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A Combined DCT-DWT based Watermarking Technique for Avoiding Illicit Reproduction using GUI

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ABSTRACT

Now in a days, there is a vast use of images in many applications. Today duplication of any digital items or multimedia have become very easy task. So digital image watermarking technique becomes the best solution for the protection of illicit operation. In this technique some kind of secret data is embedded to the cover image and this information is used for the authentication purpose. In this paper a combined DCT-DWT based watermarking algorithm is proposed in which the secret data is hidden to the lower frequency band of the cover image.

Introduction

Now in a days, it is necessary to create a copy, transmit & sharing a digital data as a part of internet technology. So it has become the essential task to keep away the unauthorized duplication problem. Digital image watermarking is a technique by which the owner can authenticate the ownership.

Digital image watermarking is a technique by which the secret image data can be hidden in a cover image by allowing minimum amount of perceptual disturbance in the cover image. There are several parameters like robustness, transparency, capacity & blind watermarking by which the quality of the watermarking can be determined. The watermarking can either be done in spatial domains where the intensity values are modified or in frequency domain where the image coefficients are modified. However DWT is widely used in digital image watermarking just because of its multi resolution characteristics & spatial localization which are most equivalent to the practical models of human visual system. While DCT has a property of concentrating the useful information data of the image in just few coefficients. Furthermore while using DCT for watermarking; it compresses the image and DWT gives the scalability. The idea of using two transformations is based on the fact that joint transformation could overcome the limitations of each other, resulting in efficient watermarking.

After transformation function in a natural image, low frequency contains the energy of each and every block. If the watermark is embedded in low frequency it makes it perceptible but if it is embedded in to higher frequency then it would not make it perceptible. All previous research work on digital image watermark techniques used middle frequency range to embed the watermark [9].although we used low frequency band of DCT block of selected DWT sub band to embed. To have the invisible watermark proper value of alpha factor should be chosen.

Binary bits of secret image are get embedded to the low frequency of DCT coefficient of the selected frequency sub band of DWT. Here for the embedding purpose two pseudorandom code are generated. One code is used for embedding the watermark bit 0 and another code is used to embed the watermark bit 1 to the cover image. The method for watermark extraction is the total reversal process. Section II describes the proposed algorithm flow chart. The performance parameters are computed in section III. Finally the conclusion is given in section IV.

The Proposed Algorithm flow chart

In this section how the watermark bits are embedded to the cover image as well as watermark extraction process is explained.

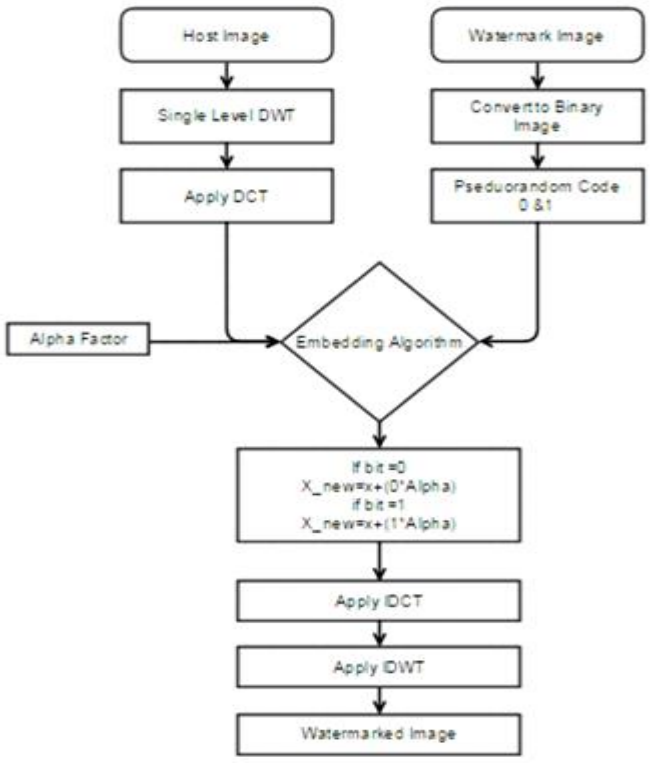

Figure 1. Embedding watermark

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Embedding Watermark

In figure 1 the flow chart of proposed algorithm for embedding watermark bit to the cover image is shown. Following steps are required for the embedding watermark process.

- DWT to the cover image: In the initial stage of this process single level DWT transform is applied to the cover image. The cover image is decomposed to its four non overlapping multi resolution coefficients which can be described below.

$$W_{LL}^{J} = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} g(x)g(y)W_{LL}^{J-1}(2u-x)(2v-y)$$

$$W_{LH}^{J} = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} g(x)g(y)W_{LL}^{J-1}(2u-x)(2v-y)$$

$$W_{HL}^{J} = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} g(x)g(y)W_{LL}^{J-1}(2u-x)(2v-y)$$

$$W_{HH}^{J} = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} g(x)g(y)W_{LL}^{J-1}(2u-x)(2v-y) \quad (1)$$

Where J =Level of the 2-D DWT, Here J=1
g(n) = Impulse response of low pass filter
h(n) = Impulse response of high pass filter
W^{0}_{LL} = W(u,v) = Original Image

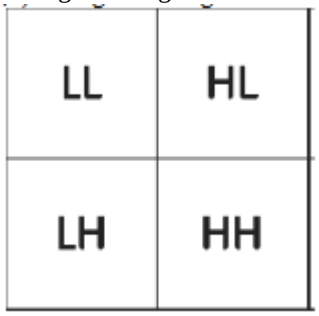

Figure 2. Single Level 2D-DWT decomposition of an image

- Choose W_{HL} coefficient for watermark embedding process.
- Divide the W_{HL} in to 4×4 blocks: Starting from left to right and from the top to bottom ,divide the W_{HL} set in to 4 × 4

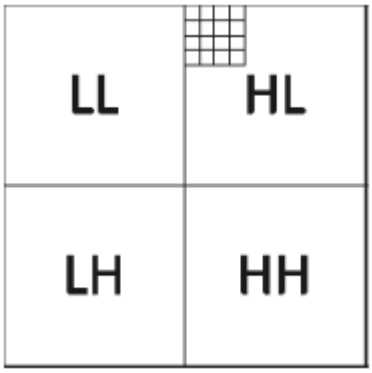

Figure 3. 4 × 4 blocks created in to the W_{HL} coefficient set.

- Discrete Cosine Transform of selected block : After Diving W_{HL} set in to 4 × 4 block, Apply DCT to each block.2D-DCT of the matrix can be calculated from the formula below.

$$F(u,v) = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} g(x,y,u,v) \quad (2)$$

Where the kernel is given by the mathematical expression below.

$$g(x,y,u,v) = a(u)a(v)\cos\left[\frac{(2x+1)u\pi}{2N}\right]\cos\left[\frac{(2y+1)v\pi}{2N}\right] \quad (3)$$

Where a(u) = a(v) = $\frac{1}{\sqrt{N}}$ $for\ u, v = 0$

Otherwise a(u) = a(v) = $\sqrt{\frac{2}{N}}$

- Convert watermark image in to binary form: watermark image is converted to the binary data for the embedding process.
- Generate pseudorandom code : to make the watermarking process more secure & robust we use two code. Code 0 is generated to embed the watermark bit 0 similarly code 1 is generated to embed the watermark bit 1.
- Embedding in low frequency band: Embed the two random code with the alpha factor in the DCT transformed block of the W_{HL} set of the cover image.

Here we embed the watermark bits only to the lower frequency band of DCT stored in Zig Zag format as shown in figure 4 below.

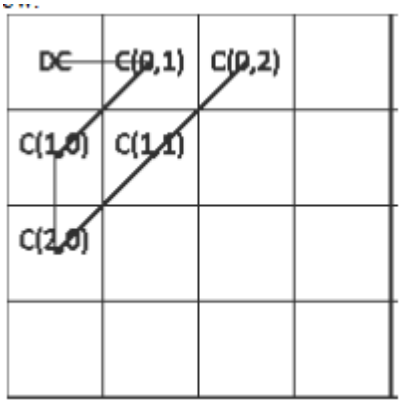

Figure 4. Position of DC low frequency component in DCT block

The mathematical equation for embedding the watermark bit is below. Consider x is the 4 × 4 DCT transformed block then embedding can be carried out by the following formula

If watermark bit is 1 then

X_new = x+(alpha×code 1) (4)

If watermark bit is 0 then

X_new = x+(alpha×code 0) (5)

- Inverse DCT: apply the inverse DCT on each block after embedding the watermark bit to the cover image.
- Inverse DWT:Perform the inverse DWT on DWT transformed image. The output image will be final watermarked image.

Extraction Watermark

In figure 5 the proposed extraction watermark block diagram is shown. To extract the watermark from the watermarked image following steps are required.

- DWT Transform : Apply single level DWT transform to the watermarked image to decompose it in to four multiresolution coefficient sets. Consider W_{HL} coefficient set.
- Divide the W_{HL} in to 4 × 4 blocks: Starting from left to right and from the top to bottom ,divide the W_{HL} set in to 4 × 4
- Then DCT is applied to each block in the chosen coefficient set.
- Then watermark bits are computed from the following equations

Code 0 = (X_new – x) / Alpha
Code 1 = (X_new – x) / Alpha

Then rounding value of code 1 and code 2 is computed for binary bit consideration.

- Then extracted watermark bits are rearranged in the form of image.

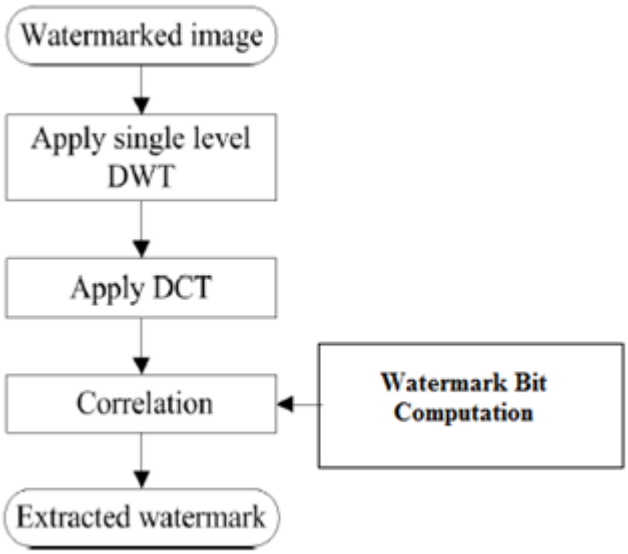

Figure 5. Proposed Watermark Extraction Diagram

- Computation of similarity: finally the similarities between the original watermark image and extracted watermark image is calculated in terms of statistical parameters like MSE,PSNR and normalized correlation (NC).

Performance Parameters

We have taken standard image Lena.jpg as cover image whose dimensions is 512×512 which is shown in figure 6(a).64 × 64 watermark is used as shown in figure 6(b) below.

Figure 6a. Original cover image: Lena.jpg (512 × 512)

Figure 6b. watermark image (64 × 64)

Invisibility: Invisibility means the observed quality of the cover image should not be distorted by the presence of the watermark. To measure the quality of the watermarked image, the peak signal to noise ratio is used. The PSNR is used to calculate the similarity between the original image and watermarked image which can be represented in term below.

$$PSNR = 10\,log_{10}\frac{255^2}{MSE} \qquad (7)$$

Where,

$$MSE = \frac{\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}[x(i,j) - X_{new(i,j)}]^2}{N \times N} \qquad (8)$$

The mean square error is computed first and then the value of PSNR is calculated from the equation no (1).here x(i,j) and X_new(i,j) returns the gray level value of original image an the watermarked image.

Robustness: Robustness is the measure of the protection of the watermark against various watermark attacks like image resize, cropping, re-quantization & Adding noise etc. we measure the similarity in terms of normalized correlation (NC) between the original watermark image and extracted watermark image under the various watermark attacks.

$$NC = \frac{\sum_{j=0}^{J-1}\sum_{k=0}^{K-1} W_1(j,k)W_2(j,k)}{\sum_{j=0}^{J-1}\sum_{k=0}^{K-1} W_1(j,k)^2} \qquad (9)$$

Where,

W_1 (j, k) = Original Watermark Image

W_2 (j, k) = Extracted Watermark Image

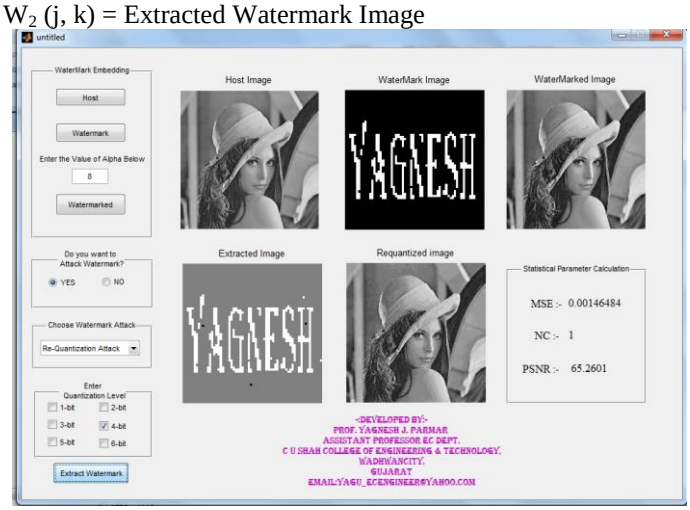

Figure 7. Watermark Embedding & Extraction under Re-quantization Attack

Figure 7 shows various images like host image(cover image),watermark image, watermarked image, extracted watermark image & re-quantized watermarked image. also the performance parameter is like MSE, PSNR & normalized Correlation are calculated between original watermark image and extracted watermark image.

In above figure we have selected re-quantization type of watermark image, in this attack the watermarked image is quantized from 1 to 6 bit. We have selected the value of alpha factor equal to 8 and quantization bit equal to 6.so we get the PSNR is about 65.26 dB as shown in figure 7.

Re-Quantization

In TABLE I some data are computed between watermark image and extracted watermark

Re-Quantization bits	Alpha Factor	PSNR	NC
4 –bit	8	65.26	1
3-bit	8	25.52	1.1
2-bit	8	9.08	1.24

Noise Attacking

In TABLE I some data are computed between watermark image and extracted watermark

Table 1

Type of noise	Alpha Factor	PSNR	NC
Gaussian Noise (mean = 0 variance = 0.002)	8	18.0009	1.0255
Gaussian Noise (mean = 0 variance = 0.001)	8	29.8505	1
Salt & Pepper Noise (Noise density=0.01)	8	16.0238	1.0036
Salt & Pepper Noise (Noise density=0.001)	8	41.1307	1
Speckle Noise (Noise density = 0.01)	8	16.04	0.9836
Speckle Noise (Noise density = 0.001)	8	83.1777	1

Cropping Attack

Cropping refers to any part discarded in the image. Below figure8(a) shows 128×128 cropped region in the watermarked image and figure 8(b) shows the extracted watermark image. We get 35.42 dB PSNR and 0.89 NC.

Figure 8a. Cropped Watermark Image

Figure 8b. Extracted watermark after cropping Attack

Resize Attack

The watermarked image is resized to 510 × 510.Then it is again resized to its original size .Figure 9(a) shows the watermarked image after resizing & figure 9(b) shows the extracted watermark after resizing attack, where PSNR33.83 & NC 0.74 are respectively.

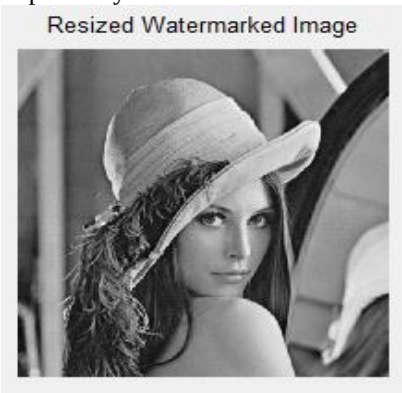

Figure 9a. Resized Watermark

Figure 9b. Extracted watermark after resizing attack

Conclusion

In this paper a combined DCT & DWT based low frequency watermarking with Normalized correlation has been developed. This algorithms is based on frequency domain in which the watermark is added in to the low frequency of selected DWT sub band. To increase the robustness of the algorithm we have used pseudorandom code 0 & 1.to increase the invisibility we have used to gain Alpha factor, which is also useful for imperceptibility. The experimental results shows that the adapted method has efficient visibility and stronger robustness when the watermarked image is attacked by re-quantization process, cropping, addition of noise and averaging filtering process. Our algorithm proves that in most of cases the normalized correlation between watermark image & extracted watermark is nearer to 1.by this method it is possible to avoid illicit duplication of digital data like image copyright.

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