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Image Compression using Vector Quantization

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***Abstract*—The one of the basic technologies of the multimedia are image, audio and video compression.It is necessary to code image and audio at the lowest possible data rates.The transmission and storage of information becomes costly as bandwidth cost money.The transmission and storage become cheaper if less data is used to represent image and audio.The signals plays an important role in our daily life ; examples are audio,speech, music, picture and video signals.A signal is a function of independent variables such as time, distance,position,temperature.A signal is is defined as any physical quantity that carries information which varies with other independent or a dependent variable.Image compression is minimizing the dimensions in bytes of a graphics file without degrading the standard of the image to an unacceptable level.The representation of information in compact form is called compression.The compression is the process used to reduce the bit rate for transmission or storage. While compressing it is also necessary to maintain acceptable fidelity or data quality.**

***Index Terms*— Compression, VQ, PSNR, BPP, MSE, Compression Ratio.**

I. INTRODUCTION

The main objective of data compression is to reduce the amount of redundant information in the stored or communicated data.Data compression techniques are mainly used for speed and performance efficiency along with maintaining the cost of transmission.The different data compression methodologies are used to compress different data formats like text,source code,video,audio,speech and image files.The reduction in file size allows more images to be stored during a given amount of disk or memory space.It also reduces the time required for images to be sent over the web or downloaded from sites.

One of the important aspects of image storage is its efficient compression.To make this fact clear let's see an example,an image,1024 pixel x 1024 pixel x 24 bit,without compression,would require 3 MB of storage and seven minutes for transmission,utilizing a high speed,64 Kbit/s, ISDN line.If the image is compressed at a 10:1 compression ratio,the storage requirement is reduced to 300 KB and therefore the transmission time drops to under 6 seconds.

Image compression addresses the problem of reducing the amount of data required to represent a digital image.The underlying basis of the reduction process is the removal of redundant data.From a mathematical viewpoint,this amounts to transforming a 2-D pixel array into a statistically uncorrelated data set.The transformation is applied prior to storage and transmission of the image.The compressed image is decompressed at some later time,to reconstruct the original image or an approximation to it.The image compression is a type of data compression that encodes the original image with fewer bits.

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The two ways of classifying compression techniques are

(a) Lossless

(b) Lossy

In lossless compression schemes,the reconstructed image,after compression,is numerically identical to the original image.However lossless compression can only achieve a modest amount of compression.An image reconstructed following lossy compression contains degradation relative to the original.Often this is due to the compression scheme completely discards redundant information However,lossy schemes are capable of achieving much higher compression.Under normal viewing conditions,no visible loss is perceived (visually lossless).

II.WAVELET TRANSFORMS

A wavelet is a waveform of effectively limited duration that has an average value of zero.Wavelets are irregular and asymmetric in nature.Similarly,wavelet analysis breaks a signal into shifted and scaled versions of the original (or mother) wavelet.The signals with sharp changes might be better analyzed with an irregular wavelet than with a smooth sinusoid.

A windowing technique with variable-sized regions is the next logical step in wavelet analysis.Wavelet analysis use a time-scale region rather than a time-frequency region.It is possible to compress or de-noise a signal without appreciable degradation by using wavelet analysis.In this work,it is possible to reduce the storage need and transmission bandwidth with the help of wavelet transform.The signal is broken into a shifted and scaled versions of the original wavelet.The biggest advantage of wavelets is its ability to perform local analysis.

III. PROPOSED APPROACH

Two fundamental components of compression are redundancy and irrelevancy reduction.Redundancy reduction aims at removing duplication from the signal source (image/video).Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver,namely the Human Visual System (HVS).In this paper,we propose an approach for image compression based VQ.A classical quantization technique from signal processing is Vector quantization.It allows the modeling of probability density functions by the distribution of prototype vectors.It was originally used for data compression.Vector quantization is an efficient codebook design for image compression.Vector quantization technique is efficiently used in various areas of biometric modalities like finger print [4] pattern recognition,face recognition [5] by generating codebooks of desired size.VQ was first proposed by Gray in 1984.Firstly, it constructs codebook which is composed of codevector.The Euclidean distance determines the nearest vector in codebook for one vector being encoded.Then it replaces the vector by the index in codebook.It finds the vector corresponding to the index in codebook while decoding.

The VQ is classical technique for quantization from signal processing.The modeling of probability density functions by the distribution of prototype vectors is allowed by VQ.It was orginally used for data compression.Vector quantization falls under the category of lossy data compression which is method based on the principle of block coding[2][3].Due to the need for multi-dimensional integration the design of a vector quantizer is considered to be a challenging problem in the earlier days.A VQ design algorithm based on a training sequence is proposed by Linde,Buzo, and Gray (LBG) in 1980.

This technique of VQ is nothing more than an approximator.The idea in VQ is similar to that of ``rounding-off" (say to the nearest integer).The concept of 1-dimensional VQ as an example is shown below:

In this example,every number less than -2 are approximated by -3 and every number between -2 and 0 are approximated by -1.Every number greater than 2 are approximated by +3. It is to be noted that the approximate values are uniquely represented by 2 bits. So,it is called a 2-bit VQ.[1]

To quantize signal vectors VQ is an efficient coding technique.It has been widely used in signal and image processing.There are two main steps in a VQ compression procedure

1. codebook training (codebook generation)
2. Coding (i.e.codevector matching)

IV. PROPOSED ARCHITECTURE

The proposed architecture for image compression is shown in Fig.1.In VQ the amount of compression is described in terms of the rate which is measured in bits per sample.If we have a codebook of size k and the input vector of dimension L ,then we need to use [log 2 k] bits to specify which of the codevectors are selected.The rate for an L-dimensional vector quantizer with a codebook of size K is [log 2 k] /L.

Linde-Buzo-Gray (LBG) Algorithm-It is used for designing of codebook efficiently with minimum distortion and error.It was proposed by Yoseph Linde,Andres Buzo and Robert M. Gray in 1980.It is the most common algorithm for generation of code that generates a codebook with minimum error from a training set.This algorithm assumes the codeword length to be fixed.The set of vectors that are derived from image vectors are the training sets.The code vectors must minimize the distortion.It is an iterative procedure and the basic idea is to divide the group of training vectors and use it to find the most representative vector from one group.These representative vectors from each group are gathered to form the codebook.

Procedure for LBG Algorithm:

1. Divide the given image into blocks, so that each block appears as a d-dimensional vector. For example, if image size is 712×712 and block size is 4×4, then the number of blocks is equal to (712*712)/(4*4)=31684.
   And each block is a 16 dimension vector.
2. Initial codebook is chosen randomly.
3. The initial chosen codebook is set as the centroid and the other vectors are grouped according to the nearest distance with the centroid similar to the k-mean clustering.
4. Find the new centroid of every group to get a new codebook iterative.The steps 2 & 3 are repeated till the convergence of the centroid of every group.

The image is first read and by using transform coding such as wavelet,then it is converted from one kind of representation to other kind of representation.Then the transformed values (coefficients) are encoded by compression techniques.A better transform coding has the ability to compress the data using less number of coefficients.

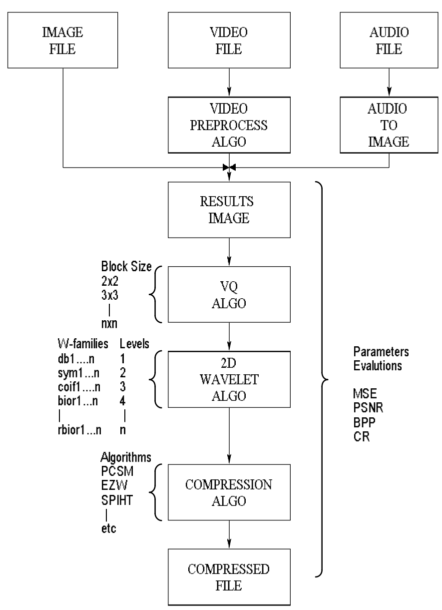


Figure.1 Proposed Architecture

V. SIMULATION RESULTS

Here, we report simulation results of the proposed approach using VQ for different block size .The table I,II and III shows the result for standard Lena image (Color & Gray) for various performance measures.

TABLE I. LENA IMAGE (COLOR) 359×359

Block Size	Performance Measures				
	MSE	PSNR (dB)	CR	Computational Time for (in Second)	
				Compression	Decompression
2×2	9.44	35.042	24.86	85.84	0.0496
3×3	21.27	30.325	10.98	42.57	0.0220
4×4	30.44	27.539	6.14	26.94	0.0140
5×5	48.26	25.289	3.91	20.56	0.0119
6×6	54.70	23.750	2.70	18.97	0.0080

The table II shows the result for standard lena image (colour) for various algorithm indicated.The table also shows various performance measures.

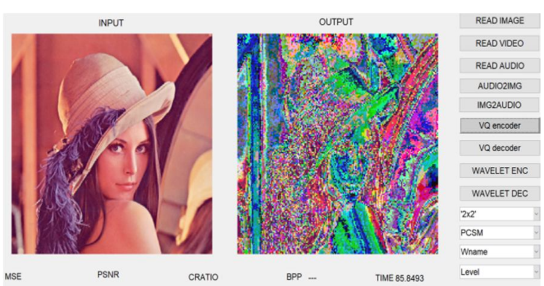
TABLE II. LENA IMAGE (GRAY) 256×256

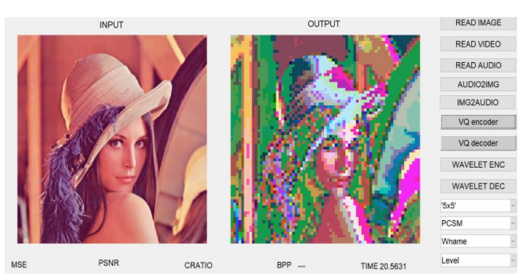
Block Size	Performance Measures				
	MSE	PSNR (dB)	CR	Computational Time for (in Second)	
				Compr-ession	Decomp-ression
2×2	13.22	33.326	25	23.664	0.0496
3×3	28.30	28.320	11.0	12.180	0.0220
4×4	41.38	25.351	6.25	7.930	0.0140
5×5	49.79	23.616	3.96	5.923	0.0119
6×6	58.22	22.282	2.69	5.375	0.0080

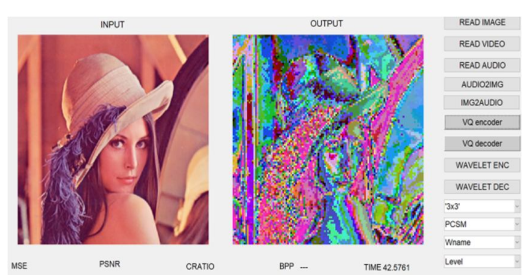
TABLE III .LENA IMAGE (GRAY) 359×359

Block Size	Performance Measures				
	MSE	PSNR (dB)	CR	Computational Time for (in Second)	
				Compression	Decompression
2×2	8.48	35.365	24.86	47.380	0.024
3×3	20.93	30.303	10.98	23.280	0.0144
4×4	31.69	27.452	6.14	14.820	0.0085
5×5	43.87	25.165	3.91	11.537	0.0069
6×6	49.70	23.965	2.70	10.928	0.0055

For comparison purpose the original image and reconstructed images are shown in figure 2,3 and 4.







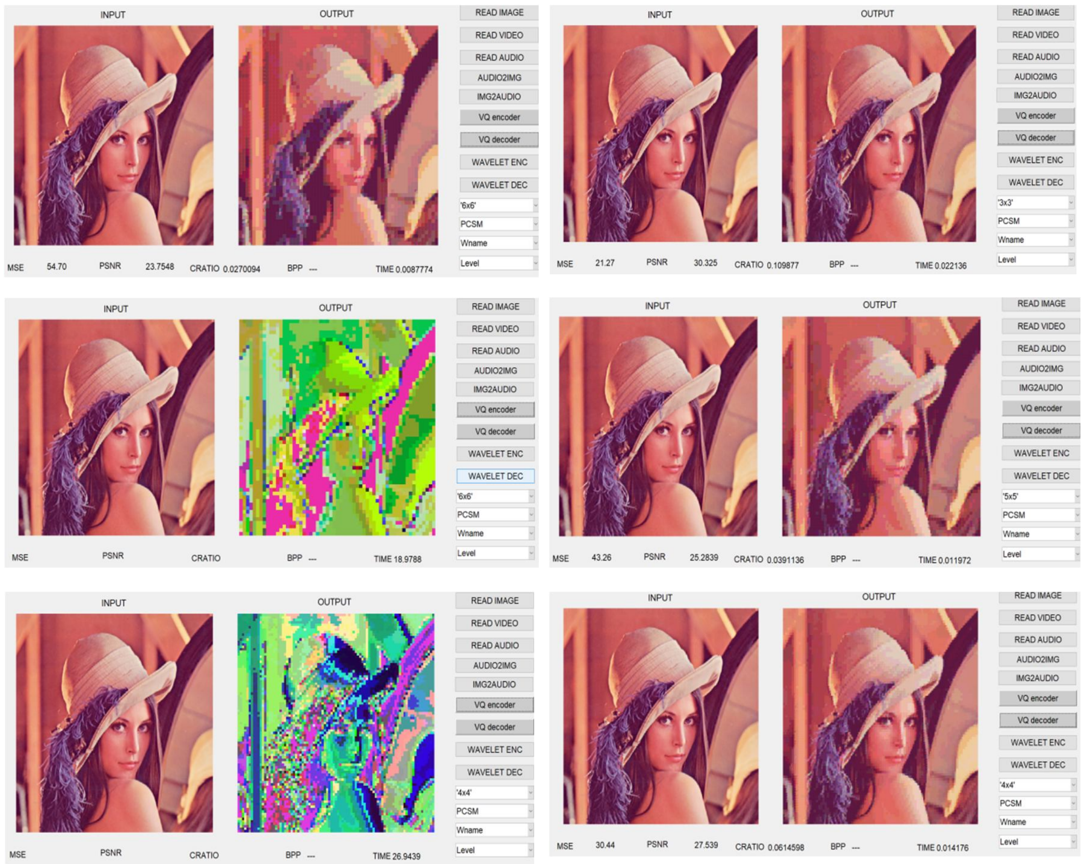
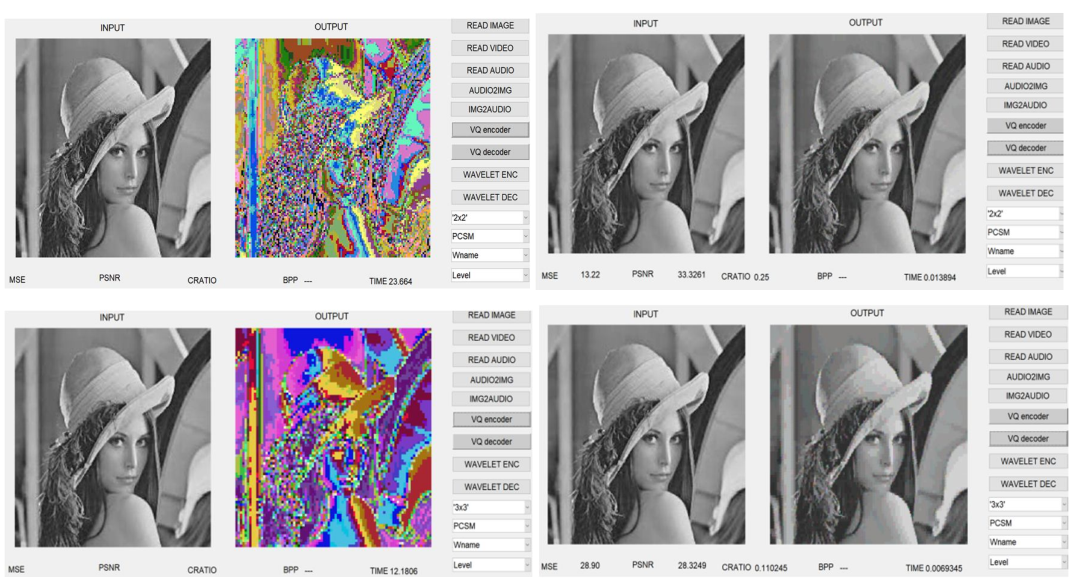


Fig 2.Original and reconstructed images for standard Lena image (Colour) 359×359



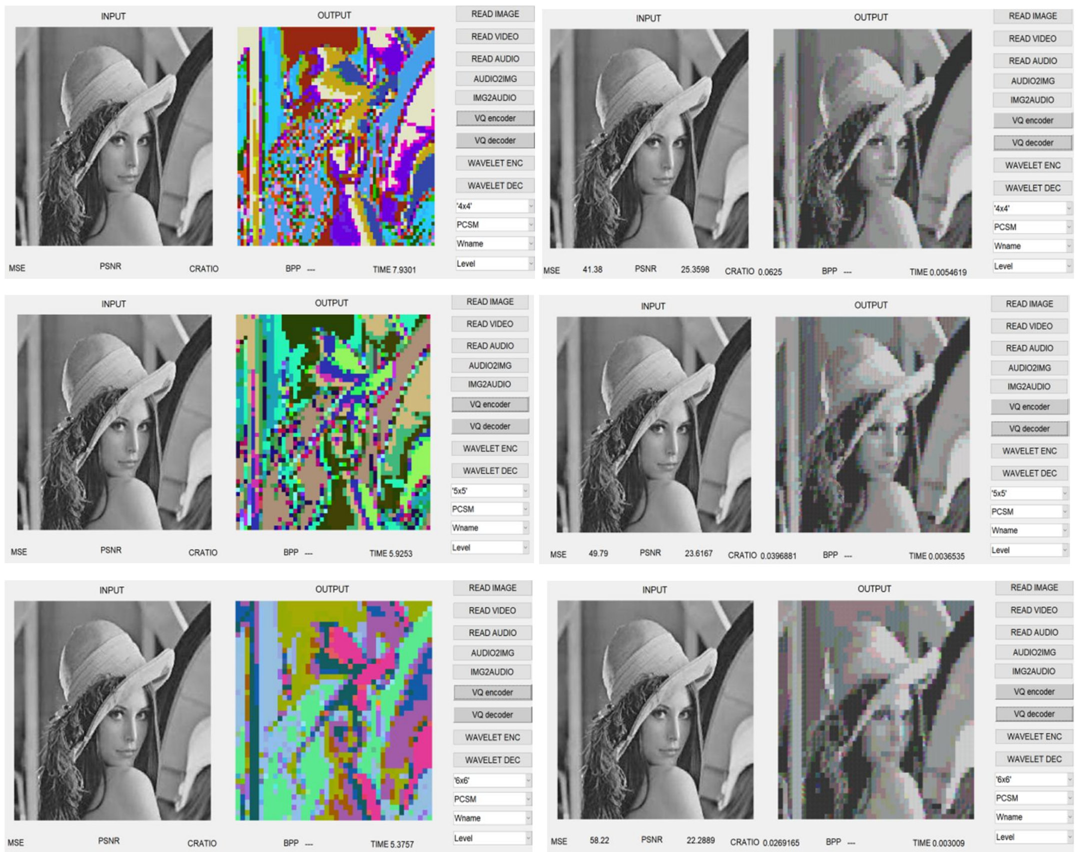
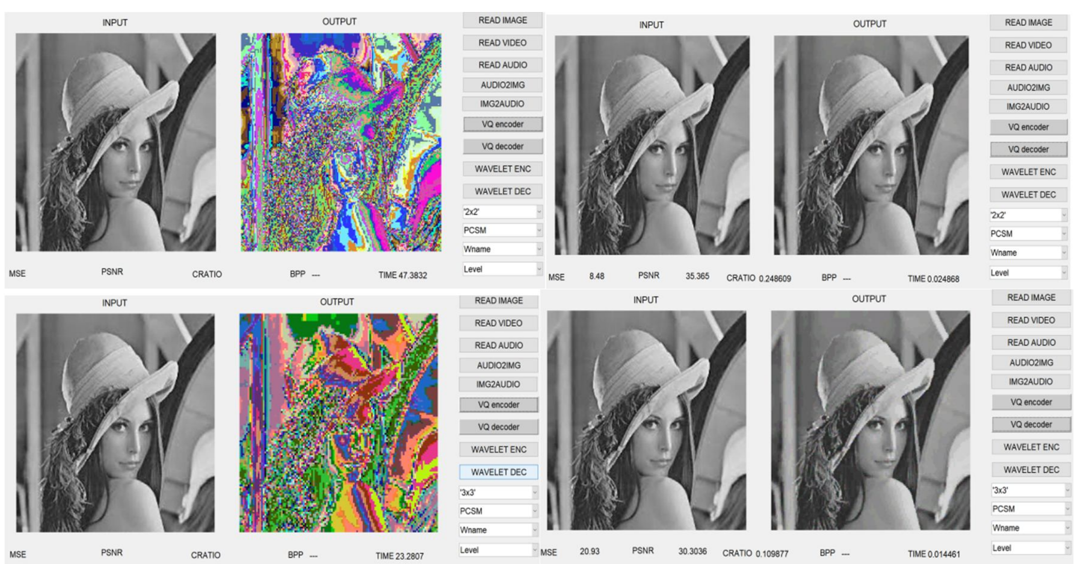


Fig 3.Original and reconstructed images for standard Lena image (Gray) 256×256



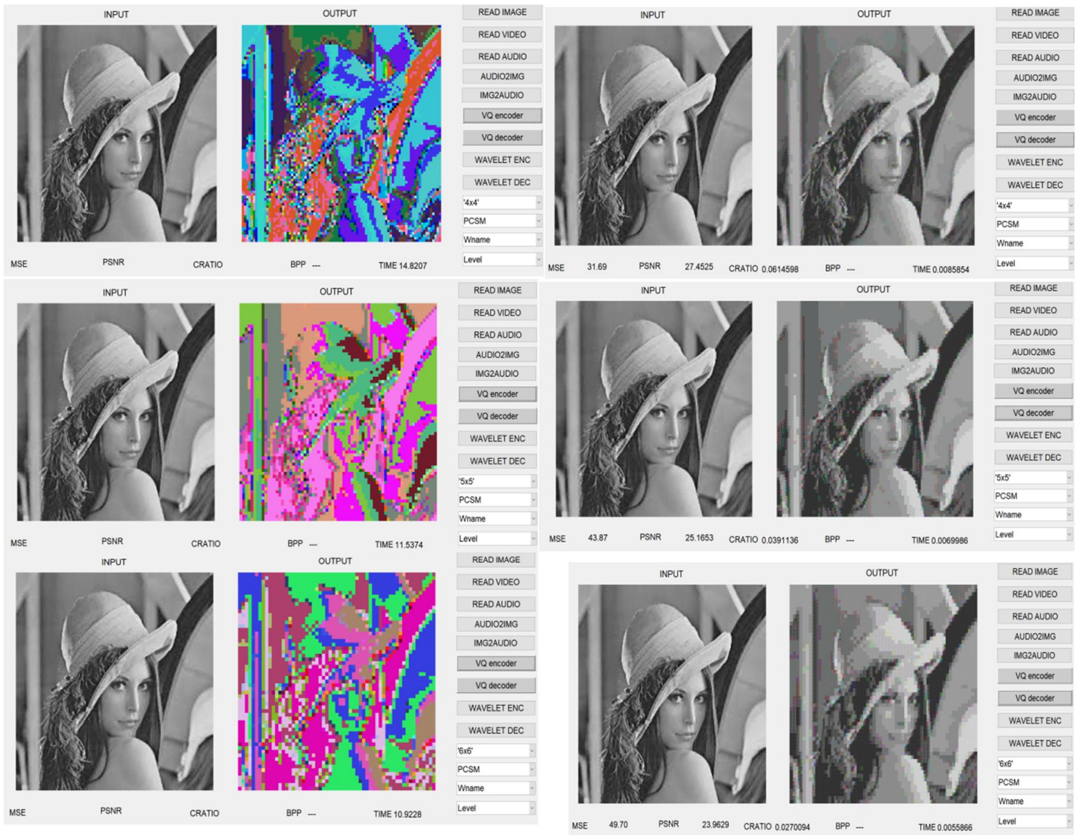


Fig 4. Original and reconstructed images for standard Lena image (Gray) 359×359

VI. Results and Discussion

The images taken for the experiment are ‘Lena’ of size (359 X 359 and 256 X 256). hey are subjected to VQ for different block size.The table 1,2 and 3 represents the corresponding values of performance measures like MSE,PSNR,Compression Ratio (CR) and computational time for standard image size.From these tables, it is clear that as the value of MSE increases,the CR decreases.The quality of the reconstructed image is degraded as the size of the block increases.The higher the value of PNSR,the better is the quality of the reconstructed image [6].The MSE stands for Mean Square Error which represents the cumulative squared error between the compressed and original image.The lower the value of MSE, the lower the error [7].To verify the effectiveness (qualities and robustness) of the proposed Image Compression Using VQ,we conduct several experiments with this procedure on several images.Image compression is performed in the MATLAB software using wavelet toolbox.

In our proposed technique,compression ratio is enhanced while maintaining the image quality which is must for digital data,image or video file to transfer in fast way and lesser amount of time.

VII. Conclusion

With this paper,we came to conclude that the proposed technique is able to compress the color as well as gray images with in a short span of time compared to other Algorithms.We are able to have compression ratio’s for different images like for gray scale images as 2% to 25% and for colour images 2% to 24.8%.Also,we came to conclude that the time required for computation (Compression and decompression) is more for color image than gray images.This computational time depends upon image size.The time needed for compression and decompression also depends upon selected block size and reduces as the size of block increases.But,the quality of the reconstructed image degrades with increase in selected block size in VQ.

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