# An Analysis of Vector Quantization Based Image Compression Approaches

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***Abstract: -*** Digital image processing helps in manipulation of the digital images by using computers. The term image compression refers to the process of reducing the amount of data necessary to represent a given quantity of information. Compression methods are rapidly developed to compress large data files such as images. There are two types of compression techniques are lossy and lossless. Vector Quantization is an essential and fundamental technique for lossy image compression. An efficient image compression technique is essential to achieve better compression for storing and transmitting huge multimedia content. The most popular technique used for the image compression is vector quantization (VQ). In this paper, various VQ based image compression techniques are analyzed and attempt to find out best approach among them. The techniques of VQ based image compression, improvement in metrics such as peak signal noise ratio, mean square error, computation time, fitness value, distortion ratio are briefly discussed.

***Keywords:*** Vector Quantization, Image Compression, Compression Ratio, Lossy Compression, Computation Time.

## I. INTRODUCTION

Vector quantization (VQ) [1] is a quantization technique from signal processing that allows the modelling of probability density functions by the distribution of prototype vectors. It's used for lossy data compression. Lossy image compression means reducing size of file without degrading the quality of the image to certain level. The main aim of any image compression system is to minimize the storage volume as much as possible, and the decoded image must be similar to the original image as much as it can be. (Reference paper)

Image compression [2] domain is one of the most popular techniques. In the Lossy image compression bits are removed from images without degrading the visual quality of image while the Lossless image compression doesn't permit to remove data from image. The proposed method vector quantization technique with some other compression algorithm such as SPIHT, Fuzzy VQ, FF-VQ, HBA, CVQ etc used for increasing the storage and transmission in terms of peak signal noise ratio, mean square error, computation time, fitness value, distortion ratio. PSNR is most commonly used to measure the quality of reconstruction of lossy compression codec's (e.g., for image compression). The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codec's, PSNR is an approximation to human perception of reconstruction quality. Although a higher PSNR generally indicates that the reconstruction is of higher quality, in some cases it may not. One has to be extremely careful with the range of validity of this metric, it is only conclusively valid when it is used to compare results from the same codec (or codec type) and same content.

The main goal of this paper is analyse the various compression technique [3] to improve the quality of the image without loss the original quality. In literature survey we discuss about the merits and demetits of the each compression algorithm for increasing the reconstructed quality image.

## II. LITERATURE REVIEW

Yang Shuyan et al [4] proposed evolutionary based vector quantization and set partitioning in hierarchical trees (SPIHT) coding method for image compression. The proposed method used to global searching capability of one step gradient descent genetic algorithm (OSGD-GA) and also obtain contextual constraints on membership condition. The OSGD-GA designed for optimizing the codebook of the low frequency wavelet coefficient by defining the important degree of each co efficient and utilizing fuzzy membership to address the automatic clustering. The proposed method shows that the improvement in PSNR value however degrades at high bit rate.

Tsolakis Dimitrios et al [5] proposed fuzzy clustering based vector quantization algorithm for deal with the following problems. The first one is the high computational cost. The second one is the vector quantization is required to assign each training sample to only one cluster. The third one is the dependence on initialization. The proposed method having two basic design facts. The first facet concerns the minimization of the specialized objective function that unifies three potentially different approaches namely, c-means, fuzzy c-means and the competitive agglomeration. C-means and fuzzy C-means algorithm used to reduce the computational cost, reduce the number of distance then competitive agglomeration used to reduce the size of the cloud clusters. The second facet concerns the development of a novel codeword migration technique. The proposed techniques reduce the computational complexity as well as maintain the high performance level at local minima.

Huwi Horng Ming et al [6] proposed honey bee macthing optimization (HBMO) based firefly algorithm to construct the codebook of vector quantization. The proposed method initially used LBG algorithm for develop the vector quantization and this

method called as the FF-LBG algorithm. The experimental results prove that HBMO is faster than other compression algorithm such as LBG, particle swarm optimization and quantum particle swarm optimization.

Huwi Horng Ming et al [7] proposed quantum particle swarm optimization (QPSO) algorithm based honey bee mating optimization to construct new codebook of vector quantization. The QPSO algorithm mainly developed to improve the results of the original PSO algorithm. The experimental results shows that the proposed HBMO-LBG algorithm is more reliable and reconstructed images get higher quality than those generated from other algorithm such as LBG, PSO-LBG, and QPSO-LBG.

Hosseini seyed morteza et al [8] proposed contextual vector quantization (CVQ) for increase the storage and transmission of images in medical image database system. In CVQ algorithm; contextual region of interest (CROI) applied on important encoded information and Background (BG) of the input image encoded with low resolution. The CVQ algorithm used to merge the encoded contextual region and encoded background region then reconstruct the output image. It shows improvisation over existing Contextual Set Partitioning in hierarchical methodology.

Tsolokis Dimitrios et al [9] proposed the fast fuzzy clustering based Vector Quantization for grayscale image compression. This approach mainly implemented for reducing computational cost as well as maintaining the optimal performance. The proposed method having three modules. The first one concerns the reduction of the number of code words. The second one reduces the number of training patterns in design process. The third one is to increase the size of the small clusters. The proposed algorithm produces standard distortion mean value compare to other compression algorithm such as LBG, ELBG, FLVQ, FVQ, and IFLVQ.

Orest Vascan, O et al [10] used Hilbert scan for improve the quality of the reconstructed image in VQ based image compression. Here two methods are used for improving the quality of the reconstructed image that is Linde-Buzo-Gray (LBG) algorithm and self organizing map (SOM) neural network. First the input image scanned by Hilbert scan then vector quantized with LBG and SOM neural network. The result shows that the PSNR value increased in low bpp (bits per pixel).

Thepade, S.D et al [14] proposed Thepade's Transform Error Vector Rotation (TTEVR) algorithm with Kekre, Walsh, and Slant orthogonal transform and wavelet transform used for code book generation. The proposed algorithm is conducted with various code book sizes of 256 and 512 on a test bed of 10 images of sizes of 256X256X3 and 512X512X3.The proposed algorithm gives better compression ratio.

Karri Chiranjeevi et al [15] proposed Bat algorithm. It will produce efficient codebook with less computational time and loudness of bat. From the result the Bat Algorithm (BA-LBG) produce high PSNR (Peak Signal to Noise Ratio) compared to Linde Buzo Gray (LBG), Particle Swarm Optimization (PSO)-LBG, and Quantum PSO-LBG, (Honey Bee mating Optimization) HBMO-LBG and (Firefly Algorithm) FA LBG. This algorithm gives convergence speed is 1.841 times faster than HBMO-LBG and FA-LBG. Bat Algorithm provides global codebook with minimum number of iterations and with two tuning parameters like loudness and pulse rate.

Chiranjeevi karri et al [18] proposed cuckoo search (CS) Meta heuristic optimization algorithm to generate near optimal code book in vector quantization for image compression. CS optimizes the Linde Buzo Gray (LBG) codebook by levy fight distribution function which follows the Mantegna's algorithm instead of Gaussian distribution. Cuckoo search consumes 25% convergence time for local and 75% of convergence times for global codebook so its guarantees the global codebook with the appropriate mutation probability and this behavior is the major merit of cuckoo search. The proposed algorithm having high peak signal noise ratio and finest fitness value than other Meta heuristic algorithms.

## III. OVERALL METHODS USED

**II. *Table 1.1Comparison Table***

| Method | Approaches used | Merits | Demerits | Results |
|---|---|---|---|---|
| [4] | Evolutionary based VQ and SPIHT | Improve the quality of compressed image | High bit rate | PSNR=30.61 dB |
| [5] | Fuzzy clustering based vector quantization | Reduce the dependence on initialization and computational complexity, increase performance | No of iterations increased | PSNR=35.139 dB |
| [6] | HBMO based firefly algorithm | Improve the quality of the image | Average computation time | PSNR=31.5 dB |
| [7] | QPSO | Increase the quality of reconstructed image | Less efficiency | Computation time=4384<br>Execution time=9812 |
| [8] | Contextual vector quantization(CVQ) | Reduce the storage cost and transmission time | 1. Cannot select different scaling values for different ROI.<br>2. Relative importance of ROI and the background coefficients cannot defined by an arbitrary scaling value. | PSNR=42.36 dB |

| | | | | |
|---|---|---|---|---|
| [9] | Fast fuzzy clustering based vector quantizes | Reduce the dependence on initialization. | High computational cost | PSNR=32.856 dB Distortion Mean=693.537 |
| [10] | Hilbert scan method | Increase the quality of reconstructed image | Size of the block increased | PSNR=31.9979 dB |
| [11] | DPCM and VQ | Less power consumption | Increase pixel size | PSNR=33.146 dB |
| [12] | Generalized fuzzy c means clustering approach employing improved fuzzy partitions (GIFP-FCM) | Transition from crisp to fuzzy mode is very efficient compared to other approaches. | Problem with reliability and robustness. | Compression ratio=30.911 |
| [13] | Deterministic compressive sensing VQ | High PSNR value obtained | Having channel noise and receiver end noise | PSNR=33.146 dB MSE=31.759 Bpp=1.296 |
| [14] | Thepade's Transform error vector Rotation (TTEVR) with Kekre, Walsh and Slant wavelet Transform | TTEVR with Wavelet transforms gives better compression quality as compared to all transforms. | Kekre and Walsh gives less compression compared to TTEVR and Slant wavelet transforms. | Mean Square Error=144.58 |
| [15] | Bat Algorithm | Provide high PSNR(Peak Signal to Noise Ratio)value compared to LBG(Linde-Buzo-Gray) | No Significance difference in Particle Swarm optimization(PSO) | PSNR=32.5 dB Computation Time=2587.64 Fitness Value=79 |
| [16] | Adaptive image segmentation approach | High computation time | Computational complexity quite high | PSNR=32.9dB Computation time=5492.47 Fitness value=72 |
| [17] | Vector quantization and hybrid wavelet transform | KMCG and KMFG VQ algorithm gives better image quality | N/A | 35% error reduced by KMCG and KMFG |
| [18] | Cuckoo search (CS) Meta heuristic optimization algorithm | High peak signal noise ratio(PSNR),high fitness value | Low computation time | PSNR=32.5 dB Fitness Value=72 Computation time=5492.47 |

**Peak Signal Noise Ratio (PSNR)**

Peak Signal-to-Noise Ratio, it is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation.

$$\mathbf{PSNR=20.\log_{10}(MAX_I) - 10.\log_{10}(MSE)}$$

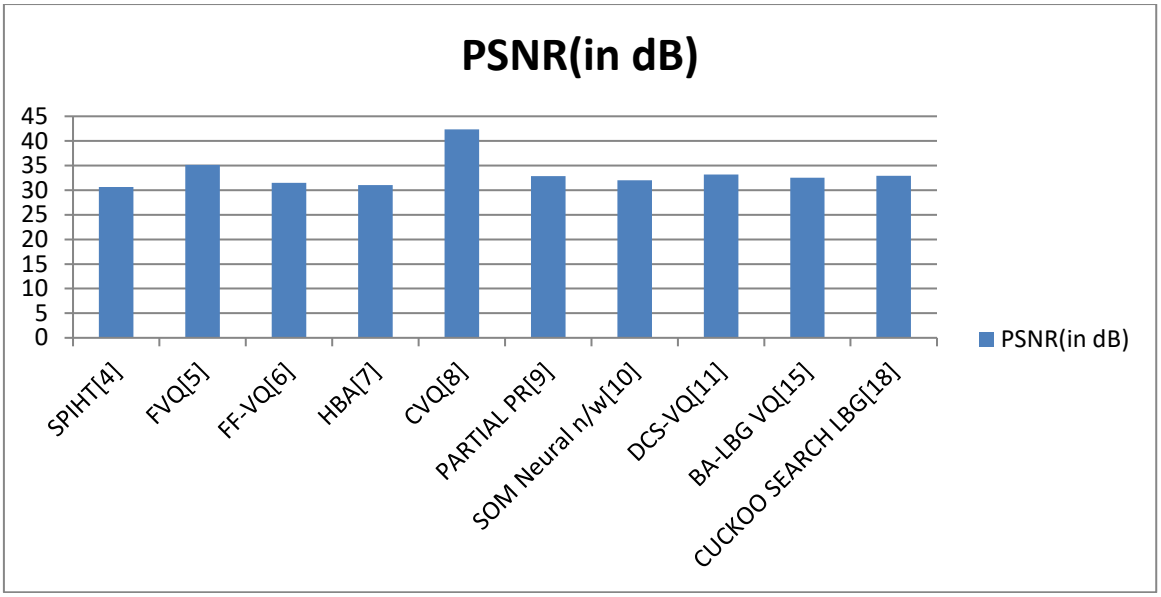


***Figure:1.1 PSNR values for various compression algorithm***

The PSNR values for various compression algorithms are shown in Figure 1.1. The comparison of bar chart shows that the CVQ method provide high PSNR value (42.36 dB) compare to all other algorithms.

***Mean Square Error***

In statistics, the mean squared error (MSE) or mean squared deviation (MSD) of an estimator (of a procedure for estimating an unobserved quantity) measures the average of the squares of the errors or deviations—that is, the difference between the estimator and what is estimated.

$$\mathbf{MSE}=\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[\boldsymbol{I}(\boldsymbol{i},\boldsymbol{j})-\boldsymbol{K}(\boldsymbol{i},\boldsymbol{j})]^2$$

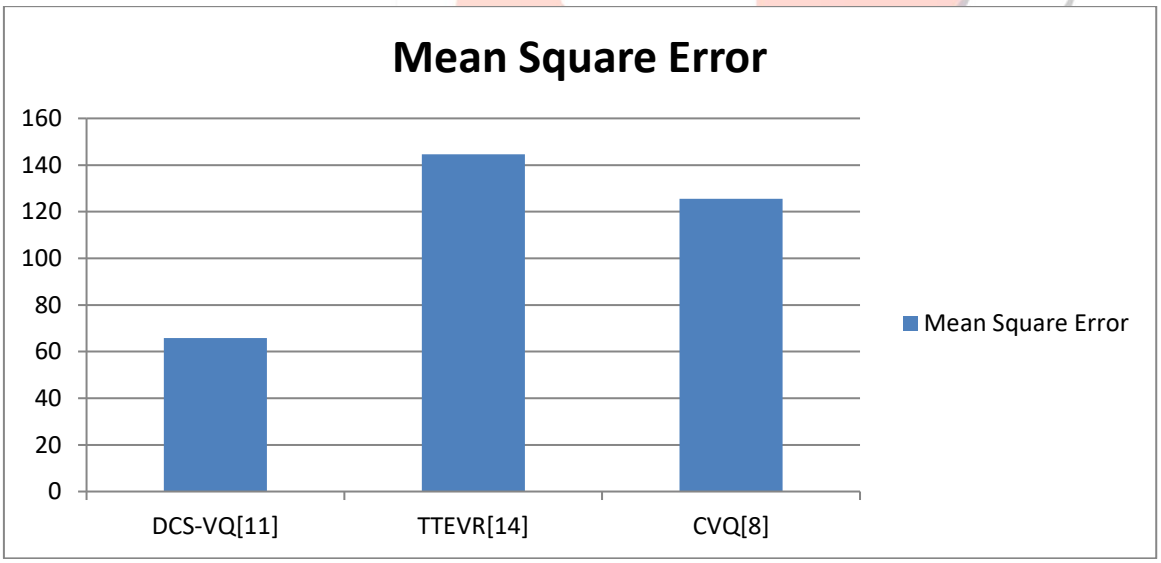


***Figure:1.2 Mean Square Error comparison between various compression algorithms***

The MSE values for various compression algorithms are shown in Figure 1.2. The comparison of bar chart shows that the TTEVR method provide high Mean Square Error value (144.58) compare to all other algorithms.

***Computation Time***

CPU time (or process time) is the amount of time for which a central processing unit (CPU) was used for processing instructions of a computer program or operating system, as opposed to, for example, waiting for input/output (I/O) operations or entering low-power (idle) mode.

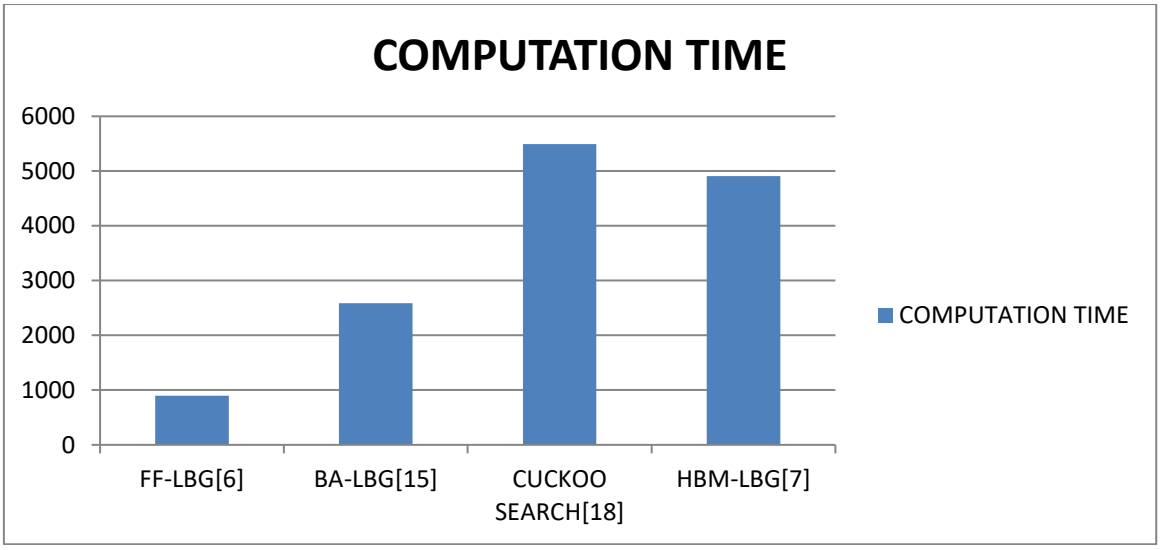


***Figure:1.3 comparison of computation time between various compression algorithm***

The computation values for various compression algorithms are shown in Figure 1.3. The comparison of bar chart shows that the cuckoo search method provide high computation time value (5492.47) compare to all other algorithms.

***Fitness Value***

A fitness function is a particular type of objective function that is used to summarise, as a single figure of merit, how close a given design solution is to achieving the set aims.

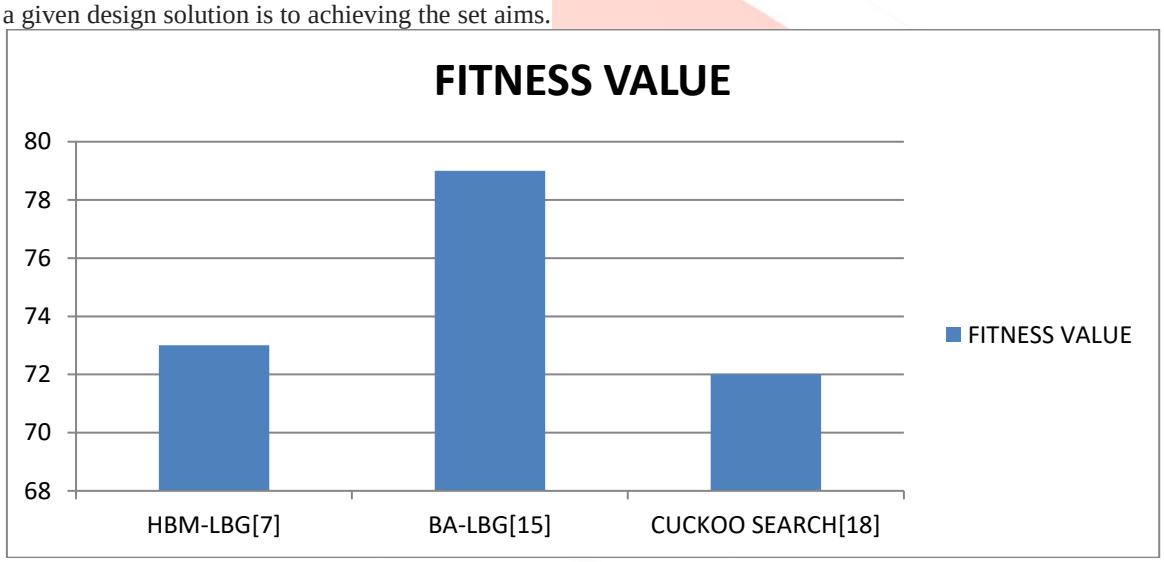


***Figure:1.4 Comparison of fitness value between various compression algorithm***

The Fitness values for various compression algorithms are shown in Figure 1.4. The comparison of bar chart shows that the BA-LBG method provides high fitness value (79) compare to all other algorithms.

***Distortion Ratio***

The total harmonic distortion, or THD, of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.

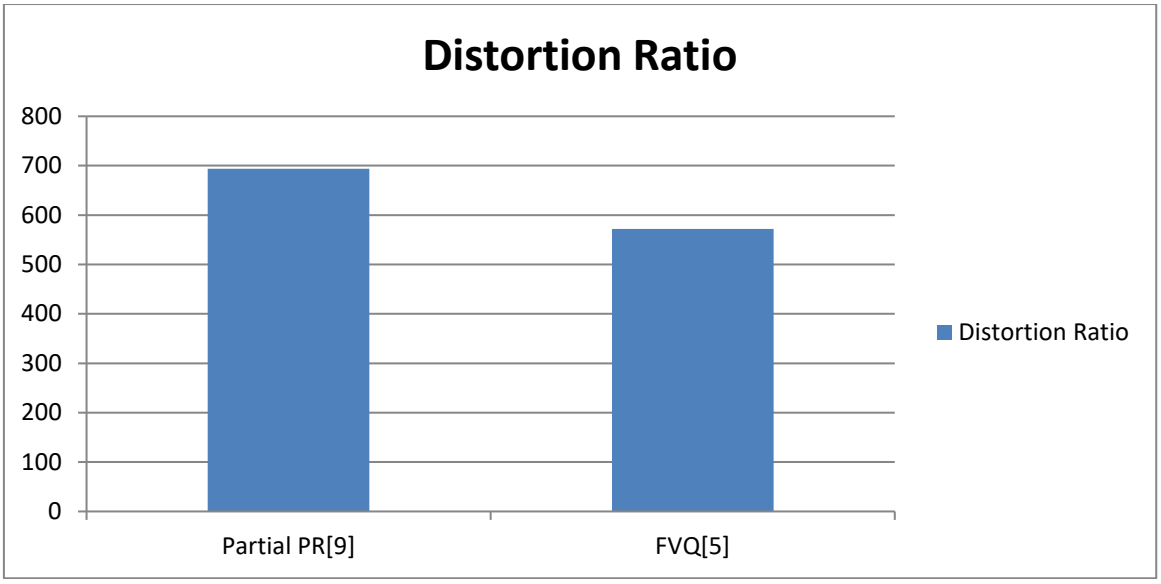


***Figure:1.5 Comparison of distortion ratio between various compression algorithm***

The Distortion Ratio values for various compression algorithms are shown in Figure 1.5. The comparison of bar chart shows that the partial PR method provides high distortion mean value (693.537) compare to all other algorithms.

## IV. CONCLUSION

This work focused on different types of vector quantization methods used. The various VQ based image compression algorithms are analyzed for improving compression ratio and retain the quality of the reconstructed images. The various comparison parameters used to decide the quality of the image. The CVQ method provides better PSNR value, the TTEVR method provides better Mean Square Error Value, the cuckoo search method provides better computation time, the BA-LBG method provides better fitness value, the Partial PR method provides better distortion time.

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