Fast Efficient Transforms for Contours Extraction and Image Compression using Zonal Sampling Methods

Ali abdrhman Ukasha[1*], Abdolhameed Ali Madi[2]

[1] ali.ukasha@sebhau.edu.ly, [2] abdolhameed.madi@sebhau.edu.ly

[1.2] Department of Electrical & Electronics Engineering, Faculty of Engineering & Technology Sciences, Sebha University, Libya

*Corresponding author email: ali.ukasha@sebhau.edu.ly

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ABSTRACT

People who use digital image processing techniques usually deal with a huge amount of data. Because storing image data for future needs requires a lot of storage space. In a similar way, sending image data at a reasonable time requires a high-capacity channel. To minimize these needs, it uses a technique called data compression. In this paper we have implemented the digital image compression process using fast walsh transform (FWT) and discrete cosine transform (DCT). The regions selection of compression is done by using of low-pass filter (LPF); while the extracted contours is performed using high-pass filter (HPF) through Matlab programming language. In this work the nine different shapes of zonal sampling in spectral domain will be tested. The comparison between FWT and DCT using different shapes of zonal sampling is implemented in terms of peak signal to noise ratio (PSNR), compression ratio (CR), and bit per pixel (bpp). Experimental results and analysis for image compression using LPF show that DCT gives higher PSNR (45 decibels) with CR=89.0144% than FWT (36 decibels) with CR=79.6921%; while the FWT introduce better quality than that by using DCT for contour extraction using HPF.

Keywords: Walsh and discrete cosine transform; Low- and High-pass filters; Zonal sampling forms; Image compression; Contour extraction

1 Introduction

Mostly In the recent period, there has been a significant development in the field of computers and communications to move from the analogous world to the digital world, which has achieved many features that did not exist in the past as speed of performance and quality of work in addition to providing space, size, weight, cheap and confidential data. The process of processing and compressing images is an attractive area for the scientists and researchers. The first focus of researches was to reduce the amount of memory needed to store the image, and also to reduce the band-width required to send the image. This is because the main problem with sending images is to contain an infinite number of information which requires an infinite amount of bandwidth to be transmitted at once. Two filters (low and high-pass) are used to contour extraction and image compression depends on transforms. A lot of transform coding are found in the literature review such as Fourier [1], Walsh transform [2], DCT [3], and Periodic Haar Piecewise-Linear (PHL) transform which is based on the integration of Haar functions [4, 5]. In this paper the DCT transform will be used. An efficient transform based on sub-band coding used in JPEG2000 standard compression known as wavelet transform [6, 7]. The expansion of applications and digital image processing has expanded to include medicine, space sciences, visual broadcasting, defense, space research and communications. The digital image has four main types: Binary Image - Color images (RGB color) - Gray Image (Gray Image) - Indexed images [8, 9].

2 Discrete Cosine Transform (DCT)

The two-dimensional DCT is applied to the split image in order to convert the matrix from the spatial field to the coefficients matrix in the spectral domain *F(u,v)* field according to the following equation:

$$F(u,v)=\frac{4C(u)C(v)}{n^2}\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}f(i,j)\cos[\frac{(2i+1)u\pi}{2n}]\cos[\frac{(2j+1)v\pi}{2n}] \quad (1)$$

where $C(u)$, $C(v)=1/\sqrt{2}$ for $u, v=0$ and $C(u)$, $C(v)=1$ otherwise.
The inverse DCT transform can be expressed as follows:

$$f(i,j)=\sum_{u=0}^{n-1}\sum_{v=0}^{n-1}C(u)C(v)F(u,v)\cos[\frac{(2i+1)u\pi}{2n}]\cos[\frac{(2j+1)v\pi}{2n}] \quad (2)$$

3 Fast Walsh Transform (FWT)

There are many ways to generate Walsh that are defined in order of rows and are divided into three groups as follows [10, 11, and 12]:

1. Natural Washed transform.
2. Dyadic-ordered Walsh transform
3. Sequence-ordered Walsh transform.

Using the interlayer of the natural order of the Walsh function, the acceleration of O (n ^ 2) to $O(n\ln n)$ is likely to occur, and the result here is often referred to as fast Walsh transform (FWT) which are widely used in signals and image processing and could be used for image compression. The order of the Hadamard transform is different from the order of the Walsh which are based on the gray code.

4 The Proposed Algorithm

The programming for simulation was done using Matlab 7.0.4. At the beginning the forward fast Walsh transform / discrete cosine transform is applied to the input image. Then the zonal sampling selection shapes depends on the low- and high-pass filters is performed. The flowchart of the analyzed algorithm is shown in Fig. 1.

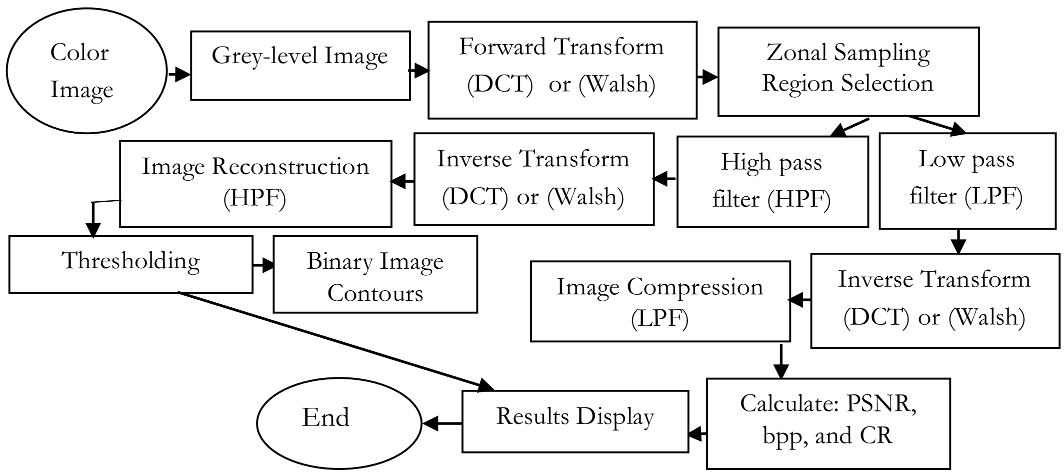

Figure 1: *General scheme for image compression and contour extraction*

5 Zonal Sampling Forms

Many different algorithms based on zonal sampling region shapes are proposed as in [13, 14]. Nine different selection forms for zonal sampling are used in this paper as shown in Fig. 2.

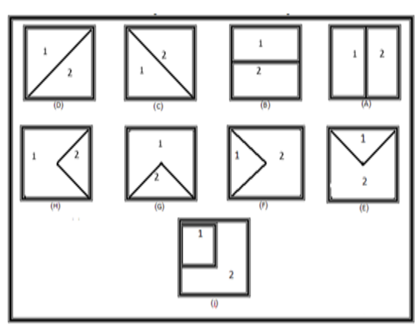

Figure 2: *Proposed zonal sampling formats*

In this paper we used a suitable threshold value to obtain the binary image.

6 Applied Measures

6.1 Peak signal to noise ratio (PSNR)

Assume we have reconstructed image which is obtained after the compression process is performed, we use the so-called Peak-Signal-to-Noise-Ratio (PSNR). If PSNR is larger, it indicates how close the reconstruction image is from the original image (i.e. higher quality). It should be kept in mind that larger PSNR values do not always mean better quality. Some images with high quality as seen by the viewer but the PSNR value is very low. To calculate the value of PSNR, we first calculate the Mean Square error value (MSE) by the given equation:

$$MSE(I,\tilde{I}) = \frac{1}{(n*m)}\sum_{i=0}^{n}\sum_{j=0}^{m}(I(i,j)-(\tilde{I}(i,j))^2 \tag{3}$$

where I and $\tilde{I}$ are the grey-level and reconstructed images respectively.

$$PSNR(I,\tilde{I}) = 10\log_{10}\frac{(L-1)^2}{MSE(I,\tilde{I})} \tag{4}$$

where L is the grey-level number.

6.2 Compression Measurement

1) bit per pixel (bpp)

The region compression depends on the number of bits per pixel (bpp) given by the following formula:

$$bpp = \frac{N^2 * 8}{(n*m)} \tag{5}$$

where: N^2 is coefficients number in the desired zonal form used as LPF filter and $n * m$ is size of the image.

2) compression Ratio (CR)

The compression ratio is depends on zeros numbers in spectral domain as follows

$$bpp = \frac{NOZ}{(n*m)} * 100\% \tag{6}$$

where: NOZ is Coefficients number in the desired zonal shape used as LPF filter and $n * m$ is size of the image.

7 Experiments Results

One image is tested by the proposed analyzed algorithm and shown in Fig. 3. The reconstructed image using LPF and DCT transform for many different zonal sampling forms are shown in Fig. 3 (related results are in Table I).

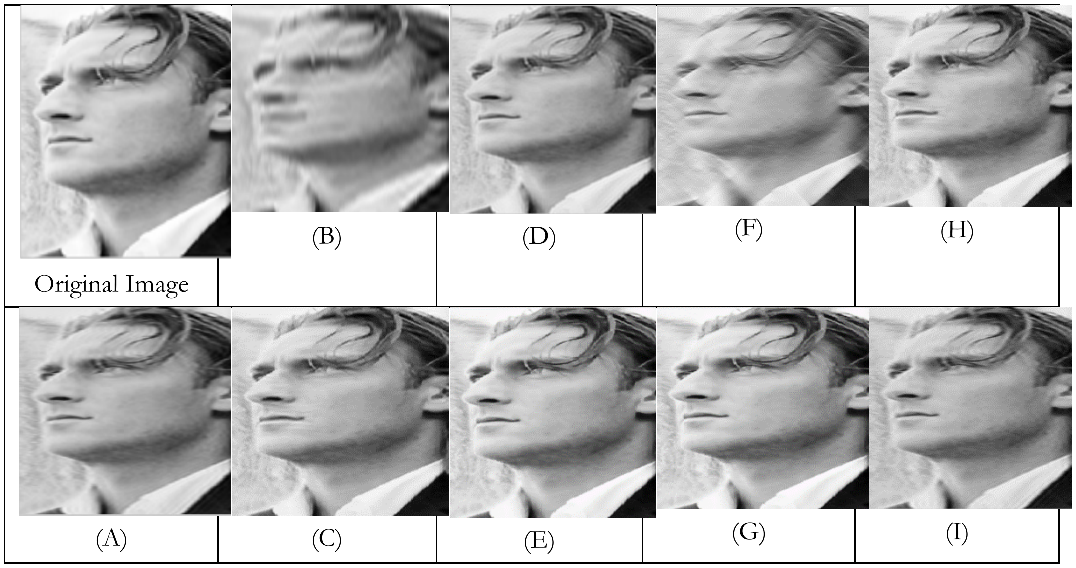

Figure 3: *Reconstructed compressed image using DCT and LPF filter*

From the Table I, we were able to know which of the zonal forms are the best in accuracy, compression ratio, and quality value of the image in the case of LPF, and we found that the best forms is the form (E); where the value of bits per pixel is (5.1328) the compression ratio (CR) was 64.16% as shown in Table II.

Table 1: *Applied measures of tested image using DCT transform*

Used Form	A	B	C	D	E	F	G	H	I
NxM	512x64	28x512	169048	141358	168192	70912	86272	67107	128x128
MSE	53	229	18	34	2	170	4	18	28
PSNR	31	25	36	33	45	26	42	36	34
bpp	1	0.444	5.1589	4.3139	5.1328	2.1641	5.13	2.0452	0.500

Table 2: *Best quality for zonal sampling forms measures using LPF filter and DCT transform*

Used Form	NxM	MSE	PSNR	bpp
E	168192	2	45	5.1328

Figure 4 represents the images in the case of using (HPF) (i.e. boundaries image), after applied DCT to the original image for the nine different regions forms (i.e. from A to I).

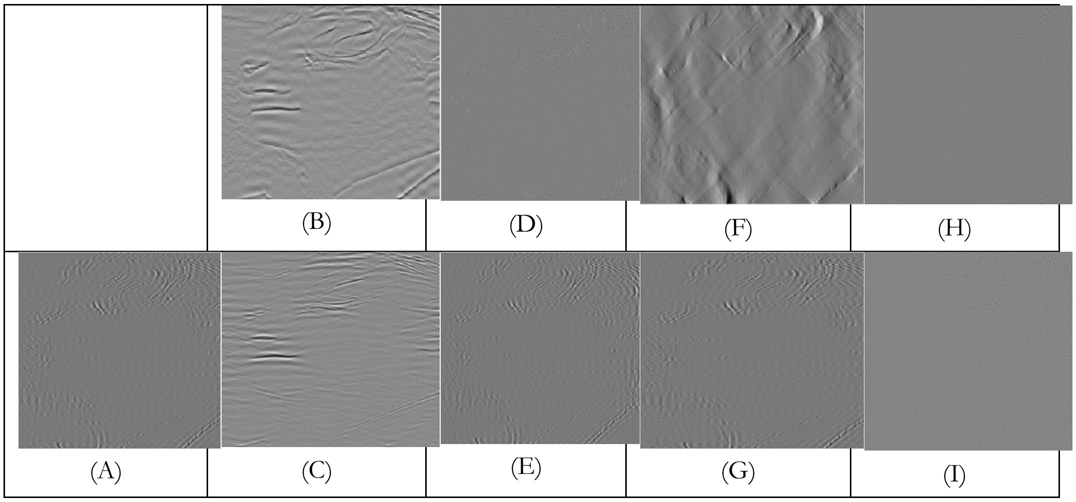

Figure 4: *Reconstructed boundaries image using HPF filter and DCT transform*

Table 3, show that the higher compression is in the form (H) where CR=89.0144% and the lower compression was in shape form (B) where the CR=52.8973%. The binary image using (HPF) for (H) form which are obtained using threshold value gives CR=88.1813%. Fig. 5 represents the images using LPF and HPF resulting from applying the FWT to the original image by nine different zonal sampling region forms (A to I). Some results by using Fast Walsh Transform (FWT) are in Table 4. Its show which of the zonal sampling forms are the best in accuracy, compression ratio, and the quality value of the reconstructed image. We found that the best of the forms was the shape (G) with compression ratio CR=62.70% (see Table 4).

Table 3: *CR for zonal sampling forms using DCT transform*

Used Form	A	B	C	D	E	F	G	H	I
CR %	58.46	52.89	56.13	70.34	88.18	53.47	74.20	89.01	79.36

Table 4: *Applied measures of tested images using FWT transform at different sizes*

Used Form	A	B	C	D	E	F	G	H	I
NxM	512x64	28x512	169048	48828	168192	70912	168192	67107	128x128
MSE	110	378	75	29	21	367	17	59	84
PSNR	28	22	29	34	35	22	36	30	29
bpp	1	0.444	5.1589	1.4901	5.1328	2.1641	5.1328	2.0452	0.500

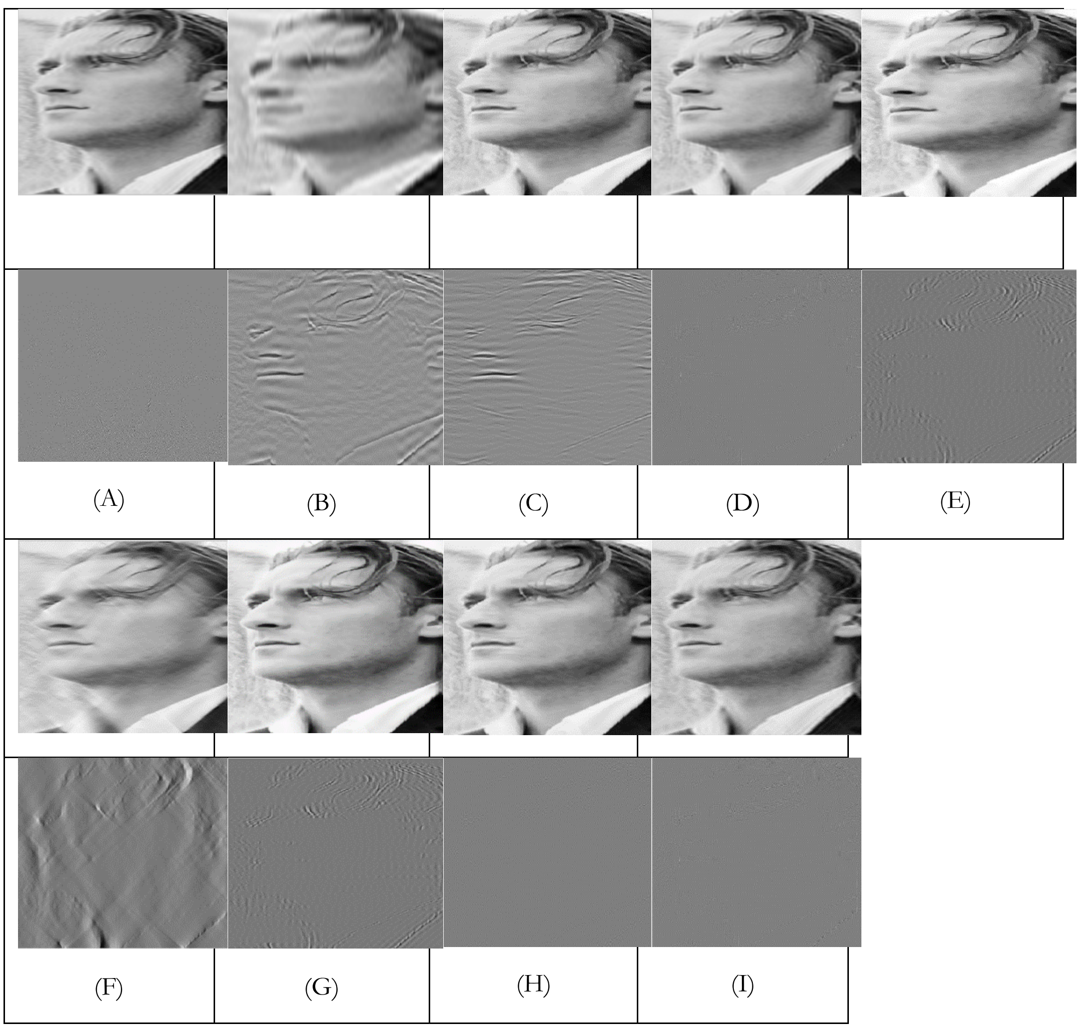

Figure 5: *Reconstructed compressed image using FWT and LPF and HPF filters*

Table 4: *CR for zonal sampling forms using FWT transform*

الشكل المستخدم	A	B	C	D	E	F	G	H	I
CR %	59.24	50.70	52.21	61.18	66.95	51.25	62.70	79.69	81.58

From the Table 4, it can be said that the best detailed border images that can be obtained from the HPF are the image that applies the logarithm form (B) and the compression ratio is (50.7011%). Also the highest compression was in zonal sampling shape form (I) where the compression ratio was (81.5895%). The lowest compression was in zonal sampling shape form (B) where the CR was (50.7011%).

8 Conclusions

Image compression and contour extraction using discrete cosine transform (DCT) and fast Walsh transform (FWT) based on low- and high-pass filters is studied and developed in this work. Nine different zonal sampling forms are introduced and compared. From our practical experiments on a tested images, we can judge that the discrete cosine transform (DCT) is more accurate in the results obtained, the more accurate in the quality and higher compression ratio (CR=88.18%) than the fast Walsh transform (FWT) (CR=62.70%), i.e. for images obtained by LPF. For images of contours which are obtained by HPF, the images quality obtained from the FWT are clearer shape but has less compression ratio. The highest compression ratio for all images from HPF was in the case of using DCT to CR = 89.0144%, whereas for FWT, the highest percentage was CR 79.6921%. This indicates that the DCT is better in image compression and higher in accuracy than in using Walsh transform, but the FWT is better at contours extraction than DCT. That is why Walsh transform is therefore widely used in radars to derive the required image boundaries if the image movement is fast. The best experimental results and analysis for image compression that obtained using LPF was when using zonal sampling shape form (E). It's shows that DCT gives higher PSNR (45 decibels) and the bit per pixel equals to 5.1328 with CR=89.0144% than FWT (36 decibels) with CR=79.6921%; while the FWT introduce better quality than that by using DCT for contour extraction using HPF.

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