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Efficient HAAR Wavelet Transform with Embedded Zerotrees of Wavelet Compression for Color Images

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***Abstract*—**This study is expected to compress true color image with compression algorithms in color spaces to provide high compression rates. The need of high compression ratio is to improve storage space. Alternative aim is to rank compression algorithms in a suitable color space. The dataset is sequence of true color images with size 128 x 128. HAAR Wavelet is one of the famous wavelet transforms, has great potential and maintains image quality of color images. HAAR wavelet Transform using Set Partitioning in Hierarchical Trees (SPIHT) algorithm with different color spaces framework is applied to compress sequence of images with angles. Embedded Zerotrees of Wavelet (EZW) is a powerful standard method to sequence data. Hence the proposed compression frame work of HAAR wavelet, xyz color space, morphological gradient and applied image with EZW compression, obtained improvement to other methods, in terms of Compression Ratio, Mean Square Error, Peak Signal Noise Ratio and Bits Per Pixel quality measures.

***Keywords*—**Color Spaces, HAAR Wavelet, Morphological Gradient, Embedded Zerotrees Wavelet Compression.

I. Introduction

RECENT techniques in the discipline of image analysis resulted large amount of images in each time. Processed image or video takes large storage area during the time of download or upload. Similarly, the storage and transmission of statistics is big hassle and there is a necessity to take essential steps. As stated by way of Parkirson's first law [13], as the necessity of storage increases, transmission capacity twice will increase. Though it is far boom in rate, the storage capacity is good than the technology. Data compression deals with morse code later hired in the famous Huffman code. In order to overcome this challenge, data compression [17] has been presented to compress the size of data being stored or transmitted. Eliminating redundancies is subsequent state of artwork method to symbolize information in binary form. The velocity of moving records rate in WIFI is becoming important these days because of thousands and thousands of users in social media. The storage and computation speed are not in direct percentage. Like sparse matrix, the redundant records are compressed by suitable compression algorithms like EZW, SPIHT, Spatial Orientation Tree Wavelet (STW), Wavelet Difference Reduction (WDR), Adaptively Scanned Wavelet Difference Reduction (ASWDR) and SPIHT 3-D.

II. Related Works

In this section existing papers applied inside the discipline of image compression are explained elegantly. The wavelet remodel [5] has important role with image compression. The wavelet is outstanding than Discrete Cosine Transform (DCT) [10]. Similarly, wavelet based compression is best in interpreting mistakes and transmission of images because of the purpose of high resolution nature [7] and degradation tolerance. In [1], the Huber–Markov random field model with objective artifact achieved good Bits per pixel (BPP) and PSNR.

Alzahir and Borici [4] compress discrete color images used the method codebook row column reduction coding in comparison with maps and binary images.

Babu et al. [2] overcome the drawback of Run Length Coding (RLC) with matrix based on mapped-pair approach. In addition, the author analysed the performance metric of compressed images .tiff, .jpg, .gif and text documents by RMSE, SNR, PSNR and CR. The robustness and compression efficiency [9] is performed in lossless compression [2] technique for color images and raster images. Consequently, DCT area has been introduced in most video compression techniques [2]. The overall performance of DCT degrades in high compression ratio [14]. Moreover, many researchers substantially target Discrete wavelet transform (DWT). DWT [14] is appropriate for human visible gadget for purpose of adaptive spatial frequency. At the same time, another compression algorithm, Embedded zerotree, does no longer need preknowledge of image. EZW is good enough in encoding and accuracy rate for true color images.

In embedded image coding, the usage of zerotree of wavelet coefficient (EZW) using stream of bits [6] is an efficient lossy compression image technique. Larger coefficients of EZW are the prime factors than smaller coefficients regardless of their scale [16]. An embedded code is produced in the order of importance. It defines a string of binary selections. In EZW, encoding and decoding may be ended when the goal is reached. EZW [17] is the basic method for tree shape approach and it is an effective embedded image compression that generates bit circulation. Ultimately SPIHT [11] is refinement to EZW and it uses the principle of operation. Evaluation of EZW, SPIHT is high in terms of compression parameter [12]. In alternative, SPIHT coding operates in exclusive scales on the equal spatial vicinity within the wavelet subbands. This yields embedded bits with less MSE. Similarly, SPIHT can be useful to lossless algorithm [15].

Jamel [21] pointed that SPIHT algorithm is simple computation approach. The work in SPIHT algorithm [18] suggests that the execution time is reduced when compression ratio value is elevated. DWT-SPIHT is good in quality with high PSNR. The wavelet based contourlet transform (WBCT)

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using SPIHT like algorithm is visually superior to the wavelet SPIHT in preserving data and texture details.

Ajala et al. worked on hybrid compression. The LZW and Huffman image compression strategies are helped to broaden hybrid compression [1] in clinical images. Concatenation of LZW code words and Huffman blunders detection techniques are implemented to get size reduction, high compression ratio and high signal noise ratio.

SPIHT algorithm is a powerful wavelet based image compression algorithm, here the tree structure is chosen to represent the transformed image which is identified by the coefficients of each node. The existing work focused that Runlength Encoding [17] employs high redundant data in loss less compression. Pearlman pointed that SPIHT [15] method is efficient for wavelet image compression [3]. SPHIT uses arithmetic coding to improvise image quality and it is suitable for hardware implementations. Later days SPIHT has become benchmark algorithm. It is one of the best wavelet based coding algorithms. 3D SPIHT coding is an excellent technique to color image compression than conventional methods such as EZW; SPIHT always generates local optimal values. 3D SPIHT [11], [19] is the modern octal tree technique for 3 dimensional true color image compression. In this study 3D SPIHT with different color conversion methods are applied to different types of images. SPHIT algorithm is applied to sequence of images with consequent angles. It is experimented with true color image as well as gray scale image.

The LZW and Run length Encoding compression methods are excellent to Tiff documents. Especially LZW is suitable for textual content files. Another technique LVL_MMC (subband thresholding of coefficients and Huffman Encoding) is a level thresholding wavelet compression method. The parameters of this subband thresholding are calculated from the differences between means method. One of the most important papers on image compression within 1977, by Ziv and Lempel notably pointed about compression with all varieties of facts. In the paper [20], LZ coding, dictionary based coding with loss much, less strategies are applied on Tiff, Gif, Pdf, Gzip, Zip, V.42 and Png files.

III. Material and Method

A sequence of portable network graphics (png) file formats are taken as input images. This image contains a single or multi image in an extensible structure of chunks, encoding with the basic pixels and other textual information. The file size is 128x128.

A. Color Space Based Compression Algorithm

In this observation, the three goals are as follows:

The first objective is to discover best color space with HAAR wavelet based compression techniques EZW, SPHIT, SPIHT 3D, LVL-MMC using true color images.

The second objective is to find best compression method for sequence of true color images as well as gray color images for best compression ratio.

The third objective is applying morphological gradient input image to get best compression ratio and PSNR using proposed frame work.

Fig. 1 Sample True Color Images

The motive of this work is to lessen the storage area and improve compression ratio using HAAR wavelet compression approach. The proposed work is dealt with series of images with .png files. Further the file formats png, bmp, tiff files are checked using color space conversion techniques rgb, yuv, kit, yiq and xyz. Here yuv represents YUV colour space transform, klt represents Karhunen-Loeve transform, yiq represents YIQ color space transform, xyz represents CIE-XYZ color space transform. XYZ color space transform gives suitable for true color single object image.

There are legitimate compression strategies which can be progressive coefficients significance method (PCSM) and Coefficient thresholding method. Embedded zerotree wavelet, SPIHT, Spatial Orientation Tree, wavelet difference reduction, Adaptively Scanned Wavelet difference reduction, SPIHT 3-D are the compression techniques comes beneath PCSM category. Among these compression techniques the proposed work uses EZW, SPHIT, SPHIT 3-D and LVL-MMC methods which are suitable for png type single object files.

On this segment, the technique for assessing reconstruction and overall performance of HAAR wavelet for compressing unique record codecs has been investigated using MATLAB. To schematic diagram of experiment is shown in Fig. 2. During the evaluation period EZW, SPIHT, SPIHT 3-D, LVL-MMC are examined for gray scale and true color single object sequence images. Also same strategies are tried to Tiff, Bmp, Jpg, Png file formats. The Compression ratio, PSNR and Saving space % measure the reconstruction performance of an image. Here compression ratio represents compressed image in terms of storage. PSNR represents maximum pixel magnitude of original image.

B. Morphological Gradient

In order to achieve good PSNR and compression ratio, morphological internal gradient method is applied. This internal gradient (G_i) operation forms edge enhanced image with 3x3, 6x6, 12x12 in x, y axes. Transitions of image edges'

representation from dark to bright and bright to dark region in morphological gradient's procedure is as:

Step1. Create a duplicate of the input image. Let it be Q.
Step2. Apply Erosion operation to the input image (P).
Step3. Edge = Input Image – Eroded Image,
i.e., $G_i = P - (P \ominus Q)$
Step4. Display the Gradient image
Step5. Exit

Here image may be either True Color Image or Gray Scale Image.

IV. Result and Discussion

The SPIHT algorithm gives good PSNR value and the values are plotted as graph below. Fig. 3 shows that when the angle increases from 5 to 85 degree the PSNR value decreases. When the angle reached at 90 degree the curve goes down. In addition, at the angle of 90 to 160 degree the PSNR values are in increasing order for gray scale image as shown in Fig. 3.

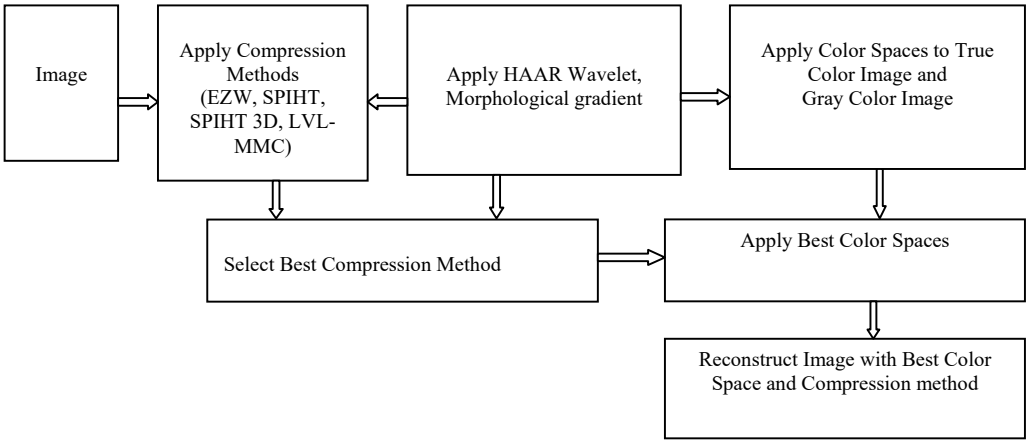


Fig. 2 Schematic Diagram

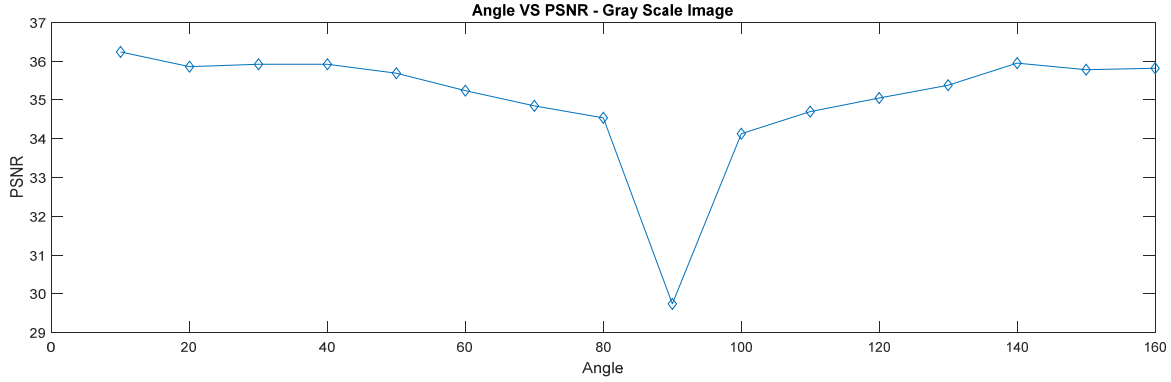


Fig. 3 PSNR attained for Gray Scale image

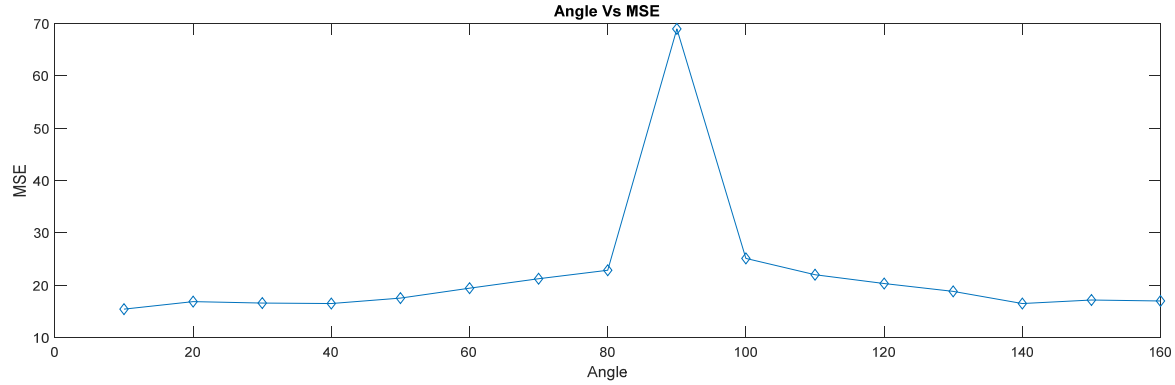


Fig. 4 MSE attained for Gray Scale Image

Fig. 4 shows that the MSE value of gray scale images slowly increase from the angle 5 to 80 degrees and suddenly

increase from the angle 20 to 70. Along with this, there is decrement in angle from 70 to 25 then it slowly decreases from 100 to 160 degree. True color image's MSE value is higher than gray scale image in SPIHT method.

In SPIHT method, the compression ratio is lesser in true color images than gray scale images. Fig. 4 shows that compression ratio also displays the result similar to PSNR graph, Fig. 3.

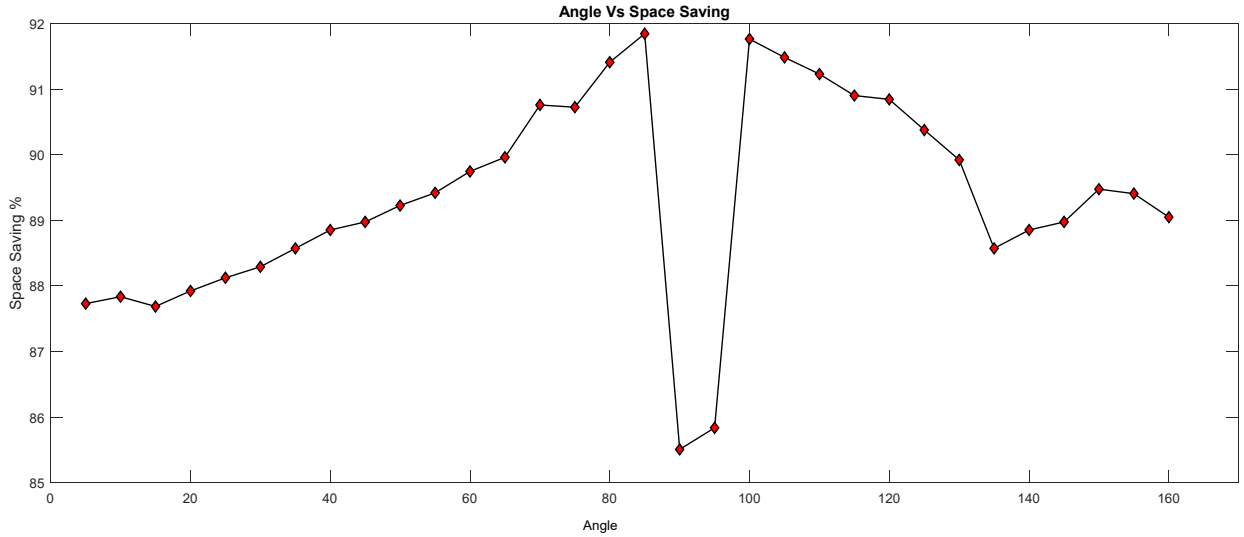


Fig. 5 Space Saving for True Color Image

Even though the lossy EZW coding algorithm reduces number of bits, still it cannot compromise loss of information.

$$\text{SpaceSaving}=1 - \frac{Number\ of\ bits\ in\ compressed\ data}{Number\ of\ bits\ in\ uncompressed\ data} \quad (1)$$

Space saving is a second quality measure compression method using compression ratio. This gives the numerical value of storage space saved by the HAAR-EZW method. Equation (1) shows the unity difference of ratio between number of bits in compressed data and uncompressed data gives the storage value of SpaceSaving.

The SPIHT algorithm has been applied to true color images. The notable point is that PSNR values received from true color images using SPHIT are greater than gray color with SPIHT method.

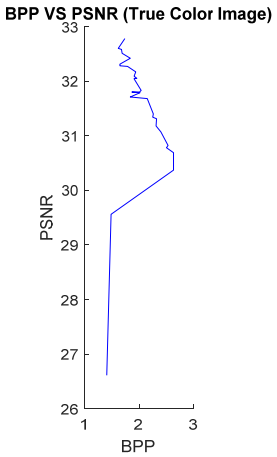


Fig. 6 Comparison of PSNR and BPP for True Color Image

Fig. 7 Sample compressed gray scale images of SPIHT Method and true color images O1,O2,O3,O4,O5

In order to achieve good PSNR and compression ratio, morphological internal gradient method is applied.

Fig. 8 shows the results for test gray scale images. The LVL-MMC compression method is driven by morphological gradient to increase PSNR value. The results of true color

image shows that when the BPP value increased by 0.2, also MSE value is decreasing randomly. The value of PSNR increased excellently. Added with this, compression ratio is reasonably increased. Hence the LVL-MMC subband thresholding method attains commendable PSNR and compression ratio. Thus, several methods are applied to both gray scale and color images. Images are taken in sequence and single forms. The results showed that grayscale image is best for compression. So in prosed work the true color images are converted to gray scale image with same size.

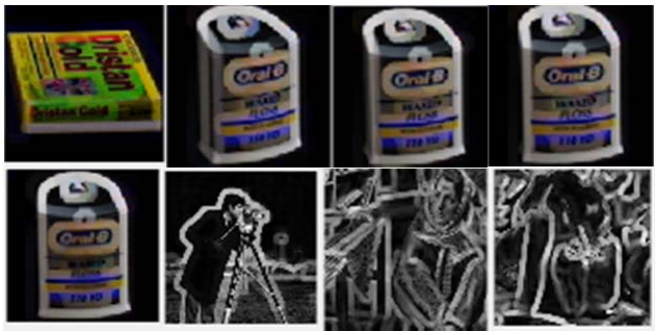


Fig. 8 Morphological gradient applied true color and gray scale images

A. Proposed Morphological Gradient with EZW Compression

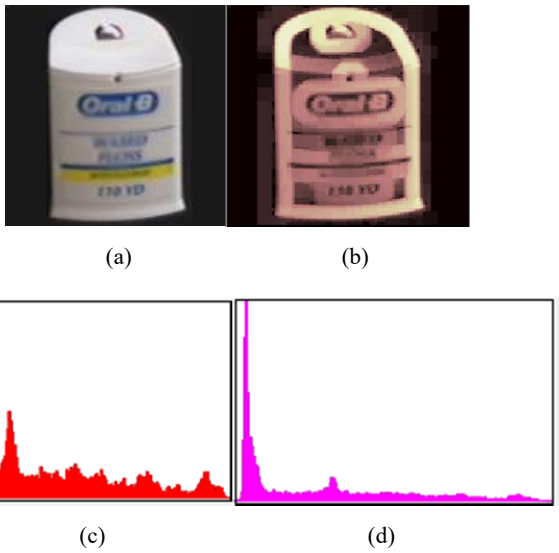
EZW is an edge wise compressed zerotree algorithm, Hence the other name of EZW could be EWZ. In EZW the coefficients are close to zero after the transformation. Among compression methods, Embedded Zerotrees Wavelet method is termed as conventional compression method.

Fig. 9 Morphological Gradient with EZW Compressed Sequence images

Compared to other recent methods, EZW is giving appreciable results in sequence gray color images. Also producing a fully embedded bit stream is one of the good properties of EZW compression. No training data of any kind are required. EZW is a lossy compression method proved again with good compression ratio. Here the levels of HAAR is seven. Number of encoding loops is taken as nine.

The above morphological gradient applied images, Fig. 9, give good compression ratio and quality of image also viewable.

In this work, Fig. 10 (d) normalized histogram Original Image shows that the storage space is higher than compressed Image of Fig. 10 (c).



(a) (b)

(c) (d)

Fig. 10 (a) Original Image, (b) Compressed Gray Scale Image, (c) Normalized Histogram of Original Image, (d) Normalized Histogram of Compressed Gray Scale Image

V. Performance Evaluation

Firstly, the proposed HAAR-MG-EZW compression method is compared with SPIHT, SPIHT-3D, LVL-MMC methods for gray scale images in terms of PSNR (dB) and compression ratio. EZW with morphological gradient compression scheme shows good results than other methods, Fig. 11.

$$\text{PSNR} = 20 \log_{10} \frac{max(Xi)}{RMSE} \quad (2)$$

Here X_i is original data; RMSE is Root Mean Square Error.

Another important measure, Peak Signal Noise Ratio (PSNR) computes the value in decibels, between two true color and gray scale compressed images.

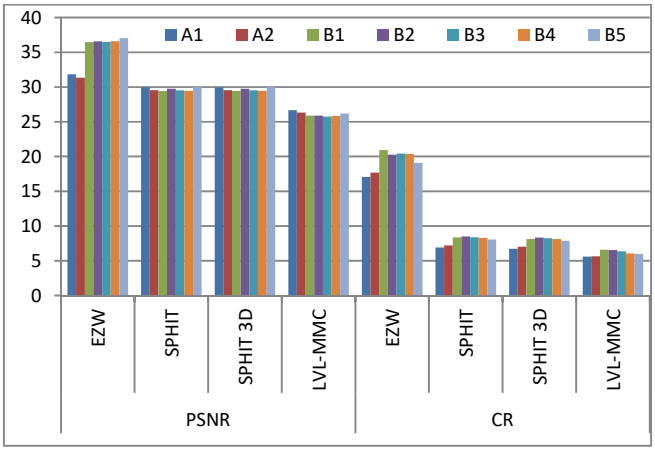


Fig. 11 Evaluation of wavelet based compression methods for HAAR wavelet on gray scale images

The most popular measure to calculate efficiency of a compression algorithm is compression ratio (CR). It is defined as the ratio of bits to store uncompressed data and total number of bits to store compressed data.

$$\text{CR} = \frac{Number\ of\ bits\ in\ uncompressed\ data}{Number\ of\ bits\ in\ compressed\ data} \quad (3)$$

Secondly the HAAR-MG-EZW scheme is compared in terms of BPP for all test images as Fig. 12. EZW-BPP value is 1.67. Hence for true color image, BPP ratio is 24:1.67. This is notably high than other methods. But, the smallest BPP value is 0.45 for LVL-MMC method and BPP ratio is 24:0.45. Here, BPP is an absolute value which represents the average number of bits needed to encode the image pixel information with HAAR-MG-EZW compression scheme.

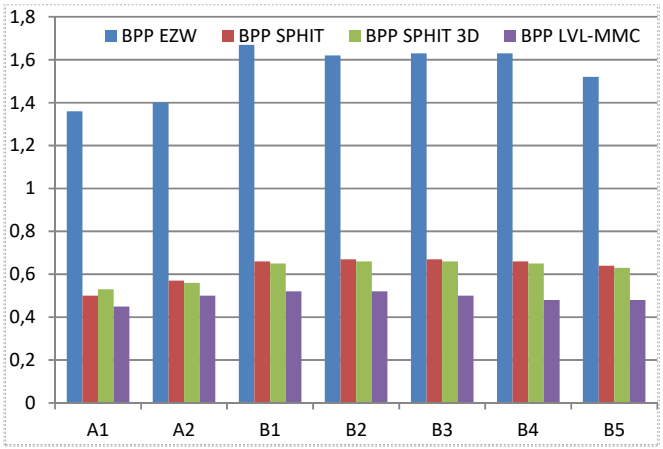


Fig. 12 Bits Per Pixel attained for test images

In Fig. 12, A1, A2, B1, B2, B3, B4, B5 are gray scale sequence images as per Fig. 7.

$$\text{MSE} = \frac{1}{n} \sum_{i=1}^{n} (\text{Xi} - \text{Yi})^2 \quad (4)$$

Here X_i is original data, Y_i is reconstructed data.

TABLE I
MSE FOR SEQUENCE OF GRAY SCALE IMAGES

IMAGES	HAAR-MG-EZW	HAAR-MG-SPIHT	HAAR-MG-SPIHT 3D	HAAR-MG-LVL_MMC
O1	14.72	73.94	73.94	168.5
O2	14.31	69.04	69.07	167.8
O3	14.67	72.62	72.62	**173.4**
O4	14.24	73.81	73.81	169.9
O5	**12.90**	64.90	64.90	156.0

CR% FOR SEQUENCE OF GRAY SCALE IMAGES

IMAGES	HAAR-MG-EZW	HAAR-MG-SPIHT	HAAR-MG-SPIHT 3D	HAAR-MG-LVL_MMC
O1	**20.92**	8.36	8.15	6.6
O2	**20.27**	8.5	8.34	6.54
O3	**20.43**	8.39	8.26	6.34
O4	**20.39**	8.29	8.13	6.06
O5	**19.09**	8.07	7.87	6

The Mean Square Error is used to compare the image quality. This work gives the result such that when the MSE value is low then the quality of compressed image is high. Table I depicts that HAAR-MG-EZW method gives the lowest MSE value 12.90. HAAR-MG-LVL-MMC method shows the highest error value 173.4.

Compression Ratio percentage of EZW is higher than SPIHT, SPIHT-3D AND LVL_MMC methods. In this work, the results of YUV and YIQ color space methods gave high MSE values whereas, KIT and XYZ methods showed low MSE and Max Error values.

VI. Conclusion

Image compression is one of the exceptional applications of data compression to lessen information redundancy in an efficaciously way. Image Reconstruction in overall performance of HAAR Wavelet is vital due to the fact that series of coefficients are used for extraordinary instance of time. The exceptional choice of color space xyz using png image is implemented to series images and different file formats with varying dimensions also evaluated. The end result confirmed that HAAR wavelet method is comparatively faster and much less complexity than other wavelet methods. Experimental effects additionally show that HAAR-EZW is satisfactory in compression ratio. The image satisfactory is relying on the image type and compression ratio. This study confirms that high compression ratio produces low image quality. HAAR_LVL_MMC is good in PSNR value. In consequent sequence image using SPIHT is the best technique in phrases of compression errors and compression ratio.

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