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JPEG Image Compression and Decompression by Huffman Coding

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Abstract :- **Image compression is considered as application performed for compression of data in digital format images. Digital images are comprised with large amount of information that requires bigger bandwidth. The techniques of image compression can be generally categorized into two types: lossless & lossy technique. DCT (discrete cosine transform) can also be used for compressing an image and also approaches like Huffman encoding, quantization & such steps are required for compression of images with JPEG format. The format of JPEG can be used for both of the RGB (colored) & YUV (gray scale) images. But here our main concentration is over decompression & compression of gray scale images. Here 2D-DCT can be used for transformation of a 8x8 matrix of images to an elementary frequency elements. The DCT is considered to be a mathematical function which will transform an image of digital format from spatial to frequency domain. It is very much easy to implement Huffman encoding & decoding for minimizing the complexity of memory. In this proposed technique, the analog image pixels are transformed to discrete image pixel, and therefore compression is preformed. On the receiving side, the pixels are decompressed for obtaining the actual image. The PSNR is computed for analyzing the quality of image.**

Key words:- *JPEG, DCT, IDCT, Huffman Image Technique, PSNR.*

I. INTRODUCTION

In the processing of digital images, Image compression is considered as a technique for compression of an image that is stored in a computer for upgrading its visual properties. As an illustration, the image is made either bright or dark or enhancing contrast of image through implementation of some transformation functions or any other approach [1].

The process of image enhancement works by making adjustments over digitized images so that outcomes are more appropriate for presentation or image analysis. As an illustration, several non-required elements are eliminated by using the approaches like Wiener filter, Gaussian filter etc. Also the image can be brighten or sharpen & making it easy to recognize prime attributes. Though, it will improvise dynamic range of the selected features and they can be identified very easily. The most difficult part of this technique is that it quantifies enhancement criteria. Hence, several techniques for image enhancement are considered to be empirical & need interactive process to generate outcomes. A selection for suitable techniques is supported by imaging modality, task over hand & viewing scenario. The general involvement of input & output image in process of image enhancement is demonstrated in figure 1 [1][2].

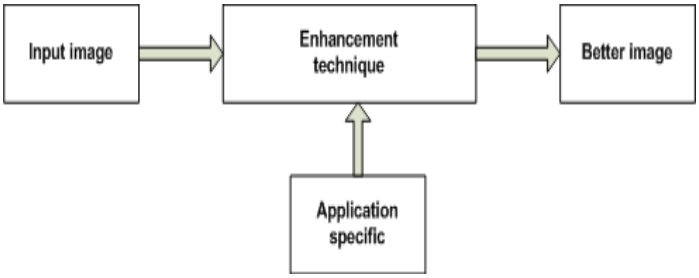

Figure 1:- Image Enhancement Procedure

A. Performance Criteria In Image Compression

The performance can be estimated by implementation of below two necessary criteria the CR (compression ratio) & PSNR (quality measurement of reconstructed images).

- *Compression ratio*

The CR (compression ratio) is a ration in original & compressed size of an image.

$$CR = n1/n2 \qquad \text{.....(1)}$$

- *Distortion measure*

MSE (Mean Square Error) is considered as a measure for computing rate of distortion in the reconstructed image.

$$MSE = \frac{1}{HW}\sum_{i=1}^{H}\sum_{j=1}^{W}[X(i,j) - Y(i,j)]^2 \qquad \text{……(2)}$$

PSNR is considered as a majorly used quality measuring parameter in section of image compression.

$$PSNR = 10\ log_{10}\frac{255^2}{MSE}(dB) \qquad \text{……..(3)}$$

B. DCT Transformation

DCT (discrete cosine transforms) is mostly using for image compression from last many years. The selection as standard for JPEG is considerably onto the popular reason for popularity. DCT can be implemented in several non-analytical applications like signal processing & image processing DSP applications like video conferencing. The DCT can be used in the transformation for data compression. DCT is an actual transform that has a fixed set of basic functions. DCT is used for mapping an image space in a frequency [15]. DCT aims various superiorities: (1) It is capable of confining the energy in lower frequency for image data. (2) It is capable of minimizing the blocking artifact & this impact will lead to visibility of boundaries in sub-images. Below we mention some advantages of the DCT :-

- real-valued.
- higher energy compaction (most of the signal energy can be represented by only some coefficients).
- coefficients are nearly uncorrelated.
- experimentally observed to work well.

C. JPEG Compression

The JPEG standard is majorly known as ISO/ITU-T standard that is generated in late years of 1980s. The JPEG standard concentrates over full-color still frame applications. A basic compression standard is the JPEG standard. Various modes are presented as JPEG comprising [1][2][3] baseline, lossless, progressive & hierarchal.

The general modes using DCT is JPEG baseline coding system, also it seems to be appropriate for majority of compression applications. In spite of the development in lower compression JPEG, it is highly helpful for DCT quantization & compression. JPEG compression will minimize the size of file through minimal image degradation by elimination of least required information. Though, it is referred as lossy image compression method as final image & actual image are not similar. The information of lossy compression will be lost while missed is affordable. Sequential steps will be performed for JPEG compression [11].

JPEG format will make use of lossy compression form constituted over DCT (discrete cosine transforms). Every field/frame of video source originated from spatial 2D-domain will be transformed to frequency domain (transom domain) with the help of some mathematical operations. A loosely operation constituted over perceptual model implemented over psychological system will eliminates the information having higher frequency i.e. sharp transitions of intensity & color hue. The process for minimizing the information in transform domain is termed as quantization. In a general wording, the process of quantization is explained as minimization of a larger number scale (having distinctive probabilities for every number) to the smaller values in optimal manner, and also the transform domain is an appropriate presentation of image as the frequency components re of higher value, that will contribute less to the whole picture than the other remaining coefficients, are having characteristically of lesser values with higher compressibility. The quantized coefficients will be further indulged to a sequence & loss loosely packed to output bit stream. Accordingly, all of the software applications of JPEG will allow control of user over compression ratio (also as per optimal parameters), permitting the user for trading off picture-quality for smaller size of file. In the incorporated applications (like mini DV, that makes use of a similar type DCT-compression schema), the attributes are pre-selected & described for an application.

The technique of compression will be generally lossy, which means that some original information about image will be lost, and it is not possible to restore them which will affect quality of image. The JPEG standard will define an additional lossless mode. Though, this mode will not be supported much by the products.

Also there is an interlaced progressive JPEG format, where data get compressed in several passes with progressively higher details. This works much fine for images of bigger size while it has to be downloaded from a slower connection. This will permit a sensible preview after obtaining a segment of the data. Though, progressive JPEG is not universally supported. As the programs receive progressive JPEGs which will not be supporting them (like versions of Internet Explorer even before Windows 7) [15] the software will present the image once it is downloaded completely.

There are several traffic & medical imaging systems which will generate & process 12-bit JPEG images, generally grayscale images. A 12-bit HPEG format has been considered as a segment of JPEG specification for some instances, but such format is not supported on wide scale.

D. JPEG Process Steps For Color Images

- An RGB to YCbCr color space conversion (color specification).
- Actual image is segmented into blocks of 8 x 8 size.
- The pixel values within every block ranging from[-128 to 127] but pixel values of a black & white image range from [0-255] hence, every block is shifted from[0-255] to [-128 to 127].
- The DCT works from left side to right, top to bottom thereby it is implemented over every block.
- Quantization will compress every block.
- Quantized matrix is entropy encoded.
- Reverse process will help in reconstruction image. This process uses the IDCT (inverse Discrete Cosine Transform) .

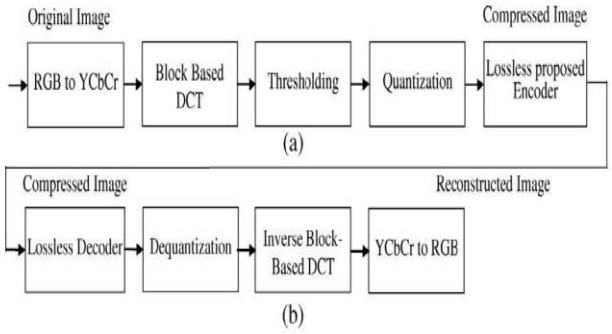

Figure 2. Compression algorithm scheme: (a) compression step and (b) decompression step

Below mention some advantages of Jpeg Image Compression

- This file type has the lowest file sizes but compression artifacts may be visible as you lower the quality option.
- Since JPEG is a lossy format.
- The quality loss is especially easy to see on sharp borders, on smooth borders and shading.
- Similar as photos or realistic looking drawings.
- The loss of quality is barely notices, if a JPEG image of high quality is selected.
- As the image is saved as JPEG, it should not be changed, saved or opened again, as it will drop its quality.

E. Discrete Cosine Transform

After the transformation of color coordinates, further step involves dividing the three color elements of an image to several 8 x 8 blocks. Every component of original block in an 8-bit image will be considered in the range of [0,255]. A data range is produced that will center around zero after subtraction of the mid pint (128 value) from every component of real block, so refined range will shift from [0,255] to [-128,127]. Images are segregated to several parts with different value of frequency by DCT. The step of quantization will eliminates the less needed frequencies while decompression will make use of necessarily required frequencies for retrieval of image .

$$F(u,v) = \frac{2}{N} C(u)C(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) cos[\frac{\pi(2x+1)v}{2N} \ldots . (4)$$

for u = 0,.....N-1 and v =0 ,....N-1

where N= 8 and

$$C(k) = \begin{cases} 1/\sqrt{2} & for\ k = 0 \\ 1 \end{cases} \quad \ldots \ldots (5)$$

F. Quantization In JPEG

Generally, the data is eliminated through the Quantization. The quantization is performed through division of transformed image DCT matrix by making use of quantization matrix. The values for outcome matrix will be rounded off automatically. Quantization coefficient is presented in (6) & (7) will lead to reversal process.

$$F(u,v)_{Quantization} = round\left(\frac{F(u,v)}{Q(u,v)}\right) \quad \ldots \ldots (6)$$

$$F(u,v)_{deQ} = F(u,v)_{Quantization} * Q(u,v) \quad \ldots \ldots (7)$$

Quantization focus over eliminating majority of the high frequency DCT coefficients that are not much important to 0, more will be the number of 0s better will be the compression of image. Lower frequencies are required for reconstruction of image as human eye possess more sensitiveness towards them & higher frequencies get discarded. Matrixes (8) & (9) stands for Q matrix defining luminance & chromatic elements [8][12].

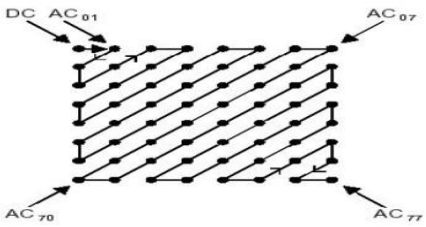

Figure 3. Zigzag Sequencing

G. Decompression

The phase of decompression works vice-versa to the compression. The initial step of this process is to restore Huffman tables from pictures & further decompression of Huffman tokens into the image. in the next step, DCT values for every block are firstly requires for decompressing a block. JPEG will help in decompression of remaining 63 values in every block by filling in required number of 0s. In the last step, combined zigzag order will be decoded and blocks of 8x8 sizes are formed. The IDCT (Inverse DCT) considers every value in the spatial domain & evaluates the contributions that are made by every 64 frequency values forming a pixel [7].

II. PROBLEM STATEMENT

Image compression is considered as a high need for storing the images & efficient transmission. By the implementation of digital products like cameras, transfer & storage of media has also been increased. The image files can be of bigger size & consume much memory. Any gray scale image of 256 x 256 size will be having around 65,536 elements for storing whereas a 640 x 480 colored image will be having around a million. The main aim of image compression is searching for an image representation where pixels barely correlate to each other. VHDL & architectural design of 2D-DCT when combined with the zigzag layout & quantization is mentioned in this paper. In the mentioned thesis, we are working for enhancing the performance of image compression & decompression attributes. The proposed methodology is capable of enhancing the performance given by PSNR (Peak Signal to Noise Ratio), NK (Normalized Cross). These mentioned attributes can enhance the performance produced by image compression & decompression if the value of NK & PSNR is raised from the presented structure. The values of AD (Average Difference), MD (Maximum Difference), MSE (Mean Square Error), SC (Structural Content), NAE (Normalized Absolute Error) have to minimized for enhancing the performance given to by image compression & decompression.

III. PROPOSED METHODOLOGY

A novel technique for post-processing the JPEG encoded images is proposed for minimizing coding artifacts & improvises quality of visualization. Our proposed technique is re-applied over JPEG towards shifted versions of the images that are already been compressed & makes an average. In spite of the simplicity, this technique perform better that other methodologies while comprising non-linear filtration, redundant wavelets & POCS.

Block transform coding of pictures through DCT (Discrete Cosine Transform) has observed to be a basic though efficient technique for

image compression. Various implementations of these techniques are observed to be accepted widely as per international standards of image & video compression, like MPEG & JPEG standards.

The prime approach for block transformation compression is very basic. The process of encoding is comprised of diving a image in blocks of standard 8x8 size. A block transform algorithm, generally DCT is implemented over these blocks & transform coefficients are quantized on individual basis (scalar quantization). Some lossless compression functions are executed for presenting the resultant data efficiently, while precisely comprising zigzag scanning of coefficients & entropy coding. A basic diagram of the whole process is demonstrated in figure 4.

The process of block encoding, while being simple & efficient, presents several non-desirable artifacts in an image; most prominently observant artifacts (discontinuities over block boundaries) & ringing artifacts (oscillations because of Gibbs phenomenon). The artifacts will sound more with an increase in compression ratio.

A significant working schema has been proposed for addressing the improvisation of DCT compressed images. The working in JPEG enhancement method is gaining much interest as the present number of JPEG encoded images is in millions and will keep on rising beyond impending introduction about JPEG 2000. A major illustration of this proliferation is over internet in which several web pages will makes use of JPEG encoded images. Another illustration is the images generated by digital cameras.

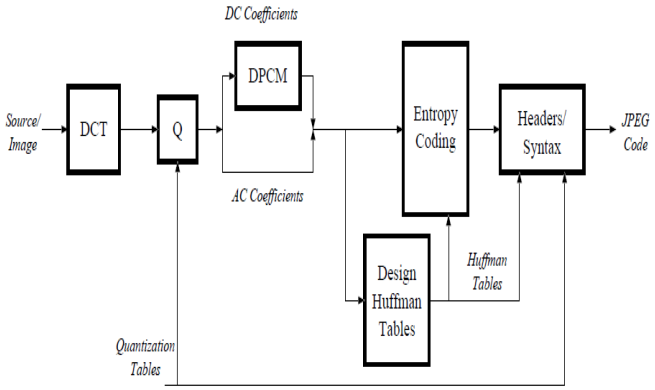

Figure 4. The JPEG encoding system

A novel post processing technique is presented for minimizing compression artifacts in JPEG encoded pictures. This technique is termed as significant departure from past few signs processing techniques, in this it don't particularly observe discontinuities in the boundaries of blocks, or neither it makes use of smoothness criterion. It follows JPEG process for minimizing compression artifacts of JPEG encoded images. This technique can be easily executed & apart from its simple nature, has a super competitive performance.

A. Huffman Coding

Huffman coding is considered as lossless data compression algorithm. The motive behind this is allocating variable-length codes for inputting characters; length of allocated codes is constituted over frequency of associated characters. The most frequently used character will be having smallest code & least frequent character will be having biggest code.

Huffman coding is considered as some of the most prominent techniques for elimination of redundancy in coding. It is been implemented in several compression algorithms, incorporating image compression. It is the most basic, but yet elegant, compression methodology will supplement multiple compression algorithms. It is also implemented in CCITT Group 3 compression. Group 3 is referred as compression algorithm that was produced by International Telegraph & Telephone Consultative Committee in th year 1958 for encoding & compression of 1-bit (monochrome) image data. Group 3 & 4 compressions are generally implemented in TIFF format. It will make use of statistical characteristics of alphabets in a source stream & further generates associated codes for such alphabets. These codes have a variable code length while making use of integral number of bits. The alphabetical codes processing higher probability for occurrence has short length than the codes for alphabets possessing lesser probability. Hence it is considered over frequency of occurrence of a data item (pixels or small blocks of pixels in images). It requires lesser number of bits for encoding frequency used information. The codes will be accumulated in a code book. A code book will be made for every image or set of images. Huffman coding is considered as most optimal lossless schema for compression of a bit stream. It operates by firstly making calculations of probabilities. Defining permutations {0,1} n by allocating symbols, termed as A;B;C;D. The bit stream may be seemed as AADAC. As an illustration. Now the symbols are allocated newer codes, higher will be the probability, lower will be the number of bits in code [3]. These codes serve as outcome of Huffman coder in form of bit stream. Now stopping point of code must be known & point for starting a new code. This problem is solved through enforcement of unique prefix condition: no code is prefix of any other code. The initial codes are referred as 01; 11; 001; 101; 0000; 1000l; 1001. In the Huffman coding schema, shorter codes are allotted to the symbols that are incorporated on frequent basis & longer codes to those which seems to occur less frequently [1].

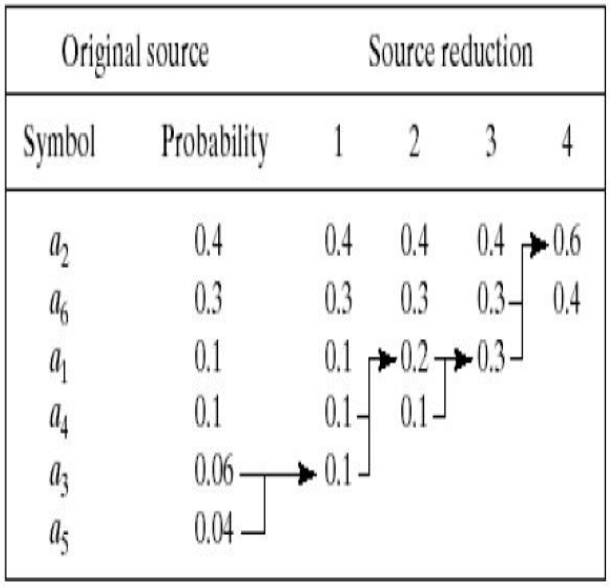

Figure 5:- Huffman Source Reductions

B. Huffman Code Construction

Huffman Coding Algorithm works as bottom-up approach.

- *Algorithm*

Steps of Huffman Coding algorithm are mentioned as below [9]:

1. Generating a series of source reduction: combining two minimal probability symbol to a single symbol; it is repeated till a minimized source having two symbols is obtained.

2. Coding every reduced symbol: starting from smallest source & coming back to actual source.

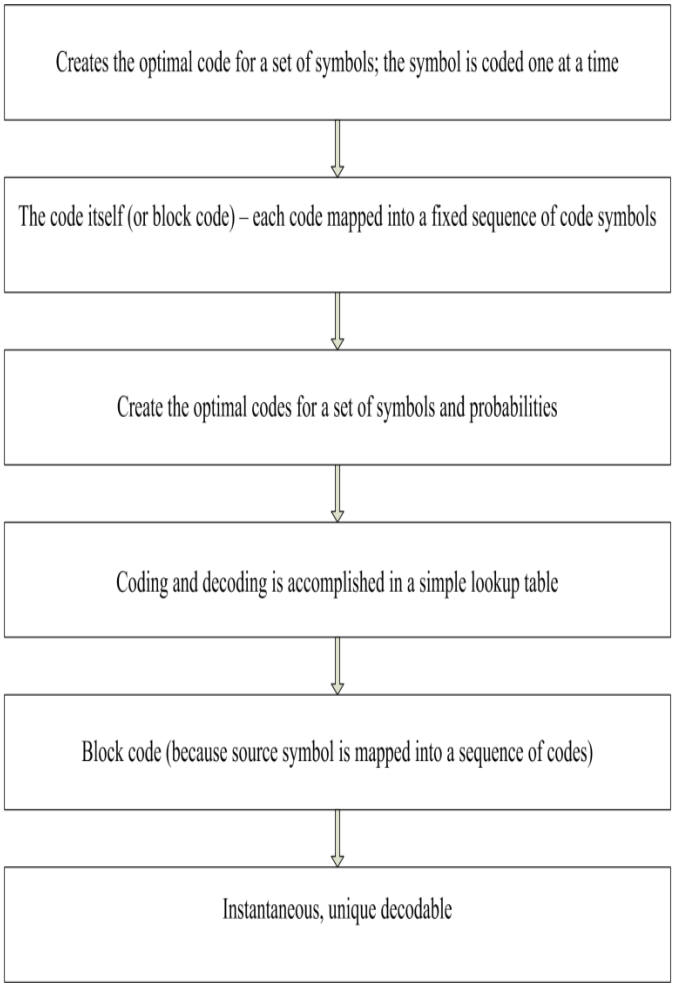

Figure 6 :- Huffman Coding Steps

Huffman codes are considered as optional prefix codes produced through a set of probabilities by a definite algorithm i.e. Huffman Coding Algorithm.

IV. RESULTS

Image compression is an important technique for reducing the size of the image and for sending it in low size. Image have many types in this lossy compression is widely using in network-related applications .The applications of lossless compression is file image/video/audio compression, big size file data zip and much more. In this research, we are comparing two types of images

1:- Gray Scale Color Image

2:- Color Image

As fig 9 is showing the gray color image . It is out original image which we have to compress.

Figure 9:- Original Image

Fig 10 is showing the Compressed image of the original image .

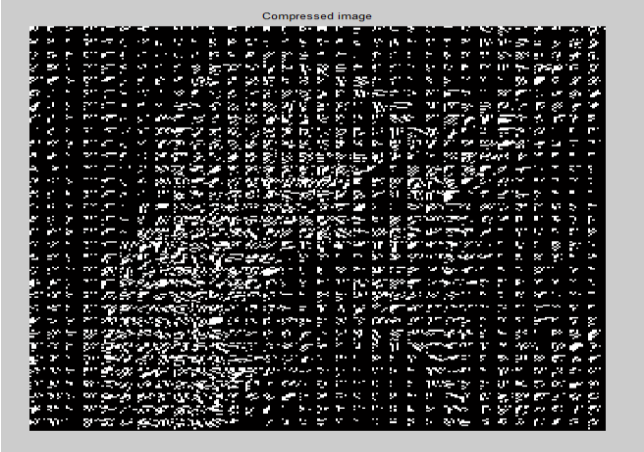

Figure 10 :- Compressed image

Fig 11 is showing the Decompressed image of the compressed image by the DCT technique .

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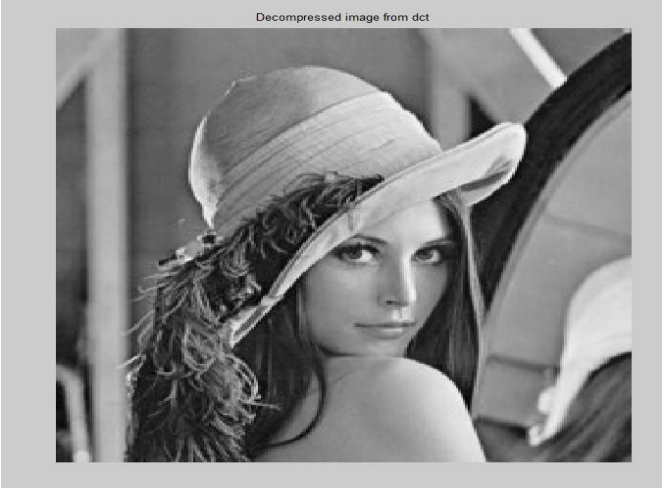

Figure 11 :- Decompressed Image

Fig 12 is showing the original color image . For show the results we will compress the color image also. In the figure 5.5 and 5.6 we will show the compressed and decompressed image .

Figure 12:- Original Image

Figure 13 is showing the compressed color image of the original image.

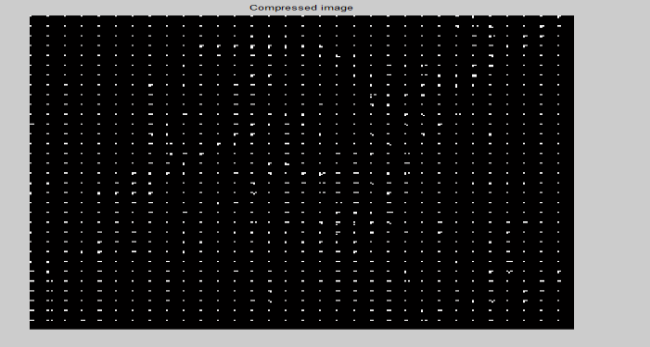

Figure 13:- Compressed Image

In fig 14 is showing the decompressed image which get from the compressed image .

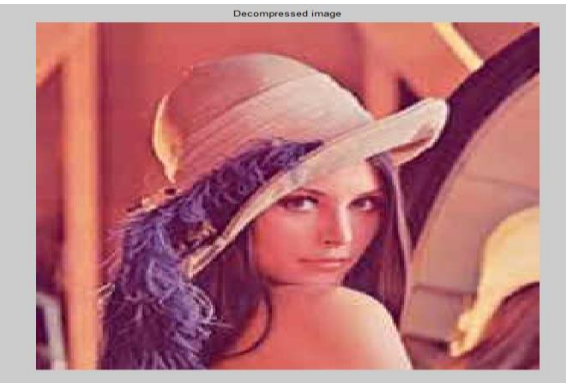

Figure 14:- Decompressed Image

Method	JPEG Existing	JPEG Proposed
MSE	17502.21	63.63
PSNR	5.70	30.09
NK	0.00	1.00
AD	123.58	-0.02
SC	64979.04	1.00
MD	239.00	58.00
NAE	1.00	0.04

Table 1 :- Comparison Table

V. CONCLUSION AND FUTURE SCOPE

A. Conclusion

In this paper, we are improving the performance of the image compression. For improve the performance of the image compression , we are improving the parameter of MSE(Mean Square Error , PSNR(Peak Signal to Noise Ratio) , NK(Normalized Cross Correlation) , AD(Average Difference) , SC(Structural Content) , MD(Maximum Difference) , NAE(Normalized Absolute Error). As we can check from the results session, PSNR and NK value is getting increase and remaining all the values are getting the decrease . For improving the performance of the image compression, we have to decrease the value of NAE, MD, SC, AD, MSE and PSNR, NK values we have to increase.

B. Future Scope

For further enhance the performance of the image compression and decompression, can be done by other lossless methods of image compression because as it is concluded above, that the result of the decompressed image is almost same as that of the input image, so it indicates that there is no loss of information during transmission. So other methods of image compression, any of the type i.e., lossless or lossy can be carried out as namely JPEG method, LZW coding, etc. Use of different metrics can also take place to evaluate the performance of compression algorithms.

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