ORIGINAL ARTICLE

The Effect of Set Partitioning in Hierarchical Trees with Wavelet Decomposition Levels Algorithm for Image Compression

Mohammed Rasheed*, **Asma Abdulelah Abdulrahman, Suha Shihab**

Applied Science Department, University of Technology, Baghdad, Iraq. E-mail: rasheed.mohammed40@yahoo.com, 10606@uotechnology.edu.iq

Abstract: The transfer and storage of images is done through compression technology using various transformations to find suitable transformations for image analysis and compression, wavelet based images are analyzed with image compression technology, which is necessary for channel image transmission. The purpose of this article is to determine the appropriate wavelengths for compressing images by recording the parameters that are created by compressing and using an appropriate compression method. The compression method Set Partitioning in Hierarchical Trees (SPIHT) is used to obtain a better compression of the image with a high compression ratio using different wavelets and to compare the results that the techniques were implemented in the Matlab program through the results such as basic criteria for the compressed image quality scale.

Keywords: Haar Wavelet; Symlets Wavelet; Daubechies Wavelet; Image Compression; Image Processing

1. Introduction

Converting images to a digital form when processing, such as storage and transmission, to reduce data duplication and their inconvenience to that data in order to store and send well and effectively, as pressure is the technology to reduce and repeat data, in addition to reducing the transmission time[1-3]. The method used to compress the image is the compression method[4], which is characterized by the non-loss of the image of its data and is considered a powerful image compression technology with the help of wavelets, where a good image is obtained through the results obtained. Basic criteria for the compressed image quality scale wavelets used were compared between the results obtained. Many researchers used different numerical methods as a filter in order to enhance different images; the descriptions of these methods and the images in the field of applied sciences are introduced in[5-79].

Work on this article, daubechies, symlets and haar are used. Primary and compact wavelet proposed by daubechies is orthogonal wavelets, which are called daubechies wavelets. It is a designed with a very high stage and highest number vanishing moments to offer specific support.

2. The effect of wavelet and SPIHT in image analysis

The proposed theorem SPIHT by which the image is compressed by analyzing the image into four sub-domains and by repeating this decomposition the final scale is reached where each analysis sub-band of one low frequency and three high frequencies ranges. EZW-[Embedded Zero Wavelet] algorithm[80], Eq. 1 rep

doi: 10.18686/esta.v7i3.126

resents SPIHT.

$$I_n(X) = \begin{cases} 1, \max(c,d) \in X \{|C_{c,d}|\} \geq 2^n \\ 0 \quad\quad Otherwise \end{cases} \quad (1)$$

where: $I_n(X)$: important coordinates T and $C_{c,d}$: represents the values of the coefficients (c, d).

Figure 1 demonstrates the result of using the proposed theorem with wavelet in the process of compression and obtaining an image that has not lost its characteristics.

SPIHT is summarized in three steps like sorting, optimizing, and quantifying with three menus like LIP, LIS, and LSP that encode image data[81].

$$n_{max} = [log_2(maxc, d\{|C_{c,d}|\})] \quad (2)$$

Figure 2 shows different levels of decomposition and their effect on flow of compression algorithms.

Original Image	Original decomposition	Compressed decomposition	Compressed Image
			

Figure 1. The effected the wavelet and SPIHT of decomposition of image.

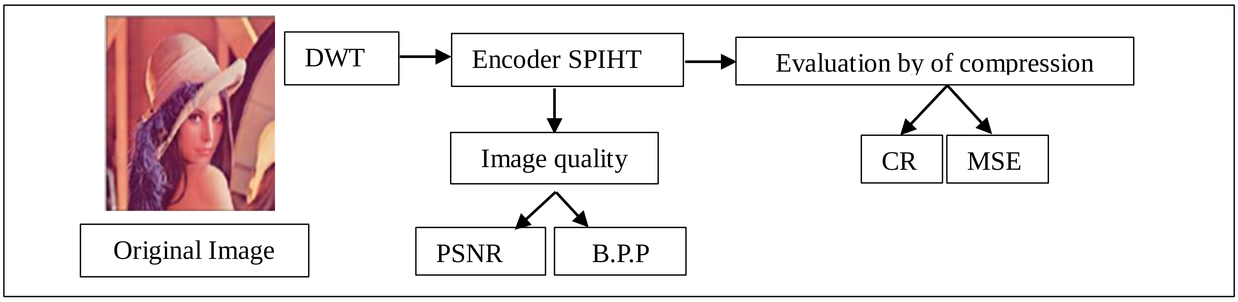

Figure 2. Different levels of decomposition and their effect on flow of compression algorithms.

3. Discussion of the results

Color image has been suggested for applying the discrete wavelet transformation and decomposition algorithm where wavelets were used haar, db 1and symlet 2 at Levels (1-8) of decomposition is adopted. After the decomposition, the theory used in compression is evaluated by MSE, PSNR, and compression ues bit-per-pixel ratio in **Table 1**, measure the resulting image quality[81].

$$CR = \frac{Original\ image\ size\ in\ (bit)}{Compressed\ image\ size\ in\ bit}$$

$$Bir\ Per\ Pixel = \frac{Compressed\ image\ size\ in (bit)}{Total\ number\ of\ pixels\ in\ the\ image}$$

To view more color image information from the above equations MSE is between the original image and the recreated image is defined in the decoder as

$$MSE = \alpha_q^2 = \frac{1}{N}\sum (I(c,d) - G(c,d))^2$$

N is pixels for each image. The sum is above c, d to the sum across all pixels in image ratio between signal contrast and reconstruction error variance is the peak signal-to-noise ratio PSNR.

$$PSNR = 10log10\left(\frac{255^2}{MSE}\right)$$

Table 1 and **2** show the pressure process for eight levels and the comparison of the three wavelets in the results.

Decomposition level 1			
Transforms	**Haar**	**db1**	**Sym**
MSE	10.06	10	8.85
PSNR	38.11	38.11	38.66
CR%	120.70	120.70	114.41
BPP	28.9672	28.967	27.4583
Decomposition level 2			
Transforms	**Haar**	**db1**	**Sym**
MSE	8.314	6.296	6.466
PSNR	38.93	40.14	40.02
CR%	73.65	73.65	70.80
BPP	17.6763	17.676	16.9915
Decomposition level 3			
Transforms	**Haar**	**db1**	**Sym**
MSE	9.589	9.589	4.923
PSNR	38.31	38.31	41.21
CR%	59.94	59.94	58.60
BPP	14.3864	14.3862	14.0643
Decomposition level 4			
Transforms	**Haar**	**db1**	**Sym**
MSE	11.37	4.506	4.266
PSNR	37.57	41.59	41.83
CR%	56.31	56.31	55.19
BPP	13.5145	13.5144	13.2456

Table 1. Levels of decomposition with performance evaluation levels (1-4)

Decomposition level 5			
Transforms	**Haar**	**db 1**	**Sym**
MSE	3.036	4.521	4.301
PSNR	33.31	41.58	41.79
CR%	55.40	56.40	54.21
BPP	13.2852	13.295	13.0109
Decomposition level 6			
Transforms	**Haar**	**db 1**	**Sym**
MSE	2.263	2.263	1.676
PSNR	44.58	44.58	45.89
CR%	55.14	56.14	53.94
BPP	13.2345	13.2344	12.9453
Decomposition level 7			
Transforms	**Haar**	**db 1**	**Sym**
MSE	2.764	2.764	2.211
PSNR	43.72	43.72	44.68
CR%	41.49	41.49	40.06
BPP	9.9585	9.9584	9.6136
Decomposition level 8			
Transforms	**Haar**	**Db 1**	**Sym**
MSE	2.764	2.764	2.211
PSNR	43.72	43.72	44.62
CR%	41.41	41.47	40.03
BPP	9.9519	9.9518	9.6074

Table 2. Levels of decomposition with performance evaluation levels (5-8)

Figure 3. Compressed image at decomposition with three waves at levels 1 and 8.

From the above two Tables from the first level, the decrease in decomposition in PSNR at the wavelets haar, db and sym, but sym is better than wavelets haar and db.

As for the eighth level, in level 8 is reduced, the error level decrease is almost equal, which leads to PSNR close in the three wavelets, with the compression ratio approximately equal to BPP.

Figure 3 shows the difference theoretically between the original image and the compressed image of the first and eighth levels of the three wavelets.

4. Conclusion

Achieving a high level of compression ratio the focus is in this work is to prove that the symlet 2 wave at the eighth level is achieved per bit per pixel. Fewer values are obtained for PSNR using symlet 2 than it is in the first level. During the results of the PSNR values that proved that, the wavelets have a major role with the pressure algorithm Set Partitioning in Hierarchical Trees SPIHT, which can be applied to artificial and medical images.

References

1. Bhammar MB, Mehta KA. Survey of various image compression techniques. International Journal on Darshan Institute of Engineering Research & Emerging Technologies 2012; 1(1): 85-90.
2. Sashikala MY, Solomon AS, Nachappa MN, *et al.* A survey of compression techniques. International Journal of Recent Technology and Engineering 2013; 2(1): 152-6.
3. Mohammed AA, Hussein JA. Hybrid transform coding scheme for medical image application. The 10th IEEE International Symposium on Signal Processing and Information Technology. 2010. p. 237-240.
4. NirmalRaj S. SPIHT: A set partitioning in hierarchical trees algorithm for image compression. Contemporary Engineering Sciences 2015; 8(5): 263-70.
5. hihab SN, Sarhan MA. Convergence analysis of shifted fourth kind Chebyshev wavelets. IOSR Journal of Mathematics 2014; 10(2): 54-8.
6. Al-Rawi SN. Numerical solution of integral equations using Taylor series. Journal of the College of Education 1998; 5: 51-60.
7. Shihab SN, Naif TN. On the orthonormal Bernstein polynomial of order eight. Open Science Journal of Mathematics and Application 2014; 2(2): 15-19.
8. Delphi M, Shihab S. State parametrization basic spline functional for trajectory optimization. The Journal of Nature Life and Applied Sciences 2019; 3(4): 110-119.
9. Delphi M, Shihab S. Modified basic spline multiscaling and wavelets algorithms for optimal control problems [MSc thesis]. Baghdad: University of Technology; 2019.
10. Shihab SN, Naif TN. Direct methods based on orthonormal bernstein polynomials for solving optimal control problems [MSc thesis]. Baghdad: University of Technology; 2014.
11. Shihab SN, Sarhan MA. Numerical solution of variational calculus using chebyshev wavelet method [PhD thesis]. Baghdad: Al-Mustansiriyah University; 2014.
12. Shihab SN, Falah AH. Efficient numerical algorithms for the optimal control problem [MSc thesis]. Baghdad: University of Technology; 2008.
13. Shihab SN, Al-Janabi ASAR. On the numerical solution for solving some continuous optimal control problems [PhD thesis]. Baghdad: Al-Mustansiriyah University; 2005.
14. Al-Faour O, Shihab SN, Al-Saleni BF. Multistep methods for solving nonlinear integral equations. Journal of the College of Basic Education 2001; 12(2).
15. Al-Faour O, Shihab SN, Al-Nasser RH. Expan-

sion method for solving volterra equations. Journal of Babylon University 2000; 7(3): 1355-1362.
16. Al-Faour O, Al-Ani FID, Al-Rawi SN. Numerical evaluation of fourier transformation using orthogonal functions. Engineering and Technology Journal 2000; 17(7).
17. Al-Ani FID, Al-Faour O, Al-Rawi SN. Numerical solution of variational calculus using Chebyshev wavelet method. Journal of Al-rafidian University 1997; 2: 1-10.
18. Shihab S, Dephi M. Direct iterative algorithm for solving optimal control problems using B-spline polynomials. Emirates Journal for Engineering Research 2019; 24(4): 1-9.
19. Alrawy SS, Salih AA. Shifted modified chebyshev direct method for solving quadratic optimal control problem. Samarra Journal of Pure and Applied Science 2020; 2(1): 67-75.
20. Shihab S, Ali HA, Kasheem BE. Legendre wavelets method for solving boundary value problems. Journal of the College of Basic Education 2012; 18(76): 73-85.
21. Shihab SN, Abdulrahman AA, Mayada NMA. Collocation orthonormal bernstein polynomials method for solving integral equations. Engineering and Technology Journal 2015; 33(8): 1493-1502.
22. Delphi M, Shihab S. Modified iterative algorithm for solving optimal control problems. Open Science Journal of Statistics and Application 2019; 6(2): 20.
23. Al-Rawi SN. On the solution of certain fractional integral equations. Kirkuk University Journal for Scientific Studies 2006; 1(2): 125-136.
24. Shihab SN, Abdalrehman AA. Numerical solution of calculus of variations by using the second Chebyshev wavelets. Engineering and Technology Journal 2012; 30(18): 3219-3229.
25. Shihab SN, Abdelrehman AA. Some new relationships between the derivatives of first and second Chebyshev wavelets. International Journal of Engineering, Business and Enterprise Application 2012.
26. Shehab SN, Ali HA, Yaseen HM. Least squares method for solving integral equations with multiple time lags. Engineering and Technology Journal 2010; 28(10): 1893-1899.
27. Shihab SN, Abdalrehman AA. Solving optimal control linear systems by using new third kind Chebyshev wavelets operational matrix of derivative. Baghdad Science Journal 2014; 11(2): 229-234.
28. Delphi M, Shihab S. Operational matrix basic spline wavelets of derivative for linear optimal control problem. Electronics Science Technology and Application 2019; 6(2): 18-24.
29. Shihab SN, Sarhan AA. New operational matrices of shifted fourth Chebyshev wavelets. Elixir International Journal-Applied Mathematics 2014; 69(1): 23239-23244.
30. Rasheed MS. Study of the effects of acidic solutions on the physical properties of polymeric materials superimposed. Al-Mustansiriyah Journal of Science 2012; 13(49): 6.
31. Rasheed MS, Mahde HS. Electronic combination lock design using remote control. Journal of the College of Basic Education 2012; 18(75): 265-280.
32. Rasheed MS, Mohammed AN. Design of a laser based free space communication system. Germany: LAP LAMBERT Academic Publishing; 2012.
33. Rasheed MS. Approximate solutions of barker equation in parabolic orbits. Engineering & Technology Journal 2010; 28(3): 492-499.
34. Rasheed MS. An improved algorithm for the solution of kepler's equation for an elliptical orbit. Engineering & Technology Journal 2010; 28(7): 1316-1320.
35. Rasheed MS. Acceleration of predictor corrector halley method in astrophysics application. International Journal of Emerging Technologies in Computational and Applied Sciences 2012; 1(2): 91-94.
36. Rasheed MS. Fast procedure for solving two-body problem in celestial mechanic. International Journal of Engineering, Business and Enterprise Applications 2012; 1(2): 60-63.
37. Rasheed MS. Solve the position to time equation for an object travelling on a parabolic orbit in celestial mechanics. Diyala Journal for Pure Sciences 2013; 9(4): 31-38.
38. Rasheed MS. Comparison of starting values for implicit iterative solutions to hyperbolic orbits equation. International Journal of Software and Web Sciences 2012; 1(2): 65-71.
39. Rasheed MS. On solving hyperbolic trajectory using new predictor-corrector quadrature algorithms. Baghdad Science Journal 2014; 11(1): 186-192.
40. Rasheed M. Modification of three order methods for solving satellite orbital equation in elliptical motion. Journal of University of Anbar for Pure Science 2013.
41. Rasheed M, Barillé R. Room temperature deposition of ZnO and Al: ZnO ultrathin films on glass and PET substrates by DC sputtering technique. Optical and Quantum Electronics 2017; 49(5): 1-14.
42. Rasheed M, Barillé R. Optical constants of DC sputtering derived ITO, TiO2 and TiO2: Nb thin films characterized by spectrophotometry and spectroscopic ellipsometry for optoelectronic devices. Journal of Non-Crystalline Solids 2017; 476: 1-14.
43. Rasheed M, Barillé R. Comparison the optical properties for Bi2O3 and NiO ultrathin films deposited on different substrates by DC sputtering technique for transparent electronics. Journal of Alloys and Compounds 2017; 728: 1186-1198.

44. Saidani T, Zaabat M, Aida MS, *et al.* Influence of precursor source on sol–gel deposited ZnO thin films properties. Journal of Materials Science: Materials in Electronics 2017; 28(13): 9252-9257.
45. Guergouria K, Boumezoued A, Barille R, *et al.* ZnO nanopowders doped with bismuth oxide, from synthesis to electrical application. Journal of Alloys and Compounds 2019; 791: 550-558.
46. Bouras D, Mecif A, Barillé R, *et al.* Cu:ZnO deposited on porous ceramic substrates by a simple thermal method for photocatalytic application. Ceramics International 2018; 44(17): 21546-21555.
47. Saidi W, Hfaidh N, Rasheed M, *et al.* Effect of B2O3 addition on optical and structural properties of TiO2 as a new blocking layer for multiple dye sensitive solar cell application (DSSC). RSC Advances 2016; 6(73): 68819-68826.
48. Aukštuolis A, Girtan M, Mousdis GA, *et al.* Measurement of charge carrier mobility in perovskite nanowire films by photo-CELIV method. Proceedings of the Romanian Academy Series a-Mathematics Physics Technical Sciences Information Science 2017; 18(1): 34-41.
49. Dkhilalli F, Megdiche S, Guidara K, *et al.* AC conductivity evolution in bulk and grain boundary response of sodium tungstate Na2WO4. Ionics 2018; 24(1): 169-180.
50. Dkhilalli F, Borchani SM, Rasheed M, *et al.* Structural, dielectric, and optical properties of the zinc tungstate ZnWO4 compound. Journal of Materials Science: Materials in Electronics 2018; 29(8): 6297-6307.
51. Dkhilalli F, Borchani SM, Rasheed M, *et al.* Characterizations and morphology of sodium tungstate particles. Royal Society Open Science 2018; 5(8): 1-12.
52. Enneffati M, Louati B, Guidara K, *et al.* Crystal structure characterization and AC electrical conduction behavior of sodium cadmium orthophosphate. Journal of Materials Science: Materials in Electronics 2018; 29(1): 171-179.
53. Kadri E, Krichen M, Mohammed R, *et al.* Electrical transport mechanisms in amorphous silicon/crystalline silicon germanium heterojunction solar cell: Impact of passivation layer in conversion efficiency. Optical and Quantum Electronics 2016; 48(12): 1-15.
54. Kadri E, Messaoudi O, Krichen M, *et al.* Optical and electrical properties of SiGe/Si solar cell heterostructures: Ellipsometric study. Journal of Alloys and Compounds 2017; 721: 779-783.
55. Kadri E, Dhahri K, Zaafouri A, *et al.* Ac conductivity and dielectric behavior of a−Si:H/c−Si1−yGey/p−Si thin films synthesized by molecular beam epitaxial method. Journal of Alloys and Compounds 2017; 705: 708-713.
56. Azaza NB, Elleuch S, Rasheed M, *et al.* 3-(p-nitrophenyl) coumarin derivatives: Synthesis, linear and nonlinear optical properties. Optical Materials 2019; 96: 109328.
57. Enneffati M, Rasheed M, Louati B, *et al.* Morphology, UV–visible and ellipsometric studies of sodium lithium orthovanadate. Optical and Quantum Electronics 2019; 51(9): 299.
58. Rasheed M, Sarhan MA. Solve and implement the main equations of photovoltaic cell parameters using visual studio program. Insight-Mathematics 2019; 1(1): 18-26.
59. Rasheed M, Sarhan MA. Characteristics of solar cell outdoor measurements using fuzzy logic method. Insight-Mathematics 2019; 1(1): 1-8.
60. Rasheed M, Sarhan MA. Measuring the solar cell parameters using fuzzy set technique. Insight-Electronic 2019; 1(1): 1-9.
61. Rasheed M. Linear programming for solving solar cell parameters. Insight-Electronic 2019; 1(1): 10-16.
62. Rasheed M. Investigation of solar cell factors using fuzzy set technique. Insight-Electronic 2019; 1(1): 17-23.
63. Rasheed M, Barille R. Development and characterization of single and multilayer thin films for optoelectronics application [PhD thesis]. France: University of Angers; 2017.
64. Rasheed M, Shihab S. Analytical modeling of solar cells. Insight-Electronics 2019; 1(2): 1-9.
65. Rasheed M, Shihab S. Modeling and simulation of solar cell mathematical model parameters determination based on different methods. Insight-Mathematics 2019; 1(1): 1-16.
66. Rasheed M, Shihab S. Parameters estimation for mathematical model of solar cell. Electronics Science Technology and Application 2019; 6(1): 20-28.
67. Ouda EH, Shihab S, Rasheed M. Boubaker wavelets functions for solving higher order integro-differential equation. Journal of Southwest Jiaotong University 2020; 55(2).
68. Sarhan AM, Shihab S, Rasheed M. A new boubaker wavelets operational matrix of integration. Journal of Southwest Jiaotong University 2020; 55(2).
69. Abdulrahman AA, Rasheed M, Shihab S. Discrete hermite wavelet filters (DHWF) with prove mathematical aspects. Journal of Southwest Jiaotong University 2020; 55(2).
70. Rasheed M, Abdulrahman AA, Shihab S. Discrete Chebyshev wavelet transformation with image processing. Journal of Southwest Jiaotong University 2020; 55(2).
71. Abbas MM, Rasheed M. Solid state reaction synthesis and characterization of Al doped TiO2 nanomaterials. Journal of Southwest Jiaotong University 2020; 55(2).
72. Sarhan AM, Shihab S, Rasheed M. On the properties of two dimensional normalized boubaker polynomials. Journal of Southwest Jiaotong University 2020; 5(3).

73. Aziz SH, Rasheed M, Shihab S. New properties of modified second kind Chebyshev polynomials. Journal of Southwest Jiaotong University 2020; 5(3).
74. Mitlif RJ, Rasheed M, Shihab S. An optimal algorithm for fuzzy transportation problem. Journal of Southwest Jiaotong University 2020; 5(3).
75. Kashem BE, Ouda EH, Aziz SH, *et al.* Some results for orthonormal boubaker polynomials with application. Journal of Southwest Jiaotong University 2020; 5(3).
76. Mohammedali MN, Sabri RI, Rasheed M, *et al.* Some results on G-normed linear space. Journal of Southwest Jiaotong University 2020; 5(4).
77. Sabri RI, Mohammedali MN, Rasheed M, *et al.* Compactness of soft fuzzy metric space. Journal of Southwest Jiaotong University 2020; 5(4).
78. Rasheed M, Shihab S. Numerical techniques for solving parameters of solar cell. Applied Physics 2020; 3(2): 16-27.
79. Mohammed SR, Suha S. Analysis of mathematical modeling of PV cell with numerical algorithm. Advanced Energy Conversion Materials 2020; 70-79.
80. Nema M, Gupta L, Trivedi NR. Video compression using SPIHT and SWT wavelet. International Journal of Electronics and Communication Engineering 2012; 5(1): 1-8.
81. Pandian R, Vigneswara T, Kumari SL. Effects of decomposition levels of wavelets in image compression algorithms. Journal of Biomedical Sciences 2016; 5(4): 29.