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## Image Watermarking using Integer Wavelet Transform and Discrete Cosine Transform

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### Abstract

In the current research work, a system of hiding a text in a digital grayscale image has been presented. The algorithm system that had been used was adopted two transforms Integer Wavelet transform and Discrete Cosine transformed. Huffman's code has been used to encoding the text before the embedding it in the cover image in the HL sub band. Peak Signal to Noise Ratio (PSNR) was used to measure the effect of embedding text in the watermarked image; also correlation coefficient has been used to measure the ratio of the recovered text after applying an attack on the watermarked image and we get a good result. The implementation of our proposed Algorithm is realized using MATLAB version 2010a.

**Keywords:** Digital watermarking, Integer wavelet transform (IWT), Discrete Cosine Transformation (DCT), Huffman Code.

### العلامة المائية للصورة باستخدام تحويل الموجة الصحيح و تحويل الجيب تمام

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### الخلاصة

ضمن هذا البحث نقدم عملية إخفاء نص داخل صورة رقمية رمادية. خوارزمية النظام المقترح تعتمد على تحويل الموجة الصحيح وتحويل الجيب تمام. وتستخدم الخوارزمية أيضا على ترميز النص قبل الإخفاء بطريقة هوفمان وإخفاء النص داخل HL sub band. وتم قياس درجة الضوضاء الصورة ذات العلامة المائية بمقياس PSNR. وإيضاً تم قياس مقدار النص المسترجع من الصورة ذات العلامة المائية بعد تنفيذ بعض طرق الهجوم على الصورة ذات العلامة المائية وكانت النتائج جيدة. تم تنفيذ الخوارزمية باستخدام برنامج ماتلاب نسخة 2010a.

### 1. Introduction

Digital watermarking is the procedure of embedding data into the digital image in a way that is hard to modify or remove. Digital watermarking is considered as an effective tool to demonstrate the ownership for information. Any watermarking structure comprises of two stages; (1) Watermark embedding (2) Watermark extraction. Watermark embedding is the procedure in which the secret image is covered up inside the cover image without modifying the visibility of the cover image. Watermarking can be grouped depending on the information sort who is being utilized. They are an image watermarking, video watermarking, sound watermarking and text watermarking. As per human discernment, the advanced watermarks are named visible watermark and Invisible watermark. Visible watermarking frameworks are those in which watermark embedded is visible to the human visual framework (HVS) when the image is seen,[1]. Visible watermarking is regularly used to anticipate unapproved access to the information. In invisible watermarking, watermark installed is perceptually

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invisible to the HVS. The real qualifications of watermarking frameworks are perceptual transparency, payload of the watermark, robustness, Security and effectiveness. The digital watermarking has been utilized as a part of a wide assortment of utilizations, for example, copyright assurance, proprietor recognizable proof, exchange following, therapeutic applications and clandestine correspondences, [1].

## 2-Related work

1. Lafta [2], the researcher used laplacian sharpening method to embed the compressed data. And they use Huffman's coding to compress the secret data before embedded processes. The researcher, used the Laplace filters to determine the effective hiding places, and then based on threshold value found the places with the highest values acquired from these filters for embedding the watermark.
2. Vijay,M. et al.[3], the researcher decomposed the cover image by using Integer Wavelet transformed and embeds the message bit stream into the LSB's of the integer wavelet coefficients of the image.
3. Lafta.et al. [4], this paper, the watermarking based on slantlet transform of original image. The secret data is embedded into mid band frequencies of slantlet coefficients in the transform domain. The embedded information in this band becomes invisible. And compare the rustles slantlet transform with DWT.
4. George.et al. [5], the proposed scheme is a digital image of the action of watermarking on the basis of the combination of DCT and quantization. The Watermarking is done by changing the coefficients DCT from carefully selected DCT sub band after dividing the image into non overlapped with the size of  $8 \times 8$  pixels and is seeking the blocks has a higher standard deviation for examination only on AC coefficients, followed by the application of quantization, S- Shift and encoding Hoffman . The purpose of performing these procedures during a watermark embedding to fortify the attack against such compression.
5. Abdullah. et al. [6 ],In this paper, transforming the medical image to wavelet domain was done as a process of embedding in an image. Also, the thresholding was computed to choose the best location of hiding the watermark inside image coefficients.

## 3-Problem statement

Illegal copying, modification and protection of copyright issues become very important with the rapid use of the internet, no one can deny the importance of the Internet in our lives. Moreover, everyone can access the wide range of information on the Internet that includes the form of an image, video, audio, text, and also be used for personal or commercial purposes. The problem how to embedding secret information into cover media without noticeable degradation, Also, to achieve robustness watermark quality against different watermark attack such as noise and geometrical attack,[7]. In this paper, we propose a solution for the illegal copy write protection by encoding secret text message through of using Huffman coding and embedding this encoding secret message in mixed transform domain; the transform domain consists of Integer Wavelet transform preceded by Discrete Cosine transform to achieve security and privacy and get good robustness by apply Salt & Pepper attack and rotation.

## 4- Integer Wavelet Transformation

Integer wavelet transform maps a whole number data set into another whole number data set. In discrete wavelet transform, the utilized wavelet transforms to have floating point coefficients so that when we hide information in their coefficients, any truncations of the floating point estimations of the pixels that ought to be integers might bring about the loss of the concealed data which might prompt the disappointment of the information concealing framework. To maintain a strategic distance from issues of coasting point accuracy of the wavelet channels when the info information is an integer as in digital images, the yield information will never again be numbered, which doesn't permit to idealize remaking of the data picture and for this situation, there will be no loss of data through forward and backwards transform. Because of the specified contrast between integer wavelet change (IWT) and discrete wavelet change (DWT) the LL sub band on account of IWT has all the earmarks of being a nearby duplicate with littler size of the first picture while on account of DWT, the subsequent LL sub band is twisted[8].

The Haar wavelet transform can be written as simple pair wise averages and differences, [8]:

$$\begin{aligned}
 S_{1,n} &= (S_{0,2n} + S_{0,2n+1})/2 \\
 d_{1,n} &= S_{0,2n} - S_{0,2n+1}
 \end{aligned}
 \tag{1}$$

Where  $S_i$ ,  $d_i$ ,  $i$  is the  $n$ th low frequency and high frequency wavelet coefficients at the  $i$ th level respectively.

As we can see from the equation that the output is not showing any integer, we can be reformed equation number (1) where the Haar wavelet transform can be manipulated using two steps lifting that lead to successively executed, [8]:

$$\begin{aligned}
 d_{l,n} &= S_{0,2n+1} - S_{0,2n} \\
 S_{l,n} &= S_{0,2n} + d_{l,n}/2
 \end{aligned}
 \tag{2}$$

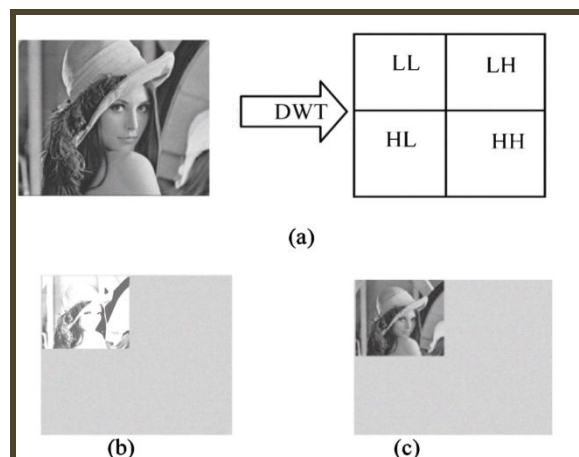
From equation (1) and equation (2) we can estimate the integer wavelet to transform [8].

$$\begin{aligned}
 d_{l,n} &= S_{0,2n+1} - S_{0,2n} \\
 S_{l,n} &= 0.2n + (d_{l,n}/2)
 \end{aligned}
 \tag{3}$$

Inverse transform was estimate using, [8]

$$\begin{aligned}
 S_{0,2n} &= S_{l,n} - (d_{l,n}/2) \\
 S_{0,2n+1} &= d_{l,n} + S_{0,2n}
 \end{aligned}
 \tag{4}$$

We can see in the Figure -1 the different between the one level 2D-DWT and the one level 2D-IWT in sub band LL, [2].



**Figure 1-** (a) Cover image Lena and analyze in wavelet domain (b)One level 2D-DWT in sub band LL (c) One level 2D-IWT in sub band LL.

### 5. Discrete Cosine Transform

With the character of the separate Fourier Transform (DFT), discrete cosine transform turn (DCT) on the edge of the image to make the image turns into a form that even a job. It is one of the most common linear shifts in technology digital signal process. Known two-dimensional discrete cosine transform (2D-DCT) is defined as reverse shift interview (whether 2D-IDCT) in question (1) as, [9]

$$F(jk) = a(j)a(k) \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f(mn) \cos\left[\frac{(2m+1)j\pi}{2N}\right] \cos\left[\frac{(2n+1)k\pi}{2N}\right] \tag{5}$$

The corresponding reverse conversion definition (both 2D-IDCT) in equation (2) as, [9]

$$f(mn) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} a(j)a(k)F(jk) \cos\left[\frac{(2m+1)j\pi}{2N}\right] \cos\left[\frac{(2n+1)k\pi}{2N}\right] \tag{6}$$

And 2 D-DCT cannot just focus on the key information of the original image in a smaller low-frequency coefficient, but also can cause the picture effect block being smaller, which can achieve a good compromise between a centralized information and complications computing. So it gets widespread application in the compression codec [9].

## 6-Huffman Encoding and Decoding

Huffman encoding, utilizes fewer numbers of bits to encode the picture pixels. For the given picture, a codebook (table) is created. The codebook alongside encoded information is transmitted. The pixels which are more continuous are given littler codes. Given the encoded message and codebook, interesting translating happens from the codes. This gives a noteworthy pressure proportion in both lossy and lossless stego pictures. The proportion of a number of bits in the first picture to a number of bits in the compacted picture gives pressure proportion [10].

Huffman encoding is utilized to serve the accompanying three:

- Lossless Compression: It expands the inserting limit.
- Security through coding.
- Huffman coding bit stream cannot detect anything. To remove the precise significance, the Huffman table is required to decode. It gives one sort of verification, as any single-piece change in the Huffman coded bit stream, Huffman's table can't decode [11].

## 7-The Proposed Method

The main aim of this current research work was design an invisible watermark by embedding a text message in a cover image after encoding the secret text message. The first step of this project was encoding the hidden text message by using Huffman's code, as a show in Figure -2. The second step was embedding the encoding hidden text message in a grayscale cover image size (512x512) by decomposed the cover image using integer wavelet transformation (IWT), and choose one sub band (HL) then applied a discrete cosine transformation DCT to this sub band.

After that embedded encoding secret text message in coefficient value above the diagonal of the HL sub band. All these steps of the embedding method were explained visually as shown below in a block diagram in Figure -3.

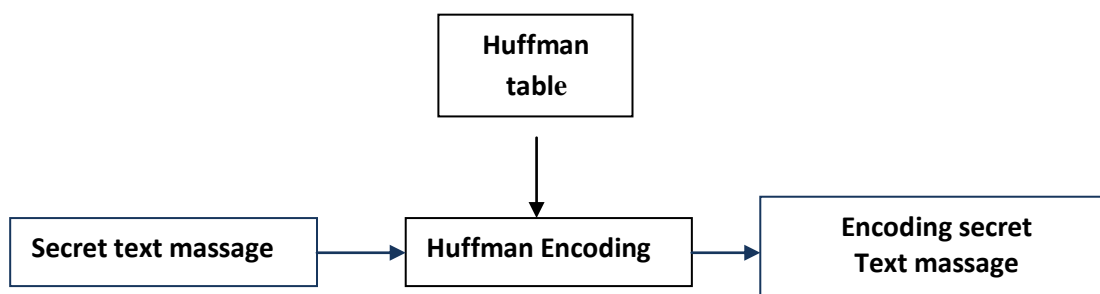


Figure 2- Huffman encoding of secret text message

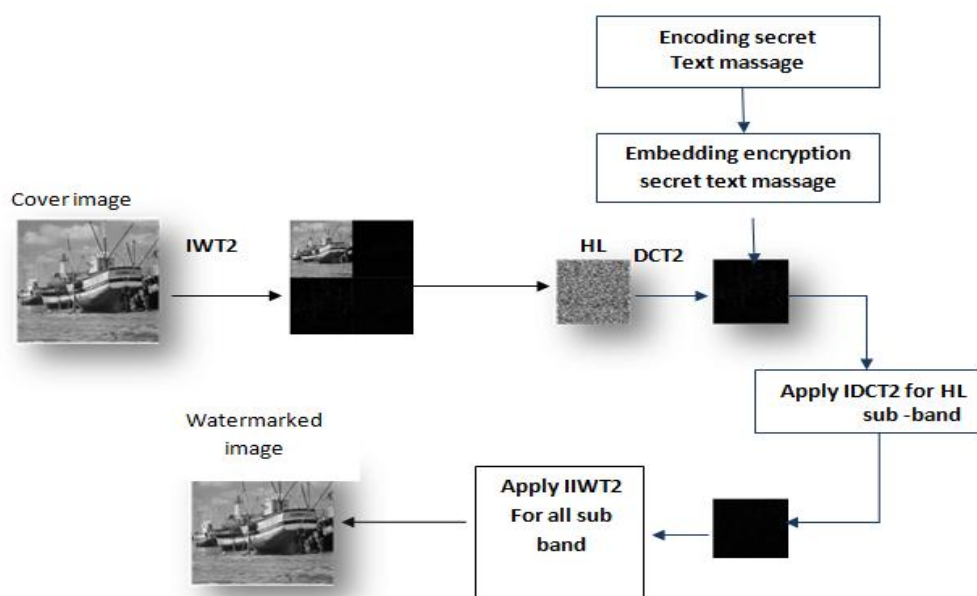


Figure 3- Block diagram of the Embedding Process

The extraction process included decomposed the watermark image by using integer wavelet transformation (IWT), and chooses one sub band (HL) then applied a discrete cosine transformation (DCT) to this sub band, after that extract hidden encoding text from the coefficient value above the diagonal in HL, as a show in Figure -4, and the last step decoding the secret text message by using the Huffman decoding, as a show in Figure -5.

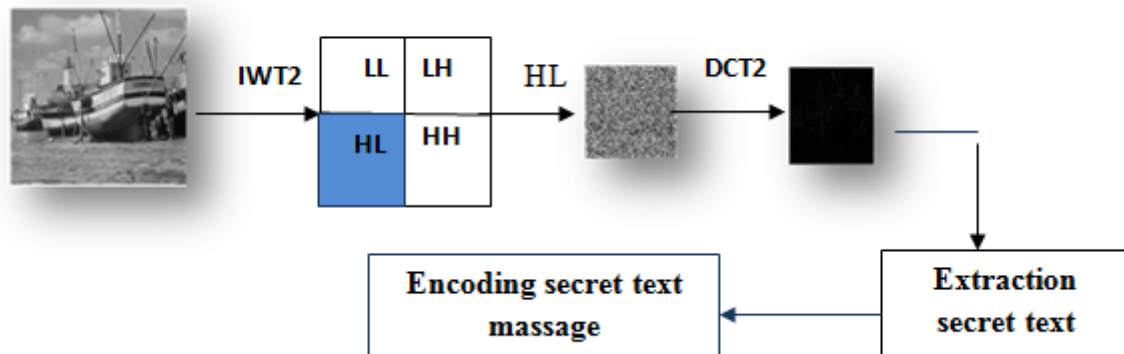


Figure 4- Block diagram of the Extraction Process

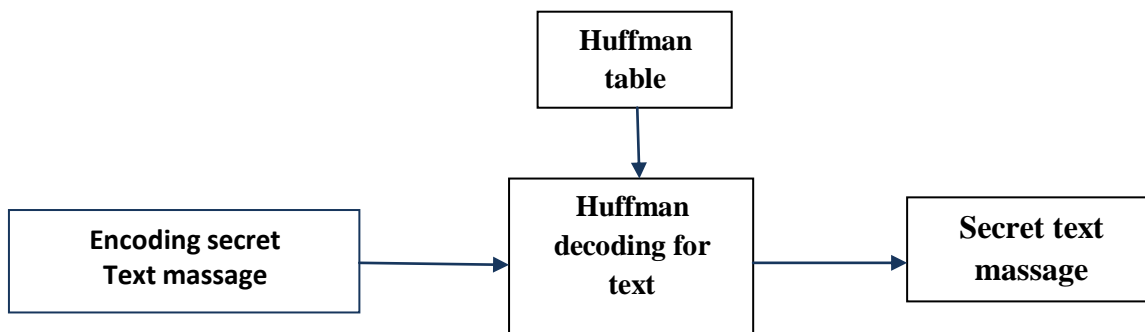


Figure 5- Huffman decoding of secret text message

In the following the description for embedding algorithm and extraction Algorithm

#### Embedding algorithm

1. Input: Cover image of size  $m \times n$ , texts secret message and Huffman table.  
Output: watermark Image  $m \times n$ .  
Load the Cover image.
2. Decompose the cover image by using integer wavelet transformation and select one sun-band HL.
3. Apply discrete cosine transform (DCT) for HL band.
4. Applying Huffman encoding to secret text message by using Huffman's table.
5. Embedding the encoding secret text message in a coefficient value above the diagonal in HL, and The embedding method is worked according to the following equation(7):

$$Z'_{m,n} = z_{m,n} + \alpha z_{m,n} * w_k \quad (7)$$

Where  $z_{mn}$  is indicating to DCT coefficient and  $\alpha$  indicate to scaling factor for imperceptibility and  $w_k$  indicate to encoding binary text.

6. Applying the inverse discrete cosine transforms (IDCT) for HL band after hiding message.
7. Applying inverse integer wavelet to get the watermark image (IIWT).
8. Display watermark image.

The description of extraction algorithm was explained visually in the steps below:

#### Extraction Algorithm

Input: watermark image and Huffman table.

Output: Secret text message.

1. Read the watermark image.

2. Decompose the watermark image using Integer Wavelet transformation to get [LL, LH, HL, HH] sub bands, and select one sub-band HL.
3. Apply discrete cosine transform (DCT) for HL band.
4. Extract secret encoding text from the coefficient value above the diagonal in HL, the extraction method is worked by the equation (8):

$$wr_k = (z'_{m,n} - z_{m,n}) / (\alpha z_{m,n}) \tag{8}$$

Where  $z_{m,n}$  the original DCT coefficients,  $z'_{m,n}$  modified DCT coefficients after embedding and  $\alpha$  indicate to scaling factor for imperceptibility and  $wr_k$  indicate to encoding binary text.

5. Applying Huffman decoding to encoding secret text message by using Huffman's table.
6. Display secret text message.

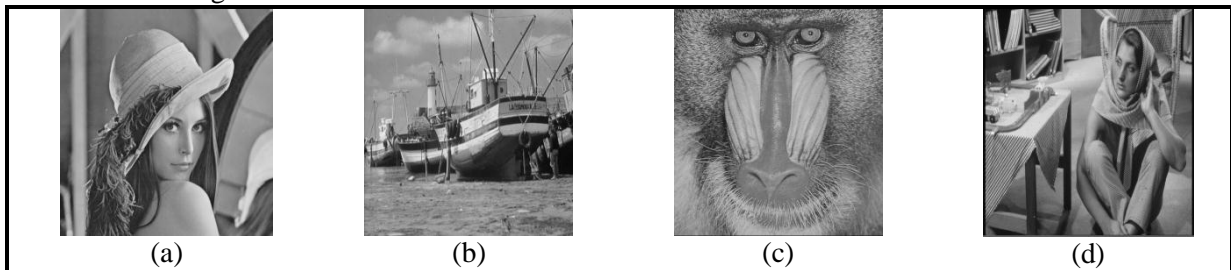
**8-Simulation the results**

The results that have obtained through this proposal, where a set of grayscale cover images 512 x 512 have been used, as shown in Figure -6 . Then we used secret message that have size is 304 bit we encoding text messages that have been embedded in these cover images. The Peak Signal to Noise Ratio (PSNR) parameters have been used to measure the embedding performance as explained in the equation (9) below:

$$PSNR = 10 \log_{10} (255^2 / MSE) \tag{9}$$

$$MSE = (1/N)^2 \sum \sum (x_{ij} - x'_{ij})^2 \tag{10}$$

Where  $x_{ij}$ 's denote the original pixel values,  $x'_{ij}$  denote the modified pixel values, and N is the modified dimension of image.



**Figure 6 - Cover images for test.**

The PSNR parameter and the watermark images show an acceptable result more than 30dB for evaluation this method as shown in Table -1 below:

**Table 1-The PSNR parameter values for the watermark images**

Cover image 512x512	PSNR
Lena	57.669
boat	57.078
baboon	57.321
barbara	58.50








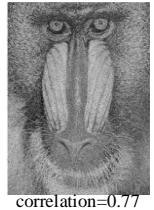




**9-Effect of Attacks**

The efficiency of the proposed method has been tested by using salt & peppers noise attack and rotating the image by 30°. The quantities robustness of the method was shown in Table -2, the table below watermark images before and after the attacks and correlation factors values after attack. And the correlation factor computes by equation (11) and used to measure of the recovered data that matching the original data for hidden text.

$$cf = \frac{\sum_m \sum_n (O_{mn} - \bar{O})(W_{mn} - \bar{W})}{\sqrt{(\sum_m \sum_n (O_{mn} - \bar{O})^2)(\sum_m \sum_n (W_{mn} - \bar{W})^2)}} \tag{11}$$

Where O is a cover image, W is a watermarked image. And  $\bar{O}$  = mean2 (O) and  $\bar{W}$  = mean2 (W).

**Table 2-**The correlation parameter values for the watermark images after the attack of the watermarked images

number	watermark image	salt & peppers noise	Rotate 30°
1		 correlation=0.75	 correlation=1
2		 correlation=0.76	 correlation=1
3		 correlation=0.77	 correlation=1
4		 correlation=0.76	 correlation=1

Lastly, several research workers work on digital watermark and the obtained good accuracy. However, after comparing the previous method with proposed one, the proposed method gives the best result as show in Table -3.

**Table 3-** PSNR comparison

Researcher	[2]	[3]	[4]	[5]	Our method
Method	laplace	IWT	DWT	DCT	IWT & DCT
PSNR	45.44	54.92	44.77	55.72	57.66

## 10-Conclusion

Through the testing of the proposed method was concluded the following:

1. Based on the PSNR values that explained in Table -1 above, the algorithm supply good results for the imperceptible, because acceptable rang of PSNR above 30dB.
2. Acceptable security by applying Huffman coding and at the same time provides coding for secret text.
3. Good robustness is achieved explained by correlation factor because the proposed method robust against adding noise and rotation.

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