Comparative Study for Image Compression Using 'Haar' and 'Daubechies' Mother Wavelets for Two Decomposition Levels: 2 And 3

Shiva Sharma, Rajesh Mehra
NITTTR, Chandigarh

Abstract- This paper depicts the Wavelet based compression using 'Haar' mother Wavelet and 'Daubechies' mother Wavelet for three different types of images. The results are analysed and compared on the basis of Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Compression Ratio (CR) using MATLAB. Storage area reduction in the image is 58.33 percent using 'Haar' mother wavelet where as 57.38 percent using 'Daubechies' mother wavelet. It has been inferred that there is an increase in CR and MSE but decrease in PSNR with increase in wavelet decomposition level from 2 to 3 for all the three images. On comparing results from 'Daubechies' and 'Haar' mother wavelets in terms of PSNR, MSE and CR it has been observed that for two images out of three images, which have less number of redundant bits than a particular threshold level have same type of results for both the decomposition levels i.e. level 2 and level 3 where as for third image containing more number of redundant bits than the threshold possesses different types of results for both the levels.

Keywords- Wavelets, Fourier Transform, Resolution, Compression

I. INTRODUCTION

The image transforms have variety of applications in image filtering, data description etc. Wavelet theorems have a wide role in image processing, de-noising and compression. Wavelets are considered to be the prerequisite for not only various internet and multimedia applications but also for the face recognition [1,2]. Wavelets transform is compatible for the non stationary signals. The biomedical signal in processing application is provided by the Wavelet Transform [3]. In processing biomedical signal by using Wavelets, filtering is required to de-noise the image [4,5]. Adders are utilized in processing devices for image processing [6]. These processing devices should be highly power efficient to get better, fast and cost effective processing results. For increasing Power Conversion Efficiency (PCE), Tin Halide Perovskite Solar Cells can be considered as an efficient renewable way which is sustainable and safe to the environment [7]. Wireless Power generation using microwaves is the non-intermittent, sustainable and renewable way of extracting power for image processing devices [8]. Continuous or discrete wavelet transforms are the classic techniques in Image processing and analysis. For getting ability to construct a time-frequency representation of a signal that offers very good time and frequency localization the continuous wavelet transforms are used [9]. The ability of Data Reduction formulates the Discrete Wavelet Transform (DWT) as the standard tool in the Image Compression [10]. Bandwidth and storage area reduction is done with the help of Image compression [11]. Wavelets (little waves) are concerted in time and frequency about a certain point [12]. Downside of Fourier transform is to deal with just the Frequency component of the signal with the lack of temporal details [9]. But wavelet Transform is depicted to attain good frequency resolution for low frequency signals (average intensity values of the image) and high temporal resolution for high frequency components (edges) [9]. Three types of mother wavelets are "Haar", "Daubechies" and "Mortlet" [9]. To repress noise and to inspect EEG signals the proper selection of wavelet level and mother wavelet (smoothing function) is required [13]. Wavelet signal processing provides proficient resolution at conclusive frequencies that separate the noise components from the adulterated EEG signal while the essential frequencies are conserved [14].

II. DISCRETE WAVELET TRANSFORM

The discrete wavelet transform (DWT) transforms the image into components consisting low-frequency and high-frequency coefficients. Wavelets are more efficient at low bit rates due to its scalability [15]. Fig. 1 shows that the analysis of Wavelets which can be used to divide the information of an image into approximation and detail sub-signals [9]. The DWT transforms an image into sub-bands such that the wavelet coefficients in the lower-level sub-bands typically consist of more energy than those in higher-level sub-bands [10]. In discrete time domain by a successive chain of low-pass and high-pass filters, the discrete wavelet transform DWT can be acquired [16].

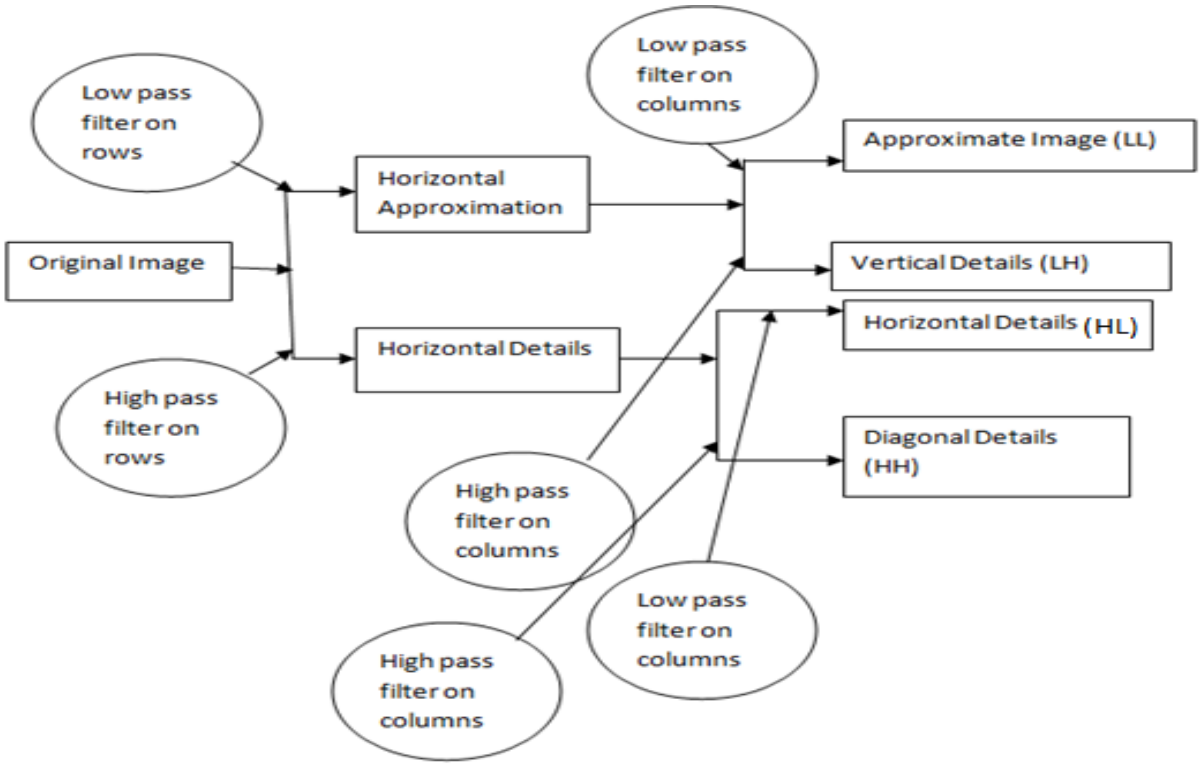
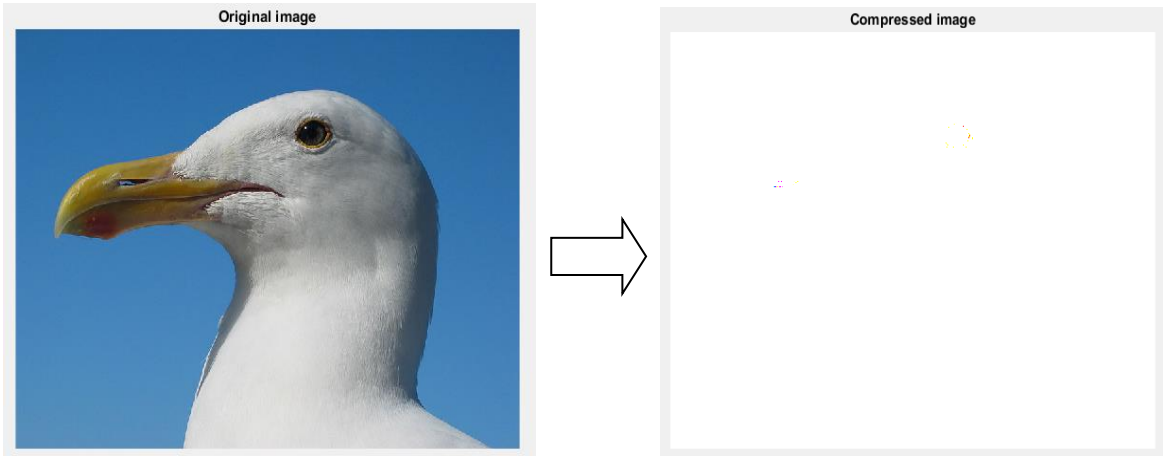


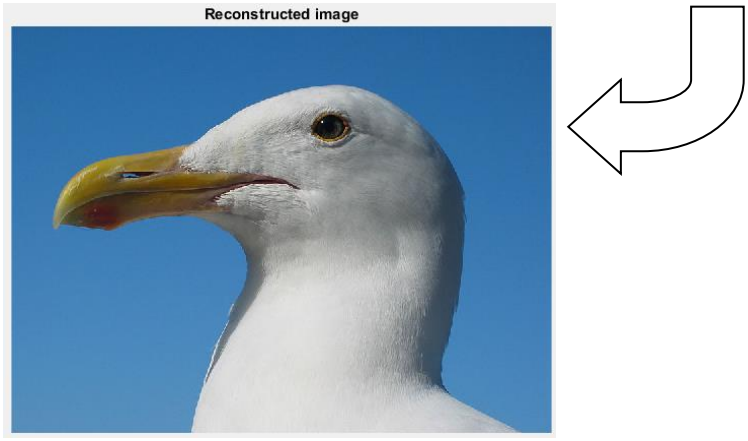
Fig.1: Block diagram of DWT

III. RESULTS AND DISCUSSIONS

The original image of the bird which is compressed using Wavelet compression to reduce the storage area by 58.33% using 'Haar' and 57.38% using 'Daubechies' mother wavelet used for Wavelet compression is given in Fig. 2 where Fig. 2 (a), (b) and (c) represents original image, compressed image and reconstructed image respectively. This helps the image to occupy minimum bandwidth during transmission. This image is recovered again at the receiver end by reconstructing it at the receiver end using wavelet reconstruction and the same storage area is recovered again as that of original image. For image 'A' of bird as shown in Fig. 2 and for the image 'B' of turtle as shown in Fig. 3, there is an increase in CR and MSE but decrease in PSNR with increase in wavelet decomposition level from 2 to 3 for all the images as shown in table 1. On comparing 'Daubechies' and 'Haar' mother wavelets in terms of PSNR, MSE and CR it has been observed that the images with less number of redundant bits than a particular threshold value have same type results for both the decomposition levels i.e. level 2 and level 3.



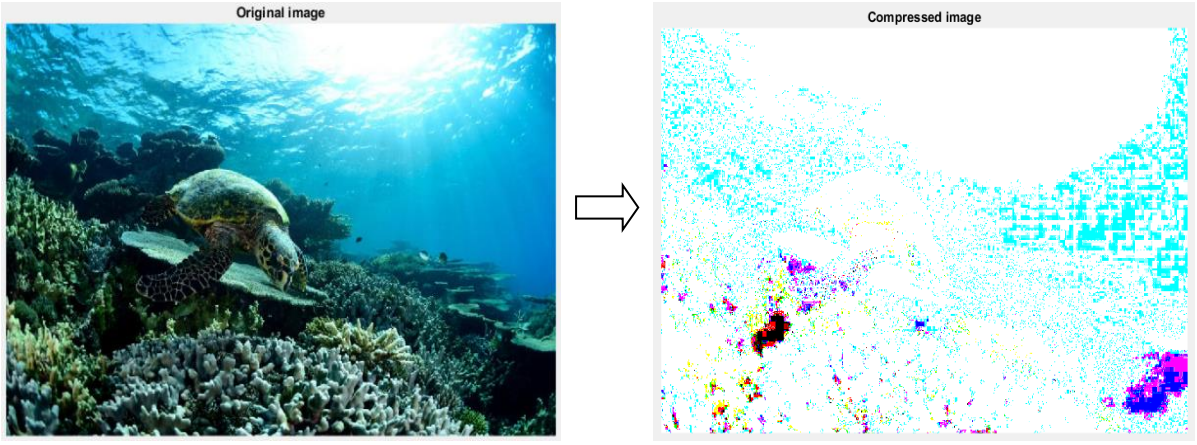
(a) (b)



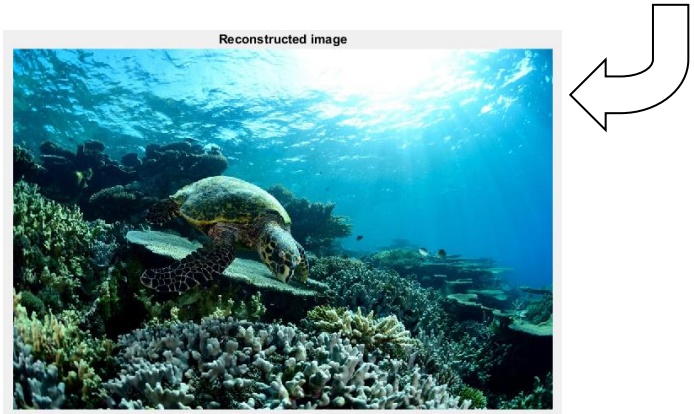
(c)

Fig.2: Wavelet Compression and Reconstruction for Image 'A' (Bird)

In both images, 'A' in Fig. 2 and 'B' in Fig. 3 with less redundant bits than the particular threshold, PSNR using 'Daubechies' is higher than that of 'Haar' mother wavelet where as CR and MSE using 'Haar' is greater than 'Daubechies' mother wavelet for wavelet decomposition level 2 and 3. For image 'C' representing alphabets as shown in Fig. 4 containing more number of redundant bits than the threshold possesses different types of results for both the levels (2 and 3) as in table 1.



(a) (b)



(c)

Fig.3: Wavelet Compression and Reconstruction for Image 'B' (Turtle)

For image 'C' in Fig. 4 with more redundant bits than the particular threshold, PSNR and CR using 'Haar' is higher than that of 'Daubechies' mother wavelet where as MSE using 'Daubechies' is greater than 'Haar' mother wavelet for wavelet decomposition level 2. In level 3 wavelet decomposition CR using 'Haar' is higher than that of 'Daubechies' mother wavelet where as MSE and PSNR using 'Daubechies' is greater than 'Haar' mother wavelet.

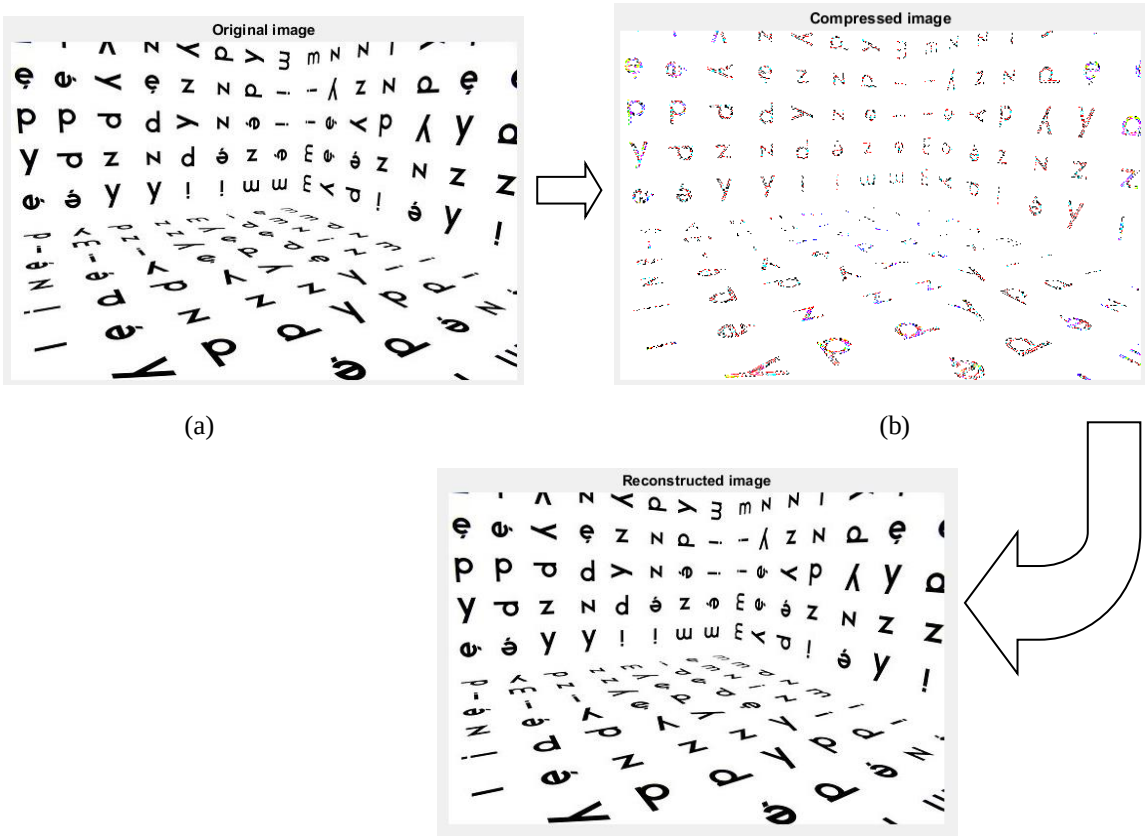


Fig.4: Wavelet Compression and Reconstruction for Image 'C' (Alphabets)

TABLE I. WAVELET RESULT COMPARISON TABLE

Type of Mother Wavelet	Decomposition Level	Image Type	Peak Signal To Noise Ratio (PSNR)	Mean Square Error (MSE)	Compression Ratio (CR)
Haar	2	A	47.2111	1.2359	25.4072
Haar	3	A	40.3228	6.0367	31.6803
Daubechies	2	A	47.8097	1.0767	24.1066
Daubechies	3	A	41.0006	5.1643	30.5171
Haar	2	B	33.9052	26.4582	25.9226
Haar	3	B	27.0504	128.448	32.5077
Daubechies	2	B	35.3176	19.1127	23.0962
Daubechies	3	B	28.1550	99.4438	29.8278
Haar	2	C	35.6836	17.5680	23.9663
Haar	3	C	22.7392	346.0701	30.2013
Daubechies	2	C	33.9570	26.1444	23.4864
Daubechies	3	C	23.7392	275.1145	29.6521

Table 1 shows comparison of 'Haar' and 'Daubechies' mother wavelets on the basis of PSNR, MSE and CR for image 'A', 'B' and 'C' with decomposition level 2 and 3.

IV. CONCLUSION

Wavelet based compression using 'Haar' mother Wavelet and 'Daubechies' mother Wavelet for three different types of images is depicted. Inference is made on the comparison of results on the basis of Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Compression Ratio (CR) using MATLAB. Storage area reduction in the image is 58.33 percent using 'Haar' mother wavelet where as 57.38 percent using 'Daubechies' mother wavelet. It has been analysed that there is an increase in CR and MSE but decrease in PSNR with increase in wavelet decomposition level from 2 to 3 for all the three images viz. 'A', 'B' and 'C'. On comparing results from 'Daubechies' and 'Haar' mother wavelets in terms of PSNR, MSE and CR it has been observed that for two images 'A' and 'B', which have less number of redundant bits than a particular threshold level have same type of results for both the decomposition levels i.e. level 2 and level 3 where as for image 'C' containing more number of redundant bits than the threshold possesses different types of results for both the levels (2 and 3). Either 'Haar' or 'Daubechies' mother wavelet is selected depending on the type of application.

V. ACKNOWLEDGEMENT

Authors would like to thank Dr. S.S. Pattnaik Director NITTTR, Chandigarh for providing research environment.

VI. REFERENCES

[1]. Buddhi Prakash Sharma, Rajesh Rana, Rajesh Mehra, "Face Recognition Using Gabor Wavelet for Image Processing Applications" Association of Computer Electronics and Electrical Engineers, pp. 201-206, 2013.

[2]. Pattanaik, S.K.; Mahapatra, K.K.; "A Lossless Image Compression Technique using Simple Arithmetic Operations and its FPGA Implementation"; IEEE International Conference on Industrial Technology, ICIT Page(s): 2211 – 2216, 2006.

[3]. I. Daubechies, "Ten lectures on wavelets" of CBMS-NSF Regional Conference Series in Applied Mathematics. Society for Industrial and Applied Mathematics (SIAM), vol. 61, Philadelphia, PA, 1992.

[4]. Amit Kumar Rana, Kumud, Rajesh Mehra, Shallu, "A COMPARATIVE ANALYSIS OF WAVELET AND CURVELET TECHNIQUES FOR NOISE REMOVAL" JETIR Volume 4, Issue 11 pp. 615-618, November 2017.

[5]. Bhupender Singh, Dr. Rajesh Mehra, Parul Sharma, Shallu Sharma, "Image Compression and Denoising using Wavelet Transform" International Journal of Modern Electronics and Communication Engineering (IJMECE) Volume No. - 5, Issue No. – 6, pp.42-47, November, 2017.

[6]. S. Sharma, R. Mehra, "Design, Simulation and Comparative Analysis of CMOS Ripple Carry Adder" IJRECE VOL. 6 Issue 2, pp. 694-700 apr.-june 2018.

[7]. Shiva Sharma, Rajesh Mehra, Neha Thakur, "Effect of different inorganic Hole Transport Material Layers on the performance of Tin Halide Perovskite Solar Cells " IJRECE VOL. 6 pp. 1245-1251 ISSUE 2 APR.-JUNE 2018.

[8]. S. Sharma, "Wireless Power Generation in Sustainable Technology" IJRECE Vol. 5 Issue 4, pp. 10-14 oct.-dec. 2017.

[9]. www.thelearningsquare.in

[10]. Sugreev Kaur and Rajesh Mehra, "High speed and area efficient 2d dwt processor based image compression" Signal & Image Processing: An International Journal(SIPIJ) Vol.1, No.2, pp.22-31 December 2010.

[11]. Vivek Kumar, D. Sriramulu, Rajesh Mehra, Shallu, "A Survey on Lossless Compression Algorithms for Medical Images" International Journal of Electrical Electronics & Computer Science Engineering Volume 4, Issue 6 pp. 96-102 (December, 2017).

[12]. http://inside.mines.edu/~whoff/courses/EENG510/lectures/24-Wavelets.pdf

[13]. P. Senthil Kumar, R. Arumuganathan, K. Sivakumar and C. Vimal, "A Wavelet based Statistical Method for De-Noising of Ocular Artifacts in EEG Signals," International Journal of Computer Science and Network Security, vol. 8, pp. 87-92, 2008.

[14]. C. Dean, D. Elif, C. Irena, "Wavelet transform feature extraction from human PPG, ECG, and EEG signal responses to ELF PEMF exposures: A pilot study " Elsevier Digital Signal Processing, vol. 18, pp. 861–874, 2008.

[15]. Piotr Porwik, Agnieszka Lisowska, "The Haar–Wavelet Transform in Digital Image Processing: Its Status and Achievements" M ach i n e GRAP HI CS & VI S I O N vol . 13, n o. 1/2, p p .79-98, 2004.

[16]. Mahmoud I. Al-kadi, M. .B. I. Reaz, M. A. Mohd Ali, "Compatibility of Mother Wavelet Functions with the Electroencephalographic Signal" IEEE EMBS International Conference on Biomedical Engineering and Sciences, Langkawi, pp. 113–117, 17th - 19th December 2012.

Authors:

Shiva Sharma: Shiva Sharma received her B.E. degree in Electronics and Communication Engineering from Chandigarh University in 2016. She has worked as an AGD developer in Hewlett Packard Enterprise which is currently known as EIT Services India Private Limited in Bangalore, India from 19th September 2016 to 28th April 2017. She is currently pursuing her M.E. degree in ECE from NITTTR Chandigarh in Regular Batch (2017-2019). She has 3 papers to her credit in International Journal of Research in Electronics and Computer Engineering (IJRECE).

Dr. Rajesh Mehra: Dr. Mehra is presently Head of Electronics and Communication Engineering Department at National Institute of Technical Teacher Training & Research, Chandigarh, India. He has received his Doctor of Philosophy and Masters Degree in Electronics & Communication Engineering from Punjab University, Chandigarh, India. Dr. Mehra has completed his Bachelor of Technology from NIT, Jalandhar, India. Dr. Mehra has 22 years of Academic Experience along with 10 years of Research Experience. He has nearly 500 publications in Refereed Peer Reviewed International Journals and International Conferences. Dr. Mehra has guided more than 100 PG scholars for their ME thesis work and also guiding 03 independent PhD scholars in his research areas. His research areas include VLSI Design, Digital Signal & Image Processing, Renewable Energy and Energy Harvesting. He has authored one book on PLC & SCADA.Dr. Mehra is senior member IEEE and Life member ISTE.