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Research Article

Image Compression through DCT and Huffman Coding Technique

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Abstract

Image compression is an art used to reduce the size of a particular image. The goal of image compression is to eliminate the redundancy in a file's code in order to reduce its size. It is useful in reducing the image storage space and in reducing the time needed to transmit the image. Image compression is more significant for reducing data redundancy for save more memory and transmission bandwidth. An efficient compression technique has been proposed which combines DCT and Huffman coding technique. This technique proposed due to its Lossless property, means using this the probability of loss the information is lowest. Result shows that high compression rates are achieved and visually negligible difference between compressed images and original images.

Keywords: *Huffman coding, Huffman decoding, JPEG, TIFF, DCT, PSNR, MSE*

1. Introduction

Image compression is a technique in which large amount of disk space is required for the raw images which seems to be a very big disadvantage during transmission and storage. With increase in technology an efficient technique for image compression is needed. Even though there are so many compression techniques which is present already, but the need for better compression technique is required which is faster, memory efficient and simply suits the requirements of the user. To analyze the parameters of image compression Peak Signal to noise ratio and compression ratio is an important parameters it gives synthetic performance of the compression of images. Image is a 2 Dimensional signal represented by Digital system. Normally Image taken from the camera is in the analog form. However for processing, transmitting and storage, images are converted in to digital form. A Digital Image is basically two Dimensional arrays of pixels. Basically compressing an image is different from compressing digital data. Data compression algorithm which is generally used for Image compression but it gives us result which is less than optimal. In remote sensing, bio medical and video processing techniques different types of images are used which require compression for transmission and storage. Compression is achieved by removing redundancy or extra bits from the image. There are numerous data compression algorithm which can be considered as universal number of universal compression algorithms that can compress almost any kind of data. These are the lossless methods they retain all the information of the compressed data.

However, they do not take advantage of the 2-dimensional nature of the image data. Images have certain statistical properties, which can be exploited by encoders especially designed for them. Also, for the sake of saving a little more storage space and bandwidth some of the finer details in the image can be sacrificed. In this paper, a new technique to achieve image compression algorithm is proposed that combines a DCT transform and Huffman coding. Huffman coding is a well - known algorithm for generating minimum redundancy codes as compared to other algorithms. The Huffman coding has effectively used in text, image and video compression. The DCT transform is not new to image coding problems, some approaches based on DCT transforms have been recently reported in literature. The synergy of DCT is for better tackle the problem has been proposed. The method is shown to efficiently encode images in terms of high peak signal to noise ratio (PSNR) values.

2. Image Compression Techniques

The image compression techniques are broadly classified into two categories depending whether or not an exact replica of the original image could be reconstructed using the compressed image.
These are:

1. Lossless technique
2. Lossy technique

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2.1 Lossless compression technique

In lossless compression techniques, the original image can be perfectly recovered from the compressed (encoded) image. These are also called noiseless since they do not add noise to the signal (image).It is also known as entropy coding since it use statistics/decomposition techniques to eliminate/minimize redundancy. Lossless compression is used only for a few applications with stringent requirements such as medical imaging. Following techniques are included in lossless compression:

1. Run length encoding
2. Huffman encoding
3. LZW coding
4. Area coding

2.1.1 Run Length Encoding technique

This is a very simple compression method used for sequential data. It is very useful in case of repetitive data. This technique replaces sequences of identical symbols (pixels), called runs by shorter symbols.

2.1.2 Huffman Encoding

This is a general technique for coding symbols based on their statistical occurrence frequencies (probabilities). The pixels in the image are treated as symbols. The symbols that occur more frequently are assigned a smaller number of bits, while the symbols that occur less frequently are assigned a relatively larger number of bits. Huffman code is a prefix code. This means that the (binary) code of any symbol is not the prefix of the code of any other symbol

2.1.3 LZW Coding

LZW (Lempel- Ziv- Welch) is a dictionary based coding. Dictionary based coding can be static or dynamic. In static dictionary coding, dictionary is fixed during the encoding and decoding process. In dynamic dictionary coding, the dictionary is updated on fly. LZW is widely used in computer industry and is implemented as compress command on UNIX.

2.1.4 Area Coding

Area coding is an enhanced form of run length coding, reflecting the two dimensional character of images. This is a significant advance over the other lossless methods. For coding an image it does not make too much sense to interpret it as a sequential stream, as it is in fact an array of sequences, building up a two dimensional object. The algorithms for area coding try to find rectangular regions with the same characteristics. This type of coding can be highly effective but it bears the problem of a nonlinear method, which cannot be implemented in hardware.

3. Huffman Algorithm

This coding technique is basically based on frequency of occurrence of a data item. The principle behind this technique is to use lower number of bits to encode the data that occurs more frequently. A Huffman code dictionary, which associates each data symbol with a code-word, has the property that no code-word in the dictionary is a prefix of any other code-word in the dictionary. The basis for this coding is a code tree according to Huffman, which assigns short code words to symbols frequently used and long code words to symbols rarely used for both DC and AC coefficients, each symbol is encoded with a variable-length code.

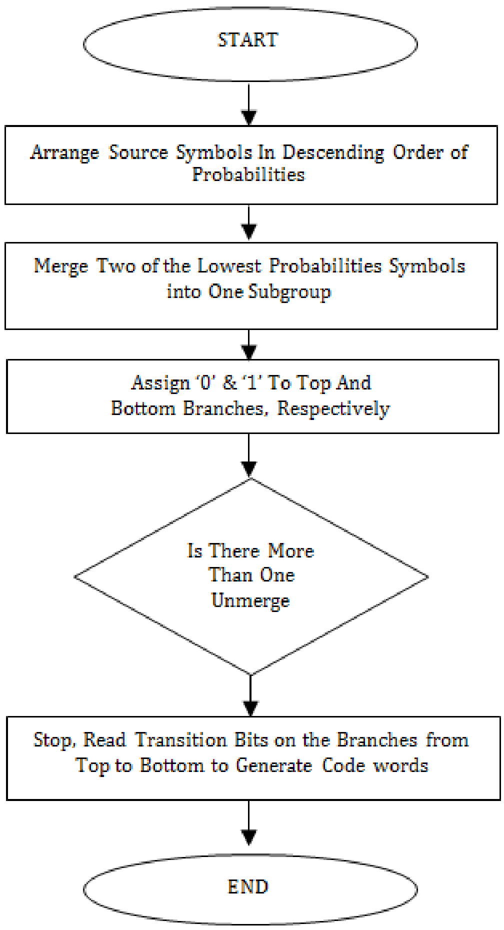

Figure 2(a) Flowchart of Huffman Algorithm

3.1 Huffman Coding

The Huffman encoding algorithm starts by constructing a list of all the alphabet symbols in descending order of their probabilities. It then constructs, from the bottom up, a binary tree with a symbol at every leaf. This is done in steps, where at each step two symbols with the smallest probabilities are selected, added to the top of the partial tree, deleted from the list, and replaced with an auxiliary symbol representing the two original symbols. When the list is reduced to just one auxiliary symbol (representing the entire alphabet), the tree is complete. The tree is then traversed to determine the code-words of the symbols.

3.2. Huffman Decoding

Before starting the compression of a data file, the compressor (encoder) has to determine the codes. It does that based on the probabilities (or frequencies of occurrence) of the symbols. The probabilities or frequencies have to be written, as side information, on the output, so that any Huffman decoder will be able to decompress the data. This is easy, because the frequencies are integers and the probabilities can be written as scaled integers. It normally adds just a few hundred bytes to the output. It is also possible to write the variable-length codes themselves on the output, but this may be awkward, because the codes have different sizes. It is also possible to write the Huffman tree on the output, but this may require more space than just the frequencies. In any case, the decoder must know what is at the start of the compressed file, read it, and construct the Huffman tree for the alphabet. Only then can it read and decode the rest of its input. The algorithm for decoding is simple. Start at the root and read the first bit off the input (the compressed file). If it is zero, follow the bottom edge of the tree; if it is one, follow the top edge. Read the next bit and move another edge toward the leaves of the tree. When the decoder arrives at a leaf, it finds there the original, uncompressed symbol, and that code is emitted by the decoder. The process starts again at the root with the next bit. Decoding a Huffman-compressed file by sliding down the code tree for each symbol is conceptually simple, but slow. The compressed file has to be read bit by bit and the decoder has to advance a node in the code tree for each bit.

4. Discrete Cosine Transform

Transformation of image is necessary in the field of image processing. Discrete cosine transform (DCT) can be used at feature extraction, filtering, image compression and signal processing. There a lot of transforms different from DCT as Karhunen-Loeve transform (KLT), Discrete Fourier transforms (DFT), and Hadamard transform and Slant transform. DCT has more efficient feature on energy compaction than DFT. DCT has also less complex calculation than KLT and DCT has good energy compaction feature as KLT. DCT converts an image to spatial domain into a frequency domain.

5. Proposed Algorithm

Algorithm for compression of image using Huffman techniques with Discrete Cosine Transform has been proposed in this section. The algorithm of the proposed method is:

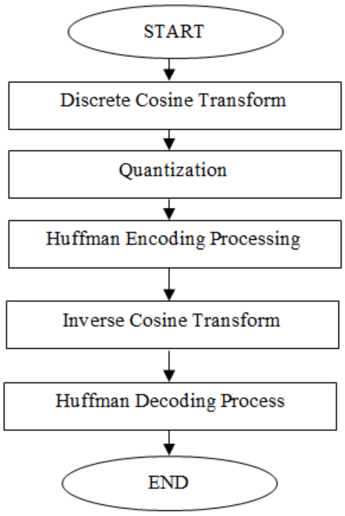

Figure 3(a) Flowchart of Huffman Algorithm

5.1. Simulation Parameters

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. MATLAB stands for matrix laboratory, and was written originally to provide easy access to matrix software developed by LINPACK (linear system package) and EISPACK (Eigen system package) projects. MATLAB is therefore built on a foundation of sophisticated matrix software in which the basic element is array that does not require pre dimensioning which to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of time.

6. Result and Discussions

In this paper MATLAB Simulator has been used to evaluate the performance of Huffman coding technique in the field of image compression behalf of compression parameters. The proposed algorithm has been applied on the different images having TIFF and JPEG format.

Figure 4(a) cameraman original image

Figure 4(b) cameraman compressed image

Figure 4(a) shows cameraman original image in TIFF format having image size 256×256. When proposed algorithm has been applied on the cameraman image which is showing in figure 4(a) then obtained the cameraman compressed image which is showing in figure 4(b).

When Barbara original image in JPEG format having size 512×512 shown in figure 4(c). When proposed algorithm has been applied on this image than found Barbara compressed image which is shown in figure 4(d).

Figure 4(c) Barbara original image

Figure 4(d) Barbara compressed image

Compression rate shows that how much an image can be compressed from its original size. There are two error metrics which is used to compare the quality of image compression, that are known as MSE and PSNR. The MSE represents the cumulative squared error between the compressed and the original image whereas PSNR represents a measure of the peak error. Lower the value of MSE lowers the error and PSNR tells us about the quality of image, more the PSNR value better will be the result.

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

Where m, n is the size of the original image.

$$PSNR_{db} = 10log_{10}\frac{(2n-1)2}{MSE}$$

Table 1 Compression ratio with PSNR using Huffman Coding based on Histogram Information and Image Segmentation

Compression ratio	PSNR
CR= 20%	23.8251
CR= 30%	26.2095
CR= 40%	28.0295
CR= 50%	30.0878
CR= 60%	33.2995
CR= 70%	34.3515

Table 2 Compression ratio with MSE using Huffman Coding based on Histogram Information and Image Segmentation

Compression Ratio	MSE
5	4.864
10	3.215
15	2.973
20	2.468
25	2.096

Table 3 Compression parameter Through DCT and Huffman Coding Technique

Parameter	Cameraman image	Barbara image
Compression rate	1.05	1.32
PSNR	21.3057	23.9774
MSE	481.4025	260.2180

Table (1) shows that the compression parameters for both the images which is shown in figure 4(b) and figure 4(d).

Conclusion

After observing the results it can be concluded that the objective of the research is achieved with following observation.

It is concluded that Image Compression is an important technique in digital image processing. There are different types of compression techniques but

Huffman Coding technique is a good compression technique in lossless image compression.

Huffman compression is a variable length type of compression technique. In Huffman, the coding redundancy can be eliminated by assigning the codes in better way.

Discrete Cosine Transform with Huffman codes has been used in the proposed algorithm and better quality of compressed image with high PSNR value and MSE has been achieved with high compression rate.

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