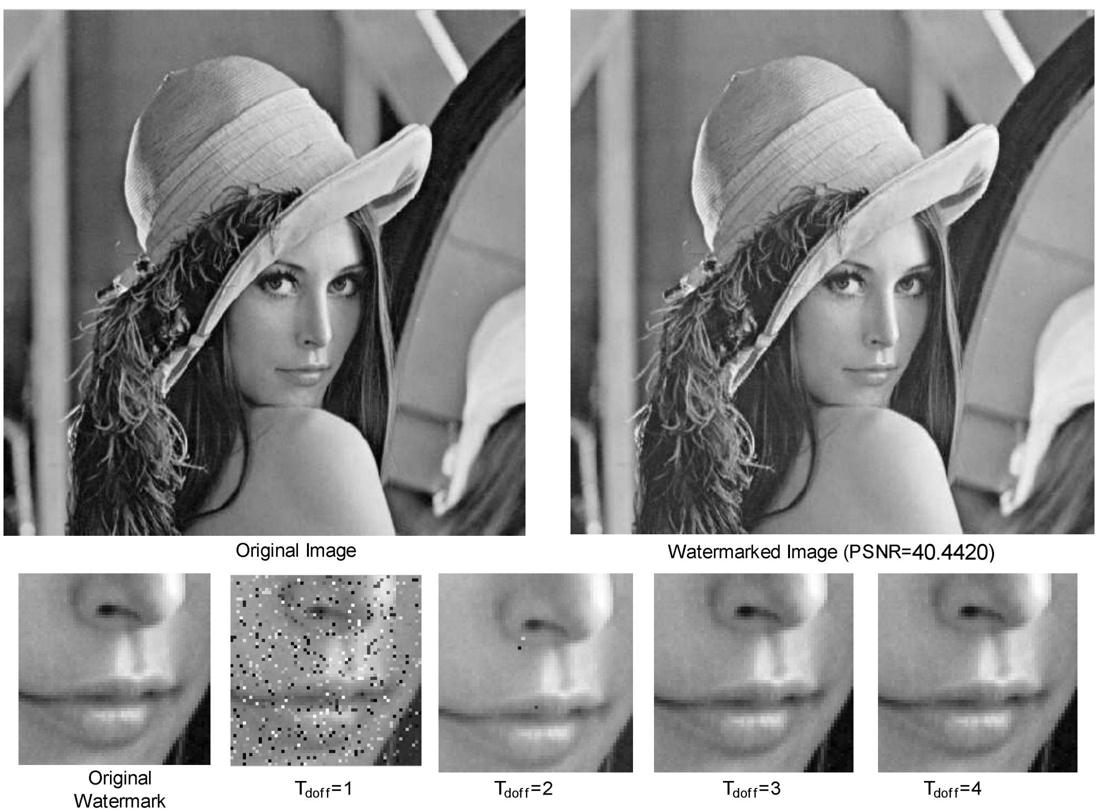

Figure 7.The Effect Of Tdoff Parameter On Embedding And Extraction Of The Watermark. Embedding Is Done By Changing The Lowest LL-DCT Coefficients

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

embedding quality is about 40 dBs for T_{doff} approximately equal 3, HVS can't discriminate the watermarked image and original image. Figure 8 shows the results of embedding 8 bits in each of 8 x 8 blocks of 512 x 512 images. PSNR is 37.64, 39.89, 40.39, 33.45, 36.40 dB for 'F16', 'Lena', 'Pepper', 'baboon', and 'sail boat' watermarked images respectively. From the figure; the highest PSNR value is for 'Pepper' image and the lowest PSNR is for 'baboon' image. Pepper image has extensively large amount of low frequencies, it appears at the smooth bodies of the peppers. As opposite to 'baboon' which contains an extensive amount of high frequency components. In the embedding process, data is embedded into the high frequency components of the LL-DCT. In other words, the embedding perturbs the high frequency components and leaves the low frequency components intact. 'baboon' has mostly high frequency bands which will be perturbed and consequently the corresponding 'baboon' watermarked image quality will be reduced. 'Pepper' image includes low bands more than high bands, in the embedding process, perturbation will not affect the low bands and consequently the corresponding 'Pepper' watermarked image quality is not affected. In other words, the most efficient host images used for LL-DCT watermarking are the images with mostly low frequency bands. $T_{doff} = 3$ is applicable to all images and hence is the optimal value that can be used in embedding.

The algorithm is robust to JPEG compression. We test the embedding procedure against JPEG compression. For example we applied JPEG compression with 30% on the 512x512 'F16' image, the resulting quality of the attacked watermarked image is PSNR=32.86 dB; when extracting the watermark, the watermark is distorted, SSIM=0.38, but can be recognized by HVS . This is shown in Figure 9 in the upper image row. To raise the quality of the extracted watermark, we choose to embed into the middle bands of the LL-DCT instead of the lowest bands. We tried to embed into the middle bands of LL-DCT for 'F16' image, after embedding, we obtained PSNR =27.81 dB. After extracting the watermark we obtained SSIM=0.42 which means less distortion than embedding into the lowest bands. When embedding is done into the highest coefficients except DC coefficient, PSNR of 21.01 dB is obtained and watermark structure similarity SSIM=0.47; this shown in the lower row of Figure 9.

Embedding 8 bits in single block is not robust to Gaussian noise attack. 'Pepper' image is used for testing Gaussian noise attack again the watermarking procedure. After attacking the watermarked image with 3%, 0.3%, 0.003% of Gaussian noise, the resulting SSIM is successively 0.015, 0.019, 0.066 as Shown in Figure 10. We obtained an average of PSNR=29 dB. When extracting the watermark, the watermark is extremely distorted, and can't be recognized by HVS. This due to the fact that most of image

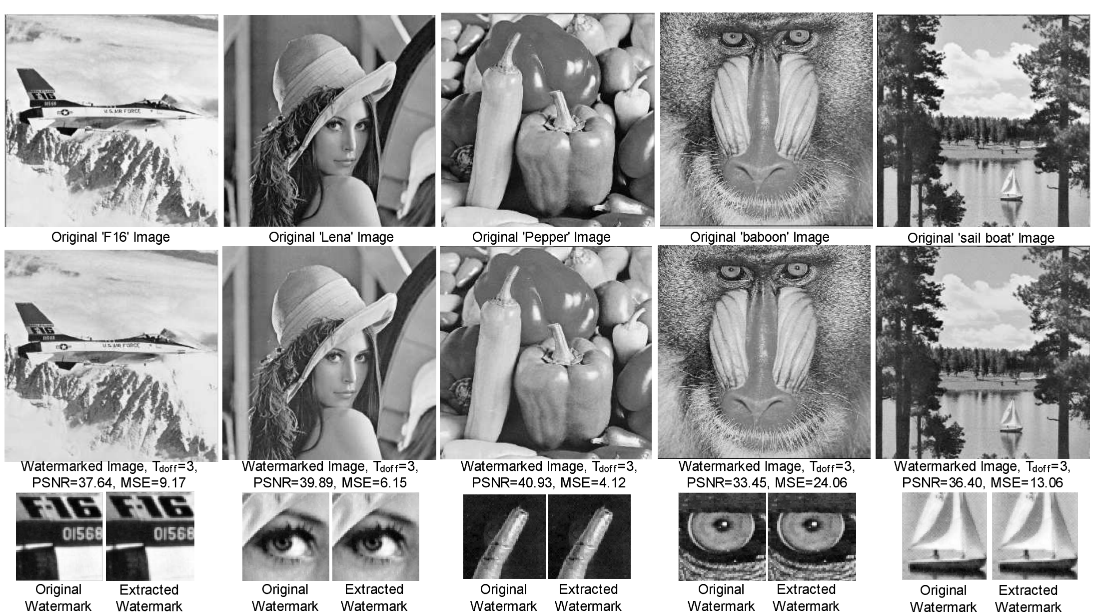

Figure 8. Embedding ROI Into The Lowest LL-DCT Coefficients, Tdoff=3, Images Are All 512x512 And ROI Is 60 X 60 Pixels.

Journal of Theoretical and Applied Information Technology
30th November 2015. Vol.81. No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

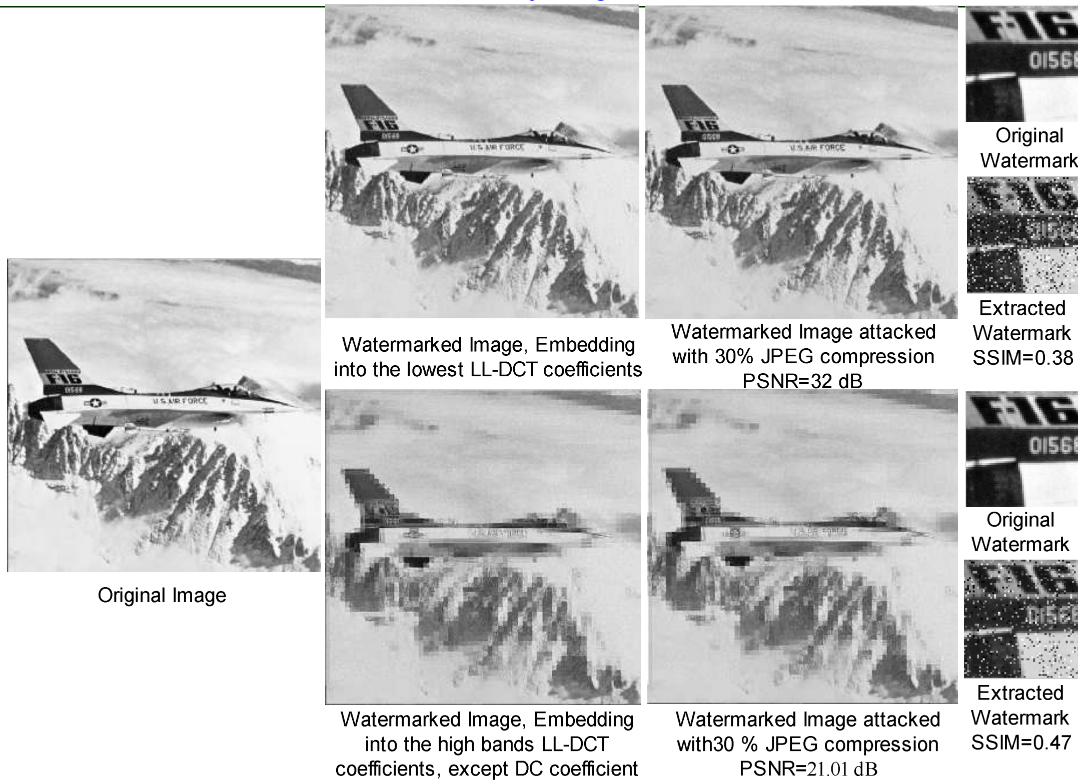

Figure 9. Embedding Into The Lowest LL-DCT (Upper Image Row) And The High Band LL-DCT (Lower Image Row)

information are carried into the low frequency bands (highest coefficient values) which is in fact countable when we talk about 8x8=16 LL-DCT coefficients. In other words, 50% of the block coefficients are used for embedding, it is expected that the watermarking algorithm with 8-bits for each block is not robust to Gaussian noise addition attack.

For rotation, the algorithm is not robust to rotation; even with single degree rotation the watermark is extremely distorted. After rotating the watermarked 'Pepper' image with 2 degrees counter-clockwise, PSNR is 16.5110 and SSIM is 0.0093 which means HVS can't recognize the extracted watermark. For cropping attack, the watermarked image is attacked with 34% , 15% cropping. The quality of the watermarked images is PSNR=8.5578, PSNR=11.8429 for 34%, 15% attacks respectively, this is shown in Figure 10 (e), (f) . The extracted watermark can be recognized by HVS, SSIM is 0.3392, 0.6383 for 34%, 15% attacks respectively. For multiplicative, as shown in Figure 10 (g), (h). The algorithm is more robust than Gaussian noise addition, in Gaussian noise attacks, the addition of 0.003% noise distort the watermark with SSIM=0.0663, while in multiplicative noise attack, an addition of a higher noise value (0.1% noise) distort the image with SSIM=0.1095 which is lower distortion value.

6.2 Embedding single bit in each block

Actually single block with 16 coefficients are too vulnerable to attacks especially when 50% of the block coefficients are used. To overcome this drawback, there are two approaches, either to increase the block size, or use one block for embedding single bit, instead of 8 bits.

The preferred idea was to use single block for embedding single bit, or in other words reducing embedding capacity of the carrier image to 1/8 of the previous capacity. We obtained promising results even after noise attacks and JPEG attacks.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

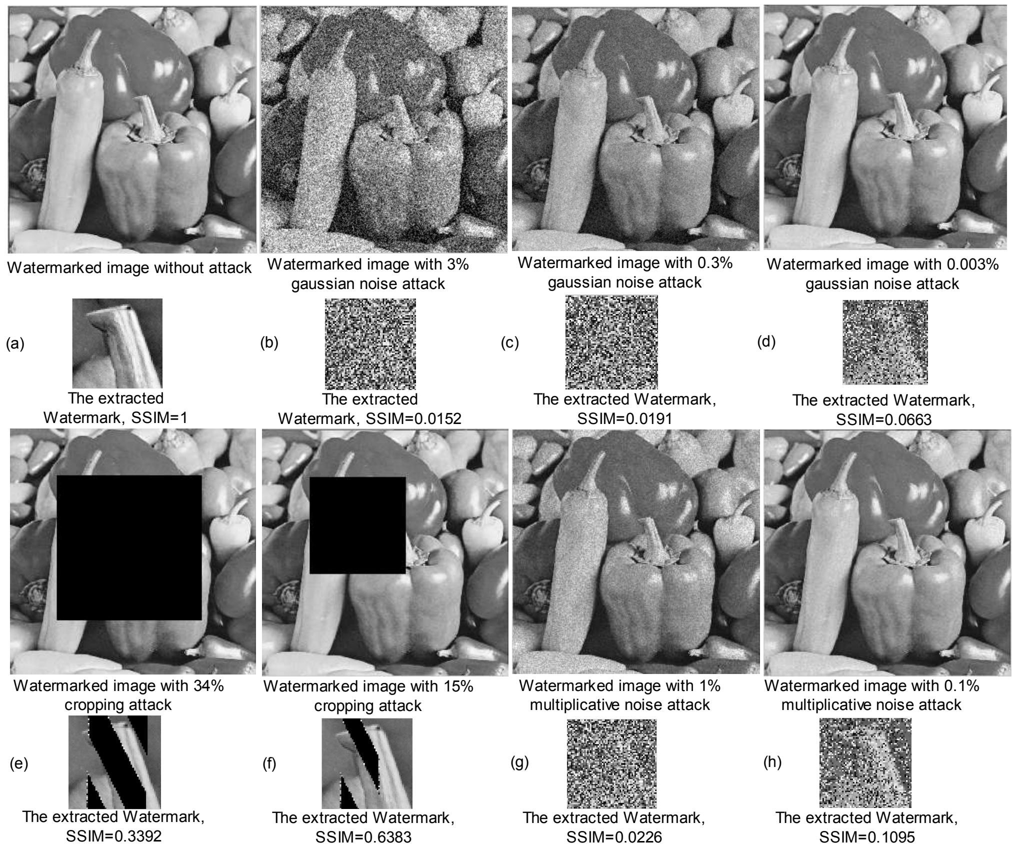

Figure 10: The Robustness Of Embedding Into The Lower Bands LL-DCT Against, Gaussian Noise Addition, Cropping, And Multiplicative Noise Attacks.

To prove that embedding single bit into single block is more efficient and robust than embedding 8-bits into the same block, we used 'F16' image as an input to our experiment Figure 11. F16 image is 512x512 pixels. Instead of using ROI with 8-bits depth, we used ROI as 1 bit depth image, i.e. binary image. So the embedding is done as single bit into single block, instead of 8 bits into single block. ROI is of size 60 x 60. F16 image is divided into 8x8 blocks so it contains 4096 blocks. 3600 blocks only will be needed to embed the entire ROI. We assumed T_{doff} Parameter =10. For each block in F16 image we applied DWT to obtain LL coefficients of size 4x4 then we applied DCT on LL to obtain 4x4 LL-DCT coefficients. The 16 LL-DCT coefficients are sorted in descending order. In the experiment we refer to the largest coefficient as Index 1 and the lowest coefficient as Index 16.

In addition when the expression "Embedding into Index 1" is used this exactly the same as embedding binary ROI into F16 image with one bit embedded into Index 1 of the corresponding block. The results of the experiment are shown in Figure 11. The first and second rows show the extracted watermark after attacking the watermarked image with 30% JPEG compression. Embedding into index 1 means embedding or perturbing the DC value, perturbing the DC value distorted completely the extracted watermark, this is shown in Index 1 image as white colored image, the border is shown for presentation purpose, it is not part of the image. Embedding into Index 2 (as shown in Index 2 image) is more robust to JPEG compression but the quality of the watermarked image is low PSNR =24 dB. This is shown in the lower row of the image to the right. When embedding into higher indexes, the quality of the extracted watermark is reduced as shown in the figure. For example embedding into Index 16 leads to bad robustness (as shown Index 16 image in Figure 11) but high quality in the watermarked image (As shown in the lower row, the middle image Figure 11). As a result we derived the following fact

FACT: The coefficient index value is proportional to the image quality and inversely proportional to

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

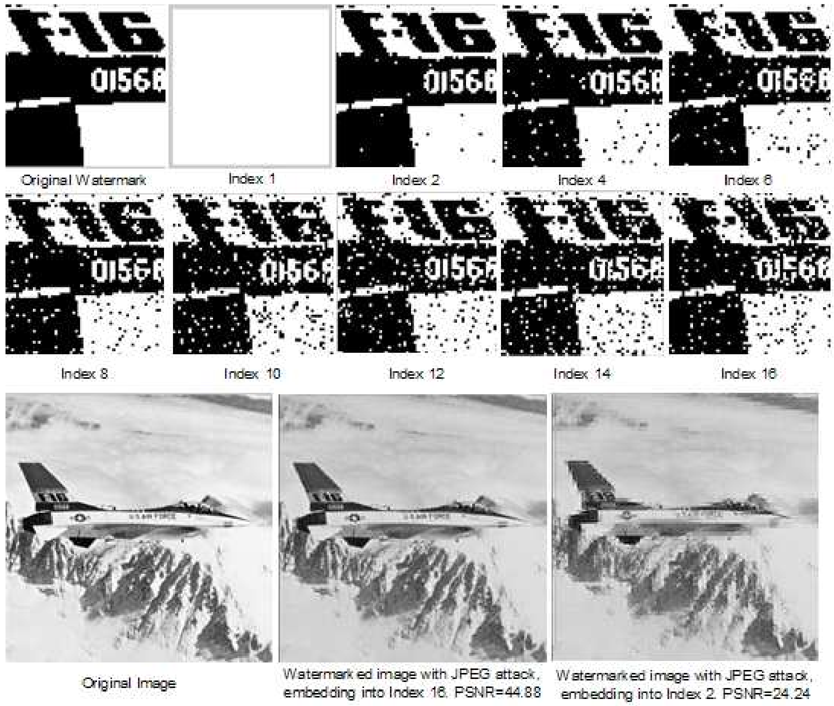

Figure 11: Embedding Into Different Coefficient Indices Of LL-DCT Coefficient, Single Bit For Each Block. Tdoff=10 And JPEG Attack Is 30%.

the watermark robustness (assuming the highest coefficient with index value 1 and the lowest coefficient with index value 16).

FACT is proved by plotting the results of attacking the watermarked F16 image with 30% JPEG compression and different index values. The results for PSNR, MSE and SSIM are shown in Figure 12.

The plotting is shown on the same log plot for comparison purposes, so Y axis express 3 ranges for each measurement. With low index value, i.e. high coefficients, the quality of the watermarked image (PSNR) is low and the error (MSE) is high. However the structure similarity (SSIM) is high, this means the robustness of the watermark is high. When we gradually increase the coefficient index the image quality is gradually increases and the error decreases but the robustness decreases. So embedding into the highest indexes make the embedding too sensitive to attacks. Highest index embedding is similar to LSB embedding [5] in which the LSB is used for embedding with good quality and less sensitivity to attacks, when embedding into positions near MSB the image quality is decreased. In our experiment MSB is comparative to Index 1 and LSB is comparative to Index 16.

In figure 13, the watermarking algorithm is tested against Gaussian noise addition, cropping and multiplicative noise. Comparing the results with

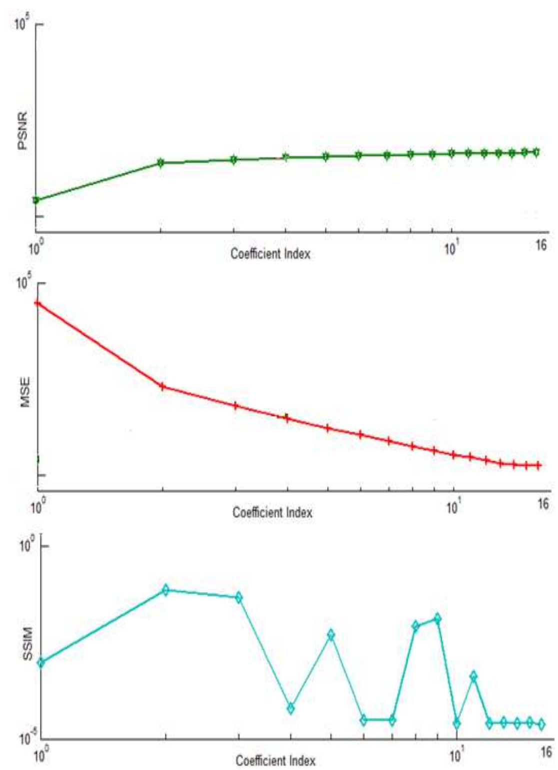

Figure 12 The Relation Between The Watermarking Quality, The Watermark Robustness And Coefficient Index Used For Embedding.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

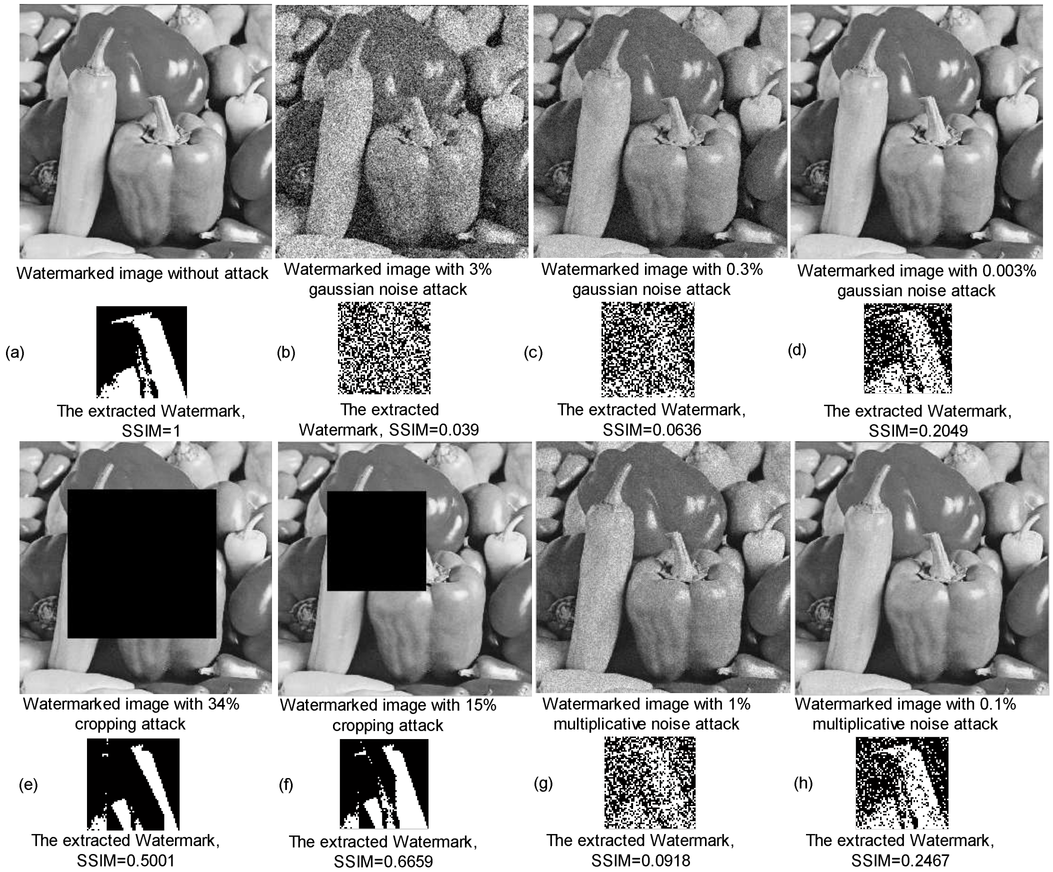

Figure 13: The Robustness Of Embedding Single Bit Into Each Block. Tdoff=4, The Bit Is Embedded Into Index 8 Of Each LL-DCT Coefficients Blocks. The Robustness Is Tested Against Gaussian Noise Addition, Cropping, And Multiplicative Noise Attacks.

that obtained in Figure 10, here single bit is embedding into index 8 of each LL-DCT block. T_{doff} =4, obtaining best T_{doff} is achieved by trial and error. Without attacks as shown in Figure 13(a), the watermarked image quality is 44.098 dB which is higher than embedding 8-bits procedure, that's because in single bit embedding, single LL-DCT coefficient is perturbed and in 8-bits there are 8 coefficients perturbed. With Gaussian noise attacks as shown in Figure 13(b,c,d), The extracted watermark SSIMs are 0.039, 0.0636, and 0.2049 for 3%, 0.3%, 0.003% Gaussian noise respectively. Compared to Figure 10, single bit embedding is more robust to Gaussian noise attacks. For cropping attacks as shown in Figure 13 (e,f), the extracted watermark SSIM is 0.5001 for 34% cropping, and 0.6659 for 15% cropping, which is comparably enhanced over 8-bits embedding. For multiplicative noise attacks as shown in Figure 13 (g,h), the extracted watermark SSIM is 0.0918, and 0.246 for 1% and 0.1% multiplicative noise respectively. The overall robustness of single bit algorithm is better than 8-bits algorithm.

CONCLUSION

A combined DCT and DWT block based watermarking approach is proposed. The embedding is done into LL-DCT transforms of each block. The quality of the watermarked image is high if single bit is embedded into each block. The single bit is embedded into the middle LL-DCT coefficient. We found that the embedding index is inversly proportional to the robustness of watermark. In comparison between embedding 8-bits and single bit in each LL-DCT block, the quality and robustnees and watermarking quality of single bit embedding is higher than 8-bits embedding. In future work we concentrate on using DCT and DWT combined approach for embedding ROI after applying LL-DCT transform instead of embedding ROI pixels.

Journal of Theoretical and Applied Information Technology
30th November 2015. Vol.81. No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

REFRENCES:

[1] W. Bender, D. Gruhl, N. Morimoto, and A. Lu, "Techniques for data hiding", IBM. Syst. J., vol. 35, pp. 313-335, 1996.

[2] D. Rosiyadi, S. Horng, P. Fan, X. Wang, M.K. Khan, and Y. Pan, "Copyright protection for e-government document images", IEEE Multi Media., vol. 19, no. 3, pp. 62-73, 2012.

[3] Osama Hosam, and A.S. Alraddadi, "Novel image watermarking technique based on adjacent pixel position switch", JNI.T, vol. 4, no. 3, pp. 81-88, 2013.

[4] X. Li, and J. Wang, "A steganographic method based upon JPEG and particle swarm optimization algorithm", Inform. Sci., vol. 177, no. 15, pp. 3099-31091, 2007.

[5] Chunhua Dong, Jingbing Li ; Yen-wei Chen "A DWT-DCT Based Robust Multiple Watermarks for Medical Image" Symposium on Photonics and Optoelectronics (SOPO), pages 1 – 4, DOI: 10.1109/SOPO.2012.6270462, May 2012.

[6] Dashun Que, Li Zhang, Ling Lu and Liucheng Shi, "A ROI Image Watermarking Algorithm Based on Lifting Wavelet Transform", Proceedings of International Conference on Signal Processing, Vol. 1, No. 1, 2006.

[7] L. Itti, C. Koch, and E. Niebur, "A model of saliency-based visual attention for rapid scene analysis," IEEE Trans. on Pattern Analysis and Machine Intelligence, vol. 20, no. 11, pp. 1254 –1259, Nov. 1998.

[8] M. Oakes, D. Bhowmik, and C. Abhayaratne, "Visual attention-based watermarking," in IEEE International Symposium on Circuits and Systems (ISCAS), , pp. 2653–2656. 2011

[9] X. Li, J. Wang, "A steganographic method based upon JPEG and particle swarm optimization algorithm" ,Information Sciences, vol. 177(15) pp.3099-31091, 2007.

[10] Abbasfard, Mitra. "Digital image watermarking robustness: A comparative study." Delft University of Technology, RERTRE, 2009: 74 pages (2009).

[11] Osama Hosam,"Side-Informed Image Watermarking Scheme Based on Dither Modulation in the Frequency Domain", The Open Signal Processing Journal, 2013, Issue 5, Pages1-6.

[12] Pithiya, Pravin M., and H. L. Desai. "DCT Based Digital Image Watermarking, De-watermarking & Authentication." image 1.2: 7.

[13] Wen Yuan Chen and Shih Yuan Huang "Digital Watermarking Using DCT Transformation."

[14] Osama Hosam, Zohair Malki. "Steganography Technique for Embedding Secure Data into the Image Regions with Abrupt Changes". Life Sci J 2014;11(9):126-130

[15] Fung, Charles, Antônio Gortan, and Walter Godoy Junior. "A review study on image digital watermarking." ICN 2011, The Tenth International Conference on Networks. 2011.

[16] Cox, Ingemar J., et al. "Secure spread spectrum watermarking for multimedia."Image Processing, IEEE Transactions on 6.12 (1997): 1673-1687.

[17] Koch, Eckhard, and Jian Zhao. "Towards robust and hidden image copyright labeling." IEEE Workshop on Nonlinear Signal and Image Processing. Neos Marmaras, Greece

[18] Tung-Shou Chen, Jeanne Chen, Jian-Guo Chen, "A simple and efficient watermarking technique based on jpeg2000codec," Proceedings of the IEEE Fifth International Symposium on Multimedia Software Engineering (ISMSE'03) 0-7695-2031-6/2003.

[19] Ali Al-Haj, "Combined DWT-DCT Digital Image Watermarking". Journal of Computer Science 3 (9): 740-746, 2007.

[20] Rajkumar.V1 and Arunkumar.J.R2. "A ROI and Block Based digital image watermarking using Discrete Wavelet Transform." International Journal of Emerging Trends & Technology in Computer Science (IJETTCS) Volume 2, Issue 3, May – June 2013.

[21] Razieh Keshavarzian, "A New ROI and Block Based Watermarking Scheme Using DWT" 20th Iranian Conference on Electrical Engineering, (ICEE2012), May 2012.

[22] Johnson, Neil F., ZoranDuric, and SushilJajodia. "Information hiding: steganography and watermarking: attacks and countermeasures". Vol. 1.Springer, 2001.

[23] Havlicek, J. P., P. C. Tay, and A. C. Bovik. "AM-FM image models: Fundamental techniques and emerging trends." Handbook of Image and Video Processing 2 (2005).

[24] Z. Wang, A. C. Bovik, H. R. Sheikh and E. P. Simoncelli, "Image quality assessment: From error visibility to structural similarity," IEEE Transactions on Image Processing, vol. 13, no. 4, pp. 600-612, Apr. 2004.