Performance Analysis of Still Image Compression Based on SPHIT Compression Technique

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Abstract—**The high demand on storage capacity at low bit rate in transmission has opens an interest among researcher to integrate new compression technique to meet demand requirement in the future. In this paper, a set of wavelet functions (orthogonal and biorthogonal) is tested using 256 x 256 still images samples in different image format (PNG, JPEG and TIFF) and numbers of level decomposition (3, 4, 5) based on SPHIT compression technique. The performance analysis discussed wavelet transform features in still image compression and the quality of the image performance is degraded by level of compression and decompression process using MATLAB software. The image quality is measured based on PSNR, MSE and compression ratio performance. The result shows that suitable number of decomposition is 4. This number of decomposition gives high PNSR and good visual quality performance.**

Keywords — orthogonal; biorthogonal; SPHIT; PNSR;

I. INTRODUCTION

The need of high capacity storage at low bit rate transmission require high reliability comparison method.

Nowadays, the most popular and reliable compression scheme is by using discrete wavelet transform (DWT). This wavelet transform been used to solve many problem in image compression and restoration. The coefficient that been produced in wavelet transform is to reconstruct the image back by using finite precision and quantization result in lossy scheme. There is a lifting scheme that been introduced to wavelet transform for the reduction of computational complexity by factor of two and no auxiliary memory needed. In lifting scheme, there are three modules which is splitting, lifting and scaling.

As the advanced scheme been introduced, SPHIT coding scheme been used in this paper. The basic principle is progressive coding been applied by processing the image to a lowering threshold. This scheme takes consideration between coefficients across subbands at different level.

This paper is divided into several sections. Section 2 briefly explains the SPHIT compression method. Section 3 describing methodology been used in image compression. Section 5 describes the samples been used and process using of graphical user interface (GUI) in MATLAB software. Section 7 provides the results and discussion and finally Section 8 concludes the overall work done.

II. SPHIT COMPRESSION TECHNIQUE

The SPHIT technique that been presented by Amar Said and W. A. Pearlman offers the reasons for its excellent performance can be better understood. These principles are partial ordering by magnitude with a set partitioning sorting algorithm, ordered bit plane transmission and exploitation of self similarity across different scales of an image wavelet transform.

The implemented based on three concepts which are i) partial ordering of the transformed image elements by magnitude with transmission of order by a subset partitioning algorithm that is duplicated at the decoder; ii) ordered bit plane transmission of refinement bits; iii) exploitation of the self similarity of the image wavelet transform across different scales [3].

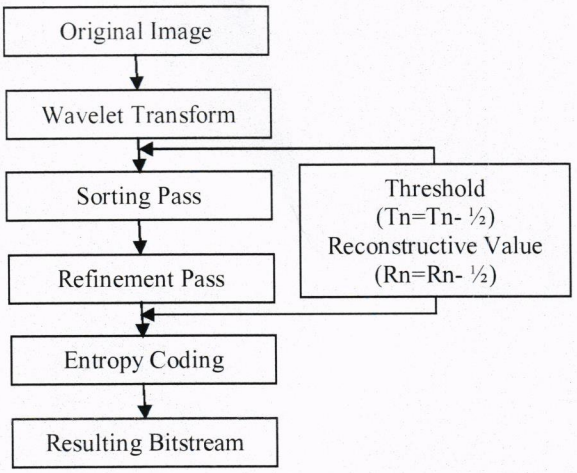
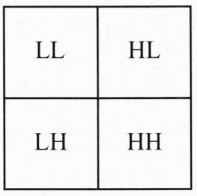
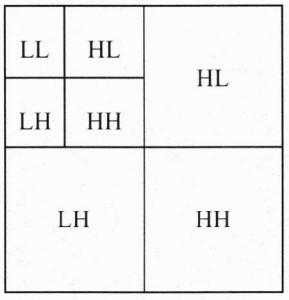


Figure 1: SPHIT method

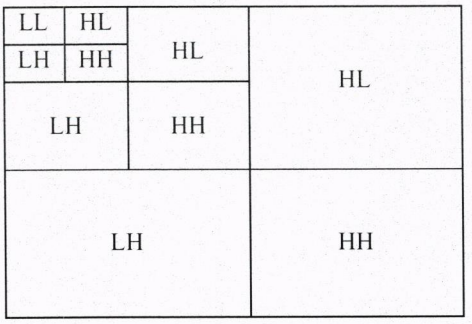
Figure 1 shows the flow of SPHIT method where it is briefly shows the flow on how the SPHIT compression technique works. In SPHIT, it decomposed the sample image into different steps before been transmitted. The sample image been transformed into subbands before applying the DWT coefficient to find the significant coefficient and encoded the coefficient. The coefficient value that been obtained used to reconstruct using two bits for approaching the real value. The encoding bits transmitted in the form of bitstream. [1].



a. Single Level Decomposition



b. Two Level Decomposition



c. Three Level Decomposition

Figure 2: Level of decomposition

Figure 2 is presented as the level of decomposition in image compression. The original or sample image is decomposed into four subbands based on the frequency by sampling horizontal and vertical channels using subbands filter. The subband LL is further decomposed and critically subsampled to obtain the next coarser scaled wavelet coefficient. This process will be repeated based on the level of decomposition that been chosen. Each level has various band information based on the frequency being applied such as Low-Low (LL), High-Low (HL), High-Low (HL) and High-High (HH) [1] [2] [6].

This technique provides highest image quality for compression approved when extensive research has shown that the images obtained with wavelet based method yield very good quality. In fact, SPHIT exploit the properties of the wavelet transform images to increase the efficiency.

SPHIT also provide bits that are allocated automatically for local optimality among the color components unlike other algorithm that encode component separately based on global statistics of the individual components.

Other than SPHIT properties is progressive image transmission that been used in some system with internet the quality of the displayed images are very slow to load the image. This advantage can be seen when applying with a different speed of bit rate transmission of connection.

SPHIT has been using a simple quantization algorithm that shown when SPHIT represent a small 'revolution' in image compression. It broke the trend to more complex compression schemes. SPHIT has achieved superior result using the simplest method; uniform scalar quantization whiles the other try to improve previous schemes. Thus, it is much easier to design fast SPHIT codec [8].

III. METHODOLOGY

The methodology is consists of subsection that include analyzing wavelet, the number of decomposition level and types of image format as part of discussion in this section.

A. *Analyzing wavelet*

For this paper, orthogonal and biorthogonal wavelet been used as the types of wavelet for the image compression. Each of this wavelet would give different types of properties that would affect the image quality and its properties after being compressed. By this analyzing wavelet, it will show the good and acceptable image compression can be used for the types of file formats for this paper.

Asymmetric is the strong limitation orthogonal wavelet property in construction of wavelet. By this, it put the approximation of image in higher level is shifted to the lower right corner. It is hard to find an orthogonal wavelet come with a desirable properties of orthogonality and symmetry.

On the contrary, biorthogonal wavelets provide a symmetry property in construction of wavelet. Therefore, it become the concerning fact for standard image application and cited as the superior performance. Hereby, it does not shifting approximation of image of any level of decomposition. In addition, biorthogonal wavelets transform providing an invertible matrices and perfect construction of wavelet [7] [10].

B. *Types of Wavelet and Level of Decomposition*

There are many type of orthogonal wavelet that can be chosen as the experimental variables for image compression that can be considered as the analyzing wavelet. For this paper, it has been decided to choose Haar, Symlet and Daubechies wavelet as the experimental variable for image compression. For contrary or different properties of analyzing wavelet for this sample of images for this paper, the biorthogonal wavelet is Coiflet, Biorsplines and "Discrete" Meyer wavelet.

Haar wavelet is the oldest and simplest wavelet which is not continuous. The Symlet and Coiflet wavelet come from Daubechies wavelet but are more symmetric. Both the scaling function and wavelet of Meyer are defined in the frequency domain. Although the scaling function and wavelet of Meyer are symmetric for its wavelet transform. Daubechies wavelet is compactly supported wavelet with extremely phase and highest number of vanishing moment for a support width and associated scaling filters are minimum-phase filters.

"Discrete" Meyer wavelet has the approximation of the Meyer wavelet where the general characteristic is infinitely regular orthogonal wavelet. Biorspline wavelet is symmetry and exact reconstruction is possible with FIR filters.Within each family of wavelet, there are wavelet subclasses distinguish by the number of filter coefficients and the level of iteration [10][11].

Level of decomposition for this paper had been varied to obtain the good and acceptable image compression. For this paper, level of decomposition that been taken as experimental variable is level 3, 4 and 5.The best level of decomposition depends on the sample images until the level is found good and acceptable by observing the measured parameter such as compression ratio, mean square error (MSE) and peak and signal noise ratio (PNSR). Each of the measured parameter may give different meaning and implication of the compressed image. However, theoretically is when the high level of wavelet decomposition is applied, the quality of the compressed image is low because the data are too much reduced.

C. *Performance Analysis*

Several data been taken as the measured parameter to observe the image quality compression is compression ratio, MSE and PNSR.

Compression ratio that acts as the measured parameter is equal to the size of the original image divided by the size of the compressed image. This ratio is as the indicator on how much compression is achieved for a particular image. By comparing to others algorithm, they almost have typical range of compression ratio that they can achieve over a variety of images.

Generally, if compression ratios are higher, the qualities of the resulting image are poorer. The relation between compression ratio and picture quality are significant to be consider when compressing an image. However, when about processing a highly detailed image, the compression ratio that been produced would be very small compression ratio.

$$\text{Compression ratio}=\frac{A}{B}x100 \quad (1)$$

Where A = Number of bytes in the original data set
B = Number of bytes in the compressed data set

The MSE is provided by:

$$MSE=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(f(i,j)-f'(i,j))^2 \quad (2)$$

Where x(m,n), y(m,n) are respectively the original and recovered pixel values at the m^{th} row ant n^{th} column for MxN size image.

By having a larger PNSR indicate a smaller difference between the original and reconstructed image. This value can be calculated by:

$$PNSR=20\log\left(\frac{255^2}{MSE}\right) \quad (3)$$

A good and acceptable quality of image lies between 20 to 40 dB of PNSR value [7] [9].

IV. RESULT AND DISCUSSION

Based on the tabulated data as shown in Table 1, it shows the measured parameter by using orthogonal wavelet that been taken as the analyzing wavelet for the sample images. Measured parameter that considers being as the visual quality for the compressed image is PNSR. This is due to its properties that provide ratio of noise in the compressed image. Referring to Fig. 4, it show the peaks of PNSR for different wavelets that can be concluded each of the different wavelet

still lies between the good and acceptable image quality. PNSR are related to visual quality of the compressed image where the images are good and acceptable. Analyzing wavelet that provides a consistency in orthogonal wavelet for compression image is sym 4. PNSR or visual quality performance is depending on MSE parameter based on equation (3). Compression ratio for sym 4 is the lowest ratio compared to others wavelet. By having a low compression ratio shows that the image is the quality are less intact compared to original image. On comparing the format image between the analyzing wavelet, all the samples are fixed in 8 bits per pixel (bpp) images or 256 colors in an image. It concluded that TIFF image format giving a good and acceptable image compression. TIFF image file format is used for exchanging document between application and computer platform which is good also for storing images. Based on the sample images that been used, mostly contain natural images.

For contrary, the analyzing wavelet is change to biorthogonal wavelet for image compression. By referring to Fig. 5, the measured parameter of PNSR is still lies in range of good and acceptable quality even the parameter is slightly higher than orthogonal wavelet. The analyzing wavelet of biorthogonal give an equal visual quality to all samples image since the PNSR value are not consistent toward a single wavelet only. By considering the compression ratio for biorthogonal wavelet, bior 4.4 would provide a better compression ratio since this wavelet is the lowest compression ratio compared to other wavelets in each of the sample image. For the level of decomposition, level 4 still provide the best level of decomposition based on the measured parameter that been tabulated in Table 1. File format that is best for biorthogonal wavelet as the analyzing wavelet is TIFF file format by referring Fig. 6 which is same goes by using orthogonal wavelet. Figure 6 made the comparison based on measured parameter of MSE where it is related to equation (3) of PNSR. TIFF file format is providing the lowest of MSE parameter than others file format, hence, having a high values of PNSR parameter and visual quality performance.

Figure 3: Sample images

Table 1: Measured parameter using orthogonal wavelet

		PNSR			CR (%)			MSE		
Sample	Format	haar	db 4	sym 4	haar	db 4	sym 4	haar	db 4	sym 4
Blason	.PNG	37.91	37.76	37.8	21.94	21.84	21.10	10.52	10.88	10.78
Devil		35.63	35.36	35.42	41.08	37.05	36.99	17.81	18.93	18.67
Person		39.00	38.93	38.95	16.73	15.84	15.38	8.186	8.314	8.273
Catherine	.JPG	36.46	36.34	36.19	26.92	25.31	24.84	14.68	15.1	15.63
Woodsculp		37.68	38.24	38.17	18.37	15.45	14.85	11.08	9.748	9.919
Woodstatue		39.14	39.55	39.37	12.69	11.64	11.74	7.924	7.209	7.525
Facetscol	.TIFF	38.04	38.15	37.92	22.50	20.69	19.94	10.22	9.966	10.49
Laure		42.84	39.51	39.41	23.17	9.77	9.65	3.378	7.272	7.449
Flower		33.08	36.89	33.30	31.29	27.74	27.64	32	13.32	30.44

Table 2: Measured parameter using biorthogonal wavelet

		PNSR			CR (%)			MSE		
Sample	Format	bior 4.4	coif 4	dmey	bior 4.4	coif 4	dmey	bior 4.4	coif 4	dmey
Blason	.PNG	37.74	37.5	37.47	20.27	21.35	21.50	10.94	11.56	11.64
Devil		35.38	35.65	35.57	35.69	36.50	36.34	18.82	17.72	18.02
Person		38.76	38.84	38.64	14.63	15.43	15.61	8.652	8.501	8.898
Catherine	.JPG	32.33	36.48	36.19	24.42	24.89	25.13	38.06	14.61	15.62
Woodsculp		38.08	38.26	38.19	14.21	14.97	14.91	10.11	9.712	9.874
Woodstatue		39.52	39.23	39.25	10.77	11.56	12.22	7.266	7.763	7.723
Facetscol	.TIFF	37.85	34	37.74	19.26	20.45	20.21	10.66	25.9	10.94
Laure		42.95	39.68	39.06	16.54	9.43	9.53	3.297	6.995	8.071
Flower		36.64	36.82	31.53	26.82	27.41	27.02	14.11	13.54	45.67

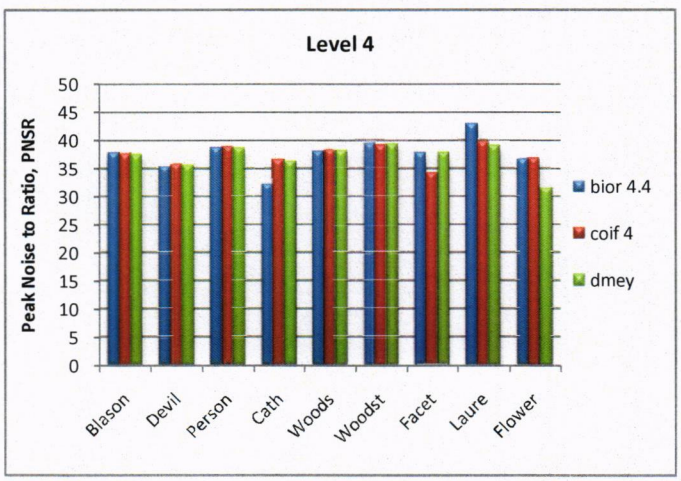


Figure 4: PNSR parameter for orthogonal wavelet

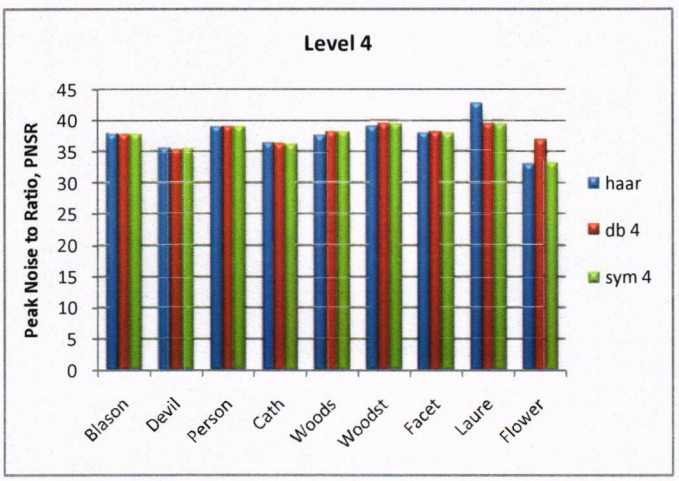


Figure 5: PNSR parameter for biorthogonal wavelet

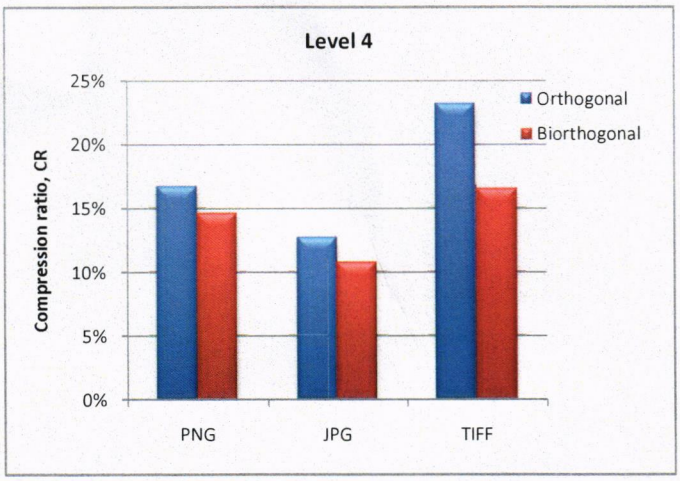


Figure 6: Comparison between compression ratios by types of wavelet

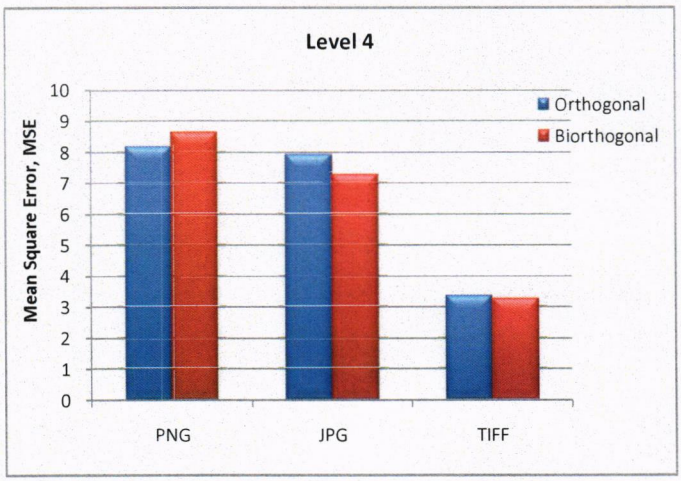


Figure 7: Comparison between MSE by type of wavelet

V. CONCLUSION

Level 4 level of decomposition provide a good and acceptable image compression both of analyzing wavelet, orthogonal and biorthogonal wavelet. However, most of the result shows that biorthogonal provide good and better image compression than orthogonal compression based on measured parameter in Table 1 and Table 2. We can conclude that 256 x 256 images are better to be compressed with biorthogonal wavelet by PNG, JPG and TIFF file format even the data that has been calculated and recorded are just slightly out of range for 20 dB to 40 dB for PNSR. The compression ratio also are not too high between these orthogonal and biorthogonal wavelet. It still consider as good and acceptable image compression by maintaining the image quality.

TIFF file format would give a better image compression than other file format since the properties of TIFF itself for storing images. The PNSR and visual image performance are better and acceptable for image compression based on Fig. 7 of MSE parameter.

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