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A Comparison of Non Blind Image Watermarking Using Transformation Domain

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Abstract
Purpose: This study aims to know which of the algorithms had the better results for image processing by comparing these two algorithms for blind watermarking as the prevention of image plagiarism.
Methods: The DCT and HWT algorithms used to get better results.
Result: The results of this study indicate that HWT has better results for image processing, especially blind watermarking because the results with MSE, PSNR, and NC show that HWT has advantages in every aspect. using 512x512 pixels grayscale image as cover image, the MSE result from HWT is 0.0004156 with PSNR 81.9440 better than MSE from DCT 0.003 with PSNR 73.2949.
Novelty: Robustness aspect has been tested using NC. DCT has good NC than HWT only in JPEG compression attack with value is 1, while another attack has better NC in HWT that yield close to 1.

Keywords: Non Blind, Watermarking, DCT, HWT, Imperceptibility, Robustness
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INTRODUCTION

Many images are uploaded to the internet. However, in some cases, these images are used by irresponsible parties, this is because it is easy to download anything from the internet, including images. If the party includes the source of the image, it will not be a problem, but what often happens is that the downloaded image is stamped and acknowledged by the side until the party is said to have committed an act of image piracy [1]. There are ways to anticipate the problems that occur with the rapidly developing field of image processing that can be used as a countermeasure for image piracy and as confirmation of the copyright of an image, so that it is difficult for the image to be hijacked by irresponsible parties, if it is not immediately handled. This will cause most of the creators of imagery to suffer losses due to works that are bothered to be hijacked by irresponsible parties.

There are many ways that can be taken to overcome this, but they still cannot stop and make these irresponsible parties stop and become deterrent. Due to the above reasons, in order to reduce the level of plagiarism by irresponsible parties, the most appropriate way to use is to embed watermarks on the image. Watermarking is an activity to insert or embed messages into a digital image using a watermarking algorithm. Watermarking is divided into 2 types based on the verification process, namely non-blind watermarking and blind watermarking [2]. Non-blind watermarking is watermarking which when the verification process occurs requires the original image, while blind watermarking does not require the original image in the verification process.

In this paper, the blind watermarking method is used with the Haar Wavelet Transform (HWT) and Discrete Cosine Transform (DCT) algorithms. DCT is a way to convert a signal into basic frequency components by considering the real value of the transform. DCT is widely used in many cases, especially in terms of hiding data because it is faster than Fast Fourier (FF) [3] and is resistant to attacks such as cropping, filter

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blurring, and noise and gives very satisfying results. HWT is a Wavelet Transform using the Haar filter [4], and is the simplest form of all wavelet transform [5]. In this case, the low-frequency wavelet coefficient is generated from the average of the two pixel values and the high-frequency coefficient is generated by taking half the difference from the same two pixels [6]. HWT is a very fast compute wavelet transform and supports coding efficiency [7], high compression ratio, and good image restoration quality [8]. HWT has resistance to image attacks such as salt & pepper noise, image rotation, text addition and image compression.

For method evaluation techniques, researchers used the Mean Square Error (MSE) technique, Peak Signal to Noise Ratio (PSNR) [9], and Normalized Correlation (NC) [10]. MSE is an estimator of the expected value of the squared error. The error in question is the difference between the estimated value and the estimation results obtained. PSNR is the result of a comparison between the maximum value of the measured signal along with the amount of noise attack that affects the signal to measure the imperceptibility level of a watermark image. NC is a technique for assessing the similarity level of two images with a value range of 0-1 where the resulting image value with a value of 1 is stated to be very similar to the original image. Meanwhile Structural Similarity Index Measurement (SSIM) [11] [12] used to investigated an imperceptibility between original and watermarked image, and this ensure the PSNR values.

METHODS

State of The Art

Based on Table 1, it can be concluded that the use of the HWT and DCT algorithms produces satisfactory results for the imperceptibility level and the robustness level with an average PSNR value above 40 dB and an NC value close to 1. The difference with previous research is using color images and use of Haar filters in the blind watermarking process.

Tabel 1. State of the art based on blind watermarking

Year	Authors	Algorithm					Results
		VQ	DCT	LSB	DWT	SVD	
2015	Xu Ding, Zhe-Ming Lu and Fa-Xin Yu [13]	✓					NC results obtained from various attacks on images without attack 1.0000, VQ re-encoding 1.0000, JPEG with QF = 80 0.972, Image cropping 0.7378, Median filtering 0.7306, Blurring 0.9557, Sharpening 0.9064, Gaussian noise 0.9602, and Rotation by 0: 1o 0.7870.
2017	Yu-Wen Chang [14]		✓				Watermark image quality is better around 0.2 to 1.1dB compared to conventional watermaking algorithms based on the frequency domain, namely Peppers 32.413 dB, Lena 32.411 dB, Plane 33.074 dB.
2017	Adi Suheryadi [15]			✓			The results of the experiment resulted in an average PSNR value of 34.08 dB and an MSE of 14.62.
2017	Muhammad Rifqi Fadhilah, Imam Santoso, and Ajub Ajulian Zahra [16]			✓	✓	✓	PSNR ranges from 39 to 47 dB, NC values that are close to 1 when under attack.
2018	Christy Atika Sari, Titien Suhartini Sukamto dan Eko Hari Rachmawanto [17]		✓		✓		Producing a CC value with a JPEG Compression (Q50) attack of 0.9477 and NC of 0.9449, while for salt and paper attacks (0.01) the CC value was 0.8731 and NC was 0.9217. For the Gaussian Noise attack (0.002), the CC obtained is 0.9184 and NC is 0.9342.

Discrete Cosine Transform (DCT)
Discrete Cosine Transform (DCT) is a way to convert a signal into basic frequency components by considering the real value of the transformation results [14][18]. In general, the DCT operation model can be illustrated in Equation (1), while IDCT is illustrated in Equation (2).

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

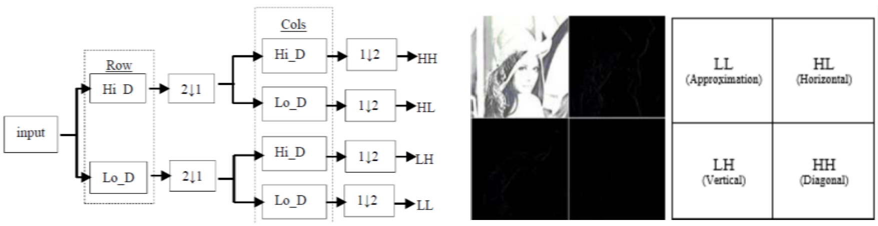
$$S(x) = \sqrt{2/n}\sum_{x=0}^{n-1}S(u).\alpha(u)\,cos\left(\frac{\pi(2x+1)u}{2N}\right)cos\left(\frac{\pi(2Y+1)v}{2M}\right) \quad (2)$$

When the pixel value changes to the frequency domain, it will be divided into 2 components, Alternating Current (AC) and Direct Current (DC). DC is the key coefficient of an image because it stores the main information of an image so that if a change is made to this coefficient, a significant change will occur [19]. If a message is inserted in this section, it will be difficult to delete even with various image manipulations [20].

Haar Wavelet Transform (WHT)
Haar Wavelet Transform is the simplest domain model of all wavelet transforms [21], in this case the low frequency wavelet coefficient is generated from the average of the two pixel values and the high frequency coefficient is generated by taking half the difference of the same two pixels [22]. HWT is a highly computable wavelet transform and supports coding efficiency, high compression ratio, and better image restoration quality compared to traditional transformations [23]. In the wavelet transform 1-D consists of two Haar filters, namely the high filter and the low filter [24][25]. The decomposition process on DWT can be shown using Equation (3) and Equation (4).

$$Y_{high}[k] = \sum_n X[n]h[2k-n] \quad (3)$$

$$Y_{low}[k] = \sum_n X[n]g[2k-n] \quad (4)$$



(a) (b)
Figure 1. (a) DWT Downsampling, (b) Image result based on DWT downsampling

$$LL = \frac{1}{2}\begin{bmatrix}1 & 1\\1 & 1\end{bmatrix} \quad (5)$$

$$LH = \frac{1}{2}\begin{bmatrix}1 & 1\\-1 & -1\end{bmatrix} \quad (6)$$

$$HL = \frac{1}{2}\begin{bmatrix}1 & -1\\1 & -1\end{bmatrix}] \quad (7)$$

$$HH = \frac{1}{2}\begin{bmatrix}-1 & 1\\1 & -1\end{bmatrix} \quad (8)$$

As for the application of the 2-D wavelet transform image, the filter Haar will divide the input image into four parts of the multi-resolution sub-band frequency, LL LH, HL and HH [26] according to Figure 1. LL is a low frequency which is often referred to as an estimate image while LH and HL are intermediate frequencies and HH are high frequencies.

Proposed Method
Here, we proposed 2 schemes of blind watermarking process as describe in Figure 2 for DCT and Figure 3 for HWT.

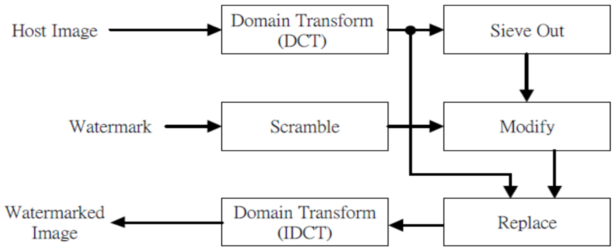


Figure 2. DCT blind watermarking

Based on Figure 2, the flow of blind watermarking using the DCT algorithm can be described as below:
1) The original image is an RGB image so that before transforming the image block with DCT, it is necessary to change the RGB image to a grayscale image using Equation (1).
2) F is the result of changing the image to grayscale. After that, the F image is transformed using the DCT algorithm using Equation 2 to produce DCT in AD and DC coefficients.
3) The watermark image undergoes coefficient randomization randomly so that it gets the `mark_` coefficient.
4) Step 4: Inserting the watermark coefficient into the DC coefficient on the selected FA image (which has been in DCT) with the coefficient `mark_` produces FB (watermarked image).
5) Step 5: The FB which already contains the watermark is placed and returned to its original position, then the back transformation (IDCT) using Equation (3) is carried out on the entire DCT coefficient to obtain a watermarked image.

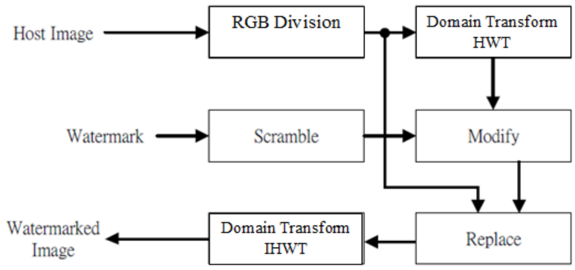


Figure 3. HWT blind watermarking

Based on Figure 3, the flow of blind watermarking using the DCT algorithm can be described as follows:
1) The original image is decomposed using RGB division.
2) For watermark images, go through the same steps, namely coefficient randomization.
3) After that, we immediately carried out a wavelet transformation using the Haar filter and the insertion of the watermark coefficient that had been randomized.
4) Perform IDWT using equation (5) to reconstruct the image from the wavelet coefficient so that an image that has been watermarked is formed.

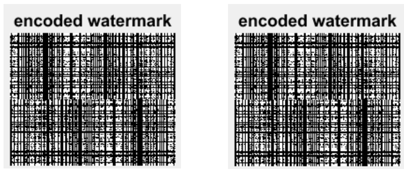
RESULT AND DISCUSSION
At this point, we will discuss the experimental results that have been carried out by researchers by displaying the output of the Blind Watermarking process using the DCT and HWT algorithms and an attack has been carried out to test imperceptibility and robustness. Here, the original image pixels in RGB form become grayscale, while for the HWT the initial image, RGB division is divided. The original image is a color image with a size of 512x512 pixels while the watermark image is 256x256 pixels in size as shown in Figure 4.

(a) (b)

Figure 4. (a) Cover image, (b) Watermark image

In this research, several attacks will be provided for both algorithms, namely DCT and HWT with the aim of knowing which algorithm is more imperceptibility and robustness. The results of randomization coefficients for each method are shown in Figure 5.

Maize Dataset Testing
Dataset on maize collected was 120 obtained from BMKG and BPS. The following is a sample dataset for maize food crops, as shown in Figure 5.



DCT HWT

Figure 5. Coefficient Randomization Results

The reason for choosing noise and cutting attacks is because DCT and HWT are strong in both attacks so it is fair to both algorithms. The results obtained from the attack test are as shown in Figure 6. Based on Figure 6, we know that using a human visual system there is no difference between the results on the DCT and HWT.

(a) (b) (c) (d)

Figure 6. Sample of Visual Result : (a) Noise attack in DCT, (b) Noise attack in HWT, (c) Cutting attack in DCT, (d) Cutting attack in HWT

Thus, empirical calculations are needed to determine the level of imperceptibility of the two algorithms by comparing the resulting PSNR values as shown in Table 2. Here, we use PSNR as follow in Equation (9) and Equation (10). To ensure the quality of the resulting image, in this paper we also use the Structural Similarity Index Measurement (SSIM) calculation according to Equation (11).

$$MSE = \frac{1}{m\ x\ n} \sum_{i=1}^{n} \sum_{j=1}^{m} \left(X_{ij}{}^{o} - X_{ij}{}^{i} \right)^2 \quad (9)$$

$$PSNR = 10 \log 10 \left(\frac{255^2}{MSE} \right) \quad (10)$$

$$SSIM = \frac{(2\mu_A \mu_B + c_1)(2\sigma_{AB} + c_2)}{(\mu_A^2 + \mu_B^2 + c_1)(\sigma_A^2 + \sigma_B^2 + c_2)} \quad (11)$$

Where, X^i is the cover image, and X^o is watermarked image. A good PSNR, according to [27] that is in the 60 to 80 dB range. In other studies, it is stated that, algorithm is more impercept because the resulting watermark image is less damaged by the watermark insertion process, even values above 40 dB can be said that the resulting image is almost invisible the damage. In Equation (11), it is known that μ, σ, and σxy are the mean, variance and covariance of an image, respectively, and c1, c2 are the balancing constants. SSIM has a value ranging from 0 to 1. SSIM with a value close to 1 means that the image being tested has a close proximity to the original image [28].

Table 2. Imperceptibility Result of DCT and HWT

Algorithm	DCT	HWT
MSE	0.0030	0,0004156
PSNR	73.2974 dB	81.9440 dB
SSIM	0.9838	0.9987

After doing the experiment, the results are as in Table 2, the MSE value generated by the HWT algorithm is 0.0004156 which means that the error rate is smaller than the DCT algorithm which produces a value of 0.003. In PSNR the value generated by the HWT algorithm is 81.9440 dB higher than the DCT algorithm which only produces a value of 73.2974 dB. On the other hand, it is necessary to investigate the resulting robustness. In this paper, we use Normalized Correlation (NC) calculations to determine the robustness level of the resulting image [10] in accordance with Equation (12).

$$NC = \frac{1}{SxT} \sum_{S=1}^{s} \sum_{t=1}^{T} ©(s,t) x ©_{r}(s,t) \tag{12}$$

In the extraction process, a test is carried out to compare the watermark image and the embbeded message image, where the good NC value is close to the value 1. The following are the results of robustness generated in several image processing attacks, as shown in Table 3.

Table 3. Robustness result using several image processing attacks

Attacks	DCT	HWT
Noise (Salt and Pepper d=0.2)	0.9403	0.9794
Cutting	0.8429	0.8490
Blurring	0.8892	0.9231
JPEG Compression (QF = 50)	1	0.8824
JPEG Compression (QF = 70)	1	0.8712
Median Filter	0.9112	0.9366
Sharpening	0.9389	0.9499
Gaussian Filter	0.8672	0.9137
Rotation 45^0	0.8661	0.9731
Rotation 90^0	0.8693	0.8927

Based on Table 3, the NC value generated by all images after being given various attacks is close to value 1.It is known that a good NC value is between 0 and 1.In the JPEG compression attack, it can be seen that DCT produces NC values better than HWT in both JPEG compression attacks at QF = 50 and QF = 70. This is due to the superiority of DCT in the image compression process. In addition to the JPEG compression attack, HWT produces higher NC values. This proves that the Haar filter is quite effective in increasing the robustness value.

CONCLUSION

This study compares imperceptibility and robustness in blind watermarking from 2 algorithms, namely DCT and HWT. The watermarking process was successfully carried out on sample images, namely g11.jpg with a size of 512x512 pixels and message images with a size of 256x256 pixels. From the experimental results shown in Table 1, Table 2 and Table 3, it can be concluded that the HWT algorithm is more imperceptible to blind watermarking compared to the DCT algorithm, this is evidenced by the lower MSE value on HWT accompanied by a higher PSNR HWT value. On the other hand, the HWT algorithm is also more robust because the NC value obtained is closer to 1 in the two attacks that have been given. Only in JPEG compression attacks, DCT is superior to HWT.

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