A Hybrid BTC Based Compression Techniques of General Images

C. Jenifer Kamalin [1], Dr. G. MuthuLakshmi [2]

[1] *Research Scholar, Department of Computer Science, Manonmaniam Sundaranar University, Tamil Nadu, India.* manisha.jeni@gmail.com

[2] *Associate Professor, Department of Computer Science, Manonmaniam Sundaranar University, Tamil Nadu, India.* *lakshmimsucse@gmail.com*

Abstract: In this paper we propose a new approach for the compression of the general images by combining the Discrete Wavelet Transform (DWT) with Adaptive Block Truncation Coding –Edge Quantization (ABTC- EQ). At the first the standard image is processed by DWT decomposition and into its approximations and details. From this finer and approximation details are separated. The finer details of the image then noted and discarded. The approximate details are noted and further processed in to ABTC-EQ. This approach i.e combination of DWT with AMBTC-EQ gives a better result than other techniques. The Peak Signal to Noise Ratio (PSNR), Weighted Peak Signal to Noise Ratio (WPSNR), Bit Rate (BR), and Structural SIMilarity Index (SSIM) are among the parametric measurements that are used to evaluate image quality. The comparison analysis demonstrates that the suggested algorithm outperforms both BTC and ABTC-EQ.

Keywords: DWT, BTC, AMBTC-EQ, Compression Ratio.

1. INTRODUCTION

Image compression is essential for many applications that need large amounts of data to be stored, transmitted, and retrieved, such as multimedia, documents, videoconferencing, and medical imaging. Uncompressed photos need a large amount of storage space as well as transmission bandwidth. The goal of image compression is to eliminate redundancy in image data in order to store or transmit data in an efficient manner. This reduces file size and enables for more photos to be saved in a given amount of disk or memory space [1-3]. Lossy or lossless image compression may be used [4, 5]. Compressed data in a lossless compression technique may be utilized to rebuild an identical clone of the original; no information is lost during the compression process. Entropy coding is another name for this form of compression. This moniker derives from the fact that a compressed data is typically more random than the original; when a signal is compressed, patterns are eliminated. While lossless compression is helpful for correct reconstruction, it seldom provides high enough compression ratios to be genuinely effective in picture reduction.

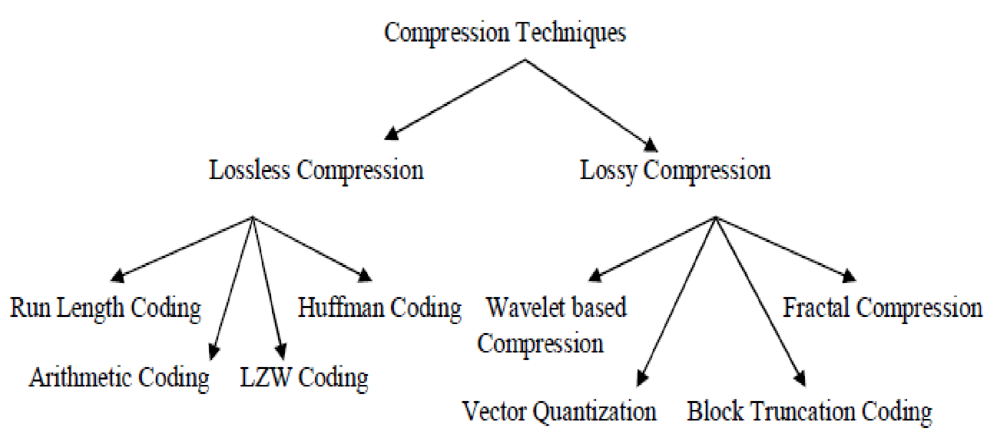

Fig 1. A Few Image Compression Techniques

Lossless image compression is very beneficial for picture archiving, such as storing legal or medical data. Entropy coding, Huffman coding, Bit-plane coding, Run-length coding, and LZW (Lempel Ziv Welch) coding are all lossless image compression methods. The original data cannot be precisely recreated from the compressed data in lossy compression. The reason for this is that most of the information in a picture may be removed without significantly altering the image's look. Consider a tree picture, which might be several hundred gigabytes in size. Though extremely fine features of the photos are lost in lossy image compression, the image size is dramatically decreased. Lossy image compressions are beneficial in applications such as broadcast television, videoconferencing, and facsimile transmission, where a little amount of mistake is an acceptable trade-off for higher compression performance. Fractal compression, Transform coding, Fourier-related transform, DCT (Discrete Cosine Transform), and Wavelet transform are all lossy compression methods.

2. BACKGROUND

2.1 Block Truncation Coding (BTC)

The first phase of the technique is partitioning the picture into non-overlapping rectangular areas. To ensure simplicity, we consider the blocks as square areas with dimensions of n x n, where the value of n is often set to 4. In the context of a two-level (1-bit) quantizer, the objective is to designate two specific brightness values for the purpose of representing every individual pixel inside the given block. The selection of these values is done in such a way that the mean and standard deviation of the rebuilt block match exactly with those of the original block. A bitmap of size n x n is then used to ascertain if the brightness value of a pixel exceeds or falls below a certain threshold. To elucidate the functioning of BTC, we will designate the sample mean of the block as the threshold. Consequently, a value of "1" would signify that an original pixel value above this threshold, while a value of "0" would indicate that it falls below. The production of a bitmap by BTC for the purpose of representing a block categorizes it as a technique of binary pattern image coding [10]. The use of thresholding enables the accurate replication of a well-defined boundary, capitalizing on the human visual system's capacity to locally integrate spatial information and conceal inaccuracies. The reconstruction technique is able to determine the relative brightness or darkness of a pixel compared to the average by using the bit map associated with each block. Hence, in order to depict the two areas inside each block, it is necessary to use two gray scale values, denoted as a and b. The aforementioned values are derived from the sample mean and sample standard deviation of the block, and are thereafter stored in conjunction with the bit map.

2.2 Discrete Wavelet Transform (DWT)

A wavelet may be described as a compact waveform that exhibits a concentrated energy distribution in the temporal domain. This characteristic makes wavelets a valuable analytical tool for studying events that are transitory, non-stationary, or subject to temporal variations. The phenomenon under consideration exhibits both oscillatory wave-like characteristics and the unique capability to provide concurrent investigation of time and frequency. The Wavelet Transform has become a prominent mathematical tool in several scientific and technical domains, particularly in the realm of audio and data compression. A wavelet may be described as a compact waveform that exhibits a concentrated energy distribution in the temporal domain. This characteristic makes wavelets a valuable analytical tool for studying events that are transitory, non-stationary, or subject to temporal variations. The phenomenon under consideration exhibits both oscillatory wave-like characteristics and the unique capability to provide concurrent investigation of time and frequency. The Wavelet Transform has become a prominent mathematical tool in several scientific and technical domains, particularly in the realm of audio and data compression. A wavelet expansion coefficient denotes a constituent that has inherent locality and is more readily interpretable. In contrast, wavelets possess the advantageous characteristic of having compact or finite support, which facilitates the representation of distinct segments of a signal at varying levels of resolution. Wavelets provide the desirable characteristics of adjustability and adaptability, making them suitable for the creation of adaptive systems that possess the capability to self-adjust in accordance with the characteristics of the signal. Wavelets may be designed to rapidly approach zero. The aforementioned characteristic is what makes wavelets so efficient.

2.3 ABTC – EQ

ABTC-EQ is an image compression method that uses edge-based block truncation. In order to quantize the pixel values based on the edge information; the method first uses the canny edge detector to determine the edge information in an input image. The tri-clustering method matches pixel gray scale values using three values, which can lower mean square error and enhance image quality. This technique, improves on BTC by handling more complicated images and achieving higher compression rates without affecting image quality. This method is as follows:

1. Enter a gray scale image with a size of M x N pixels together with the block size k that will be used to separate the image into non-overlapping blocks.
2. Locating the edge map using emap

   The canny edge operator is used to derive the edge map of the input image. The canny edge detector is a superior edge detection technique with multiple stages that can identify a variety of edges in images. The noise reduction phase of the technique involves applying a Gaussian filter on the image in order to smooth it out. Find the intensity gradient in the second stage and use the edge thinning method known as non-maximum suppression, then use connection analysis and double thresholding to follow the image's edges.
3. The image should be divided into blocks of size k x k, where k can have a value of 4, 8, 16, etc.
4. 4.Block classification : Classify the blocks so that the corresponding image block W is defined as an edge block, otherwise a non-edge block, if any one of the edge values in E is 1, but not all of the edge values are 1. When defining an identifier flag, it is given the values 0 for an edge block and 1 for a non-edge block.
5. Adaptive Encoding.
6. Adaptive Decoding.

The resulting matrix indicates the reconstructed image. Repeat the process for each block. There may be blocks in the edge map that have all values of 0 or 1, in which case there are no edges, creating a visually continuous effect. For these non-edge blocks, quantization is carried out depending on the thresholds, which is the average of the maximum, minimum, and mean value. The mean values of the upper range and lower range are used as the reconstruction values when recreating such blocks. For the edge block, it is assumed that an edge separates the region into three sections: the background, the foreground, and the section with edge pixels.

3. PROPOSED TECHNIQUE

The input image undergoes direct processing in order to perform wavelet decomposition and get its corresponding approximation. Both lossless and lossy image compression may be accomplished effectively with the use of the Haar wavelet compression. It does this by taking the values in an image matrix and averaging and differentiating them, which results in a matrix that is sparse or almost sparse. A matrix in which a significant number of its elements are 0 is referred to as a sparse matrix. It is possible to store a sparse matrix in an effective way, which results in files with a lesser size. The Harr wavelet is capable of achieving high coefficients in the vertical, diagonal, and horizontal directions. The coefficients that capture the finer characteristics of an image are referred to as strong coefficients.

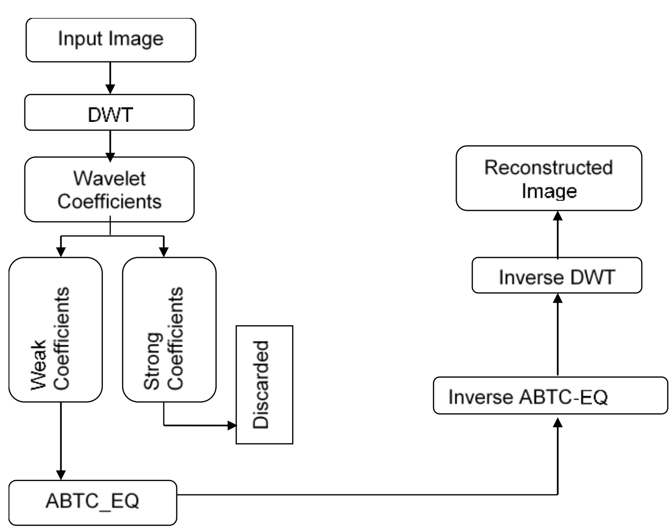

Fig. 2. The block diagram of the proposed technique

The robust coefficients are partitioned and then excluded. The coefficients with lower magnitudes are isolated and chosen for further analysis. The coefficients of lesser magnitude are then encoded using the ABTC-EQ scheme. The method of image reconstruction is fundamentally the inverse of image compression. The methodology of the suggested approach is elucidated in the accompanying Figure. This technique combines the benefits of discrete wavelet transform with ABTC-EQ.

4. PERFORMANCE METRICS

The performance of the proposed technique is compared with a few existing techniques with respect to the following metrics which assess the quality of digital image compression such as PSNR, WPSNR, SSIM, FSIM and CR.

PSNR

The Peak Signal-to-Noise Ratio (PSNR) is a metric used to quantify the relationship between the greatest potential strength of a signal and the power of the noise that introduces distortion to its representation, so influencing its quality. The ratio between two images is calculated using decibel notation. The calculation of the Peak Signal-to-Noise Ratio (PSNR) often involves the use of logarithmic scaling in decibels due to the large dynamic range shown by the signals. The dynamic range exhibits variability by including the upper and lower limits that may be altered based on their inherent characteristics.

PSNR is denoted as:

PSNR=10log10(peakval2)/MSE -------- 1

Table 1 shows comparisons between the proposed technique and other commonly used alternatives, including BTC, ABTC, and ABTC-EQ.

Table 1. Comparison of proposed technique PSNR with the existing techniques

Sl.No	Images	BTC	ABTC-EQ	Proposed Approach
1	Airplane	25.5456	56.3138	59.3532
2	Car	24.2778	54.2376	56.2356
3	Cat	22.9458	49.7525	52.2457
4	Dog	24.1183	50.4316	54.1467
5	Flower	22.8451	49.5328	49.9586
6	Fruit	22.7923	49.6527	51.9533

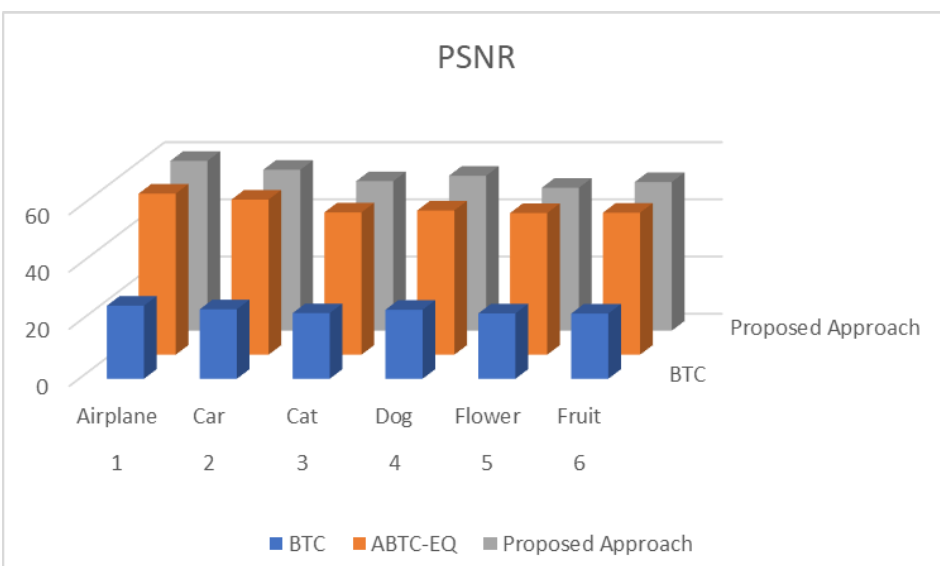

Fig 3. Performance analysis based on PSNR value

SSIM

The SSIM index method, a quality measurement metric is calculated based on the computation of three major aspects termed as luminance, contrast and structural or correlation term. This index is a combination of multiplication of these three aspects.

Table 2. Comparison of proposed technique SSIM with the existing techniques

S.No	Images	BTC	ABTC-EQ	Proposed Approach
1	Airplane	0.7519	0.9637	0.9487
2	Car	0.7954	0.9894	0.9961
3	Cat	0.7913	0.9843	0.9724
4	Dog	0.7818	0.9760	0.9543
5	Flower	0.7624	0.9755	0.9486
6	Fruit	0.7835	0.9763	0.9612

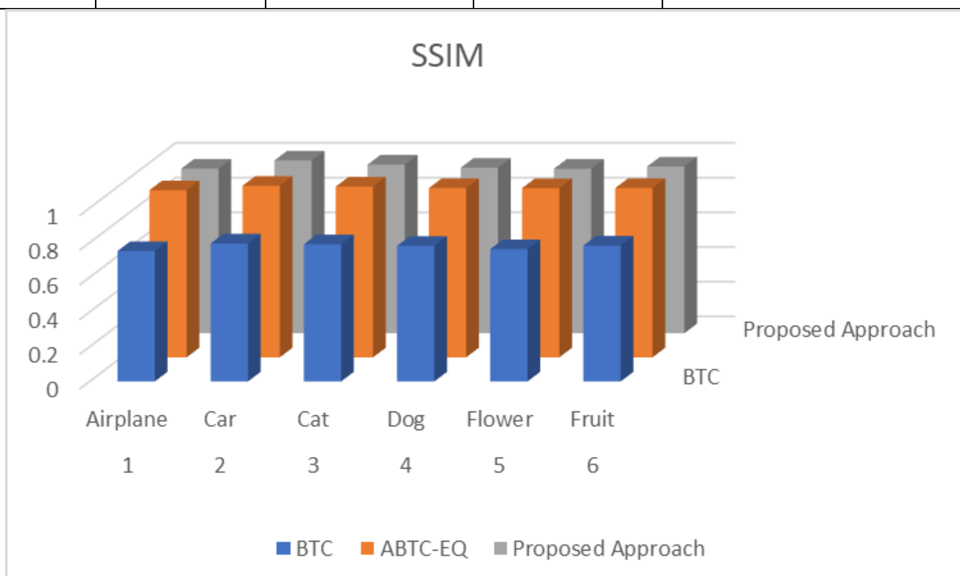

Fig 4. Performance analysis based on SSIM value

FSIM

The Feature Similarity Index (FSI) is a metric used to quantify the similarity between two or more features. It involves the process of feature mapping and the subsequent measurement of similarities between two images. It is essential to elucidate two specific criteria with more clarity.

Table 3. Comparison of proposed technique FSIM with the existing techniques

S.No	Images	BTC	ABTC-EQ	Proposed Approach
1	Airplane	3.9153	4.9588	5.4169
2	Car	3.6531	4.8744	4.9675
3	Cat	2.9582	4.5329	4.7648
4	Dog	3.9531	4.9658	5.6813
5	Flower	4.2157	5.2344	5.8264
6	Fruit	4.1971	5.1974	5.7281

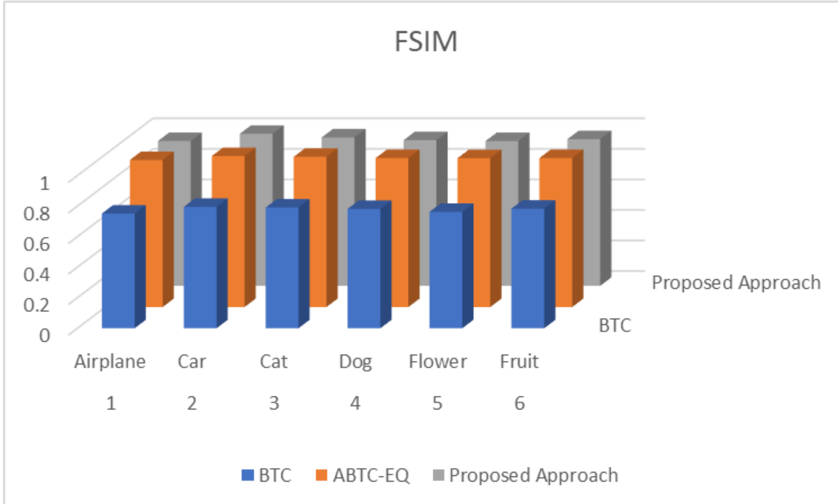

Fig 5. Performance analysis based on FSIM value

CR

Compression ratio is the ratio of the size of original image to the size of the compressed image; the bit rate is the number of bits per pixel required by the compressed image.

CR = size of original image / size of the compressed image.

Compression ratio in terms of number of pixels which can be expressed as:

CR (Bits/Pixel) = Number of bits in compressed image/Number of pixels in original image

Table 4. Comparison of proposed technique CR with the existing techniques

S.No	Images	BTC	ABTC-EQ	Proposed Approach
1	Airplane	0.7519	0.9637	0.9487
2	Car	0.7954	0.9894	0.9961
3	Cat	0.7913	0.9843	0.9724
4	Dog	0.7818	0.9760	0.9543
5	Flower	0.7624	0.9755	0.9486
6	Fruit	0.7835	0.9763	0.9612

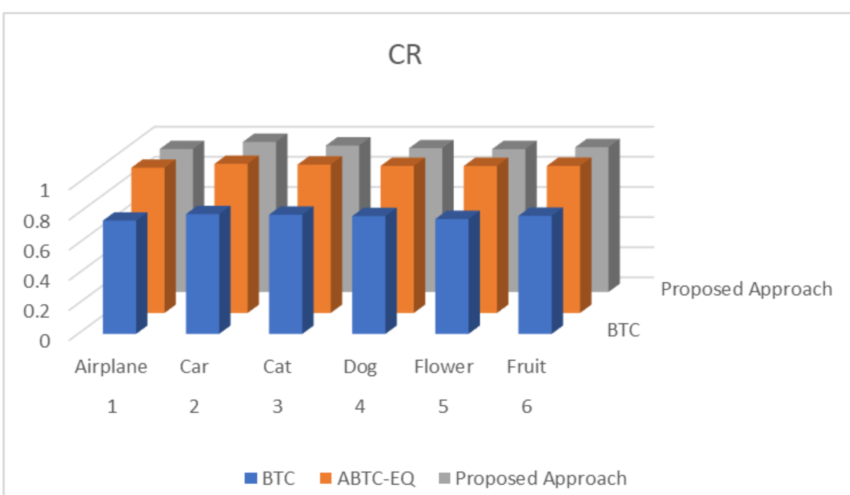

Fig 6. Performance analysis based on CR value

5. CONCLUSION

In this paper a hybrid image compression method based on ABTC-EQ and DWT is proposed. The test images are in gray scale image, of size 512 × 512. The evaluation of performance using objective criteria including PSNR, SSIM, FSIM, and CR show that the proposed method achieves a good compression ratio while keeping a good quality of the reconstructed images. The evaluation metric proves that the proposed method performs better than the existing techniques.

6. REFERENCES

[1] S. Muramatsu, D. D. Han, T. Kobayashi, and H. Kikuchi, “Directional lapped orthogonal transform: theory and design,” IEEE Trans. on Image Process., vol. 21, no. 5, pp. 2434-2448, May 2012.

[2] G. Fracastoro, S. M. Fosson, and Enrico Magli, “Steerable discrete cosine transform,” IEEE Trans. Image Process., vol. 26, no. 1, pp. 303-314, Jan. 2017.

[3] W. Hu, G. Cheung, A. Ortega, and O. C. Au, “Multiresolution graph Fourier transform for compression of piecewise smooth images,” IEEE Trans. Image Process., vol. 24, no. 1, pp. 419-433, Jan. 2015.

[4] Y. P. Sun, X. M. Tao, Y. Li, L. H. Dong, and J. H. Lu, “HEMS: Hierarchical exemplar-based matching-synthesis for object-aware image reconstruction,” IEEE Trans. Multimedia, vol. 18, no. 2, pp. 171-181, Feb. 2016.

[5] J. Xiao, R. M. Hu, L. Liao, Y. Chen, Z. Y. Wang, and Z. X. Xiong,“Knowledge-based coding of objects for multisource surveillance video data,” IEEE Trans. Multimedia, vol. 18, no. 9, pp. 1691-1706, Sept.2016.

[6] G. Fracastoro, F. Verdoja, M. Grangetto, and E. Magli, “Super pixel driven graph transform for image compression,” in Proc. IEEE Int. Conference on Image Process., Sept. 2015.

[7] W. Lin and L. Dong, “Adaptive downsampling to improve image compression at low bit rates,” IEEE Trans. Image Process., vol. 15, no. 9, pp. 2513-2521, Sept. 2006.

[8] T. Frajka and K. Zeger, “Down sampling dependent up sampling of images,” Signal Process. Image Commun., vol. 19, no. 3, pp. 257-265,Mar. 2004.

[9] X. L. Wu, X. J. Zhang, and X. H. Wang, “Low bit-rate image compression via adaptive down-sampling and constrained least square supconversion,” IEEE Trans. Image Process., vol. 18, no. 3, pp. 552-561,Nov. 2009.

[10] Dipeeka O. Kukreja, S.R. Suralkar , and A.H. Karode , Performance Analysis of Various Image Compression Techniques, International Journal of Science, Spirituality, Business and Technology (IJSSBT), Vol. 1, No.1, March 2012.

[11] L. Ma, S. N. Li, and K. N. Ngan, “Perceptual image compression via adaptive block-based super-resolution directed down-sampling,” in Proc.IEEE Int. Symposium on Circuits and Systems, May 2011.

[12] Y. B. Zhang, X. Y. Ji, H. Q. Wang, and Qionghai Dai, “Stereo interleaving video coding with content adaptive image subsampling,” IEEE Trans. on Circuits and Systems for Video Technology, vol. 23, no.7, pp. 1097-1108, Jul. 2013.

[13] J. M. Guo and Y. F. Liu, “Improved block truncation coding using optimized dot diffusion,” in Proc. IEEE Int. Symp. Circuits Syst., May–Jun.pp. 2634–2637, 2010.

[14] Z. Wang and Q. Li, “Information content weighting for perceptual image quality assessment,” IEEE Trans. Image Process., vol. 20, no. 5, pp. 1185–1198, May 2011.

[15] Wang Z, Bovik AC, Sheikh HR, Simoncelli EP. Image quality assessment: from error measurement to structural similarity. IEEE Trans Image Process;13(1), 2004.

[16] Mathews Jayamol, Nair Madhu S, Jo Liza. Modified BTC algorithm for gray scale images using max–min quantizer. In: International multi conference on automation, computing, control, communication and compressed sensing – iMac4s 2013 (India). IEEE Computer Society Press;. p. 377–82, 2013.

[17] L. Zhang, X. Y. Xiu, J. L. Chen, M. Karczewicz, Y. W. He, Y. Ye, J. Z. Xu, J. Sole, and W.-S. Kim, “Adaptive color-space transform in HEVC screen content coding,” IEEE Journal on Emerging and Selected Topics in Circuits and Systems, vol. 6, no. 4, pp. 446-459, Dec. 2016.

[18] J. M. Guo and Y. F. Liu, “Improved block truncation coding using optimized dot diffusion,” in Proc. IEEE Int. Symp. Circuits Syst., May–Jun. 2010, pp. 2634–2637.

[19] M. J. Weinberger, G. Seroussi and G. Sapiro, “The LOCO-I lossless image compression algorithm: Principles and standardization into JPEG-LS”, IEEE Trans. on Image Processing, Vol. 2, pp. 1309-1324,

Aug. 2000.

[20] Alice Blessie1, J. Nalini and S.C.Ramesh, “Image Compression Using Wavelet Transform Based on the Lifting Scheme and its Implementation”, IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 3, No. 1, May 2011.

[21] Bai, J.; Chang, C.C. A high payload steganographic scheme for compressed images with Hamming codeg. Int. J. Netw. Secur., 18, 1122–1129, 2016.

[22] Kim, C.; Shin, D.; Yang, C.N. A (2, 2) secret sharing scheme based on Hamming code and AMBTC. In Proceedings of the Asian Conference on Intelligent Information and Database Systems (ACIIDS 2012), Kaohsiung, Taiwan, 19–21; Volume 7197, pp. 129–139, March 2012.

[23] Chang, I.C.; Hu, Y.C.; Chen, W.L. High capacity reversible data hiding scheme based on residual histogram shifting for block truncation coding. Signal Process.108, 376–388, 2015.

[24] Lin, C.; Liu, X. A reversible data hiding scheme for block truncation compressions based on histogram modification. In Proceedings of the 2012 Sixth International Conference on Genetic and Evolutionary Computing, Kitakushu, Japan, 25–28 August; pp. 157–160, 2012.

[25] Chang, C.C.; Lin, C.Y.; Fan, Y.H. Lossless data hiding for color images based on block truncation coding.Pattern Recognit. 41, 2347–2357, 2008.

[26] Ou, D.; Ye, L.; Sun,W. User-friendly secret image sharing scheme with verification ability based on block truncation coding and error diffusion. J. Vis. Commun. Image Represent.29, 246–60, 2015.

[27] Eskicioglu A.M., Fisher P.S. A Survey of Quality Measures for Gray Scale Image Compression. Proceedings Space and Earth Science Data Compression Workshop, Snowbird, Utah, 49-61,1993.

[28] Kanungo, T.; Mount, D.M.; Netanyahu, N.S.; Piatko, C.D.; Silverman, R.; Wu, A.Y. An efficient k-meansclustering algorithm: Analysis and implementation. IEEE Trans. Pattern Anal. Mach. Intell. 2002, 24, 881–892.

[29] Jayamol Mathews, Madhu S. Nair, “Modified BTC Algorithm for Gray Scale Images using max-min Quantizer”, 978-1-4673-5090-7/13/$31.00 ©2013 IEEE.

[30] Jayamol Mathews, Madhu S. Nair, “Modified BTC Algorithm for Gray Scale Images using max-min Quantizer”, 978-1-4673-5090-7/13/$31.00 ©2013 IEEE.

[31] Jing-Ming Guo, Senior Member, IEEE, and Yun-Fu Liu, Member, IEEE, “Improved Block Truncation Coding Using Optimized Dot Diffusion”, IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 23, NO. 3, MARCH 2014.

[32] Shuyuan Zhu, Zhiying He, XiandongMeng, Jiantao Zhou and Bing Zeng, “Compression-dependent Transform Domain Downward Conversion for Block-based Image Coding”, IEEE Transactions on Image Processing, Volume: 27, Issue: 6, June 2018.

[33] C. Senthilkumar, “Color and Multispectral Image Compression using Enhanced Block Truncation Coding [E-BTC] Scheme”, accepted to be presented at the IEEE WiSPNET, PP. 01-06, 2016 IEEE.

[34] C. C. Chang, H. C. Hsia, and T. S. Chen. A progressive image transmission scheme based on block truncation coding. In LNCS Vol 2105, pages 383–397, 2001.

[35] C. C. Chang and T. S. Chen. New tree-structured vector quantization with closed-coupled multipath searching method. Optical Engineering, 36:1713 – 1720, 1997.

[36] Delp EJ, Mitchell OR. Image compression using block truncation coding. IEEE Trans Commun;27(9):1335–42, 1979.

DOI: https://doi.org/10.15379/ijmst.v11i1.3587