International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-6, Issue-11, Nov 2018 E-ISSN: 2347-2693

Comparative Study of Image Compression Techniques based on Vector Quantization

Cibi Castro. V[1]*, Arul Raj. T[2], Ilam Parithi.T [3], Balasubramanian. R [4]

[1,2,4]Dept. of CSE, Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli, India
[3]Dept. of CS, MSU College, Puliangudi, India

**Corresponding Author: cibicastro07@gmail.com*

Available online at: www.ijcseonline.org

Accepted: 25/Nov/2018, Published: 30/Nov/2018

Abstract: Image Compression is the art and Science of reducing the amount of data required to represent an image. It is one of the useful and commercially successful technique in the field of Digital Image Compression. The innumerable images are compressed and decompressed daily. Image compression techniques are classified into lossless and lossy compression techniques. This paper covers three lossy compression techniques such as Tree Structured Vector Quantization (TSVQ), TSVQ reduces the quantizer search complexity by replacing full search encoding with a sequence of tree decisions , and Multi Stage Vector Quantization (MSVQ) , Multistage Vector Quantization is a modification of Unconstrained Vector Quantization technique. It is also called as Multistep, Residual or Cascaded Vector Quantization. Multistage Vector Quantization (MSVQ) technique preserves all the features of Unconstrained Vector Quantization technique while decreasing the computational complexity, memory requirements and spectral distortion. And Side Match Vector Quantization (SMVQ), In SMVQ Neighbor pixels within an image are similar unless there is an edge across. But the topic of our interest is Side Match Vector Quantization.

Keywords- SMVQ, MSVQ, TSVQ

I. INTRODUCTION

Image compression [5] is the application of data compression on digital images. Image compression is the process of encoding or converting an image file in such a way that it consumes less space than the original file. It is a type of compression technique that reduces the size of an image file without affecting or degrading its quality to a greater extent. Digital Image Compression compresses and reduces the size of images by use of various algorithms and standards. Two of the common Digital Image Compression Techniques [13] are lossless compression and lossy compression. The lossless compression technique, as the name indicates, produces no loss in the data of image. This technique is used in places where the quality and accuracy of image is extremely important and cannot be compromised. Some of the examples are technical drawings, medical images etc. Lossy compression technique is one which produces a minor loss of data to the output image. This minor loss is almost invisible and hard to identify. This technique use minor alteration or loss of quality, which causes no problem like photographs. There are different techniques used in lossless and lossy compression.

Digital Image Compression has numerous applications which range from image compression for personal use to compressing more crucial images like medical images. Digital Image Compression helps in saving a lot of memory space and hence is extensively satellite images used for compression of photographs, technical drawings, medical imaging, artworks, maps etc. The compressed images can be sent, uploaded or downloaded in much lesser time and thus it makes sharing of images lot easier.

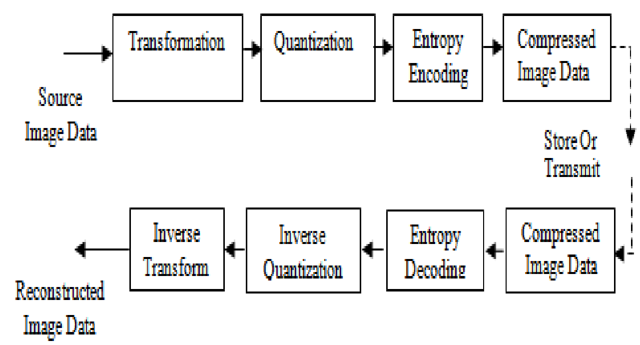

Fig.1 Compression & Decompression Process

II. COMPRESSION TECHNIQUES

Image compression techniques [5] are broadly classified into following categories:

1. Lossless image compression
2. Lossy image compression

A. Lossless Image Compression Techniques

The decompressed image is exact replica of the original image then compression is called lossless image compression [3], in which there is no information loss. Therefore lossless compression results in a compressed file that is identical to the original file. Lossless compression is used in applications where exact reproduction of original image is highly desirable. Lossless compression breaks up original files into smaller segments that can be stored for future use or transmission to remote location and by reassembling those segments original image file can be reproduced without any information loss. Some of the lossless compression techniques are following below [8, 9]:

1. Huffman Coding
2. Run length Coding
3. Arithmetic Coding
4. LZW Coding
5. Bit Plane Coding

B. Lossy Image Compression Techniques

The decompressed image is not exact match of the original image then compression is called lossy image compression [6]. Some image information is lost in lossy compression technique. Lossy compression can be used in applications where exact reproduction of original image is not much important but higher compression ratio is desirable. Lossy compression techniques give higher compression ratio (50:1) then lossless because of information loss. JPEG (Joint Photography Expert Group) is the best known lossy compression standard and widely used to compress still images stored on compact disc. Lossy compression is most commonly used to compress multimedia data such as audio, video, still images especially in applications such as streaming media and internet telephony. Some of the lossy compression techniques are:

1. Transformation Coding
2. Vector Quantization
3. Fractal Coding
4. Block Truncation Coding
5. Sub Band Coding

III. VECTOR QUANTIZATION TECHNIQUES

Quantization [7] refers to the process of approximating the continuous set of values in the image data with a finite set of small values. The input to a quantizer is the original data and the output is always the one among a finite number of levels. The quantizer is a function whose set of output values are discrete and usually finite. Obviously, this is a process of approximation and a good quantizer is the one which represents the original signal with minimum loss or distortion. There are two types of quantization: Scalar Quantization and Vector Quantization. In scalar quantization, each input symbol is treated separately in producing the output. Vector Quantization, each symbol is grouped into vectors (non-overlapping) and quantize each vector. The following are some of the vector quantization techniques are discussed in the forth coming sections.

1. Tree Structured Vector Quantization
2. Multistage Vector Quantization
3. Side Match Vector Quantization

A. Tree Structured Vector Quantization

Tree Structured Vector Quantization[12] is characterized by a k-dimensional codebook. The design and performance of the quantizer depends on the method that is used to extract the vectors. Tree Structured Vector Quantization technique is summarized as follows[11].

Step 1: Start with a set of training vectors $\{t_0\}_{n=1}^{N}$ and a single node vector R_0 as the root node.
Step 2: Compute the average of all training vectors in the training set.
Step 3: At level 0, R_0 is the centroid vector of all vectors in the training set. Each node vector Ri is used for the creation of subset of t_i .
Step 4: For next new level, a vector R_i is splitted into two intermediate node vectors and labeled as R_{2i+1}(left node) and R_{2i+2} (Right node). The above two vectors are considered to be the perturbation vectors.
Step 5: If a subset of training vector t_i is closer to the left node $R_{2i+1,}$ assign t_i as left node. Otherwise assign t_i `to the right node.
Step 6: Replace the intermediate node vectors R_{2i+1} and R_{2i+2} with the centroid of the new subsets V_{2i+1} andV_{2i+2} respectively.
Step 7: Group all the new (k+1) level node vectors and (k+1) level represent the leaf level of the tree.
Step 8: Compute the average distortion between the training vectors and the corresponding node vector by using Euclidean distance measure formula.
Step 9: If the total distortion is less than the threshold limit or the maximum codebook Size (2^L) is reached, stop the process. The leaf node vectors are treated as the code vectors in the codebook.

Otherwise continue the process until the maximum number of output level is reached. The threshold value can be selected arbitrarily to be a small value. Increasing the size of the codebook will increase the rate of quantizer. The quantized code vectors are encoded using encoding method.

B. Multi Stage Vector Quantization

MSVQ is a structured Vector Quantization which can achieve very low encoding and storage complexity[1].
Step 1 : Divide the encoding task into successive stages, where the first stage performs a relatively crude quantization of the input vector. Then a second-stage quantizer operates on the error vector between the original and the quantized first-stage output.

Step 2 : The quantized error vector then provides a second approximation to the original input vector thereby leading to a refined or more accurate representation of the input.
Step 3 : A third stage quantizer may then be used to quantize the second-stage error to provide a further refinement and so on.
Step 4 : The input vector is quantized by the initial or first stage vector quantizer denoted by VQ1 whose code book is $C_1 = \{ c_{10}, c_{11}, ...c_{1N}\}$ with size N1.
Step 5 : The quantized approximation $x1$ is then subtracted from x producing the error vector. This error vector is then applied to a second vector quantizer VQ2 whose code book is $C_2 = \{c_{20}, c_{21}, c_{2N})\ \}$ with size $N2$ yielding the quantized output.
Step 6 : The encoder transmits a pair of indices specifying the selected codeword for each stage and the task of the decoder is to perform two table lookups to generate and then sum the two code words.
Step 7 : The overall codeword or index is the concatenation of code words or indices chosen from each of two codebooks.

Thus, the equivalent product codebook can be generated from the Cartesian product $C1xC2$. Compared to the full-search VQ with the product codebook C, the two stage VQ can reduce the complexity from $N = N1 \times N2$ to $N1 + N2$.

C. Side Match Vector Quantization

In SMVQ, sender and receiver both have the same codebook with W codewords and each codeword of length is n2.
Step 1 : The original input image (I) sized M×N. Image I is divided into n×n non-overlapping blocks.
Step 2 : Mean square error is calculated for 2n-1 pixels of residual blocks X. Mean square error value is nothing but E*r*.
Step 3 : If the value of E*r* is greater than a pre-determined threshold T for, it implies that the current residual block X locates in a relatively complex region and it has less correlation with its neighboring blocks.
Step 4 : If Er ≤ T, it implies that the current residual block locates in a relatively smooth region and it has higher correlation with its neighboring blocks.
Step 5 : At the sender side, Vector Quantization is performed on topmost and leftmost blocks and SMVQ is applied on remaining blocks.
Step 6 : The residual blocks X are encoded progressively in raster scanning order.
The leftmost and topmost blocks are used to compress residual blocks are used to predict elements of residual block. At the receiver end, compressed code can be reconstructed to get decompressed input image.

IV. PERFORMANCE ANALYSIS

The performance of the Conventional TSVQ, MSVQ, and SMVQ are measured. The performance is assessed using the parameter PSNR(Peak Signal to Noise Ratio). In this experiment different set of images shown in Fig.2 are used as test images. The performance has been compared with the codebook size of 1024 with level5 decomposition and a bit rate of 0.125 bpp with sym8 wavelet function. The results are tabulated in Table 1.

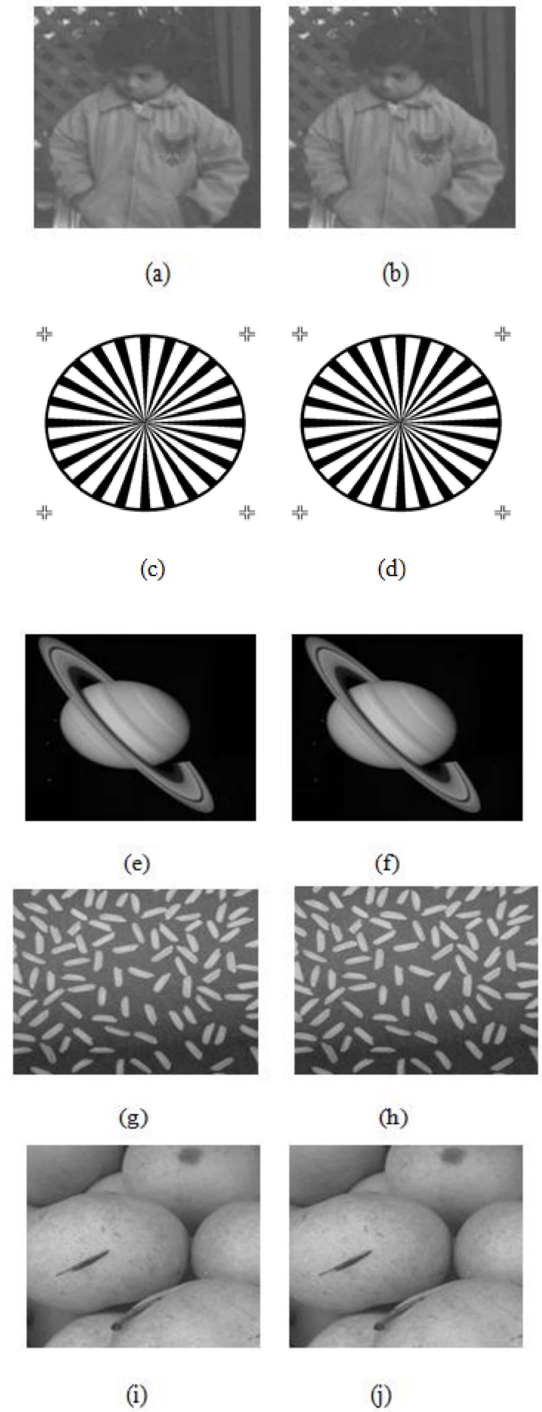

Fig.2 (a), (c), (e), (g), (i) Pout, Testpat1, Saturn, Rice, Pears. (b), (d), (f), (h), (j) Reconstructed images using different quantization techniques

Peak Signal To Noise Ratio (PSNR) And Mean Square Error (MSE):

Peak Signal-to-Noise ratio (PSNR) - The visual quality of the embedded images can also be measured using the peak signal-to-noise ratio.

The Peak Signal to Noise Ratio is defined as

$$PSNR = 10\log_{10}\left(\frac{L^2}{MSE}\right) \text{ dB}$$

Mean Square Error (MSE) - compares two images on pixel-by-pixel basis.

Where L is the maximum gray level of the image and

$$MSE = \sum_{i=1}^{M}\sum_{j=1}^{N}\left(\frac{o(i,j)-d(i,j)^2}{M*N}\right)$$

o (i,j) is the original image.
d (i,j) is the reconstructed image.
M and N are the dimensions of the image

Table 1: Performance Comparison of PSNR (in dB) for different Quantization Techniques

Images	Quantization Algorithms (With Symlet Wavelet, Decomposition Level=5 , bpp=0.125 CR=10:1) PSNR values in dB		
	TSVQ	MSVQ	SMVQ
Pout	34.56	36.84	37.24
Testpat1	34.65	36.89	36.95
Saturn	34.87	37.24	37.32
Rice	35.04	37.44	37.53
Pears	35.23	37.78	37.86

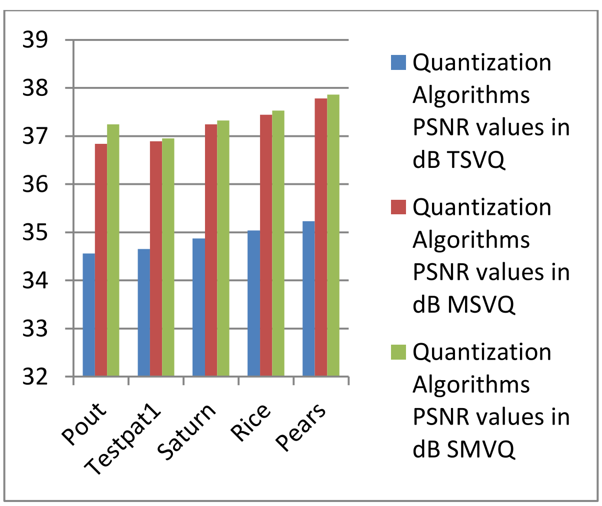

Fig.3 Analysis of various quantization techniques based on PSNR value

From the Table 1 is evident that, SMVQ yields a better quality reconstructed image when compared to other techniques.

Table 2: Performance Comparison of compression ratio for different Quantization Techniques

Images	Compression Ratio		
	TSVQ	MSVQ	SMVQ
Pout	15.62	12.54	9.54
Testpat1	18.65	16.89	10.95
Saturn	13.87	11.24	10.12
Rice	12.04	10.44	9.14
Pears	16.23	12.78	11.94

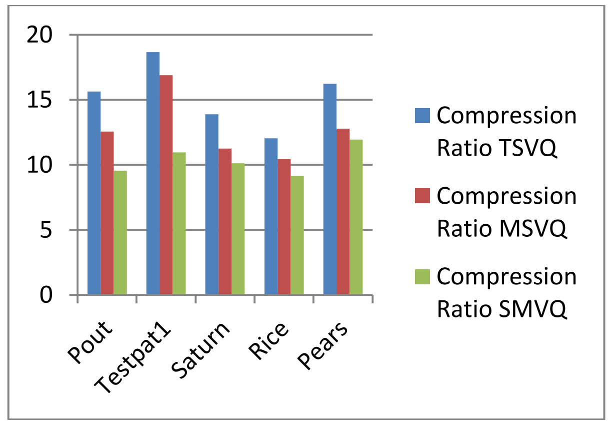

Fig.4 Analysis of various quantization techniques based on compression ratio

From the Table 2 is evident that, for higher compression ratios, the compression performance of SMVQ is superior to that of TSVQ and the visual quality of the reconstructed image is better.

IV. CONCLUSION

In this paper, various existing techniques are related to VQ technique have been discussed. Due to ease of implementation and better marked image quality, SMVQ gives a better powerful Compression. This paper discusses various techniques to improve the compress ratio and also improve the quality of the image. Combinations of various schemes can be done to get more efficient compressed image. The compress ratio and image quality can be improved by combining soft computing with image compression techniques.

REFERENCES

[1]. V.Krishna, Dr. V.P.C.Rao, P.Naresh, P. Rajyalakshmi,"Incorporation of DCT and MSVQ to Enhance Image Compression Ratio of an image" International Research

Journal of Engineering and Technology (IRJET), Volume: 03, Issue: 03 | Mar-2016.

[2]. Sarita S. Kamble, A.S. Deshpande,"Image Compression Based on Side Match Vector Quantization" International Journal of Engineering Science and Computing, Volume 6 ,Issue No. 5,ISSN 2321 3361 © May 2016.

[3]. Malwinder Kaur, Navdeep Kaur, "A Litreature Survey on Lossless Image Compression", International Journal of Advanced Research in Computer and Communication Engineering, Vol. 4, Issue 3, March 2015.

[4]. Chuan Qin, Chin-Chen Chang and Yi-Ping Chiu, "A Novel joint Data-Hiding and compression scheme based on SMVQ and Image Inpainting", *IEEE Trans. on Image Process.*, vol. 23, no. 3, pp. 969-978, March 2014.

[5]. Richa Goyal, Jasmeen Jaura, "A Review of Various Image Compression Techniques", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 4, Issue 7, July 2014.

[6]. Kaur M. and Kaur G. "A survey of lossless and lossy Image compression technique" International Journal of Advanced Research in Computer Science and Software Engineering Volume 3, Issue 2, February 2013.

[7]. Mukesh Mittal, Ruchika Lamba,"Image Compression Using Vector Quantization Algorithms: A Review" International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 6, June 2013.

[8]. Arup Kumar Bhattacharjee, Tanumon Bej, Saheb Agarwal, "Comparison Study of Lossless Data Compression Algorithms for Text Data", IOSR-JCE Volume 11, Issue 6, May-June 2013, pp 15-19.

[9]. Shruti Porwal, Yashi Chaudhary, Jitendra Joshi, Manish Jain, "Data Compression Methodologies for Lossless Data and Comparison between Algorithms", IJESIT Volume 2, Issue2, March 2013.

[10]. C.C.Chen and C. C. Chang, "High capacity SMVQ-based hiding scheme using adaptive index," Signal Process vol. 90, no. 7,pp. 2141–2149, 2010.

[11]. C.C.Chang, Y.C.Li, and J. B. Yeh, Fast codebook search algorithms based on tree-structured vector Quantization, Pattern Recognition Letters, vol. 27, no. 10, pp. 1077-1086, 2006.

[12]. S.Mitra, R.Shuyu Yang Kumar, B.Nutter. "An optimized Hybrid Vector Quantization for efficient source Encoding IEEE 2002, 45th Midwest Symposium, Vol. 2, 2002.

[13]. Subramanya A, "Image Compression Technique," Potentials IEEE, Vol. 20, Issue 1, pp 19-23, FebMarch 2001.

[14]. Z.M.Lu, J.S.Pan and S.H Sun, "Image Coding Based on classified side match vector quantization",IEICE Trans. Inf. & Sys. Vol. E83-D(12),Pp.2189-2192, Dec.2000.

Authors Profile

Mr.V.Cibi Castro is an active Researcher in the field of Image Compression .He has received his Masters in Engineering from Manonmaniam Sundaranar University, Tirunelveli, India in 2012. He is pursuing his Doctoral Degree from Manonmaniam Sundaranar University India. He has 3 years of teaching experience in M.S.University, India. He has published 2 articles in leading international journals. He has presented 2 International and 1 National conferences.

Mr. T.Arul Raj is an active Researcher in the field of Face Recognition. He has received Master of Philosophy from Manonmaniam Sundaranar University in year 2016. He is pursuing his Doctoral Degree from Manonmaniam Sundaranar University India. He has published 1 article in leading international journals. He has presented 1 International and 1 National conference.

Dr.T.Ilam Parithi currently working as a assistant professor, Department of Computer Science, MSU College, Puliyankudi. He has published 10 international journals and presented paper in both national and international conferences. His area of Interest is image & video Processing, IOT and machine learning.

Dr.R.Balasubramanian currently working as a Professor, Department of Computer Science and Engineering, Manonmaniam Sundaranar University, Tirunelveli, India. He has published more than 30 international journals and 2 national journals. He has presented more than 50 International and National conferences. He has published 8 books. His area of interest are Digital Image Processing, Data mining, Network security.