

## Comparison of DWT-CRT And TLDCT-CRT Methods In Digital Watermarking

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**Abstract:** CRT method is an example of embedding method for fragile watermarking which closely related to document image protection. This study compares the use of watermarking schemes using the DWT-CRT and TLDCT-CRT methods. The DWT method is capable of providing good compression results to support the quality of watermark extraction, while the CRT method can produce a low level of distortion. This scheme is capable of producing watermark results with PSNR range of 45 dB and in the extraction process yields an average of 25 dB PSNR. While the TLDCT-CRT scheme has PSNR in the range of 45 dB and an average PSNR of 24 dB in the extraction process.

**Keywords:** Digital Watermarking, Discrete Wavelet Transform, Chinese Remainder Theorem

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Date of Submission: 26-05-2018

Date of acceptance: 11-06-2018

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### I. Introduction

The rapid development of internet makes the exchange and distribution of digital information become much more easier. In the other hand, it also creates new problems, one of which is the abuse of copyright digital data. Digital data misuse includes illegal use, altering digital data, and other cases that may violate the copyright's owner. It urges many researchers to create new methods to prevent such problems, and watermarking method becomes one of the solutions. Digital watermarking is a technique that hides information on digital data, so it cannot be seen and detected by bare eyes. In digital imagery, watermarking technique consists of two processes, i.e. generating watermark process which includes image compression, and embedding process on cover image, while the process is the inversion of both previous processes.

There are two types of digital watermarking based on its resistance, i.e. robust watermarking and fragile watermarking. Robust watermarking is mostly used for copyright while fragile watermarking is for document protection and authentication. The TLDCT-CRT study [5] is one of the fragile watermarking schemes. The use of CRT methods improves security and generates good watermark imagery. The TLDCT method is used for generating watermark process which greatly influences the image extraction. The DWT method is another option in the image compression process, as mentioned in a study which comparing the DCT and DWT methods [3]. As a result, the DWT method has lower Information Loss compared to DCT method. DWT method can be optimized by the use of adaptive quantization[1].

### II. Preliminaries

The watermarking process consists of watermark embedding process and extraction process. The embedding process begins with generating watermark using TLDCT and another scheme is using DWT Haar model of DWT method, while CRT method is used in embedding process.

#### A. Haar Discrete Wavelet Transform

For a series of input signal data represented in a numerical  $2^n$ , Haar wavelet transformation states that each pair of input data numbers can be expressed in one difference value and one sum value of both numbers. The portion of the sum value is expressed as the approximation coefficient which contains the global information or low frequency component contained in an image, while the difference value portion is known as the wavelet coefficient which contains detailed information or high frequency information. The process of 2D Haar DWT is as follows.

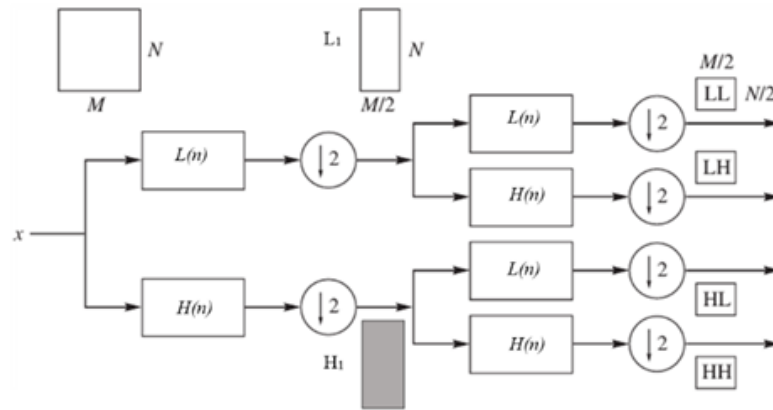


Figure 1. Process of 2D Haar DWT [10]

**B. Adaptive Quantization for DWT Coefficients**

The use of adaptive quantization compared to the use of uniform quantization in DWT greatly influences the size and quality of compression. The adaptive quantization process involves the median value of selected subband and is applied to the uniform quantization of JPEG2000. The following is adaptive quantization steps of DWT [1]:

- Step 1- Calculate median value of the subband
- Step 2- Subtract all the subband coefficients by median value
- Step 3 - Determine the quantization interval
- Step 4 - Calculate  $\Delta b_R$  by dividing subband maximum coefficient with quantization interval value. And also divide subband minimum coefficient by quantization interval value to calculate  $\Delta b_L$
- Step 5 Calculate quantization value using formula (1), where  $H'(i, j)$  is the subband coefficient in  $(i, j)$  position after step 2. Use  $\Delta b_R$  if the coefficient > median and use  $\Delta b_L$  if the coefficient < median.

$$Q'(i, j) = \text{sign}(H'(i, j)) \left\lceil \frac{|H'(i, j)|}{\Delta b} \right\rceil \tag{1}$$

**C. Two Level Discrete Cosine Transform (TLDCT)**

Based on the research that has been done [5], the use of TLDCT is able to make transformation coefficient become more evenly. That way the difference coefficient values are common in DCT i.e. coefficients on the top left that have a very large difference compared to the bottom right can be overcome. The following is TLDCT process:

- Step 1- Divide the image into 8x8 block
- Step 2- Perform DCT transformation on each block
- Step 3 - Create a new 4x4 block by taking the 4x4 coefficient on the top left
- Step 4 - Perform a DCT transform on the new 4x4 block

**D. Chinese Remainder Theorem**

Chinese Remainder Theorem is a method that utilizes the concept of simultaneous congruence which is a group of congruence relation that related each other on the same variable but have different moduli. In its usage on digital watermarking system, this method explains that an integer number can be represented by two smaller numbers. If there are two integer numbers  $S_1$  and  $S_2$  where  $S = S_1 * S_2$ , then a  $Z$  number is in the range of 0 to  $S - 1$  ( $0 \leq Z \leq S - 1$ ). So, any value of  $Z$  can be represented by a pair of integers  $(R_1, R_2)$ , where  $R_1 < S_1$  and  $R_2 < S_2$ . The values of  $R_1$  and  $R_2$  can be determined by involving modulo operations in form of following congruence relations [5]:

$$\begin{aligned} Z &\equiv R_1 \pmod{S_1} \\ Z &\equiv R_2 \pmod{S_2} \end{aligned} \tag{2}$$

**III. Method**

The purpose of this study is to compare the use of DWT-CRT and TLDCT-CRT methods in the process of fragile watermarking. It will include generating watermark process, embedding process, extraction process, and testing of editing. The image used as the cover image and the watermark image are the same image with the same size.

**A. Generating Watermark Process**

Prior to this process, the image is conditioned by preprocessing, by ensuring that the image size is divisible by 2 so it can be processed using DWT Haar method. If the image size is not divisible by 2, then padding will be done.

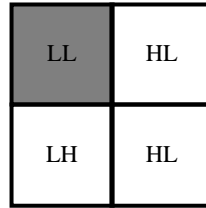


Figure 2. Selected subband

In the Fig. 2, the subband chosen is subband LL because it contains the most information of the image and the other subband will be ignored, while the interval used in quantization is 16 (4 bits), thus each pixel of cover image will be embedded by 1 bit of watermark. Similar to the DWT method, in the TLDCT method, the image will be conditioned by ensuring that the image size must be divisible by 8, if it is not then padding will be done. The generating process begins by classifying the image based on the color channel, and then the DWT process and quantization are done. The result of quantization will be represented by the binary value through the binarization process. The designed process flow can be seen in Figure 3.

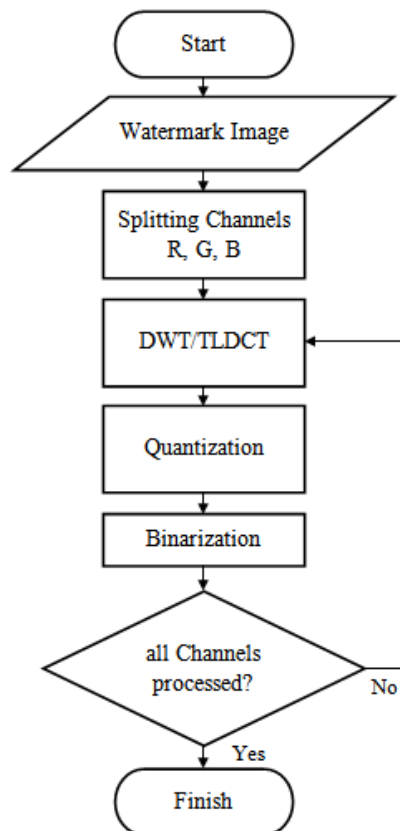


Figure 3. Generating watermark process

**B. Embedding Process**

Once the watermark bit is obtained, the next process is to insert the watermark bit into the cover image. To increase the security of watermarking, the location of the bit embedding will be done randomly using Pseudo Random Number Generator (PRNG) process which involves seed/key so that the same random position can be recovered after the extraction process. The outline of the embedding process flow is shown in Figure 4.

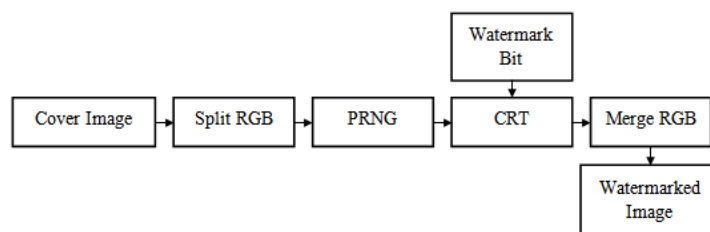


Figure 4. Watermark embedding process

In the CRT process, the embedded pixel will be taken 2 Least Significant Bit (LSB) of its color intensity value. The value of 2 LSB is included in equation (2) as the value of Z to calculate R1 and R2, while the value of S1 and S2 has been determined first. After obtaining R1 and R2 values, it should be checked whether the values meet one of the following conditions [5]:

$$\begin{aligned}
 & \text{Watermark bit} = 1 \ \& \ R1 \geq R2 \\
 & \text{Watermark bit} = 0 \ \& \ R1 < R2
 \end{aligned}
 \tag{3}$$

If the condition is not met, then a modification will be done by adding or subtracting its color intensity value by 1.

**C. Extraction Process**

Maximum value, minimum value, subband median value, and the key of the PRNG are required in extraction process. The flow of the watermark image extraction process is shown in Figure 5.

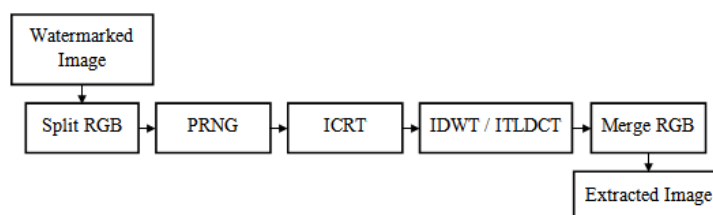


Figure 5. Extraction Process

In similar way, the CRT extraction process also uses 2 LSB and equation (2) to obtain R1 and R2. Then it is checked. If the value of  $R1 \geq R2$ , then the watermark bit is 1. Otherwise, it will be 0.

**IV. Result And Discussion**

Data used in this test is 20 images consisting of 11 images commonly used in digital image research and 9 document images containing text with several background colors.

The parameter used to test the quality of the watermarking process results is the Peak Signal to Noise Ratio (PSNR) value between the initial image and the watermark image. The following is the equation used to calculate PSNR [10]:

$$PSNR = 10 \log_{10} \frac{MN(\max P_{x,y})^2}{\sum_{x=1}^M \sum_{y=1}^N [P_{x,y} - P'_{x,y}]^2}
 \tag{4}$$

where M and N is the image size,  $P_{x,y}$  is the initial image pixel and  $P'_{x,y}$  is the watermarked image pixel, while  $\max P_{x,y}$  is the maximum intensity value of the image.

The results of the watermarking process for the designed scheme are shown in Table 1.

**Table 1.** Comparison of watermarked image PSNR

Image	TLDCT-CRT[5] (dB)	DWT-CRT (dB)
Airplane	44.404	44.586
Baboon	44.822	44.762
Lenna	47.434	47.545
Pepper	45.118	44.957
Barbara	45.547	44.934
Boats	45.251	45.375
Cable Car	45.698	45.497
Gold Hill	46.013	46.448
Monarch	45.591	45.328
Sail Boat	44.790	44.983
Zelda	45.024	45.573

CIMB Bank Cheque	45.078	44.936
Danamon Bank Cheque	45.207	45.284
BCA Bank Cheque	46.465	46.683
Credit Card	45.171	45.567
ID Card	45.216	45.186
Passport	45.395	45.588
Harvard Certificate	47.703	47.651
PAP Cetificate	44.775	44.826
TPA Certificate	45.272	45.063

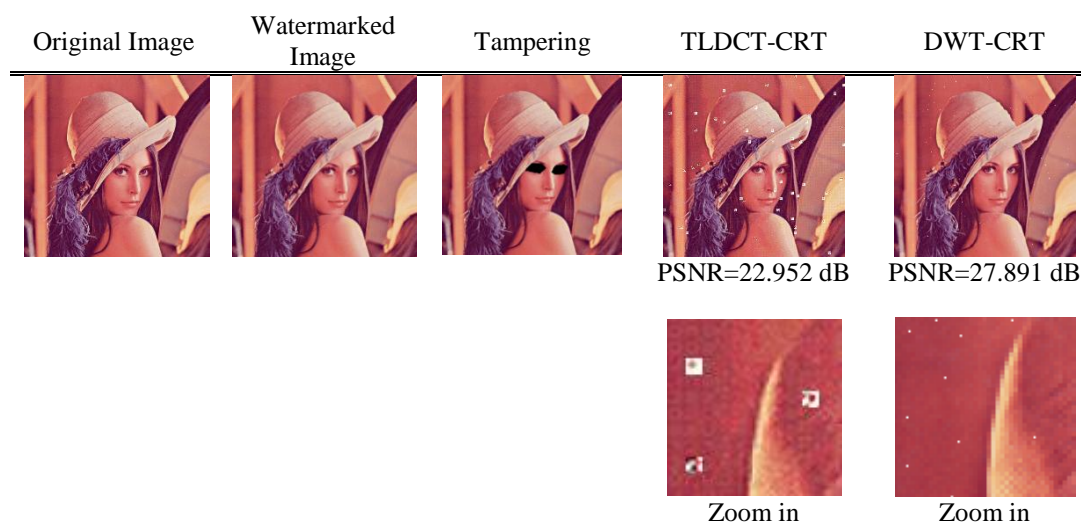
As shown in Table 1, the watermarking process using TLDCT-CRT and DWT-CRT has relatively similar PSNR values because each method uses 4 bit watermark which means that in the TLDCT method, 16 coefficients has been taken on each block where each coefficient has 4 bits and makes the total number of bits inserted is 64 bits or 1 bit per pixel. The difference in PSNR value is due to the difference of watermark bit value and the embedded pixel value.

**Table 2.** Comparison of extracted image PSNR

Image	TLDCT-CRT (dB)	DWT-CRT(dB)
Airplane	27.116	28.014
Baboon	21.284	21.519
Lenna	26.905	29.234
Pepper	26.871	28.334
Barbara	24.773	25.584
Boats	27.414	28.041
Cable Car	26.975	27.858
Gold Hill	27.645	30.148
Monarch	27.636	28.578
Sail Boat	28.451	26.580
Zelda	22.675	31.671
CIMB Bank Cheque	23.338	24.981
Danamon Bank Cheque	22.201	24.112
BCA Bank Cheque	21.838	21.991
Credit Card	23.830	30.148
ID Card	23.679	21.982
Passport	25.977	23.742
Harvard Certificate	22.717	22.310
PAP Cetificate	23.174	23.731
TPA Certificate	21.679	21.981

Table 2 shows that the DWT-CRT method has slightly better extraction image quality than the TLDCT-CRT method with PSNR values between 21.519 to 31.671 dB, whereas the TLDCT-CRT method has PSNR values between 21.284 to 28.451 dB.

The next test is conducted to see how both schemes resist the attack. In this experiment, the image is tested as described in Fig. 6:



**Figure 6.** Extracted image after tampering attack

Fig. 6 shows watermarked image will be given a tampering attack, the test results show that the DWT-CRT scheme has better durability with a PSNR value of 27.891dB than TLDCT-CRT scheme which has 22.952 dB. Since the TLDCT-CRT scheme divides the block into 8x8, then the damage caused by the attack will also be spread over each block with same size on the image. While the DWT-CRT scheme do not use the block so that the error will have a pixel size.

## V. Conclusion

Based on the research results, there are several points that can be concluded related to the comparison of DWT-CRT and TLDCT-CRT schemes. The same embedding method and watermark bit value in watermarking process result in relatively same PSNR value.

The use of adaptive quantization optimization on DWT method is able to increase watermark extraction result which has PSNR value ranged from 21.519 dB to 31.671 dB. While the ranged PSNR value of 21.284 dB to 28.451 dB is obtained from TLDCT-CRT scheme.

## References

- [1]. Chen, P.Y. & Chang, J.Y. 2013. *An Adaptive Quantization Scheme for 2-D DWT Coefficients*. International Journal of Applied Science and Engineering. 1: 85-100.
- [2]. Haribabu, M., Bindu, C.H. & Swamy, K.V. 2016. *A Secure & Invisible Image Watermarking Scheme Based on Wavelet Transform in HSI Color Space*. 6th International Conference on Advances in Computing & Communications. ICACC. Cochin, 6-8 September 2016.
- [3]. Katharotiya, A., Patel, S. & Goyani, M. 2011. *Comparative Analysis between DCT & DWT Techniques of Image Compression*. Journal of Information Engineering and Applications. Vol 1, No.2.
- [4]. Nguyen, T.S., Chang, C.C. & Yang, X.Q. 2016. *A Reversible Image Authentication Scheme Based on Fragile Watermarking in DWT Domain*. International Journal of Electronics and Communications. 70: 1055-1061.
- [5]. Nugraha, D.A., Rahmadwati & Muslim, M.A. 2017. *Skema Digital Watermarking Citra dengan Metode TLDCT dan Chinese Remainder Theorem*. Jurnal Nasional Teknik Elektro dan Teknologi Informasi. Vol 6, No 2.
- [6]. Patra, B. & Patra, J.C. 2012. *CRT-Based Fragile Self-Recovery Watermarking Scheme for Image Authentication and Recovery*. Makalah dalam International Symposium on Intelligent Signal Processing and Communication Systems. ISPACS. 4-7 November 2012.
- [7]. Patra, J.C., Khartik, A. & Bornand, C. 2009. *A Novel CRT-Based Watermarking Technique for Authentication of Multimedia Contents*. Digital Signal Processing. 20(2): 442-453.
- [8]. Patra, J.C., Phua, J.E. & Bornand, C. 2010. *A novel DCT domain CRT-based watermarking scheme for image authentication surviving JPEG compression*. Digital Signal Processing. 20(2010): 1597-1611.
- [9]. Vaidya, P. & Mouli, C. 2015. *Adaptive Digital Watermarking for Copyright Protection of Digital Images in Wavelet Domain*. Second International Symposium on Computer Vision and the Internet (VisionNet'15). 58: 233-240
- [10]. Sayood, K. 2012. *Introduction to Data Compression*. 4th Edition. Waltham: Morgan Kaufmann.

IOSR Journal of Computer Engineering (IOSR-JCE) is UGC approved Journal with Sl. No. 5019, Journal no. 49102.

\* Nanda Martyan Anggadimas. "Comparison of DWT-CRT And TLDCT-CRT Methods In Digital Watermarking." IOSR Journal of Computer Engineering (IOSR-JCE) 20.3 (2018): 73-78