DWT based Approximation Co-efficient Image Compression Technique

Nandeesha R
Research Scholar, Dept of ECE Research Centre,
SJB Institute of Technology, Bengaluru-560060, Karnataka, India
Email: rnandeesha@gmail.com

Dr. Somashekar K
Professor, Dept of ECE,
SJB Institute of Technology, Bengaluru-560060, Karnataka, India
Email: drsomashekar@sjbit.edu.in

Abstract

The proposed paper suggests an image compression and decompression method that simply relies on the approximation coefficients based on three level decomposition of discrete wavelet transformation (3D-DWT). Image compression techniques are essential for storing and processing digital data. Compression lowers the quantity of data, which is vital to explain a picture in bits while maintaining image quality. Compression is achieved by the removal of redundant data. In this process, the encoding strategy is primarily based on a scalar quantized three level approximation sub-band co-efficient, which improves the compression ratio and increases image reconstruction quality. This approach has indeed been tried on a variety of commonly used samples with varying formats of size 256x256 of 8-bit depth and has produced good CR, PSNR, and SSIM values, illustrating the method's advantages.

Keywords-Image compression, DWT, CR, SSIM, PSNR.

1. INTRODUCTION

With the rising interest of video processing such as photos and videos in enormous digital forms of data transferred via communication networks and through the internet, the demand for transmission capacity, storage capacity, and large processing time is increasing [3,4]. High-resolution digital photographs with excellent image quality are becoming increasingly popular. Pixels comprise digital pictures, which are finally stored using bits [4]. Computer images are large and information, requiring greater storage memory. Additionally, data transfer consumes a substantial amount of network capacity. Image compression technologies allow us to significantly reduce image sizes while keeping image quality and integrity [7]. Compression facilitates the storage, transport, and creation of pictures of respectable level. Compression and decompression techniques are particularly beneficial for reducing our visual resources effectively and reversibly, allowing the signal to be rebuilt without quality loss [3]. Transform-based compression improves spatial domain-based compression in picture compression. Image compression is a method of reducing the amount of archiving and sending digital photos. By removing the spatial and spectral components, the goal is to minimize the number of bits necessary to represent a picture to the least achievable level. During compression, image redundancy and irrelevancy are removed. The objective is to minimize the quantity of picture data that has to be provided and preserved. Image compression is divided into two types: lossy and lossless:

Lossless compression: This type of compression shrinks the image in relation to the quantity of data saved. This sort of compression has nothing to do with the original image. This process has no effect on the image's uniqueness.

Lossy compression: This compression approach reduces picture size by removing some information It reduces picture quality while having no effect on image quality [15]. However, because the data compression ratio is relatively large, lossy compression results [16].

The discrete cosine transform (DCT) is a prominent image processing method that is frequently used for image compression due to its excellent energy packing features. DCT is used to translate the data from the spatial domain to the frequency domain [28]. A succession of sinusoidal impulses of varied magnitudes and frequency comprise the image. DCT can produce higher quality even at high data compression ratios. This is known as energy compaction. The lossy image compression uses DCT to compress pictures [24].

Even after compression, lossless compression techniques preserve the original image's information. Lossless image compression methods use DWT and huffman coding [35].

DWT technique is important in lossless picture compression. Lossless image compression excels image quality also improves compression ratio [39]. The PSNR is wisely good with respect to lossless compression.

The aim of this research is to give a grayscale picture compression method with different formats uses DWT and scalar quantization to obtain significant compression ratios while maintaining picture quality. It is employed for a variety of communication tasks, including videoconferencing and the broadcast of television. The paper structure is as: Section 2 offers instances of comparable work. Section 3 includes a full overview of the recommended approach, Section 4 provides comprehensive performance review, and Section 5 discusses results and comparisons.

2. CONNECTED WORK

[1] Proposes a suggestion for a better lossless image compression technique that, Huffman coding and integer wavelet transform (IWT) are combined with output coefficients linear and processing prediction to offer around quadruple compression. The key contribution of this approach is a novel hybrid transform that uses a new prediction pattern and an IWT coefficient processing step. The experimental findings demonstrate that the suggested algorithm outperforms both the most recent approaches and other state-of-the-art algorithms.

[2] suggests a method for 3D medical imaging to improve the calibre of medical images. The encoder employs Huffman encoding, and the decomposition is carried out using the 3D-DWT. Utilizing a mean value approach for thresholding enhances compression while preserving image quality. It takes a little too long to compute. Future research will employ parallel computing strategies with sophisticated progressive coding to reduce the difficulty of these calculations.

[3] suggests a sensible method for image compression based on a variety of color image datasets. The images are divided into sub-images using a 3-level DWT method, and these sub-images are quantized by a non-uniform quantizer before being coded using Huffman code. This reduces complexity and compression ratio while maintaining image quality.
[4] In order to create an effective image compression system, this study modifies the wavelet coefficient and uses wavelet transformations to approximate images. The methods employed are the 2D-daubechies wavelet transformation with large for wavelet coefficients and quantitative presentation using Matlab programming.

Using a hybrid DWT-DCT technique, significant CR and PSNR values may be attained, according to [5]. This method involves first decomposing the input image up to the third level, followed by the separate application of Arithmetic and Huffman coding on the quantization subband on the second and third level coefficients from estimated subband. The simulation results show that huffman coding has a lower CR than arithmetic coding, while having lower PSNR values.
The hybrid compression used in this study [6] enhances the appearance of the rebuilt image. This hybrid method uses Huffman coding on various blocks. The suggested method enhances reconstruction and has a higher PSNR, however it also results in inaccurate contouring and picture artefacts.
DWT and canonical huffman coding were used in [7] to provide a highly compressed image with better PSNR, CR, and BPP. In comparison to conventional huffman coding, this technique requires less processing time and uses a smaller codebook.
This work proposes an algorithm where reconstructed image is constructed using only the approximation coefficient by completely neglecting the detail coefficients. This results in better SSIM when compared with other work [1,2]. The compression ratio is very good compared to [3, 6, 7].

3. METHODOLOGY

This section demonstrates a three-level DWT decomposition-based image compression approach that divides the image's approximation and detail coefficients. To create a compression method, only the approximation coefficient at the third level is finally taken into account.
The proposed system is demonstrated using a collection of standard database test photos such as barbara, Lena, Foreman, Butterfly, fishingboat, peppers and also some unusual images are considered along with different background which includes lady, flower, man, gerunde and bird with different formats such as tif, jpg, png and raw image formats. All images are of size 256x256. The novelty of this work is in the DWT, where first row transformation and then column transformation applied results in eight subbands. Scalar quantization is done as quantisation without threshold and quantization with threshold which is achieved by dividing the intensity values of each pixel by 11. Then huffman encoding is applied to get the compressed image. At reconstruction stage, considered only the approximation coefficient to get the original image by neglecting all detail coefficients which is main features of the proposed work.

Figure 1 depicts an image compression block diagram. The input image is first converted with DWT on three levels and the resulting image with the approximation coefficient is then scalar quantized on three levels. The compressed Image is created using Huffman encoding [2, 4].

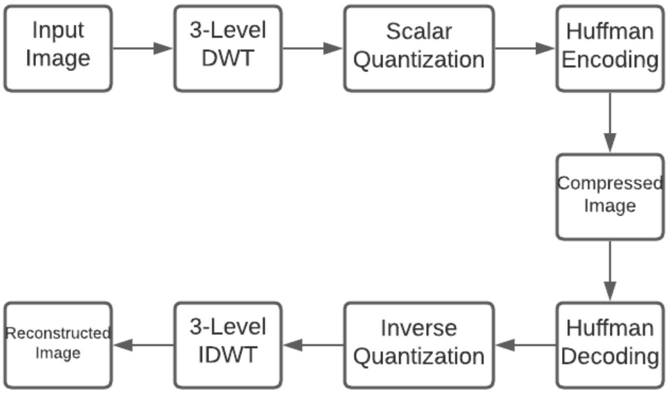


Figure 1. Image compression block diagram

In order to decompress images, wavelet coefficients are obtained. The inverse quantization is created for each of the quantization levels and huffman decoding is used for decoding the data.

A. Images fundamentals & types

By employing the two-dimensional function f, an image may be created (x, y). The intensity or grey level of the picture at each specific location is defined by the amplitude off at that coordinate, where x and y are spatial coordinates. When x, y, and the measured values of f are all finite, discrete numbers, the image is referred to as a digital image. It's critical to select the appropriate file format when working with images. Need to be familiar with the various image file formats and their applications.

A method for storing and arranging a digital image is referred to as an image file format. The proposed algorithm is verifying for different test images formats in jpg, png, tif and raw image formats. All test pictures of databases utilized in this proposed technique are 256x256 in size. A JPEG, often known as a JPG, is a compressed image format in which the image quality declines as the file size increases. PNG, or Portable Network Graphics, format are lossless formats. Format for Tagged Image Files Without losing any information, this format stores image data. It does not perform any picture compression, resulting in a high-quality image with a large file size that is ideal for printing and professional printing. raw files were produced by a camera or scanner. RAW images can be captured by many digital SLR cameras and stored as raw, .cr or .nef files. These photos include a great deal of image data and are comparable to a digital negative. An editor like Adobe Photoshop or Lightroom must be used to modify these pictures. It is used for photos and stores metadata.

B. Discrete Wavelet Transform

Signals with an a typical shape that are local in time and space are called wavelets. A waveform containing a wavelet has an average value of zero and an effective duration of zero. Wavelets are so-called because in addition to oscillating up and down the axis, they integrate to zero. The orthogonality trait is a feature that many wavelets also have, which makes them perfect for tiny signal encoding. This characteristic inhibits overrepresentation of data. There are numerous scaled and shifted representations of a signal that can be created from the original mother wavelet.

To divide a signal itself into the wavelet components, apply a wavelet transform. To discard some of the content, wavelet coefficients could be decimated. The ability of wavelets to spot tiny features in a signal is one of its main advantages. Although enormous wavelets may determine broad details, tiny wavelets can isolate extremely fine characteristics in a signal.

The basic approach to wavelet-based image processing is to

- Calculate an image's two-dimensional wavelet transform.
- The transform coefficients should be changed.
- The inverse transform should be calculated.

DWT offers great insight into the spatial and frequency properties of a picture. A family of transformations known as DWT differs not only in the transformation kernels employed but also in the fundamental characteristics of the functions utilised and the manner in which they are applied. Haar wavelet, Daubechies, Coiflets, Symlets, discrete Meyer, biorthogonal and reverse biorthogonal wavelets are only a few of the wavelets families available. DWT is an efficient approach that provides a mathematical way for layering information based on the level of detail. The wavelet transform is notable for its ability to decompose data at several resolutions. A wavelet-decomposed image can be recreated with the necessary resolution. It comprises of two approaches for obtaining the frequency range that are mutually exclusive. The DWT has the ability to split pictures into several resolution sub-bands [5]. However, majority image information is in the low frequency coefficients, but coefficients of high frequency represent the important visualised data. The computational approach to the DWT demonstrated in the following figure 2.

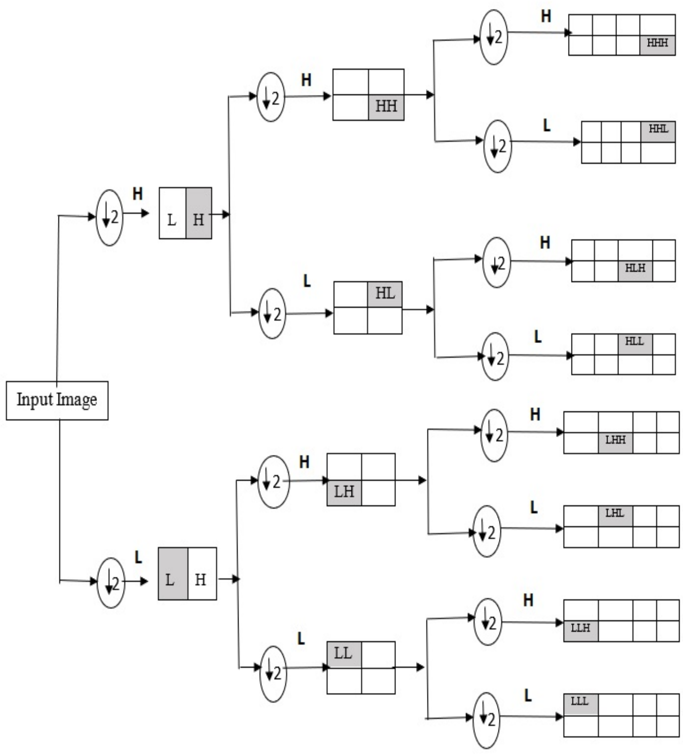


Figure 2. 3D DWT block diagram

Accordingly, the highpass and lowpass decomposition filters outputs—this were mathematically the results of the computation's filtering and down sampling operations—are the DWT coefficients. The two-dimensional DWT is carried out via a two-channel wavelet filter bank. A first level decomposition is obtained by horizontally scanning a picture of size R x C passing it through a low and high pass filters to produce approximation L subband at low frequency and high-frequency H sub-band data in detail. Again, this data is vertically scanned to produce several sub-bands [13]. The LH, HL, and HH sub-bands represent the picture details of dimension R/2 x C/2, which is level two decomposition. The approximation image is the low frequency LL subband that preserves considerable information from the original image. This output is scanned again horizontally, each of the four subbands is divided into There are eight R/2 x C/4 sub-bands, designated as HHH, HHL, HLH, HLL, LHH, LHL, LLH, and LLL, respectively [8]. The decomposition method's main objective is to have as few coefficients in the low and high frequency classifications as is practical. With minimal obvious distortion, the unquantized coefficients are reduced to zero. Haar-wavelet transformation is used in DWT decomposition [10]. The 3-level decomposition representation is shown in figure 3.

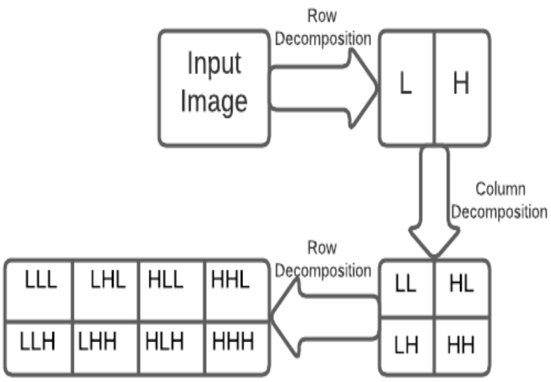


Figure 3. 3-level DWT Decomposition

This guarantees a three-fold division of the specified grayscale picture. The subsequent phase only makes use of the LLL sub-approximation band's co-efficient component and ignores all other detail co-efficient components.

Inverse transformation is carried out to get the image using reconstruction only the approximation coefficients and by setting the detail coefficients to zero.

C. The Scalar Quantization

Quantization, often known as rounding numbers to a certain precision unit, is the act of reducing a sizable a collection of input parameters to a reduced set of values [40]. At the expense of image quality, the DWT quantizes the subband coefficients. Quantization would be a vital component of a compression system, and limiting the amount of bits necessary in order to depict them to optimize compression efficiency [29]. Following the DWT, the energy is primarily held by the approximation components, while the detail component retains partially relevant information such object shapes. The proper approximation frequency values must be transmitted. This results in a string of integer integers that must be bit-by-bit encoded. The quantization steps associated with specific bands are changed to control the image reconstruction's quality [28]. For a high compression ratio, a lengthy quantization phase is required; however, this reduces picture quality and method becomes lossy. The compression is lossless since no quantization step is required. To maintain picture quality, the approximation coefficients (LLL) need a shorter quantization step. The quantization procedure reduces the correctness of the integer by decreasing the amount of bits required to save an integer value. Two types of quantization exist:

- Vector quantization
- Scalar quantization

A set of values are compressed to a quantized value using the lossy compression technique known as quantization in image processing. The image was quantized using scalar quantization because it is simpler than vector quantization. Reduced pixel resolution or the amount of grey levels is a phenomenon known as scalar quantization.

The formula for grey level is $L=2^N$.

Bits per pixel = the number of grey levels (BPP). (N in the formula)

Finding the maximum grey level value of the DWT resulting picture LLL is the first step in scalar quantization. In quantization step done in two steps; without thresholding this is achieved by retaining the original value, with thresholding this is done by dividing the value with 11 in order to limit the number of pixels per bit, which in turn lowers the grey levels. Images that have been quantized are denoted as Q1 and Q11. Inverse quantization is carried out at the final step to get the image reconstruction.

D. Huffman Encoding

For lossless data compression, a The Huffman code is a popular type of optimum prefix code. Huffman coding is used in the procedure of locating or employing such a code. A useful method for compressing photos is Huffman encoding [13]. Huffman coding outperforms others in terms of algorithm complexity and compression impact [20]. The method via means of constructing a binary tree of nodes. These may be kept in a typical array, the dimensions of which varies depending on the number of symbols. The result of the Huffman algorithm may be viewed as a variable-length code table for the encoding of a source symbol. Based on the determined likelihood or the probability (weight) to every potential value of the input symbol, the computer created this table. The symbols' probabilities are shown in decreasing order [7]. Huffman encoding is a fundamental compression method used in video and picture compression standards. The intensity of the pixels or function of intensity mapping output could be utilized as the source symbols for huffman encoding. Unlike the run duration, which only applies to data with periodic values [9], this is appropriate for a variety of values. A code for the actual data is created with the help of this verification.

This kind of coding technique makes use of the frequency measurement of an information variable. This approach requires that data bits be present throughout the encoding process. Fewer bits are used to encode high frequency data bits. The huffman encode dictionary is also useful in linking a codeword for each data symbol. The most crucial aspect of this property was discovered during the encoding processes, which include each codeword having a prefix [16]. A prefix will be assigned to each codeword in the Huffman code dictionary.

This method makes it easier to convert binary string to a character. It decreases the amount of bits required to transmit a series of symbols by using statistical coding. The Huffman encoding method is used to help with data reduction. It has been demonstrated to be the best encoding technique and to produce the finest compression outcomes. [2].
If some symbols occur more frequently than others, this coding may substantially lower the amount of data it carries; however, LZW will not be able to do so. Data has been encoded and a dictionary that will be utilized in the reconstruction process [6]. The technique minimizes the compressed image's bit size. The decoder correctly gets the original data by using the encoded sequence and their code. To retrieve the image from the compressed state, a reverse compression approach is used [9]. The encoded string and their code are used by decoder to effectively retrieve the actual data.

E. The suggested flowchart

The proposed approach is developed by discrete wavelet decomposition of the picture in three stages. DWT is one of the most effective compression methods. It offers a method for stacking data according on the degree of detail. In this work, the haar wavelets serve as the foundation for transformation functions. A collection of low pass and high pass filters make up the filter bank in the Haar wavelet transformation. Scalar quantization and huffman encoding are used to reduce the redundant information in the DWT detail coefficients. The proposed approach is built on the characteristics of the DWT coefficients. The Huffman coding technique is used to lower the bit size of the compacted picture. Huffman coding makes use of the regularity that a data object appears (pixel in images). The objective is to express data that occurs more frequently with fewer bits. A Code Book, and this may made for each image or for a group of photographs, is used to keep track of codes. The encoded sequence and their coding are used by the decoder to precisely retrieve the original data. The compressed image is reversed through the compression process to retrieve the original image. Before the indices can be recovered, the data that has been Huffman encoded must first be decoded. The inverse discrete wavelet transform is used to retrieve the original image (IDWT). Peak Signal to Noise Ratio (PSNR) and Compression Ratio (CR) have both been used to rate the quality of compressed images (PSNR). Eexperimentation outcomes show that the recommended method makes available a sufficient higher compression ratio when compared to existing compression thresholding strategies. The proposed procedure is as shown.

Proposed Algorithm

Step: 1 Start the process by selecting a greyscale image as an input.
Step: 2 Apply DWT to decompose using row/column procedure to divide into L &H, then the image using 2-DWT to divide it into four sub-bands (LL, LH, HL, and HH). Last but not least, approximation (LLL) & detailed coefficients into eight sub-bands (LLH, LHL, LHH, HLL, HLH, HHL, HHL).
Step: 3 Think of the LLL sub-band (Approximation coefficients), without thresholding means without changing the intensity called Q_1 and with thresholding means divide the intensity by 11 results in Q_{11}.
Step: 4 Apply Huffman encoding to quantized images captured at different quantization levels to provide a range of encoded data. Determine the encoded length.

Step: 5 The encoded data is decoded using the Huffman Decoding method, and the decoded data is reshaped to generate an image.
Step: 6 All quantization levels are applied to the decoded image via inverse quantization.
Step: 7IDWT is used in order to rebuild with an inverse quantized image and additional zero-filled sub-bands.
Step: 8 Calculate the SSIM, PSNR, MSE, original image length, encoded length, and CR of the input and image reconstructions.

4. EVALUATION OF PERFORMANCE

Several performance measures can be used to assess the effectiveness and performance of the suggested compression algorithms. Those are
PSNR (peak signal to noise ratio):
PSNR is a statistic for evaluating the quality of compressed pictures.
The PSNR [5] for the general case of 8-bit images is given as
$psnr(dB) = 10log10\ (255^2/mse)$ ——-(1)

where the highest possible value that the picture data might possibly obtain is 255.
MSE (Mean-square error):
MSE calculates the total error squared between the original picture and the compressed image. This denotes the image's mean squared error, which is denoted by the formula
$mse = \frac{1}{n}\sum i \sum j\ (X(i,j) - Y(i,j))^{\wedge}2$ ——— (2)
MSE = 1/n, where n is the total number of pixels, Y(i,j) denotes the value of a pixel in the compressed image, and X (i, j) denotes the value of a pixel in the original image.
CR (Compression Ratio):
Compression ratio (CR) is the ratio of total number of bits in the original image divided by the number of bits in the compressed image.
This follows in terms of math:
Where Ycompressed is the compressed image and Xoriginal is the original image, the formula
CR = $\frac{Ycompressed}{Xoriginal}$ ————— (3)
SSIM (Structure Similarity Index):
The similarity between the actual and compressed pictures is measured using the SSIM technique. [32].
The following is the formula for SSIM:
SSIM=$\frac{(2\mu_f\mu_{-f}+C_1)(2\delta_{f-f}+C_2)}{(\mu_f^2+\mu_{-f}^2+C_1)(\delta_f^2+\delta_{-f}^2+C_2)}$ —— (4)
Here, f represents the original image and -f represents the rebuilt image. The constants C1 and C2 represent, respectively, the average grey value and the variance.
BPP (Bits Per Pixel):
The BPP is defined as the ratio between the total number of bits and the total number of pixels in the compressed image [36].

$$BPP = \frac{Size\ of\ the\ compressed\ \ image}{Total\ no.\ of\ Pixel\ in\ the\ image} \quad \_\_\_\_(5)$$

5. *RESEMBLANCE*

The proposed method is implemented using Matlab software.

A. Results

The proposed algorithm's outcomes have been assessed utilising performance evaluation criteria. Table 1 illustrates the performance metrics for various image types acquired without thresholding, which is accomplished by keeping the intensity values represented by Q_1 constant. Table 2 lists the performance metrics that were acquired for various image types using thresholding, which is accomplished by dividing the intensity quantization level by 11 and represented as Q_{11}, with regard to various test images.

Table 1. Different types of images with CR, MSE, PSNR & SSIM without threshold.

TYPE	IMAGES	CR	MSE	PSNR (dB)	SSIM
TIFF	Barbara	7.3389	175.5452	25.6869	73.721
	Butterfly	7.3451	578.7575	20.5058	75.3236
	cameraman	7.6187	354.5092	22.6345	77.0932
	fishingboat	7.5624	225.8737	24.5921	74.3407
	foreman	7.5925	61.2547	30.2594	87.2274
	Lena	7.3132	202.0065	25.0772	77.5066
	peppers	7.1588	211.2256	24.8833	79.8264
JPG	barbara	7.3391	180.8419	25.5578	72.7523
	cameraman	7.6041	360.6776	22.5596	76.6382
	lady	6.9066	382.4112	22.3055	74.8038
	Lena	7.3086	284.1327	23.5956	72.2748
	flower	7.2149	238.3093	24.3594	71.7936
	man	7.1708	199.2687	25.1364	74.4522
PNG	gerunde	7.6476	76.6964	29.2831	90.5763
	bird	7.5023	73.1843	29.4866	91.2265
	lady	7.424	98.4998	28.1964	74.6291
	Lena	7.3089	224.1106	24.6262	53.7993
	flower	7.6594	89.5245	28.6114	81.8871

Table 2. Different types of images with CR, MSE, PSNR & SSIM with threshold.

TYPE	IMAGES	CR	MSE	PSNR (dB)	SSIM
TIFF	Barbara	11.824	186.7173	25.4190	73.2418
	Butterfly	11.801	590.1395	20.4213	74.9468
	cameraman	12.545	365.127	22.5064	76.0471
	fishingboat	12.41	237.1441	24.3807	73.8323
	foreman	12.195	72.2261	29.5439	86.4614
	Lena	11.784	213.3524	24.8398	76.945
	peppers	11.381	222.4168	24.6591	79.2364
JPG	barbara	11.827	191.7448	25.3036	72.4042
	cameraman	12.525	370.9389	22.4378	75.6979
	lady	10.703	393.3814	22.1827	74.4777

	Lena	11.769	295.209	23.4295	71.8423
	flower	11.482	249.283	24.1639	71.4918
	man	11.4	210.1383	24.9058	74.0747
PNG	gerunde	12.605	88.1273	28.6797	89.5334
	bird	12.037	84.8792	28.8428	90.2751
	lady	12.002	109.2883	27.7451	72.7926
	Lena	12.927	235.4489	24.4118	51.4838
	flower	12.651	100.5692	28.1062	80.9836

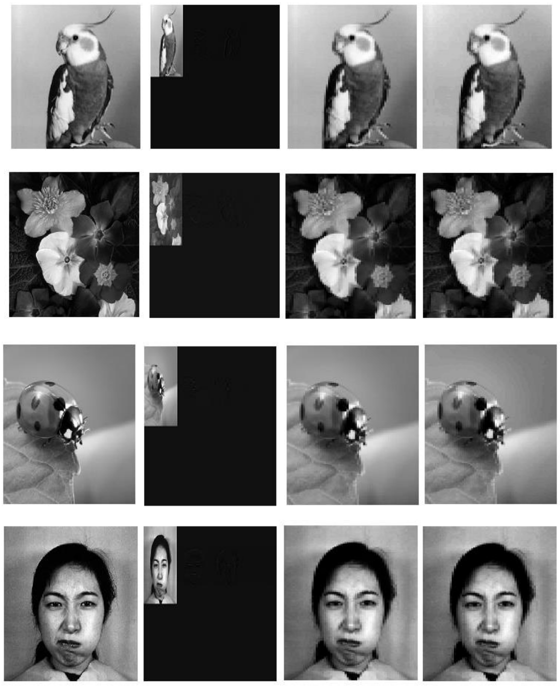
B. Images

The suggested method is tested on a number of images by utilizing DWT to divide the image into three levels, followed by huffman encoding, scalar quantization, and finally coding. Figure 4 shows the TIF format original images of size 256x256, three level DWT, image reconstruction without thresholding and image reconstruction with thresholding. where various images are considered.

(a) (b) (c) (d)

Figure 4 (a) Original Image (tif) 256x256, (b) three level DWT Sub-Image, (c) Image Reconstruction without threshold, (d) Image Reconstruction with threshold

Figure 5 shows the PNG format original images of size 256x256, three level DWT, image reconstruction without thresholding and image reconstruction with thresholding. where various images are considered.



(a) (b) (c) (d)

Figure 5: (a) Original Image (png) 256x256, (b) three level DWT Sub-Image, (c) Image Reconstruction without threshold, (d) Image Reconstruction with threshold

Figure 6 shows the JPG format original images of size 256x256, three level DWT, image reconstruction without thresholding and image reconstruction with thresholding. where various images are considered.

(a) (b) (c) (d)

Figure 6 (a) Original Image (jpg) 256x256, (b) three level DWT Sub-Image, (c) Image Reconstruction without threshold, (d) Image Reconstruction with threshold

Simulations are carried out using MATLAB R2020b. Matlab2020b is used because it is easy to use. The image processing tools in MATLAB is significantly utilized in this work. When done in MATLAB, image processing and method implementation are more straightforward and effective. Finding a solution to any image processing problem is simple because to the picture decomposition and compression features. Although several programming languages can be used for image compression, MATLAB's inclusion of libraries and functions makes it simpler to carry out picture compression.

In experiments, images of various sizes—from 256 x 256 to 128 x 64—are used. These images are then subjected to quantization, which further reduces the image bit size, and encoding, which further reduces the amount of bits needed for data representation. Finally, all of these stages are reversed to give the reconstructed picture, which is the actual size of 256 × 256. Figure 4, 5 & 6 displays the original 256x256 image and the image reconstruction for various levels.

The suggested approach offers a decomposition structure that includes detail and approximation coefficients. using lossless picture compression, provides good quality as well. Both the compression and computation performances are strong. The suggested approach provides higher resolution photos with higher compression ratios and improved image quality.

C. Comparison:

The comparison results of the different formats images where CR, MSE, PSNR and SSIM are compared for without thresholding and with thresholding quantization. Figure 7 shows the Flow graph of quantization without thresholding for various different format of images.

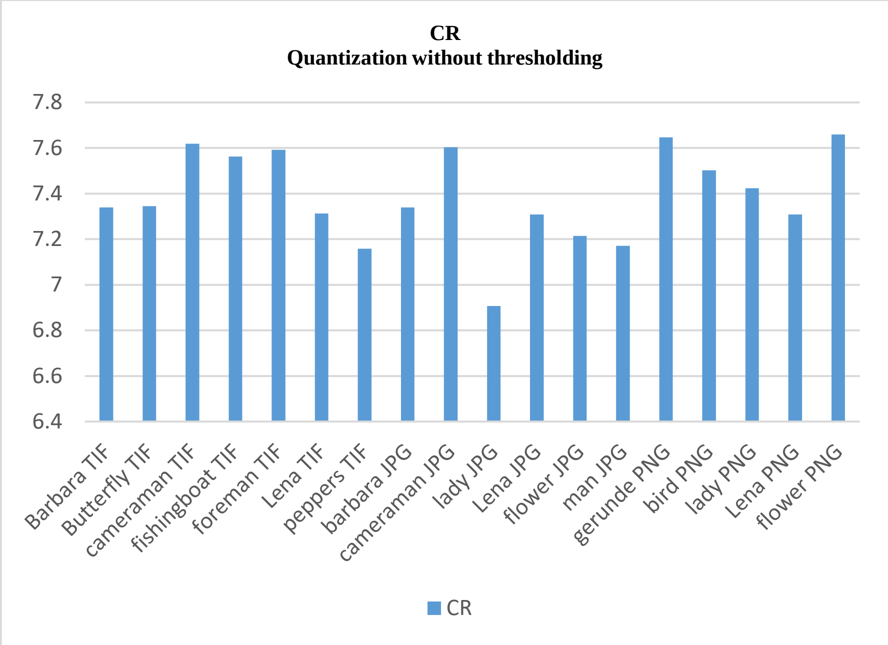


Figure 7 Flow graph of CR quantization without thresholding for various images

Figure 8 shows the Flow graph of quantization with thresholding for various different format of images.

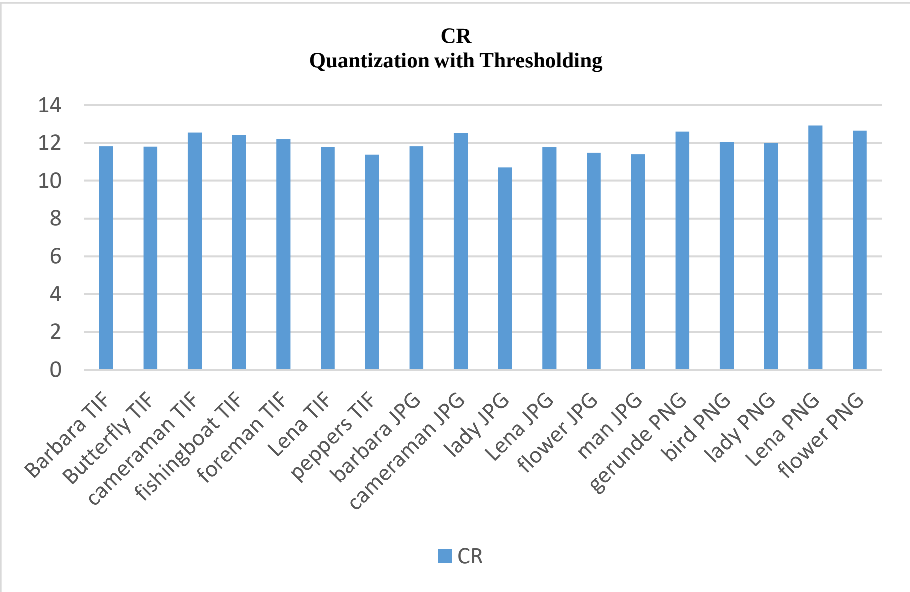


Figure 8 Flow graph of CR quantization with thresholding for various images

Figure 9 shows the Flow graph of MSE without thresholding for various different format of images.

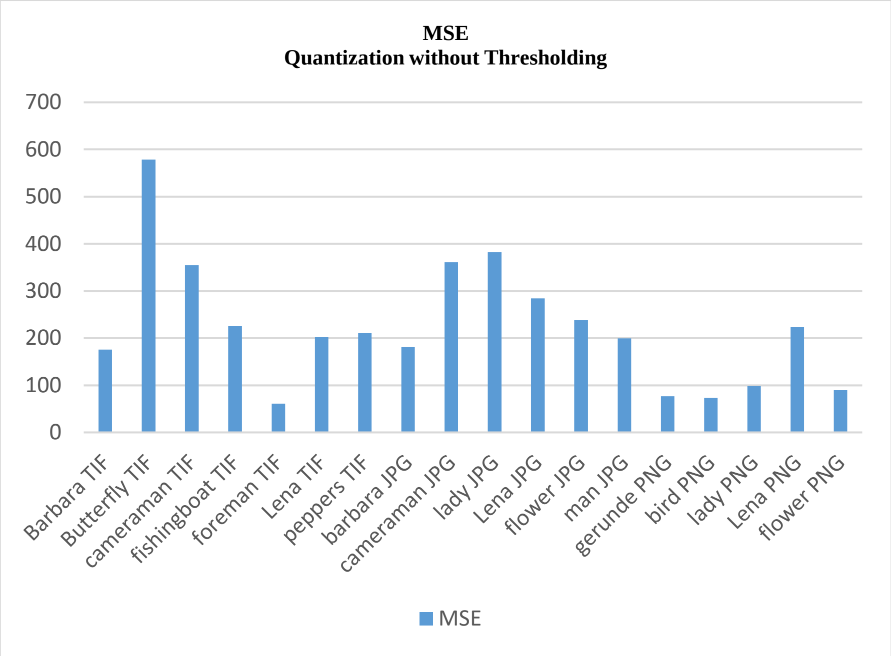


Figure 9 Flow graph of MSE without thresholding for various images

Figure 10 shows the Flow graph of MSE with thresholding for various different format of images.

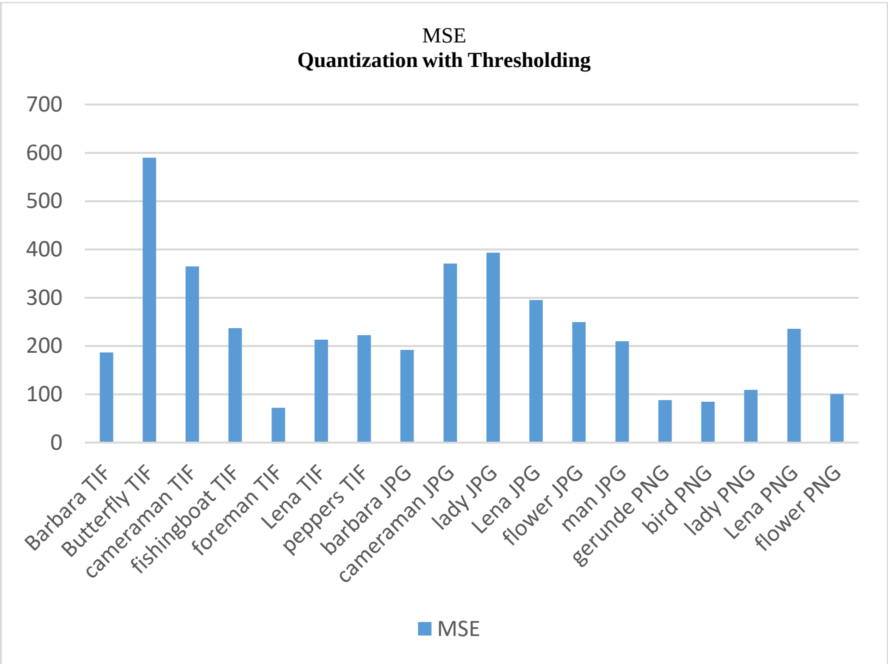


Figure 10 Flow graph of MSE with thresholding for various images

Figure 11 shows the Flow graph of PSNR without thresholding for various different format of images.

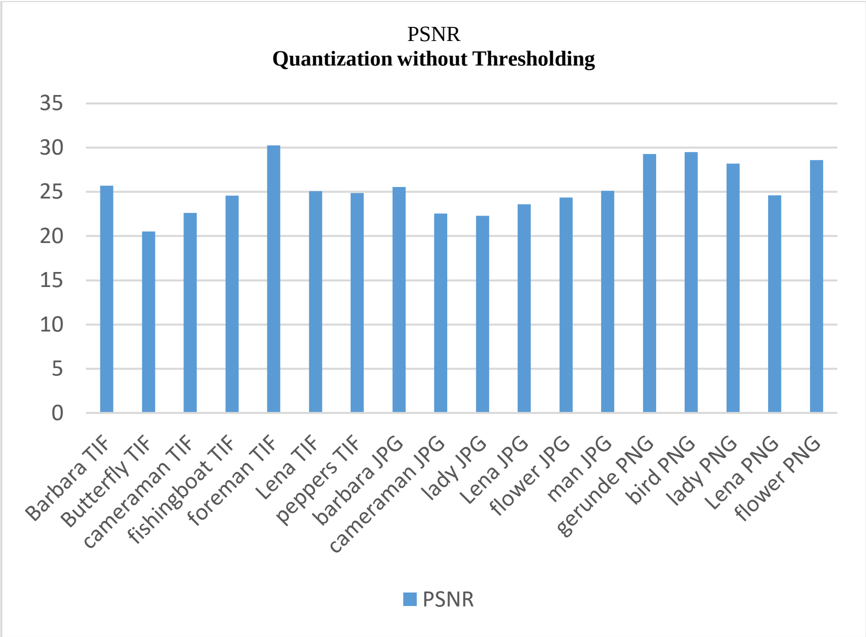


Figure 11 Flow graph of PSNR without thresholding for various images

Figure 12 shows the Flow graph of PSNR with thresholding for various different format of images.

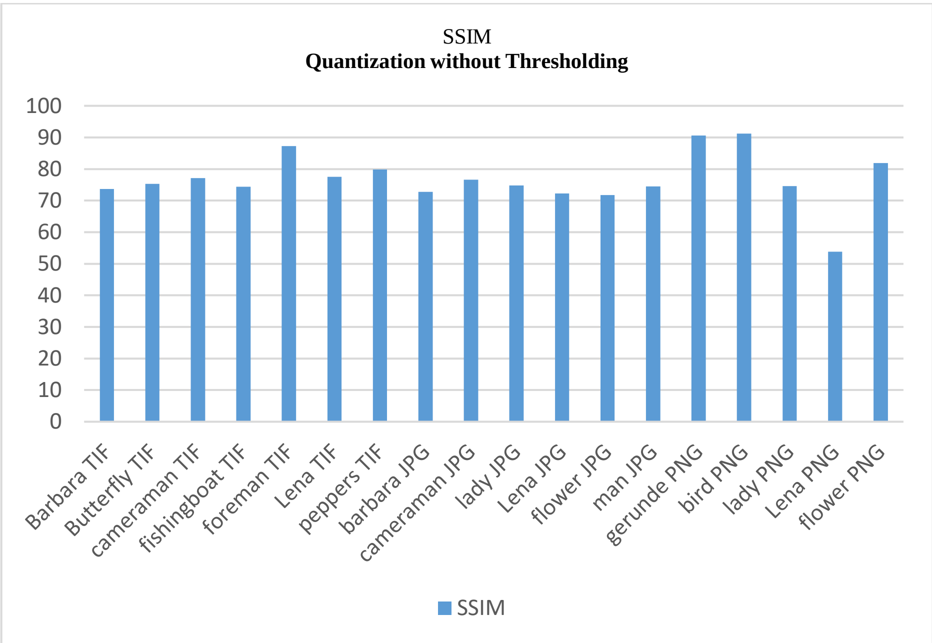


Figure 12 Flow graph of PSNR with thresholding for various images

Figure 13 shows the Flow graph of SSIM without thresholding for various different format of images.

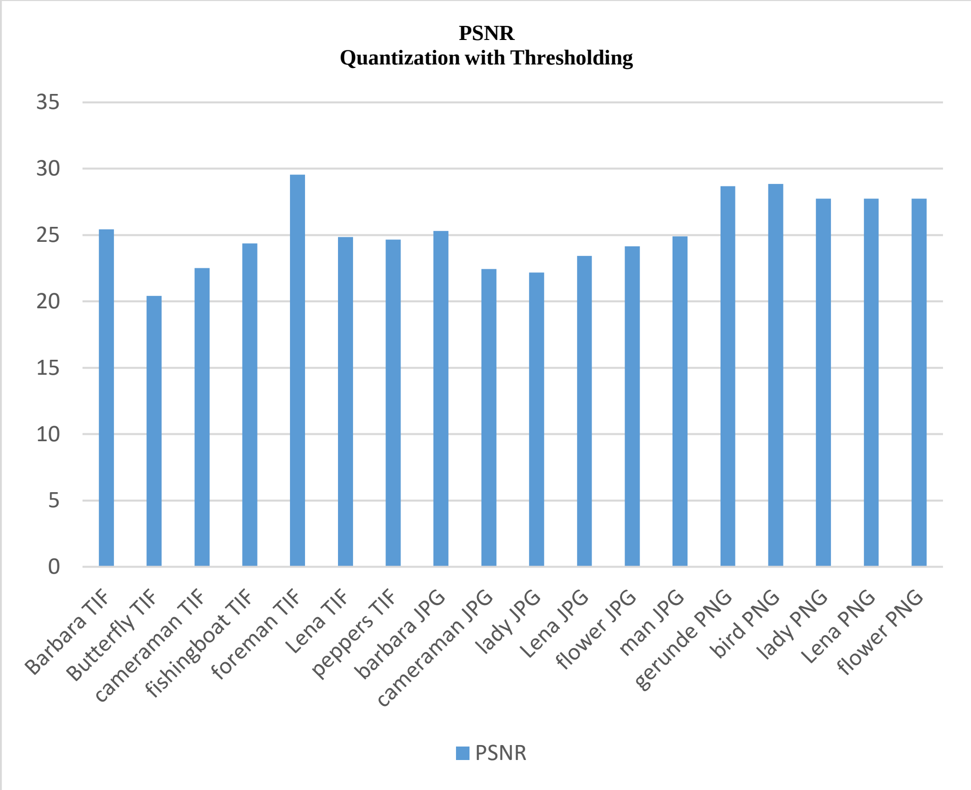


Figure 13 Flow graph of SSIM without thresholding for various images

Figure 14 shows the Flow graph of SSIM with thresholding for various different format of images.

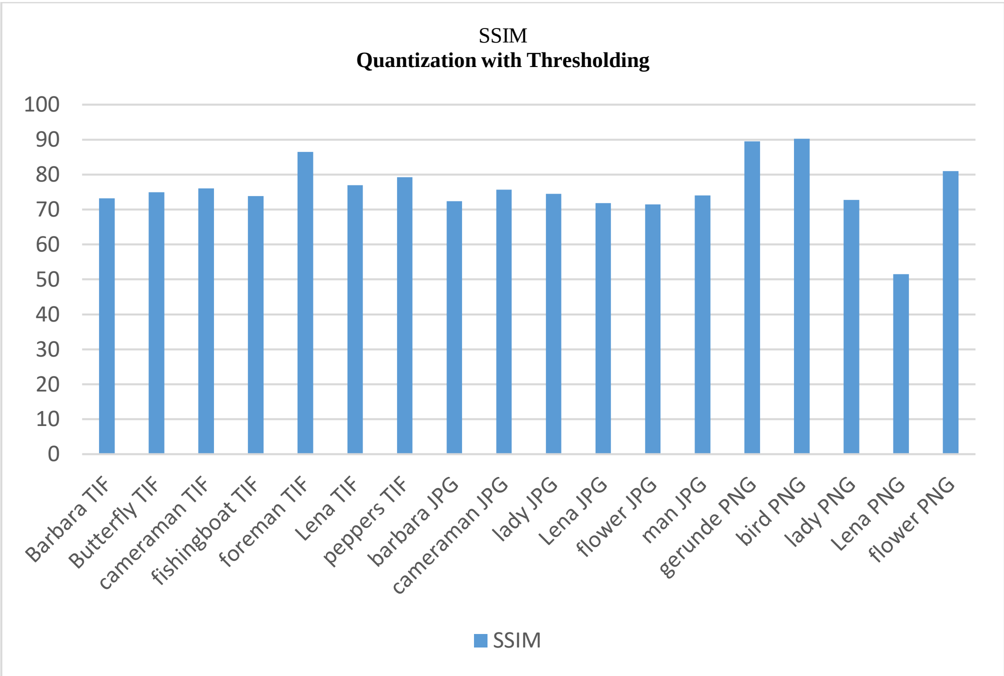


Figure 14 Flow graph of SSIM with thresholding for various images

6. CONCLUSION

To compress and decompress an image, a approximation DWT compression technique is applied. This method results in greater data compression. Following DWT, scalar quantization is used to represent the approximation coefficients level with less weight, allowing each quantized level to be coded with fewer bits. Huffman encoding ensures great compression and a good SSIM. Scalar quantization has the potential to lessen the amount of bits necessary in a pixel-based picture to encode an image size. The inverse coder employs a large similarity index to recreate an image, but the encoder uses fewer bits to represent picture data. This analysis is validated in terms of image storage and digital transmission by comparing anticipated PSNR and CR values to those of different systems. As a result, when compared to other picture formats, this approach has the possibility of being extremely beneficial for image compression.

ACKNOWLEDGMENT

Visvesvaraya Technological University, Jnana Sangama, Belagavi - 590018, Karnataka, India provided support for the study.

REFERENCES

[1] S. UmaMaheswari · V. SrinivasaRaghavan, "Lossless medical image compression algorithm using

[2] Ankur Gupta., et al., "Implementing lossless compression during image processing by integrated approach", Emerging Trends in Materials Science, Technology and Engineering. October 2020.

[3] Mohammed Babatunde Ibrahiim, Kazeem Allagbe Gbollagade, "Performance enhancement of Huffman coding image compression with chinses reminder theorem", Annals. Computer Science Series. 17th Tome 2nd Fasc. – 2019.

[4] Paul Nii Tackie Ammah, Ebenezer Owusu, "Robust medical image compression based on wavelet transform and vector Quantization", Informatics in Medicine Unlocked 15 (2019) 100183, Published by Elsevier Ltd.

[5] Md. Atiqur Rahman & Mohamed Hamada, "A semi-lossless image compression procedure usinga lossless mode of JPEG", 2019 IEEE 13th International Symposium on Embedded Multicore/Many-core Systems-on-Chip (MCSoC).

[6] Yusra Ahmed Salih., et al., "Improved Image Compression Scheme Using Hybrid Encoding Algorithm", Kurdistan Journal of Applied Research · October 2019.

[7] Abhilasha Sharma., et all., "*Image Compression and Sparsity Measurement by using Multilevel and Different Wavelet Functions",* Proceedings of the Third International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC 2019) IEEE Xplore.

[8] Arka Provo Mukhopadhyay., et.al., "*ROI based Medical Image Compression using DWT and SPIHT Algorithm",* 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN).

[9] Shree Ram Khaitu & Sanjeeb Prasad Panday, "Fractal Image Compression Using Canonical Huffman Coding", *Journal of the Institute of Engineering January 2019, Vol. 15 (No. 1): 91-105*

[10] Sandhya Kadam and Vijay Rathod, "Medical and Color Image Compression with Fractal Quadtree with Huffman Coding for Different Threshold Values", *Computing, Communication and Signal Processing*, Advances in Intelligent Systems and Computing 810, 2019.

[11] Md. Atiqur Rahman and Mohamed Hamada, "Lossless Image Compression Techniques: A State-of-the-Art Survey", Symmetry 2019, Vol 11, 1274;

[12] S. Boopathiraja, P. Kalavathi, "A Near Lossless Multispectral Image Compression using 3D-DWT with application to LANDSAT Images", International journal of computer science and engineering, Vol 6, Spl issue 4, may 2018.

[13] Md.Atiqur Rahman, et.al., "Histogram modification based lossy image compression scheme using Huffman coding", 4th International Conference on Electrical Engineering and Information & Communication Technology, IEEE 2018.

[14] Rana Krisnanda.,et.al., "Huffman Coding Medical Image Watermarking with Compressive Sensing L1 Norm", 2018 3rd International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE), Yogyakarta, Indonesia.

[15] Ajala F. A.,et.,al., " Development of Hybrid Compression Algorithm for Medical Images using Lempel-Ziv-Welch and Huffman Encoding", International Journal of Recent Technology and Engineering (IJRTE), Volume-7 Issue-4, September 2018.

[16] Priyanka Chouksay& Prof. Neha Rathore, "Survey Paper on Image Compressor using Discrete Wavelet Transform and Block Based Image Coding", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 7, Issue 12, December 2018.

[17] Irma Safitri., et.al., "Wavelet Huffman Coding Image Watermarking in the Presence of Compressive Sensing", 2018 3rd International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE), Yogyakarta, Indonesia.

[18] Shaurya Agarwal, et.al., "Multidimensional Compression of ITS Data Using Wavelet-Based Compression Techniques", IEEE Transactions on intelligent transportation systems, vol 18, NO. 7, July 2017.

[19] Priya Vasanth Sundara Rajan* and A. Lenin Fred, "An Efficient Compound Image Compression Using Optimal Discrete Wavelet Transform and Run Length Encoding Techniques", Journal of Intelligent. System. 2017.

[20] Uday Bhade., et al., "*Comparative study of DWT, DCT, BTC and SVD Techniques for Image Compression",* Proceeding International conference on Recent Innovations is Signal Processing and Embedded Systems (RISE-2017) 27-29 October,2017.

[21] P. Kalavathi and S. Boopathiraja, "A Wavelet Based Image Compression with RLC Encoder", Computational Methods, Communication Techniques and Informatics.

[22] Md.Atiqur Rahman, et.al., "Histogram modification based lossy image compression scheme using Huffman coding", 4th International Conference on Electrical Engineering and Information & Communication Technology, IEEE 2018.

[23] Rana Krisnanda.,et.al., "Huffman Coding Medical Image Watermarking with Compressive Sensing L1 Norm", 2018 3rd International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE), Yogyakarta, Indonesia.

[24] Ajala F. A.,et.,al., " Development of Hybrid Compression Algorithm for Medical Images using Lempel-Ziv-Welch and Huffman Encoding", International Journal of Recent Technology and Engineering (IJRTE), Volume-7 Issue-4, September 2018.

[25] Priyanka Chouksay& Prof. Neha Rathore, "Survey Paper on Image Compressor using Discrete Wavelet Transform and Block Based Image Coding", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 7, Issue 12, December 2018.

[26] Irma Safitri., et.al., "Wavelet Huffman Coding Image Watermarking in the Presence of Compressive Sensing", 2018 3rd International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE), Yogyakarta, Indonesia.

[27] Shaurya Agarwal, et.al., "Multidimensional Compression of ITS Data Using Wavelet-Based Compression Techniques", IEEE Transactions on intelligent transportation systems, vol 18, NO. 7, July 2017.

[28] Priya Vasanth Sundara Rajan* and A. Lenin Fred, "An Efficient Compound Image Compression Using Optimal Discrete Wavelet Transform and Run Length Encoding Techniques", Journal of Intelligent. System. 2017.

[29] Uday Bhade., et al., "*Comparative study of DWT, DCT, BTC and SVD Techniques for Image Compression",* Proceeding International conference on Recent Innovations is Signal Processing and Embedded Systems (RISE-2017) 27-29 October,2017.

[30] P. Kalavathi and S. Boopathiraja, "A Wavelet Based Image Compression with RLC Encoder", Computational Methods, Communication Techniques and Informatics.

[31] Allaeldien Mohamed G. Hnesh, Hasan Demirel, "*DWT-DCT-SVD based Hybrid lossy image compression technique",* IEEE IPAS'16: International image processing applications and systems conference 2016.

[32] Ahmed A. Nashat, N. M. Hussain Hassan, "Image Compression Based upon Wavelet Transform and a Statistical Threshold", International Conference on Optoelectronics and Image Processing. 2016.

[33] Rachit Patel et al., "A Fast and Improved Image Compression Technique Using Huffman Coding", IEEE WiSPNET 2016 conference.

[34] Gaurav Kumar et all., "A Review: DWT-DCT Technique and Arithmetic-Huffman Coding based Image Compression", *Published by MECS Publisher. Modern Education and Computer Science.2015*

[35] Mridul Kumar Mathur & Gunjan Mathur, "Image Compression Using Wavelet Transform", International Journal of Engineering Research & Technology (IJERT) ETRASCT' 2014 Conference Proceedings.

[36] En-Hui Yang et al., "Quantization Table Design Revisited for Image/Video Coding", IEEE Transactions on image processing, Vol 23, No 11 Nov 2014.

[37] Y.Sukanya, J.Preethi " Analysis of image compression algorithms using wavelet transform with GUI in Matlab", IJRET: International Journal of Research in Engineering and Technology, Volume: 02 Issue: 10, Oct-2013.

[38] Sandeep Kaur, et al., "A Review: Various Wavelet Based Image Compression Techniques", IJSR – Int journal of scientific research Volume 2, Issue: 5, May 2013.
[39] M. Mozammel Hoque Chowdhury and Amina Khatun, "Image Compression Using Discrete Wavelet Transform", IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 4, No 1, July 2012.
[40] Nik Shahidah Afifi Md et al," Image compression using wavelet algorithm", International Seminar on the Application of Science & Mathematics 2011.
[41] Mamta Sharma, "Compression Using Huffman Coding", IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.5, May 2010.
[42] Zhou Wang et al., "Image Quality Assessment: From Error Visibility to Structural Similarity", IEEE Transactions on image processing, VOL. 13, NO. 4, April 2004.
[43] Yu-Chen Hu, et al., "A new lossless compression scheme based on Huffman coding scheme for image compression", Signal Processing: *Image Communication* 16 (2000) pp 367-372.