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IMAGE COMPRESSION USING WAVELET ALGORITHM

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As the coming era of digitized image information, it is critical to produce high compression performance while minimizing the amount of image data so the data can be stored effectively. Compression is one of the indispensable techniques to solve this problem. The Wavelet Algorithm contains transformation process, quantization process, and lossy entropy coding. Wavelets are functions which allow data analysis of signals or images, according to scales or resolutions and it provide a powerful and remarkably flexible set of tools for handling fundamental problems in science and engineering, such signal compression, image de-noising, image enhancement, image recognition. For the transformation process, Haar Wavelet Algorithm is introduced. In the quantization process, it reduces the precision of the sub-bands and achieves the compression. The lossy entropy coding process replaces the symbol stream produced in quantization stage. The main purpose of this project is to maintain the quality of image after the image compression process using Wavelet Algorithm. Besides that, it can produce high compression performance and minimize the amount of the image data so that it can be stored effectively. Moreover, the performance of compress image will be analyzed. For this project, JPEG and PNG image is used and the system is built on MATLAB. So, by developing this system using Wavelet Image Compression technique, it is hope that the image will compressed perfectly without harming the image.

Keywords: Image compression, Wavelet Algorithm, lossy entropy coding.

I. INTRODUCTION

Image compression is a great important topic of practical. It has a huge application in information theory [1], applied harmonic analysis [2] and signal processing.
Image compression is a process of reducing the amount of data required to represent a particular amount of information by exploiting the redundancy within the data. The common redundancies are inter-pixel redundancy, psycho-visual redundancy and statistical redundancy [3].

There are several technique can be use to compress image which are Discrete Cosine Transform (DCT) and Wavelet Algorithm Transform. DCT works by separating images into parts of differing frequencies. During the step quantization, where part of compression usually occurs, the less important of frequencies are discarded, hence the use of the term of “lossy”. Then, only the most important frequencies are use to retrieve the image compression process. As a result, the reconstruct image contains some distortion but this level of distortion can be adjusted during the compression stage. There is some loss of quality in the reconstructed image below; it is clearly recognizable, even though almost 85% of the DCT coefficients were discarded.

Images contain large amounts of information that requires large transmission bandwidths, much storage space and long transmission times. Therefore it is crucial to compress the image by storing only the essential information needed to reconstruct the image. An image can be thought of as a matrix of pixel (or intensity) values. In order to compress the image, redundancies must be exploited, for example, areas where there is little or no change between pixel values. Therefore large redundancies occur in the images which having large areas of uniform colour, and conversely images that have frequent and large changes in colour will be less redundant and harder to compress.

In general, there are three essential stages in a Wavelet transform image compression system: transformation, quantization and entropy coding. Figure 1 depicts the encoding and decoding processes in which the reversed stages are performed to compose a decoder. The de-quantization is the only different part in the decoding process and it followed by an inverse transform in order to approximate the original image.

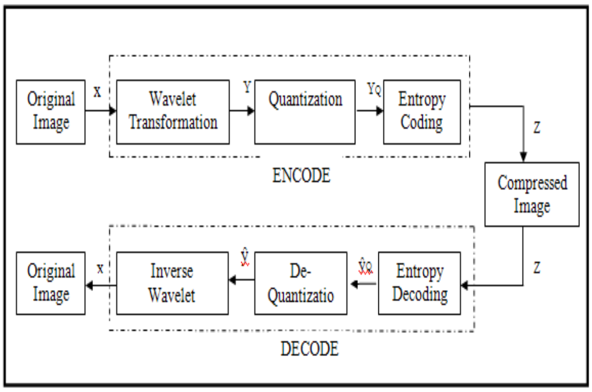

Figure 1: Block Diagram of Encode and Decode Process by using Wavelet Transformation Algorithm.

In order to compress the image, wavelet analysis can be used to divide the information of an image into approximation and detail sub-signals. The approximation sub-signal shows the general trend of pixel values, and three detail sub-signals show the horizontal, vertical and diagonal details or changes in the image. If these details are very small then they can be set to zero without significantly changing the image. The value below which details are considered small enough to be set to zero is known as the threshold. The greater the number of zeros the greater the compression that can be achieved. The amount of information retained by an image after compression and decompression is known as the energy retained and this is proportional to the sum of the squares of the pixel values. If the energy retained is 100% then the compression is known as lossless as the image can be reconstructed exactly. This occurs when the threshold value is set to zero, meaning that the detail has not been changed. If any values are changed then energy will be lost and this is known as lossy compression. Ideally, during compression the number of zeros and the energy retention will be as high as possible. However, as more zeros are obtained more energy is lost, so a balance between the two needs to be found.

II. PREVIOUS WORK

Jingyu Yang [4] in his journal was developed a system "Image Coding Using 2-D Anisotropic Dual- Tree Discrete Wavelet Transform". In this journal, image coding has received great success using 2D- Discrete Wavelet Transform (2D-DDWT). It captures point singularities efficiently but fails to capture directional structures which are often anisotropic at different orientation. They develop 2D-DDWT-based video coding scheme system without motion compensation. 2D-DDWT has 3 main advantages; direction selectivity, limited redundancy and shift invariance. Basic functions with direction selectivity can characterize directional structure efficiently. Limited redundancy would facilitate sparse representation without imposing too much overhead of coding redundant location. The implementation of 2D-DDWT consists of two steps. Firstly, an input image decomposed up to a desired level by two separable 2D-DDWT branches. Secondly every two corresponding sub-bands which have the same pass-band are linearly combined by either averaging or differencing.

H. Pan [5] developed a system "Lossless Image Compression Using Binary Wavelet Transform". In this journal, the purpose of Binary Wavelet Transform (BWT) is originally designed for binary image to the lossless compression of gray-scale images. A sample embedded lossless BWT-based image coding algorithm, called Progressive Partitioning Binary Wavelet- Tree Coder (PPBWC), which uses a joint bit scanning method and non-casual adaptive context modeling. Because all calculations in BWT are performed by Boolean operations, PPBWC introduce no quantization errors and is computationally simple. Similar to the lifting scheme, the implementation structure of BWT is designed to further reduce the computational complexity of the PPBWC. Due to its energy concentration ability, BWT is able to reduce entropy in the transformed image significantly which can help to decrease the bit budget. Different to another zerotree-based algorithm, this algorithm only produces two symbols '0' and '1'. By applying a non-casual adaptive context modeling to each bit stream, the PPBWC exploits self similarity and the joint coefficient statistic in the wavelet spartial oriental tree. The ability to look into forthcoming information generally reduces the uncertainty of the encoding coefficient is the factor of the high coding efficiency of the PPBWC.

Harish Kumar [6] designed a system "Image Compression Using Discrete Cosine Transform Implementing MATLAB". In this journal, Discrete Cosine Transform works great success in many data points in term of a sum of cosine functions oscillating by separating images into parts of different frequencies. The JPEG process is widely used from a lossy image compression that enters on the DCT. DCT and Fourier transform convert images from time-domain to frequency-domain to decorate pixels. The DCT transformation is reversible. The DCT works by separating image into parts of difference frequencies. During a step called Quantization where the part of comprehension actually occurs, the less important frequencies are discarded hence the use of the term 'lossy'. Then only the most important frequencies that remain are used retrieve the image in the composition process. As a result reconstructed contain some distortion but it can be adjusted during the compression process.

Anoop Mathew [7] developed a system "Image Compression Using Lifting Based Discrete Wavelet Transform (DWT)". Based from the journal, wavelet-based image compression are using JPEG2000 image. It proposed that an Energy Efficient Wavelet Image Transform Algorithm (EEWITA) consists of techniques to eliminate computation of certain high-pass coefficients of an image. The use of EEWITA can significantly reduce both; (i) computation energy, by minimizing the computation needed to compress an image and (ii) communication energy, consumed by the RF (Radio Frequency) component of the mobile appliance, which is proportional to the number of bits transmitted. The reduction in energy is obtained with minimally perceptible loss in image quality. Energy efficient wavelet image transform algorithm (EEWITA) is a wavelet-based transformation algorithm that aims at minimizing computation energy (by reducing the number of arithmetic operations and memory accesses) and communication energy (by reducing the number of transmitted bits). We can estimate the high-pass coefficients to be zeros (and hence avoid computing them) and incur minimal image quality loss. This approach has two main advantages. First, because the high-pass coefficients do not have to be computed, EEWITA helps to reduce the computation energy consumed during the wavelet image compression process by reducing the number of executed operations. Second, because the encoder and decoder are aware of the estimation technique, no information needs to be transmitted across the wireless channel, thereby reducing the communication energy required.

III. METHODOLOGY

As for the methodology, first, the original image is embedded into the system. Then, the system will transform image into grayscale image to minimize the storage size in disk. The grayscale image is gone to Wavelet transformation either first, second and third level of level decomposition. For this analysis, the image is transform up to 3 levels. The purpose of this transformation is to separate information into sub-signal. Then, the system is quantized the image. The result is a wavelet compressed image where the compressed image size is reduced but the quality of the image is quite similar to original image.

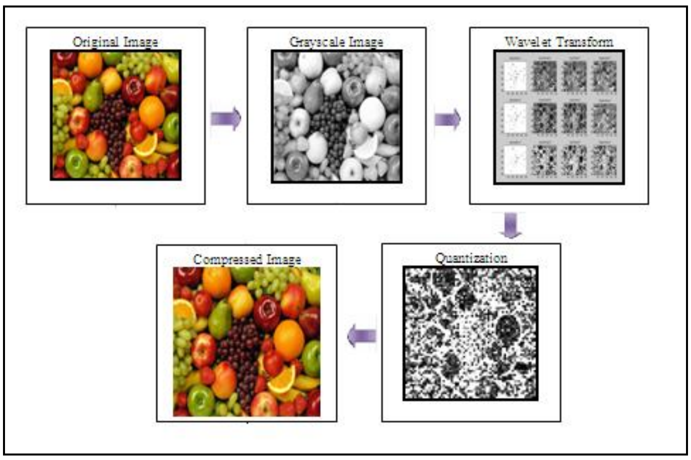

Figure 2: Step by step image compression transformation using Wavelet Algorithm.

The purpose in transformation stage is to convert the image into a transformed domain in correlation and entropy can be lower and the energy can be concentrated in small part of transformed image. Quantization stage results in loss of data because it reduces the number bits of the transform coefficients. Coefficients not make significant contributions to the total energy or visual appearance of the image are represented with a small number of bits or discarded while the coefficient in the opposite case are quantized in a finer fashion. It is such the operations to reduce the visual redundancies of the input image. The entropy is at the end of the whole encoding process. It assigns the fewest bit code words to the most frequently occurring output values and most bit code words to the unlikely outputs. This reduces the coding redundancy and thus reduces the size of the resulting bit-stream.

IV. RESULT AND ANALYSIS

The main goal for this system is to maintain the quality of image after the compression process using Wavelet Algorithm.

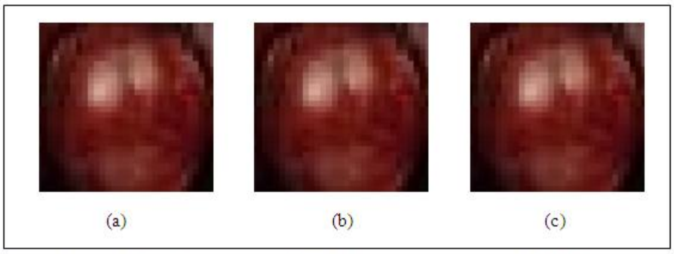

Figure 3: (a) Original Image (b) JPG image (c) PNG image

Image quality is one of those concepts that is greater than the sum of its parts and normally, the goals of image compression is to produce compressed image of the highest quality. From Figure 3, it indicate that the quality of original image and compressed image are simmiliar and it is the best overall trade-off between image quality and load time for the image compression. Microsoft Window Viewer software is used to zoom-in the original image and compressed image. The purpose of zoom-in these image is to compare the quality image into larger form between pixel by pixel. From Figure 3, it clearer represent these images are with no perceptible distortion eventhough it compressed with 3 level of decomposition compression. There is no image data are lost during higher compression.

It can be conclude that when images used to achieve high compression, Wavelets can cause images to appear smooth, with a wavy appearance, sometimes described as looking similar to grains of rice. Because wavelets operate on a entire image at once, they avoid the "blockiness" associated with JPEG methodology.

Other than that, it can be seen from the experiment done that the image size is reduced tremendously. From Figure 4, it show that comprarison between size of original image and compressed image. From previous, the quality of original image are same without degradding the any image pixel of it and and there are no information loss in this image compression. Eventhough the quality images are similiar, it reduces the size of image so that it can be transmit efficiently.

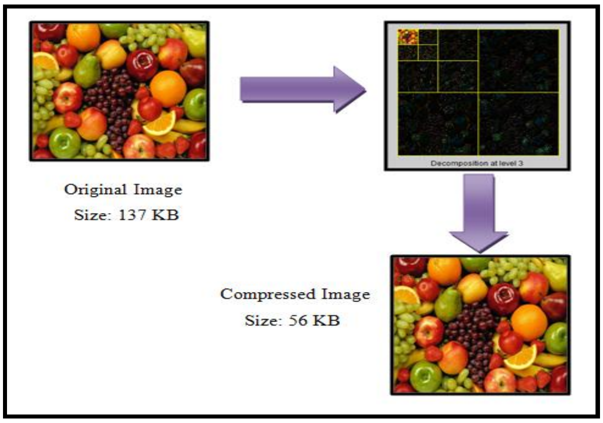

Figure 4: Decomposition and Reconstruction
Image at level 3

Some analysis is also done to the the compression performance between multi image size in multiple image format. JPG and PNG image is used in 128x128, 256x256 and 1024x1024 size. The compression ratio (CR) is represent the equality of size of the original image divided by the size of the compressed image. This ratio gives an indication of how much compression is archieved for a particular image. The compression ratio typically affected the image quality. Generally, the higher compression ratio, the poor quality of the resulting image. The trade-off between compression ratio and quality is an important and should be consider when compressing image.

Table 1: 128 x 128: Comparison between JPG and PNG format

Types of images : 128 x 128	JPG image	PNG image
Original Image	8.50 KB	50.3KB
Compressed Image	4.14 KB	37.3 KB
Compression % (Size Image)	51.29 %	25.85%
Compression Ratio (CR)	8.97%	8.83%
Bit Per Pixel (BPP)	0.72	0.71
Retained Energy	98.57%	90.20%
Number Of Zeros	95.61%	95.61%

Table 1 shows a comparison between jpg and png images with size of 128x128. As it bring out, the retained energy and the number of zeros for both image format is quite similar. The image is compressed up to half of its' original size for both image format . As we can see, compression ratio and bit per pixel for JPG image is slightly higher than PNG image. It can be conclude that, JPG image is compressed better than PNG image in size of 128x128.

Table 2: 256 x 256: Comparison between JPG and PNG format

Types of images : 256 x 256	JPG image	PNG image
Original Image	55.2 KB	184 KB
Compressed Image	20.2 KB	149 KB
Compression % (Size Image)	63.41%	19.02%
Number Of Zeros	96.84%	96.48%
Retained Energy	95.85%	96.48%
Compression Ratio (CR)	7.49%	7.39%
Bit Per Pixel (BPP)	0.60	0.59

As previous analysis, we can see that from Table 2, the JPG image show a higher compression which is 63.41% and reducing it's image size from 55.2 KB to 20.2 KB. While compression of PNG image is quite low with 19.02% and it reduce the image size from 184 KB to 149KB. The number of zeros, retained energy and Bit Per Pixel (BPP) for the JPG and PNG image seems quite similar.

Table 3: 512 x 512:Comparison between JPG and PNG format

Types of images : 512 x 512	JPG image	PNG image
Original Image	137 KB	542 KB
Compressed Image	55.4 KB	334 KB
Compression % (Size Image)	59.56%	38.38%
Number Of Zeros	98.09%	98.18%
Retained Energy	99.49%	97.76%
Compression Ratio (CR)	6.17%	5.62%
Bit Per Pixel (BPP)	0.4938	0.4493

From table 3, the image dimension used is 512 x512. For JPEG image, the original image sized is 137KB and original PNG image is 542KB. After compression process up to three level, the size of image is reduced with 55.4 KB for JPEG image and 334KB for PNG image. As it shown in table, the percentage of image compression for JPEG image is about 59.56% and PNG image is 38.38%. The compression ratio of JPEG image is indicating higher than compression ratio of

PNG image with 6.17% and 5.62%. The bit per pixel (BPP) for PNG image is quite lower than BPP of JPEG which is 0.4493 and 0.4938 respectively.

V. CONCLUSION AND RECOMMENDATION

As conclusions, from the analysis done it is clearly seen that the use of Haar Wavelet Algorithm in compressing the image can maintain the quality of image, produces high compression performance and minimizes the amount of the data so that it can be transmitting effectively. It is also noted that for JPG image, it be can reduced almost half of original image by using Haar Wavelet Algorithm. While for PNG image it just can reduced up to quarter of original image size. This is because, JPG image used lossy compression type which is it degrading the quality and information of image after doing multiple compression. For PNG image, it use lossless compression which is when doing multiple compression in this image, it still maintain the quality and information of the image. One of the limitations of this system is it cannot support image more than 1024x1024 dimensions.

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