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SPIHT BASED IMAGE COMPRESSION USING QUADTREE DECOMPOSITION

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ABSTRACT

Contemporary lightweight devices such as mobile phones, cellular sensor systems, and high-consumption power devices, low-complexity picture compression techniques are critical. Low small bit rate and acceptable picture quality are vital criteria in such applications. This study offers low and average complexity methods for the picture mentioned above compression issue. The first will be level focused adaptive quantization coding, while the second will be a combination of discrete wavelet transforms and the depth established adaptive quantization coding method. Adaptive quantization coding provides a good peak signal to noise ratio (PSNR), but at the expense of a high little rate compared to other simple methods. The proposed methods generate a low small bit rate while maintaining an acceptable PSNR and picture quality. The acquired findings indicate a decent rate decrease with the same PSNR, or just a little less than any solo adaptive quantization coding algorithm's PSNR. Decomposing the type image using various wavelet filters and intensity focused adaptive quantization coding resulted in a bit of rate reduction. The suggested method includes several parameters that may be tweaked to alter the compressed image's performance. To improve picture compression, the Set Partitioning in Hierarchical Trees (SPIHT) method was recommended, based on the previous scanning of the coefficients around which there were more significant. Before being coded, the coefficients or items were ordered by the degree of significant coefficients. The more recent significant coefficients were preferable when the devices around us with significant coefficients were scanned. The findings of the experiments indicate that the approach can enhance PSNR and evident subjective experience compared to SPIHT.

Keywords: Image Compression; Wave; style; styling; insert (keywords)

INTRODUCTION

Image compression is defined as applying a suitable copy function to a visual signal to limit a wide range or programme of bandwidth restriction or bitrate reduction to a visual signal to fit it within the confines of a channel with a lower capacity. In general, it may be described as a technique that entails finding ways to reduce the size of picture documents while retaining critical information. The fact that adjacent pixels are typically linked and carry the same information is a common feature of pictures. The most important thing to do now is to determine the image's least correlated representation. The following are two crucial components of compression:

(i) Redundancy

(ii) Irrelevancy lowering.

The primary reason for picture compression is the massive storage devices needed for most photographs. Almost all commercial and private companies are heading toward a "paperless" workplace, producing large-scale pictures, multimedia databases, and complex and costly transmission systems. For quicker and easier communication, people are using a variety of transmitting equipment and methods such as Standard Packet Radio Service (GPRS), Multimedia Messaging Services (MMS), ONLINE VIDEO transmission, HI-DEF Television (High definition television), Video Instructional Conferencing. The bulk of these interactions need pictures, which

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must be sent quickly and effectively, resulting in market demand for improved compression algorithms[1].

In terms of compression rate and low bit rates, several current picture compression methods work well. However, pictures that need specific treatment during compression, such as doc images, standard substance images, facsimile images, decrease their performance.

Image compression is a field that has been the subject of study for more than 35 years. However, owing to the rising need and technology for new communication and storage devices, there is constantly a reliance on new, better compression algorithms. This project is one effort at developing a few picture compression methods.

In the media, entertainment, and other fields, many types of pictures are trusted. They may be realistic or photographic pictures, collected arts, designs, maps, all of which have unique management and compression requirements[2]. Many experts have proposed lossy compression methods for natural pictures with significant deficient consistency components, few components with a high recurrence rate, and more extensive derivatives.

The main aim for this function was to "develop up compression methods that can compress colour pictures rapidly and reduce the compression rate for still colour photographs while maintaining a high level of visual quality."

Four new methods based on wavelets and wavelet packets are proposed and shown below.

i) Mostly Wavelet-based Color Image Compression[12].
ii) Log Energy Entropy Wavelet Packet Image Compression[12]
iii) Quadtree Decomposition[12]
iv) Set Partition in Hierarchical Tree (SPIHT)[11] is a fourth option.

Figure 1 depicts the suggested method utilized in this study.

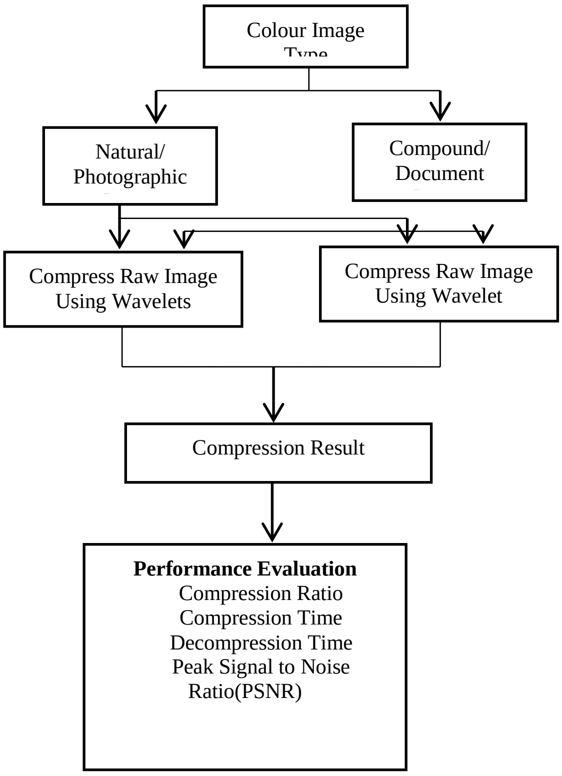

Fig. 1. Proposed Methodology

The following two goals are common to all of the systems, as mentioned earlier.

i) Use wavelets to reduce the size of colour pictures.

ii) Using PSNR, compression percentage, and execution acceleration, evaluate the performance of wavelet-based compression methods.

Colour pictures are used as test images in all of the proposed methods, and the term "images" throughout this dissertation refers to solely colour photographs.
The study's overarching aim is to develop a few practical and successful colour picture compression methods that can satisfy the needs of minimal storage space while maintaining high visual quality and using less time. The following is a breakdown of the work. Several researchers have addressed compression and the numerous possible methods linked to this study effort, classified as "high tech" in Section 2. Section 3 discusses the research's issue description, and the following suggested method, wavelet packet image compression utilizing Set Partition in Hierarchical Tree (SPIHT). Section 4 contains a comprehensive explanation of the proposed ingredient image compression method, including experiments and results, as well as a description of the suggested combination picture compression utilizing wavelet packets. The closing comments and planned expansion efforts are described in section 5. Several researchers' work is cited and utilized as support for the ideas presented in this paper.

RELATED WORK

Several researchers have done extensive picture compressing research. This section provides a short overview of a few critical contributions from the current literature. The wavelet transform's power has recently been studied and improved in the picture compression community. When methods to decompose discrete temporal signals were developed in 1976, Discrete Wavelet Transform (DWT) foundations were laid. Similar work was done in the field of subband coding, which is a kind of signal coding. Pyramidal coding, which is comparable to subband coding, was invented in 1983. Many refinements to these coding methods were developed afterwards, resulting in effective multiresolution analysis systems. Various image coding algorithms have been created based on DCT and DWT. This section discusses a few of them that are relevant to this study[3].

A. Compression algorithms built on DWT

Since the introduction of Baseline JPEG in 1992, the wavelet focused coding has more than doubled. In the beginning, wavelet coders had a similar performance to change coding with DCT[3]. In addition, these early wavelet coders were created utilizing the same methods as were used in subband coding. The introduction of Embedded Zero-tree Wavelet (EZW) coding[7] was a true milestone in wavelet transform-based coding.
The EZW method may use the wavelet transform's multi resolution characteristics to offer a computationally more straightforward approach with excellent performance. Similar methods, such as collection partitioning in hierarchical timber (SPIHT) and zero trees entropy (ZTE) coding, have emerged from improvements and enhancements to EZW. Lifting programme (LS), a fresh new method for constructing integer wavelet transforms, has just been recommended. The program's biorthogonal wavelet filtering is highly lucrative for lossy picture compression applications. This section examines the operation of a different algorithm[12].

a) Embedded Zero-Tree Wavelet (EZW) Algorithm

In contrast to the previously established DCT method, this approach was inspired by modern wavelet coders and provided outstanding performance for the compression of still pictures. This method, developed by Shapiro in 1993, takes advantage of the wavelet transform's multiresolution characteristics. As the name implies, placed indicates that the encoder may stop encoding picture data at any specified pace. Furthermore, because the zero-tree platform is analogous to the zigzag scanning of the transform coefficients and the End of Stop (EOB) icon within DCT organized algorithms[10], the decoder can stop decoding at any point, resulting in image quality produced at the truncated tad stream of the image data.

b) Set Partition in Hierarchical Tree (SPIHT) Algorithm

In 1996, Pearlman and Said improved the inlaid zero tree wavelet (EZW) algorithm and created established partitioning in hierarchical timber (SPIHT), a faster and better image coding technology. SPIHT reveals a step toward spotting lower costs regarding compression intricacy and prediction, as recommended in JPEG and JPEG 2000, to realize higher compression shows. [4].

c) Zero-Tree Entropy (ZTE) Coding Algorithm

ZTE coding is a new efficient method of coding wavelet transform coefficients based on the EZW algorithm but differs substantially. This new ZTE method, like EZW, takes use of the self-similarity inherent in the wavelet transform of image and video residuals to predict information placement across wavelet scales[13].

d) DWT Based Image Compression/Decompression in JPEG 2000

The discrete wavelet transform (DWT), scalar quantization, framework modelling, arithmetic coding, and post-compression rate allocation are all used in JPEG 2000, an ISO/ITU-T standard for still picture coding. The DWT is a dyadic process that may be carried out using either reversible filter systems for lossless coding or non-reversible bi-orthogonal filter systems for more excellent compression but not lossless coding. The quantize is the 3rd party for each subband and uses an added dead-zone scalar technique. Each subband is divided into 64x64 rectangular blocks (referred to as code-blocks in JPEG 2000) and entropy coded using framework modelling and a little bit of aircraft arithmetic coding. Using the post-compression rate allocation and result to the code stream in packets, the coded data is organized in so-called levels, which may be quality levels.

The following facts were discovered after a review of the most often used methods. Because DCT-based image coders work flawlessly at modest negligible rates, picture quality decreases with larger compression ratios owing to artefacts produced by the block-based DCT structure. On the other hand, wavelet-based coding improves display quality significantly at low bitrates due to overlapping basis functions and wavelet transformations' superior energy compaction characteristic. Wavelet-based coders aid in the progressive transmission of pictures by enabling shifting bitrates due to their inherent multiresolution features. The JPEG-2000 standard includes wavelet-based coders and solves some of the drawbacks of DCT. Wavelet packets are a generalization of wavelets that provides a more flexible tool for image analysis. Wavelet packets retain all of the characteristics of wavelets and are thought to be a common technique in image control[10].

PROBLEM DEFINITION AND PROPOSED SOLUTION

There are two types of image compression: lossy and lossless. The lossy type is intended to reduce the number of bits required for storing or transmitting a graphic without sacrificing picture quality. The lossless kind aims to keep the compressed image's quality as close to the original as possible. Image compression is essential for effective image transmission and storage. The need for media data to be sent via a telecommunications network and to be able to access media data via the Internet is skyrocketing. The need for storage space, processing, and digital picture copying has exploded due to digital camera types. These picture files may be huge, requiring much memory. It is possible that downloading things from the Internet will take a long time. Image data make up a large portion of multimedia data and use most of the transmission bandwidth used by multimedia systems. As a result, the development of efficient picture compression techniques is becoming more critical.

For colour image compression, the present study proposes two strength structured adaptive quantization coding schemes. To reduce the bit cover of the compressed picture, the first model will consider the various intensity variations of image regions. The following calculates the strength of the primary one level decomposed picture using ASPIHT algorithm rules. To further reduce the bit rate, the type picture is deconstructed using several wavelet filtering methods. In addition, the proposed algorithms regulate the bit rate and PSNR for improved performance. The following are the plans for all of the other studies. First, the SPIHT algorithm's conclusion is presented. Suggested algorithms based on strength have been launched. There are other examples of the findings achieved. Finally, conclusions are handed forth.

B. Proposed Solution

Researchers have developed many methods for both image compression kinds; many of these algorithms utilize the Discrete Cosine Transform (DCT) or Discrete Wavelet Transform (DWT), while others sidestep the difficulties of using such transformations[5,6].

Several methods for picture compression utilizing DWT have been proposed, including the adaptive algorithm for scalable wavelet image coding, among others. The increasing usage of colour pictures in the continuous development of media applications has raised the need for practical methods for storing and transmitting aesthetic data. As a result of this need, picture compression has become a critical element, necessitating the development of efficient algorithms capable of achieving high compression rates with slight loss. The wavelet compression structure is used to suggest a progressive method of compressing colour still pictures. The wavelet transform has been widely used in picture coding because of localization in both the spatial and recurrence domains. In terms of compression percentage and picture quality, the proposed method employs DWT to enhance compression. The gadget has been designed to enhance colour still pictures. This is accomplished by concentrating on using binary vector morphology-based predictors for subbands across various colour components. The main goal of today's study is to design and develop a system capable of performing colour picture compression effectively. The following objectives were devised in order to achieve the above-mentioned main goal.

o Using discrete wavelet change, build a competent and efficient colour picture compression method.
o The following methods are used in the proposed system:
• Quantization for Codebook design and storage space of the codebooks in the picture and usage for Search Optimization via Quadtree decomposition to enhance image compression based on DWT.
• Use Bit Plane Coding (BPC) and Binary Arithmetic Coding (BAC) to encode the coefficients generated, then use the customized Set Partitioning In Hierarchical Trees (ASPIHT) method.
o To compare the suggested system to a standard method.

The suggested system compresses color pictures using wavelet change, tree-structured vector quantization, and binary vector morphological prediction to achieve the mentioned goals. The significance of coefficients in subbands across various colour components may be predicted using binary vector morphology. The use of tree-structured vector quantization lowers quantization and coding search time. In terms of compression and decompression time, this significantly improved the suggested method.

C. Techniques Used

- Color Space Transformation

A colour model is an abstract numerical model that describes how colours may be represented as tuples of quantities, usually as three or four prices or colour components (e.g. RGB and CMYK are colour models). The colour space is the mapping of colours from the colour model. RGB colour space and B/W colour space are the two most used colour spaces for storing digital images[14].

The three chromaticities of the red, inexperienced, and blue additive primaries define the RGB colour space, which may create any chromaticity. For each colour level, Red, Green, and Blue, RGB holds a colour value. It stores pixel colour information in 24 bits, with eight parts for each colour level. The total colour space change formula is provided in equation 1.

$$\begin{bmatrix} S_1' \\ S_2' \\ S_3' \end{bmatrix} = \begin{bmatrix} C_{12} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ S_3 \end{bmatrix}$$

The original colour space is [S1 S2 S3]T, the modified colour space is [S1' S2' S3']T, and the coefficient matrix of change is [Cij].

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Figure 2 depicts an excellent sample picture in RGB colour space and each of the three components. This demonstrates the benefit of utilizing the RGB colour space, in which the Red Part contains nearly all of the information.

Fig. 2. Example image in RGB colour space and its components

- Wavelet subband decomposition

Filter banks are used in the computation of Discrete Wavelet analysis. Filter systems with various cut-off frequencies analyze the signal at various scales. The filtering affects image resolution while up sampling and down sampling increase range. When a signal is passed through two filters, the high-frequency information is retained while the low-frequency information is lost. Low-frequency information is retained, whereas high-frequency information is lost in a minimum pass filtering device. The indicator is thus essentially split into two parts: an in-depth portion (with a high occurrence) and an approximation part (low rate of recurrence).

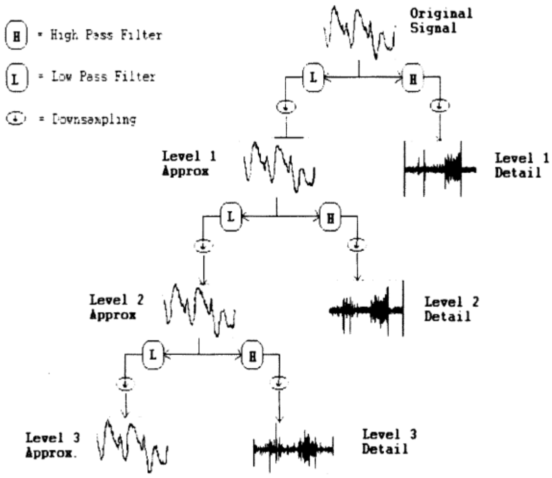

Fig. 3. Working of DWT

Figure 3 depicts the concepts. The optimal frequency adds up to 1 / 2 of the original sub-transmission generated by the decreased filtering method. This change in the rate of recurrence range, according to Nyquist sampling, implies that just 1 / 2 of the original instances must be preserved in order to rebuild the indication properly. More precisely, upsampling may be used to eliminate every second test. After that, the approximation sub-signal is passed through a filter bank, repeated until the desired degree of decomposition is achieved. The DWT is calculated by adding up the coefficients of the ultimate approximation sub-indication and all of the fine detail sub-signals, as shown in equation 3.3.

$$W_t(a,b) = \int_{-\infty}^{\infty} X(t)\, \Psi_{a,b}(t) dt$$

Overall, the filter systems separate finer and finer depths, and if each of these features is 'added' together with our initial signal, our initial indication is replicated.

- Quantization

Quantization is a one-to-many mapping that substitutes many values with a single representative value. This plan is lossy in the sense that the original value cannot be retrieved precisely after mapping. (a) Scalar quantization and (b) Vector quantization are the two most common forms of quantization.

Scalar quantization (SQ) does a many-to-one mapping on each value; for example, it may only save the six most essential bits from an 8-bit ideal. The simplest method of quantizing and compressing pictures is Vector Quantization (VQ). It substitutes arrays of beliefs (i.e., pixels) with a single value, the index from "codebook." As a consequence of a lossy many-to-one mapping, the same index may be used to indicate slightly different arrays of prices.
Codebook design and storage space of the codebooks in the picture and Search Marketing - Computation complexity and time via the search for most effective code vectors are the main execution problems in the look of the VQ algorithm.
The reconstructed picture will be almost identical to the original image if the codebook size is big. The picture produced with a small measured codebook, on the other hand, will have a lot of apparent artefacts. When calculating the transmission over the head, the size of the codebook is also essential to keep in mind. Another essential feature is the safekeeping of codebooks in the picture, which increases with the size of the record. Smaller codebooks result in lower transmission and storage costs, but the quality of the reconstructed picture suffers.
Traditional methods encode all picture blocks with a fixed number of components, regardless of their information value. However, the amount of information in typical pictures is not distributed evenly throughout the various areas. This demonstrates some inefficiencies. A hierarchical composition, in which the number of bits required to encode a visual area is proportionate to the information richness of the spot, is one solution to the issue. One of the most appropriate structures for this purpose is quadtree data composition. A quadtree is a graphic decomposition into sections of uniform colours that may be useful in image compression or picture segmentation, resulting in a better compression percentage. Quadtrees are very helpful in image processing applications because each stop may be split into four equal quadrants, preserving the spatial features of neighbouring blocks[8].

- The SPIHT Algorithm

Set partition in Hierarchical Tree is perhaps one of the most helpful techniques in picture compression (SPIHT). Essentially, it uses a sub-band coder to create a pyramid structure. A graphic is progressively deconstructed using electric power complementary low forward and high filter systems, followed by decimating the resulting images[11].

- Binary Arithmetic Coding (BAC) and Bit Plane Coding (BPC) (BAC)

Bit Plane Coding (BPC) and Binary Arithmetic Coding are the entropy encoders utilized (BAC). Tier 1 coding is a combination of BPC and BAC. Value Propagation Forward, Magnitude Refinement Go Away, and Cleanup Go are the three BPC movements in each tad plane. Each step generates framework models and binary data equivalents. The compressed tad stream is the result of BPC and BAC. As a result, each coding halt has its independent stream. Tier 2 coding is used to blend the self-employed bitstreams of all code blocks into a single tad stream based on rate-distortion search engine optimization. Tier 2 coding multiplexes the so-called unbiased bitstreams created by Tier 1 coding to produce the final compressed output little bitstream. It also efficiently offers header information to direct the purchase of the causing coded blocks and associated coding passes.

D. The Proposed Algorithm

The suggested algorithm stages are as follows:

1) Take a look at the Input pictures.

2) The picture will be partitioned into non-overlapping pieces at first. Then, for every block of the picture, DWT will be used.

3) The DWT coefficients of each picture block will then be quantized.

4) Using quadtree decomposition and a threshold value of 0.2, divide the resulting picture into 2 and 64 dimensions, respectively.

5) From the quadtree decomposition, note the x and y coordinate values, mean value, and block size.

6) Finally, record the fractal picture compression value to finish the image encoding phase using ASPIHT and compute the compression ratio.

7) Reconstruct the original picture from the encoded image using ASPIHT decoding.

8) Finally, determine the image's measurement characteristics, such as PSNR, compression ratio, encoding, and decoding time.

This section overviews the existing image compression problems, their current state, and informed views for future research. Various experts have worked to improve image compression techniques that need or do not require PSNR results, and the research related to this work is described in the next section.

IMPLEMENTATION & RESULT ANALYSIS

E. Simulation Environment

MATLAB was used to implement the ASPIHT algorithm. Figure 4 depicts the Picture Handling test performed on the Lena image, which includes View Components, Equalizer, and different quantization settings. In such a simulation, we used the SPIHT method in MATLAB with DWT. The RGB picture is burned up to 5 degrees of bit plane in Shape 2. (from the utmost of 128 bit-planes). Even though the MATLAB version of the SPIHT is sluggish, no attempt was made to optimize Quadtree and ASPIHT execution code. The desire to be ready for a test run with an execution. When using the equalization, you will see that the recovered picture is visually quite similar to the original. Our original picture is fully recovered if all of the little planes are utilized (up to rounding mistakes). Their understanding of MATLAB and the tools available will quickly improve the code and decrease development time. One approach, for example, has been tested by modifying the SPIHT algorithm to use Lossy/Lossless region appealing (ROI) coding. Our students may modify the algorithm in the same manner to incorporate other types of ROI coding.

F. Result Analysis

The suggested system was thoroughly tested with test pictures, and the results were analyzed. Subband decomposition is done on the picture at the first level using both dimensions wavelets transform. This function may be implemented using the Daubechies category of DWT essential functions, which is well-known for image compression. Using colour space change, we select and evaluate the RGB in the various sections of the picture of the check. The three chromaticities of the red, renewable, and blue additive primaries define the RGB colour space. The chromaticity from the test image's Red, Green, and Blue are generated. Every colour level, Red, Green, and Blue, has a colour value stored in RGB. It stores pixel colour information in 24 bits, with eight parts for each colour level. Our bodies have RGB and Black colour analyzers, as well as a weight view component analyzer.

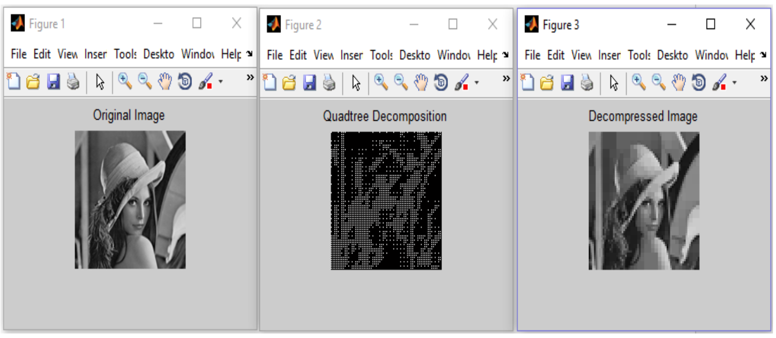

Fig. 4. Quadtree Decomposition of the Image

The Quadtree Decomposition of the test picture yielded this result. Low-Low (LL), High-Low (HL), Low-High (LH) and High-High (HH) The Quadtree Decomposition method for Low-Low (LL), High-Low (HL), Low-High (LH) and High-High (HH).

As shown in the diagram, the HH strap has the least energy-packed with the most redundant group. Thus it is ignored with the least amount of information. The LH (lower subband) and HL (higher subband) rings likewise have more excellent frequency characteristics. However, there is a connection between the list of horizontal and vertical pixels for the previous and subsequent rings, respectively.

Quantization should be done before compressing these rings for the reasons stated above unless they can be disregarded as sounds. As a quantization-compression system, these rings are usually used with scalar quantization and entropy coding.

The proposed system's ultimate step is encoding. The LL subbands' next level coefficients are entropy encoded separately. The other coefficients are encoded on a fine-to-coarse scale, with each colour aspect image being treated separately. The low subbands are then separately encoded using the DWT method mentioned above. All coefficients that are not part of the prediction maps are stored separately.

Fig. 5. The output of the 8 Level Modification of Image

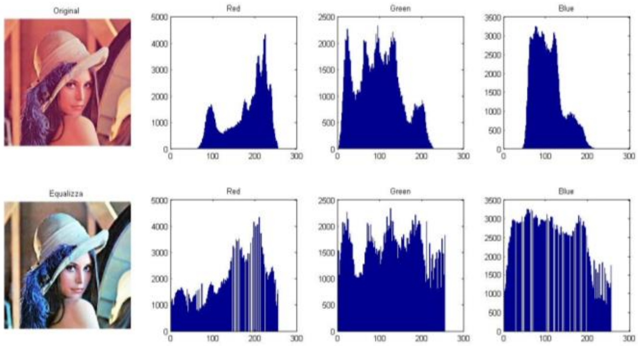

Fig. 6. Histogram Analysis of the RGB Image Compression

Quality criteria such as compression %, compression and decompression time, and Peak Signal to Noise Ratio were used to evaluate the proposed method (PSNR). The email address information is compared to the usual SPIHT image compression method to authenticate the recommended system. The following sections go through the specifics of email addresses.

CR (Compression Ratio): The compression ratio is the image's uncompressed (original) size to its compressed size. It determines the compression algorithms efficiency. CR = original picture size / compressed image size

PSNR (peak signal to noise ratio) is a quality measuring ratio that compares the original and compressed picture quality. The higher the PSNR number, the better the image is compressed quality. It may be calculated using the following formula:

$$PSNR = 10Log\frac{255^2}{MSE}dB$$

(3)

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[I(i,j) - I'(i,j)]^2$$

(4)

Encoding is the process of storing or transmitting a picture that is represented by a less amount of memory.

bpp% Technique	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
SPIHT(dB)	29.90	32.82	34.65	35.88	36.90	37.68	38.28	39.95	39.60
Proposed code(dB)	29.33	32.28	34.03	35.50	36.65	37.49	38.05	38.86	39.85

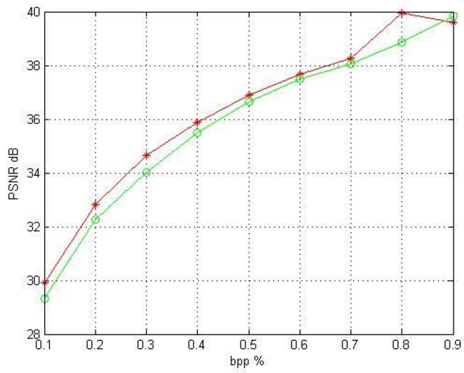

Fig. 7. Analysis of PSNR vs bpp %

The comparative analysis is represented in Table I.

That measured Along with the quality criteria that are being. PSNR and bpp % from Proposed System and SPIHT are compared in the table. We found that by retaining a higher PSNR, the suggested approach significantly decreased encoding time and improved compression ratio.

CONCLUSION AND FUTURE WORK

This study offers four methods for compressing colour still pictures, which are suitable for both natural and photographic photographs and commercial images. The developed algorithms are listed here in their entirety. The proposed platform compresses colour pictures using wavelet change and Quad tree Decomposition for binary vector morphological prediction. The use of Quad tree Decomposition to produce vector quantization cut down on quantization and coding search time. The informed algorithm's performance was significantly improved as a result of (i) an increase in compression ratio from 39.60 per cent to 39.85 per cent, (ii) a reduction in compression time of 7.05 per cent, and (iii) a reduction in decompression time of 5.4 per cent.

Furthermore, the results show that the proposed method generated a high compression ratio with excellent picture quality, with PSNR ranging from 23.90 to 39.85dB. The method was shown to be helpful in situations where the compression ratio was raised (by more than 8% compared to SPIHT), compression time was decreased (by 0.9 events), and picture quality was improved (PSNR in the number 29.33dB - 39.85dB). Future study techniques may take into account noisy pictures and images with varying strength and frequency.

REFERENCES

[1] D. Saupe, H. Hartenstein, “Evolutionary fractal image compression,” IEEE International Conference on Image Processing, Lausanne, September 1996.

[2] C. Chunling, S. Wang, B. Shan, “A fractal image Coding based on the quadtree,” International Conference on Signal Processing, pp. 783–786, 1998.

[3] Chandan Singh Rawat, Sukadev Meher, “A hybrid image compression scheme using DCT and fractal image compression,” The International
Arab Journal of Information Technology, 2015.

[4] NirmalRaj S, “SPIHT algorithm for image compression,” Contemporary Engineering Sciences, 2015.

[5] Chetan, Deepak Sharma, “Fractal image compression using quadtree decomposition and DWT,” International Journal of Scientific Engineering and Research, 2015.

[6] X.Y. Wang, D.D. Zhang, “Discrete wavelet transform-based simple range classification strategies for fractal image coding,” Nonlinear Dyn, 75, 3, pp. 439–448, 2014.

[7] Jinshu Han, “Speeding up fractal image compression based on local extreme points,” IEEE Computer Society, pp. 732-73, 2007.

[8] F. Keissarian1, "A New Quadtree-based Image Compression Technique using Pattern Matching Algorithm”, ICCES, vol.12, no.4, pp.137-143.

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & MANAGEMENT

[9] J. Shapiro, Dec. 1993. Embedded image coding using zero trees of wavelets coefficients, IEEE Trans. Signal Processing, vol. 41, no. 12, pp. 3445–3462.
[10] Jerome M. Shapiro David Sarnoff Research Center, "Smart Compression using the Embedded Zero tree Wavelets (EZW) Algorithm", CN5300, Princeton, NJ 08543-5300.
[11] F. W. Wheeler and W. A. Pearlman, Low-memory packetized SPIHT image compression, 33rd Asilomar.
[12] G.M. Davis, A. Nosratinia. "Wavelet-based Image Coding: An Overview. Applied and Computational Control", Signals and Circuits, Vol. 1, No. 1,1998.
[13] N.Bansal, H.Tyagi, "An Elevation of Image Compression Techniques", IJCSIT, Vol. 8 (1) , 34-41,2017.
[14] Dr E. Loay. George, A. Devart. Minas, "Speeding up fractal image compression using DCT descriptors," Journal of Information and Computing Science, vol. 6, no. 4, pp. 287-294, 2011.
[15] Rao, K. R., Yip, P., "Discrete Cosine Transforms - Algorithms, Advantages, Applications", Academic Press, 1990.
[16] N.M. Nasrabadi, R.A. King, "Image coding using vector quantization: a review", IEEE Trans. On Communications,vol. 36, 957-571, 1988.
[17] Y. Linde, A. Buzo, R. M Gray, "An algorithm for vector quantizer design", IEEE Trans. on Communications, vol. 36, 84-95, 1980.