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An Improved Image Compression Technique Using EZW and SPHIT Algorithms

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Abstract

Uncompressed form of the digital images are needed a very large storage capacity amount, as a consequence requires large communication bandwidth for data transmission over the network. Image compression techniques not only minimize the image storage space but also preserve the quality of image. This paper reveal image compression technique which uses distinct image coding scheme based on wavelet transform that combined effective types of compression algorithms for further compression. EZW and SPIHT algorithms are types of significant compression techniques that obtainable for lossy image compression algorithms. The EZW coding is a worthwhile and simple efficient algorithm. SPIHT is an most powerful technique that utilize for image compression depend on the concept of coding set of wavelet coefficients as zero trees. The proposed compression algorithm that combined dual image compression techniques (DICT) invest an excellent features from each methods, which then produce promising technique for still image compression through minimize bits number that required to represent the input image, to the degree allowed without significant impact on quality of reconstructed image.

The experimental results present that DICT will improve the image compression efficiency between 8 to 24%, and will result high performance of metrics values.

Key words: Dual compression, image compression, SPHIT and EZW.

1. Introduction

As a result of large growth in new technology like smart phones and powerful applications in the civil communication fields, as the image be the core of these technology development which basically faces from large image size which required large number of bits. There are many difficulties to develop solutions for this large amount of information [1]. The large storage capacity and high bandwidth are needed to transfer uncompressed data of images. In order to efficiently transmit large multimedia data, it must be reduce the file size by utilizing proposed compressed technique [2]. The suitable solution for large image data is image compression that depends on the reducing of the required number of redundancy bits, that completely affecting the saved or transmitted information. Digital image is ordered of pixels in a matrix that represent a form of specific rows and columns which identify image width and height. Each individual pixel contains an intensity value which declared by fixed bits number. The compression technique be a goal to overcome the wasted bytes, depend on the utilization of redundancy, in which cover all types of repetition or similarity, and needless or undesired values of image pixel. Generally, there are two categories image redundancy, (i) statistical and (ii) psych-visual redundancy [3]. Image compression basically reduces the size of image by represent the important image data with smaller size of bits, by removing the not important image information [4, 5]. Most significant topics in the techniques of image compression are how to manage digital image data in order to increase grade of compressed image and the ratio of compression efficiency during data transmission and storage. The above-mentioned problems are among the topics of interest to researchers working in the field of image compression. One of these solutions is a dual compression method for high compression ratio [6]. A DICT is a technique that combining superior features for each group of methods. The goal of this paper is to identify how to develop a dual compression technique that being utilize to improve the performance metrics of image compression. This technique based on using two separate compression schemes, firstly, the wavelet transform with SPHIT method and the resulting data reduction file will be compressed again with LZW. The resulting compressed file will have a good quality, data reduction and there is large percentage in performance improving.

2. Related Works

Many researchers present various image compression techniques, improvements and developments have been going on for several decades. In [7], a modified combined wavelet methods which presents better image compression was introduce, new wavelet transform that based on bi-orthogonal filter can give better result for calculate PSNR and MSE metrics. Comparison the previous method with (wavelet 9/7 and wavelet 5/3) filter. A new concept for compression technique presents from [8], which improve ultrasound and angio images by utilizing wavelet transform, the experimental simulation give better results as compared with DCT. An image compression scheme by utilizing bi-orthogonal wavelet transform is present from [9], which results high compression efficiency and fast processing speed. In [10], the researcher introduces a practical method used for MR image compression, the transform coding method depends on wavelet transform and vector quantization. A summarized survey of elected famous wavelet coding techniques used to compression data of true color images introduce in [11], which present suggestions to enhance new algorithms for better implementation. Sharing of multi-image compression algorithms is presents from Sure. From [12], presents that the application of combining EZW, SPIHT and with modified SPIHT algorithms are engage with Huffman encoding. The researcher also offered the pros and cons of each of these compression algorithms. The efficiency of uses bi-orthogonal scheme over the hybrid compression technique performance is presents in [13], also offer a comparison study of bi-orthogonal family filters through utilizing Huffman coding, run length coding and a combining of both techniques and presents the enhancement on the compression performance. A hybrid wavelet compression scheme is present from [14], which used three compression methods (a hybrid of bi-orthogonal filter, quantization and Huffman coding). This combined method will saved 20% for decoding time and at the same advantage in decompressing the compressed image. The improvement in the compression performance after using a combined of orthogonal and bi-orthogonal filters with discrete wavelet transform is presents in [15]. In this paper, utilizing of two types for wavelet families to explain the performances of each one separately, the experimental results show that bi-orthogonal wavelet family give better performance than orthogonal wavelet family. In [16], present that the implementation of Lifting Wavelet Transform (LWT) method has good compression performance for color images, also this method is faster than classical wavelet.

3. Image Compression

Data compression technique is the art of how to representing image data in a compact form. The main aim is to minimize the number of bits that required representing a series of data. Therefore, the storing and transmission of data image must be performed with efficient manner. Decreasing data redundancy is the main topic in compression process. Image compression technique, is the process of encode the original data image with at least as possible number of bits, and will reduce the size of data storage. The original image will retrieve by decoding the compressed image. The decoding image must be similar to original image as much as possible [17]. Normally, the capture images from camera will be in analog form. But in order to transmit, process, and store data images must be in transform to digital form [18]. The adjacent pixels in digital image are correlated, thus these pixels comprise from redundant bits [19]. The compression technique will remove the redundant bits from the data of image, which reduce the image size accordingly [18]. The advantages that gained from image compression techniques basically are to eliminate redundant information from the proposed image [19]. The main types of data redundancy can be counted in three kinds [18].

- Inter pixel redundancy.
- Psychovisual redundancy.
- Coding redundancy.

Image compression not only reduces storage capability, but also minimizes the transmission time [20, 21]. There are many types of image compression techniques, but more common of these techniques will be split in two categories: Lossless compression and Lossy compression techniques.

4. Embedded Zerotrees of Wavelet transforms (EZW)

The EZW coding is a worthwhile and simple effective algorithm. EZW coding take advantage of the multi resolution features of the wavelet transforms, to gain an easy method that give acceptable performance if it's compared with another wavelet transforms. The procedure of embedded coding and decoding is called a progressive transmission. The Wavelet encoder with this method is based on progressive coding for image compression which produces a stream of bit which increases accuracy. This yield that if extra bits will be added to the bit stream, the decomposed image will has an explained detail. EZW is one of the powerful algorithms for lossy image compression . For pixel representation of low bit rates, which means, high compression ratios, major coefficients that generate by a sub-band transform (like wavelet transform) will be tend to zero, or close to zero. This is happen because very close in "real world" tend to consist of primary highly correlated low frequency information. In the edges of the image where the information of high frequency will exists, this is especially important in the terms of image quality for human perception, and thus must be carefully represented in each high quality coding platform. The EZW encoding process is depend on two main perceptions [22].

1. In wavelet transformation, the sub bands energy is decreases as the scale decreases. This means that coefficients of wavelet will be larger in the lower sub bands than in the higher sub bands. This will present to us that the higher sub bands will append detail only.
2. Large wavelet coefficients are very necessary as compared to small ones. The smaller wavelet coefficient, it is left for the next pass.

5. Set Partitioning in Hierarchical Trees (SPIHT)

SPIHT coding is an advance algorithm from EZW algorithm; SPIHT will produce higher compression and improve performance efficiency than EZW [22]. Is hierarchical tree algorithm that used for lossy image compression algorithm. SPIHT will invest the inherent similarities through the sub-bands of image wavelet decomposition [23,24]. SPIHT algorithm is refers to next generation for wavelet transform, which employing more advanced coding. SPIHT in fact will develop wavelet transformed images properties to increase its efficiency**.** This method becomes image compression state-of-the-art method. Nowadays SPIHT is one of the best powerful methods in wavelet image compression techniques which used for lossy image compression. One of the most advantages of this method its capability to provide an output image with good quality, high PSNR value and it is consider as the better method for continually image transmission [24]. SPIHT algorithm generate an embedded bit stream, this bit stream will reconstruct best images with low mean square error which resulted from different bit rates. SPIHT algorithm will produce best results of compression ratio with highest PSNR values for a speared range of images [21]. The SPIHT technique is not an easy addition of classical image compression methods, but it performs a significant enhanced in the domain. The prime characteristics of SPIHT wavelet method are [24], [21].

1. High quality, good PSNR, particularly for color images
2. Cumulative image transmission
3. The coded file is fully embedded
4. Straightforward quantization algorithm
5. Speedy coding/decoding method
6. Large applications, fully adaptive
7. Basically, utilized with lossless compression
8. Efficient combination with error protection
9. Exact bit rate coding and error protection
10. Completely adaptive

6. The Proposed Compression System

This paper is presenting the development of compression technique that depends on utilizing dual combined compression techniques. The type of data compression will have a powerful advantage on achieving important reduction of data in image size, in turn the image distortions didn't influenced on the quality of image.

To use the proposed dual combined image compression system, the steps bellow must be under consideration:

Step 1: Load input uncompressed image and read by MATLAB software, then store it in a file.

Step 2: Compress the original image component by using Set Partitioning in Hierarchical Trees SPIHT compression method with Bior 4.4 wavelet filter.

Step 3: Load the saving compressed image and use the uncompressing method.

Step 4: Decompress the image gained from step 2 and compare the result image with the original image.

Step 5: Calculate the performance metrics for the compressed image: CR, MSE, BPP and PSNR. Then utilize these measures to determine the error between compressed and original images.

Step 6: Extra compression technique must be used to improve the results; by compress the gained components of decoded image through used a new progressive compression method.

Step 7: The resulted decoded image from step 4 will compress, by using a progressive compression method EZW (Embedded Zero trees) with Haar wavelet method.

Step 8: Again load the gained dual compressed image and step through the extra dual uncompressing process.

Step 9: Extra dual decompress the retrieved image from step 7 file and then compare it with the original image.

Step 10: Calculate the performance metrics for the compressed image: CR, MSE, BPP and PSNR. Then utilize these performance measurements to determine the difference between original and dual compressed images. The gained image must be useful while preserve a better visual perception.

7. System Performance Measures

The compression system performance rating is measured utilizing some compression performance measures. The commonly used metrics are:

A- Compression Ratio (CR)

This metric is used to measure the decrease in data representation size produced by a compression algorithm. CR also called compression power is computed as the ratio of the uncompressed image (original image) file size to the compressed file size [25].

$$CR = \frac{Uncompressed\ File\ Size}{Compressed\ File\ Size} \tag{1}$$

B- Mean Square Error (MSE)

Another metric for determine the performance of image compression algorithms, is by used a vital estimation parameter to compute the compressed image quality. The comparison of the original data image with decompress image, then show the distortion level [26]. Generally the distortion is the difference between the original and compressed image. The error function Er is compute as a difference between the original (input G(x,y)) and the reconstructed (output G'(x,y)) image [27].

$$Er = G(x,y) - G'(x,y) \tag{2}$$

The MSE is defined as:

$$MSE = \frac{1}{W \times H} \sum_{x=0}^{W-1} \sum_{y=0}^{H-1} Er^2 \tag{3}$$

It is present that Mean Square Error (MSE) is measured in dB. Where W, H is the width and height of the image individually.

C- Peak Signal to Noise Ratio (PSNR)

PSNR is one of the most important tools for the estimate of the compressed image. It is more powerful than the MSE measure, and it is easy to calculate. It presents the similarity between the original and reconstruct image.

The PSNR is measured in decibels (dB) and is defined as [28].

$$PSNR(dB) = 10 log_{10} [\frac{(R-1)^2}{MSE}] \quad (4)$$

Where; R is the intensity level number of the image.

D- Compression Gain (CG)

The compression gain is defined as:

$$CG = 100 \log_e \frac{Reference\ Size}{Compressed\ Size} \quad (5)$$

Where, reference size is present the input stream size. The unit of compression gain is percent log ratio, which is indicated by % [29].

E- Data Compression Rate

This metric is measured by divide the average bits number that needed to represent a single element. It is presented by the term of Bits per Pixel (bpp) [30].

$$\text{Bits per pixel (bpp)} = \left(\frac{Number\ of\ bits}{Number\ of\ pixels}\right) \rightarrow \left(\frac{8 * Number\ of\ bytes}{N * N}\right) \quad (6)$$

F- Speed of Compression

The compression speed is depending on the used compression technique, as well as, the platform nature of the hosts that include the compression process. The speed of compression is influenced by memory size and calculation complexity [17].

G- Power Consumption

The power consumption is the significant performances metric. The multimedia nature needs large capacity of storage and high bandwidth which dissipate high power. The power of transmission that needed to utilize for visual flows, the energy-aware compression methods used to decrease transmission time. Thus, regulate the processing complexity, will reduce the data size, the reduction of transmission power will save energy [30].

8. Discussions of Experimental Results

This paper presents a dual combined compression technique to enhance the data reduction of still color images, the resultant image must satisfactory while remaining a good visual observation.

The test images which utilize in this work are selected from a dataset of JPEG images.

- The proposed true color dataset images are shown in **Figure 1.**
- **Table 1,** shows the results of compression test images by using dual combined (SPHIT + EZW) compression algorithms based on (Bior 4.4 + Haar) wavelet methods.
- **Table 2,** shows the results of compression test images by using dual combined (SPHIT + EZW) compression algorithms with (Bior 4.4 + Haar) wavelet methods based on metric features.
- **Figure 2,** presents the result of 1st compression by using SPHIT compression algorithm based on Bior 4.4 wavelet method.

- **Figure 3,** presents the result of 2nd compression by using EZW compression algorithms based on Haar wavelet method.
- **Figure 4,** presents bar chart of the data set test images before and after compression by using dual combined (SPHIT + EZW) compression algorithms based on (Bior 4.4 + Haar) wavelet methods.
- **Figure 5,** presents bar chart of the compression ratio by using dual combined (SPHIT + EZW) compression algorithms based on (Bior 4.4 + Haar) wavelet methods.

a. Friends

b. Child

c. Old car

d. Battle

e- Sport man

e. Patrol

Figure 1. The original dataset color images**.**

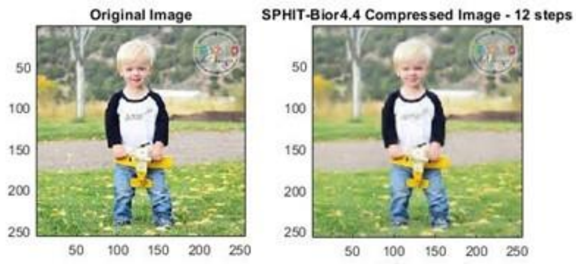
Table 1. The results of compression test images by using dual combined (SPHIT + EZW) compression algorithms based on (Bior 4.4 + Haar) wavelet methods.

Image title	File size in byte	File size after 1st compression	File size after 2nd compression
Friends	15087	11712	10448
Child	15803	12257	11128
Old car	10362	9595	8855
Battle	17329	13935	12461
Patrol	11559	9249	7986
Sport man	8054	6820	5673

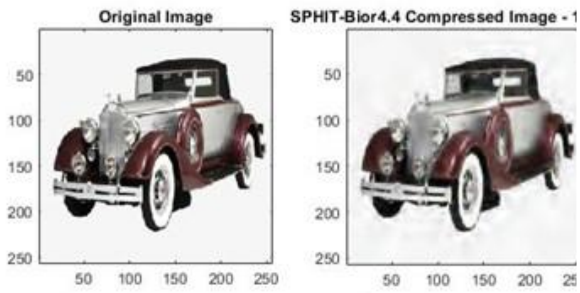
Table 2. The results of compression test images by using dual combined (SPHIT + EZW) compression algorithms based on (Bior 4.4 + Haar) wavelet methods based on metric features.

	Performance Measures	**Image Title**					
		Friends	**Child**	**Old car**	**battle**	**Patrol**	**Sport man**
1st compression	**CR**	6.230164	6.280518	3.274028	8.763123	4.859416	4.981995
	BPP	1.495239	1.495239	0.785767	2.103149	1.166260	1.195679
	MSE	10.089981	10.089981	17.406113	12.028411	7.063161	1.537283
	PSNR	28.091900	28.091900	28.048731	27.328721	29.640813	36.263264
2nd compression	**CR**	15.787252	17.548625	16.198222	23.392741	12.343343	8.164469
	BPP	3.788940	4.211670	3.887573	5.614258	2.962402	1.959473
	MSE	12.939852	13.775117	18.829529	15.383667	8.721612	2.590226
	PSNR	27.011511	26.739850	25.382409	28.724836	28.724836	33.997427

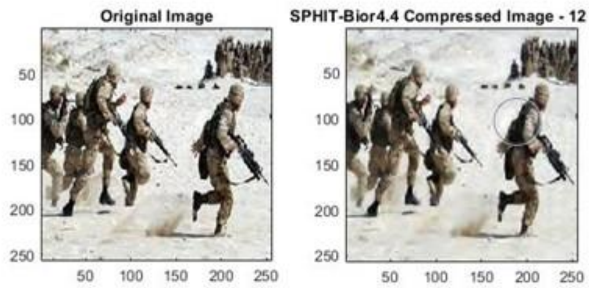
a. Friends



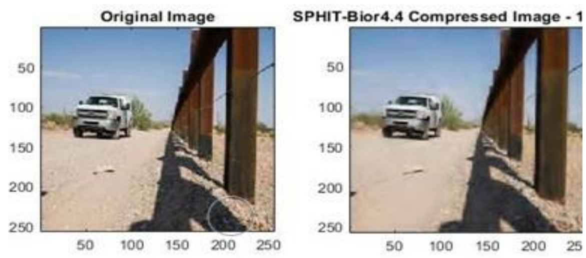
b. Child



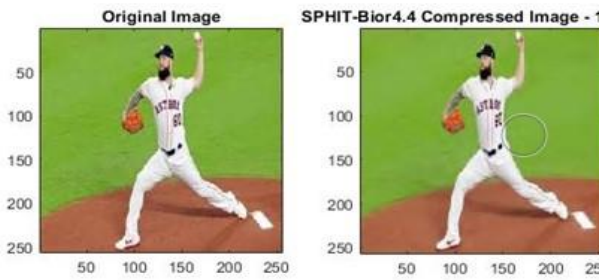
c. Old car



d. Battle

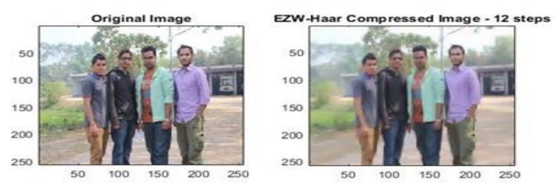


e. Patrol



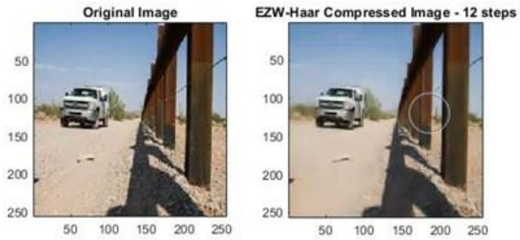
f. Sport man

Figure 2. Shows the result of 1st compression by using SPHIT compression algorithm based on Bior 4.4 wavelet method.

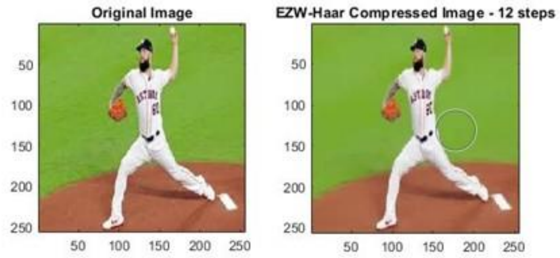


a. Friends

b. Child



e. **Patrol**



f. **Sport man**

Figure 3. Shows the result of 2nd compression by using EZW compression algorithms based on Haar- wavelet method.

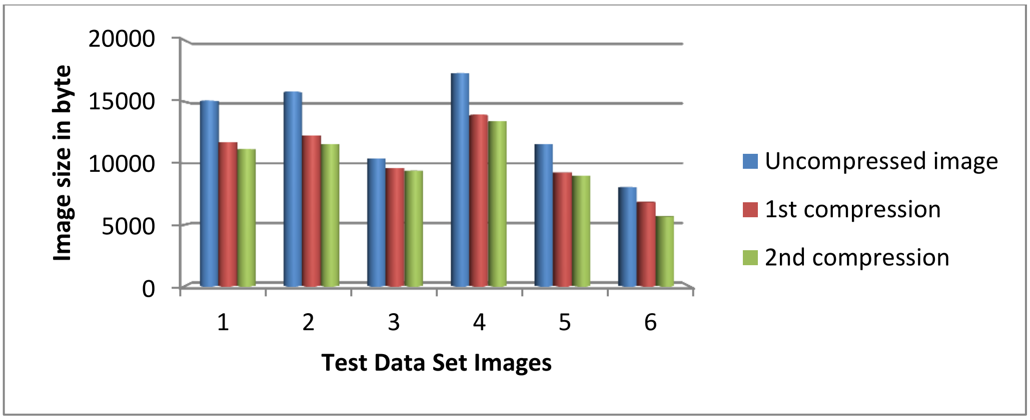


Figure 4. Shows bar chart of the data set test images before and after compression by using dual combined (SPHIT + EZW) compression algorithms based on (Bior 4.4 + Haar) wavelet methods.

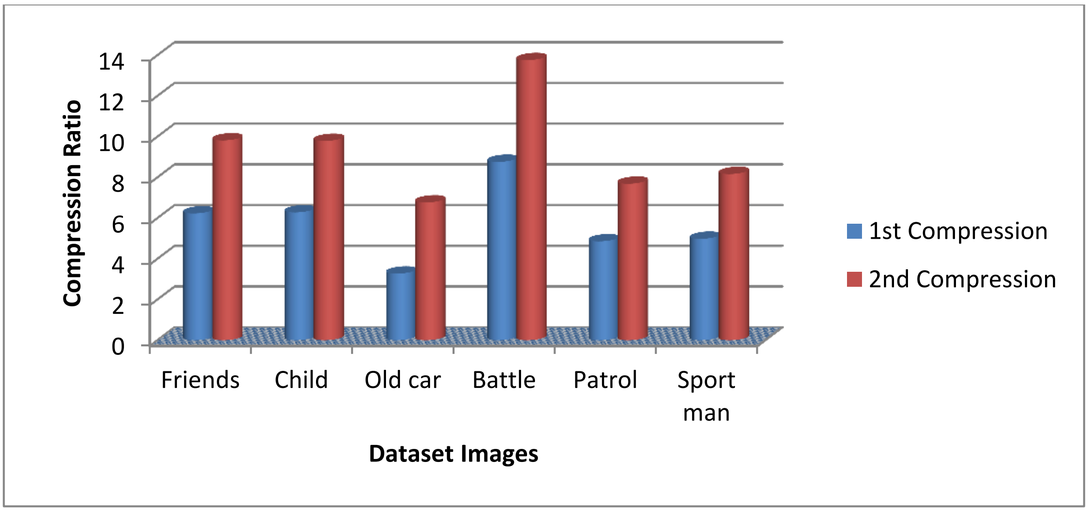


Figure 5. Shows bar chart of the compression ratio by using dual combined (SPHIT + EZW) compression algorithms based on (Bior 4.4 + Haar) wavelet methods.

9. Conclusion

In this paper we performed DICT which involve two compression approaches SPIHT and EZW that based on Bior 4.4 and Haar wavelet methods, the performance metrics for six test color images will be compared. Among the different wavelet families, the Haar wavelet presents a better metrics performance (CR, BPP, MSE and PSNR) as compared with other types. SPIHT and EZW dual combined algorithms be tested on different elected color images, from experiment results that obtained, we can see that the utilizing of DICT, have an excellent performance on several estimation measurements like CR and PSNR as compared with another lossy compression techniques that used for still color image. Through the results obtained, it became clear to us that the image with high color variation has high compression ratio and image with low color variation has low compression ratio. From DICT practical results the efficiency of image compression is improved between 8 to 24%, which yields better performance metrics values.

References

1. Raid, A.M.; Khedr, W.M.; El-dosuky, M.A.; Ahmed, W. JPEG Image Compression Using Discrete Cosine Transform - A Survey. *International Journal of Computer Science & Engineering Survey (IJCSES)*. **2014**, *5*, *2*, 39-47.
2. Tripathi, B.A. Survey on Various Image Compression Techniques. MSc. Thesis of Bachelor of Technology In Computer Science & Engineering Bachelor. Department of Computer Science & Engineering National Institute of Technology. India. **2014**.
3. Saha, S. Image Compression—from DCT to Wavelets: a Review. *ACM Crossroads Student Magazine*.**2000**, *6*, *3*,12-21.
4. Subramanya, A. Image Compression Technique. *Potentials IEEE. Feb-March*. **2001**, *20*, *1*, 19-23.
5. Shrikhande, R.N.; Bairagi, V.K. Comparison of Different Methods for Lossless Medical Image Compression, *Global Journal of Engineering, Design& Technology (GJEDT)*.**2013**, *2*, *3*, 36-40.
6. Setyaningsih, E.; Harjoko, A. Survey of Hybrid Image Compression Techniques. *International Journal of Electrical and Computer Engineering (IJECE)*.**2017**, *7*, *4*, 2206-2214.
7. Swetha, K.P. Still Image Compression by Using New Wavelet Bi-Orthogonal Filter Coefficient. *Indian Journal of Applied Research (IJAR)*, **2013**, *3*, *7*, 304-306.
8. Puniene, J.; Punys, V.; Punys, J. Ultrasound and angio image compression by cosine and wavelet transforms. *International Journal of Medical Informatics*.**2011**, *64*, *2–3*, 473–481.
9. JunKim, H.; Li, C.C. Unified Image Compression Using Reversible and Fast Biorthogonal Wavelet Transform. *Proceedings IWISP '96. Elsevier* ScienceDirect. *Manchester*. United Kingdom.**1996**, 263-266.
10. Angelidis, P. A MR image compression using a wavelet transform coding algorithm. *Magnetic Resonance Imaging*. **2014**, *12*, *7*, 1111–1120.
11. Rehna, V.J.; Kumar, J.M.K. Wavelet Based Image Coding Schemes: A Recent Survey. *International Journal on Soft Computing (IJSC)*.**2012**, *3*, *3*, 101-118.
12. Srikanth, S. Compression Efficiency for Combining Different Embedded Image Compression Techniques with Huffman Encoding. MSc. Thesis of Technology in Electronics and Communication Engineering National Institute of Technology Rourkela. Odisha-INDIA.**2013**
13. Tawfiq, L.N.M.; Jabber, A.K. New Transform Fundamental Properties and its Applications. *Ibn Al-Haitham Journal for Pure and Applied Science*. **2018**, *31*, *1*,151-163, doi: http://dx.doi.org/10.30526/31.2.1954

14. Yap, V.V.; Comley, R. A Hybrid Wavelet-Based Compression System. *Proceedings of the Third International Conference on Information Technology and Applications (ICITA'05). IEEE*. **2005**.
15. Sharadha, R.; Bhanuprakash, C. Image Compression Technique for Color Images using Wavelets. *International Journal of Advanced Research in Computer Science and Software Engineering*.**2013**, *3*, 322–327.
16. Samson, C.; Sastry, V.U. An RGB Image Encryption Supported by Wavelet- based Lossless Compression. *International Journal of Advanced Computer and Applications (IJACSA).***2012**, *3*, *9*, 36–41.
17. Al-Khafaji, Gh.; Al-iesawi, S.; Abd Rajab, M. A Hybrid Lossy Image Compression based on Wavelet Transform. Polynomial Approximation Model. Bit Plane Slicing and Absolute Moment Block Truncation. Baghdad University. Dept. of Computer Science. *International Journal of Computer Science and Mobile Comp*.**2015**, *4*, *6*, 954 – 961.
18. Neelamani, R.; de Queiroz, R.; Fan, Z.; Dash, S.; Baraniuk, R.G. JPEG Compression History Estimation for Color Images. *IEEE Transactions on Image Processing*.**2006**, *15*, *6*, 1365 – 1378.
19. Parmar, C.K.; Pancholi, K. A Review on Image Compression Techniques. *Journal of Information. Knowledge and Research in Electrical Engi*neering.**2015**, *2*, *2*, 281-284.
20. Singh, P.; Panda, S.A. Survey of Image Compression Techniques**.** *International Journal of Engineering and Innovative Technology (IJEIT).***2014**, *4*, *2*, 83-86.
21. Kumar, V.V.S.; Reddy, M.I.S. Image Compression Techniques by using Wavelet Transform. *Journal of Information Engineering and Applications*.**2012**, *2*, *5*, 35-39**.**
22. Raid, A.M. Image Compression Using Embedded Zerotree Wavelet. *Signal & Image Processing: An International Journal (SIPIJ)*.**2014**, *5*, *6*, 33-39.
23. Tawfiq, L. N.M.; Hussein, W. R. Design Suitable Neural Network for Processing Face Recognition. Global Journal of Engineering Science and Researches.**2016**, *3*, *3*, 58-64.
24. Rajakumar, K. Implementation of Multiwavelet Transform Coding for Image Compression. Ph.D. Thesis Submitted for Anand Nagar. Krishnankoil –126. **2015**.
25. Bannore, V. *Iterative-Interpolation Super-Resolution Image Reconstruction*. eBook ISBN 978-3-642-00385-1. Springer-Verlag Berlin Heidelberg. South Australia. **2009**.
26. Umbaugh, S.E. *Computer Vision and Image Processing: A Practical Approach using CVIP Tools.* Book. Prentice Hall, Inc.**1998**.
27. Ibraheem, N.A.; Hasan, M.M.; Khan, R.Z.; Mishra, P.K. Understanding Color Models: A Review. *ARPN Journal of Science and Technology*.**2012**,*2*,*3*,265-275.
28. Salomon, D. *Data Compression: The Complete Reference*; 4th Edition; Springer Computer Science Department California State University Northridge, USA.**2007**.
29. Setyaningsih, E.; Harjoko, A. Survey of Hybrid Image Compression Technique, *International Journal of Electrical and Computer Engineering (IJECE).***2017**, *7*, *4*, 2206-2214.
30. Rehna, V.J.; Jeya Kumar, M.K. Wavelet Based Image Coding Schemes: A Recent Survy. Department of Electronics & Communication Engineering. Noor al Islam University. *International Journal on Soft Computing (IJSC).***2012**, *3*, *3*, 101-118.