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Watermarking using DCT and DWT on Pneumonia images

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Abstract – Watermarking is a branch of the data hiding technique. Watermarking is a technique used to insert a copyright label on an image, the copyright of the image can be protected. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are techniques hasd been used to watermark. In this study, the Discrete Cosine Transform and Discrete Wavelet Transform methods will be used to watermark images to 5 different host images. In the tests carried out, watermarking techniques will be compared using DCT, DWT, DCT-DWT combination and DWT-DCT combination. The results obtained in this study were the highest PSNR value obtained at 41.931, the highest SSIM obtained 0.99515, the highest entropy was also obtained at 7.4186, The best UACI value is 0.0071158 and the best NCPR value is obtained at 93.9068% then, for the best CC value is obtained at 0.99953. As well as the NCC value, the value obtained is the same all in each test, namely with a value of 1.

Keywords – DCT, DWT, Watermarking, Testing, Image, Combination

1. INTRODUCTION

Pneumonia is a disease affected anyone who has low body resistance data. Okazaki, et. al [1], suggests pneumonia is one of the main causes of death especially in the elderly. Pneumonia is a disease attacks the lungs, where this disease can be caused by viruses, bacteria, or fungi [2]. Pneunomia is a disease can be treated with medical treatment and by administering antibiotic and antiviral drugs to increase immunity [3]. Although it can be treated with the help of drugs, pneumonia can also endanger life if not treated in a timely manner, therefore, the process of handling the results of early diagnosis is very important [4]. In the data shown in 2019, There were 740,180 reported deaths of children due to pneumonia and with 14% of deaths with children under 5 years of age [5]. With these data, it can be seen pneumonia not only attacks elderly people, but attacks anyone, including children. This of course must be a concern, especially for the authorities in the health sector to be able to take preventive and curative actions for pneumonia sufferers [6]. Image processing is the branch of science studies how an image can be analyzed and processed. Nowadays, the science of image processing is increasingly popular, because many technologies are available to be able to capture images well [8]. Image processing aims to improve image quality so the image can be easily analyzed by humans or by computer machines [9]. The purpose of image processing is also the resulting image has better image quality than the original image [10]. Image processing in the medical field is an area is affected due to advances in technology, especially in image manipulation and analysis, computer-assisted diagnosis can be made [7]. In images exist or relate to the medical field, information from patients is usually inserted [11]. Therefore, medical image processing is vital in hospitals [12]. Watermarking is a process used to insert information or images on the host image which is usually a multimedia media such as image, video or audio, where the watermark is the information inserted and the host is the main data [13]. Watermarking provides security and authentication to the digital products used [14]. Because watermarking is a technique plays a role in protecting copyright [16], content from users is expected to be safe and not misused illegally [15]. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are methods used to watermark. DCT works by converting an image into a transformation domain by manipulating its frequency component [17]. Typically, DCT is widely used to perform data compression and image compression [18], But DCT can also be done for image watermarking. DWT works by processing wavelet waves. Wavelet is a small wave with an ever-changing frequency, therefore DWT is able to optimize capacity explicitly, so it is widely used for image compression and watermarking methods [19].

Research conducted by Kavitha et. al [20], discusses watermarking using the concept of a combination of DCT and DWT and extraction of watermarking results using Neural Networks. The purpose of this study is to conduct a hybrid algorithm, namely DCT and DWT to be able to do digital watermark. The results obtained from this study are by using a combination of the two methods, namely DCT and DWT, resulting in a strong and effective watermark.

Research conducted by Abdulrahman, et. al [21], discusses watermarking color images using a combination of DCT and DWT methods. This study aims to see how robust or resilient the image results from the DCT and DWT combination method after manipulation of the image such as cropping, resizing, filtering, etc. The results obtained from this study are the method used, namely the combination of DCT and DWT, showing resilience after image manipulation and also transparency of watermarked images protected by information.

2. RESEARCH METHOD

2.1. Dataset

Pneumonia is a disease attacks the lungs, where this disease can be caused by viruses, bacteria, or fungi [2]. Pneunomia is a disease treated with medical treatment and by administering antibiotic and antiviral drugs to increase immunity [3]. Although it can be treated with the help of drugs, pneumonia can also endanger life if not treated in a timely manner, therefore, the process of handling the results of early diagnosis is very important [4]. To detect pneumonia or not, it can be seen from the results of X-Ray scans. X-Ray is a diagnostic examination used X-rays to bring up images or images of internal cavities or organs in the human body. In this study, it will use a dataset in the form of X-Ray scans of pneumonia patients consisting of 5 images to be used as host images or main images. Where the five images are of type .jpeg and the size is resized, all sizes in each host image become 512 * 512 pixels. As for the image used as a watermark, it is an RGB image is transformed into grayscale and binarize operations are carried out, the value or value of the image becomes 0 and 1 or black and white.

Figure 1. Host Images

Figure 2. Watermark Images

2.2. Discrete Cosine Transform (DCT)

Discrete Cosine Transform (DCT) is a method used to watermark. DCT works by converting images into transformation domains by manipulating their frequency components [17]. DCT uses transformations to be able to change the spatial domain of the image. The watermark given is then encrypted and then inserted into the image has been transformed DCT, the resulting image difference is not detected by the human eye. In this study, it will be used to change the host image M x N with frequency representation by grouping or dividing into 8 x 8 pixel blocks, the pixel block becomes 64 at the DCT coefficient. After taking the dct coefficient using DCT-2D, the signal is returned to the spatial domain using Inverse DCT-2D. DCT-2D formula of N-x N sized imagery:

$$DCT(x,y) = \frac{2}{N} D(x)D(y) \sum_{c=0}^{N-1} \sum_{z=0}^{N-1} f(c,z) \cos\left[\frac{(2c+1)x\pi}{2N}\right] \cos\left[\frac{(2z+1)\, y\pi}{2N}\right] \tag{1}$$

Rumus Inverse DCT-2D:

$$f(c,z) = \frac{2}{N} \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} D(x)D(y)DCT(x,y) \cos\left[\frac{(2c+1)\, x\pi}{2N}\right] \cos\left[\frac{(2z+1)\, y\pi}{2N}\right] \tag{2}$$

Psuedocode:

1) Input citra host
2) Input citra watermark
3) Split pixel blocks on the host image
   blockSize = 8
   [height, width] = size(hostImage)
   numBlocksH = height / blockSize
   numBlocksW = width / blockSize
4) Apply DCT to the divided block
   for i = 1:numBlocksH
   for j = 1:numBlocksW
   *block = hostImage((i-1)*blockSize+1:i*blockSize, (j-1)*blockSize+1:j*blockSize)*
   dctBlock = dct2(block)
5) Combine watermark with DCT coefficient of divison result
   *dctBlock(1, 1) = dctBlock(1, 1) + alpha * dctBlock(1, 1);*
6) Return the signal to the spatial domain
   watermarkedBlock = idct2(dctBlock);
   *watermarkedImage((i-1)*blockSize+1:i*blockSize, (j-1)*blockSize+1:j*blockSize) = watermarkedBlock*

2.3. Discrete Wavelet Transform (DWT)

Discrete Wavelet Transform (DWT) is a method used to watermark images. DWT or Discrete Wavelet Transform works by processing wavelet waves. Wavelet is a small wave with an ever-changing frequency, therefore DWT is able to optimize capacity explicitly, so it is widely used for image compression and watermarking methods [19]. The idea used in the Discrete Wavelet Transform or DWT method is to decompose into high-frequency signals and low-frequency signals [22]. In the process, the host image becomes 4 parts, namely LL, LH, HL and HH. For LL is the part with a low frequency and for LH, HL and HH is a part with a high frequency.

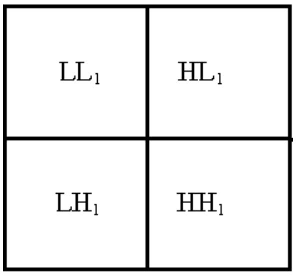


Figure 3. DWT Decomposition

After decomposition of the host image, the watermark image will be resized according to the LL subband. Because the information usually resides on subband [23]. After resizing, it will be inserted into the subband. Because the LL subband is a low-frequency part, the watermark can be hidden properly and robust against attacks. In this study using a haar image filter, which works at low frequencies. The use of the haar filter because the watermarking image used will be inserted into the LL area, which is a low frequency and also for its use, the haar filter is the simplest. Other filters used on DCT, there are scaling filters and filter details.

Pseoudocode:

1) Input citra host
2) Input citra watermark
3) Splits the host image into 4 parts (LL, LH, HL, HH)
   [cA, cH, cV, cD] = dwt2(hostImage, 'haar')
4) Resize watermark image into size LL
   watermark = imresize(watermark, [size(cA, 1), size(cA, 2)])
5) Insert watermark on subband LL
   watermarked_cA = cA
   *watermarked_cA(watermark == 1) = cA(watermark == 1) + alpha * cA(watermark == 1)*
   *watermarked_cA(watermark == 0) = cA(watermark == 0) - alpha * cA(watermark == 0)*
6) Reconstruct the image to its original spatial domain
   watermarkedImage = idwt2(watermarked_cA, cH, cV, cD, 'haar')

2.4. Workflow

To be able to carry out the watermarking process with DCT and DWT algorithms, along with a combination of the two algorithms, this study will use MATLAB with version R2022a. The data used is public data obtained from Kaggle.com website. After the data used is prepared, the watermarking process can be carried out. For workflow processes are described below.

Watermarking with DCT or DWT

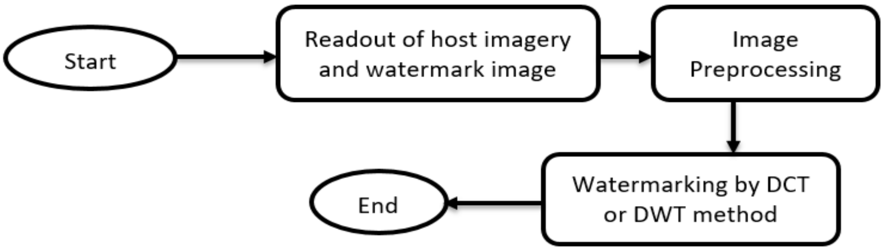


Figure 4. Workflow process DCT or DWT

The following are the stages of the process carried out by watermarking the DCT or DWT method.

a. Reading pneumonia imagery and watermark imagery
b. Image preprocessing, on the host image or pneumonia image is resized, it becomes an image size of 512 * 512 pixels. In watermark images, conversion is carried out into grayscale images and the conversion process is carried out into binary images.
c. After image prerpcessing, the watermarking process is carried out using the DCT or DWT method.
d. After the watermarking process is carried out, the image resulting from the watermark is compared with the original image. Watermarking dengan kombinasi DCT dan DWT

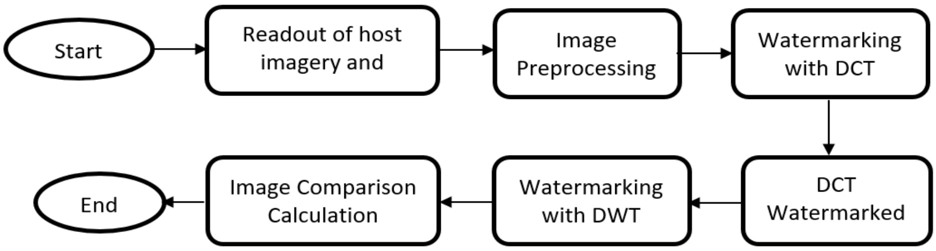


Figure 5. Workflow process DCT+DWT

The following are the stages of the process carried out by watermarking the DCT or DWT combination method.

a. Reading of pneumonia image and watermark image
b. Image preprocessing, the host image or pneumonia image is resized, the image size is 512 * 512 pixels. In the watermarked image, it is converted into a grayscale image and converted into a binary image.
c. After preprocessing the image, a watermarking process is carried out between the host image and the watermarked image using the DCT method.
d. After processing with the DCT method, the image resulting from the DCT process is stored in a variable, later the watermarking process can be carried out again with DWT.
e. After obtaining the image resulting from the DCT process, the watermarking process for the image resulting from the DCT is carried out again using the DWT method.
f. Then after obtaining the image resulting from the combination of DCT and DWT processes, a comparison is made with the original image.

Watermarking with a combination of DWT and DCT

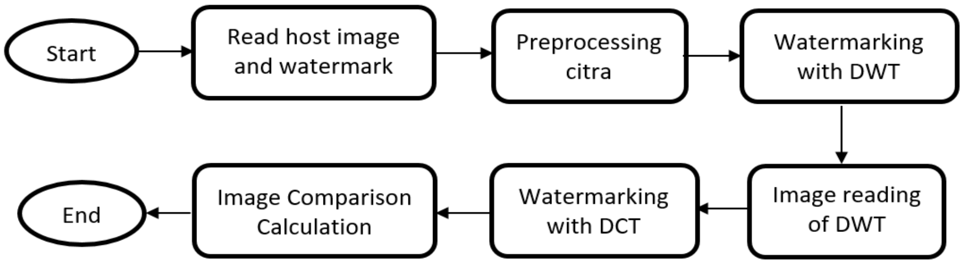


Figure 6. Workflow process DWT+DCT

The following are the stages of the process carried out by watermarking the DWT or DCT combination method.

a. Reading of pneumonia image and watermark image.
b. Image preprocessing, the host image or pneumonia image is resized, the image size is 512 * 512 pixels. In the watermark image, it is converted into a grayscale image and the image conversion process is carried out into binary.
c. After preprocessing the image, a watermarking process is carried out between the host image and the watermarked image using the DWT method.
d. After processing with the DWT method, the image resulting from the DWT process is stored in a variable, later the watermarking process can be carried out again with DCT.
e. After obtaining the image from the DWT process, the watermarking process for the DWT image is carried out again using the DCT method.
f. Then after obtaining the image resulting from the combination of the DWT and DCT processes, a comparison is made with the original image.

2.5. Test Metrics

In order to see how the performance of the watermarking results is, whether using the DCT, DWT, DCT and DWT combination or DWT and DCT combination, a test metric is needed. Sarah et. al [24], explained if the original image has an mse value close to 0, then the quality of the image is not much different from the original image. The MSE formula can be seen in Figure (3). Setiadi [25], described the PSNR value obtained from calculations using the formula from the MSE logarithm of the image. The formula for PSNR can be seen in figure (4). The SSIM similarity value is obtained by considering the structural similarities in the watermarked image with the original image. In performing SSIM calculations, which color space should be used for an image, because the color space has never been defined [26]. For SSIM mathematical calculations can be seen in figure (5). The histogram is a form of visualization shown the difference between the watermarked image and the original image. In addition to seeing the differences in the image, the histogram can also be used to improve image quality [27], by normalizing the histogram

$$MSE = \frac{1}{x}\sum_{y=1}^{x}(Z_y - Q_y)^2 \quad (3)$$

$$PSNR = 10 * \log_{10}(\frac{Piksel^2}{MSE}) \quad (4)$$

$$SSIM\ (M,N) = \frac{(2 * \mu M * \mu Y + C_1) * (2 * \sigma MN + C_2)}{(\mu^2 M + \mu^2 N + C_1) * (\sigma^2 M + \sigma^2 N + C_2)} \quad (5)$$

Another metric used is Unified Averaged Changed Intensity or UACI. Hidayati et. al [28], stated UACI analysis is important to be able to calculate the average change in pixel intensity in an image. The formula for performing UACI calculations can be seen in figure (6). Then there is the Number of Changing Pixel Rate or NCPR. NPCR has a goal to find out how much the number of pixels has changed between the original image and the resulting watermarked image [28]. The NCPR calculation can be seen in formula (7). There are also Cross Correlation or CC and Normalized Cross Correlation or NCC metrics to find how an image has a correlation between one image and another. For the CC formula, it can be seen in exposure (8) and for the NCC calculation, it can be seen in figure (9). Then there is also entropy which is used to measure the degree of uncertainty of the pixel intensity in an image. The entropy formula can be seen in formula (10).

$$UACI = \frac{\sum_{x=1}^{M} | Img_{watermark}(x) - Img_{original}(x)|}{\sum_{x=1}^{M} Img_{original}(x)} \tag{6}$$

$$NCPR = \frac{Img_{change}}{Img_{total}} * 100\% \tag{7}$$

$$CC(O,W) = \sum O_{(i,j)} * W(i + \delta i, j + \delta j) \tag{8}$$

$$NCC(O,W) = \frac{\sum[(O_{(i,j)} - \mu\_O) * (W_{(i,j)} - \mu\_W)]}{[sqrt(\sum(O_{(i,j)} - \mu\_O)^2) * sqrt(\sum(W_{(i,j)} - \mu\_W)^2)]} \tag{9}$$

$$Ent\ (C) = -\sum_{x=1}^{n} P_x \, log_2(P_x) \tag{10}$$

3. RESULTS AND DISCUSSION

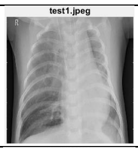
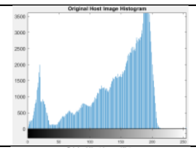
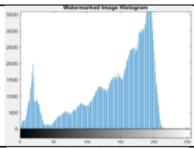
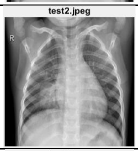
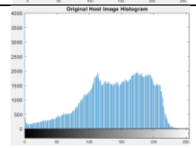
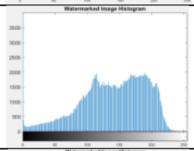
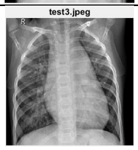
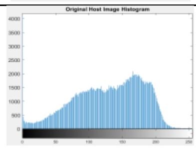
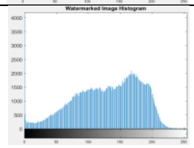
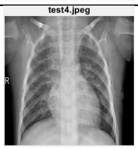
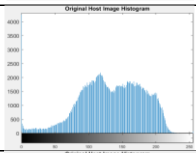
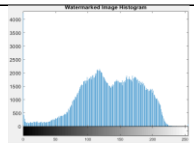
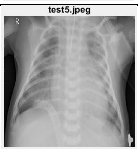
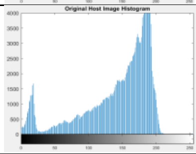
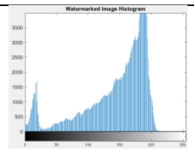
To carry out the process of implementing and running the program, this study will use the MATLAB R2022a software. The methods used are DCT, DWT, a combination of DCT and DWT and a combination of DWT and DCT to be able to perform image watermarking processes.

3.1 Discrete Cosine Transform (DCT) Testing

In this study, when carrying out the watermarking process using the DCT method. The image which is the host image will be embedded or inserted with a watermark image. Based on this process will produce images of the results of the DCT process. After getting the DCT result image, we can compare the original image with the watermarked image. To see this comparison, it can be seen in the following histogram results.

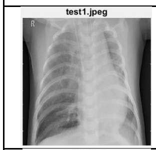
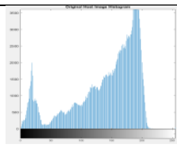
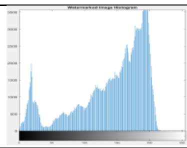
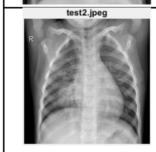
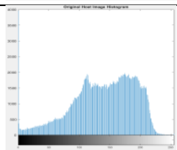
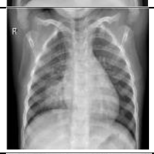
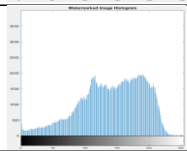
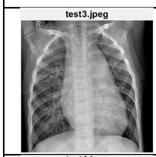
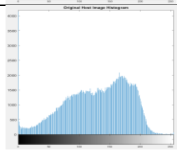
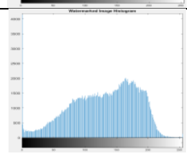
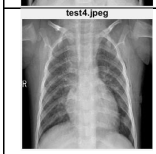
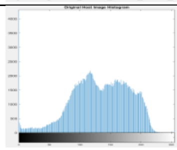
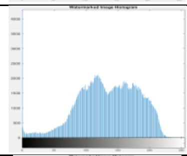
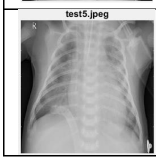
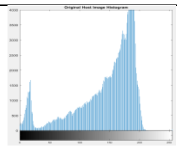
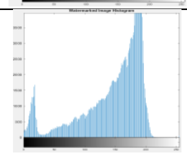
Based on the results shown in the table, it had been seen there is no significant difference between the original image and the watermarked image using the DCT method. In the image, the orange line shows the slight pixel changes occur in the image after the watermarking process. After the watermarking process occurs, there are no visible changed by naked eye, which means the inserted watermark image can be hidden properly. In this study, when carrying out the watermarking process using the DWT method. The image which is the host image will be embedded or inserted with a watermark image using the DWT method. After getting the DWT image, we can compare the original image with the watermarked image. To see this comparison, it can be seen in the following histogram results. Based on the results shown in Table 2, it had been seen there is no significant difference between the original image and the resulting image with the DWT method of watermarking. In the image, the orange line shown the slight pixel changes occur in the image after the watermarking process and indicates the inserted watermark image can be hidden properly.

Table 1. DCT Testing using Histogram

Original	Original Image Histogram	Watermark	Watermark Image Histogram
			
			
			
			
			

3.2 Discrete Wavelet Transform (DWT) Testing

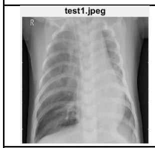
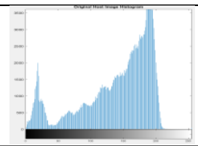
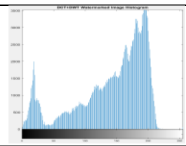
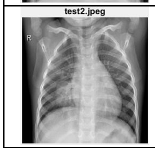
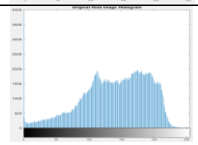
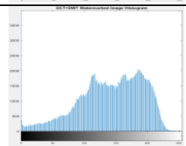
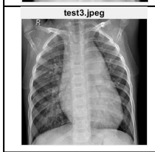
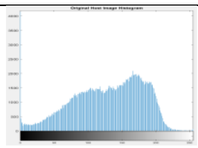
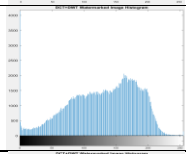
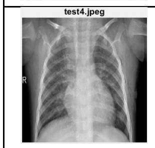
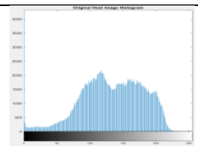
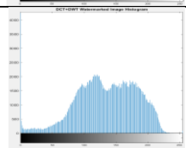
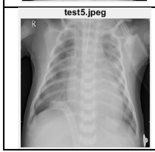
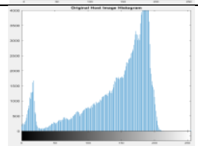
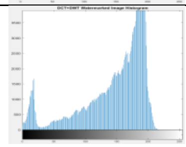
Table 2. DWT Testing using Histogram

Original	Original Image Histogram	Watermark	Watermark Image Histogram
			
			
			
			
			

3.3 Testing with a Combination of Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT)

In this study, when carrying out the watermarking process using the DCT and DWT combination method. The image which is the host image will be embedded or inserted with a watermark image using DCT, then watermarking will be carried out again using DWT. After getting the DCT+DWT image, we can compare the original image with the watermarked image. To see this comparison, it can be seen in the following histogram results as in Table 3.

Table 3. DCT+DWT Testing using Histogram

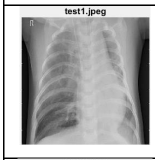
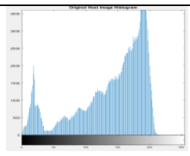
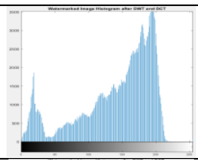
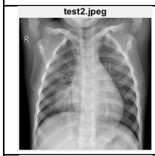
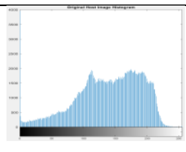
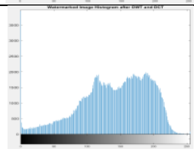
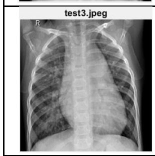
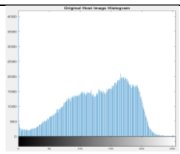
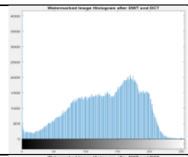
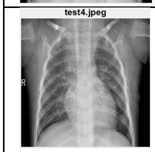
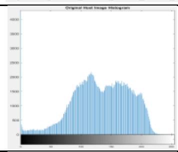
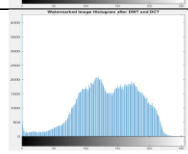
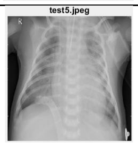
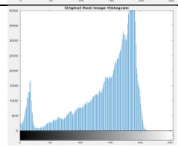
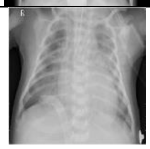
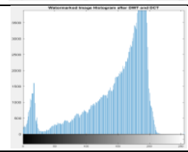
Original	Original Image Histogram	Watermark	Watermark Image Histogram
			
			
			
			
			

Based on the results shown in the table, it had been seen there is no significant difference between the original image and the resulting watermarked image using the DCT+DWT method combination. In the image, the orange line shows the slight pixel changed was occur in the image after the watermarking process. Aafter the watermarking process occurs, there are no visible changed by naked eye, which means the inserted watermark image can be hidden properly.

3.4 Testing with Discrete Wavelet Transform (DWT) Combination of Discrete Cosine Transform (DCT)

In this study, when carrying out the watermarking process using the DWT and DCT combination method. The image which is the host image will be embedded or inserted with a watermark image using DWT, then watermarking will be carried out again using DCT. After getting the DWT + DCT image, we can compare the original image with the watermarked image. To see this comparison, it can be seen in the following histogram results.

Table 4. DWT+DCT Testing using Histogram

Original	Original Image Histogram	Watermark	Watermark Image Histogram
			
			
			
			
			

Based on the results shown in the table, it had been seen no significant difference between the original image and the resulting watermarked image using the DWT+DCT method combination. In the image, the orange line shows the slight pixel changed was occur in the image after the watermarking process. The watermarking process occurs, there are no visible changes can be seen by naked eye, which means the inserted watermark image can be hidden properly.

3.5 PSNR Matrix Testing, SSIM, UACI, NPCR, CC, NCC, Entropy

In the PSNR test was carried out, when using the single method (only DCT or DWT), the average value for DCT was 41.27578 db and DWT was 41.26894 db. Which is where the number indicates the image number can be accepted by the human eye. Whereas when using the combination of the DCT + DWT method, the average is 36,818 db and the DWT + DCT combination gets an average of 37.56322 db. This figure is not a bad number, because the PSNR value is close to 40 dB, it can be accepted by the human eye.

In testing SSIM on images, it shows using the DCT method gets an average of 0.993166 db. Using the DWT method to get an average of 0.990666 db. Using the DCT+DWT combination, you get an average of 0.983972 db and using the DWT+DCT combination, you get an average of 0.985552 db. From all the results obtained, it shown the resulting watermarked image has a slightly high similarity value. Therefore, it can be concluded the image resulting from the watermarking process does not significantly reduce the similarity value with the original image. In the entropy test, it can be seen in the table the best entropy value is obtained by the test3.jpg image with an entropy value of 7.4186. This value indicates the uncertainty value exists after the watermarking process increases, the more random the intensity of the pixels in the image.

Table 2. PSNR Testing

No	Images	PSNR			
		DCT	DWT	DCT+DWT	DWT+DCT
1	test1.jpeg	40.7985	40.7934	36.3195	36.8806
2	test2.jpeg	41.3115	41.2998	36.884	37.3865
3	test3.jpeg	41.9321	41.9035	37.4403	37.993
4	test4.jpeg	41.7553	41.7656	37.3477	37.8466
5	test5.jpeg	40.5805	40.5824	36.0985	36.7094

Table 3. SSIM Value

No	Images	SSIM			
		DCT	DWT	DCT+DWT	DWT+DCT
1	test1.jpeg	0.99116	0.9884	0.97965	0.98207
2	test2.jpeg	0.9939	0.99187	0.98601	0.98732
3	test3.jpeg	0.99515	0.99344	0.98852	0.98997
4	test4.jpeg	0.99432	0.99252	0.98687	0.98823
5	test5.jpeg	0.9903	0.9871	0.97781	0.98017

Table 4. Entroty Value

No	Images	Entropy			
		DCT	DWT	DCT+DWT	DWT+DCT
1	test1.jpeg	7.3166	7.3156	7.3402	7.3452
2	test2.jpeg	7.4094	7.4094	7.4175	7.4177
3	test3.jpeg	7.4107	7.4107	7.4206	7.4186
4	test4.jpeg	7.2971	7.2935	7.3045	7.3044
5	test5.jpeg	7.1319	7.1316	7.1556	7.1603

Table 5. UACI and NPCR

Images	DCT		DWT		DCT+DWT		DWT+DCT	
	UACI	NPCR	UACI	NPCR	UACI	NPCR	UACI	NPCR
test1.jpeg	0.0083339	90.5849%	0.0083411	90.7207%	0.01393	90.5239%	0.012941	93.9068%
test2.jpeg	0.0077845	90.6055%	0.0077925	90.6284%	0.012919	90.3828%	0.011969	90.3004%
test3.jpeg	0.0071158	89.6225%	0.0071223	89.3093%	0.011919	89.0991%	0.010977	88.6105%
test4.jpeg	0.0073634	90.4507%	0.0073458	90.3362%	0.012212	90.0692%	0.011333	89.4009%
test5.jpeg	0.0086794	92.9493%	0.0086762	93.1141%	0.014507	92.8917%	0.013299	93.4898%

Table 6. CC and NCC

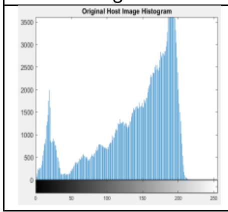
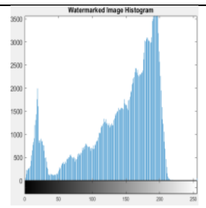
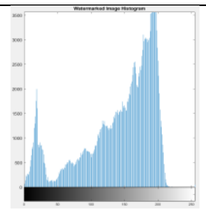
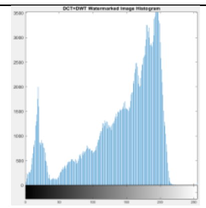
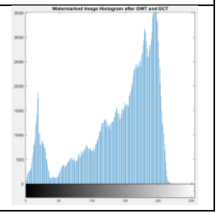
No	Images	DCT		DWT		DCT+DWT		DWT+DCT	
		CC	NCC	CC	NCC	CC	NCC	CC	NCC
1	test1.jpeg	0.9993	1	0.99932	1	0.99808	1	0.99837	1
2	test2.jpeg	0.99944	1	0.99946	1	0.99848	1	0.9987	1
3	test3.jpeg	0.99952	1	0.99953	1	0.99867	1	0.99888	1
4	test4.jpeg	0.99945	1	0.99946	1	0.9985	1	0.99872	1
5	test5.jpeg	0.99912	1	0.99915	1	0.99759	1	0.99798	1

In the test table with UACI, the results shown the single method (only DCT or DWT), the UACI values obtained range from 0.00799479. When using a combination of the DCT+DWT or DWT+DCT method, the UACI value is between 0.0133066. Therefore, with these results it had been seen the average value of changes in pixel intensity in the image does not change significantly the difference between the watermarked image and the original image is not significant. Meanwhile, the NPCR test with all methods obtained a good percentage of 90.55386%. These results indicate the watermarking results have good quality.

It can be seen in the test table using CC and NCC, for all methods, both DCT, DWT, the DCT+DWT combination and the DWT+DCT combination, the average CC results are 0.999073 and the NCC is 1 or perfect. These results indicate the value of the similarity or correlation of the watermarked image with the original image has very good results.

3.6 Comparison of the Watermarking Process with the Original Image

Table 7. Evaluation using sample of histogram

Original	DCT	DWT	DCT+DWT	DWT+DCT
				

The table above shows changes to the histogram of the original image after all the watermarking processes, namely DCT, DWT, combination of DCT and DWT and combination of DWT and DCT. The histogram shows the pixel changes occur after the watermarking process. It had been seen the difference in pixels after the watermarking process carried out on the original image is only slightly. Therefore, it can be concluded the watermarking process has been carried out has worked well to hide the image without changing many pixels of the original image.

4. CONCLUSION

The results of the research and discussion have been presented show how the watermarking process is carried out using the DCT, DWT, combination of DCT and DWT as well as a combination of DWT and DCT. After testing the watermarking process, from all the tests carried out it had been seen highest PSNR value was obtained at 41,931 from the test3.jpeg image using the DCT method. The highest SSIM value was obtained 0.99515 from the test3.jpeg image using the DCT method. The highest entropy value was also obtained at 7.4186 from the test3.jpeg image using the DWT+DCT method. The best UACI value was also obtained by the test3.jpeg image using the DCT method, resulting in a value of 0.0071158 and the best NCPR value was obtained at 93.9068% from the test1.jpg image with the DWT+DCT method. Meanwhile, the best CC value was obtained at 0.99953 from image 3 using the DWT method. As well as for the NCC value, the values obtained are all the same in each test, namely with a value of 1. For further research, it is expected to be able to add other filters used for DWT, such as scaling filters and filter details. For DWT development can also be carried out using the level 2 or level 3 decomposition method.

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