IMAGE COMPRESSION BASED ON MODIFIED WALSH-HADAMARD TRANSFORM (MWHT)

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Abstract- Image compression techniques are used for reducing the amount of data required to represent a digital image. An image can be compressed with the use of Walsh-Hadamard Transform (WHT), quantization and encoding steps in the compression of the JPEG image format. In this system, RGB components of color image are converted to YCbCr. For image quantization, YCbCr color space is more convenient than RGB color space. The original image is broken into 8×8 blocks of pixel. In this system, the proposed method is mainly performed by modifying Walsh-Hadamard transform (WHT) method to optimize the processing time of image compression. Each block is calculated by using the modified Walsh-Hadamard Transform (MWHT). Then image quantization calculates probability index for each unique quantity. After applying quantization, Huffman code for each unique symbol is calculated so as to compress the image using Huffman compression. The main objective of this system is to decrease the transmission time for transmission of images. Experimental result shows that the result of the performances for the proposed method of BMP and GIF images is compared. So, the performances are evaluated in term of Bit Per Pixel (BPP), Compression Ratio (CR), Compression Time (CT). The system is implemented by using C# programming Language.

Index Terms- Huffman encoding, Image compression, Modified Walsh-Hadamard Transform (MWHT), Quantization, YCbCr.

I. INTRODUCTION

Image compression is a technique used to reduce the storage and transmission costs. The existing techniques used for compressing images are broadly classified into two categories, namely lossless and lossy compression techniques. In a digital true color image, each color component that is R, G, B components, each contains 8 bits data [1]. Also color image usually contains a lot of data redundancy and requires a large amount of storage space. In order to lower the transmission and storage cost, image compression is desired [2]. Most color images are recorded in RGB model, which is the most well known color model. However, RGB model is not suited for image processing purpose. For compression, a luminance-chrominance representation is considered superior to the RGB representation. Therefore, RGB images are transformed to one of the luminance-chrominance models, performing the compression process, and then transform back to RGB model because displays are most often provided output

image with direct RGB model. The luminance component represents the intensity of the image and look likes a gray scale version. The chrominance components represent the color information in the image [3,4]. In lossy compression techniques, the original digital image is usually transformed through an invertible linear transform into another domain, where it is highly de-correlated by the transform. This de-correlation concentrates the important image information into a more compact form. The transformed coefficients are then quantized yielding bit-streams containing long stretches of zeros. Such bit-streams can be coded efficiently to remove the redundancy and store it into a compressed file. The Walsh-Hadamard transform (WHT) is an invertible linear transform and is widely used in many practical image compression systems because of its compression performance and computational efficiency [5]. WHT-based image compression relies on two techniques to reduce data required to represent the image. The first is quantization of the image's WHT coefficients; the second is entropy coding of the quantized coefficients. Quantization is the process of reducing the number of possible values of a quantity, thereby reducing the number of bits needed to represent it. Quantization is a lossy process and implies in a reduction of the color information associated with each pixel in the image [6]. Entropy coding is a technique for representing the quantized coefficients as compactly as possible. Huffman coding is normally used in the entropy coding phase.

II. RELATED WORK

K.Veeraswamy [7] discussed designing quantization table for Hadamard transform based on Human Visual System (VHS) for Image Compression. Quantization table plays significant role in image compression (lossy) that improves the compression ratio without sacrificing visual quality. In this work, Human Visual system (HVS) is considered to derive the quantization table, which is applicable for

Hadamard Transform. By incorporating the human visual system with the uniform quantizer, a perceptual quantization table is derived. This quantization table is easy to adapt to the specified resolution for viewing. Results show that this quantization table is good in terms of improving peak signal to noise ratio (PSNR), Normalized Cross correlation (NCC) and to reduce blocking artifacts. This work is extended to test the robustness of watermarking against various attacks.

V. Orest and W. Mircea [8] discussed improving SOM vector quantization for image compression with Walsh-Hadamard transform. The bandwidth reduction or storage lowering in digital image transmission confers to the image compression a key role. In this system, they propose a new approach for lossy image compression: the source image is vector quantized by applying Self-Organizing Map (SOM) with several dictionaries. Each dictionary is originally designed based on the feature vectors resulted after applying the Walsh-Hadamard transform to the image blocks. For Lena, the value of PSNR for this method with 64 clusters outperforms with 0.7 dB the values obtained in the classical case with the same number of clusters. The penalty for bpp is very small. When comparing the proposed method with the classical SOM vector quantization, Zelda and Elaine: the gain for PSNR is 0.6-0.7 dB and the bpp values are greater than 0.02 bpp. Instead, when using classical SOM vector quantization for increasing the value of PSNR with 1 dB the penalty in bpp is 0.0625.

III. THE PROPOSED SYSTEM

Fig. 1 shows a block diagram of Modified Walsh-Hadamard Transform (MWHT) for image compression. The image is first divided into 8x8 blocks of pixels. The image blocks are transformed into the block of 8x8 coefficients using Modified Walsh-Hadamard Transform (MWHT). These coefficients are then quantized and eliminating the redundancies. At this stage, a tradeoff between the quality of the image and the compression efficiency is decided. Finally, Huffman encoding is used to remove coding redundancy from the image.

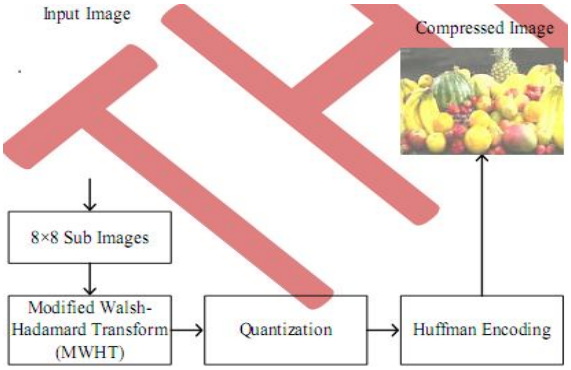


Fig.1: Block Diagram of Modified Walsh-Hadamard Transform (MWHT) for Image Compression

A. Color Space Conversion from RGB to YCbCr

RGB components of color image are converted to YCbCr (Y is luminance component; Cb and Cr are chrominance components of the image) because color spaces with luminance and chrominance components are more appropriate to be used with Walsh-Hadamard transform (WHT). Changing color is necessary to transform for image

quantization because the human eye is more susceptible to change in luminance (gray) than changing in chrominance (colors). Fig. 2 shows RGB fruit image and YCbCr fruit image. The operation of the color space conversion is presented in equations (1), (2) and (3).

$$Y=0.299R+0.587G+0.11B \quad (1)$$
$$Cr=128+0.5R-0.418G-0.081B \quad (2)$$
$$Cb=128-0.168R-0.331G+0.5B \quad (3)$$



Fig. 2: (a): RGB Fruit Image Fig. 2: (b): YCbCr Fruit Image

B. 8×8 sub-images

In this system, the image size is divided into 8×8 block of pixels, and and according to the image of w x h, pixels will W x H blocks. Then, the transform coefficients are calculated for each block. The input fruit image is shown in Fig. 3.

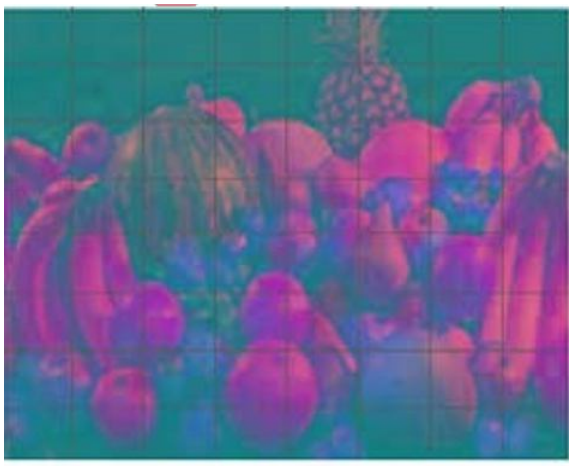


Fig. 3: Input Fruit Image

C. Modified Walsh-Hadamard Transform (MWHT)

The simplest form of the orthogonal transforms is Walsh-Hadamard transform (WHT) which is widely

used in the fields of digital signal processing and communications. Walsh-Hadamard transform (WHT) is derived from the Walsh functions. Since the Walsh functions form an ordered set of rectangular waveforms, they consist of two amplitude values (+1or -1). Walsh-Hadamard Transform (WHT) coefficients are rounded off to the nearest integers and the entropy coded.WHT equation is divided with block size (1/N). In this system, the modified Walsh-Hadamard Transform (MWHT) equation removed the division of block size (1/N) from WHT equation. The transform fruit image is shown in Fig. 4. This equation is defined as follow:

$$WH(u,v) = \sum_{r=0}^{N-1}\sum_{c=0}^{N-1} I(r,c)(-1)^{\sum_{i=0}^{n-1}[b_i(r)p_i(u)+b_i(c)p_i(v)]} \quad (4)$$

Where, WH (u,v) is the result of the transform(i.e, the WHT coefficient). I(r,c) is image pixel values at rth row and cth column.

N refers to the dimension of the image.

N = 2n, the exponent on the (-1), and bi(r) is found by considering r as a binary number and finding the ithbit.

In addition, pi (u) is found as follows:

$$p_0(u) = b_{n-1}(u)$$

$$p_1(u) = b_{n-1}(u) + b_{n-2}(u)$$

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$$p_{n-1}(u) = b_1(u) + b_0(u)$$

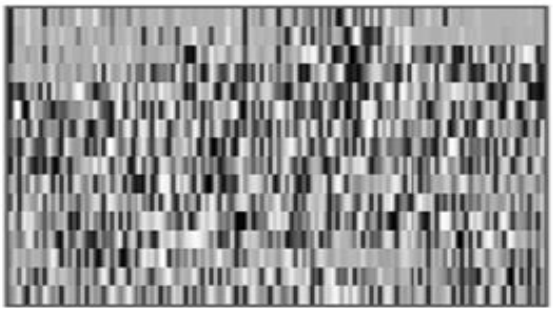


Fig. 4: Transformed Fruit Image

D Quantization

The human eye is insensitive to variations in brightness of high-frequency components over a large area. Therefore, the high frequency values in the image matrix can be rounded off to zero without the user noticing any difference in the quality of the image. Quantization achieves this compression by dividing the WHT output for each block by a quantization co-efficient, and then

rounding the result into the closest integer. The quantization formula with rounding to the quantized values is shown in equation (6).

$$Quantization = round\left(\frac{Transformrd\,Image\,Matrix}{Quantization\,Matrix}\right) \quad (6)$$

TABLE I shows quantization table for luminance.

TABLE I: Quantization Table forLuminance

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

TABLE II shows quantization table for chrominance

TABLE II: Quantization Table for Chrominance

17	18	24	47	99	99	99	99
18	21	26	66	99	99	99	99
24	26	56	99	99	99	99	99
47	66	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99

The quantized fruit image is shown in Fig.5.



Fig. 5: Quantized Fruit Image

E Huffman encoding

Huffman encoding has effectively used in text, image, video compression and conferencing system such as JPEG, MPEG-2, MPEG-4 and H.263 etc. Huffman coding is an entropy encoding algorithm used for lossless data compression. Huffman coding procedure is based on the two observations.

(1) More frequently occurred symbols will have shorter code words than symbol that occur less frequently.
(2) The two symbols that occur least frequently will have the same length.
Huffman encoding technique collects unique symbols from the source image and calculates its probability value for each symbol and sorts the symbols based on its probability value. Further, from the lowest probability value symbol to the highest probability value symbol, two symbols combined at a time to form a binary tree. To obtain Huffman code for a particular symbol, all zero and one collected from the root to that particular node in the same order. Example: coefficient 69 is in category 7. Thus the bit for the value, 69 is 1000101. To represent commonly used strings of values with a shorter code, Huffman table is created. This is shown in TABLE III.

TABLE III: The Huffman Encoded Table

Category	Values	Bits for the value
0	0	…
1	-1,1	0,1
2	-3,-2,2,3	00,01,10,11
3	-7,-6,-5,-4,4,5,6,7	000,001,010,011,100,101,110,111
4	-15,...,-8,8,...,15	0000,...,0111,1000,...,1111
5	-31,...,-16,16,...31	00000,...,01111,10000,...,11111
6	-63,...,-32,32,...63	000000,...,011111,100000,...,111111
7	-127,...,-64,64,...,127	0000000,...,0111111,1000000,...,1111111
8	-255,..,-128,128,..,255	...
9	-511,..,-256,256,..,511	...
10	-1023,..,-512,512,..,1023	...
11	-2047,...,-1024,1024,...,2047	...

The compressed image is obtained after Huffman encoding. The compressed image using modified WHT method is shown in Fig. 6.



Fig. 6: Compressed Fruit Image

IV. EXPERIMENTAL RESULTS

Fig. 7 shows the original images, transformed images, quantized images and compressed images of Orange, Pineapple and Pepper images.

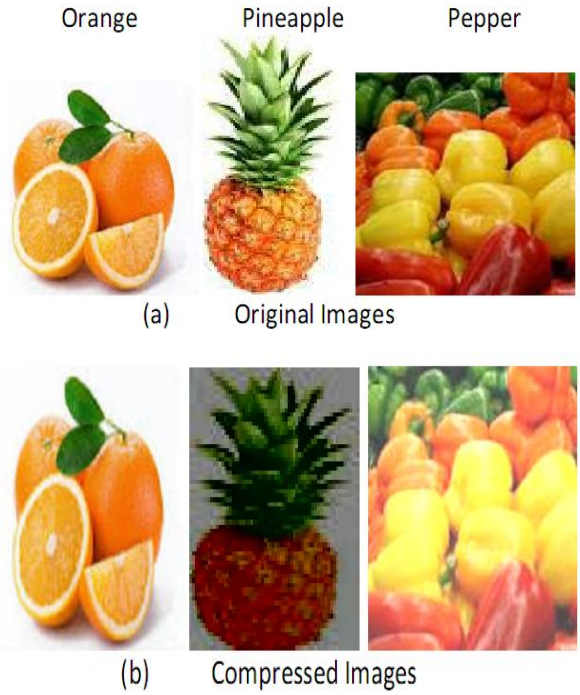


Fig. 7: Original and Compression of Orange, Pineapple and Pepper images

The size of the compressed image is evaluated with the compression ratio (CR) and bite per pixel (bpp) in equation (7 and equation (8).

$$CR = \frac{\text{original RGB color image size}}{\text{compressed image size}} \quad (7)$$

$$bpp = \frac{\text{size of compressed color image in bits}}{\text{number of pixels}} \quad (8)$$

The following TABLE IV describes the performance comparison of WHT method and proposed method.

TABLE IV: Performance Comparison of Proposed Method for BMP and GIF

Images / Performance	Orange		Pineapple		Pepper	
	BMP	GIF	BMP	GIF	BMP	GIF
Original File Size (KB)	29.3	8.37	29.3	8.27	43.1	9.75
Compressed File Size (KB)	4.18	4.20	3.43	3.43	4.72	4.74
Compression Ratio (KB)	7.0	2.0	8.5	2.41	9.13	2.1
Bit Per Pixel	0.17	0.18	0.14	0.14	0.20	0.2
Processing Time (ms)	441	519	569	461	316	461

In this table, it can be seen that every data has decreased from the proposed method of original file size. The proposed method of BMP images can be compressed nearly the same result compared with its GIF images. The compression ratio is above 7.0 in BMP images and above 2.0 in GIF images. Moreover, for the images of Orange, Pineapple and Pepper the processing time of its BMP images are faster than its GIF images. The graphical view of the result of Compression Ratio (CR) for Image Compression is shown in Fig. 8.

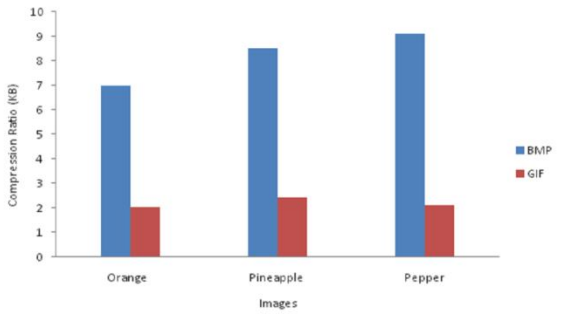


Fig. 8: Graphical View of the Result of Compression Ratio (CR) for BMP and GIF Images

CONCLUSION

Image compression is an extremely important part of modern computing. By having the ability to compress images of their original size, the valuable disk space can be saved. In addition, the transportation of images from one computer to another becomes easier and less time consuming. In this system, the proposed method cannot effect on the compression size by removing the block size. This system is designed by using C# programming language. The performance of this system is measured by Compression Ratio (CR), Bit Per Pixel (BPP) and Compression Time (CT). The original images are compressed up to 85% of Orange, 88% of Pineapple and 89% of Pepper for its BMP images. On the otherhand, the original images are compressed up to 50% of Orange, 58% of Pineapple and 52% of Pepper for its GIF images in this system. In the future work, this system will be extended by using other entropy encoding techniques or hybrid compression methods based on proposed method and other methods to get better compression ratio. In addition, speech compression or MPEG compression experiments will be extended by using this approach.

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