www.ijecs.in
International Journal Of Engineering And Computer Science ISSN: 2319-7242
Volume 6 Issue 1 Jan. 2017, Page No. 19999-20002
Index Copernicus Value (2015): 58.10, DOI: 10.18535/ijecs/v6i1.28

Image Compression Using Huffman Coding

Nehal Markandeya, Prof.Dr.Sonali Patil
Department of Computer Engineering
Pimpri Chinchwad College of Engineering
Pune-44
Email: markandeya.nehal@gmail.com
Department of Computer Engineering
Pimpri Chinchwad College of Engineering
Pune-44
Email: sonalimpatil@gmail.com

***Abstract*— Image can be represented with minimum number of bits by using image compression. When images are transferred over the network it requires space for storage and time to transmit image. The present work investigates image compression using block truncation coding. Three algorithms were selected namely, the original block truncation coding (BTC), Absolute Moment block truncation coding (AMBTC) and Huffman coding and a comparison was performed between these. Block truncation coding (BTC) and Absolute Moment block truncation coding (AMBTC) techniques rely on applying divided image into non overlapping blocks. They differ in the way of selecting the quantization level in order to remove redundancy. In Huffman coding an input image is split into equal rows & columns and at final stage sum of all individual compressed images which not only provide better result but also the information content will be kept secure. It has been show that the image compression using Huffman coding provides better image quality than image compression using BTC and AMBTC. Moreover, the Huffman coding is quite faster compared to BTC.**

***Keywords*— Image compression, Block truncation coding, Absolute moment block trunication coding, Huffman coding.**

I. INTRODUCTION

A good Image will be analysed in terms of better picture quality parameters along with memory space requirement which is very important for an image analysis. Image compression is one very important application of Digital Image Processing. The aim of image compression is to remove unwanted information from image so that it can be able to transmit or store data in an efficient form. Compression basically means removing unwanted information from image which only lead to the enhancement of memory space requirement without affecting quality of image.

The field of image compression continues to grow at a rapid pace. As we look to the future, the need to store and transmit images will only continue to increase faster than the available capability to process all the data. Image compression involves reducing the size of image data files, while retaining necessary information. Retaining necessary information depends upon the application. Image segmentation methods, which are primarily a data reduction process, can be used for compression. The reduced file created by the compression process is called the compressed file and is used to reconstruct the image, resulting in the decompressed image.

The original image, before any compression is performed, is called the uncompressed image file. The ratio of the original, uncompressed image file and the compressed file is referred to as the compression ratio.

II. LITERATURE SURVEY

In the paper [1], Rachit Patel, Virendra kumar, vaibhav tyagi, vishal asthana proposed that Image Compression using Huffman coding technique is simpler & easiest compression technique. Compression of image is an important task as its implementation is easy and obtains less memory. The purpose of this paper is to analyse Huffman coding technique which is basically used to remove the redundant bits in data by analysing different characteristics or specification like Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) Bits Per Pixel (BPP) and Compression Ratio (CR) for the various input image of different size and the new method of splitting an input image into equal rows & columns and at final stage sum of all individual compressed images which not only provide better result but also the information content will be kept secure. An image compression technique has various advantages in the field of image analysis and also for the security purpose for the image[3].

In the paper [2], Christian L. F. Corniaux, Hossein Ghodosi proposed that Secret sharing is a technique that can distribute partial secret information (also called ‘shares’) to a specific group member. These individual shares are of no use on their own, but they can reconstruct the original secret information when the members collect all of the shares. In this paper, we proposed a novel, polynomial-based, secret sharing scheme using the absolute moment block truncation coding technique block truncation coding (AMBTC) compression technique. By using simple, exclusive-OR operations, the group embers can easily recover the secret image with 100% correctness. Experimental results demonstrated that the AMBTC compressed image in our scheme had the same quality as the original AMBTC scheme, but the compression ratio in our scheme was better than that of the original AMBTC scheme.

In the paper [3], Doaa Mohammed, Fatma Abou-Chadi proposed that the present work investigates image compression using block truncation coding. Two algorithms were selected namely, the original block truncation coding (BTC) and Absolute Moment block truncation coding (AMBTC) and a comparative study was performed. Both of two techniques rely on applying divided image into non overlapping blocks. They differ in the way of selecting the quantization level in order to remove redundancy. Objectives measures were used to evaluate the image quality such as: Peak Signal to Noise Ratio (PSNR),Weighted Peak Signal to Noise Ratio (WPSNR), Bit Rate (BR) and Structural Similarity Index (SSIM).The results have shown that the ATBTC algorithm outperforms the BTC. It has been show that the image compression using AMBTC provides better image quality than image compression using BTC at the same bit rate. Moreover, the AMBTC is quite faster compared to BTC[4] .

III. ALGORITHM OF BLOCK TRUNCATION CODING

Block truncation coding is a type of lossy compression technique for images having gray scale. In BTC the effort required for computation is less as compare to the other compression techniques and also it reduces the channel error. Quantization process in BTC preserves the moment for block pixels, which makes the quality of image acceptable and also it reduces the demand for the storage space.

Step1: The image is split into rectangle shape regions which don't overlap with each other. To make it simple, blocks were made in square region with size n*n

Step 2: Each Pixel in block is represented by two values i.e mean $\bar{y}$ and standard deviation σ. These values are called as luminance value. Luminance values are selected for two level quantizer.

$$\bar{y} = \frac{1}{\mathrm{m}} \sum_{\mathrm{j}=1}^{\mathrm{m}} y_j \qquad (1)$$

$$\sigma = \frac{\sqrt{1}}{\sqrt{\mathrm{m}}} \sum_{\mathrm{j}=1}^{\mathrm{m}} (y_j - \bar{y_j})^2 \qquad (2)$$

y_{j} = jth Pixel value of the image block.

m= total number of the pixels in that block.

Step3: The Luminance value i.e mean and standard deviation are quantizers of BTC. To form two level bit plane, each pixel value y_j compared with the mean $\bar{y}$ which is used as threshold value. If the pixel's gray level value is greater than or equal to $\bar{y}$ then it can be represented as 1 and If the pixel's gray level value is less than to $\bar{y}$ then it can be represented as 0.

$$\mathrm{D} = \begin{cases} 1 & y_j \geq \bar{y} \\ 0 & y_j < \bar{y} \end{cases} \qquad (3)$$

D = binary block

Step 4: In this step the 1's in the bit plane are replaced with HV and '0's in the bit plane are replaced with LV

$$HV = \bar{y} + \sigma \frac{\sqrt{\mathrm{s}}}{\sqrt{\mathrm{t}}} \qquad (4)$$

$$LV = \bar{y} - \sigma \frac{\sqrt{\mathrm{s}}}{\sqrt{\mathrm{t}}} \qquad (5)$$

s = number of '0's in compressed bit plane

t = number of '1's in compressed bit plane

IV. ALGORITHM OF ABSOLUTE MOMENT BLOCK TRUNCATION CODING

Step 1: The image is split into blocks, these blocks are non-overlap blocks.The size of a block could be (4 x 4) or (8 x 8), etc.

Step 2: Calculate the average gray level of the block (4x4) as shown in equation (6)

Step3: In this step Pixel are classified in such a way that there will be two ranges of values i.e upper range values and lower range values. Pixel whose value is greater than $\bar{y}$ are the upper range values and pixel whose value is less than $\bar{y}$ are lower range, then mean of higher range values y_{HV} and lower range values y_{LV} are calculated.

$$y_{HV} = \frac{1}{\mathrm{K}} \sum_{y_j > \bar{y}_j}^{\mathrm{m}} y_j \qquad (6)$$

$$y_{LV} = \frac{1}{16 - \mathrm{K}} \sum_{y_j < \bar{y}_j}^{\mathrm{m}} y_j \qquad (7)$$

K = number of pixels whose gray level value is greater than $\bar{y}$

Step 4: If the pixel's gray level value is greater than or equal to $\bar{y}$ then it can be represented as 1 and If the pixel's gray level value is less than to $\bar{y}$ then it can be represented as 0.In encoding process y_{HV} , y_{LV} are written.

$$\mathrm{D} = \begin{cases} 1 & y_j \geq \bar{y} \\ 0 & y_j < \bar{y} \end{cases} \qquad (8)$$

D = binary block

Step 5: The 1's in the bit plane are replaced with y_{HV} and '0's in the bit plane are replaced with y_{LV} to reconstruct the image block. AMBTC and BTC both requires 16 bits to code bit plane. Computation required by AMBTC is less than BTC.

$$y = \begin{cases} y_{LV} & D = 0 \\ y_{HV} & D = 1 \end{cases} \qquad (9)$$

V. ALGORITHM OF HUFFMAN CODING

The image compression techniques are categorized into two main classifications namely Lossy compression techniques and Lossless compression techniques.

1] Lossless compression:

A technique in which the compressed image is reconstructed without any loss of data is called lossless compression. Lossless compression ratio gives good quality of compressed images, but yields only less compression.

2] Lossy compression:

A technique in which the compressed image is reconstructed with loss of data is called lossy compression. The lossy compression techniques lead to loss of data with higher compression ratio.

Huffman coding is loss less technique with more attractive features in various application such as medical survey and analysis, technical drawing etc. Huffman coding has better characteristics of image compression. As we know that huffman coding algorithm is a step by step process and involves the variable length codes to input characters & it is helpful in finding the entropy and probability of the state[3]. It is very easy to calculate quality parameter in Huffman algorithm. Original image can be reconstructed with the help of digital image restoration[1].

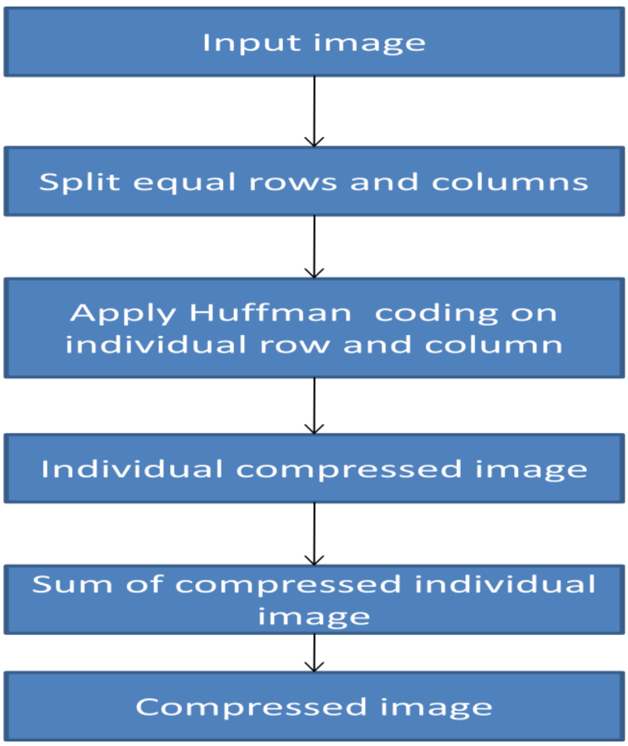

Fig. 1 Block diagram of Huffman compression

- Analysis of Huffman coding algorithm

This matrix represent digital image N x N. These matrix arrays given in matrix are the elements of image.

$$f(x,y) = \begin{matrix} b_{0,0} & b_{0,1} \dots\dots & b_{0,M-1} \\ b_{1,0} & b_{1,1} \dots\dots & b_{1,M-1} \\ b_{M-1,0} & b_{M-1,1} \dots\dots & b_{M-1,M-1} \end{matrix}$$

This digital image f(x, y) is break into a set of non-overlapping four sub images i.e two row and two column this can be represented as

f(x, y) which is a digital image is divided into four small images. These small images is also called as non-overlapping sub images.

$$f(x,y) = \begin{bmatrix} f_1(x,y) & f_2(x,y) \\ f_3(x,y) & f_4(x,y) \end{bmatrix}$$

These $f_1(x,y)$, $f_2(x,y)$, $f_3(x,y)$, $f_4(x,y)$ are the sub-matrix of original image after applying Huffman coding on these sub-matrix they gives

f_1` (x, y) $f_2$`(x, y) f_3`(x, y), $f_4$`(x, y) respectively the compressed image can be obtain by adding these matrixes.

VI. COMPRATIVE STUDY

Compression technique / parameter	Block truncation coding	Absolute moment block truncation coding	Huffman coding
Lossy/ Lossless	Lossy image	Lossy image	Losseless
Image quality	Good	Better than BTC	Better(high PSNR)
Time complexity	High	Low	High
Speed	Slow	Fast	Fast
Cost	High	Low	Low
Coding and decoding process	Slow	Fast	Fast
BR	1.25	1.25	1.09

VII. IMAGE QUALITY PARAMETER

There are four major important parameters measure between uncompressed image and compressed image [3], these are following-

A. Compression ratio (CR)

Compression ratio is used to measure the compression efficiency. Compression ratio is the ratio of original image and compressed image. As compression ratio increases the image quality increases.

CR=Size of original image/Size of compressed image.

DOI: 10.18535/ijecs/v6i1.28

B. Bit Rate:

It is information (bits) stored per pixel of an image. This is ratio of number of bits in the compressed image to total number of pixel in original image.

Number of bits per pixel required by the compressed image.

BR= (b/CR)

b= No. of bits per pixel.

When bit rate is large it means large memory required to store an image. High bit rate indicate that image acquire more colours so bit rate should be less.

C. The Mean Squared Error(MSE):

The difference between original image data and compressed image data is called mean square error (MSE). MSE is inversely proportional to PSNR, as MSE decreases the PSNR increases. PSNR indicate quality of image. Image compression is lossless when MSE is zero. Its better to have less MSE

D. Peak Signal to noise Ratio(PSNR):

PSNR is the ratio between maximum signal powers to noise appear in signal. PSNR is related to quality of image. For good quality of image the PSNR of image should be high. PSNR is depends upon the mean square error(MSE)of image. When the difference between the original image and compressed is less the PSNR is high so eventually the quality of image is also high.

$$\mathrm{PSNR} = 10\log\frac{MAX^2}{\mathrm{MSE}}$$

VIII. CONCLUSION

Image compression plays vital role in saving memory storage space and saving time while transmission images over network. Compression technique increase storage capability and transmission speed.Using compression coding techniques the shares size in image secret sharing is reduced. By using Huffman coding the image is compressed by 40%. Huffman algorithm is comparatively easier because of its simpler mathematical calculation in order to find the various parameters than BTC and AMBTC. Image compression plays vital role in saving memory storage space and saving time while transmission images over network. Compression technique increase storage capability and transmission speed.

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