IMAGE COMPRESSION
USING LOSSLESS AND LOSSY METHODS

Project Work submitted in Partial Fulfilment of the requirements for the Degree

BACHELOR OF TECHNOLOGY

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By

BININDITA SUTRADHAR (GAU-C-10/241)
SUKANTA SARKAR (GAU-C-10/215)
MANMITA BISWAS (GAU-C-10/325)
SARITA SINGH (GAU-C-10/318)
POORNIMA (GAU-C-10/219)

Under the supervision of

Prof. Haradhan Chel

Asst. Professor, Dept. of ECE

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

केन्द्रीय प्रौद्योगिकी संस्थान कोकराझार

CENTRAL INSTITUTE OF TECHNOLOGY KOKRAJHAR

(A Centrally Funded Institute under Ministry of HRD, Govt. of India)

OLAND TERRITORIAL AREAS DISTRICTS:: KOKRAJHAR :ASSAM ::783

Website :www.cit.kokrajhar.in , www.cit.ac.in

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CENTRAL INSTITUTE OF TECHNOLOGY, KOKRAJHAR

(An Autonomous Institute under, MHRD)

Kokrajhar – 783370, BTAD, Assam, India

CERTIFICATE OF APPROVAL

This is to certify that the work embodied in this project entities as **"IMAGE COMPRESSION using Lossless and Lossy methods "** submitted by Sukanta Sarkar (Roll No: Gau-C-10/215,University Registration No: 67156 ,2010-11), Poornima(Roll no :Gau-C-10/219, University Registration No : 67145,2010-11),Manmita Biswas (Roll no :Gau-C- 10/L -325, University Registration No : 015324 ,2010-11) Binindita Sutradhar (Roll no :Gau-C-10/241, University Registration No : 67163 ,2010-11), Sarita Singh (Roll no : Gau-C -10/L-318, University Registration No : 015355 ,2010-11),to the **Department of Electronics & Communication Engineering,** is carried out under my direct supervisions and guidance.

This project work as been prepared as per the regulation of Central Institute of Technology and I strongly recommend that the project work be accept in partial fulfilment of the requirement for the degree of B. Tech .

Supervisor

Asst. **Prof. Haradhan Chel**

HOD (i/c), Dept. of ECE

Countersigned by

Prof. Arindum Mukharjee

Asst. Professor, Dept. of ECE

DEPARTMENT OF ELECTRONICS COMMUNICATION ENGINEERING

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CERTIFICATE BY THE BOARD OF EXAMINERS

This is to certify that the work embodied in this project entities as **"IMAGE COMPRESSION using Lossless and lossy methods**" submitted by Manmita Biswas (Roll no : Gau-C- 10/L -325, University Registration No : 015324 ,2010-11)Sukanta Sarkar (Roll No: Gau-C-10/215 ,University Registration No:67156 ,2010-11), Poornima (Roll no :Gau-C-10/219, University Registration No : 67145 ,2010-11) ,Binindita Sutradhar (Roll no :Gau-C-10/241, University Registration No : 67163 ,2010-11), Sarita Singh (Roll no : Gau-C -10/L-318, University Registration No :015355 ,2010-11), to the Department of **Electronics & Communication Engineering of Central Institute of Technology, Kokrajhar** Has been examined and evaluated.

This project work as been prepared as per the regulation of Central Institute of Technology and I strongly recommend that the project work be accept in partial fulfilment of the requirement for the degree of B. Tech .

23/05/14

Project Coordinator

Examiner

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Bimindita Sutradhar
Hanmita Biswas.
Sarita Singh
Sukanta Sarkar
Poornima

OBJECTIVE AND MOTIVATION

The objective of our project entitled as ***"Image compression and decompression using lossy and lossless methods"*** *is* to reduce the size of image using lossless algorithm and lossy - algorithm with the help of MATLAB programming. To perform these, the sequential methodology of the process has been studied. Target of image compression is to eliminate redundant bits present in the image using two methods and to calculate the MSE, SNR, PSNR, C.F (compression factor) and evaluate the basic differences between decompressed images from these two methods of compression. After that different approaches are implemented to reduce more and more bits with less degradation of image information.

The growing field of image compression and its increasing future prospects on various fields has encouraged us to take over this project. Image compression is a research based project and a very challenging task in the field as well as several researches are going on and we are really keen to enrich our knowledge in this field and to focus in its implementations in various technology in future days.

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ABSTRACT

Image compression is the application of data compression on digital images. Image compression can be lossy or lossless. In this paper it is being attempted to implement basic JPEG compression using MATLAB. In this project both the lossless and lossy compression techniques have been used. Lossless compression cannot affect the image clarity but its compression factor is relatively smaller and when further compression is required lossy compression is used. Image compression addresses the problem of reducing the amount of data required to represent a digital image. It is also used for reducing the redundancy that is nothing but avoiding the duplicate data. It also reduces the storage area to load an image. For this purpose JPEG standard is used for image compression. JPEG is a still frame compression standard, which is based on, the Discrete Cosine Transform and it is also adequate for most compression applications.

LIST OF FIGURES

LIST OF ABBREVIATIONS

DCT -- Discreet Cosine Transform

FFT—Fast Fourier transform

RLE -- Run-Length Encoding

DPCM--Differential pulse coded modulation

IDCT--Inverse Discreet Cosine Transform

JPEG--Joint photographic expert group

SNR—Signal to Noise ratio

RMSE—Root Mean square error

CR—Compression ratio

INTRODUCTION TO IMAGE COMPRESSION

1.1 Introduction

Compressing an image is significantly different than compressing raw binary data. Of course, general purpose compression programs can be used to compress images, but the result is less than optimal. DCT has been widely used in signal processing of image. The one-dimensional DCT is useful in processing one-dimensional signals such as speech waveforms[2]. For analysis of two dimensional (2D) signals such as images, we need a 2D version of the DCT data, especially in coding for compression, for its near-optimal performance. JPEG is a commonly used standard method of compression for photographic images[5]. The name JPEG stands for Joint Photographic Experts Group, the name of the committee who created the standard. JPEG provides for lossy compression of images.

1.2 Objective of Image Compression

The discrete cosine transform (DCT) is a technique for converting a single into elementary frequency component [3] .It is widely used in the image compression. Here DCT based approach is used because DCT has good energy compaction property [1] and does not generate any complex coefficient. This approach can effectively be used for both lossless and lossy type of compression.

1.3 Definition of Image Compression

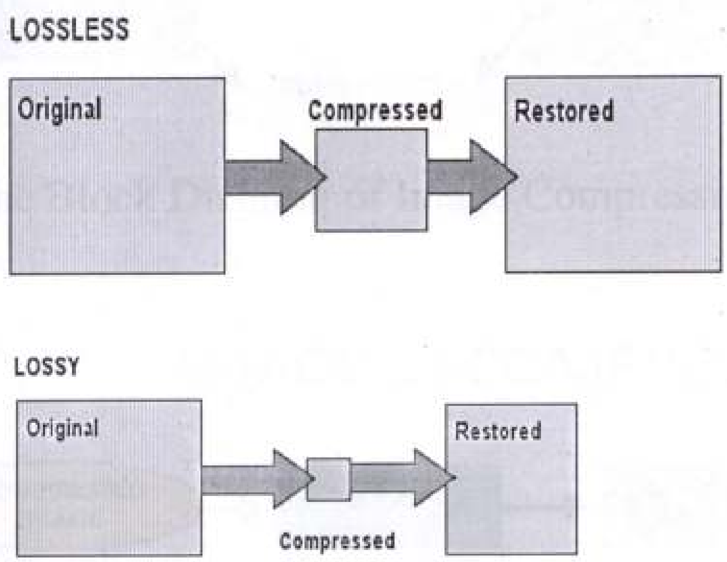
Image compression is minimizing the size in bytes of a graphical file ith or without degrading the quality of the image up to some acceptable level. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the internet or downloaded from web pages. Generally image compression schemes exploit certain data redundancies to convert the image to a smaller form.

2.1.4 Basic Types of Compression

Compressions are basically of two types: lossless (or information preserving) and lossy compression.

Lossless compression: With lossless compression, data is compressed without any loss of data. It assumes you want to get everything back that you put in i.e., we can reconstruct a perfect reproduction of the original from the compression. Critical financial data files are examples where lossless compression is required.

Lossy compression: With lossy compression, it is assumed that some loss of information is acceptable. In case of reconstruction, the information from the compressed data is closed to but not exactly the same as the original. Compression factor can be improved by allowing the algorithm to lose more information. Lossy compression algorithms usually have an adjustable parameter to control this compression vs. Quality trade off.



Figl.1: Representation of compression techniques.

Some of the data compression techniques:

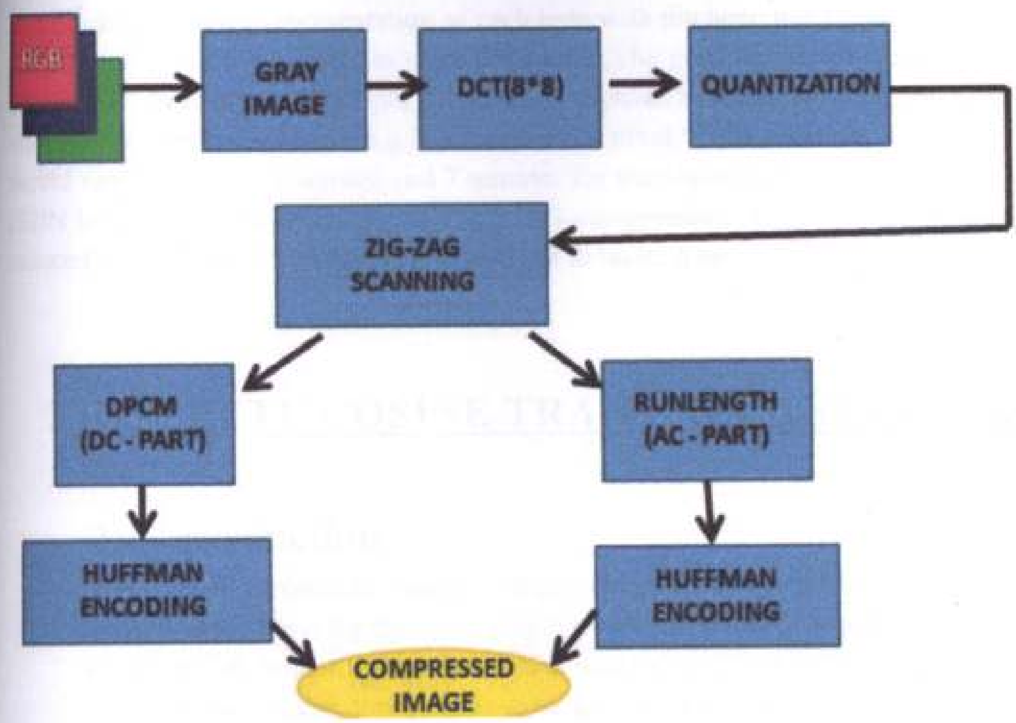
1. Lossless coding techniques
   a. Run length encoding
   b. Huffman encoding

2 .Lossy coding technique

a. Transform coding (DCT)

b.Uniform quantization

BLOCK DIAGRAM: IMAGE COMPRESSION



1.2The Block Diagram of Image Compression Model

IMAGE DECOMPRESSION

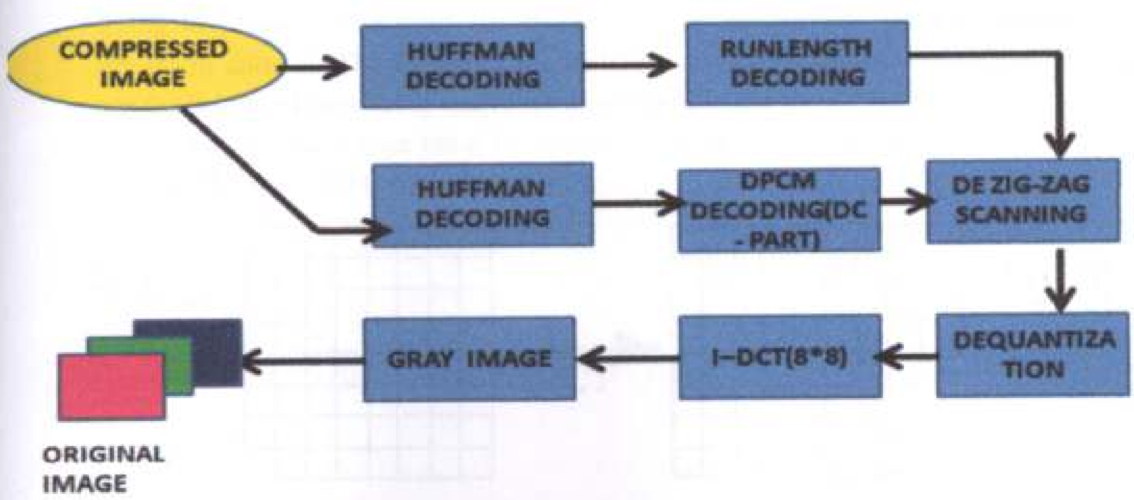


Fig 1.3 : **Image Decompression model**

WHY DO WE NEED IMAGE COMPRESSION?

Suppose, if a digital image is saved as a file on a camera or a web server, it is essentially saved as a long string of bits (zeros and ones). The idea of compression is very simple - we simply change the bit representation of each byte with the hope that the *new* dictionary yields a shorter string of bits needed to store the image .The need for image compression becomes apparent when number of bits per image are computed resulting from typical sampling rates and quantization methods. for e.g.: an image 1024 pixel *1024 pixel bit, without compression would require 3 MB of storage and 7 minutes for transmission, using high speed,64 k bits/s, ISDN line. If a image is compressed at a 10:1 compression ratio, the storage requirement is reduced to 300 kb and transmission time drops to under 6 seconds.

2.DISCRETE COSINE TRANSFORM TECHNIQUE

2.1 Introduction

It has excellent energy compaction properties, and as a result it has been chosen as the basis for the **Joint photography Experts group** (JPEG)[5] still picture compression standard. However losses usually results from the quantization of DCT Coefficients, where the quantization is necessary to achieve Compression. The advantage of DCT is not only the energy compaction properties, but also the correlation that exists between high energy coefficients in neighbouring transformed blocks.

2.2 Transformation of image into transform domain using DCT

The DCT method is an example of a transform method. Rather than simply trying to compress the pixel values directly, the images are first transformed into transform domain. The Discrete Cosine Method uses continuous cosine waves, like cos (x) below, of increasing frequencies to represent the image pixels.

Firstly, the image must be transformed into the transform domain. This is done in blocks across the whole image.

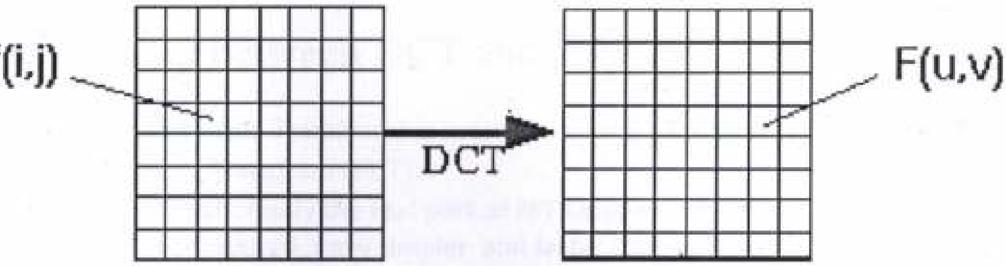


Fig 2.1 Transformation of Image into transform domain

2.3 DCT Mathematical form:-

FORWARD DCT (FOR COMPRESSION PART)

$$F(U,V) = \frac{2}{N} C(V) \sum_{X=0}^{N-1} \sum_{Y=0}^{N-1} f(x,y) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right]$$

$$where \ \ N = 8 \ and \ C(k) = \begin{cases} \frac{1}{\sqrt{2}} & for \ k = 0 \\ 1 & otherwise \end{cases}$$

2.4 Advantages of DCT

- The transformation is orthogonal (inverse is transpose and energy is preserved).
- Fast algorithms can be used for computation.
- The output for (near) constant matrices generally consists of a large number of (near) zero values.
- DCT reduce "blocking artifacts" (i.e., boundaries between sub-images do not become very visible).

2.5 Disadvantages of DCT

- Truncation of higher spectral coefficients results in blurring of the images, especially wherever the details are high.
- Quantization of some of the low spectral coefficients introduces graininess in the smooth portions of the images.

2.6 Relationship between DCT and FFT

DCT (Discrete Cosine Transform) is actually a cut-down version of the Fourier Transform / Fast Fourier Transform (FFT):

- DCT consist of only the **real part of FFT i.e.(cosine terms)**
- DCT is computationally simpler and faster than FFT/FT
- DCT **more commonly used in Multimedia** compression.
- DCT can concentrate more low frequency energy than FFT/FT
- DCT has less blocking effect than as compared to FFT/FT.

3.PROCESS INVOLVED IN IMAGE COMPRESSION TECHNIQUE

3.1 Image Compression & Decompression Process

3.1.1 JPEG Process

1. Original image is divided into blocks of 8 x 8.
2. Pixel values of a black and white image range from 0-255.
3. Forward equation of DCT is used to calculate DCT matrix. DCT is applied on each and every blocks of siz(8*8).
4. Each block is then compressed through quantization.
5. Quantized matrix is then entropy encoded.
6. Compressed image is reconstructed through reverse process.
7. Inverse DCT is used for decompression.

3.1.1.2 DCT Forward Transform

The operation of DCT is as follows:

***for e.g. f(i, j) is the intensity of the pixel in row i and column j.**

Original image

OBSERVED DCT VALUES OF 1-BLOCK (8*8)

DC-COEFFICIENT

751.25	34.3563	27.8261	28.5578	32.7500	30.5437	27.9814	15.4695
-8.2509	-26.1972	-15.5082	-15.7990	-8.3519	-11.3874	-5.1907	-3.0909
11.4789	3.3590	13.4069	-2.4865	8.2124	-5.1099	1.1036	-3.0022
6.5883	9.5185	16.7331	7.5177	11.1959	2.9540	6.6525	2.4423
-12.2500	-17.5473	-12.3795	-12.3893	-9.7500	-7.7134	-2.4490	-1.9301
6.8440	10.8077	7.4068	6.1359	2.3846	2.8671	1.9055	1.5969
0.9279	-1.3760	-0.3964	-2.0708	-0.4251	0.7351	2.0931	0.6613
-0.6525	0.0911	-1.2176	-2.1910	-3.4584	-2.5490	0.5686	-0.1876

AC-COEFFICIENT

After applying DCT on a block we observed following images:

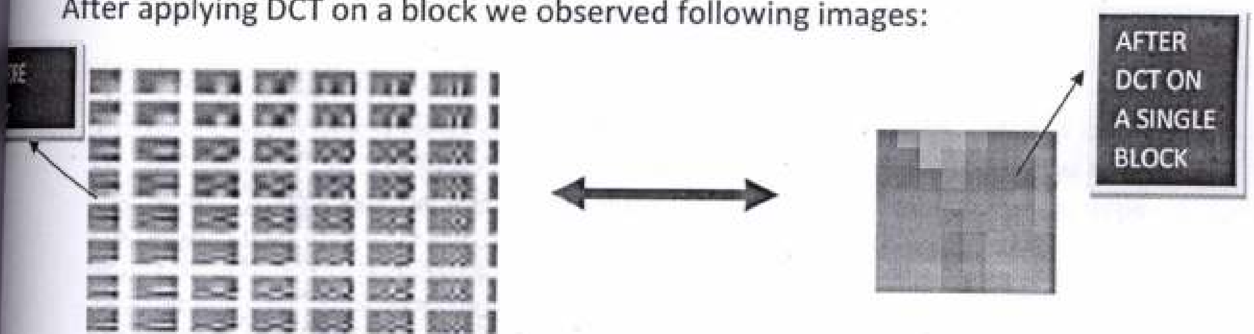


Fig 2.2. : Applying DCT on an image.

3.1.1.3 Zigzag Scanning

- **what is the purpose of the Zigzag Scan?**

*group low frequency coefficients in top of vector or a row which are more important as compared to the high frequency coefficients as they carry much of the information of the image.

*Maps 8 x 8 to a 1 x 64 vector that provides a way to neglect the high frequency coefficients .

0	1	5	6	14	15	27	28
2	4	7	13	16	26	29	42
3	8	12	17	25	30	41	43
9	11	18	24	31	40	44	53
10	19	23	32	39	45	52	54
20	22	33	38	46	51	55	60
21	34	37	47	50	56	59	61
35	36	48	49	57	58	62	63

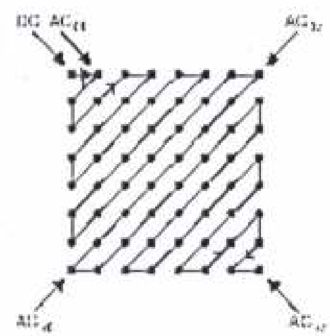


Fig3.1: The zigzag scan order

3.1.1.4 DPCM

Differential pulse coded modulation (DPCM) is used on DC part of a image. It is predicted from previously coded/transmitted samples (known at transmitter and receiver). Typical signal distortions for intraframe DPCM are granular noise, slope overload[2]

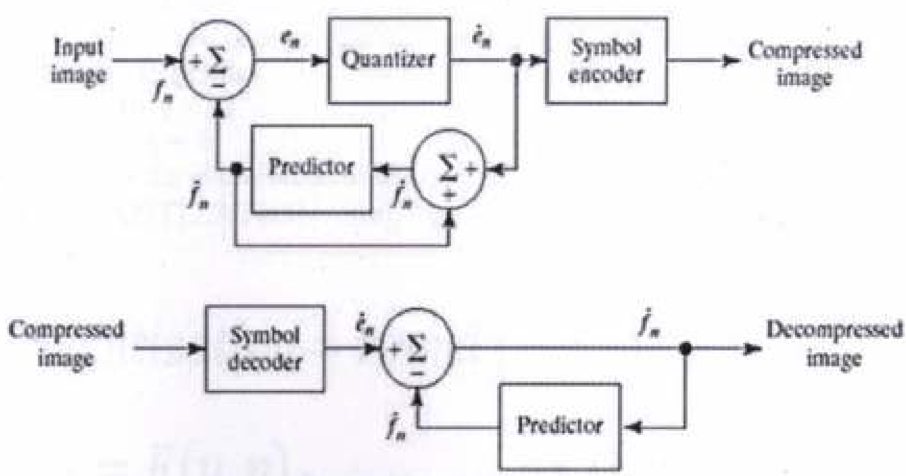


Fig3.2: DPCM Encoding and Decoding

MATHEMATICAL FORM OF DPCM:

$$E\{e_n^2\} = E\left\{[f_n - \hat{f}_n]^2\right\}$$

$$\dot{f}_n = \dot{e}_n + \hat{f}_n \approx e_n + \hat{f}_n = f_n$$

$$\hat{f}_n = \sum_{i=1}^{m} \propto_i f_n - i$$

$$E\{e_n^2\} = E\left\{\left[f_n - \sum_{i-1}^{m} \propto_i f_n - i\right]^2\right\}$$

$$\sum_{i=1}^{m} \propto_i \leq 1$$

3.1.1.4Quantization

DCT-based image compression relies on two techniques to reduce the data required to represent the image. The first is quantization of the image's DCT coefficients; the second is entropy coding of the quantized coefficients. Quantization is the process of reducing the number of possible values of a quantity, thereby reducing the number of bits needed to represent it. Entropy coding is a technique for representing the quantized data as compactly as possible. We will develop functions to quantize images and to calculate the level of compression provided by different degrees of quantization. We will not implement the entropy coding required to create a compressed image file. We need to quantization to throw out bits[3][4].

Example: 101101 = 45 (6 bits).

Truncate to 4 bits: 1011 = 11.

Truncate to 3 bits: 101 = 5.

Quantization error is the main source of the Lossy Compression.

UNIFORM QUANTIZATION: Step size is equal for all levels.

$$F(u,v)Quentization = round\left(\frac{F(u,v)}{Q(u,v)}\right)$$

$$F(u,v)_{deQ} = F(u,v)_{Quantization} \times Q(u,v)$$

UNIFORM QUANTIZATION

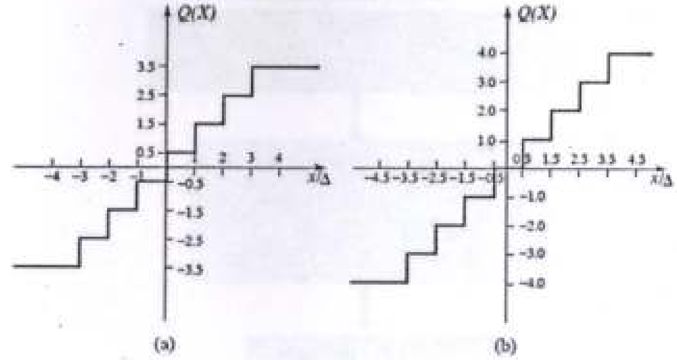


Fig. 8.2: Uniform Scalar Quantizers: (a) Midrise, (b) Midtread.

3.1.1.5Huffman Coding:

The basic idea in Huffman coding is to assign short codeword's to those input blocks with high probabilities and long code words to those with low probabilities. A Huffman code is designed by merging together the two least probable characters, and repeating this process until there is only one character remaining. The Huffman coding scheme provides a variable-length code with minimal average code-word length, i.e. least possible redundancy, for a discrete message source. (Here messages are grey-values)[3].

Huffman encoding

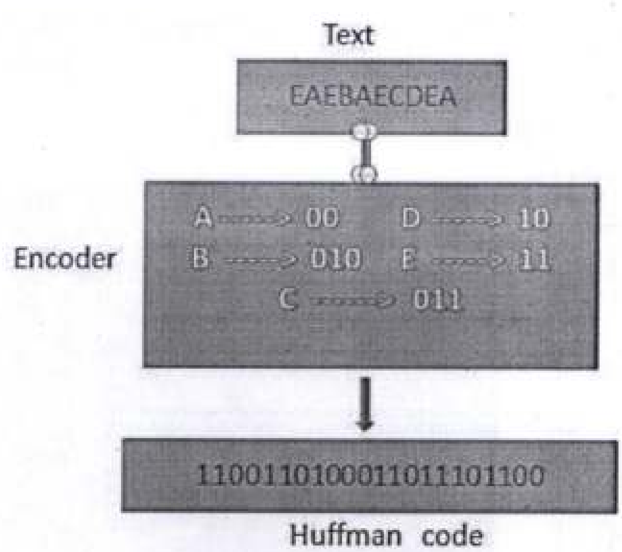


Fig 4.1 : Huffman Encoding

Huffman decoding

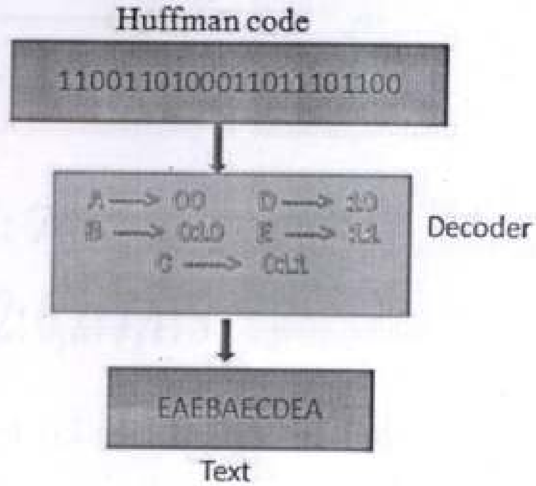


Fig 4.2 : Huffman Decoding

3.1.1.6 Run Length Encoding and Decoding Techniques:

Run length encoding is probably the simplest method of compression. It can be used to compress data made of any combination of symbols. It does not need to know the frequency of occurrence of symbols and can be very efficient if data is represented as 0s and 1s.The general idea behind this method is to replace consecutive repeating occurrences of a symbol by one occurrence of the symbol followed by the number of occurrences. The method can be even more efficient if the data uses only two symbols (for example 0 and 1) in its bit pattern and one symbol is more frequent than the other[1].

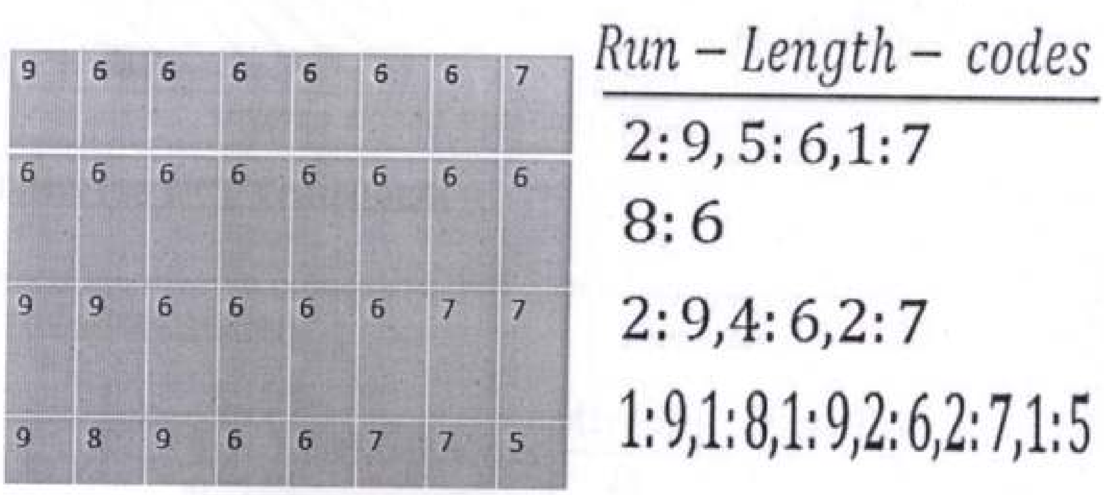


Fig 4.1.1: RLE CODING

Run – Length – codes

2: 9, 5: 6, 1: 7

8: 6

2: 9, 4: 6, 2: 7

1: 9, 1: 8, 1: 9, 2: 6, 2: 7, 1: 5

9	6	6	6	6	6	6	7
6	6	6	6	6	6	6	6
9	9	6	6	6	6	7	7
9	8	9	6	6	7	7	5

Fig 4.1.2 : RLE DECODING

3.1.1.7 INVERSE ZIGZAG SCANING

It is a reverse process of zigzag scanning. It converts a row matrix (N*1) back into a matrix of (N*M)size.

For e.g.:

P= [1 4 2 3 5 7 8 6 9] →

1	2	3
4	5	6
7	8	9

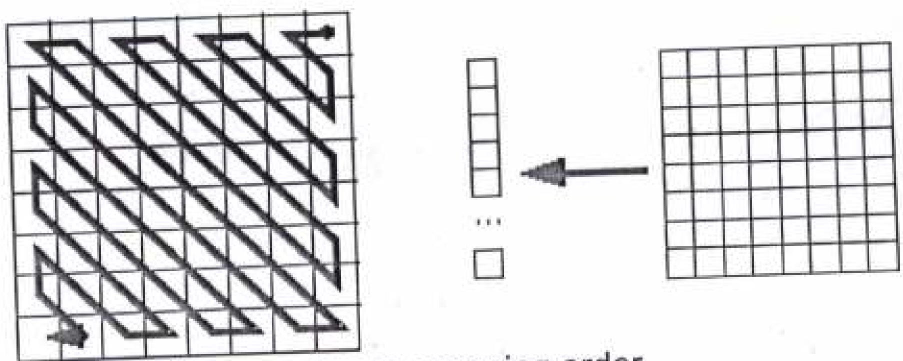


Fig 4.2: Inverse zigzag scanning order

3.1.1.8 Inverse DCT Transform

This is the reverse process of DCT transformation (FOR DECOMPRESSION).

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

For x =0,1, 2.........N-1 and y=0,1,2..........N-1 where N=8.

4. QUANTITATIVE MEASURE OF RESCONSTRUCTED IMAGE

1. **Compression Factor:**

$$CR = \frac{Size\_of\_original\_data}{Size\_of\_compressed\_data}$$

2. **Signal to noise ratio:**

$$SNR_{ms} = \frac{\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}(\hat{f}(x,y))^2}{\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}(\hat{f}(x,y) - f(x,y))^2}$$

3. **Root mean square Error:**

$$e_{rms} = \sqrt{\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}(\hat{f}(x,y) - f(x,y))^2}$$

4. **Peak signal to noise ratio:**

$$PSNR = 20\log_{10}\frac{Peak\_data\_value}{RMSE}$$

5. BENEFITS OF IMAGE COMPRESSION

Images which are used in different web pages in the internet undergo some compression methodology. Image compression benefits users providing faster picture up loading and downloading from any web Page and it is because it take less space to store. Image compression does not reduce the physical dimension of an image but instead compresses the data that make up the image into a smaller size.

Size Reduction

File size reduction remains the single most significant benefit of image compression. Depending on what file type of working with, we can continue to compress the image until it's at our desired size. This means the image takes up less space on the hard drive and retains the same physical size, unless we edit the image's physical size in an image editor. This file size reduction works wonderfully for the Internet, allowing webmasters to create image-rich sites without using much bandwidth or storage space.

Slow Devices

Some electronic devices, such as computers or cameras, may load large, uncompressed images slowly. CD drives, for example, can only read data at a specific rate and can't display images slowly. CD drives, for example, can only read data at a specific rate and can't display large images in real time. Also, for some webhosts that transfer data slowly, compressed images remain necessary for a fully functional website. Other forms of storage mediums, such as hard drives, will also have difficulty loading uncompressed files quickly. Image compression allows for the faster loading a device.

APPLICATIONS AND SCOPE

There are several applications of Image compression. Some of the major applications briefly described below:

1).Web-Designing: Image compression it is use to create faster loading web pages which in turn will make website more accessible to others. This image compression will also save a lot of unnecessary bandwidth by providing high-quality image with fraction of file size.

2).Digital Camera/Image Processing Hardware's: Users who save lots of photos on their hard drive, image compression is more important for those purposes. By compressing image received or downloaded, more images can be store on disk thus saving money from purchasing bigger hard disk.

3).Medical Science: Image compression is broadly applied in the field of medical science. It is very helpful for maintaining data structure of the images of the different parts of the body scanned for each patient during U.C.G and M.R.I and etc. and to improve the quality of images.

4).Satellite System: Using these methods the transmission and reception of data basically images would be easy and more effective from satellite, image archiving will be faster. These could be a forward step in many researches related to space and communication.

5).Security System, Navigation, Emailing, Multimedia Application etc and there are various field in which image compression plays a prominent role.

RESULT:

6.COMPRESSED IMAGE FOR LOSSY AND LOSSLESS:

In lossless JPEG scheme DPCM is not applied on dc-part, and no AC coefficients are neglected. But in lossy compression DPCM is applied for DC part and also neglect some high frequency AC coefficient. That's why there is difference in quality between decompressed images.

LOSSLESS COMPRESSED AND DECOMPRESSED IMAGE

COMPRESSED

DECOMPRESSED

LOSSY COMPRESSION WHEN (0 % OF AC COEFFICENT ARE REMOVED)

COMPRESSED & DECOMPRESSED IMAGES ARE:

LOSSYCOMPRESSION (5% OF AC COEFFICENTS ARE REMOVED)

LOSSYDCOMPRESSION (5% OF AC COEFFICENTS ARE REMOVED)

% A.C=70%

C.F=15.3429

SNR (db)
=11.4515

LOSSYCOMPRESSION (70% OF AC COEFFICENT E ARE REMOVED)

LOSSYDCOMPRESSED WHEN (70% OF AC COEFFICENT REMOVED)

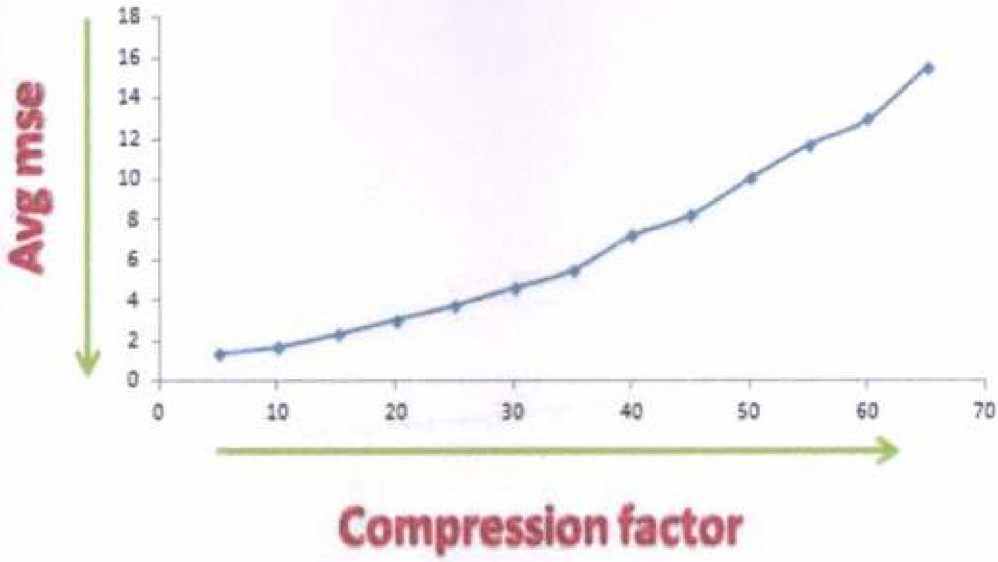
LOSSY COMPRESSED WHEN (40% OF AC COEFFICENT REMOVED)

LOSSY DCOMPRESSED WHEN (40% OF AC COEFFICENT REMOVED)

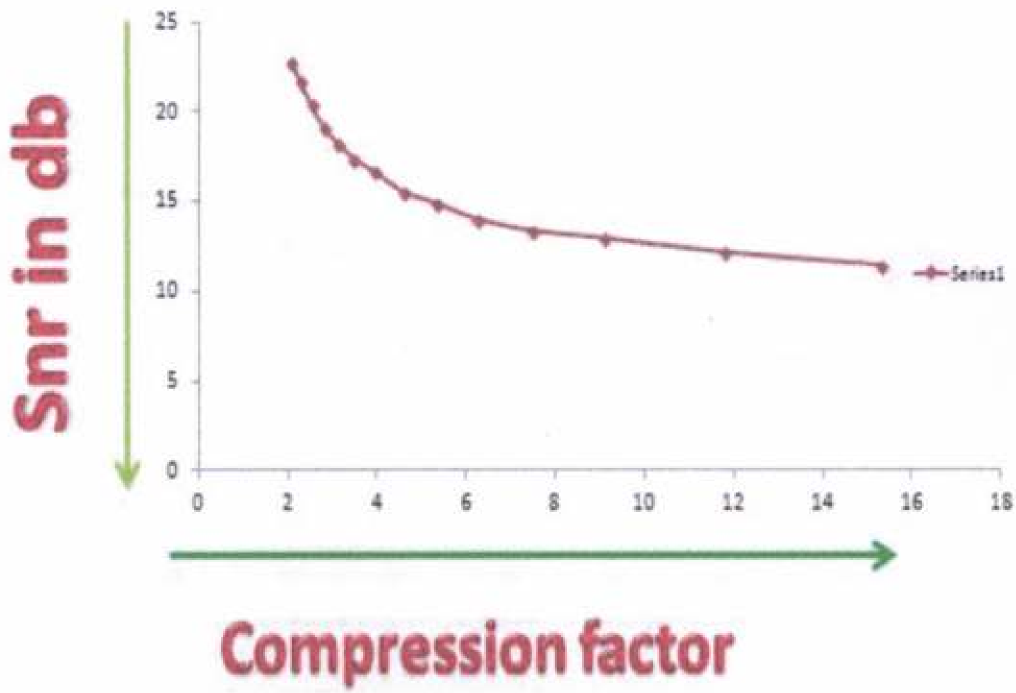
OBSEVED DATAS FOR LOSSY IMAGE:

a.c coffecient	jpeg size	original size	compression factor	average mse	snr db
5	1.927e+0.004	40545	2.1055	1.358	22.7234
10	1.7679e+0.004	40545	2.2934	1.7089	21.7341
15	1.5994e+0.004	40545	2.5429	2.3297	20.3882
20	1.4418e+0.004	40545	2.8121	3.0547	19.2116
25	1.2982e+0.004	40545	3.1233	3.7622	18.3068
30	1.1594e+0.004	40545	3.4971	4.631	17.4045
35	1.0246e+0.004	40545	3.957	5.4816	16.6721
40	8.7695e+0.004	40545	4.6234	7.1808	15.5219
45	7.5872e+0.004	40545	5.3439	8.2115	14.1731
50	4.4463e+0.004	40545	62,718	10.0175	14.0175
55	5.4086e+0.004	40545	7.4965	11.7112	13.3752
60	4.4436e+0.003	40545	9.1189	12.9396	12.9396
65	3.4283e+0.003	40545	11.8262	15.5216	12.1518

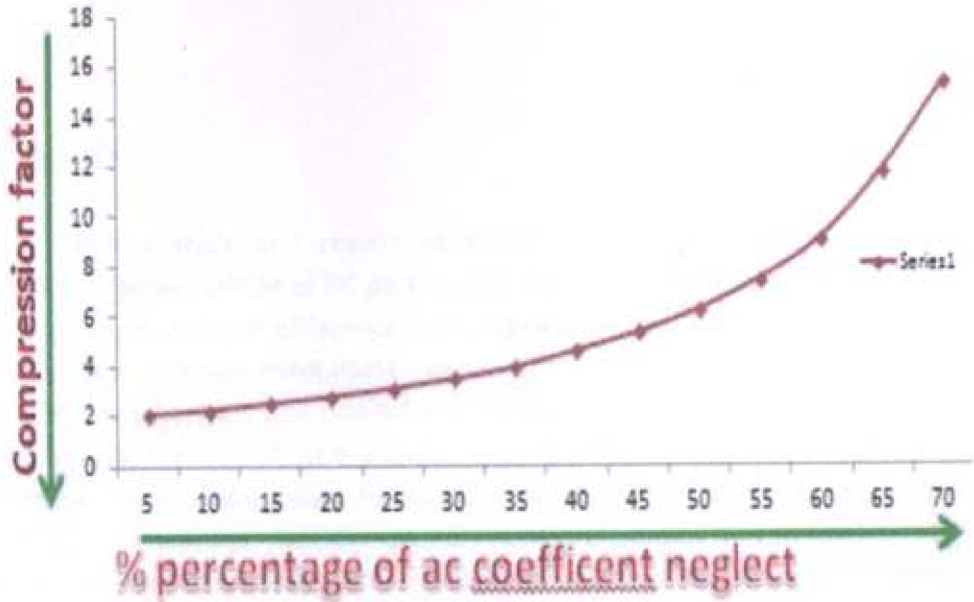
Based on above data's various graphs are drawn according to the relations between SNR,C.F,AMSE,PSNR and AC-COEFFICIENTS are:

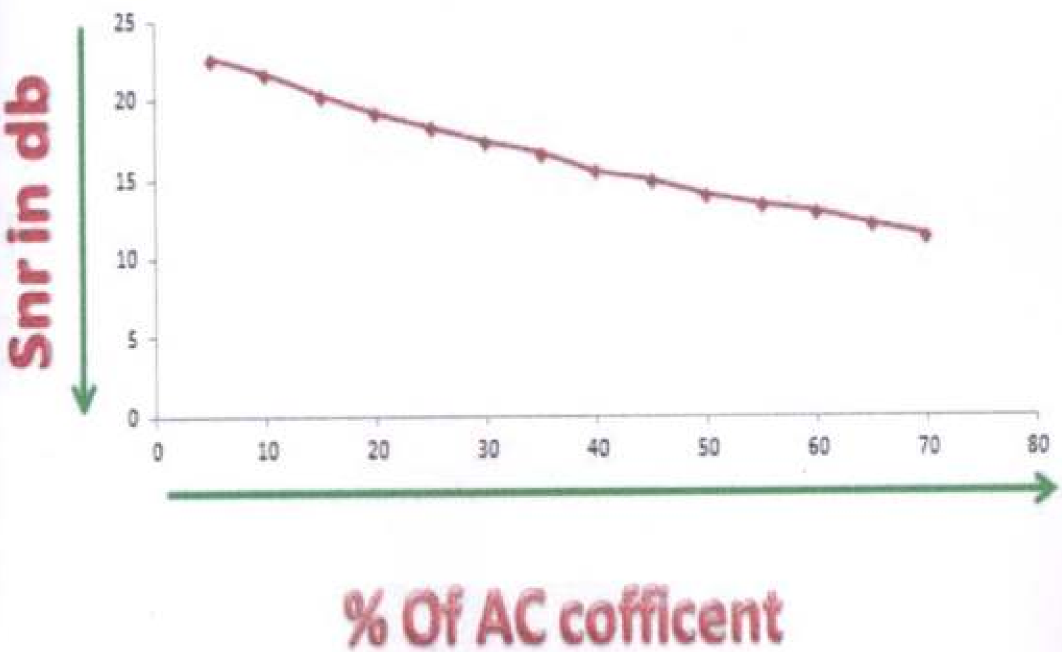


Avg mse
18
16
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
Compression factor



Snr in db
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
18
Series1
Compression factor


Compression factor
% percentage of ac coefficent neglect
Series1


Snr in db
% Of AC cofficent

CONCLUSION

From the above analysis and results obtained it is evident that in Lossless Compression technique (where DPCM of DC part is not taken and % of AC coefficient is not removed) that is why there is minor difference between original image and decompressed image in respect of size ,BW,SNR,PSNR,RMSE. But in Lossy Compression technique we observed a wide difference between the original image and decompressed image in respect of size, bandwidth, PSNR, C.F, as DPCM is applied on DC part and % of AC coefficient are also removed to reduce more storage area. In lossy if we increase % AC coefficient removal than compression factor increased, SNR decreased, Avgmse increased, but in lossless AC coefficient is fixed. We have successfully observed and implemented the two methods that could be used according to their suitability.

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