GRAY-LEVEL IMAGE CONTOURS EXTRACTION & COMPRESSION USING WAVELET TRANSFORM

Ali Abdrhman Ukasha
Faculty of Engineering, Sebha University, Brack, Libya
elokshy@yahoo.com

Keywords: Wavelet transform, Image compression, Contour extraction & compression, Ramer & Trapezoid methods.

Abstract: This paper presents a method of contour extraction and compression from grey level image. Single step parallel contour extraction (SSPCE) method is used for the binary image after inverse wavelet transform is applied to the details images. Then the contours are compressed using either Ramer or Trapezoid methods in spatial domain. The proposed algorithms are applied in spectral domain using single-level wavelet transform (WT). Effectiveness of the contour extraction and compression for different classes of images is evaluated. In the paper the main idea of the proposed procedure for both contour extraction and image compression are performed. To compare the results, the mean square error, signal-to-noise ratio criterions, and compression ratio (bit per pixel) were used. The simplicity to obtain compressed image and extracted contours with accepted level of the reconstruction is the main advantage of the proposed algorithms.

1 INTRODUCTION

Contour representation and compression are required in many applications e.g. computer vision, topographic or weather maps preparation, medical images and moreover in image compression. The transform coding method compresses image data by representing the original signal with a small number of transform coefficients. It exploits the fact that for typical images a large amount of signal energy is concentrated in a small number of coefficients. The goal of transform coding is to minimize the number of retained transform coefficients while keeping distortion at an acceptable level. Transform coding is an integral part of one of the most widely known standards for lossy image compression, the JPEG (Joint Photographic Experts Group) standard. Contour extraction and image compression can be obtained using transforms such as Fourier (Brigham, 1974), Walsh (Walsh, 1923), DCT (Clarke, 1985), Wavelet (Vetterli, Martin, Kovacevic, 1995) and Periodic Haar Piecewise-Linear (PHL) which is based on the integration of Haar functions (Dziech, Belgassem, Nern, 2000) and (Dziech, Belgassem, Aboukhres, 1996). In this paper the discrete wavelet transform will be used. The forward wavelet transform is applied to the grey-level image as shown in Figure 1.

To obtain the compressed image and binary image, inverse wavelet transform is applied to the approximation coefficients image and details coefficients images respectively. The contours are extracted from binary image using single step parallel contour extraction (SSPCE) method (Dziech, Besbas, 1997) and (Besbas, 1998). Finally the compressed contours are obtained using either Ramer or Trapezoid methods.

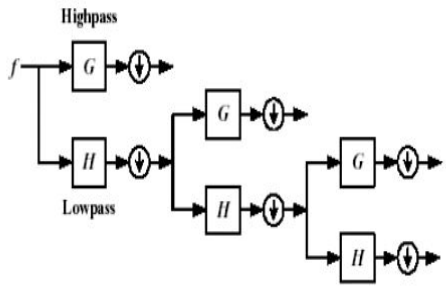


Figure 1: Image analysis using discrete wavelet transform.

Flowchart of the algorithm for image compression and contour extraction is depicted in Figure 2.

Ukasha A.
GRAY-LEVEL IMAGE CONTOURS EXTRACTION COMPRESSION USING WAVELET TRANSFORM.
DOI: 10.5220/0005414600990104
In *Proceedings of the First International Conference on Telecommunications and Remote Sensing (ICTRS 2012)*, pages 99-104
ISBN: 978-989-8565-28-0

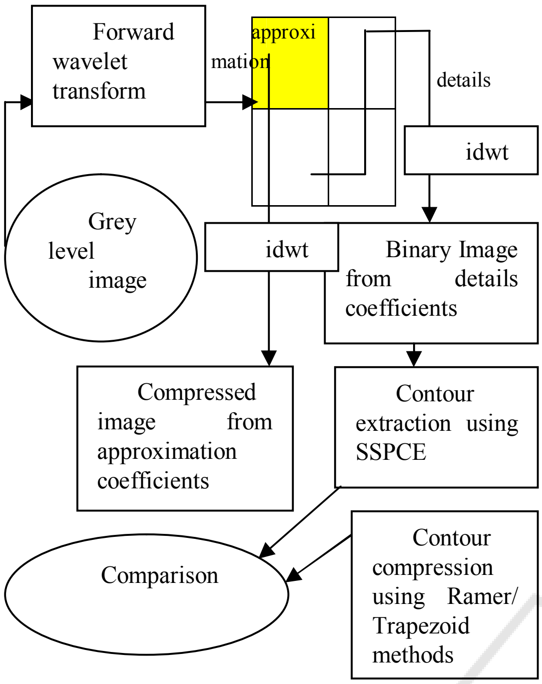


Figure 2: Block diagram of image compression and contour extraction of grey level image using single level of wavelet transform.

2 DISCRETE WAVELET TRANSFORM (DWT)

The Wavelet analysis is an exciting new method for solving difficult problems in mathematics, physics, and engineering, with modern applications as diverse as wave propagation, data compression, signal processing, image processing, pattern recognition, computer graphics, the detection of aircraft and submarines and other medical image technology (Vetterli, Martin, Kovacevic, 1995) and (Gonzalez, 1987). Wavelets allow complex information such as music, speech, images and patterns to be decomposed into elementary forms at different positions and scales and subsequently reconstructed with high precision.

Wavelets are obtained from a single prototype wavelet called mother wavelet by dilations and shifting using the equation

$$\Psi_{a,b}(t) = \frac{1}{\sqrt{a}}\Psi(\frac{t-b}{a}) \qquad (1)$$

3 RAMER ALGORITHM

Contour is represented as a polygon when it fits the edge points with a sequence of line segments. There are several algorithms available for determining the number and location of the vertices and also to compute the polygonal approximation of a contour. The well known is Ramer method which is based on the polygonal approximation scheme (Ramer, 1972).

The simplest approach for the polygonal approximation is a recursive process (Splitting methods). Splitting methods work by first drawing a line from one point on the boundary to another. Then, we compute the perpendicular distance from each point along the segment to the line. If this exceeds some threshold, we break the line at the point of greatest error.

The idea of this first curve approximation is illustrated in Figure 3.

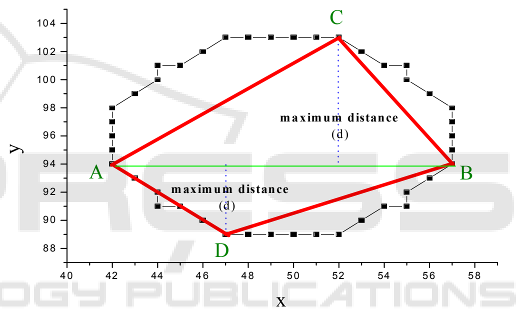


Figure 3: Curve approximation by Ramer algorithm.

4 TRAPEZOID ALGORITHM

The idea of this algorithm consists in segmentation of the contour points to get trapezoid shapes (points of SP, B, C, and EP) (Ukasha, Dziech, Elsherif, 2009) and (Ukasha, 2010).

The first and last points of each segment are called starting point (SP) and ending point (EP) respectively. The fit criterion is the ratio between distance between B and C points (dBC), and the distance between C and EP points (dCEP), as illustrated in Figure 4, and is defined by equation (2).

$$(dBC\ /\ dCEP) < th \qquad (2)$$

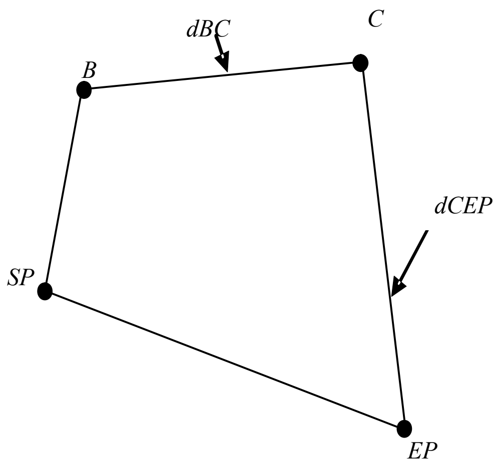


Figure 4: Illustration of the basic trapezoid idea for the Trapezoid method.

5 APPLIED MEASURES

The proposed image compression and contour extraction method is related to the data compression and extraction problems. To evaluate its compression ability, the following compression ratio was introduced if each pixel is implemented by eight bits.

$$bpp = \frac{ZS * 8}{(n * m)} \tag{3}$$

where:
NOZ - number of zero coefficients
ZS - coefficients number in the desired zonal
n * m - size of the image

The mean square error (MSE) and peak signal-to-noise ratio (PSNR) criterions were used to evaluate the distortion introduced during the image compression and contour extraction procedures. The MSE criterion is defined by the following equation:

$$MSE(I, \tilde{I}) = \frac{1}{(n * m)} \sum_{i=0}^{n} \sum_{j=0}^{m} (I(i,j) - (\tilde{I}(i,j))^2 \tag{4}$$

where I is the original image, and $\tilde{I}$ is the reconstructed image.

6 EXPERIMENTS RESULTS

To visualise the experimental results a set of five test grey levels images were selected. Selected images are shown in Figure 5.

(a) (b)

Figure 5: Test images: a) Tools (256x256), and b) Baby (128x128).

The decomposition of Tools image using first level of DWT is shown in Figure 6.

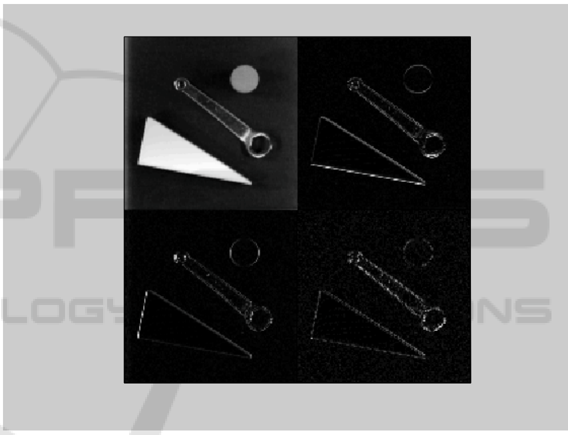
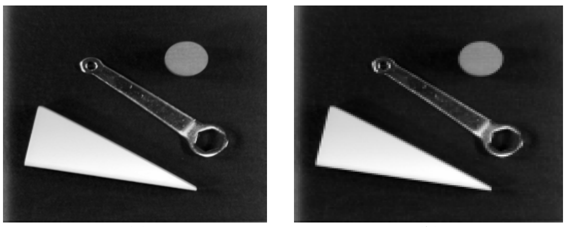


Figure 6: Tools image decomposition using first level of DWT.

The compressed Tools image can be obtained using approximation coefficients only as shown in Figure 7 (related results are shown in the Table 1).



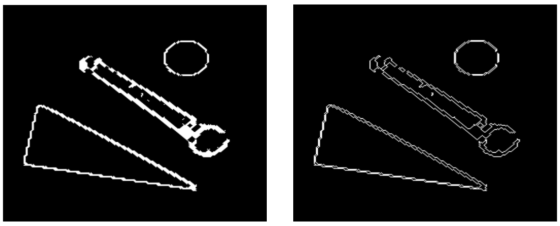
(a) (b)

Figure 7: Tools image reconstruction using approximation coefficients: a) Original image, and b) Compressed image.

Table 1: Tools image results.

	MSE	*PSNR [db]*	*Bit Per Pixel (bpp)*
b)	24.61	34.22	2

The extracted contours using SSPCE method for contour extraction of Tools image are obtained using horizontal, vertical, and diagonal coefficients as shown in Figure 8.



(a) (b)

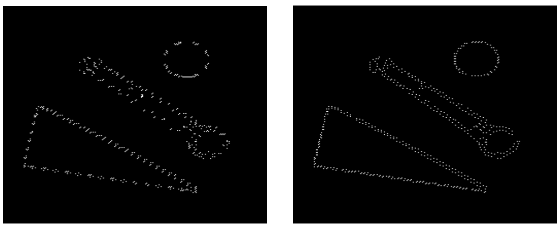
Figure 8: Tools image: (a) Binary image from details coefficients, and (b) Contours extraction using SSPCE method.

The compressed contours for Tools image are obtained using Ramer and Trapezoid methods are shown in Figure 9 (related results are shown in the Table 2).

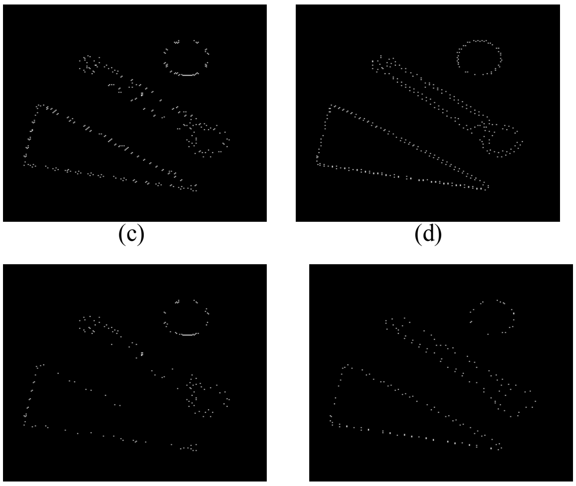
Table 2: Tools image results.

Measures / *Method (Compression)*	*MSE*	*PSNR [db]*	*CR*	*Elapsed Time*
a) Ramer	0.0175	17.58	69.46	10.65
b) Trapezoid	0.0174	17.59	69.34	10.40
c) Ramer	0.0199	17.02	78.99	8.82
d) Trapezoid	0.0197	17.05	78.57	8.31
e) Ramer	0.0226	16.47	89.80	7.35
f) Trapezoid	0.0225	16.47	89.62	7.27

where CR is the compression ratio.



(a) (b)



(c) (d)

(e) (f)

Figure 9: Tools image contour compression using Ramer and Trapezoid methods.

The decomposition of Baby image using first level of DWT is shown in Figure 10.

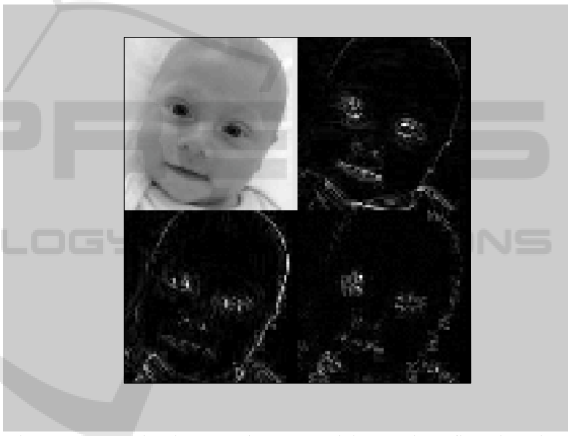


Figure 10: Baby image decomposition using first level of DWT.

The compressed Baby image can be obtained using approximation coefficients only as shown in Figure 11 (related results are shown in the Table 3).

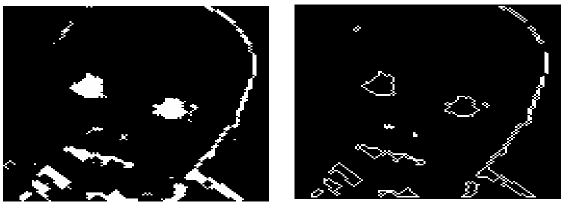
(a) (b)

Figure 11: Baby image reconstruction using approximation coefficients: a) Original image, and b) Compressed image.

Table 3: Baby image results.

	MSE	*PSNR [db]*	*Bit Per Pixel (bpp)*
b)	*15.86*	*36.13*	*2*

The extracted contours using SSPCE method for contour extraction of Baby image are obtained using horizontal, vertical, and diagonal coefficients as shown in Figure 12.



(a) (b)

Figure 12: Baby image: (a) Binary image from details coefficients, and (b) Contours extraction using SSPCE method.

The compressed contours for Baby image are obtained using Ramer and Trapezoid methods are shown in Figure 13(related results are shown in the Table 4).

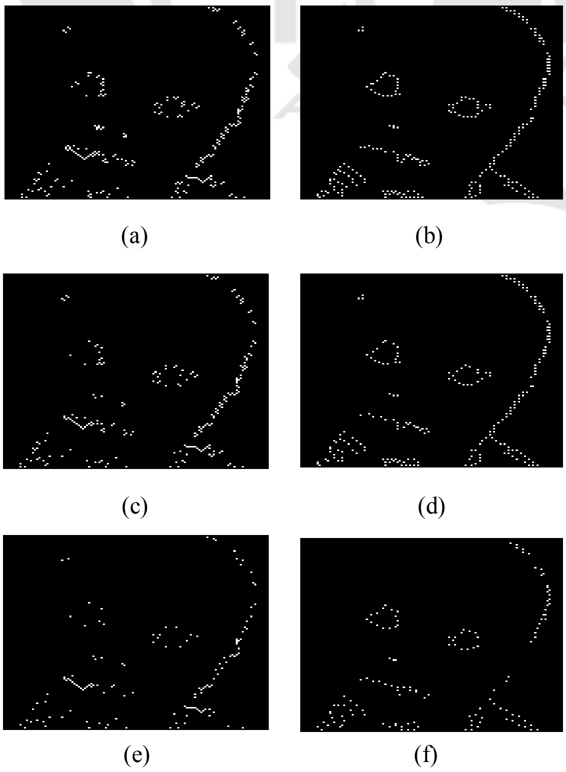
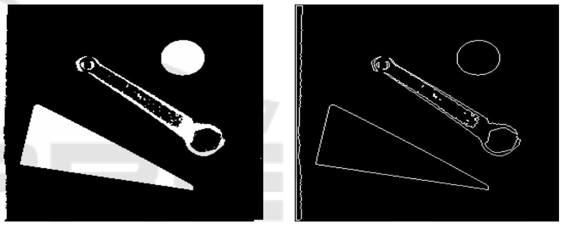


Figure 13: Baby image contour compression using Ramer and Trapezoid methods.

Table 4: Baby image results.

Measures / **Method (Compression)**	MSE	PSNR [db]	CR	Elapsed Time
a) Ramer	0.0195	17.11	56.16	3.44
b) Trapezoid	0.019	17.08	56.51	2.88
c) Ramer	0.0216	16.45	62.32	3.17
d) Trapezoid	0.0216	16.65	62.32	2.77
e) Ramer	0.0263	15.80	75.88	2.98
f) Trapezoid	0.0263	15.80	75.88	2.56

The proposed algorithm is compared with binary image which is obtained using suitable thresholding criteria as shown in Figure 14 (related results are shown in Figure 15 and in Table 5).



(a) (b)

Figure 14: Tools image: (a) Binary image using threshold, and (b) Contours extraction using SSPCE method.

Table 5: Tools image results (Threshold).

Measures / ***Method (Compression)***	*MSE*	*PSNR [db]*	*CR*	*Elapsed Time*
a) Ramer	0.0183	17.38	69.47	9.89
b) Trapezoid	0.0182	17.39	69.36	9.13
c) Ramer	0.0207	16.84	78.82	8.59
d) Trapezoid	0.0205	16.88	78.06	8.09
e) Ramer	0.0236	16.27	89.84	7.04
f) Trapezoid	0.0236	16.28	89.67	6.58

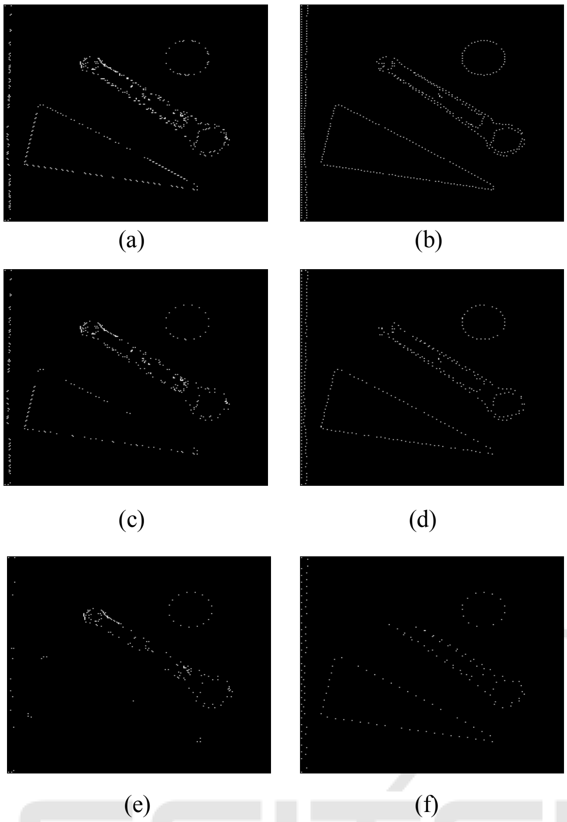


Figure 15: Tools image contour compression using Ramer and Trapezoid methods (by threshold).

The results presented show that the proposed algorithm has the best extraction property and contour compression with better quality compared with the binary image using threshold value. The results show that SNR is improved by this algorithm by about 0.2 decibels for some images.

6 CONCLUSIONS

The good quality of contour extraction and compression are the main advantage of the proposed algorithm compared with the binary image using suitable threshold value. By using single level of discrete wavelet transform the two sub-images are obtained (compressed image and extracted contour). Ramer and Trapezoid methods are used to compress the extracted contours without significant visible distortion.. The reconstruction quality improvement of compressed contour about o.2 decibels. Important advantage of the proposed method is the simplicity of implementation both in terms of memory requirement and fit criterion complication.

REFERENCES

Brigham, E.O., 1974. *The Fast Fourier Transform,* Prentice-Hall, Englewood Cliffs.

Walsh, J., 1999. A closed set of normal orthogonal functions. Amer. J. Math.

Clarke, R. J., 1985. Transform Coding of Images, Academic Press.

Dziech, A., Belgassem, F., Nern, H. J., 2000. Image data compression using zonal sampling and piecewise-linear transforms. *Journal of Intelligent And Robotic Systems. Theory & Applications*. Kluwer Academic Publishers.

Dziech, A., Belgassem, F., Aboukhres, S., 1996. Periodic Haar Piecewise Linear Transform. *Proceedings of the IMACS/IEEE-SMC Multiconference.* Lile-France.

Ramer, U., 1972. An iterative procedure for the Polygonal approximation of plane curves *Computer Graphics and Image Processing.* Academic Press.

Vetterli, Martin, Kovacevic, 1995. *Wavelets and Subband Coding*, Printice Hall Inc.

Dziech, A., Besbas, W., 1997. Fast Algorithm for Closed Contour Extraction. *Proc. of the Int. Workshop on Systems, Signals and Image Processing.*

Besbas, W., 1998. *Contour Extraction, Processing and Recognition*, Ph.D Thesis. Poznan University of Technology. Poznan.

Ukasha, A., Dziech, A., Elsherif, E., 2009. An efficient method of contour compression. *International Conference on Visualization, Imaging and Image Processing (IASTED/VIIP).*

Ukasha, A., 2010. Arabic Letters Compression using New Algorithm of Trapezoid method. *International Conference on Signal Processing, Robotics and Automation (ISPRA'10).*

Gonzalez, R. C., 1987. *Digital Image Processing*, Addison Wesley, 2nd edition.