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A Multi-Level Enhanced Color Image Compression Algorithm using SVD & DCT

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Abstract
Nowadays, computer technology is mostly concerned with storage capacity and performance. Compression of digital images has become a fundamental aspect of their transmission and storage. Due to storage and bandwidth constraints, it has become necessary to compress images before to transmission and storage. Not only can image compression techniques help to reduce storage space requirements, but they also aid increase transmission bandwidth. Color images are in trend these days during communication. Most of the researchers have worked only on grayscale images. This research proposes a hybrid approach that encompasses two cutting-edge picture compression algorithms: DCT & SVD. This research involves the advantages and strength of two cutting-edge picture compression algorithms that enable us to compress the color images without additional cost in computation, space and time. Here in this research, for experimental purposes, seam carving image dataset is used. The proposed method's performance is evaluated using the performance evaluation matrices, i.e., Size after Compression, MSE, PSNR, Normalized Co-relation (NC), Percentage Space-Saving, and Compression Ratio. The proposed method performance is also correlated with the two latest image compression techniques, i.e., DCT Block Truncation (DCTBT) and Discrete Cosine Transform - Vector Quantization (DCT-VQ). The findings show that the suggested hybrid color image compression approach is superior to existing compression according to different performance metrics.

Keywords: Hybrid Image Compression, Singular Value Decomposition (SVD), Compression, Discrete Cosine Transform (DCT), and Discrete Wavelet Transform (DWT).

I. Introduction

Image compression has become an ever–growing component and source of worry in the context of mental image quality and file size as a result of the rise of multimedia technologies (Joshi & Sarode, 2020; Dixit, 2020). Compression of data aims to eliminate redundancy in order to save money on archiving and data transmission bandwidth. Lossless compression, in which the restored image is completely identical however, it has a very low compression ratio and a lossy compression, where there is a very high compression ratio but there is a lot of data loss, are indeed the two forms of compression. We set our sights on lossy compression in particular. The SVD, DWHT, DWGT, DCT, DFT are all employed in the DWT. These are all symmetric, unitary, and reversible transformations. The primary objective is to investigate picture compression algorithms based on transforms techniques for more efficient data transfer and storage, while preserving compression rates and SNR ratio balance (Cooper & Lorenc, 2006). Despite rapid increases in mass storage density, processing speeds continues to surpass present options. Not only has the recent growth of data-intensive multimedia-based web services reaffirmed the need for more efficient signal and image encoding, but it has also elevated signal compression to a critical component of storage and communication technologies (Aishwarya et al., 2016).

Data compression is necessary for successful data transmission and storage because to the channel's constrained bandwidth and the memory space constraint, which prevents severe information loss (Jayasankar et al., (2021)). There are various methods for performing data compression, including audio, image, video, and document compression (Chen et al., (2019)). An image can contain three different forms of information: relevant, redundant, and valuable. For picture compression, irrelevant information might be omitted. While valuable information is neither redundant nor irrelevant, redundant information is essential for drawing attention to features in images. We cannot correctly rebuild or decompress photos without accurate information (Piran et al., (2020)). Two main types can be found in image compression. The first type of picture compression preserves all information, while the second type is lossy. For small-size data, lossless picture compression algorithms are particularly effective (Jamil & Piran, (2022)). But in this paper we are going to be working on the hybrid algorithms that is the combination of the SVD and DCT methods.

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All the results of the previous researchers are not upto the mark in the field of the image compression. The main reason behind this is to not using the novel approach or some combination of two or more algorithms that we call it as hybrid algorithm. In order to improve the efficiency of the model in the field of the image compression in this paper a hybrid combination of the SVD and DCT is used. The suggested method's performance is associated with that of two recent image compression techniques, namely DCTBT and DCT-VQ. Furthermore, in order to validate the results of the proposed methodology we present a discussion section which comprises the summary of the methodology and the results section of the paper and also show the comparison of the work with the state-of-the-art methods in terms of the different parameters in order to better performs the results of our proposed methodology. Following are the key highlights of the paper:

- Apart from the Quantization any new methodology can be followed after DCT or any other decomposition techniques.
- There is a strong need to work something very efficient for color image compression.
- DCT and SVD are still lagging in providing efficient compression results.
- The compressed image's image quality can be increased further.

The following sections comprise this paper: section II summarizes previous work by various authors, section III defines the datasets and the working of the proposed methodology, In section IV & V, the results and the discussion part are presented, and in section VI, the paper concludes with a discussion of prospective applications.

II. Literature Review

Methods for optimizing the picture compression algorithm are provided by (Joshi and Sarode (2020)). It can be stated that the acquired result suggests a reduction in the amount of storage space required. This immediately contributes to the reduction of the required transmission bandwidth for diverse images. The NN architecture contributes to the reduction of the time required to determine the compression ratio. By comparing the outcomes achieved before and after training, the neural network also aids in the validation of pre-training outcomes. The suggested method's present drawback is that it only works with grayscale images. The training of neural networks takes a long time and necessitates the adjustment of parameter. In order to create a lossy picture compression, (El Asnaoui, 2020) created an approach based on the block SVD power method that gets over the drawbacks of MATLAB's SVD function. The experimental findings demonstrate that the new technique outperforms existing compression algorithms that make use of the SVD function in MATLAB. Additionally, the developed approach is straightforward to use and capable of varying degrees of error resilience, which results in greater picture compression in a short period of time. To compute the DCT and compress images (Bhagat et al. (2013)), (Kaushik and Nain, (2014)), and (Prasanna et al., (2021)) created several basic functions. The MATLAB IMAP and IMAQ blocks were used to analyses and investigate the results of Image Compression utilizing DCT and changing compression co-efficient to illustrate the produced image and error image from the source images.

(Singh et al., 2018) described a parallel approach that may be executed on widely-used processors to compute the convolution-based wavelet transform of the red, green, and blue intensity components simultaneously in colour images. Thus, no additional hardware is required. On the basis of compression duration, mean square error, compression ratio, and peak signal-to-noise ratio, the outcomes are also contrasted with the nonparallel approach (Sreenivasulu & Varadarajan, 2020) developed wavelet transform and encoding technique for lossless medical image compression. Segmentation, image compression, and image decompression are the three main components of an image compression system. Using a modified region expanding technique, the input medical image is first divided into a region of interest (ROI) and a non-ROI. The non-ROI is compressed by discrete wavelet transform and merging-based Huffman encoding method, and the ROI is compressed by discrete cosine transform and set partitioning in hierarchical tree encoding method. It is therefore possible to obtain the compressed picture combination of the compressed ROI and non-ROI. The original medical image is then extracted utilising the reverse process during the decompression stage. (Rawat and Meher, (2013)) presented and evaluated a composite image compression technique that combined Fractal picture compression with DCT. Image will then be divided into 88 non-overlapping parts to proceed. Every block of the image will be subjected to DCT. Each block's DCT coefficients will then be quantized. By scanning the block values in a zig-zag fashion, the zero coefficients will be avoided; in addition to extracting the nonzero coefficients, zig-zag scanning enhances compression efficiency. Fractal image compression will be employed in this case. The image will then be encoded using the Huffman encoding method.

The PSNR was used as the major criterion in (Mehta and Chauhan (2013)), (Kodukulla, (2020)) comparison of DCT and DWT. PSNR may be calculated after an input picture has been reconstructed. It expresses the value in decibels, with a higher PSNR indicating a higher-quality reconstructed image. A unique image compression approach based on DWT & Reverse DWT was proposed by (Barbhuiya et al., (2014)). DWT and Reverse DWT are particularly notable for their ability to compress image while maintaining great image quality.

Similarly, (Ahuja and Shantaiya (2015)) compared several Image compression algorithms for various photos utilising features like MSE and so on PSNR. Without losing picture information, DWT provides superior outcomes. The disadvantage of DWT is that it demands greater computing power. DCT overcomes this drawback by using less computing power. (Koya et al., (2017)) employed a Color image compression algorithm to examine the compression strategies employed in a DCT ,the RGB, CMY, and YCBCR components of images are extracted using an arithmetic encoder image compression technique, a grayscale picture compression technique based on excerpt the RGB, CMY, and YCBCR ingredient of images, and a DCT-DWT hybrid arithmetic encoder (Zhou et al., (2018)) created a game-changing improved lossless encoder that significantly increases colour picture compression ratios. The DCT coefficients were separated into two categories: quantized direct current (DC) and quantized alternating current (AC), each of which was encoded using a distinct encoder with its own set of characteristics. Furthermore, Huffman coding for each section boosts compression performance even more. Experiments using various color images revealed that the proposed technique outperformed JPEG and CDABS. The suggested approach has a drawback in that it requires a big amount of data to store the Huffman code table.

III. Proposed Methodology

In this section, discuss the in-depth study of the proposed hybrid SVD-DCT technique that how this algorithm is applied in the area of the image compression. In the initial stages the input image which we used for the compression is decomposed in three different colors such as red, green, and the blue color. After the decomposition of the image firstly, the SVD method is apply over the decomposed image then the DCT method is apply over the image. The proposed methodology gives enough output with minimum degradation of the quality of the input image. Furthermore, the detailed of the methods that we are going to be use in the proposed methodology along with the description of the dataset is summarizes in the upcoming sub-sections.

Dataset Description

In this study the seam carving image dataset is used in order to carry out the results of the model. The trials used 5,000 original colour TIFF raw format digital photos with 24-bit, 640 480 pixel resolution and lossless true colour that were never compressed. To remove the low-complexity areas, we cropped these original photographs into 256 x 256 pixels, and we then converted the cropped images into JPEG format with the default quality. According to relative payload, which is the ratio of the number of DCT-coefficients adjusted to the total number of nonzero-valued AC DCT-coefficients, the following nonadaptive schematograms are created with various concealment ratios. The dataset is online available at: https://www.shsu.edu/~qxl005/New/Downloads/index.html.

Singular Value Decomposition (SVD)

Linear algebra is used extensively in data compression. In today's society, the necessity to reduce the amount of digital data saved and communicated is becoming increasingly important. Singular Value Decomposition (Cooper & Lorenc, 2006) is a useful tool for reducing data storage and transport. SVD is a matrix factorization that allows you to extract algebraic and geometric information from an image in a new way. Many fields have adopted SVD, including data compression, signal processing, and pattern analysis (Kang & Wei, 2008). The goal of SVD is to identify the closest match to the original data points in the fewest number of dimensions possible. This may be done by locating the areas with the greatest degree of fluctuation. SVD is being used to compress a big, highly variable number of data points to a lower-dimensional space that far more clearly displays the original data's substructure and classifies it from highest to lowest variance. Using the SVD approach, this strategy locates the most changeable region and decreases its size. To put it another way, SVD is a data reduction approach (Aishwarya et al., 2016).

Numerous eminent mathematicians regard SVD as a crucial topic in linear algebra. Apart from image reduction, SVD is useful in a broad variety of practical and theoretical contexts. SVD has the advantage of being applicable to any real (m,n) matrix. Such that,

$$A = USV^T \qquad (1)$$

Where, S is the diagonal matrix, U and V is the orthogonal matrices.

The objective of the SVD algorithm is to convert matrices A into USVT. On the left side of U, singular vectors are present. The matrices V and S contain right singular vectors and singular values, respectively. Along the major diagonal, solitary values are grouped together in this section.

$$\sigma_1 \geq \sigma_2 \geq \ldots \geq \sigma_r \geq \sigma_{r+1} = \ldots = \sigma_p = 0 \qquad (2)$$

The rank of matrix A is denoted by the letter r and The smaller of the dimensions m or n is (p).

The first step in the SVD method is to choose the A matrix with mxn. A has now been factored into three matrices. S, U, V^T. First, V is calculated, Multiplying A^T on Left hand side & Right-hand side of the equation $A = USV^T$ we get

$$A^TA = (USV^T)^T (USV^T) = V S^TU^TUSV^T \quad (3)$$

Since $U^TU = I$ this gives

$$A^TA = V S^2V^T \quad (4)$$

Now, diagonalization of A^TA is required. Matrix diagonalization A is very similar to this, $A = Q\wedge Q^T$.V and S require the eigenvectors and eigen values of ATA in order to be calculated. S's eigen values are the squares of its singular values, whereas V's eigenvectors is the columns (the right singular vectors).

V ~ U in that it can be removed from the equation. Rather than multiplying on the left by A^T, it is multiplied on the right side.

$$AA^T = (USV^T)(USV^T)^T = USV^TVS^TU^T \quad (5)$$

Since $V^TV = I$, this gives

$$AA^T = US^2U^T \quad (6)$$

Again, eigenvectors are calculated, but this time for AA^T. U's columns are listed below. (the left singular vectors).

Since A is m × n, S is m × n and

$$A^TA \quad (7)$$

produces an n × n matrix, and:

$$AA^T \quad (8)$$

produces an m × m matrix,

$$A = (u_1 \ldots u_r \ldots u_m)\begin{pmatrix} \sigma_1 & & \\ & \sigma_r & \\ & & 0 \end{pmatrix}\begin{pmatrix} v_1^T \\ v_r^T \\ v_n^T \end{pmatrix} \quad (9)$$

Where U is m × m, S is m × n, V is n × n.

DCT

A DCT is used to represent the input data points as a combination of cosine functions with different frequencies and magnitudes oscillating.1-dimensional and 2-dimensional DCT are the two most common kinds of DCT. On the foundation of DCT, JPEG was created in 1992. In the JPEG technique image is initially divided into 8x8 parts. Second, each block is subjected to DCT in a left-to-right orientation as well as in the top-to-bottom direction. Then, for compression, quantization is used, and data is stored in a precise way to reduce the amount of data in the memory. We next use the IDCT transform to recreate the compressed image.

Hybrid SVD-DCT Method for Image Compression

The proposed methodology is the combination of the two state-of-the art methods i.e., SVD and the DCT. First, the input image is decomposed in three different channels i.e., the red, green and the blue channels. Further the SVD process is applied on these three channels, for this the reconstruction is done on the individual channels and apply the compression process and provides the output in the form of the single image. Secondly, on the generated output the DCT process is applied. For this again the image is decomposed in three different colors then calculate the value of the energy coefficient on the basis of these channels. Furthermore, the threshold is set on the basis of the energy coefficient value, the coefficient which have higher value is set as the threshold. After selecting the threshold, the channels is pass on the IDCT phase after that the reconstruction is performed on all the channels and the model gives an final output image which is a compressed image. The step by step summary of the proposed hybrid methodology is seen in the below points:

1. Inputting of the color image to be compressed and decomposition of color image into Red, Green & Blue Channels.

2. The SVD method is used to divide the three channels into 3 matrices, U, S & V, therefore

$$A = USV^T \quad (10)$$

U & V= orthogonal matrices (11)

Where, S = diagonal matrix.

3. Reconstruction of all three compressed Channels and Reconstruction of SVD compressed Image by combining all three compressed channels.

4. Inputting of the color SVD compressed image to be compressed again through DCT.

5. Decomposition of color image into Red, Green & Blue Channels.

6. Application of DCT method on all three channels to find discrete cosine transform coefficients of all three channels.

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7. Calculation of the energy of each coefficient by squaring them and Sorting amongst all the coefficient from higher to lower value.

8. Declaration of a suitable threshold value as per the pixel size of the input image.

9. Extraction of higher energy coefficients from all three channels as per threshold value and replacement of all low valued coefficients by zeros.

10. Reconstruction of all three channels with high value coefficients by applying inverse DCT.

11. Reconstruction of DCT compressed Image by combining all three compressed channels.

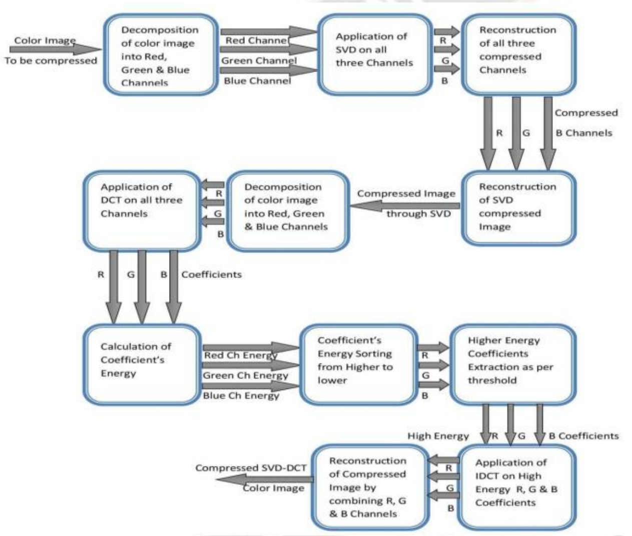

Figure 1: Block Diagram for the Proposed Methodology

Metrics for evaluating performance

To compare the outputs of various picture contraction algorithms, presentation criteria were developed. There are two sorts of performance measurements for picture quality. subjective and objective. When comparing image quality based on image evaluation and viewer reading, subjective quality measures are used. The term "objective quality metrics" refers to the use of statistical data-based indices to determine image quality. Following an examination of the literature, it might be decided that the research to be conducted involves a certain set of parameters. While some of the criteria may be universal, others may be specific to a few specified compression methods.

1. **The compression ratio:**

$$\text{Compression Ratio} = \frac{\text{Size of Original Image}}{Size of compressed Image} \quad (12)$$

The compression ratio or bit rate can be used to represent a picture's compression efficiency.

2. **MSE**:

MSE refers to the difference betwixt the original & reconstructed pictures.

$$\text{MSE} = \frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}[x(\text{m},\text{n}) - x(\text{m},\text{n})]^2 \quad (13)$$

MSE is used to ensure the quality of such a lossy-compressed reconstructed image. Because of its ease of use and mathematical comfort, it is an appealing gauge of picture quality decline.

3. **PSNR**:

This is a quantitative measurement based on the image's mean square error. MSE & PSNR are lower if the final image closely resembles the original. PSNR is a dimensionless decibel-based quantity expressed as follows:

$$\text{PSNR} = 10 \log \frac{255\hat{}2}{MSE} \quad (14)$$

4. **NC:**

The correlation function Compare two digital images and determine how similar they are. Since each picture is normalised only by root power, the correlation coefficient is computed as follows:

$$\text{NC} = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N} x(m,n).x(m,n)}{\sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N} x\hat{}2(m,n)\sum_{m=1}^{M}\sum_{n=1}^{N} x\hat{}-2(m,n)}} \quad (15)$$

5. **% Space Saving**:

This function may be used to determine how comparable two digital pictures are. The correlation value is calculated as follows since each picture is normalized by its root power.

$$\text{\% Space Saving} = (1 - \frac{\text{Compressed Image size}}{\text{Uncompressed Image size}}) \text{ x100} \quad (16)$$

IV. Experimental Results

This research involves the advantages and strength of state-of-the-art image compression methods that enable us to compress the color images without additional cost in computation, space and time. Here in this research, for experimental purposes, seven standard images have been used for compression using proposed hybrid method is done. Performance analysis of proposed hybrid method is done using the performance evaluation matrices, i.e., Size after Compression, MSE, PSNR, NC, Compression Ratio, and % space-saving. The proposed method performance is also correlated with the two latest image compression methods,

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i.e., DCTBT and DCT-VQ. The proposed hybrid colour image compression strategy outperforms existing techniques in terms of reduced image quality (PSNR, MSE, and NC) and reduced file size (Compression Ratio and percent space-saving). MATLAB R2019 has been used to implement the proposed methodology using generalized MATLAB Toolbox and Image Processing Toolbox. For experimental purposes, a set of seven standard images has been taken. These images are 'Baboon.bmp,' 'Barbara.bmp,' 'House.bmp,' 'Lena.bmp,' 'Peppers.bmp,' 'Garima.bmp' and 'Airplanes.bmp.' The pixel size of each image is 256 x256, except 'Graima.bmp.' The size of 'Garima.bmp' is 1029 x1280. To evaluate the performance of each technique, the performance review matrices, i.e. Size after Compressed, MSE, PSNR, Normalized Co-relation, Volumetric Efficiency, and percent space-saving, were considered.

The Proposed method is also incorporated for compressing RGB images. All the above-said images and performance evaluation metrics have been used for this purpose.

Table 1: Analysis of SVD+DCT method's performance on several images

S.No.	Image to be compressed	Original Memory Size (pixel size)	Size after Compression	MSE	PSNR	Normalized Co-relation	Compre ssion Ratio	% Space Saving
1	 Baboon.BMP	193KB (256x256)	15KB	50.6315	31.1326	0.9429	12.8	92.2
2	 Barbara.BMP	193KB (256x256)	12KB	29.0355	33.4849	0.9814	16.08	93.7
3	 House.BMP	193KB (256x256)	10KB	17.9235	35.5406	0.9899	19.3	94.8
4		193KB (256x256)	11KB	16.8178	35.8731	0.9878	17.54	94.3

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5	 Peppers.BMP	193KB (256x256)	10KB	15.6294	36.1914	0.9922	19.3	94.8
6	Garima.BMP 	176KB (1029x1280)	3861KB	49.8552	31.1537	0.9847	28.8	96.5
7	 Airplane.BMP	149KB (225x225)	12KB	39.1542	32.2030	0.9725	12.41	91.9

According to the analysis in Table 1, the proposed method is more efficient for all seven photos in comparison to the two cutting-edge techniques. Compression ratios range between 12 and 19. The said method is also able to compress the images with a range between 91.9 - 94.8%. The analysis depicts that the proposed method is working more proficiently as that of both state-of-the-art techniques. To showcase the effectiveness of the proposed work with standard image database all the parameters are also calculated for a standard dataset "never compressed images".

Table 2: Performance analysis of SVD+DCT methods on different images from "never compressed images" dataset

S.No.	Image to be compressed	Original Memory Size (pixel size)	Size after Compression	MSE	PSNR	Normalized Co-relation	Compression Ratio	% Space Saving
1	 10001.bmp	193KB	14KB	58.3595	30.4363	0.9573	13.38	92.74
2		193KB	16KB	78.3595	29.3398	0.8630	12.06	91.7

	10013.bmp							
3	 10024.bmp	193KB	13KB	56.6866	30.7257	0.9350	14.84	93.2
4	 10050.bmp	193KB	14KB	63.1426	30.2314	0.8886	13.38	92.74
5	 10051.bmp	193KB	12KB	63.0766	30.1965	0.9384	16.08	90.9
6	 10052.bmp	193KB	14KB	94.1126	28.3943	0.6988	13.38	92.74
7	 10072.bmp	193KB	13KB	89.1291	28.6343	0.7873	14.84	93.2
8	 10071.bmp	193KB	11KB	99.0080	28.1741	0.6861	17.54	94.2

9	 10105.bmp	193KB	12KB	81.6573	29.1444	0.8604	16.08	90.9
10	 10104.bmp	193KB	13KB	55.1225	30.7175	0.9501	14.84	93.2
11	 10123.bmp	193KB	14KB	62.7765	30.3658	0.8673	13.38	92.74
12	 10138.bmp	193KB	15KB	48.5828	31.4823	0.9555	12.86	92.2
13	 10141.bmp	193KB	11KB	32.2246	32.4769	0.9868	17.54	94.2
14	 10165.bmp	193KB	15KB	88.2669	28.8074	0.8490	12.86	92.2

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15	 10170.bmp	193KB	12KB	63.0766	30.1965	0.9384	16.08	90.9

As per the analysis given in Table 1, the proposed method is working more efficiently for all fifteen images from the said dataset. The value of the compression ratio is lying between 12.6 to 17.54. The said method is also able to compress the images with a range between 90.5 - 94.3%. The analysis depicts that the proposed method is also working proficiently for standard dataset images too.

Aside from standard state-of-the-art techniques (DCT and SVD), the performance of two exiting modified DCT compression methods, i.e., DCTBT (Joshi & Sarode, (2020)) and DCT (VQ) (Dixit, (2020)), is also compared with that of the proposed method. Two performance evaluation matrices, i.e., Compression Ratio, % space-saving, have been calculated and compared.

Table 2: Results of Proposed DCT+SVD method's performance with DCTBT and DCT (VQ)

S. No.	Image to be compressed	Original Memory Size (pixel size)	DCTBT (Joshi & Sarode, (2020))		DCT (VQ) (Dixit, (2020))		Proposed Method (DCT+SVD)	
			% Space saving	Compression Ratio	% Space saving	Compression Ratio	% Space saving	Compression Ratio
1	 Lena.png	821KB (1000 x 1000)	86.6	7.52	91.79	12.18	92.44	13.24
2	 Cameraman.tif	603KB (1000x1000)	86.6	7.52	82.5	5.72	90.04	10.05

To understand the above comparison table, a graphical detailed analysis is also prepared and given below. Two special performance evaluation matrices, i.e., Compression Ratio and % space-saving, have been calculated and compared. Figure 2 and Figure 3 are the graphical comparison of all the performance assessment parameters for both DCTBT (Joshi & Sarode, (2020)) and DCT (VQ) (Dixit, (2020)) and proposed methods.

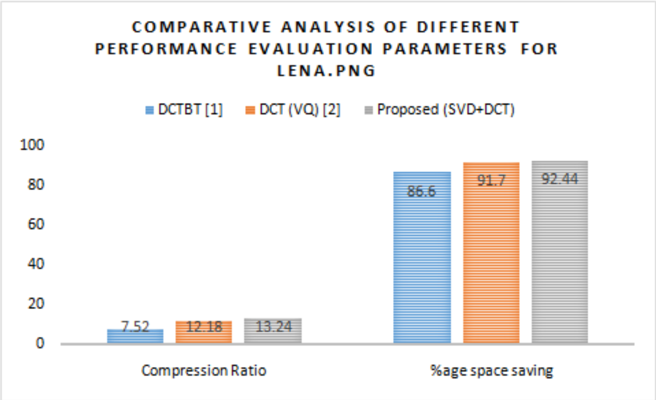

Figure 2: Comparative analysis of both DCTBT (Joshi & Sarode, (2020)) and DCT (VQ) (Dixit, (2020)) and proposed methods for Lena.png

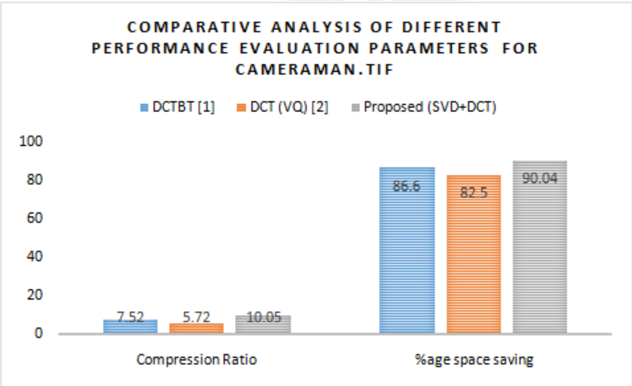

Figure 3: Comparative analysis of both DCTBT (Joshi & Sarode, (2020)) and DCT (VQ) (Dixit, (2020)) and proposed methods for Cameraman.tif

The efficiency of the proposed method may also be noticed from Table 2, Figure 2 and Figure 3 as it is working effectively for both parameters, i.e., Compression Ratio, % space-saving. The analysis depicts that the proposed method is working more proficiently as compared to both existing techniques for the compression.

V. Discussion

The proposed method's value for both parameters is significantly higher than that of existing compression methods. i.e., DCTBT (Joshi & Sarode, (2020)) and DCT (VQ) (Dixit, (2020)). The value of the compression ratio is lying between 10.05 to 13.24, whereas this is only 7.52 for DCTBT (Joshi & Sarode, (2020)) and 5.72 to 12.18 for DCT (VQ) (Dixit, (2020)). The proposed approach also has the ability to compress images with a range between 90.04 - 92.44% whereas it is only 86.6 for DCTBT (Joshi & Sarode, (2020)) and 82.5 to 91.79 DCT (VQ) (Dixit, (2020)).

VI. Conclusion and future scope

The outcome of proposed methodology and its various performance assessment matrices i.e. Size after Compression, MSE, PSNR, NC, Compression Ratio, and % space-saving says that proposed method is working more efficiently for all seven images as compared to both techniques. The value of the compression ratio is lying in between 12 to 19. The said method is also able to compress the images with a range between 91.9 - 94.8%. The analysis demonstrates that the proposed strategy is more effective than both cutting-edge techniques. The proposed method performance is also correlated with the two latest image compression methods, i.e., DCTBT and DCT-VQ. The results reveal that in terms of compressed picture quality (PSNR, MSE, and NC) and compressed file size, the proposed hybrid colour JPEG concretion strategy surpasses circulating techniques (Compression Ratio and percent space-saving).

In the digital age, videos have become an integral component of human life. Nowadays, a variety of approaches for decreasing the quantity of data to be kept and sent are used for capturing, generating, editing, and processing moving images. The proposed hybrid method can be extended for the moving images.

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References

[1]. Ahuja, M., & Shantaiya, S. (2015). A Review on Image Compression using DCT and DWT. *International Journal for Scientific Research & Development*, *3*(10).

[2]. Aishwarya, K. M., Ramesh, R., Sobarad, P. M., & Singh, V. (2016, March). Lossy image compression using SVD coding algorithm. In *2016 International Conference on Wireless Communications, Signal Processing and Networking (wispnet)* (pp. 1384-1389). IEEE.

[3]. Barbhuiya, A. J. I., Laskar, T. A., & Hemachandran, K. (2014, November). An approach for color image compression of JPEG and PNG images using DCT and DWT. In *2014 International Conference on Computational Intelligence and Communication Networks* (pp. 129-133). IEEE.

[4]. Bhagat, A. W., Deokate, B. H., & Kadbe, P. K. (2013). High Quality Color Image Compression using DCT.

[5]. Chen, S., Zhang, S., Zheng, X., & Ruan, X. (2019). Layered adaptive compression design for efficient data collection in industrial wireless sensor networks. *Journal of Network and Computer Applications*, *129*, 37-45.

[6]. Cooper, I., &Lorenc, C. (2006). Image compression using singular value decomposition. *College of the Redwoods*, 1-22.

[7]. Dixit, M. M. (2020). Image quality assessment of modified adaptable VQ used in DCT based image compression schemes implemented on DSP and FPGA platforms. *Multimedia Tools and Applications*, *79*(1), 163-182.

[8]. El Asnaoui, K. (2020). Image Compression Based on Block SVD Power Method. *Journal of Intelligent Systems*, *29*(1), 1345-1359.

[9]. Jamil, S., & Piran, M. (2022). Learning-Driven Lossy Image Compression; A Comprehensive Survey. *arXiv preprint arXiv:2201.09240*.

[10]. Jayasankar, U., Thirumal, V., & Ponnurangam, D. (2021). A survey on data compression techniques: From the perspective of data quality, coding schemes, data type and applications. *Journal of King Saud University-Computer and Information Sciences*, *33*(2), 119-140.

[11]. Joshi, N., &Sarode, T. (2020). Validation and optimization of image compression algorithms. In *Information and Communication Technology for Sustainable Development* (pp. 521-529). Springer, Singapore.

[12]. Kang, X., & Wei, S. (2008, December). Identifying tampered regions using singular value decomposition in digital image forensics. In *2008 International conference on computer science and software engineering* (Vol. 3, pp. 926-930). IEEE.

[13]. Kaushik, E. A., & Nain, E. D. (2014). Image Compression Algorithms Using Dct. *International Journal of Engineering Research and Applications*, *4*(4), 357-364.

[14]. Kodukulla, S. T. (2020). Lossless Image compression using MATLAB: Comparative Study.

[15]. Koya, T., Chandran, S., & Vijayalakshmi, K. (2017, July). Analysis of application of arithmetic coding on dct and dct-dwt hybrid transforms of images for compression. In *2017 International Conference on Networks & Advances in Computational Technologies (netact)* (pp. 288-293). IEEE.

[16]. Mehta, D., & Chauhan, K. (2013). Image Compression using DCT and DWT-Technique. *International Journal of Engmeenng Sciences & Research Technology*, *2*(8), 2133-2139.

[17]. Piran, M. J., Pham, Q. V., Islam, S. R., Cho, S., Bae, B., Suh, D. Y., & Han, Z. (2020). Multimedia communication over cognitive radio networks from QoS/QoE perspective: A comprehensive survey. *Journal of Network and Computer Applications*, *172*, 102759.

[18]. Prasanna, Y. L., Tarakaram, Y., Mounika, Y., & Subramani, R. (2021, September). Comparison of Different Lossy Image Compression Techniques. In *2021 International Conference on Innovative Computing, Intelligent Communication and Smart Electrical Systems (ICSES)* (pp. 1-7). IEEE.

[19]. Rani, N., & Bishnoi, S. (2014). Comparative analysis of image compression using dct and dwt transforms. *Int J computsci Mobile Comput*, *3*, 990-996.

[20]. Rawat, C., &Meher, S. (2013). A Hybrid Image Compression Scheme Using DCT and Fractal Image Compression. *Int. Arab J. Inf. Technol.*, *10*(6), 553-562.

[21]. Singh, P. K., Singh, R. S., & Rai, K. N. (2018). A Parallel Algorithm for Wavelet Transform-Based Color Image Compression. *Journal of Intelligent Systems*, *27*(1), 81-90.

[22]. Sreenivasulu, P., & Varadarajan, S. (2020). An efficient lossless ROI image compression using wavelet-based modified region growing algorithm. *Journal of Intelligent Systems*, *29*(1), 1063-1078.

[23]. Zhou, Y., Wang, C., & Zhou, X. (2018, August). DCT-based color image compression algorithm using an efficient lossless encoder. In *2018 14th IEEE International Conference on Signal Processing (ICSP)* (pp. 450-454). IEEE.

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