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A Novel Approach for Image Compression Using VHDL Simulation

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***Abstract*— with the reduction in bit rate for transmission and data storage by maintaining an acceptable image quality is referred to as image compression. Image compression has proven to be a vital technique for varied application such as television, transmission of printed material, transmission of remote sensing images produced from satellites.**

In this paper we are using an iterative algorithm called as linde buzo and gray algorithm. The basic requirement of LBG algorithm is generation of code books.LBG is based on minimization of squared error distortion measure. The technique that we have used here is computationally efficient, reduces significant time by avoiding the computation of unnecessary codebook.

***Index Terms*— Codebook generation, squared error distortion, computationally efficient**

I. INTRODUCTION

Fundamental goal of image compression is to reduce bit rate for transmission or data storage while maintaining an acceptable image quality[4]. Image compression reduces bit rate for transmission or data storage and also maintains acceptable fidelity or image quality.

Image compression scheme are broadly classified into two main types :-

1. Lossless image compression scheme: It can be defined as a scheme where image can easily reconstructed without loss of data. Image compression and decompression are identical to original image keeping every bit of information preserved. Reconstructed image is replica of original image. such technique is used for document and medical imaging.

2. Lossy image compression scheme: This technique on the other hand is reversible since it involves loss of data .this technique can be used for signal like natural speeches ..Due to the loss of data ,reconstructed image shows degradation because of the presence of small amount of redundancies. This scheme is further broadly classified as under:

   1. Scalar Quantization
   2. Vector Quantization

Vector quantization achieves more compression than scalar quantization ,making it useful for band limited channels.

Numerous compression techniques have been developed such as vector quantization, block truncation method , transform coding ,hybrid coding and various adaptive versions of this methods. Among these techniques, vector Quantization is widely used in image compression owing to its simple structure and low bit rate. Vector quantization is classical technique from signal processing and image compression which allows the modeling of probability density functions by the distribution of prototype vectors. It was originally used for data compression. It works by dividing a large set of points (Vectors) into groups having approximately the same number of points closest to them. Each group is represented by its centroid point, as in k-means and some other algorithms.

The density matching property of vector quantization is powerful, especially for identifying the density of large and high-dimensioned data. Since data points are represented by the index of their closest centroid, commonly occurring data have low error, and rare data high error. This is why VQ is suitable for lossy data compression. It can be used for lossy data correction and density estimation.

This methodology of vector quantization is based on the competitive learning paradigm, so it is related to the self-organizing map model. Vector quantization is used for lossy data compression, lossy data corrosion and density estimation [8]. The lossy data correction, prediction and compression are used to recover data missing from some dimensions. This is done by finding the nearest group with the data dimensions available by vector quantization and then predicting the result based on the values for the missing dimensions, assuming that they will have the same value as the group’s centroid.

Principle of vector quantization is to assist a project of continuous input space on a discrete output space, while minimizing the loss of information.

Vector quantization is also called as “Block Quantization” or “Pattern matching quantization” is often used in lossy image compression.

It works by encoding values from a multidimensional vector space into a finite set of values from a discrete subspace of lower dimension. The lower space vector requires less storage space, so the image can be easily compressed. Due to the Density matching property of vector quantization, the compressed data have errors that are inversely proportional to their density.

In the process of vector Quantization the image to be encoded is segmented into a set of input image vectors. The most important task for the VQ scheme is to design a good codebook. A good codebook is required because the reconstructed image highly depends on the codewords in this very codebook. The generated codebook store into text file for vhdl file handling or data array in vhdl code.

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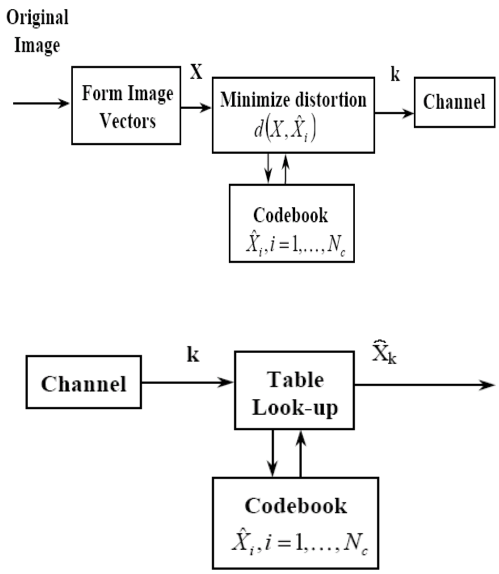


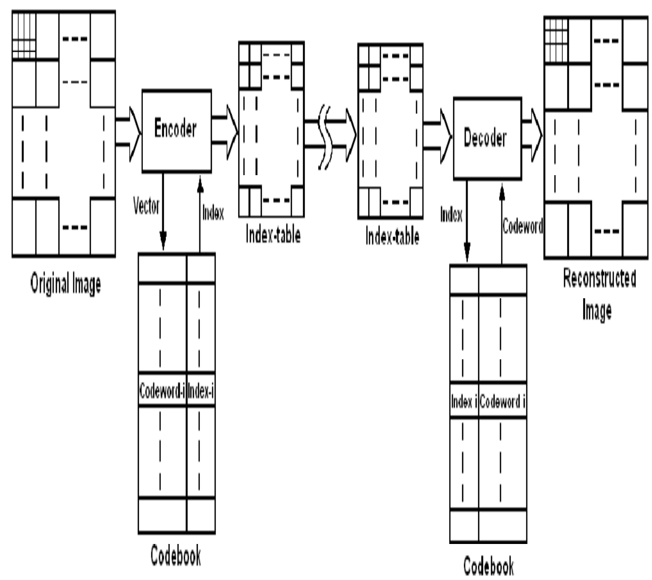
II. ALGORITHM

- LBG algorithm

This algorithm is the most cited and widely used algorithm on designing the VQ code book. It is based on minimization of the squared error distortion measure in 1980 linde buzo and gray proposed the VQ scheme for gray scale image compression and it has proven to be an excellent tool for both speech and digital image compression. The initial codebooks are chosen at random for the different training sets. These training sets may also produce bad codebooks.

Due to the bad codebook initialization, it always converges to the nearest local minimum. This problem is called the local optimal problem. In addition, it is observed that the time required to complete the iterations depends upon how good the initial codebook is. In literature, several initialization techniques have been reported for obtaining a better local minimum. The concept of VQ is based on Shannon‟s rate-distortion theory where it says that the better compression is always achievable by encoding sequences of input samples rather than the input samples one by one. In VQ based image compression, initially image is decomposed into nonover lap-ping sub image blocks. Each sub block is then converted into one-dimension vector which is termed as training vector. From all these training vectors, a set of representative vectors are selected to represent the entire set of training vectors [5]. As stated earlier, the VQ process is done in the following three steps namely (i) codebook design, (ii) encoding process and (iii) decoding process.

An initial code vector is set as average of entire training sequence is later on split to provide 2 code vectors. These are further split to double themselves and the process is repeated to procure the desired number. An identical codebook previously generated is required in both the encoding procedure and the decoding procedure in VQ scheme. In the process of vector quantization, the image to be encoded is segmented into set of input image vectors. In the encoding procedure, the closest codeword for each input vector is chosen, and its index is transmitted to the receiver. In the decoding procedure, a simple table look- up procedure is done to reconstruct the encoded image in the receiver. Thus, the encoded image of the original input image becomes available to the receiver. The whole compression process is accomplished when the encoded image is reconstructed with the corresponding index of each input image vector. codebook design process, each codeword of the codebook is assigned a unique index value. Then, in the encoding process, any arbitrary vector corresponding to a block from the image under consideration is replaced by the index of the most appropriate representative codeword. The matching is done based on the computation of minimum squared Euclidean distance between the input training vector and the codeword from the codebook. So after encoding process, an index table is produced. The codebook and the index-table is nothing but the compressed form of the input image. In decoding process, the codebook which is available at the receiver end too, is employed to translate the index back to its corresponding codeword. This decoding process is simple and straight forward(6). Figure 2 shows the schematic diagram of VQ encoding-decoding process.



The flowchart of LBG Algorithm is as given under,(7)

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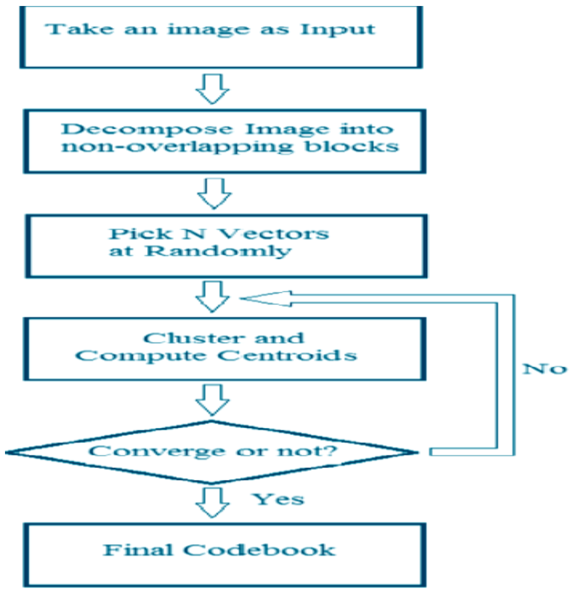

III. PROPOSED TECHNIQUE

The basic requirement for the proposed technique is the LBG algorithm in order to start LBG initial codebook is needed. The image is decomposed into non overlapping sub image block are termed as vectors. The single representative image vector is called as codeword or code vector. The set of representative image vector is called as codebook.

After the codebook design process, each codeword of the codebook is assigned a new unique index value. Then in the encoding process, any arbitrary vector corresponding to a block from the image under consideration is replaced by the index of the most appropriate representative codeword. The matching is done based on computation of minimum squared Euclidean distance between the i/p training vector and the codeword from the codebook. So after encoding process an index table is produced.

The codebook and index table is nothing but the compressed form of the input image. In decoding process, the codebook which is available at the receiver end too, is employed to translate the index back to its corresponding codeword. Decoding process is simple and straight forward.

LBG has 3 simple steps:

1) Codebook Design :

- **Step 1.** Decompose image into non-overlapping sub-image blocks. Also termed as 'vectors'
- **Step 2.** A Representative image subblock is selected to represent the entire set of image blocks.
- **Step 3.** Set of representative image vectors are c/a as 'Codebook' and representative image vectors are 'code vectors' or 'codeword's'

2) Encoding

- **Step 1.** Take a gray image as input.
- **Step 2.** Decompose the obtained reduced image from step 1 into non-overlapping blocks of size n x n pixels and convert each block into vector.
- **Step 3.** Collect the vectors from step 2 and use them as an initial codebook for VQ process.
- **Step 4.** Improve the initial codebook into an improved one through several iterative process.
- **Step 5.** Store or transmit the codebook and the index table as a compressed file of the input

3) Decoding

- **Step 1.** Perform VQ decoding using the index-table and the codebook to reconstruct the approximate image to the original image.
- **Step 2.** The reconstructed image is replica of original image (6).

Related computation is performed using MATLAB 7.11.0 We use MATLAB based image processing toolbox for generation of codebook. Since, the performance of the LBG algorithm is extremely dependent on the selection of the initial codebook. The initial codebook is chosen at random from the training data set. It is also seen that there might be the generation of poor quality codebooks. Generated codebook is stored into text file for VHDL file handling or data array in VHDL Code. Input is accepted only in the form of gray images which is further read in the MATLAB and stored into text file for VHDL file handling.

IV. EVALUATION PARAMETERS

The technique works on the gray scale image and the nature of the code will be non synthesis. For VHDL file handling, input is provided in the form of image. The algorithm can be evaluated in terms of compression Ratio (CR), mean square error (MSE) and peak signal to noise ratio (PSNR).Compression ratio is defined as ratio of the number of bits required to represent the data before compression to the number of bits required after compression. (12) Mathematically,

$$\text{Compression ratio}(\%) = \frac{\text{No of bits required before compression}}{\text{No of bits required after compression}}$$

Peak signal to noise ratio(PSNR) is defined as ratio of square the peak value of the signal to the mean square error. Where, mean square error refers to the average value of the square of the error between the original image f (m,n) and the reconstruction image g(m,n). A common measure of distortion is the mean square error (MSE). (12) Mathematically,

$$MSE = \frac{1}{M \times N} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} (f(m,n) - g(m,n)^2$$

$M \times N$ represents the size of the image.

The distortion in the decoded images is measured using peak signal to noise ratio, (12)

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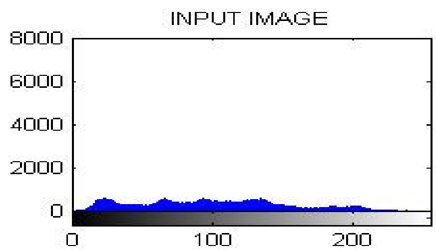
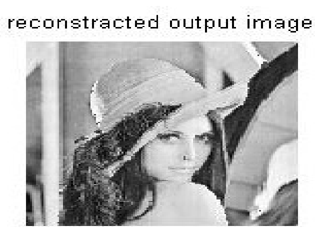
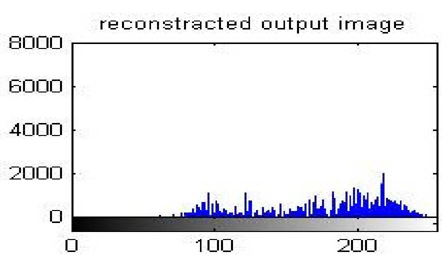
$$PSNR = 10\log_{10}\left(\frac{255^2}{\frac{1}{MXN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}\left(f(m,n)-g(m,n)\right)^2}\right)$$

V. RESULTS







EVALUATION PARAMETERS

Image	Codebook Size	Bit Used	PSNR	MSE	CR
Leena	128	7	46.806	1.369	4:1

APPLICATION

Image compression has proven to be an excellent technique for image archieving, image transmission, transmission of printed materials, transmission of remote sensing images produced from satellites.

CONCLUSION

The Most vital requirement for uncompressed image to be transferred at certain destination requires very high bandwidth. The quality of reconstructed image mainly depends upon the level of decomposition and the size of the codebook.
More the size of codebook better will be the quality of image.
The proposed algorithm reduces the computation cost and time. Reduction can also be achieved by avoiding computation of unnecessary codeword's.

FUTURE SCOPE

1. The LBG algorithm has local optimal problem where the utility of each codeword in the codebook is low.
2. There is local minimum distortion but no global minimum distortion. It always converges to nearest local minimum.
3. The future enhancement primarily focuses on developing VQ algorithm that ensures less storage space, less transfer time and less image viewing and loading time.

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