

# Image Watermarking Using Multiresolution Analysis

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## Abstract

In this paper, a new method for image watermarking by using Multiresolution Analysis (MRA) is presented. The proposed method we embed the watermarks with visually recognizable patterns into the images by selectively modifying the middle-frequency parts of wavelet domain. The qualified significant wavelet tree (QSWT) was modified to determine the best location for embedding. Only highest magnitude in each groups of QSWT was changed, the robustness can be achieved without an artifact is realized. The experimental results show that the proposed method successfully survives image processing operations. In addition, we compare the results with selected previous published method.

**Index Terms-** Digital watermarking, discrete wavelet transform, image processing, qualified significant wavelet tree, multiresolution analysis.

## I. Introduction

Nowadays, the protection methods of the illegal duplication of digital data such as digital audio/image have been developed by many researchers [1-2]. The methods are still being developed to get the best result of the fundamental requirements. The first one is perceptual transparency. The signature must be embedded by the watermarking algorithm without affecting the quality of the original image. The second is robustness. It has to prove the authenticity of the host data as to be robust against processing (such as blur operation and jpeg compression) techniques or intentional alterations of the host data. The other is capacity, this is not so highly requirement because it depending on the application. There are many papers have been presented method of embedding signature to the digital image by using multiresolution analysis [3-6]. Most important thing is that of how to classify or select the coefficients of MRA. These coefficients will be changed (e.g.usually its magnitude) with in some limitation in order to compromise between fundamental requirement as mentioned above. The very good result from a new method one is written by Ming-Shing , Din-Chang and Yong-Huai Huang [8], given the method of selection the

coefficients MRA which is called “qualified significant wavelet tree (QSWT)”. This method gives us an idea to further improve the quality of the result.

## II. Proposed method

The method can be easily visualized as illustrated in Fig. 1 below.

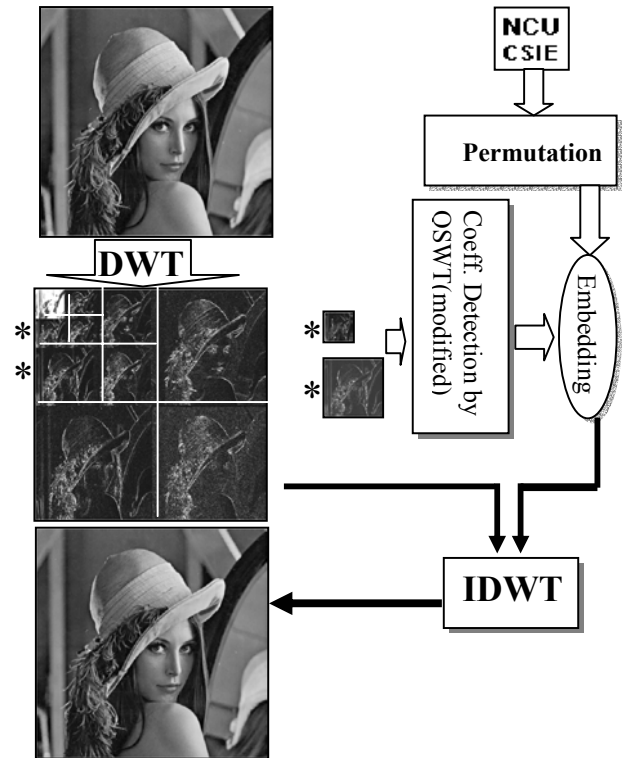
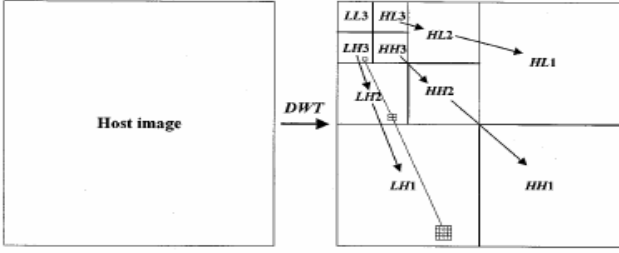


Fig.1. Watermarking embedding process

Let  $x_n(i, j) \in W$  is the parent of  $x_{n-1}(p, q)$ , where  $W$  is a subband labeled  $LH_n, HL_n$  and  $HH_n$  as shown in Fig. 2. Our proposed method select  $LH_3, LH_2$  subbands for embedding (middle frequency). The significant coefficient is the coefficient that satisfy the conditions  $|x_n(i, j)| > T_1$ ,  $|x_{n-1}(p, q)| > T_2$ , where  $p = i * 2 - 1, q = j * 2 - 1$  which  $n, i, j > 1$  and  $T_1, T_2$  are the appropriate thresholds.



**Fig.2.** DWT of image. Note that the arrow points from the parent subband to its children subband.

### A. Watermark Embedding Method

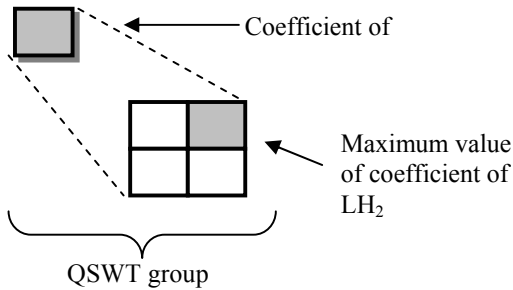
We first obtained  $r \times s$  QSWT coefficients from the MRA of original image. Where,  $r, s$  are the size of binary watermark image. Then, sort the energy of them in descending order, convert the watermark bit value ( $wk$ ) (1, 0 to 1, -1). Finally, to enhance security, watermark bits are permuted by Linear feedback shift resistor (LFSR) [7] before embedding process. We modify the coefficients as follows:

$$x_3^1(i, j) = x_3(i, j) + \alpha_1 * wk(k, l) \quad (1)$$

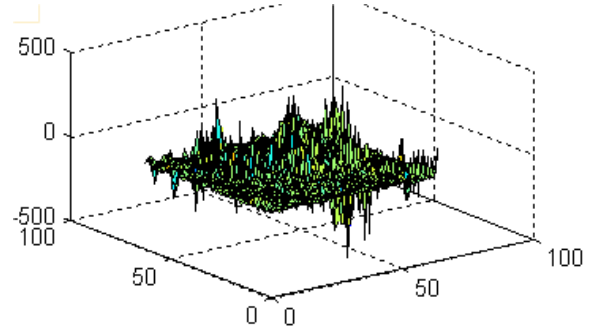
$$x_2^1(p, q) = \max(x_2(p, q)) + \alpha_2 * wk(k, l) \quad (2)$$

$\alpha_{1,2}$ : is the strength factor.

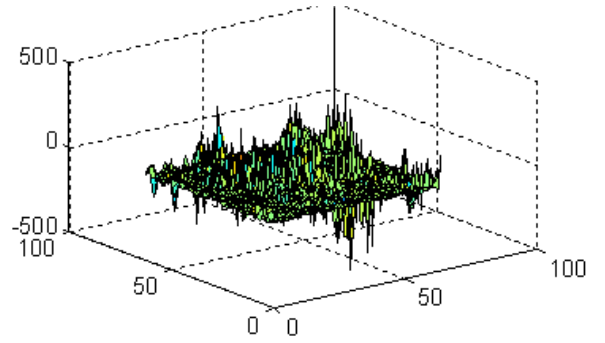
The qualified coefficients are changed up-down depending on value of watermark bit. There is only one coefficient in the group of QSWT ( $LH_2$ ) was changed (The maximum one) as shown in Fig. 3. This case quality of image not so much change when compare with the old method [8]. The time-frequency domain of embedded subband (before/after embedding) and the position for embedding are shown in Fig. 4 and Fig. 5 respectively.



**Fig.3.** The Parent and maximum values of QSWT were changed by watermark bit.



(a) Before embedding



(b) After embedding

**Fig.4.** Embedded subband of image ( $LH_2$ )

In Fig. 4, It's a bit hard to notices the different of them. We used  $T_1=190, T_2=220$  and  $\alpha_1=15, \alpha_2=17$ .



**Fig.5.** Embedded position of image ( $LH_3$ )

The number of embedding is depending on size of watermark image. In this experiment, we used size of 32x32 and the locations were selected by descending order. Fig. 5, shown the embedded locations of subband LH<sub>3</sub> (for 32x32 watermark image).

### B. Watermark Extracting Method

For the binary watermark image, it can be easily extracted. By comparing coefficient's energy at the same position of original and watermarked image.

Let  $Y_1, Y_2$  are the sum of energy at the same embedding location of original and watermarked image respectively, then the watermark bit can be retrieved as below.

$$\text{Watermark bit} = \begin{cases} 1 & Y_2 > Y_1 \\ 0 & \text{otherwise} \end{cases}$$

Finally, the extracted watermark bit values are then inversely permuted to get the reconstructed watermark image.

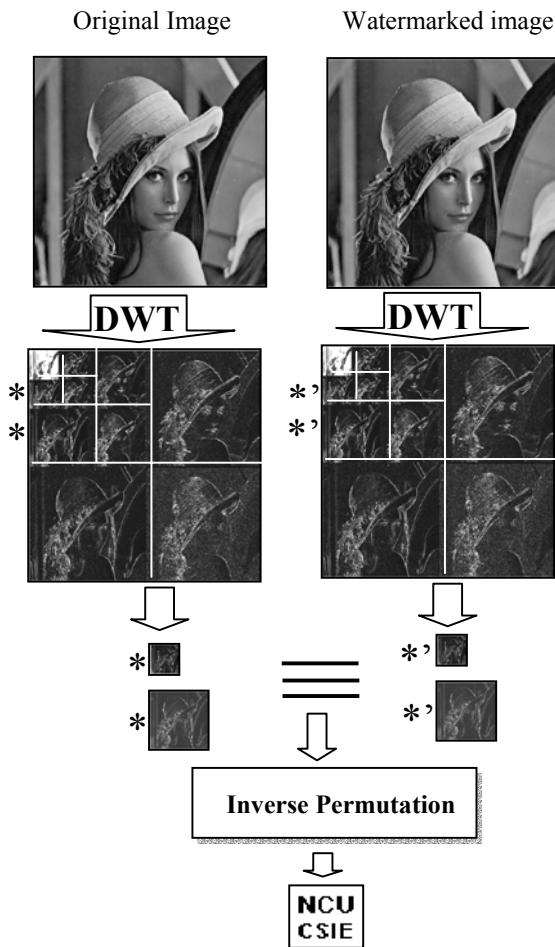


Fig.6. Extracting process

### III. Experimental

We have tested our method by using host Lena image size of 512x512 with 256 gray levels. In order to compare with the previous method [8], we also used the same watermarks image with size of 32x32 (binary image). Varieties of image processing operations have been applied to watermarked image. Some of images in our experimental have been listed below:



Fig.7. Original image



Fig.8. Watermarked image



Fig.9. Jpeg compression (PSNR = 31.7)



**Fig.10.** Smoothing image (PSNR=36.5)  
(Gaussian window size of 3x3 with variance = 0.59)

We have done with many types of degradation and the results some of them were listed in table 1.

Degradation	JPEG Lossy Compression				Smoothing	
*PSNR(dB)	38	38	32.7	31.7	36.5	36.5
Extracted watermark	<b>NCU</b> <b>CSIE</b>	<b>NCU</b> <b>CSIE</b>	<b>NCU</b> <b>CSIE</b>	<b>NCU</b> <b>CSIE</b>	<b>NCU</b> <b>CSIE</b>	<b>NCU</b> <b>CSIE</b>
Correlation	1.00	1.00	0.91	0.95	0.885	0.935
Methods	M1	M2	M1	M2	M1	M2

**Table.1.** Comparison of Proposed method and the method of [8], (M1=method [8], M2 = Proposed), (\*PSNR after attack).

$$PSNR = 10 \log_{10} \frac{255^2}{MSE} \quad (3)$$

MSE : Mean Square Error

$$Correlation \ n = \frac{\sum_i \sum_j (w_{ij} - \bar{w})(w'_{ij} - \bar{w}')}{\sqrt{\left( \sum_i \sum_j (w_{ij} - \bar{w})^2 \right) \left( \sum_i \sum_j (w'_{ij} - \bar{w}')^2 \right)}} \quad (4)$$

$\bar{w}$ ,  $\bar{w}'$  and  $w'$ ,  $w'$  are real, mean value of the original and reconstructed watermark image respectively.

#### IV. Conclusions

We have shown that, modifying only one highest manitude coefficient of QSWT (LH<sub>2</sub>) in appropriate MRA subband has no effect to quality of image so much. This allows us to reach both high robustness and imperceptibility requirement. For further research, others DWT (This experimental used the Haar wavelet with 3 levels of dcomposition) and the others subband at the same

resolution will be investigated to reach larger capacity for watermark insertion. Furhermore, reduction of the keys for extraction process must be considered.

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