IMAGE COMPRESSION USING MATLAB

Project report submitted in partial fulfilment of the requirement for the degree of Bachelor of Technology

In

Computer Science and Engineering/Information Technology

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CERTIFICATE

I hereby declare that the work presented in this report entitled **"Image Compression using MATLAB"** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science and Engineering/Information Technology** submitted in the department of Computer Science & Engineering/Information Technology**,** Jaypee University of Information Technology Waknaghat is an authentic record of my own work carried out over a period from August 2017 to May 2017 under the supervision of Professor S.P.Ghrera**, Professor (HOD), Department of Computer Science & Engineering and Information Technology.** The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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This is to certify that the above statement made by the candidate is true to the best of my knowledge.

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Dated

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Acronym Description

DCT	Discrete Cosine Transformation
DWT	Discrete Wavelet Transformation
DFT	Discrete Fourier Transformation
FFT	Fast Fourier Transformation
FWT	Fast Wavelet Transformation
JPEG	Joint Photographic Expert Group
JPEG-2000	Joint Photographic Expert Group-2000
MPEG	Moving Pictures Experts Group
MSE	Mean Square Error
PSNR	Peak Signal to Noise Ratio
SNR	Signal-to-noise Ratio
ISO	International Standards Organization
LOT	Lapped Orthogonal Transforms
IEC	International Electro-Technical Commission
DPCM	Discrete pulse code modulation
FAX	Facsimile transmission
KLT	Karhunen Lòeve Transform
IDCT	Inverse Discrete Cosine Transform
BTC	Block Truncation coding

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ABSTRACT

Picture Compression is the utilization of information pressure on advanced pictures. The field of image compression has seen an unmistakable movement since Discrete Wavelet Transform turned out to be broadly perceived. Its applications can be stretched out to numerous branches of designing. Its fundamental point is to expel excess or unessential data which isn't required in the picture or is dull. Issues with capacity and information transmission because of vast measure of information for advanced pictures are comprehended. Remote detecting by means of satellite, sight and sound, military and medicinal pictures are couple of uses of Image pressure. In this report we will see four primary calculations that we have executed: DCT, BTC, Huffman Coding and JPEG Algorithm.

Chapter 1

INTRODUCTION

1.1 Introduction

In this modern scenario, everyone requires products at cheap rate with miniaturization. Till now this is applicable only for electronic circuits. But with the growing needs of the users it is also applied to the digital images. We can easily transmit multimedia information through web network. Now a days, use of camera, transformation and manipulation of images is grown explosively. These digital picture files are huge in size and take large part of memory. While transmitting and receiving signal they waste enormous bandwidth which is a main constraint for us. For eg: an image consists of 256X256pixels and it stores 65,536 elements, while downloading of such types of files from internet takes lot of time. For the efficient utilization of the memory, bandwidth and time, we have come up with the solution i.e. image compression. Image compression is a technique which compresses all the digital images so that they cover less space. With the use of image compression system, efficiency and speed increases whereas processing time, memory storage and capacity decreases. A typical issue happens in a large portion of the pictures is that their neighboring pixels contains part of excess data which additionally impact the genuine execution of the framework. The essential target of picture pressure is to discover a picture portrayal in which pixels are less related

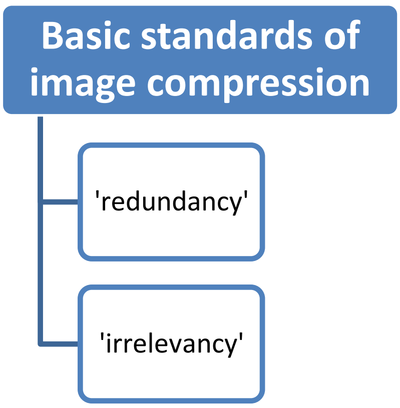

Fig 1.1: principles of image-compression

Two basic principles of image-compression are: redundancy and irrelevancy (as shown in fig1.1). Redundancy removes redundant bits inside original source and Irrelevancy removes pixel values that are not detected by human-eye. Jpeg compression & jpeg2000 are one of the best examples of image compression.

In the late 1970's the work on image compression started with the CC1ITT .They worked at dual illustration compression algorithms meant for Group 3 fax communications. Since then, lot of other committees after that principles have been created headed to generate de jure standards (like JPEG), through a number of commercially victorious initiatives have efficiently become de-facto-standards (like GIF). Image-compression consists of lot of benefits as shown in fig1.2

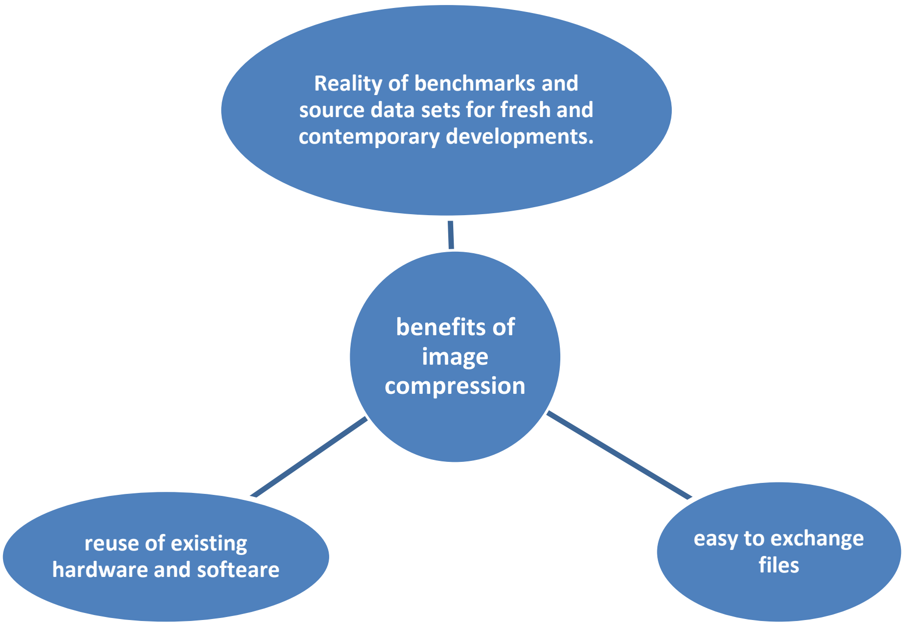

Fig1.2: Benefits of image expression

1.1.1Basic concept of image

Image formed with the combination of dots which is called pixels. Pixel can also be defined as tiniest element which is capable of being addressed. Image size contains number of pixels which consists of width and height. Pixels of image have certain color for example: 8 bits for each pixel, which is sufficient to speak to each shade of dim that a human eye can recognize. When colored pictures are chosen for analysis then it become more difficult to deal with. It is calculated by the depth of image which consists of number of bits per pixel .A bit plane of n-bits can have 2^ncolors. But human eye is capable to differentiate 2^{24} colors, , albeit some claim that the quantity of hues the eye can recognize is substantially higher. The most widely recognized shading profundities are 8, 16, and 24.two prominent approaches to distinguish shading data in a picture.

- To begin with path is to speak to every pixel's shading is by giving a requested three times of number, that is the mix of red, green, and blue. This is known as colored (RGB) image.
- The next strategy to store data is to utilize a tabular format to store three times calculated number, and utilize a reference into that very table for every pixel.

1.1.2 File Format

File formats are used to represent an image,out of many formats, these two popular formats are mainly used. Which are as given in fig1.3

- GIF (Graphics Interchange Format) The most widely recognized picture design on web is 1 to 8-bit shading or greyscale pictures.
- TIFF (Tagged Image File Format) The standard picture organize found in most paint, imaging, and work area distributing programs.

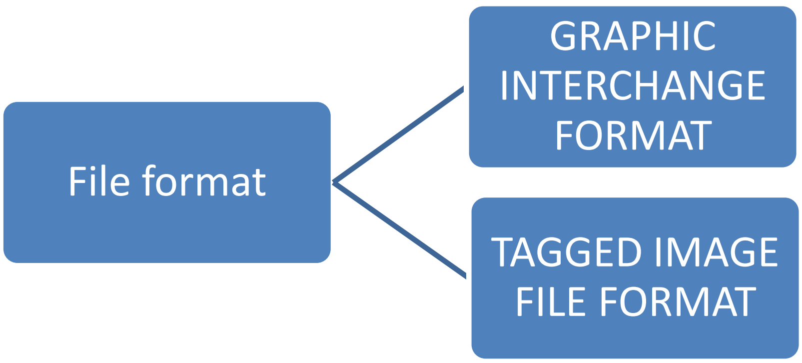

Fig1.3: types of file format

1.1.3 Image Compression

Uncompressed images occupies lot of space and difficult to transmit or download. So we opt. image compression technique. This is finished by evacuating all repetitive or pointless data. For instance, a standard 9.5" by 11" sheet of paper checked at 100 dpi and confined to highly contrasting requires in excess of 100k bytes to speak to. An Uncompressed image requires 728k of space. So it concludes that image compression reduces the memory size.

There are in all two types of compression:

- Lossless
- Lossy

Lossless compression preserve the picture as original. Its fundamental point is to decrease the bit rate of image without any poor degradation in information The bit-stream after decompression is identical to the original bitstream.

On the other hand lossy compression produces less productivity as compare to original image but its main benefit is that we can achieve more level of compression

Image-compression is a method which lessens the measure of information required to speak to an advanced image. This can be accomplished by expelling the redundancies

- Spatial Redundancy
- Spectral redundancy
- Psycho-visual redundancy

There are various algorithms which can be used for compressing the images but we can use two ways to categorize compression techniques.

Predictive coding :

It is type of coding in which value for every component in original and decoded image is identical to DPCM. It is also called lossless coding method.

Transform coding :

Transform coding is used to map the picture into an arrangement of coefficients & the subsequent coefficients are further quantized and encoded. The primary endeavors is the DCTchange space.

1.1.4 Compression Ratio

Compression ratio calculates the "quality of image" means if the compression-ratio is high then image removes more redundancy then other. In the event that "n1 & n2" are the quantity of bits in dual datasets that speak to a similar picture, the relative repetition of the main dataset is characterized as:

$$R_D = 1/CR$$

CR= compression ratio

$$CR = n1/n2$$

On the off chance that a picture is packed at a proportion of 100:1, it might be transmitted in 100th of the time, presently a days pictures have turned out to be so ordinary thus basic to the capacity of PCs. It is very difficult to see that how much is difficult without it. So there are many image-compression "models" that are unique in a way they reduce data. The main function of source codificader is u to deduce redundancy from the input-image. The purpose of channel codificader is used as equipment so that one can compensate effect of channel-noise, example: addition of parity bit at end of data bits. The main purpose of decoder is exactly reverse of encoder that is restoring the image and then presenting it with reduced size to the user.

1.1.5 Objectives

Basic purposes behind implementing this project that came into our mind was based on the increasing use of images mainly grayscale in various fields. Thus in our project there initially occurs conversion of colored into gray image if original image is colored. Then comes the output of restored image with size and quality. Areas for which the project is mainly focusing are:

(1) In case of Remote Sensing
    In order to resolve land disputes and monitor various land properties either its forest land or land owned by someone. Image kept after selling the land to buyer will be kept in government office database to ensure how much area deserves to whom. Ultimately to stop illegal land mining so that no one can illegally capture even a single unit of area of someone else's land.

(2) In biology related test labs where they need to keep the record of polynomials or other
    Micro items.

(3) For security point of view
    In Nacsalites areas, we can fix up a camera which takes pictures of those areas after every short interval and stores in database and in case it captures some people hiding the one viewing database can aware the head office and make that area secure for other villagers living there.

1.1.6 Methodology

Flow chart shows the methodology of performed work that is initially the conversion of original image if colored into grayscale and then implementing DCT, BTC, JPEG and HUFFMAN on various image file formats that is tif, gif, png, jpeg, bmp and getting the reconstructed image back of reduced size. And calculating various parameters that are MSE, PSNR, SSIM, CR on every sing image tested.

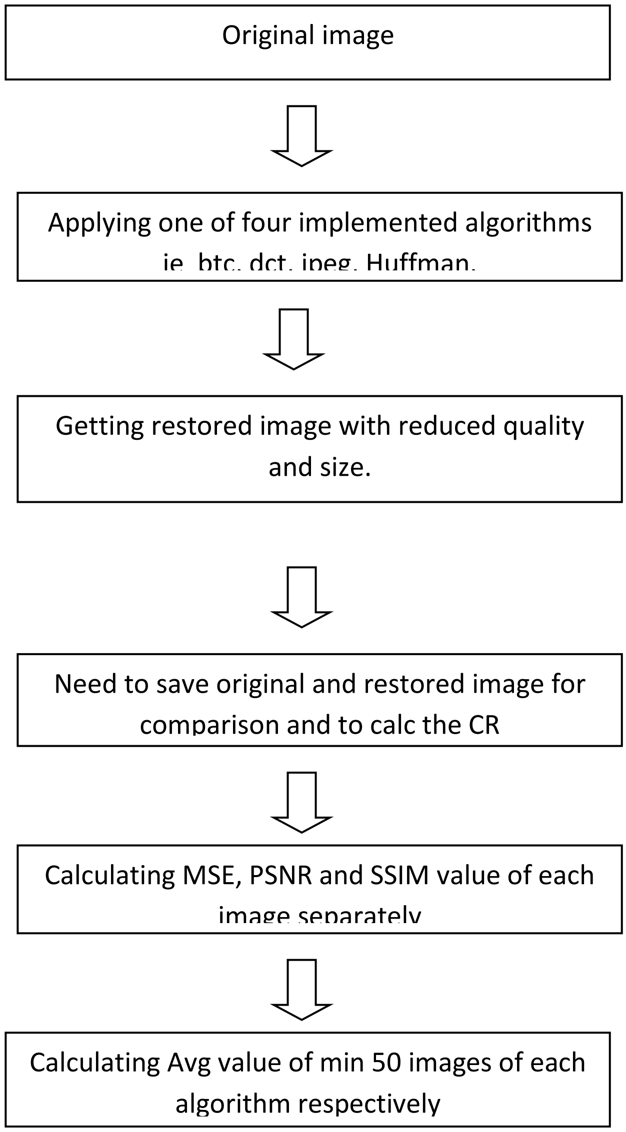

Fig 1.4 methodology

Chapter 2

Literature Survey

Alfred M. Bruckstein et al have presented Post processing of Compressed Images via Sequential Denoising on 2016. In this paper a new and innovative approach is presented, post processing technique for compression-artefact reduction. Approach depends on representing this assignment as an opposite issue, with a regularization that influences on existing best in class picture denoising calculations. A key component in our plan is a linearization of the pressure decompression process, to get a detailing that can be improved. the broad trials built up the proposed pressure antique decrease strategy as a nonexclusive technique that accomplishes front line comes about for any applicable picture pressure and over the whole piece rate extend.

M.Deriche et al proposed " a new wavelet based efficient image compression algorithm using compressive sensing" in 2015 , which is based on compressive sensing. Its begins with a customary multilevel 2-D Wavelet deterioration, which gives a reduced portrayal of picture pixels. The proposed wavelet-based CS recreation, with the standardized estimation grid, brings about execution increment contrasted with other regular CS-based methods. The proposed approach presents a totally new system for utilizing CS in the wavelet area. To assess the execution of the proposed calculation, we began by choosing ten dim scale test pictures of various sorts (.BMP,.PNG,.PGM) regularly utilized as a part of benchmarking. Exploratory outcomes demonstrate that the proposed calculation, accomplishes better remaking quality, at a similar estimation proportion, contrasted with cutting edge CS-based picture pressure strategies.

Priya bajpai et al have presented Greedy Algorithm for Image Compression in Image Processing on 8 May, 2017. In this paper, change in the WDR calculation is been proposed and change depends on choice calculation. The WDR is the productive procedure in which the entire picture is partitioned into little network and lattice which has unique properties are expelled from the picture. The proposed method has been actualized in MATLAB by taking the informational index of 10 picture which are in the greyscale. Hence this enhanced calculation is better since its pressure proportion is higher.

Cristian perra et al members of IEEE proposed an algorithm for lossy compression of unfocused light field images in 2017. The crude light field is pre-handled by demosaicing, devigneting and cutting of the crude lenset exhibit picture. The trial examination looks at the execution of the proposed technique against the immediate pressure with JPEG 2000and JPEG XR as far as BD-PSNR pick up and bit rate diminishment. The informational collection utilized for the test assessment of the proposed strategy is formed by twelve pictures. It can be watched that for all pictures the proposed calculation performed superior to the reference calculations. The normal PSNR pick up was 0.55dB with a bitrate decrease of 3.7% against JPEG 2000 encoding, and 0.60dB with bitrate lessening of 2.5% against coordinate JPEG XR encoding. The outcomes affirm that a superior comprehension of the light field flag structure can use the improvement of novel pressure calculations giving higher pressure proportion than previous calculations.

Xinfeng Zhang et al IEEE members presented "Just-Noticeable Difference-Based Perceptual Optimization for JPEG Compression" on jan 1, 2017. In this letter, we propose ajust-detectable contrast (JND) based quantization table inference technique for JPEG by improving the rate-contortion costs forall the recurrence groups. To accomplish better perceptual quality, the DCT area JND-based contortion metric is used to demonstrate the stair mutilation saw by HVS. The proposed technique accomplishes around 16.7% to 22.0% piece rate investment funds for test pictures, and 18.3% piece rate reserve funds by and large contrasted and JPEG standard. the picture created with our quantization table is all the more outwardly charming, particularly less ringing ancient rarities are seen at the back of the rider.

Aqeel Noori et al presented a Method for "Image Compression Using Discrete Wavelet Transform and Absolute Moment Block Truncation Coding" in 2011. In this paper half breed picture pressure technique has been exhibited which comprise of two phases first discrete wavelet change and second Total minute piece truncation coding . To assess the execution of the proposed picture pressure plot, four standard monochrome pictures of size 256 X 256 pixels had been utilized The trial comes about demonstrate that the proposed strategy has a decent execution, such it gives higher PSNR esteems with reasonable estimation of pressure proportion contrasted and the ordinary technique for AMBTC.

Shih-Lun Chen et al members of IEEE proposed "A Cost and Power Efficient Image Compressor VLSI Design with Fuzzy Decision and Block Partition for Wireless Sensor Networks". This paper exhibits a novel equipment situated picture pressure calculation and its substantial scale reconciliation (VLSI) usage for remote sensor networks.It consistes of fluffy choice, piece segment, advanced halftoning, and square truncation coding (BTC) strategies. Eight unique sorts of squares were encoded by Huffman coding as per likelihood to expand the pressure proportion further.It enhances picture quality and pressure execution. Contrasted and past JPEG, JPEG-LS and settled size BTC based outlines, this work lessened 20.9% entryway checks more than past plans. Also, the proposed configuration required just a one-line-cushion memory as opposed to a casing support memory required by past outlines.

Pradeep Yadav et al proposed "Content based image retrieval using dither block truncation coding with similarity comparison algorithm" in 2016. The principle point of this paper is to diminish the computational time, to build the intricacy proportion and to enhance the picture quality by applying Dither Piece Truncation coding calculation with various closeness examination calculation. A portion of the highlights of a pictures, essentially color, shape and surface are talked about. To assess the recovery execution two standard parameters, exactness and review are utilized. BTC calculation in which mean and standard deviation are figured because of which computational many-sided quality increases. So they presented the dithering based piece truncation coding in which the dither exhibit lessen the computational many-sided quality and also likewise builds the picture quality.

Mander et al proposed an algorithm of " improved image compression – decompression technique using block truncation and Wavelets" on 8 Aug, 2017. The paper centers around pressure method referred to as square truncation coding as it helps in diminishing the span of the picture with the goal that it consumes less room in memory and simple to transmit and furthermore gives the quantized reproduced picture in a brief timeframe. Along these lines, BTC is utilized to pack greyscale pictures. After pressure Discrete Wavelet Change with slpine addition is connected to remake the pictures. The proposed philosophy is tried upon a few prestigious benchmark pictures and their PSNR esteems have been recorded which brings about preferable quality pictures over in existing strategies as the distinction got is 43% of PSNR esteems when computed as a normal. The proposed technique can be additionally utilized as a part of packing and sending pictures among sensors sent to get the data gathered through pictures.

Asodllah shahbahrami, Ramin Bahrampur: This paper demonstrates the relative examination of entropy coding, number juggling or Huffman with other frame the pressure systems. they actualized and tried Huffman and number juggling calculations. The outcomes demonstrate that pressure proportion of number juggling coding is superior to anything Huffman coding, while the execution of the Huffman coding is higher than Number-crunching coding.

Veerpal kaur, Gurwinder kaur: They proposed a new method of compression which includes the combination of "Discrete Wavelet, Discrete Cosine and Huffman" compression schemes. They shows that DWT and DCT is very good to cope up compression ratio but as they are lossy techniques so their quality measurement which they concluded with the help of PSNR is decreasing due to so, further to enhance CR. they are using Huffman compression method because of its lossless compression nature and it will provide them good PSNR and high CR value. This concludes that after applying lossy techniques it's better to use lossless too to enhance compression at same PSNR.

The paper was proposed by **Ridhi Jindal** in 2017 named " Digital image compression technology" for the quick transmission and continuous preparing of computerized picture data on the web. Albeit still picture pressure is a strategy produced for quite a while, in addition to there are a few methodologies which lessen the pressure rate, and quicken calculation time, there are still a ton to go to enhance the adequacy of pressure. This paper is an examination of different pressure methods can be connected to various kinds of pictures. By breaking down the focal points and detriments of various systems, we can pick the right method that can be utilized for picture pressure.

Christy Sumitha Vincent et al proposed "N-pattern Huffman compression algorithm for medical facility" on 20 November, 2015. The principle reason for this paper is to advance a plan to lessen the extent of the therapeutic pictures to be transmitted ideally and subjectively with the extraordinary concentration in the field of telemedicine. This has been accomplished by enhancing the current Huffman lossless pressure calculation. The proposed N-Pattern Technique centers around distinguishing proof and gathering the diverse length designs in light of their power esteems and advancing the contribution to the encoder for pressure. On correlation with the current technique, the proposed strategy enormously enhances the pressure and the space sparing with the nature of the picture being as yet kept up. The current 2-3 design technique has its own particular restrictions of example length, quality and pressure change of 4-5 % over Huffman has been portrayed [2]. Comparitively, the proposed "N-Pattern Technique" demonstrates a huge change in the pressure proportion of 14-17 % and the space sparing contrasted with the current Huffman strategy. The technique additionally is relevant for more typical expansions of medicinal pictures together with an adaptability of example length. The measurements of the Entropy and the PSNR affirms with the lossless quality. The outcomes additionally demonstrate that the pressure proportion of the pictures considered relies upon the length of the non-dull examples and its recurrence of appearance. For lesser the length of the example and higher their frequencies, bigger is the pressure proportion. It additionally demonstrates that for length of the examples of range (n=5 to 20) gives better pressure. Clearly the future will be driven by conservative instruments and their network bringing greater office for the mankind. So the better pressure methods have high potential and market in telemedicine applications particularly for the countries that have still a restricted scope or data transfer capacities for correspondence. Thus the proposed technique can be additionally refined and advanced for recordings.

Shreyank N Gowda et al proposed algorihm on Image Stenography on 2nd International Conference on iCATccT in 2016. The planned algorithm is a intonation of the rank slightest substantial morsel Algorithm (LSB). Wearing the projected algorithm the in rank near exist clandestine is measured just before be present text. This passage is full as well as paramount encrypted with the statistics Encryption touchstone Algorithm (DES) along with the aid of a key. This solution toward encrypt the records is it follows that encrypted via the RSA algorithm. This encrypted book is afterward unseen in vogue an vision by means of the normal LSB algorithm as well as next the representation is sent. on the road to decrypt the data, main the solution has en route for ensue decrypted by RSA algorithm. Next, via with the intention of crucial the relaxation of the records is extracted shown sooner than decryption with DES algorithm. This provides a dual layer of security, by means of leading encrypting the wording by DES after that at that moment encrypting the recipe representing DES by RSA. This guarantee penetrating reliability of the algorithm.

Chapter 3

System Development

3.1 Need for image compression:

Load of data managed by computers has grown exponentially over past times due to evolution in fashionable teleconferencing, internet, disc, multimedia and HD television technologies. That is why “storage and transmission of digital images” has developed into a key problem. Some of the images have the storage problem because of their large size so at that time there is need of image compression technique. Using a 96000 bauds(bits/sec) modem, approximately 11 minutes are taken for the transmission of even one image, which is not suitable in most of the applications.

3.2 Standards behind compression:

Picture can be compacted by decreasing the repetition factor .There are three kinds of redundancies: spatial excess, spectral and temporal as shown in fig 3.1

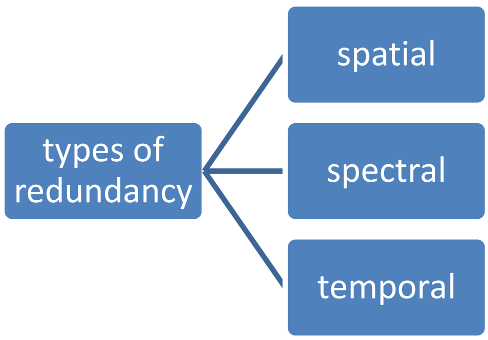

Fig3.1: types of redundancy

‘Spatial redundancy’: It is because of the reliance between neighboring pixels.

‘Spectral redundancy’: It is because of the connection between's various spectral groups.

'Temporal redundancy': Information repetition is the fundamental issue in advanced picture compaction. If n1 and n2 indicate the numbers of information/details carrying modules in 'native' and 'new' image respectively, at that point the compression-ratio can be characterized as

CR=n1/n2;

Furthermore, information excess of unique picture can be characterized as

RD=1-1/CR;

Three conceivable outcomes are:

(1) If n1=n2, at that point CR=1 and henceforth RD=0 which entails unique picture/image does not contain any excess between the pixels.

(2) If n1>>n1, at that point CR→∞ and subsequently RD>1 which implies the significant measure of excess data in the original picture.

(3) If n1<<n2, at that point CR>0 and thus RD→-∞ which demonstrates that the new picture contains a bigger number of information than old picture.

3.3 Compressing of image-types:

Compression is primarily divided into types ':losssy' and 'lossless'

3.3.1 Lossless Technique: different types of lossless techniques are given in fig 3

a. entropy

b. run time

c. LZW

d. Huffman

e. arithmetic

a. Run Length Encoding (RLE) : It goes under the class of 'lossless information compression'. ‘RLE’ is a least difficult kind of information compression strategy. Runs term is utilized to store information which additionally contains types of arrangement. RLE can be utilized as a designs document and ‘graphics file format’. It isn't reasonable for work uninterrupted tone pictures, for example, photos, despite that fact that for JPEG it very fruitful.

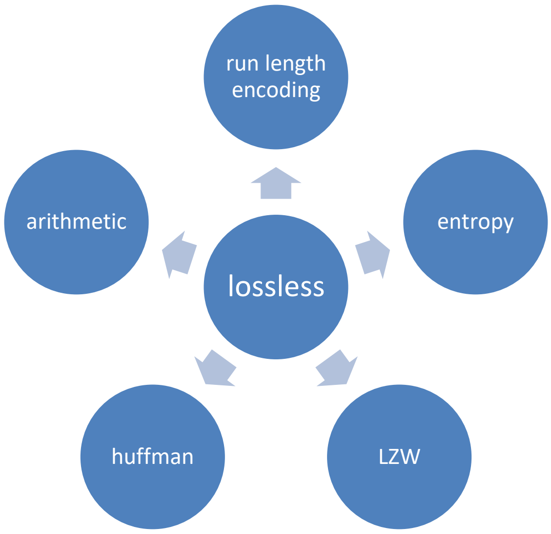

Fig 3.2 types of lossless techniques

<u>Entropy Encoding:</u> Entropy encoders are utilized to minimize information by with the assistance of cryptogram which constitute to a similar length codes by methods for images. Thus, the most widely recognized images utilize the briefest codes.

<u>Huffman coding:</u> This is most effective coding system and is accustomed to produce least excess codes contrasted with diverse calculations. This coding has effectively surmised as a part of content, picture, video pressure, and also conferencing framework.

For eg: below coefficients shows the basic algorithm behind Huffman coding

r_k	$p(r_k)$	node 1	node 2	node 3	node 4	node 5	node 6
7	0.601	0.601	0.601	0.601	0.601	0.601 0	0.601 0
4	0.082	0.082	0.114	0.130	0.152	0.244 10	0.396 1
3	0.066	0.070	0.082	0.114	0.130	0.152 11	
2	0.064	0.066	0.070	0.082	0.114		
1	0.063	0.064	0.066	0.070			
0	0.051	0.063	0.064				
5	0.047	0.051					
6	0.023						

<u>'Arithmetic Encoding (AC)'</u>: It is a technique utilized for static lossless encoding. It gives extra adaptability and more proficient capability than the Huffman coding. 'AC' for the most part conveys code words with idea length. 'AC' is valuable strategy to code images comparing to the likelihood of their event. Every image is allotted an interval by the 'AC', whose size shows the likelihood for the image's appearance. A normal number which has a place in the interval is the code expression of the image.

<u>'LZW Coding':</u> The operation based algorithm, which is the' LZW' algorithm depends on the numerous events of character arrangements in the string to be encoded. Amid the procedure the calculation goes over the stream of data, codes it; if a string isn't minor or slight than the longest word in the dictionary then it transmits. Through deciphering process, the calculation constructs the word reference again the other way; in this manner, there is no compelling reason to store it.

<u>3.3.CODING TECHNIQUES FOR REDUCING IMAGE-LOSSLESS</u>

Lossy technique is of three types as shown in fig

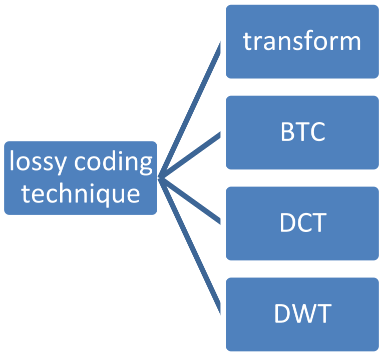

Fig 3.3 types of lossy technique

Block Truncation coding: This is mainly used for grayscale images and come under the category of lossy image compression. BTC usually divides the images in form of various blocks after which it send them to the quantizer for further process. In further process, it reduces it to grey scale levels. The main purpose of each block is to maintain mean and deviation at each point. BTC has also been adapted to color and video compression also. After BTC, AMBTC come into existence .In this, instead of standard deviation, it preserves the absolute value of image along with the mean.

Transform Coding: In this old picture , it is separated into sub parts and coefficients of each piece are computed, effectively changing over the first 8 x 8 array of pixel value into a coefficients arrays. Subsequent to computing coefficients the following stage is to quantize the picture and the yield of the quantizer is utilized by an image encoding system to deliver the yield bit stream which renders the encoded picture. At the beneficiary side (receiver), reverse of this process happens which is dequantizing.

Discrete Cosine Transform (DCT): this type of technique usually applies on blocks of '8 * 8' or '16 * 16' pixels. Following, it changes it into arrangement of coefficients which comprises of spectral synthesis of 'blocks'. The transformer in DCT changes picture such information has lesser pixel redundancies in the given picture. This is reversible and used to outline pixel onto an arrangement of coefficients, which are encoded and also quantized . The primary favorable position of this system is that the subsequent pictures have little sizes and can be quantized without causing decoded picture to be crooked.

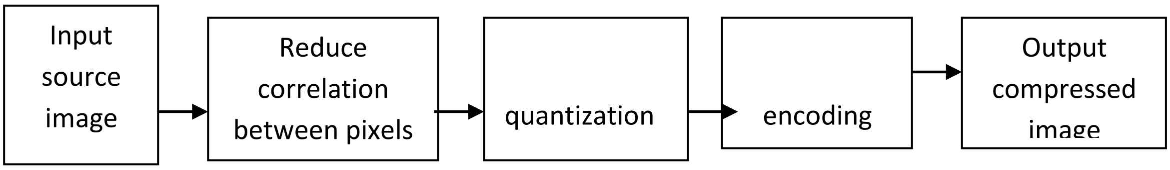

Fig 3.4. process to compress image

Discrete Wavelet Transform (DWT): In this sort of system technique, picture is taken as as a total of wavelet capacities/functions, known as wavelets, with various area and scale. The picture produces the information into an arrangement of detail and surmised coefficients. Right of the bat, the picture is separated into squares of 32×32. Each piece or block is then gone through the filters : the principle undertaking of first filter is to decmpress the information into an estimated and detailed coefficients. In the wake of getting the new transforming matrix, the detail and comparative coefficients which are isolated as 'LL', 'HL', 'LH', and 'HH' 'coefficients'. Every one of the coefficients are disposed of aside from the 'LL coefficients' that are changed into the second level. The coefficients are then gone through a steady scaling component to accomplish the coveted 'compression ratio'.

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3.4 Performance criteria for image compression :

Any image can be verified through quality measure of the new image that is formed and the its compression ratio.

Compression ratio: It can be described or interpreted as ratio of 'given image' size and size of reconstructed image .

$$CR=\frac{n1}{n2}$$

n1=original image size

n2=reconstructed image size

Quality measure: Distortion-measure:' Mean Square Error- MSE' is measure of distortion rate in the new compressed picture.

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

'**PSNR**': is for the most part used to gauge the nature of compacted picture which is given by

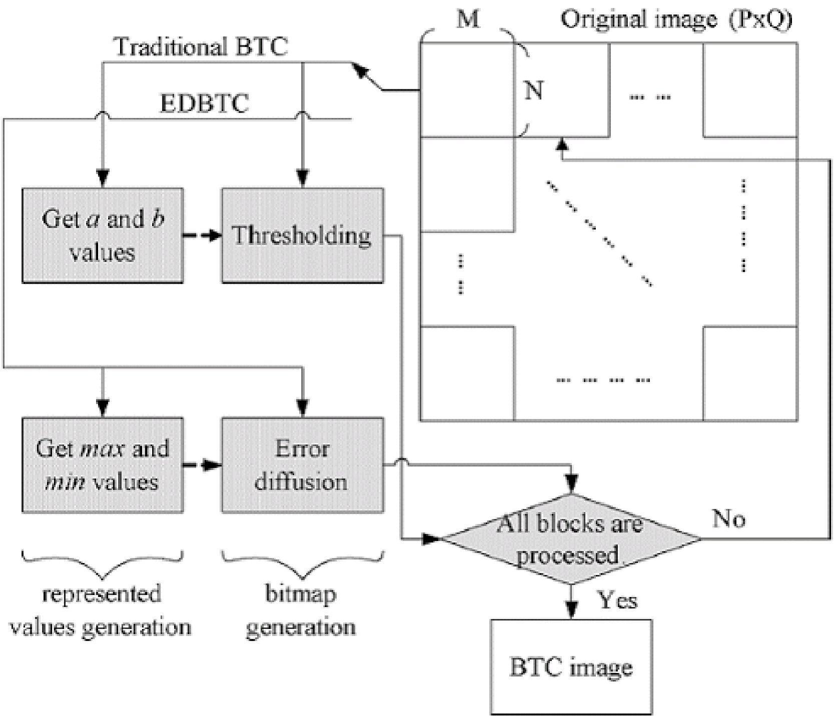
$$\text{PSNR}=10\log\frac{255\text{^}2}{MSE}$$

Chapter 4

Performance Analysis

4.1 Block Truncation Coding:

This is one of the lossy compression process used that safeguard's the first and second statistical moments of the image. This method was first proposed by in a paper by Delp and Mitchell in 1979. Basically in this process there occurs division of image into blocks. The size of a block is generally 3X3 or 4X4 pixels. Threshold is chosen within each block and each pixel value is coded as 0 or 1. Value depends on whether it is above or below threshold. Block truncation algorithm endeavor to safeguard respective mean and also variance of each block of particular image. It requires less computational effort and also btc has a good capability reducing channel effort.



BTC Flow Chart

The main advantages of using *BTC* are:

i. *BTC* is less complex.

ii. It is able to regenerate every edge of the original image.

iii. By using the variance of each block it can be compressed separately.

iv. It may be fixed or adaptive.

v. *BTC* requires little memory space.

vi. This is easy to implement.

BTC Algorithm:

1. A set of non overlapping blocks of pixels are formed by partitioning the image. Let X(m,n) = original image and block matrix be f(m,n).
2. Mean, mean square and Variance are calculated for each block
   (a) Calculating Mean:

$$\bar{f} = \frac{1}{m \times n} \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f(m, n)$$

   (b) Calculating Mean Variance :

$$\overline{f^2} = \frac{1}{m \times n} \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f^2(m, n)$$

   (c) Calculating Variance :

$$\sigma^2 = \overline{f^2} - \bar{f}^2$$

3. Construction of “Binary Allocation Matrix” B(m, n) in such a way:

$$B(m, n) = \begin{cases} 1 : f(m, n) > \bar{f} \\ 0 : f(m, n) \le \bar{f} \end{cases}$$

4. a and b are two values of each block calculated using formula :

$$a = \bar{f} - \sigma \sqrt{\frac{q}{m-q}}$$

Where q represents number of pixels greater than mean in matrix B.

$$b = \bar{f} + \sigma \sqrt{\frac{m-q}{q}}$$

m = number of pixels within each block

5. Reconstruction of block values after calculating a and b values

$$\hat{f}(m,n) = \begin{cases} a : B(m,n) = 0 \\ b : B(m,n) = 1 \end{cases}$$

4.2 DCT Algorithm :

'The discrete cosine transform (DCT)' is a method which can convert signals into frequency components. It is commonly used in compressing the images sizes.

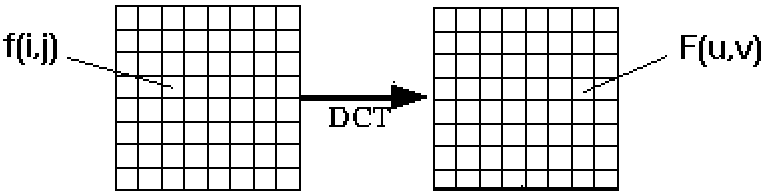


Figure 4.1 : Similarity between DCT and 'Discrete Fourier Transform': it transforming a image or signal from the 'spatial domain' to the 'frequency domain'.

Less significant coefficients are produced in DCT, which inevitably generates better larger compression. DCT usually works on 1-dimendional data. Though image data is presented in 2-dimension blocks, therefore summing term is introduced to the DCT. After which DCT becomes 2-dimensional equation. It implies that the DCT which is 1-dimensional is applied two times, once in 'x direction' and further in 'y direction'. Which leads to an efficient 2-dimensional Discrete Cosine Transform.

Few simple functions can be developed to cipher the DCT and to compressing images. MATLAB systematically implements DCT and modifications can be done to the code, for it to work in a better fashion. MATLAB has an IMAQ block which analyses and investigates the result of ‘Image Compression using DCT’. Resulting picture and error picture is also shown.

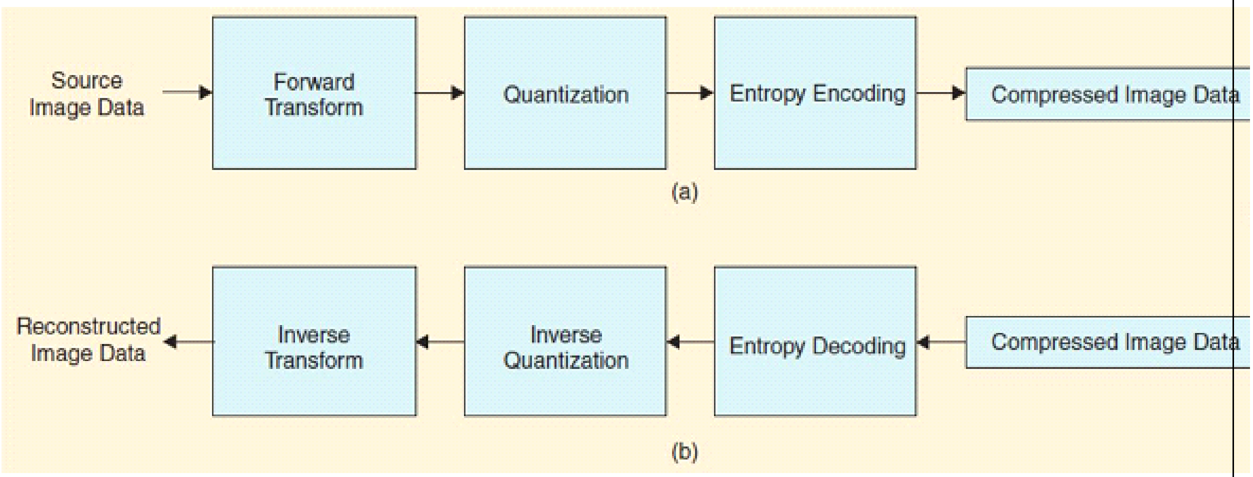


Figure 4.2 : Block diagram for DCT

A 2-dimensional DCT is studied everywhere. In the process, the original old image is altered to 8 x 8 blocks form and then Forward Transformations (DWT, DFT) are applied to filter out the image and take out the required information. After this is the Quantization which is done by Quantizer , followed by Entropy Encoding. Where redundancy is found and removed. Here, there is deconstruction of image data. Afterwards the process of reconstructing compressed image data starts with same components. Then inverse ‘Discrete Cosine Transform’ is being applied to blocks to give reconstructed picture.

This technique is used primarily in reducing space which is occupied by unimportant bits and costs. ‘ The image compression techniques’ can be slpit into two broad sections: lossy and lossless. In lossy image compression the original digital image is usually a bit distorted as quality is not maintained and there is data loss. In lossless image compression, the original image quality is maintained and image size is still reduced. Quantization is a lossy process and reduces information colour bits. ‘Entropy coding’ is a mode which illustrates the ‘quantized coefficients’ as concisely as possible.

4.3 JPEG standard:

The objective of JPEG is to enhance the compatibility and interoperability among systems manufactured by different merchants. It coincides with the international standard digital compression and coding of uninterrupted toned still photographic image. In 1988 JPEG members decided Discrete cosine as base method. The work was continued by replicating, checking, testing and certifying the standard algorithm from 1998 to 1990's. It then became (DIS) "Draft international standard" in - 1991 and further in 1992 - "International standard". It provides comparatively better "CR value" that will surely allow end user to direct the classification and size of reconstructed image. Basically jpeg standard using dct was designed in 1992 completely for compression and reconstruction of photographic images. There exist different modes in jpeg standard such as sequential, progressive and hierarchical modes. Unfortunately, jpeg cannot work appropriately with certain mechanisms like computer graphics, line-art , scanned text and other images having pointed transitions at the boundary. Here, Compression-Decompression comprise of four well defined parts. Initially, there occurs division-of-image into 8X8 pixel blocks. Next comes the appliance of dct to each and every block steadily in order to transform the data from spatial-domain to likewise frequency-domain. After applying "Discrete Cosine" the frequency data gets quantized so that unwanted data is removed. At last, jpeg-compression compress the consequence bit-stream occurring.

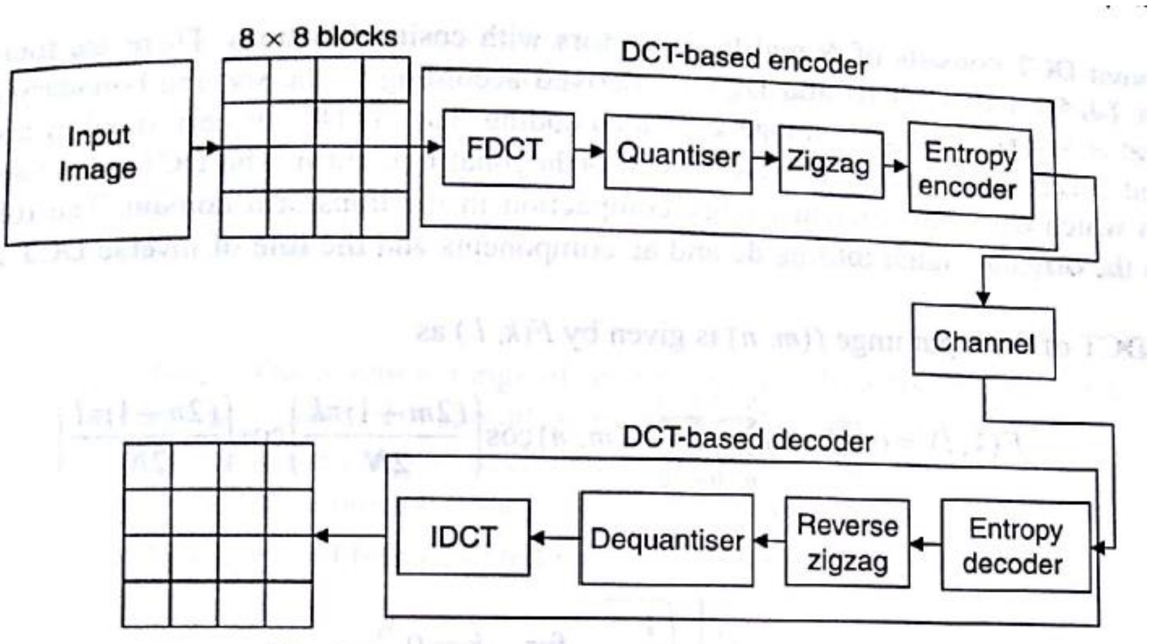


Fig. 9.38 *Baseline JPEG encoder and decoder*

Algorithm:

(1) Division of image

Compressing the entire image does not give the ideal results. Thus, JPEG initially, divides the image into matrix of 8X8 pixel-blocks. This algo tend to show similar colors together in small parts of image. One pixel is represented by 8 bits. In case of grayscale each byte has a value of 0 to 255. Whereas in case of colored images we have 3-bytes per pixel that is one for each “Red” , “Green” and “Blue” component. Conversion of color space is done before the image is broken into blocks. Ultimately, 128 is deducted from every one byte in 64-byte of block. Because of it scale byte is changed from 0o 255 to -128 to 127. Thus average value tend towards zero over large set of pixels.

(2) Conversion to frequency domain

Pixel information is converted from spatial domain to frequency domain. It simplifies for quantization-process to know ye least important chunks of the image so that it can easily de-emphasize that area in order to save space. After converting the block each value gets magnitude of different cosine-function. Each having unique frequencies. Block is represented by multiplying certain functions with consistent magnitudes and then lastly adding up the results. The functions are kept separated during jpeg-compression so that one can deduct the unwanted information that makes smallest contribution. Finally, 2- dimensional Discrete Cosine transformation is applied using equation :

$$F(u,v)=\frac{1}{4}\cdot C(u)C(v)\left[\sum_{x=0}^{7}\sum_{y=0}^{7} f(x,y)\cos\frac{(2x+1)\cdot u\pi}{16}\cos\frac{(2y+1)\cdot v\pi}{16}\right]$$

here C(x) = 1/√2 , iff x is 0,

and C(x) = 1 for all other cases.

f(*x*, *y*) represents 8-bit image value at respective (x, y) coordinates

F (*u*, *v*) implies new entry in the frequency matrix.

Values from -1024 to 1023 are contained in frequency domain matrix. DC value or lowest frequency cosine coefficient is the average value of the entire block. On moving towards right cosine functions are represented in vertical direction that is increasing frequency. Similarly moving downwards, coefficients belong to increasing frequency cosine functions in horizontal direction. This technique effectively removes half of the data per block which makes jpeg compression efficient.

(3) Quantization

The specified final image quality is used by the algorithm to decide constant-values further used to split the frequencies. The constant value = 1 denotes no loss and constant = 255 implies maximum amount of loss of coefficient. Calculation of constants is done on the basis of users desire and hit and trial values that upshot in foremost quality images. These constants are further encrypted into another 8X8-matrix which is called “quantization-matrix”. The usual “quantization-matrix” is uniform respective to the diagonal and lean to have underneath values in upper left corner and superior values in the lower right. Now the complete quantization-matrix is stored in final “JPEG-file” so that respectively decompression could also easily grab the known values used to divide each coefficient. Fairly simple equation is used to calculate the frequency matrix :

$$F_{Quantize}(u,v) = \left(\frac{F(u,v)}{Q(u,v)} \right) + 0.5$$

Here , value is taken from frequency matrix “F” and is further divided by value q in quantization-matrix “Q”. This results in absolute value of quantized frequency matrix “$F_{quantize}$”.

```
%-----------------------------------------
% Quality Matrix Formulation
%-----------------------------------------
Q50 = [ 16 11 10 16 24 40 51 61;
        12 12 14 19 26 58 60 55;
        14 13 16 24 40 57 69 56;
        14 17 22 29 51 87 80 62;
        18 22 37 56 68 109 103 77;
        24 35 55 64 81 104 113 92;
        49 64 78 87 103 121 120 101;
        72 92 95 98 112 100 103 99];
```

(4) Entropy Coding

Once the quantization is done algorithm is then leftover with block of 64-values, from which many tend to come out zero. Zig-Zag ordered encoding is done by the algorithm and collects superior frequency quantized values stored in strings of zeros. It is performed by starting at DC value and wind is way down the matrix. I basically converts 8X8 table into 1X64 vector.

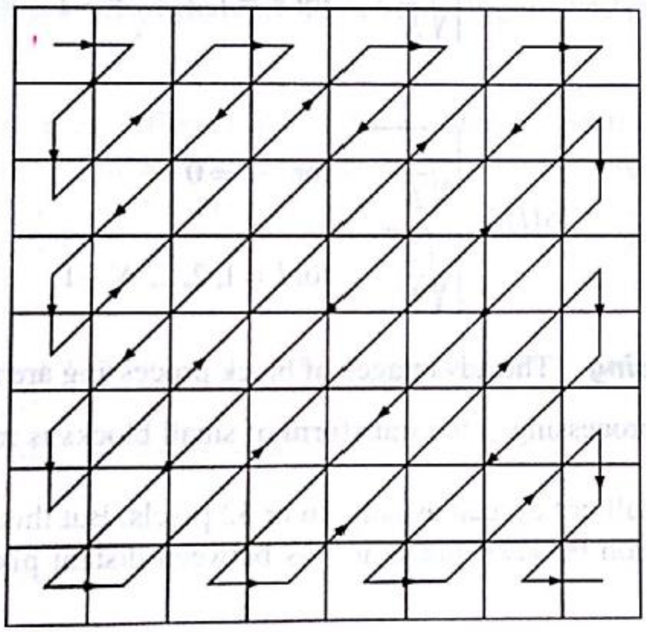


Fig. 9.39 *Zigzag scan*

Huffman Coding :

'Huffman coding' is a lossless algorithm for image compression. It is one of the most prominent data compression technique. It was put forward by 'Dr. David A. Huffman' in 1952.

In this algorithm we appoint volatile-length codes to character input which are 'Prefix Codes', which is based on characters regularity. Smallest code is given to the most frequent occurring character and the largest code is given to the least occurring character. The code being attributed to 1 character is not 'prefix of code' which is assigned something else. This confirms that there is no equivocacy when a bit stream is decoding.

The basis on which this algorithm is implemented is recurrence of event of information thing (pixel in pictures). Lower numbers of bits are used to encode most frequently occurring data and vice versa. This generates a decrease in the normal code length consequently general size of original image is minimized. Though, the two slightest appearing symbols will have a similar length. To summarize it we can say that, the shorter code is allocated to most frequently occurring symbol or data item and lengthy codes are allocated to least occurring symbol or data item.

It is designed to merge symbols with lowest probability also, and this procedure is recast until the point that lone two probabilities of two symbols are left. After which a 'code tree ' is created and 'Huffman codes' are acquired from marking of the' code tree'.

During compression, entropy decides what number of bits of information data are really accessible.

If less number of bits are assigned to for most frequently used symbols lot of storage space can be saved.

For Example: if you are to assign 26 unique codes to English alphabet and want to store an English novel (only letters) in term of these code, your memory requirement will be less.

<u>Huffman Algorithm Steps:</u>

1) Reading the image in MATLAB
2) Calling functions which will discover the images .
3) Calling functions which will evaluate the symbol's individual prospect.
4) Chances of symbols to crop up is to be orchestrated in decreasing order and lesser probabilities are combined. This progression is proceeded until just two probabilities are remaining, as per to this codes are appointed; the most highly apparent symbol will have a diminished code length.
5) Thereafter, 'Huffman encoding' is operated i.e. aligning of code words to the complementary 'symbols'.
6) Now, reconstruction of the old image i.e. decompression is executed applying' Huffman decoding'.
7) Code dictionary and code words are matched with each other to get the reconstructed image.
8) Then yield a tree comparable to the 'encoding tree'.

9) Keep checking till the last element is read.

10) Continue with the process, till all codes of corresponding symbols are known.

Result Analysis and Test Cases:

JPEG:

IMAGES	MSE	PSNR	SSIM	CR
twenty	0.57	50.57	0.9430	6.78
Zelda	7.68	39.28	0.9741	1.0
ten	62.74	30.16	0.7702	2.15
Seven	15.26	36.29	0.9578	1.06
Sailboat	37.27	32.42	0.7806	1.0
Look	8.96	38.61	0.9065	1.06
River	190.71	25.33	0.3853	1.57
Photo	86.65	28.75	0.7568	2.39
Peppers_RGB	27.23	33.78	0.8433	1.0
Parrot	33.20	32.92	0.7653	1.0
Monkey	21.86	34.73	0.8297	1.02
Murk_Marvi	17.96	35.59	0.9376	1.10
One	5.06	41.09	0.7553	4.02
Owl	37.39	32.40	0.6978	2.43
Paint	22.13	34.68	0.8405	5.05
Parking	43.28	31.77	0.6016	3.01
Parking2	23.34	34.45	0.8295	3.64
Man	38.27	32.30	0.7896	1.77
launch	32.61	33	0.8484	1.0
Lena	15.65	36.19	0.7973	4.15
Lichtenstein	34.30	32.78	0.8230	3.39
Hut	13	36.99	0.7723	2.06
Girl	14.96	36.38	0.9258	1.16
Green	55.45	30.69	0.7213	2.56
Girlface	10.42	37.95	0.7213	1
Fruits	41.99	31.19	0.8399	4.61
Four	12.72	37.09	0.9170	2.94
Fourteen	65.90	29.94	0.7493	1.48
Flower1	2.96	43.42	0.9233	1.04
Flower2	20.86	34.94	0.8726	1.28
Five	28.19	33.63	0.7921	1.26
Elaine	24.08	34.31	0.8434	1.21

Eight	43.03	31.79	0.7670	1.31
CR3	72.50	29.53	0.6597	1.26
Couple	40.70	32.03	0.7435	2.88
Cell	11.70	37.45	0.9659	1.67
Cameraman	36.40	32.52	0.7195	1.53
Building	39.11	32.21	0.8463	3.68
Brain	4.44	41.66	0.9493	1.31
Boat	54.94	30.73	0.7575	2.04
BC1	53.97	30.81	0.7553	3.47
Baboon	124.91	27.16	0.5401	2.61
Antigravity	23.31	34.46	0.8174	1.88
Airplane	46.72	31.44	0.8827	1
Boy	18.56	35.45	0.88115	1.28

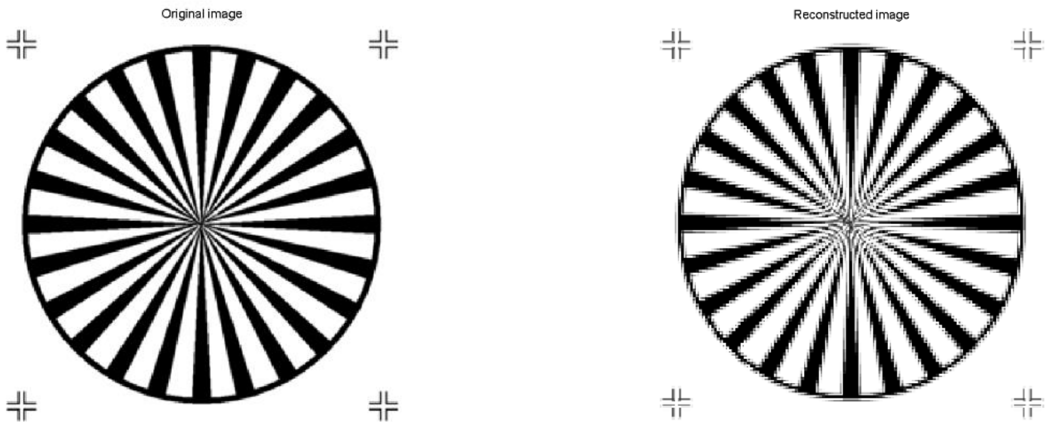
BTC:

IMAGE	MSE	PSNR	SSIM	CR
Tire	5.87	40.44	0.8637	1.19
Tissue	2.88	43.52	0.5571	1.80
Testpat1	0.15	56.31	0.7458	1.09
Tape	1.34	46.83	0.8630	2.28
Snowflakes	1.23	47.22	0.8932	1.01
Shadow	32.1	33.06	0.2487	1.13
Rice	2.47	44.19	0.7478	1.06
Pout	0.33	52.93	0.9410	1.05
Pears	0.19	55.50	0.8650	1.93
Peppers	0.02	66.30	0.9370	2.25
Onion	0.39	52.12	0.8892	2.0
Moon	0.08	58.64	0.9203	1.10
Mri	0	INF	0.7945	1.01
M83	2.36	44.39	0.2038	1.03
Mandi	0.02	63.96	0.7523	1.01
liftingbody	0.04	61.81	0.9059	1.09
hestain	0.67	49.84	0.7912	2.04
glass	0.13	56.72	0.9617	1.03
forest	107.5	27.81	0.7719	1.10
fabric	0.52	51.03	0.7747	2.07
gantrycrane	2.45	44.23	0.8031	1.81
Eight	0.004	71.21	0.8804	1.02
coins	0.01	67.74	0.8522	1.07
circuit	2.64	43.91	0.8469	1.19
canoe	4.85	41.27	0.3325	1.03
cameraman	0.85	48.79	0.7772	1.18
board	15.47	36.23	0.3598	2.17
bag	3.33	42.90	0.7146	1.10

CR3	0.91	48.23	0.6597	1.04
Couple	0.41	51.19	0.7435	1.14
Fruits	1.09	47.73	0.8399	2.04
Goldhill	1.60	49.86	0.7562	1
Green	1.70	45.80	0.7213	1.92
Launch	0.10	57.92	0.8484	1
Lichtenstein	0.77	49.44	0.8230	1.85
Paint	0.05	60.51	0.8405	1.98
Parking	0.73	49.49	0.6016	1.96
Parking2	0.34	52.78	0.8295	2.01
river	5.90	40.35	0.3853	1.004
Antigravity	0.08	58.87	0.8174	1
Baboon	2.59	43.24	0.5401	1.59
Barbara	0.96	48.29	0.3475	1.76
Bb	0.99	48.13	0.5421	1.16
Boat	1.57	46.16	0.7675	1.11
Building	1.14	47.54	0.8430	2.12

TEST CASES OF BLOCK TRUNCATION CODING:

Testpat1:



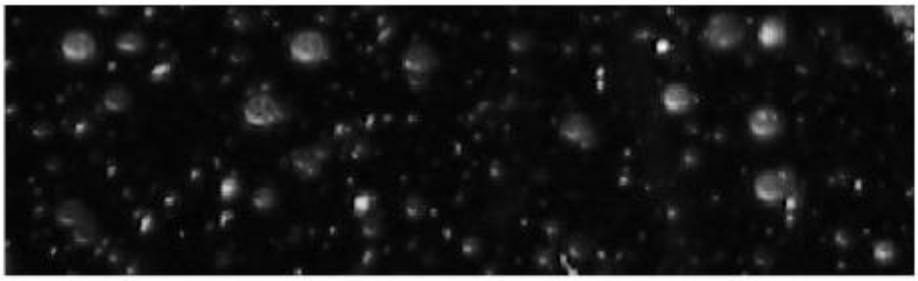
Tape:

Original image

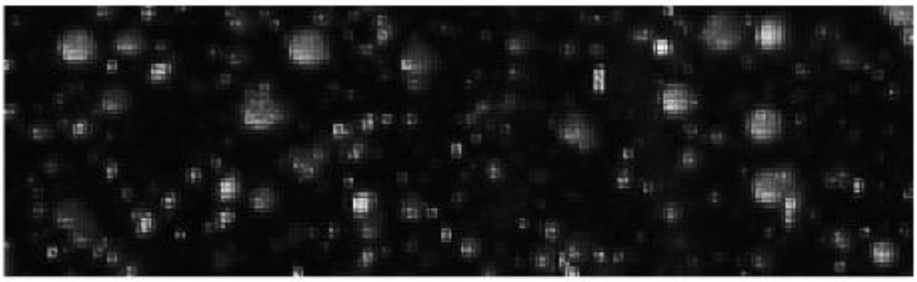
Reconstructed image

Snowflakes:

Original image

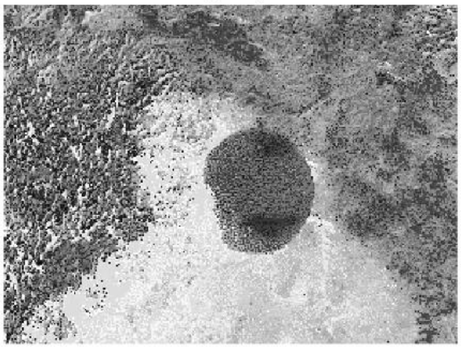


Reconstructed image



Shadow:

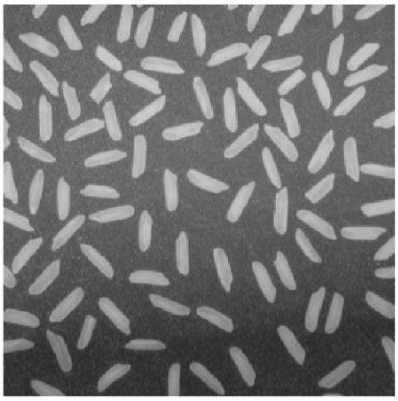
Original image



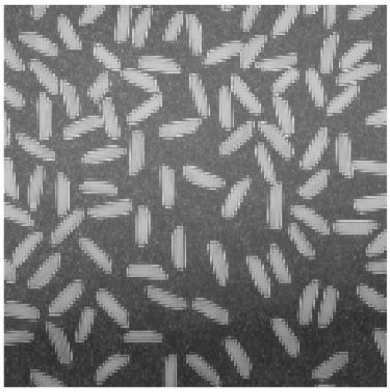
Reconstructed image

Rice:

Original image



Reconstructed image

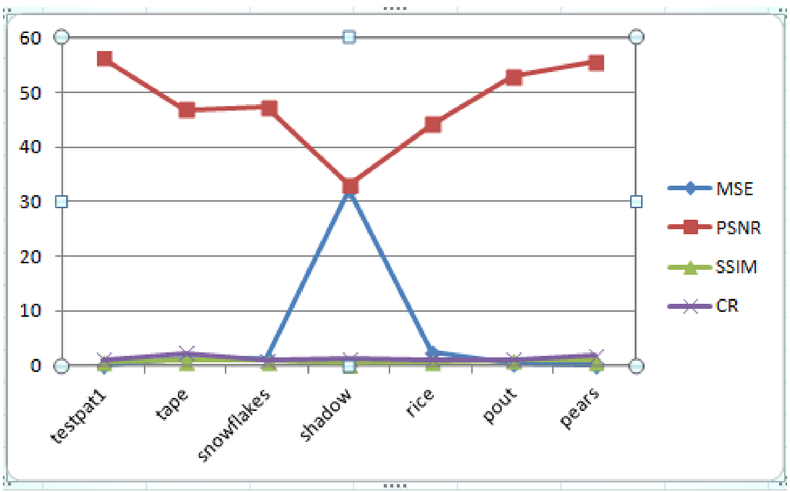


Pear:

Original image

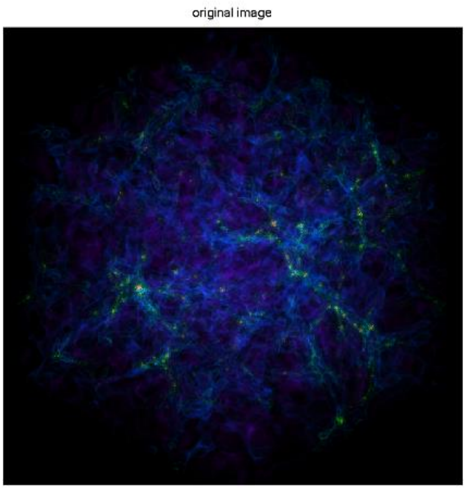
Reconstructed image

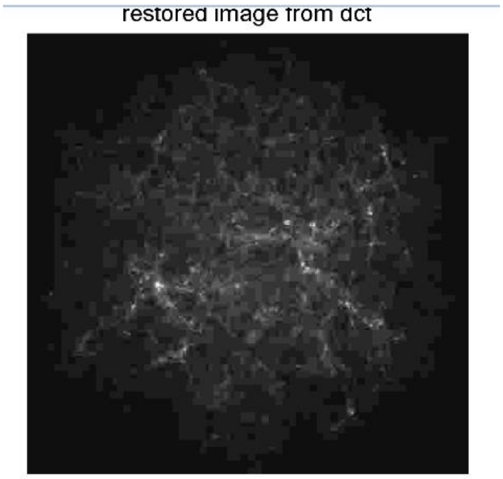
Plotting of MSE, PSNR, SSIM with CR for comparison of respective values in images:



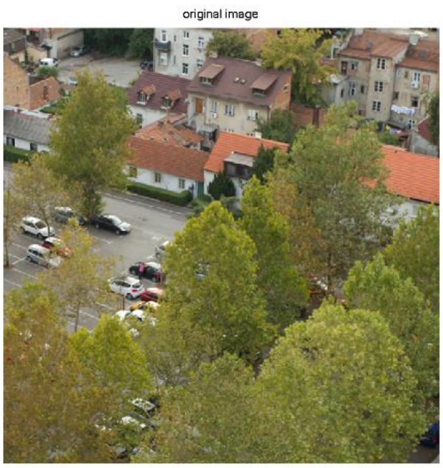
TEST CASES OF JPEG:

Twenty

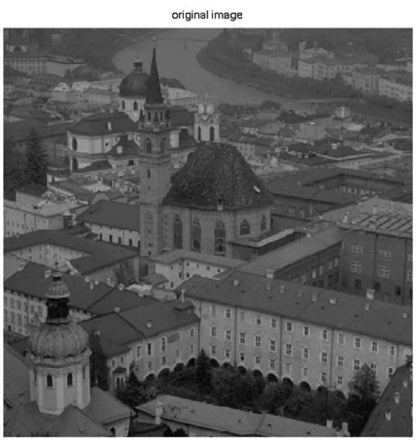


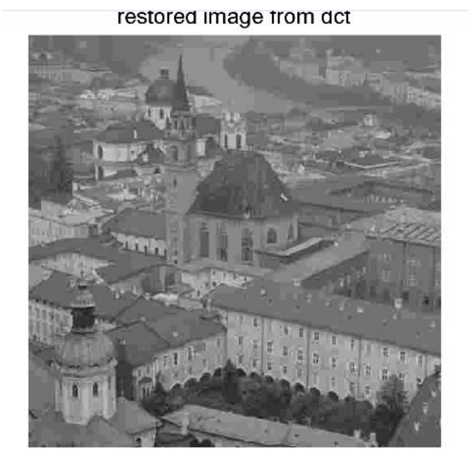


Parking:



One:





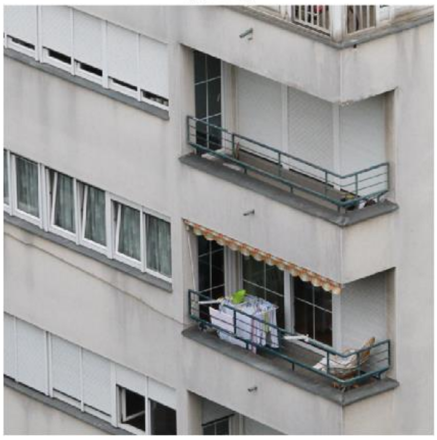
Fruits:

original image

restored image from dct

Building:

original image



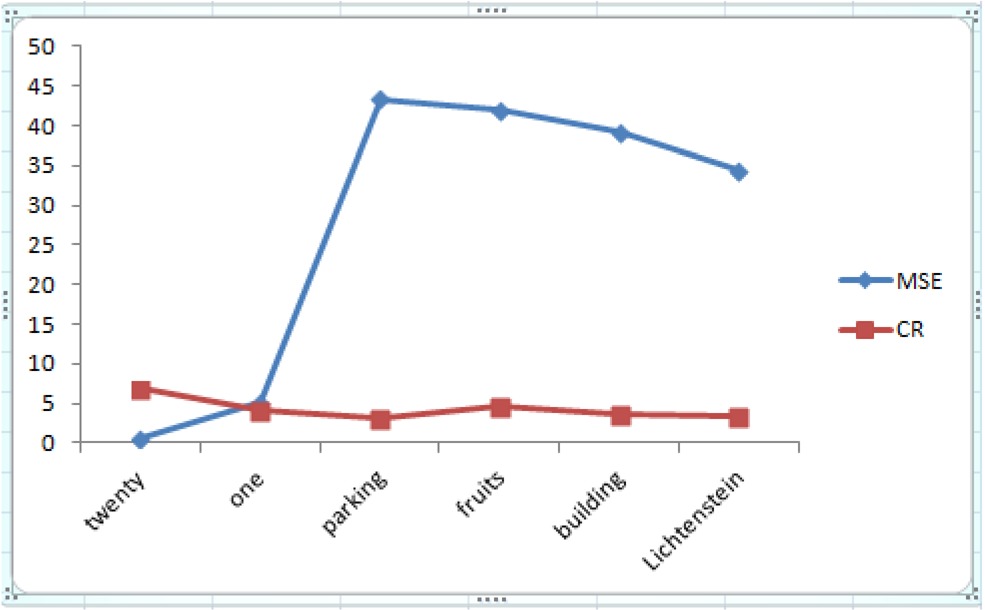
restored image from dct

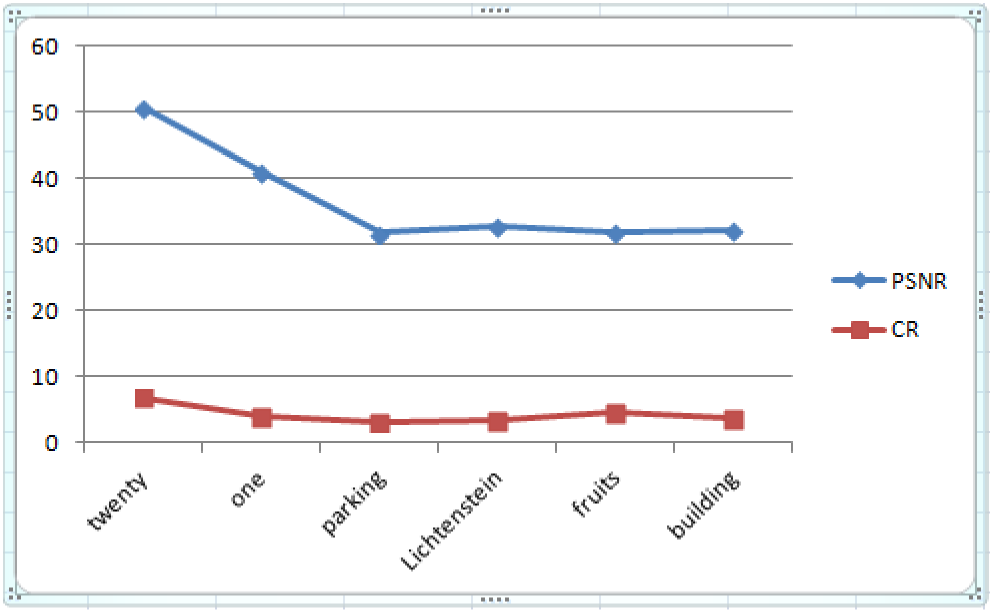
Lichtenstein:

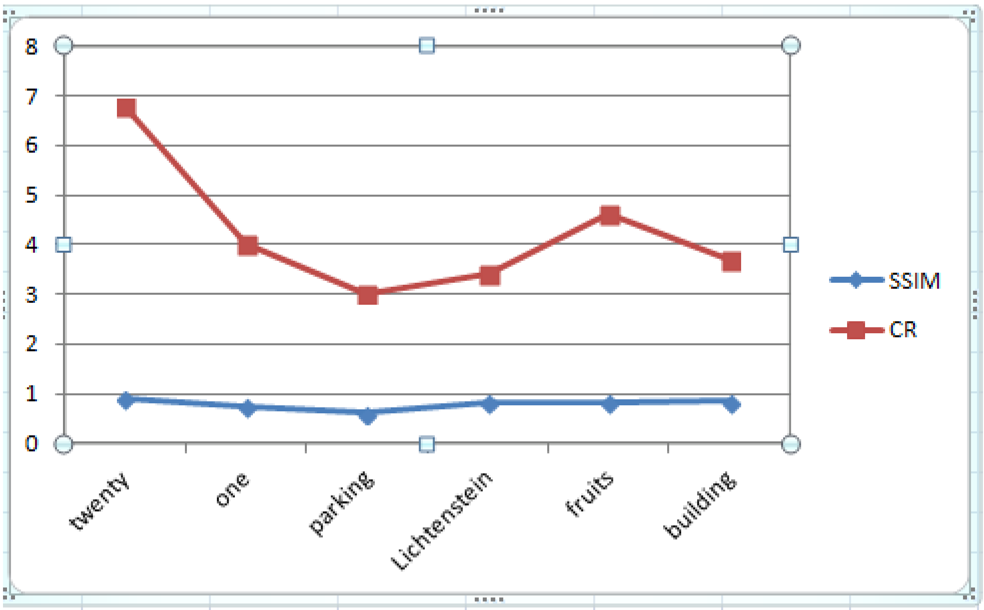
original image

restored image from dct

JPEG GRAPHICAL REPRESENATION –







DCT Coloured Image:

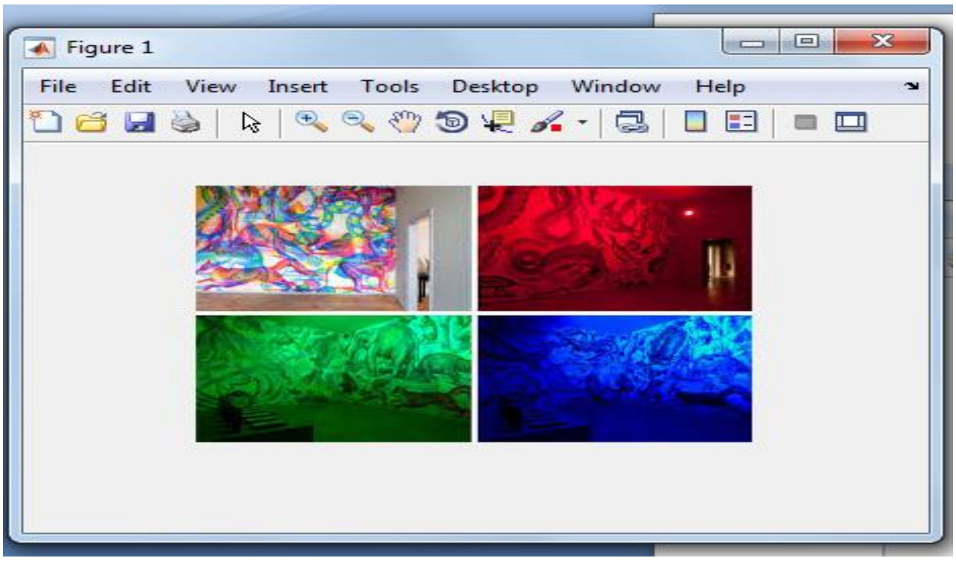


Fig4.3: input image

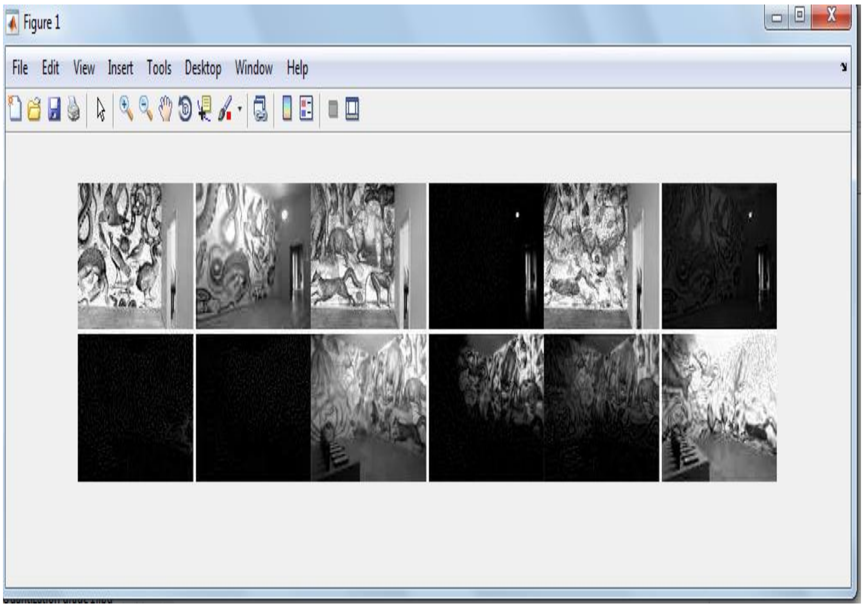


Fig4.4:Output of image using Huffman coding

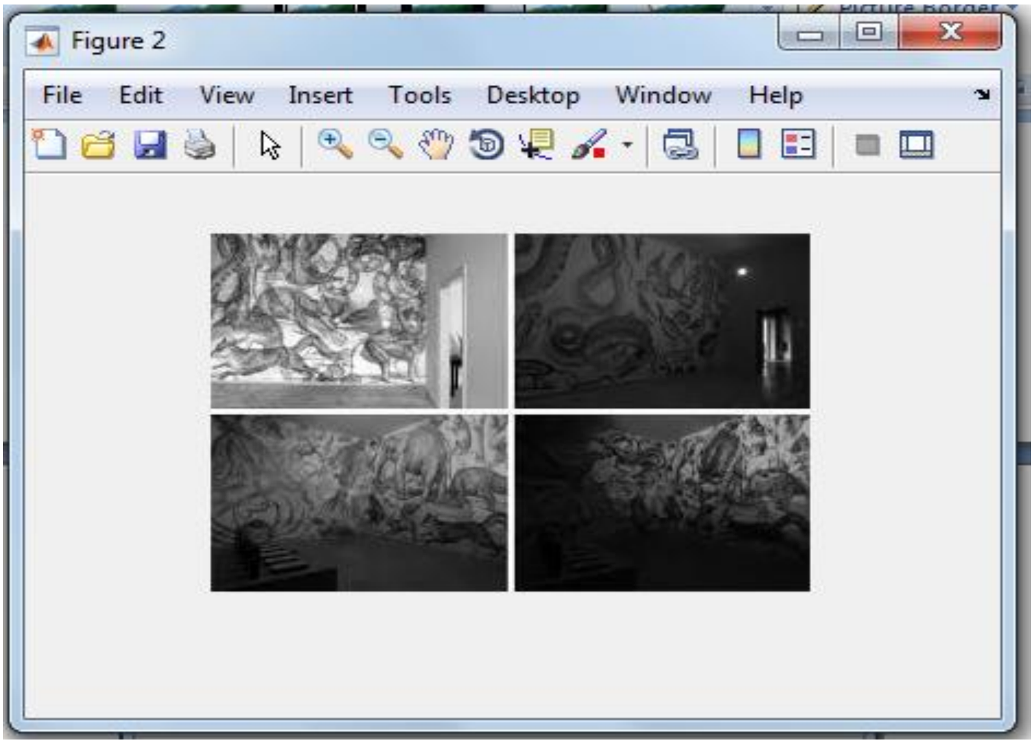


Fig4.5: Output after compression

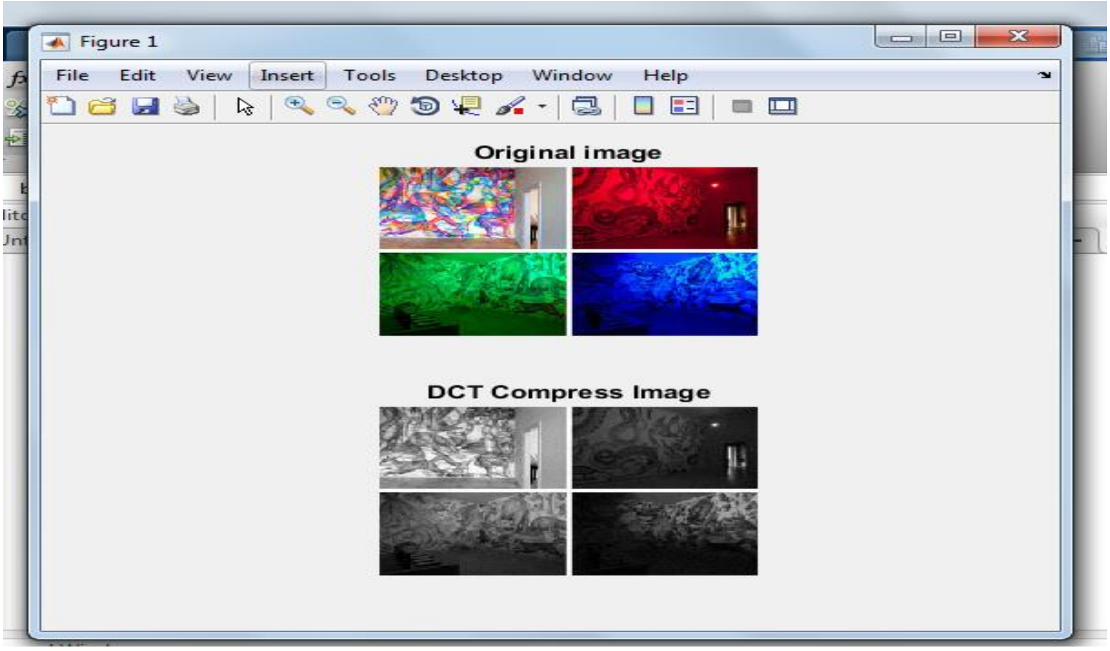


Fig4.6:Output using DCT

DCT- Grayscale with Parameters

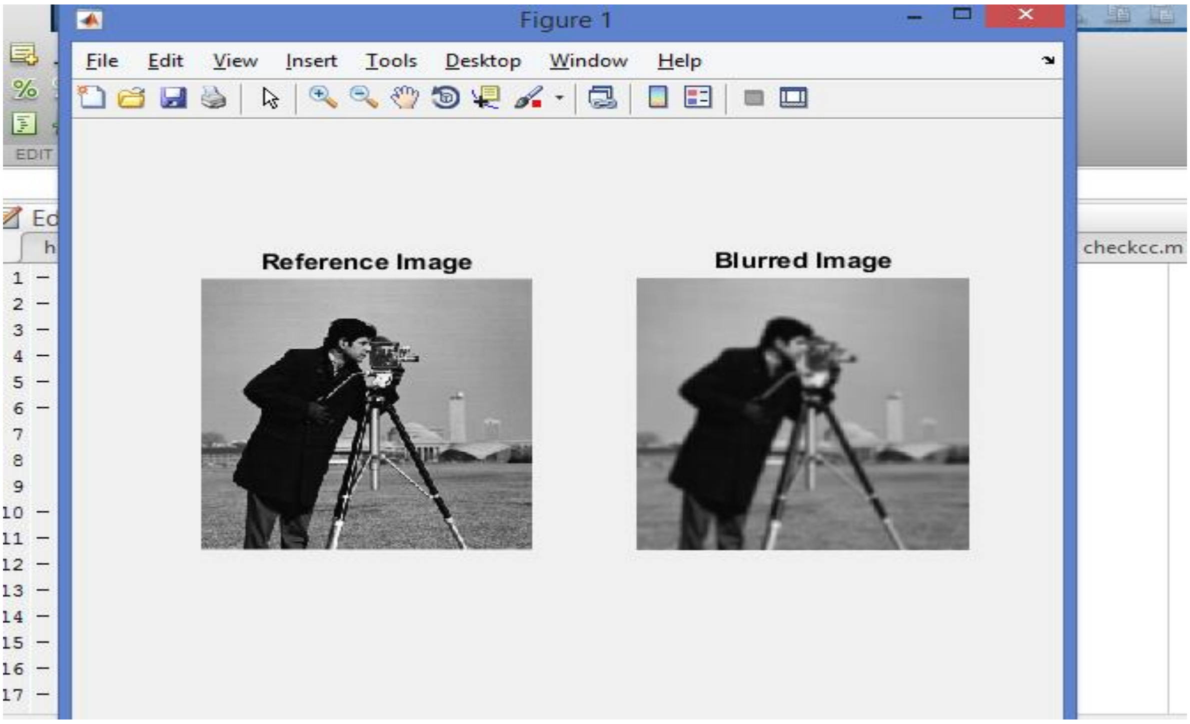


Figure 4.7

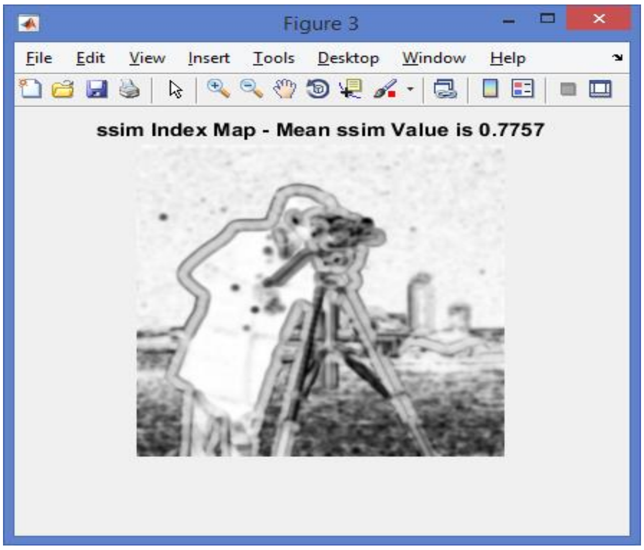
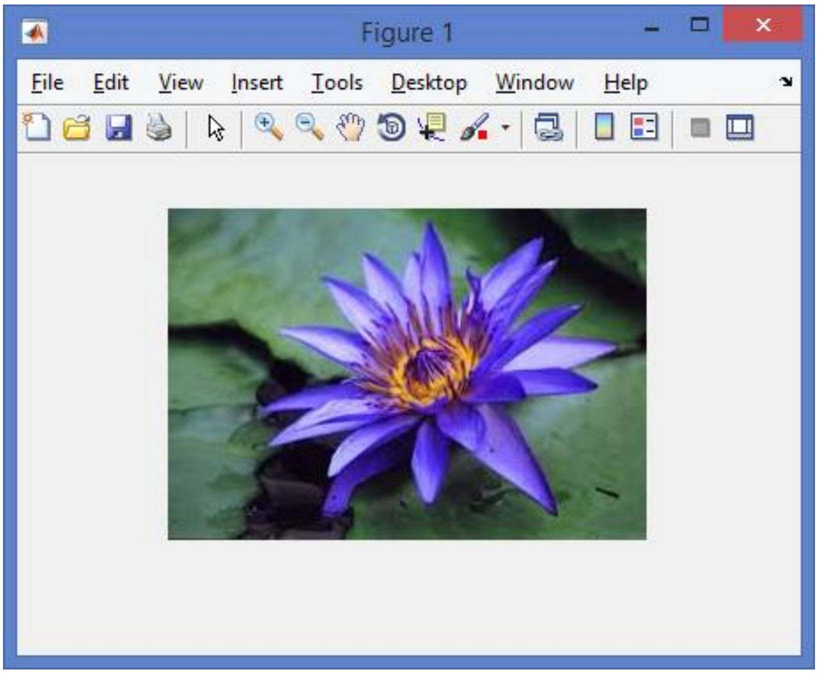


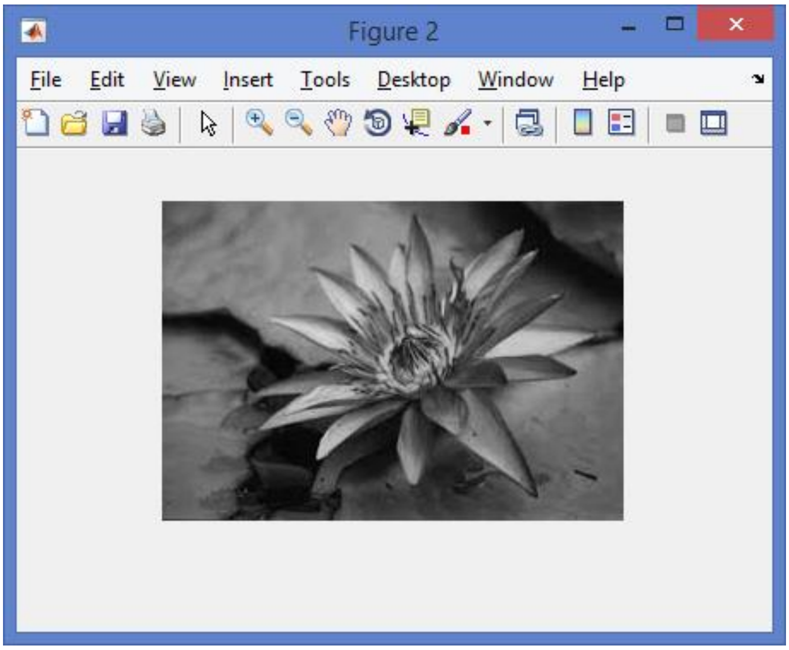
Figure 4.8 SSIM Value Implemented

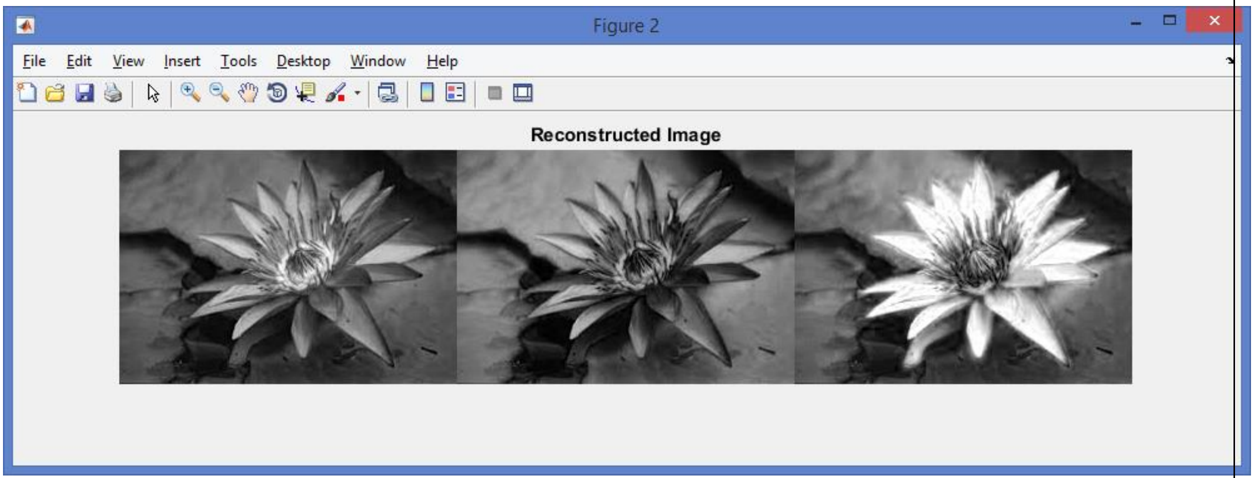
Huffman Coding

For Colored Image

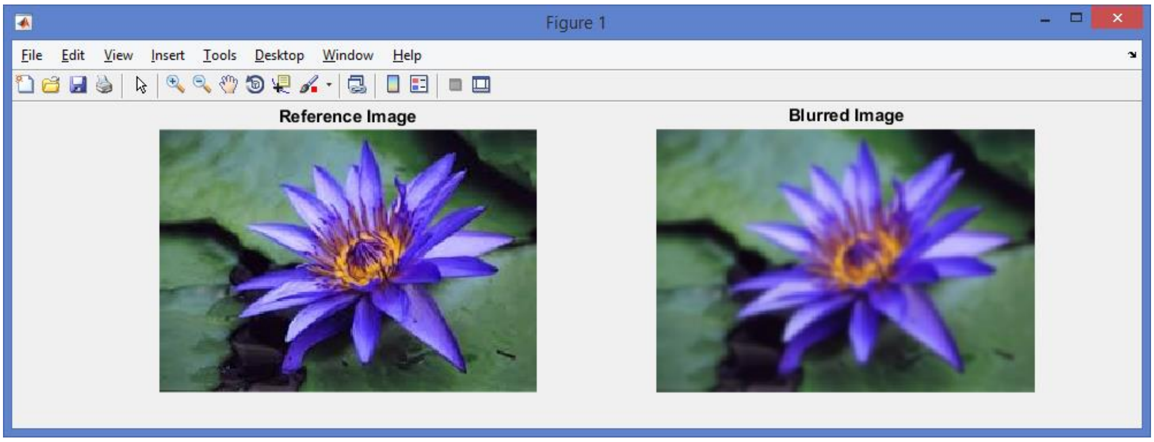


4.9 Input Image

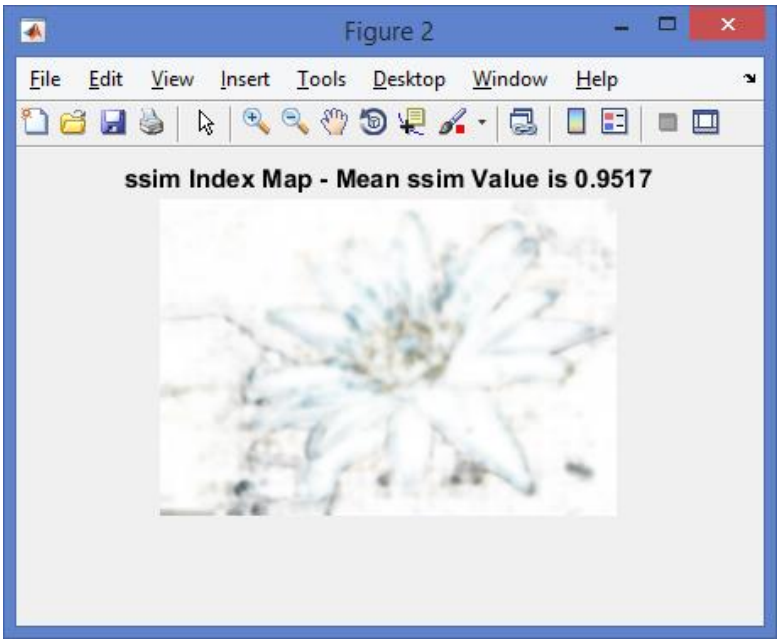




4.10 Output Image

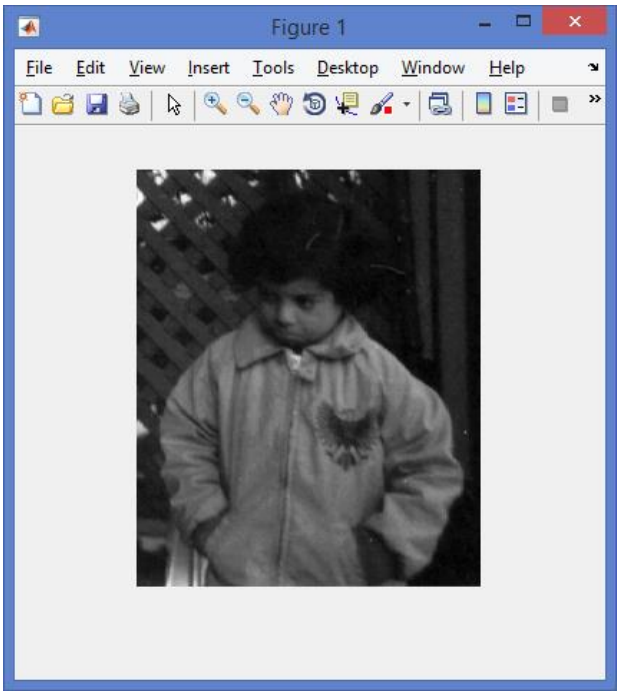


4.11 Reference and Blurred Image

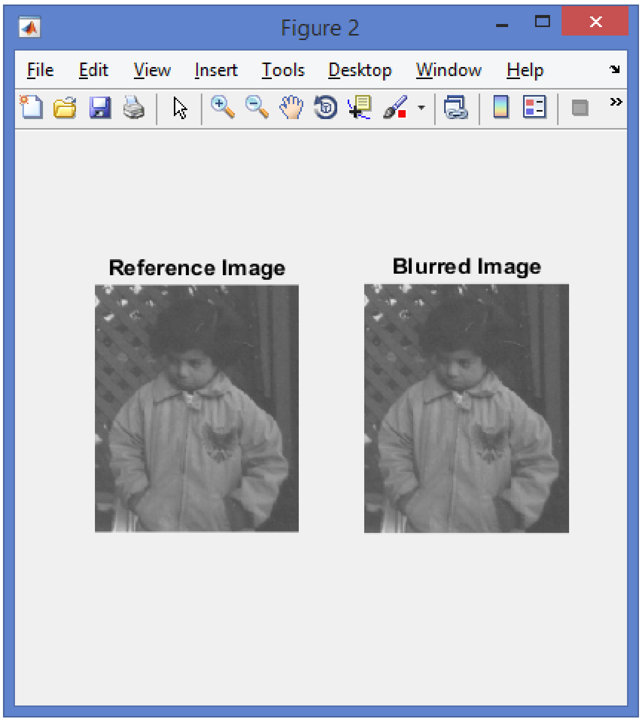


4.12 SSIM Value

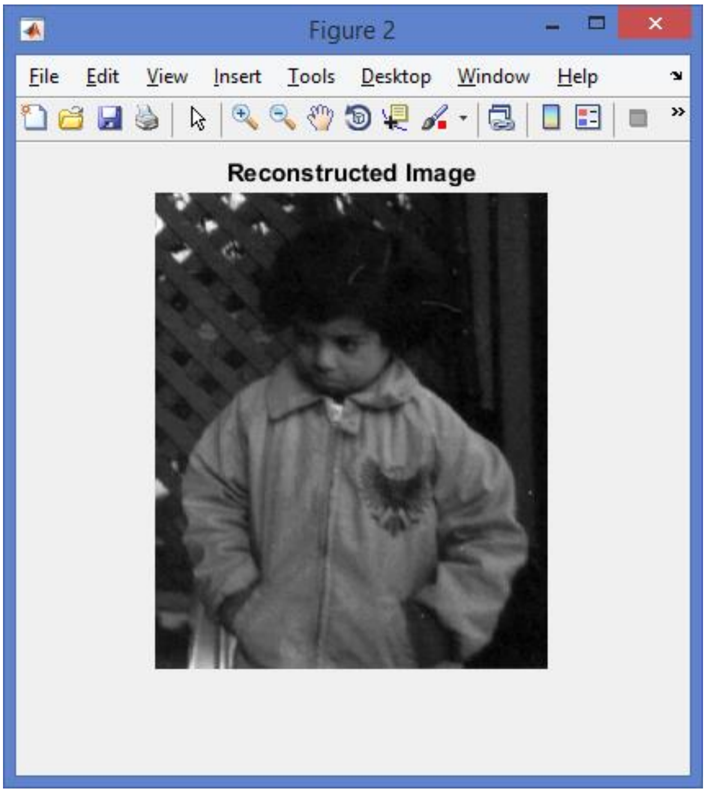
<u>For Gray Scale Image:</u>



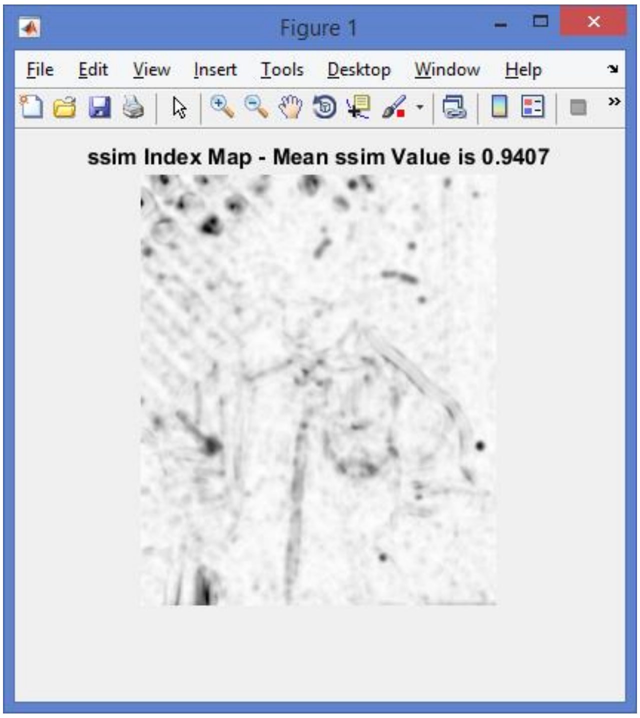
4.13 Input Image – Inbuilt



4.14 Reference and blurred image



4.15 Output Image



4.16 SSIM Value

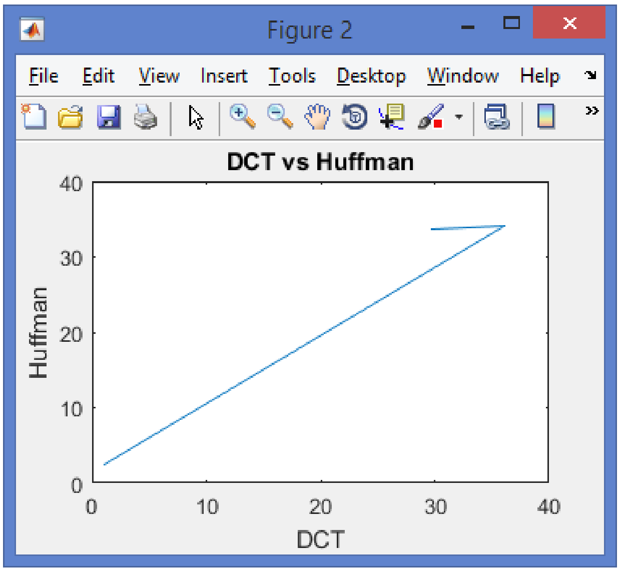


Fig 4.17 Plotting of graph between Huffman and DCT average values(Compression ratio , PSNR, MSE)

DCT

IMAGE	COMPRESSION RATIO	PSNR VALUES	MSE VALUES	SSIM VALUES
Moon.tif	1.0297	39.399	7.53	0.9207
Trees.tif	1.0599	33.83837	26.80	0.8017
Cameraman.tif	1.0534	33.502	29.26	0.7757
Grade.jpg(desktop)	1.0244	46.142	1.59	0.9904
Canoe.tif	1.0898	29.102	80.57	0.3343
Eight.tif	1.0392	37.167	12.58	0.8884
Cell.tif	1.0324	40.8905	5.34	0.9063
Coins.png	1.0510	35.29	19.35	0.8613
Shadow.tif	1.0894	28.29	97.13	0.2524
Tire.tif	1.0679	33.40	29.94	0.8606
Pout.tif	1.0367	40.89	5.34	0.9407
Snowflakes.png	1.0520	37.809	10.85	0.8935
AT3_1m4_07.tif	1.0265	35.152	7.97	0.9025
Rice.png	1.0794	31.912	42.19	0.7472
AT3_1m4_08.tif	1.0262	39.36	7.58	0.9070
M83.tif	1.0659	28.96	83.26	0.2075
Spine.tif	1.0137	50.7355	0.55	0.9909
Liftingbody.png	1.0281	38.8767	8.49	0.9088
Westconcordorthophoto.png	1.1102	30.1139	63.84	0.6363
Bag.png	1.1262	31.0540	51.41	0.7171

HUFFMAN CODING

IMAGE	COMPRESSION RATIO	PSNR VALUES	MSE VALUES	SSIM VALUES
Cell.tif	8.5823	38.0528	10.26	0.9063
Cameraman.tif	3.6582	33.5025	29.26	0.7757
Coins.png	3.3093	35.2980	19.35	0.8613
Rice.png	3.8384	31.9124	42.19	0.7472
Pout.tif	3.5996	40.8905	5.34	0.9407
Shadow.tif	3.9233	28.2911	97.13	0.2524
Images.jpg(desktop)	1.3564	31.5983	45.64	0.8900
Moon.tif	0.9404	39.3994	7.53	0.9207
Trees.tif	2.2013	33.8837	26.80	0.8017
Bag.png	4.8249	31.0540	51.41	0.7171
Spine.tif	0.9335	50.7355	0.55	0.9909
is.jpg desktop image	1.5795	34.1897	24.99	0.9517
Canoe.tif	3.5944	29.102	80.57	0.3343

Tire.tif	4.1901	33.4025	29.94	0.8606
Snowflakes.png	4.5192	37.8098	10.85	0.8935
Eight.tif	3.8313	37.1671	12.58	0.8884
Sakura.jpg(desktop)	1.5047	30.3522	60.43	0.6801
AT3_1m4_07.tif	0.7632	39.1512	7.97	0.9025
Ind.jpg(desktop)	5.6308	33.9546	26.36	0.9237
Snow.jpg(desktop)	1.6853	31.63	44.95	0.8795
Air.tiff(desktop)	1.0104	39.5155	7.33	0.9047
Download.jpg(desktop)	5.1057	33.7191	46.56	0.8892
Sun.jpg(desktop)	3.9282	32.6218	35.83	0.9687
Mount.jpg(desktop)	1.7040	36.52	14.59	0.8144
Mountain.jpg(desktop)	1.6329	30.6111	57.06	0.6613
View.jpg(Desktop)	1.4981	33.025	32.65	0.8602
Mol.tiff(Desktop)	1.3245	37.3063	12.19	0.9360
Snowm.jpg	4.9726	34.535	0.88	0.8496
House.tiff	1.7241	32.2263	39.25	0.8419
Fem.tiff	3.8070	46.358	1.52	0.08913
Cotta.jpg	2.5788	30.375	60.11	0.6820
Treeg.jpg	1.2094	31.194	49.77	0.7659
Lily.jpg	1.771	34.183	25.70	0.9368
Rose.jpg	1.412	34.209	21.60	0.9434
Sunfl.jpg	1.494	31.001	51.92	0.9110
Multi.jpg	1.482	31.645	44.86	0.8714
Gar.jpg	1.576	32.190	33.53	0.9474
Az.jpg	1.493	31.314	48.42	0.9426
Tow.jpg	1.756	32.179	39.67	0.8689
Cas.jpg	1.699	32.249	39.04	0.8367
Taj.jpg	1.672	31.693	44.38	0.8438
Lena.jpg	1.677	33.880	26.82	0.9600
Lo.jpg	1.577	32.186	39.61	0.8814
Waterf.jpg	1.511	31.796	43.34	0.8856
Mo.jpg	1.468	34.335	24.15	0.8719
Sunset.jpg	1.293	35.406	18.87	0.8682
Diwali.jpg	1.610	32.459	37.20	0.8796
Bird.jpg	1.616	32.396	37.74	0.9030
Cake.jpg	1.530	30.171	63.00	0.7876
Bread.jpg	1.611	31.155	50.22	0.9320

Chapter 5

Conclusion

BTC:

Average Compression ratio: 1.43

Highest Compression ratio: 2.28

Lowest Compression ratio: 1

Average PSNR value: 49.92

Highest PSNR value: 67.74

Lowest PSNR value: 33.06

Average MSE value: 4.64

Highest MSE value: 107.5

Lowest MSE value: 0.004

Average SSIM value: 0.7311

Highest SSIM value: 0.9617

Lowest SSIM value: 0.2487

DCT:

Average Compression ratio with image name: 1.0551

Highest Compression ratio with image name: 1.1262- bag.png

Lowest Compression ratio with image name: 1.1037-spine.tif

Average PSNR value with image name: 36.0919

Highest PSNR value with image name: 50.7355- spine.tif

Lowest PSNR value with image name 28.29-shadow.tif

Average MSE value with image name: 29.5758

Highest MSE value with image name: 80.57-canoe.tif

Lowest MSE value with image name: 0.55-spine.tif

Average SSIM value with image name : 0.7721

Highest SSIM value with image name: 0.9909-spine.tif

Lowest SSIM value with image name: 0.2705-M83.tif

JPEG:

Average Compression ratio:	2.13
Highest Compression ratio:	6.78
Lowest Compression ratio:	1
Average PSNR value:	34.24
Highest PSNR value:	50.57
Lowest PSNR value:	25.33
Average MSE value:	36.06
Highest MSE value:	190.71
Lowest MSE value:	0.57
Average SSIM value:	0.8043
Highest SSIM value:	0.9741
Lowest SSIM value:	0.3853

Huffman:

Average Compression ratio with image name:	2.4641
Highest Compression ratio with image name:	8.5823-cell.tif
Lowest Compression ratio with image name:	0.7632-AT3_IM4_07.tif
Average PSNR value with image name:	34.0766
Highest PSNR value with image name:	50.7355-spine.tif
Lowest PSNR value with image name:	28.2911- shadow.tif
Average MSE value with image name:	33.6382
Highest MSE value with image name:	97.13-shadow.tif
Lowest MSE value with image name:	0.55-spine.tif
Average SSIM value with image name :	67.6823
Highest SSIM value with image name:	0.9909-spine.tif
Lowest SSIM value with image name:	0.3343-canoe.tif

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