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MEDICAL IMAGE DATA COMPRESSION USING HYBRID METHODS

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ABSTRACT

This search focuses on Image Data compression using different methods for data compression, three images are simulated for this technique based on modified method, Huffman with local and soft threshed and three block size 4×4, 8×8 and 16×16. The second one is based on using the DCT "discrete cosine transformation" and "discrete wavelet transformation" DWT these methods are applied on the stroke brain images" Computing tomography CT images " after using the region based segmentation method to get the region of interest which is the stroke, Completing the process by calculating quality of image compression, five parameter are used ," Peak Signal to Noise Ratio (PSNR)", "Mean Square Error (MSE)","Compression Ratio(CR)","Structural Similarity Index (SSIM)" and "Universeral Image quality Index (UIQI)".

Keyword: DCT, DWT, Huffman coding, region based method.

INTRODUCTION

In medical image processing the need for the image compression is essentially important and can divided into two structure, the first one is the lossy image compression higher value of CR "compression Ratio is obtained but, the compressed image is Distorted comparing it to the original image while the lossless image compression is identical with the original one [1]. The need for the image compression require considerable storage capacity, since the medical images such as Computed Tomography CT, X-ray and Magnetic there typical size range are large and the challenge to limited band compression is one of the methods used to reduce the image size. Different methods are developed all these method tend to achieving high quality of decompressed image, the compression can be accomplished either by lossy or lossless methods [2].

The image compression technique is used to save the important data which used only in the analysis. The image compression can be divided into two phrase, the first one is known as the lossless, in this one no information is lost, the original image is completely the same as the compressed image. The most known one is the Huffman coding. The lossy one, the original image cannot match the compressed image, this compression techniques reach image compression by losing part of the information while keeping the reconstruction quality. Hence, the data cannot be restore exactly the same as the original image [3]. The most commune methods is the Discrete Cosine Transformation and Wavelet Transformation [4] the image compression decrease the size of image storage bite without losing the quality of the image, also the time required to store or send the image decrease. The edge and the pixels which repeated be decrease by image compression [5]. The DCT based on separating the compressed image into different frequency parts, it consider to be lossy because the first part of the compression called quantization and the other which is not important frequency are removed [6] so, the "DCT" basics idea depend on "disintegrating the image into segment" [7], the lossy data compression give best compression ratio[8]. The wavelet is early appear in 1990, its idea is based on dividing the information of the image into four sub-bands in which the image is transformed into "low image information" and the remaining details are in three images " Horizontal, Vertical, and Diagonal" images. The first one is also decomposed into other four sub-images, this process gives a number of features which cannot be seen in the original images and can appear in the level after the transformation so, for this the "wavelet transformation" is the best for medical image compression.

The Huffman coding which is produced by Doctor David. A. Huffman in 1952 it is a tool to build the image with less redundancy coding, the Huffman coding is a statistical coding, it try to minimize the number of the bits which is needed to represent the symbols [3]. These method is applied in this search the region of interest which is obtained using the "Base Region Method" which is the selection of the region of interest to compressed in the medical images of the diagnostic region, this method is used to have balance between the very good quality of the reconstructed and low memory Douckas *et al*. in 2007 has used the "Volumetric medical images" to analysis different region of interest [9].

Test images: The images which are used in the search are three brain stroke Gray Images of size 255×255, JPG type, (a) shows the gray scale image without skull and some noise in the image, (b) shows the image after using morphological properties "Erosion and Dilation " to remove the outer skull, (c) gives the region of interest which is the stroke after using the "region based method"[10].

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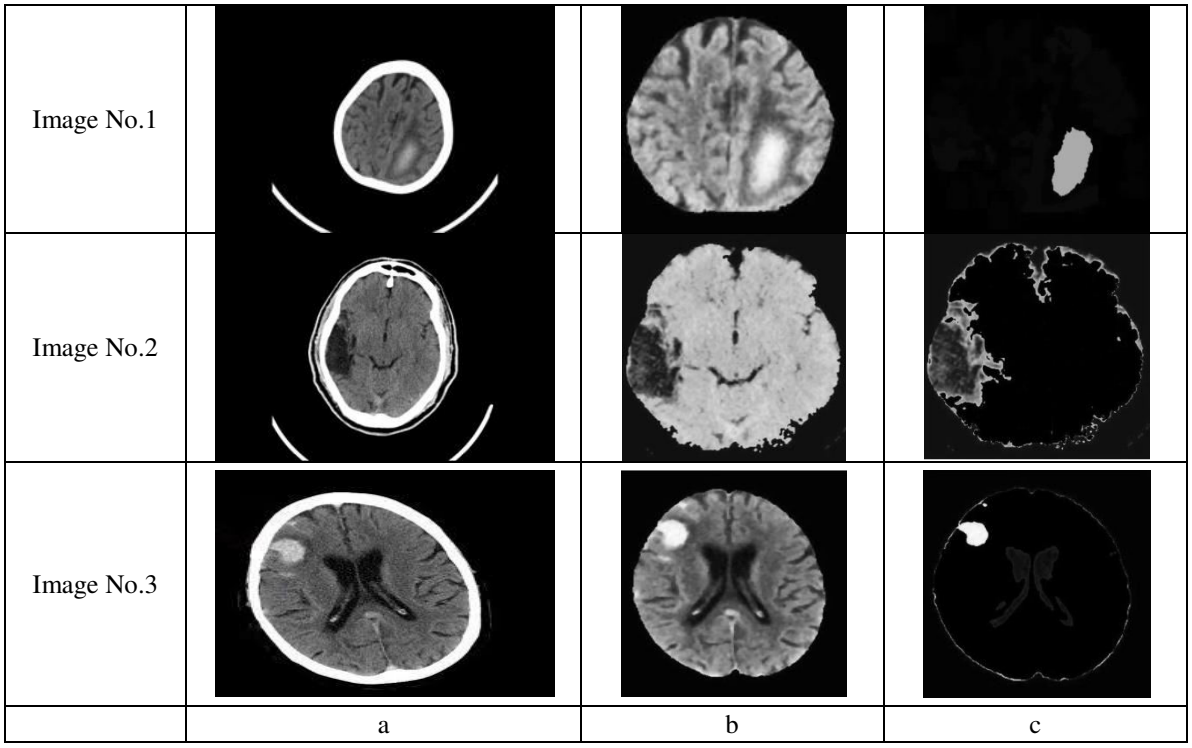

Figure-1. The CT images for brain stroke.

METHODOLOGY

a) Take three images for brain stroke of size 255×255JPG type CT images.

b) Applying the Morphological property Erosion and Dilation to remove the outer skull of the image, then the pixel based method is applied on the image pixel to find wither the pixel belong to the region seed or not

c) Finding the region of interest by the pixel based method.

d) Take the block size 4×4, 8×8 and 16×16.

e) Find the Huffman Coding

f) Find the Soft threshold and hard threshold, four threshold are taken for both type of the threshold (8, 10, 12, 15).

g) Find the "DWT" for the decomposed image (first level)

h) Find the second level "WT" on the first level.

i) Using the inverse discrete wavelet transformation to decode the image.

j) Apply the "DCT" discrete cosine transformation

k) Calculate the "Compression Ratio", "Structural Similarity Index", "The Mean Square Error", "The Peak Signal to Noise Ratio" and "Universal Image Quality Index".

Region based methods: The basic idea of "region based segmentation" is divided the image into homogenous region the pixels of this region are connected together by "homogeneity" and "similarity" features among the gathered pixels. The unwanted region is obtained when the neighbour pixels fail to match with the same features. This "segmentation" technique check the neighbour pixels of initial "seed points" and examine it if the pixel in the neighbours have to added to the region or not . This process is repeated until the image is completed and region is segmented into the region of interest [11].

Huffman algorithm: The "Huffman cod" idea is based on specify the long cod to the input block with low prospect and short cod with high prospect input block. The two lowest prospect characters of Huffman cod is merged, this process is repeated until one character is obtained, the Huffman cod is reached by created a tree cod and labelling the tree cod lead to obtaining the Huffman cod. [12]

Wavelet transformation: The compression operation, represented by "Discrete wavelet transformation , DWT", started by decomposes the image to" sub- bands", it is called the coefficient, after this step this sub-band or coefficient compared with a threshold, any value which is less than the threshold value is zero and any value higher than the threshold encoded by lossless compressed method, the idea of the compression represented the

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concept that the component with the regular signal perfectly approximated by using the following steps which is the DWT algorithm[13].

First decomposition: the level (N) is selected, the wavelet is calculated and the signal is decomposed at level N.

Second thresholding coefficients: the threshold is select from 1 to N for each level; the hard threshold is utilized to specify the coefficients.

Third reconstruct: the coefficient of the" N" level original approximation is used to calculate the wavelet reconstruction [13]. In the "DWT" the image pass through the separation of the image into "Lower, Horizontal, vertical and Diagonal resolution", "LL","HL","LH" and "HH". The compressed image is first partitioned into blocks and each one of this block must pass into the following filters [3].

a) High pass filter: the lower frequency in the image is lost and the information with high frequency is kept.

b) Low pass filter: the image information with lower frequency is kept, the image information with high frequency is lost.

As the decomposition of first level is obtained the image is parted into four parts. "LL","HL","LH" and "HH"

Thresholding Compression: As the "DWT" is completed, the step after that is finding the thresholding, the threshold type are two, "Hard and Soft" threshold [9]. The hard threshold is obtained when the absolute value are less than the given threshold, the value of element are zero, the Soft threshold is other way of Hard threshold where the elements can have value of zero, where the absolute value are less than the choose threshold the threshold value is T [14,15].

$$\text{The value of Hard signal} = \begin{cases} Xif|x| > T \\ 0\ if|x| \le \mathrm{T} \end{cases} \quad (1)$$

$$\text{The value of Soft signal} = \begin{cases} (|x| - \mathrm{T}) & if|x| > T \\ 0 & if|x| \le \mathrm{T} \end{cases} \quad (2)$$

DCT Transformation

The Discrete cosine Transformation is the orthogonal one with a constant set of fundamental function, the "DCT" is utilized to transform the image to the frequency space, this transformation is important for the following reason [16]:

a) It can bundle the energy of image data with lower frequencies.

b) The effect of the boundaries created between sub images which are resulted from the "blocking artefact" can be reduced by DCT

The Data of Images are isolated into different frequencies parts. The quantization step in the DCT disposal the frequencies which is less important and the decompression is on the essential frequencies which is important to restore the image [17]. The "DCT" is applied on the overlapping block of the data and can describe by the following equation [2].

$$D(i,j) = \frac{1}{\sqrt{2N}} C(i)C(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} I(x,y) \cos\left[\frac{2(x+1)i\,\pi}{2N}\right] \cos\left[\frac{2(y+1)i\,\pi}{2N}\right] \quad (3)$$

$$C(u) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } u = 0 \\ 1 & \text{if } u > 0 \end{cases} \quad (4)$$

Quality measure of image compression

a) Compression ratio: the compression ratio which represented by "CR" is the bit number which specify the information before data compression to the bit number signify the data information after compression [18].

$$CR = \frac{Number\ of\ the\ coded\ bits}{N \times M} \quad (5)$$

where N,M are the size of the compressed image.

b) Structural similarity index: The "SSIM" is a method for measuring the similarity between the compressed image and original image. it base idea is measuring initial uncompressed or distortion free image as refer to compressed image, the patterns "Local Patterns" of intensities of the pixels which are normalized for the contrast can be represented by the following equation [19].

$$SSIM = \frac{(2\mu_x\mu_y + C_1) + (2\sigma_{xy} + C_2)}{(\mu_x^2\mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \quad (6)$$

Where C_1 is the contrast of the original image, C_2 is the contrast of the reconstructed image.

$\mu_x\mu_y$ are the local mean of luminance respectively, σ_x and σ_y are the standard deviation of luminance for the original image and the reconstructed images respectively.

c) The mean square error: It's the simplest measurement for the image quality and its known as the statistical measurement, it compare between the original image f(x, y) and the enhanced image h(m, n) i.e. it measure the difference between the original and the result image. Its value is between (0 and ∞) when the value is high the image has poor quality, the Mean Square Error can be obtain by the following equation [20].

$$\mathrm{MSE} = \frac{1}{M \times N} \sum_{m=0}^{M} \sum_{n=0}^{N} (f(m,n) - h(m.n))^2 \quad (7)$$

where M, N is the size of original image f(m, n) and h(m. n) is the reconstructed image respectively.

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d) The peak signal to noise ratio: It is all so known as the "PSNR" it can be represented by the following equation [21].

$$\text{PSNR} = 10 \log \frac{255^2}{\text{MSE}} \quad (8)$$

In which MES is the mean square error, the peak signal to noise ratio represent here the quality parameter for the compression ratio. The lower value of PNSR represented an image with high ton quality than with higher signal to noise ratio.

e) Universal image quality index: The quality of the image is measured by so called, the universal image quality" UIQI" it can be produced by the combination of three factors "Luminance distortion", "Contrast distortion" and "Loss of correlation". represented by the following equation [22].

$$Q = \frac{4\sigma_{xy}\mu_x\mu_y}{(\sigma_x^2+\sigma_y^2)(\mu_x^2+\mu_y^2)} \quad (9)$$

μ_X , μ_y is the mean value of original and decompressed image

σ_x,σ_y is the standard deviation of original and decompressed

σ_{xy} is the covariance value.

Table-1. Quality of Image Compression Using Huffman Cod with Soft Threshold Image (1).

Threshold (T=8)					
Window size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	6.42	3.210	43.065	0.905	0.791
8×8	8.243	4.220	41.877	0.882	0.712
16×16	12.134	6.401	40.068	0.810	0.657
Threshold (T=10)					
Window size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	8.578	5.310	40.879	0.942	0.603
8×8	10.241	7.102	39.616	0.895	0.501
16×16	13.521	9.410	38.394	0.923	0.402
Threshold (T=12)					
Window size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	10.213	7.502	39.379	0.923	0.407
8×8	12.350	8.915	38.629	0.904	0.305
16×16	15.741	11.541	37.508	0.901	0.213
Threshold (T=15)					
Window size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	13.702	8.941	38.616	0.871	0.708
8×8	15.417	10.502	37.918	0.881	0.601
16×16	17.271	13.674	36.771	0.892	0.540

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Table-2. Quality of Image Compression Using Huffman Cod with Soft Threshold Image (2).

Threshold (T=8)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	10.541	4.532	41.567	0.972	0.491
8×8	14.959	6.792	39.810	0.947	0.421
16×16	16.375	8.514	38.829	0.935	0.305
Threshold (T=10)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	12.214	5.941	40.392	0.901	0.601
8×8	16.541	8.672	38.749	0.879	0.581
16×16	17.211	10.210	38.040	0.821	0.574
Threshold (T=12)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	13.541	7.210	39.551	0.940	0.810
8×8	17.230	9.451	38.376	0.932	0.798
16×16	18.510	12.201	37.266	0.901	0.764
Threshold (T=15)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	16.542	9.502	38.356	0.899	0.697
8×8	18.754	10.142	38.069	0.857	0.581
16×16	19.142	13.541	36.814	0.842	0.406

Table-3. Quality of Image Compression Using Huffman Cod with Soft Threshold Image (3).

Threshold (T=8)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	11.352	3.478	42.717	0.987	0.484
8×8	12.849	5.991	40.355	0.954	0.391
16×16	15.263	7.418	39.427	0.903	0.299
Threshold (T=10)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	11.325	6.212	40.198	0.920	0.699
8×8	15.452	7.891	39.159	0.838	0.631
16×16	16.279	11.621	37.478	0.810	0.603
Threshold (T=12)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	14.459	8.326	38.926	0.982	0.901
8×8	16. 352	10.989	37.721	0.976	0.899
16×16	17.423	13.142	36.944	0.942	0.841
Threshold (T=15)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	17.263	10.210	38.040	0.989	0.728
8×8	18.226	11.026	37.706	0.912	0.692
16×16	18.989	12.628	37.117	0.902	0.512

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Table-4. Quality of Image Compression Using Huffman Cod with Hard Threshold Image (1).

Threshold (T=8)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	6.512	6.401	40.068	0.898	0. 897
8×8	8.921	10.710	37.832	0.825	0.814
16×16	12.421	15.213	3 36.086	0.724	0.726
Threshold (T=10)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	8.542	10.320	37.994	0.901	0.892
8×8	11.012	14.201	36.607	0.892	0.814
16×16	12.593	17.920	35.597	0.882	0.727
Threshold (T=12)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	10.213	14.421	36.541	0.932	0.921
8×8	12.352	17.527	35.693	0.885	0.880
16×16	15.871	20.452	35.023	0.880	0.781
Threshold (T=15)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	13.507	20.279	35.060	0.890	0.801
8×8	15.419	23.571	34.407	0.901	0.721
16×16	17.321	29.421	33.444	0.991	0.654

Table-5. Quality of Image Compression Using Huffman Cod with Hard Threshold Image (2).

Threshold (T=8)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	8.912	7.021	39.666	0.890	0. 997
8×8	12.510	11.801	37.411	0.908	0.953
16×16	14.25	16.210	36.032	0 0.902	0. 0.828
Threshold (T=10)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	10.521	10.521	37.910	0.882	0.898
8×8	15.279	13.221	36.918	0.845	0.775
16×16	17.512	19.421	35.248	0.897	0.629
Threshold (T=12)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	11.721	13.102	36.957	0.882	0.984
8×8	16.012	16.201	36.035	0.845	0.901
16×16	18.110	20.210	35.075	0.829	0.874
Threshold (T=15)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	13.542	15.021	36.363	0.912	0.956
8×8	17.215	17.102	35.800	0.892	0.834
16×16	19.215	21.512	43.803	0.940	0.734

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Table-6. Quality of Image Compression Using Huffman Cod with Hard Threshold Image (3).

Threshold (T=8)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	10.291	8.142	39.023	0.933	0. 988
8×8	11.889	12.762	37.071	0.923	0.974
16×16	15.567	15.527	36.219	0.898	0.921
Threshold (T=10)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	11.472	11.402	37.560	0.989	0.902
8×8	16.648	12.898	37.071	0.915	0.807
16×16	18.729	18.752	35.400	0.907	0.796
Threshold (T=12)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	12.932	15.306	36.282	0.920	0.973
8×8	17.127	17.783	35.630	0.890	0.951
16×16	19.243	19.532	35.223	0.859	0.898
Threshold (T=15)					
Block size	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
4×4	14.631	16.209	36.034	0.998	0.979
8×8	16.457	18.316	35.502	0.982	0.961
16×16	18.338	20.975	34.913	0.967	0.823

Table-7. Quality of Image Compression Using DWT.

Image No.	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
1	19.456	4.987	41.152	0.965	0.986
2	19.781	3.439	42.766	0.876	0.897
3	19.981	2.897	43.511	0.984	0.923

Table-8. Quality of Image Compression Using DCT.

Image No.	**CR**	**MSE**	**PSNR**	**SSIM**	**UIQI**
1	10.741	0.786	49.176	0.847	0.873
2	11.232	1.345	46.843	0.689	0.882
3	10.245	0.651	49.994	0.926	0.915

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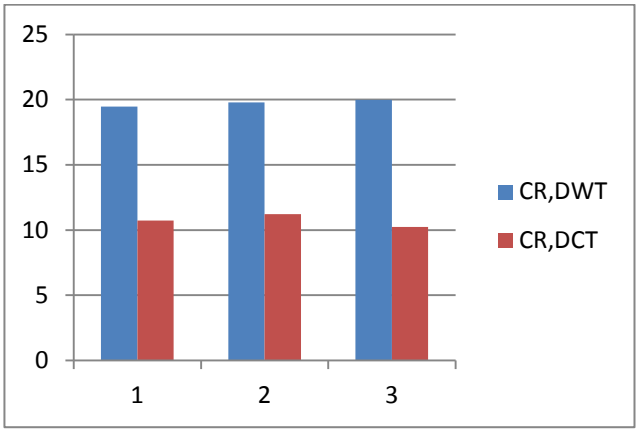

Figure-2. The compression ratio for the DWT and DCT.

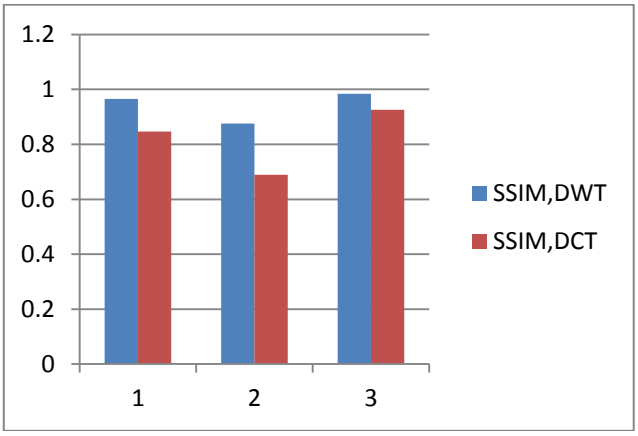

Figure-5. The structural similarity index for DWT and DCT.

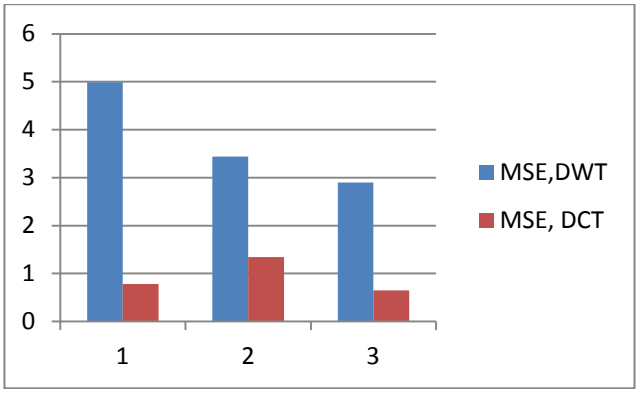

Figure-3. The mean square error for the DWT and DCT.

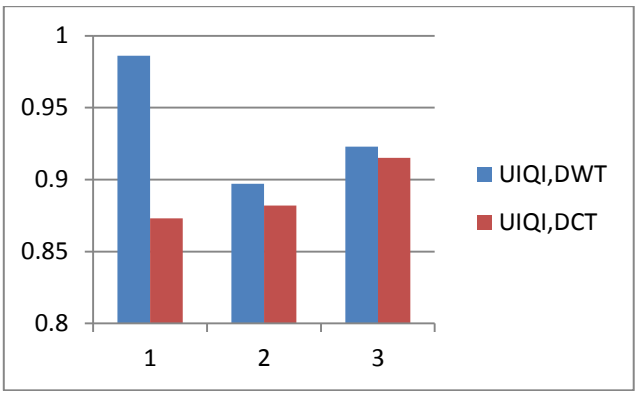

Figure-6. The universal image quality Index for DWT and DCT.

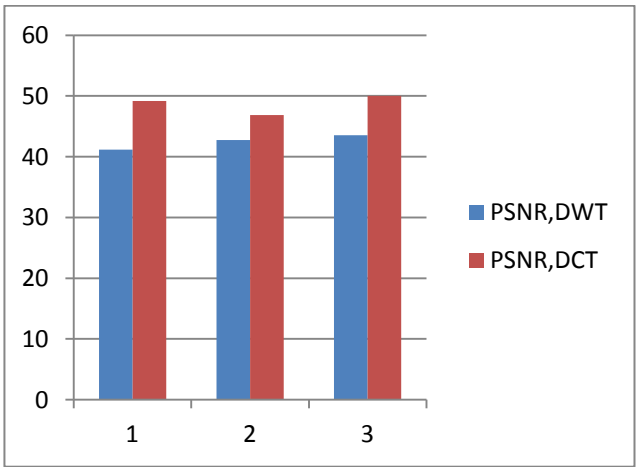

Figure-4. The peak signal to noise ratio for DWT and DCT.

DISCUSSIONS

In this paper, the image compression technique represented by Huffman cod with "Hard and Soft" threshold in which the block size is 4×4,8×8 and 16×16, the three gray images have been taken as a medical images segmented by the based segment method to get the region of interest to have a best compression and less lose of information, as the block Size increase the compression ratio increase and "Structural Similarity Index (SSIM)" and "Universeral Image quality Index (UIQI)" increase also. There is a reverse relation between the compression ratio and the peak signal to noise ratio as one increase the other decrease, when the compression ratio increased the mean square error increased, as the peak signal to noise ratio increase the "Universeral Image quality Index" and Structural Similarity Index (SSIM)" increased also, and these values decrease when the block size and mean square error increased under the same threshold. These can be seen in Tables(1,2,3,4,5,6) and these relations are the same for the soft and hard threshold, but the compression ratio for the soft threshold is higher than that for hard threshold.

Tables (7,8) which is Quality of Image Compression using DCT and DWT, the compression ratio for the DWT is higher than that for DCT and the mean

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square error for the DWT is higher than that for the DCT. The peak signal to noise ratio for the DCT is higher than that for DWT but the SSIM and UIQI for the DCT is less than that for DWT. This can clearly see in Figures (2, 3, 4, 5, 6) which shows the Quality of Image Compression using DCT and DWT.

CONCLUSIONS

a) As shown from the result of using Huffman with local, soft threshold and three block size 4×4, 8×8, 16×16 the two threshold shows that the compression ratio hold with the same variation with two type of threshold, as the block size increase the compression ratio increase .

b) The mean square error for the "DWT" is higher than that for "DCT" and from equation (8) the peak signal to noise give lower value for “DWT" than that for " DCT" and the compression ratio is increased as the peak signal to noise decreased. when the mean square error increase the quality of the image increase and low value of peak signal to noise ratio, this give high ton quality.

c) The selection of region of interest helps to reduce the image size without any effect seen on the image and its quality, the wavelet is better used with the medical image especial when selecting region of interest, because good reconstruction.

d) The cod word length is reduced by using Huffman encoding this give shorter cod words to highly "frequents symbol".

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