MSE based Algorithm for Vector Quantization using Walsh Sequence

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Abstract - The images are used as an important factor of communication on an effective scale. As Vector Quantization is an essential technique for lossy image compression and Codebook generation is an important aspect of the vector quantization. The MSE based algorithm for codebook generation give better quality of the image. This algorithm is used to take input image in bits and apply Walsh transform to input image to create codebook for Vector Quantization. The codebook generated will be more efficient for low frequency image. An overview on all existing codebook generation techniques and comparison made between proposed technique based on their different sizes like 64,128.These Algorithm is used for both greyscale and color image. The color image gives better image quality than greyscale image. The Mean square error (MSE) is calculated.

Keywords - *Image, Image Compression, Vector Quantization, Walsh, MSE, PSNR.*

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I. INTRODUCTION

An Image is a digitized engraving of storage and transmission through computer application.In today's technical world various applications are multimedia-based. These applications consists of images and videos which provides an effective tool for Education, Communication, Industrial Application, Entertainment, etc. and they need high channel of bandwidth for efficient transmission. What so ever bandwidth is available it is proven that after some period it becomes short. So the need for image compression arises for resourceful storage and transmission. Image compression addresses the problem of reducing the amount of data required to store and transmit a digital image. The data redundancies in coding, interpixel and psycho visual areas can be removed using compression. Compression methods remove these redundancies by reducing the number of bits representing the image. There are two types of compressing the image, lossy and lossless.

The original image can be reconstructed exactly in lossless image compression method while only some part of the original image can be recovered in lossy image compression technique. LZW coding, Huffman encoding and run length encoding are lossless image compression methods on the other hand transformation coding, vector quantization and fractal coding belongs to lossy image compression techniques [1].

The process of representing a large set of values using a much smaller set of values is called quantization. Image pixels are represented by codewords for vector quantization method. Output of quantization is generally much larger than the number of codewords used to represent image. There are different types of quantization in lossy compression applications. The set of inputs and outputs of a quantizer can be scalars or vectors. If the set of inputs and outputs are scalars they are called scalar quantizer and if they are vectors then called vector quantizer. In a scalar quantizer input received would be assigned a codeword, depending on the interval in which it falls. In vector quantization, a group of pixels are referred to as blocks and each block is represented by a vector. All the vectors, which are close to each other, can be represented by a single codevector.

II. LITERATURE SURVEY

A. New Clustering algorithm for Vector Quantization Using Hybrid Haar slant Error Vector

Sudeep Thepade and Vandana Mhaske proposed these in year 2015. In these research the error vector used to splitting the clusters in Vector Quantization. It is proposed to be prepared by using discrete Slant transform matrix and Haar matrix. The results show that proposed VQ codebook generation algorithm gives less MSE and less distortion as compared to KEVR, KEVRW which gives better image compression. Proposed algorithm has shown 4.76 % enhancement in the quality of compressed image as compared to KEVR [1].

B. A New Vector Quantization Clustering Algorithm

In these paper existing codebook generation algorithm like Pair wise Nearest Neighbor (PNN) algorithm and other codebook generation algorithm are discussed. The PNN algorithm derives a vector quantization codebook is a diminishingly small fraction of the time previously required, without sacrificing performance. In addition, the time needed to generate a codebook grows only like $O(N \log N)$ in training set size, and isIndependent of the number of code words desired. The proposed algorithm consist of the process of generating vector quantization code words from a training set is equivalent to the process of grouping the training set into "clusters," where each cluster is to be represented by a single code word. The Pair wise Nearest Neighbor (PNN) algorithm begins with a separate cluster for each vector in the training set and merges together two clusters at a time until the desired codebook size is achieved. The main usefulness of the PNN algorithm is as a fast alternative to the LBGalgorithm which allows vector quantization to be used in situations where it had previously been computationally prohibitive, such as in repetitive experimental work, or in situations with large training sets or codebooks[2].

C. Fast Search Algorithm for Vector Quantization

Data compression is the art of science of representing information in a compact form. Image compression can be achieved through quantization techniques, both scalar and vector. Vector Quantization (VQ) is a lossy data compression method based on the principle of block coding with high Compression Ratio (CR).One of the most serious problems for VQ is the high computational complexity of searching for the closest word in the codebook design and encoding phases.In these paper different fast search algorithms like Exhaustive Search, Partial distortion elimination search, Modified partial distortion elimination search are used to find the closest match from the codebook by rejecting many unlikely code words and thus saving a great deal of computation time. According to the experimental results, algorithms can significantly reduce the number of redundant code vectors, meaning the proposed algorithm is found efficient in both time and MSE.

After comparing the time for existing fast search algorithms, it was found that the new algorithm took very less time for the search compared to other algorithms. Better compression could be achieved & the speed can be increased if the proposed algorithm is implemented [3].

D. An Improved Image Compression method using LBG with DCT

This paper presents new algorithm based on discrete cosine transform and LBG algorithm for Vector quantization for image compression. Vector quantization is mainly divided into three parts i.e. Encoding process, Codebook design, Decoding process. In vector quantization generation of codebook is important so that the distortion between the original image and the reconstructed image is minimum.

In this paper proposed algorithm is based on LBG algorithm. In this algorithm the input image is divided into blocks or sub images and then DCT coefficients of blocks are calculated and quantized. Next step is generate a codebook using LBG in DCT domain. Applying LBG algorithm in the frequency domain reduces distortion in the reconstructed image. For each input vector a codeword is selected from the codebook. Index metrics indicates the corresponding block codeword. It is observed that the performance of new algorithm LBG using DCT is better than LBG.By using this algorithm improvement in the PSNR values as well as higher compression ratio is achieved. The proposed algorithm use different codebook sizes of 128, 256, 512 and 1024 to evaluate the performance of reconstructed image [4].

E. A Survey of VQ Codebook Generation

In this paper various techniques for codebook generation are discussed that include mean distance-ordered partial codebook search (MPS), enhance LBG (ELBG), neural network based techniques, genetic-based algorithms, principal component analysis (PCA) approaches, tabu search (TS) schemes, codeword displacement methods.ELBG, CNN-ART, ETSA, PNM and genetic-based algorithms are designed to overcome the local optimal problem and prevent the premature convergence. However, most of them need long runtime because candidate solutions must be fine-tuned by LBG [5].

III. CODEBOOK GENERATION ALGORITHM

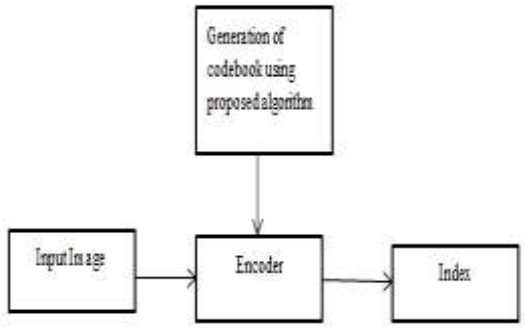
In this section proposed algorithm for codebook generation is discussed.

A. The Proposed Algorithm

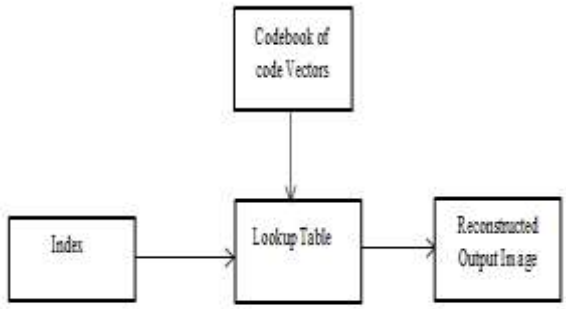
In this section, the basic concepts used in the proposed architecture are discussed. Vector Quantization is an effective and simple method for lossy image compression. Vector quantization (VQ) is also the process used for clustering of codevectors. Codebook generation is an important phase in Vector Quantization (VQ). The codebook is used to encode the image blocks for image compression. In addition to codebook generation vector quantization compression technique consists of two more phases: vector quantization encoding and vector quantization decoding. The encoding process finds a closest match codeword in the codebook for each image block. The index of this codeword is transmitted to decoder. In the vector quantization decoding phase, decoder replaces the index values with the respective codewords from the

codebook and produces the quantized image, called as reconstructed image.[6]

B. Block Diagram



Block diagram for Encoder using Vector Quantization



Block diagram for Decoder using Vector Quantization

Figure 1: The Block Diagram of Proposed System

III. IMPLEMENTATION

A. Walsh Transform

The Walsh matrix was proposed by Joseph L. Walsh in 1923.Each row of a Walsh matrix corresponds to a Walsh function.

The *natural ordered* Hadamard matrix is defined by the recursive formula below, and thesequencyordered Hadamard matrix is formed by rearranging the rows so that the number of sign-changes in a row is in increasing order. Confusingly, different sources refer to either matrix as the Walsh matrix.

The Walsh matrix (and Walsh functions) are used in computing the Walsh transform and have applications in the efficient implementation of certain signal processing operations.

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}_{4x4}$$

B. The Proposed MSE based codebook generation algorithm

Step 1: Image is divided into non overlapping blocks.

Step 2: Each block is converted into training vector of dimension k. Initially all vectors are considered to be in one cluster.

Step 3: Its centroid represents first code vector.

Step 4: Generate Walsh error vector.

Step 5: Then add and subtract all Haar sequence to the first code vector to generate two code vectors.

Step 6: To form the two clusters using Euclidean distance between the training vectors in the cluster and the code vectors.

Step 7: For newly generated centroids from first code vector MSE will calculated.

Step8: Centroids having minimum MSE will be considered for further processing.

Step 9: Repeat the steps from 5 to 8.

Step10: This process will continue as per the size of codebook.

C. Quality Measure

1. PSNR:PSNR is used to measure the quality of reconstruction of lossy and lossless compression (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 codecs, 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. PSNR is most easily defined via the mean squared error.PSNR is measured in decibel(dB)

$$PSNR=10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \quad \ldots\ldots (1)$$

2. MSE: The *Mean Square Error (MSE)* and the *Peak Signal to Noise Ratio (PSNR)* are the two error metrics used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error.

$$MSE=\frac{1}{MxN}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}[x(i,j)-y(i,j)]^2 \quad ..(2)$$

D. Example

In this section proposed method explained through small example.As taking input as image with their size like 4*4 size. Basically images are represented into pixel format. That means into 4*4 image total 16 pixel are given. Following matrix gives the pixel values of 4*4 image.

j[th]column

i[th] row →

$$\begin{bmatrix} 146 & 126 & 107 & 119 \\ 140 & 114 & 141 & 109 \\ 98 & 141 & 132 & 93 \\ 95 & 94 & 108 & 147 \end{bmatrix}$$

As above matrix is arrange into 2*2 block for generating codebook. Collection of pixels for generating codebook are generally known as codevector. So following matrix shows 2*2 block representation.

j[th]column

i[th] row →

146	126	107	119
140	114	141	109
98	141	132	93
95	94	108	147

First 2*2 block arrange into first vectors then second arrange into second vectors and so on.so all the pixels are arrange into code vectors with dimension k. And the value of k is always 4. Below matrix shows the vectors.

j[th]column

i[th] row →

$$\begin{bmatrix} 146 & 126 & 140 & 114 \\ 107 & 119 & 141 & 109 \\ 98 & 141 & 95 & 94 \\ 132 & 93 & 108 & 147 \end{bmatrix}$$

Now calculate the centroid or median from the above matrix.so it take summation of all columns and get 4 values that represent first codevector.

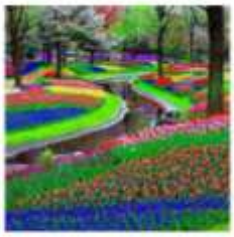
First codevector → 120.75 119.75 117.5 116

Next generate Walsh sequence then add and subtract all the Walsh sequence with above codevector to generate two separate code vectors. Using Euclidean distance two code vectors are generated. Then the Mean square error between training vector and codeword is computed and according to that these codevectors are split into two clusters. This procedure is repeated for new clusters as well till codebook of desired size is obtained.

IV. RESULT & DISCUSSION

In order to verify our proposed method, we need to carry out experiments on many standard images like Lena, cameraman, baboon, palace, pepper, lemon, BMW, bus, Ferrari, Landscape etc. of various dimensions as shown in Figure 2

Figure 2: The Sample Images

Original Image	Resultant Image Codebook Size 64	Resultant Image Codebook Size 128
		
Face	MSE=91.2931 PSNR=0.4858	MSE=70.4766 PSNR=1.4098
		
Ferrari	MSE= 79.0614 PSNR=0.5691	MSE=53.0413 PSNR=1.8483
		
Fruit dish	MSE=48.1279 PSNR=0.9657	MSE=35.1911 PSNR=3.2144
		
Landscape	MSE=143.0879 PSNR=0.2453	MSE=111.6807 PSNR=0.8217

CONCLUSION& FUTURE WORK

In this system, we introduced a new algorithm based on Mean Square Error(MSE).An overview on all existing codebook generation techniques and comparison made between proposed technique based on their different sizes like 64,128.Codebook generation using MSE approach is implement and compare with other algorithm it gives less MSE value. To overcome the heavy computational complexity of finding the closest codevector in the encoding phase in vector quantization, so we can used fast search algorithm.In the evaluation of this algorithm we examined the performances of the system. After comparing the time for existing algorithms, it was found that the new algorithm took very less time for the search compared to other algorithms.

There are many tasks on which further work can be extended.

1) New method of efficient codebook generation should be developed.
2)Search algorithm generation with respect to further reduction in search time can be developed.
3)Generation of efficient generalized codebook applicable to any image can be developed**.**

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