Comparison of discrete cosine transform and dual-tree complex wavelet transform based on arithmetic coding in medical image compression

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Abstract. Medical image contains very important information in the medical world used to diagnose diseases by doctors. Storage for storing medical imagery requires large storage media. The difficulty of sending and storing files, hence the process of compression image that can shrink the size of medical image. This research uses the Discrete Cosine Transform and Dual-Tree Complex Wavelet Transform-based Arithmetic Coding. DCT is used in the process of compression of imagery files using the cosine value approach. In DCT, there is a quantization process that causes image quality to decline, as it eliminates some information on imagery. DTCWT uses 2 trees, where tree 1 is for real value and tree 2 for imaginary value. Arithmetic Coding is one of entropy encoding that uses the range and probability values in the calculation. The value of decoding results in Arithmetic Coding has the same value as the original image. DCT produce a higher compression ratio than DTCWT, while DTCWT get higher PSNR than DCT.

1. Introduction

A medical image contains very important information in the health field. Therefore, the medical image has a large size as it has been said that every day the hospital can spend average storage of 5 GB to 15 GB for data from medical imagery [1]. Large medical image sizes will cause problems in storing and sending data such as requiring large storage and requiring a long time in data delivery. This problem will cause slowing diagnosis process and also doctor's treatment. Because of these problems, it is necessary to compress images that do not reduce the information that is important in the imagery.

Compression is the process of compressing or shrinking the size of particular data into smaller data. Image compression is minimizing the number of bits of an image so that the image data size becomes smaller. By eliminating or decreasing redundancy. Redundancy is repeatedly the same data or data set that results in memory waste. Compression technique is divided into 2 categories: lossless compression and lossy compression. Lossless compression is a method by which the compression data has a size smaller than the original data size without removing the information from the original data. The compression ratio of the lossless method is very low, because the information is omitted not too much. This method is suitable for use in data containing important information in it. While lossy compression is a method that results in compression data is smaller than the original data by eliminating some information from the original data, but the data of compression results can still be tolerated by the human eye. This technique changes the details and colors of the image file to be simpler, which causes the
image size to be smaller. This method is usually used in photo imagery that does not require image detail.

Research [2] explains that the DCT method is getting the PSNR and MSE values better than DWT. Using the Discrete Cosine Transform (DCT) method because this method removes infrequent data and also decreases the quality that can still be Intolerance by the human eye. The second method is the Dual-Tree Complex Wavelet Transform which is an enhancement of the DWT method. The increase is found in the number of wavelet coefficients resulting in more representative of the input image and also the little calculation algorithm. In research [3] stated that DWT to DTCWT provides good results, whereby the DWT method gets a PSNR value of 47.1217 and a compression ratio is 0.9430, while the DTCWT method gets the PSNR value of 55.5276 and the ratio Compression of 4.5695. The third method is Arithmetic Coding, a flexible method to combine with lossy and lossless methods and this method is better than the Huffman method [4]. In research [5] The medical image compression has been conducted using DTCWT with Arithmetic Coding with its medical image is an MRI result of a PSNR result of 65.30 and a compression ratio of 2.32, in this method also comparing with Other compression methods with the result of PSNR value and the highest compression ratio are the DT-CWT method with Arithmetic Coding. In research [6] the hybrid two dimensional discrete cosine transform method and Huffman coding get a PSNR value of 40.2938 dB with a CR = 24.36% value. The study designed a medical image compression system with DCT and DTCWT methods using Arithmetic Coding. It also compares Arithmetic Coding based DCT methods with Arithmetic Coding based DTCWT with PSNR and compression ratio as parameters.

2. Methodology

2.1. Discrete Cosine Transform

Discrete Cosine Transform (DCT) is one of the mathematical classes included in the Fast Fourier transform. The basic operation shown in this transformation is to take one signal and transform its representation from one type to another. DCT is one of the lossy compression methods. The DCT method will not cause suspicion though it is lossy, as DCT occurs in the frequency domain within an image, not in spatial, so there will be no noticeable changes in the image. The DCT method uses a cosine value approach and in its operation uses real value. The downside of the DCT method is that it cannot resist an object's change because the message is easily removed, because the location of data insertion and data creation with the DCT method is known [7]. There are 2 kinds of equations in the DCT method i.e. DCT 1 dimensions for calculating vector data and DCT 2 dimensions to calculate the matrix data.

DCT 2 dimensional (2D-DCT) is used to calculate the matrix data, then to perform the calculations each image divided into several sub block. The use of sub block is used to shorten long periods of time when transforming the pixel values one by one. The sub block used are $2^n \times 2^n$ or that are commonly used are $8 \times 8$ and $16 \times 16$. For example, there is a $512 \times 512$ pixel, each component is divided into $8 \times 8$ subblock where each subblock has $64 \times 64$ pixel, from $64 \times 64$ pixel are further divided into $8 \times 8$ sub block, so the size sub block to $8 \times 8$ pixels. A sub block split illustration can be seen in Figure 1.

![Sub Block Illustration](image)

**Figure 1.** A sub block split of $512 \times 512$ pixels.

When you specify the size of the sub block to be used, the next step is to enter the values of sub block and other values into the DCT equation. Below is the formula of compression calculation of DCT [8]:
\[
DCT(i, j) = \frac{2}{\sqrt{mn}} \times C_i \times C_j \times \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} p_{ij} \times \cos \left[ \frac{(2y+1)\pi}{2m} \right] \times \cos \left[ \frac{(2x+1)\pi}{2n} \right]
\] (1)

As for inverse/decompression 2D-DCT which serves to restore the image of the compression result to the original image using the equation (2).

\[
p_{xy} = \frac{2}{\sqrt{mn}} \times \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} C_i \times C_j \times DCT(i, j) \times \cos \left[ \frac{(2y+1)\pi}{2m} \right] \times \cos \left[ \frac{(2x+1)\pi}{2n} \right]
\] (2)

with the parameters used are the range of value \( i \) is 0 to \( (n - 1) \) and the range of the \( J \) value is 0 to \( m - 1 \), while the inverse of the \( x \) value range is 0 to \( (n-1) \) and the \( y \) value range is 0 to \( (m - 1) \), \( DCT(i, j) = DCT \) value in the index \((i, j)\), \( m \) and \( n \) is size of the matrix sub block, and \( p_{xy} \) is the value of the pixels in the index to \((x, y)\).

\[C_i, C_j = \begin{cases} 1, & i, j > 0 \\ \frac{1}{\sqrt{2}}, & i, j = 0 \end{cases}\] (3)

2.2. Quantization
Quantization is used to determine the compression quality by eliminating some information of the pixel value that has been transformed. Information omitted is information that is deemed to be at least important. Quantization is very important in the process of compression of data, because quantization determination affect the quality of the compressed image and of course the size of the files that have been compressed. The quantization matrix is done changing the value of each pixel from the original image to a value that corresponds to the quantization matrix. The formula of quantization defined in equation (4).

\[Quantization = \frac{DCT(i, j)}{Quantum(i, j)}\] (4)

As for restoring the image to the original form is used the inverse quantization. The formula of quantization inverse calculated using equation (5).

\[Inverse Quantization = Quantization \ Value(i, j) \times Quantum(i, j)\] (5)

The value of Quantum matrix\((i, j)\) is

\[
\begin{bmatrix}
16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\
12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\
14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\
14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\
18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\
24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\
49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\
72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \\
\end{bmatrix}
\]

2.3. Dual-Tree Complex Wavelet Transform
The Dual-Tree Complex Wavelet Transform (DTCWT) is a development of DWT, which for DWT uses 1 tree that generates real value while DTCWT uses 2 trees that produce real value and imaginary. Figure 2 is an illustration of 2 DTCWT trees. DTCWT uses 2 trees by doubling the number of samples at each level using even-sized sample data. The filters used in DTCWT are odd/even filters.
Figure 2. Tree of DTCWT.

Tree A is a real tree, while Tree B is an imaginary tree. Of the two trees are defined in equation (6-7) [9]:

\[ h_1(n) = (-1)^n \times h_0(N - n) \] (6)

\[ g_1(n) = (-1)^n \times g(N - n) \] (7)

with \( N \) is the length of the filter order. To ensure the filter orthogonal and the difference of the phase of \( \frac{\pi}{2} \), it must fulfill equation (8) [9]:

\[ g_0(n) = h_0(n - 0.5) \] (8)

2.4. Arithmetic Coding

Arithmetic Coding is replacing a single row of input symbols with a floating point number. The longer and more complex the message is encoded, the more bits are required. The Output of Arithmetic Coding is one number smaller than 1 and greater is equal to 0. This number can be decoded, resulting in a string of symbols used to produce the number [10]. To generate these output numbers, each symbol to be encoded is given single probability value.

The concept of Arithmetic Coding is to give the range or interval of \([0, \ldots, 1]\) to each symbol. Each range is divided into a subrange, where the subrange size is comparable to the probability size, which is likely to appear the same symbol. The higher the probability, the higher also the value range or close to 1. After obtaining the range and probability values, the encoding process is performed to determine the output of floating point numbers. The compression algorithm using Arithmetic Coding are [11]:

1) Encoding
   a) Specifies the probability of each symbol of the data.
   b) The probability value will be used as the interval of each symbol that will be used to calculate the encoding of each symbol that appears.
   c) Value Low = 0.0 and High= 1.0.
   d) Range \( = \) High – Low
   e) High = Low + Range \( \times \) highest range number of symbols
   f) Low = Low + Range \( \times \) lowest range number of symbols
   g) Perform a loop process until all the symbols are processed with the new Low and High values.
   h) The output of the Encode process is the last Low value named Tag or the encoded number.

2) Decoding
   a) Get encoded number.
   b) Get the symbol where the number encoded is in the range.
   c) Perform a loop process until all the symbols are processed.
   d) Range \( = \) highest range number symbol - lowest range number symbol
   e) Number \( = \) Number – lowest range number symbol
   f) Number \( = \) \( \frac{\text{Number}}{\text{Range}} \)
3. System Model
This paper is a research to compare the compression of medical imagery using DCT and DTCWT based Arithmetic Coding. The system is divided into 2 stages, i.e. the encoder for the compression process and the decoder for the decompression process. Compression is the process of reducing the pixel values of the original image and represented by multiple values. Decompression is the process of returning the compressed image result value. The flow of the system showed in Figure 3.

3.1. DCT
The next process is the encoding process. This process is done when the image is done preprocessing process that is resized and grayscale. The image below is a process from the encoding process using DCT based Arithmetic Coding.

The image Input is of a medical image that is in resize and grayscalling. The input image size is likened to the resize to 512 × 512. Grayscalling is transforming imagery into a grayscale image. The grayscale process uses the Mat2gray formula in the MATLAB which converts the pixel value to a range of 0-1. The formula of Mat2gray defined in equation (9).

\[
\text{Mat2gray} = \frac{Y - Y_{\text{min}}}{Y_{\text{max}} - Y_{\text{min}}}
\]  

(9)

with Y is a pixel value, Ymin is the minimum pixel value of the image and Ymax is the maximum pixel value of the image.

The input image is divided into blocks that are \(2^n \times 2^n\). The block values used are 8 × 8 and 16 × 16. Once it has been divided into subblocks, it is followed by using equation 1 by using the pixel value of the input image and the subblock used. Next is the quantization process. In this process, the input image is divided by a quantum matrix using equation (4). Quantization is done to determine the
compression quality by eliminating some information of the pixel value that has been transformed by DCT.

3.2. **DTCWT**

The Dual-Tree Complex Wavelet Transform uses a dual-tree that generates 8 subbands in the form of complex coefficients i.e. 2 subband Low-Low frequency (LL), 2 subband Low-High frequency (LH), 2 High-Low frequency (HL) and 2 subband frequency High-High (HH), where each subband has different phases.

The medical image signal is in the process by decomposing it as a subband-subband. Dual-Tree is used separately, where 2 trees are in the convolution process for the row dimensions and 2 trees in the convolution process for the column dimensions. So it looks like a quad-tree structure with the redundancy is 4:1. The components of the quad-tree of each coefficient are combined with summation and subtraction to produce complex coefficients mates. These results are part of the 2 subbands in the adjacent quadrant of the 2-D spectrum. At this stage there are generated 6 subband highpass at each level. Since DTCWT has an excess directional selectivity, the complex filter can separate positive frequency components and negative frequency components at 1-D, thus separating the adjacent quadrant from the 2-D spectrum.

3.3. **Arithmetic Coding**

The input of this process is the image of the compression result of the DCT or DTCWT methods. The input image of a matrix that is 512 × 512 pixels is transformed into a vector of 1 × 262144 pixels. Once the vector is searched then the probability and range of each pixel come out. Look for the Low and High values using the equations outlined in the theoretical foundation, repeat these steps until all the pixels get the Low and High values. The next step is to use the last Low value to be the Tag value to be used in the decoding process. The process of Arithmetic Encoding can be seen in Figure 5.

![Figure 5. Arithmetic Encoding block diagram.](image)

3.4. **Arithmetic Decoding**

The input file of this process is the Arithmetic Encoding result file which is a Tag value. After getting encoded number or the TAG value of the encoding process then the next process is looking for the value that Tag is located. Find the Tag value using an existing range. The Tag value is within the range then print the new Low and High values and print the pixel value that has the range value existing Tag value, repeat until complete. The printed pixel value from 1 × 262144 pixel sized vector that is then converted to a matrix of 512 × 512 pixel and the Arithmetic Coding image compression result. The Arithmetic decoding diagram can be seen in Figure 6.

![Figure 6. Arithmetic Decoding block diagram.](image)

3.5. **Invers DCT and Quantization**

The decompression process is to invert the image to the original shape. The input image used is Arithmetic Coding image compression. The first step is the inverse of quantization by scaling the input image with the quantum matrix that is in Equation 5. Furthermore, the inverse of DCT by using equation 2 with the caption of the block used and the image pixel used is the pixel value of the inverse of a
quantization result. The image Output in this process is a compression image whose parameters will be used for analysts.

![Diagram](image)

**Figure 7. Invers DCT block diagram.**

### 3.6. *Invers DTCWT*

The invers DTCWT is the process of returning image to the initial form after the compression process. This process starts with the upsampling process with a factor of 2 on each subband-subband. For the dimension of the column, then the convolution process with the digital filter coefficient. Then proceed with the upsampling process with a factor of 2 on each subband for the row dimensions.

### 3.7. *Invers DCT and Quantization*

The decompression process is to invert the image to the original shape. The input image used is Arithmetic Coding image compression. The first step is the inverse of quantization by scaling the input image with the quantum matrix that is in Equation 5. Furthermore, the inverse of DCT by using equation (2).

### 3.8. *Performance System*

This test was conducted to determine the performance of the system that has been created in compressing the medical image. The performance system used is the compression ratio, and the PSNR. The PSNR calculated in equation (10).

\[
PSNR = 10 \log_{10} \left( \frac{\text{Max}_i^2}{MSE} \right) = 20 \log_{10} \left( \frac{\text{Max}_i}{MSE} \right) \quad (10)
\]

with Max\(_i\) is the maximum value of a pixel in the original image. The formula of MSE calculated using equation (11).

\[
MSE = \frac{1}{M+N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (I(i,j) - R(i,j))^2 \quad (11)
\]

with i and j are the coordinates of the digital image, M and N are the height and width of the image in the pixel size, I\((i,j)\) is the original image pixel data value in the position \((i,j)\), and R\((i,j)\) is the pixel data value of the reconstruction image at the position \((i,j)\). The formula of compression ratio calculated using equation (12).

\[
\text{Compression Ratio} = \frac{\text{Original image size}}{\text{Compressed image size}} \quad (12)
\]

### 4. Result and Discussion

Test image used by 25 medical imagery with DICOM (*. DCM) file format. The test scenarios performed are as follows:

1. Combining parameters that can produce the best performance of the system. The analysis is done to get the best parameters of the system and reach from the test objectives are as follows:
   a. Effect of subblock selection on DCT against PSNR value and compression ratio.
   b. The quantization effect on the DCT against the PSNR value and the compression ratio.
2. Image compression using DTCWT-based Arithmetic Coding. This compression was done to compare the performance obtained by the Arithmetic Coding-based DCT compression system.
4.1. The Effect of Subblocks on DCT based Arithmetic Coding

In this scenario, 25 medical images with the size of each image $512 \times 512$ pixels are tested. Testing was conducted to see how the use of subblocks on the DCT method. To compare them use a parameter that is the compression ratio value and the PSNR obtained from the system test results. The Data of the system test results obtained are as follows:

![Figure 8. Effect of Subblock on Compression Ratio.](image1)

Based on Figure 8, the compression ratio on the sub block $16 \times 16$ higher than $8 \times 8$. Thus, the memory size of the compressed image on $16 \times 16$ sub block is smaller. The image of the brain gets the lowest compression ratio, while the chest image gets the greatest compression ratio. The difference in compression ratios is caused by the memory size of each different image. Therefore, if the image has a small memory size, then the compression process is not too large the memory size difference.

![Figure 9. Effect of Subblock on PSNR.](image2)

Based on Figure 9, PSNR in sub block $8 \times 8$ higher than $16 \times 16$, so that the image quality of the compression result in sub block $8 \times 8$ is still good. The average PSNR has a value above 30 dB, due to the use of Arithmetic Coding, so that the image quality of the compression results is still good.
Table 1. Effect of subblock on DCT against system performance.

|                      | Chest Image | Brain Image | Pancreas Image | Skin Image |
|----------------------|-------------|-------------|----------------|------------|
| **Sub block of 8 × 8** | ![Image](image1.png) | ![Image](image2.png) | ![Image](image3.png) | ![Image](image4.png) |
| CR = 11.40           | CR = 8.57   | CR = 11.91  | CR = 7.72      |
| PSNR = 40.42 dB     | PSNR = 42.85 dB | PSNR = 23.66 dB | PSNR = 29.58 dB |
| **Sub block of 16 × 16** | ![Image](image5.png) | ![Image](image6.png) | ![Image](image7.png) | ![Image](image8.png) |
| CR = 11.70           | CR = 8.67   | CR = 11.99  | CR = 7.89      |
| PSNR = 36.29 dB     | PSNR = 30.89 dB | PSNR = 22.44 dB | PSNR = 27.40 dB |

**Figure 10.** Effect of subblock on DCT.

Based on Figure 10, the compression ratio on the sub block 16 × 16 is higher than the sub block 8 × 8. Thus, the size of the compressed image on a 16 × 16 sub block is smaller. The PSNR value obtained on a sub block of 8 × 8 is higher than that of the 16 × 16 sub block. So, in sub block 8 × 8 have more good image quality. The greater use of sub-blocks in the DCT causes the higher compression ratio, but the PSNR will get further down.

4.2. The Effect of Quantization on DCT based Arithmetic Coding

In this scenario, 25 medical images with the size of each image 512 × 512 pixels are tested. Testing was conducted to see the effect of quantization in the DCT method. Performance system using the
compression ratio, and PSNR parameters obtained from the test results of the system. Figure 11 shows the effect of quantization on compression ratio.

![Figure 11. Effect of quantization on compression ratio.]

Based on Figure 11, the compression ratio on sub block of $16 \times 16$ with quantization higher than $8 \times 8$. Thus, the memory size of the compressed image on a $16 \times 16$ sub block with quantization is smaller. The image of the brain gets the lowest compression ratio, while the chest image gets the greatest compression ratio. The difference in compression ratios is caused by the size of each different image. Therefore, if the original image has a small memory size, the difference in memory size with the image compression result is not too large.

![Figure 12. Effect of quantization on PSNR.]

Based on Figure 12, PSNR on a sub block $8 \times 8$ with quantization higher than $16 \times 16$, so that the image quality of the compression results in sub block $8 \times 8$ with quantization still better. Based on Figure 11 and figure 12, compression ratio high then PSNR value get low. The average PSNR obtained is below 30 dB, due to the use of quantization of DCT resulting in decreased image quality.
**Table 2.** Effect of quantization on DCT against system performance.

|                      | Chest Image | Brain Image | Pancreas Image | Skin Image |
|----------------------|-------------|-------------|----------------|------------|
| **Original Image**   | ![Chest Image](image1) | ![Brain Image](image2) | ![Pancreas Image](image3) | ![Skin Image](image4) |
| **Sub block of**     | ![Sub block 8x8](image5) | ![Sub block 8x8](image6) | ![Sub block 8x8](image7) | ![Sub block 8x8](image8) |
| **8 x 8 with**       | CR = 15.41  | CR = 10.69  | CR = 16.32     | CR = 10.04 |
| **Quantization**     | PSNR = 28.58| PSNR = 31.66| PSNR = 16.23   | PSNR = 20.80|
| **Sub block of**     | ![Sub block 16x16](image9) | ![Sub block 16x16](image10) | ![Sub block 16x16](image11) | ![Sub block 16x16](image12) |
| **16 x 16 with**     | CR = 16.75  | CR = 12.12  | CR = 16.84     | CR = 9.40  |
| **Quantization**     | PSNR = 25.35| PSNR = 23.29| PSNR = 17.53   | PSNR = 19.32|

**Figure 13.** Effect of quantization on DCT.

Based on Figure 13, the compression ratio obtained at 16 x 16 sub block with quantization higher than 8 x 8, resulting in the memory size of the compressed image on sub blocks 16 x 16 with quantization is smaller. PSNR on a sub block of 8 x 8 with quantization higher than 16 x 16 which causes the image quality on sub block 8 x 8 with quantization still good. The quantization usage causes the compression ratio to be higher, but the image quality of the compression results decreases. DCT using a sub block of 8 x 8 gets the most excellent result that is with a compression ratio of 9.67 and
PSNR 34.12 dB. The imagery used is a medical image which means the quality of the compressed image should still be good.

4.3. Comparison of DCT and DTCWT based Arithmetic Coding

In this scenario, 25 medical images with the size of each image $512 \times 512$ pixels are tested. The testing was conducted to view the performance results of the Arithmetic Coding-based DTCWT method. Performance system using the compression ratio values and PSNR parameters obtained from the test results of the system. Figure 14 shows the comparison of DCT and DTCWT based Arithmetic Coding to compression ratio.

![Figure 14. Comparison of DCT and DTCWT based Arithmetic Coding to compression ratio.](image)

Based on Figure 14, the compression ratio at DCT is higher than that of DTCWT. Thus, the DCT compression image has a smaller memory size. The image of the brain gets the least compression ratio, while the chest image gets the greatest compression ratio. The difference in compression ratio due to the difference in memory size of each original image. Size small original image memory causing a relatively small compression ratio.

![Figure 15. Comparison DCT and DTCWT based Arithmetic Coding to PSNR.](image)
Based on Figure 15, PSNR on DTCWT is higher than using DCT. Therefore, the DTCWT has a good image quality. The difference between PSNR values is caused by the method used and the quality of the image used. PSNR of each average image get PSNR above 30 dB, due to the influence of DTCWT which is lossless. Thus, the image quality of the compression results still good.

**Table 3.** The result of medical image compression using DTCWT-based Arithmetic Coding.

| Chest Image | Brain Image | Pancreas Image | Skin Image |
|-------------|-------------|----------------|------------|
| ![Original Image](image1.jpg) | ![DTCWT Image](image2.jpg) | ![DTCWT Image](image3.jpg) | ![DTCWT Image](image4.jpg) |
| CR = 10.54 | CR = 8.17 | CR = 11.16 | CR = 7.50 |
| PSNR = 45.56 | PSNR = 54.41 | PSNR = 45.39 | PSNR = 47.13 |

**Figure 16.** Comparison DCT and DTCWT based Arithmetic Coding to PSNR.

Based on Figure 16, the compression ratio obtained at DCT is higher than DTCWT. Thus, the memory size of the DCT compression result is smaller than the compressed image in DTCWT. The PSNR value obtained on DTCWT is higher than DCT. So, the image quality of DTCWT is good. In Figure 16, it proves that the DCT which is lossy produces a high compression ratio, but the quality on the image of the compression results decreases. Meanwhile, DTCWT which is lossless produces higher PSNR, but the memory size of the compressed image is large. The PSNR value obtained from DCT and DTCWT is above 30 dB, so the image quality of the compression result is still good. Therefore, DCT and DTCWT are still suitable for use in medical imagery.
5. Conclusion
In this paper, compression was performed using DCT and DTCWT-based Arithmetic Coding on medical image. DCT produces a higher compression ratio than DTCWT, while DTCWT gets higher PSNR values than DCT. Quantization in DCT results in a higher compression ratio than without quantization. But the value of PSNR on quantization is smaller, resulting in decreased image quality. The $8 \times 8$ sub block on the DCT generates a higher PSNR value than the $16 \times 16$ sub block. On the other hand, the compression ratio on the $8 \times 8$ sub block is smaller, resulting in a higher image size of the compression result.

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