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Image Compression Using New Entropy Coder

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***Abstract*—Digital images contain large amount of information that need evolving effective techniques for storing and transmitting the ever increasing volumes of data. Image compression addresses the problem by reducing the amount of data required to represent a digital image. Image compression is achieved by removing data redundancy while preserving information content. In this paper a simplified and more effective version of the RUN-Length coder is described and implemented. The proposed algorithm works on quantized coefficients of the discrete cosine transform (DCT) where there are a lot of coincident tokens. Experimental results show that the new approach attains competitive performance.**

***Index Terms*—Color Image, Compression, Discrete Cosine Transform, Quantization, Entropy, Lossless Compression, Lossy Compression.**

I. Introduction

Image compression is a technique used to reduce the storage and transmission costs. The existing techniques used for compressing image files are broadly classified into two categories, namely lossless and lossy compression techniques. In lossy compression techniques, the original digital image is usually transformed through an invertible linear transform into another domain, where it is highly de-correlated by the transform. This de-correlation concentrates the important image information into a more compact form. The transformed coefficients are then quantized yielding bit-streams containing long stretches of zeros. Such bit-streams can be coded efficiently to remove the redundancy and store it into a compressed file. The decompression reverses this process to produce the recovered image. The 2-D discrete cosine transform (DCT) is an invertible linear transform and is widely used in many practical image compression systems because of its compression performance and computational efficiency [1-3]. DCT converts data (image pixels) into sets of frequencies. The first frequencies in the set are the most meaningful; the latter, the least. The least meaningful frequencies can be stripped away based on allowable resolution loss. DCT-based image compression relies on two techniques to reduce data required to represent the image. The first is quantization of the image's DCT coefficients; the second is entropy coding of the quantized coefficients [4]. Quantization is the process of reducing the number of possible values of a quantity, thereby reducing the number of bits needed to represent it. Quantization is a lossy process and implies in a reduction of the color information associated with each pixel in the image. Entropy coding is a technique for representing the quantized coefficients as compactly as possible.

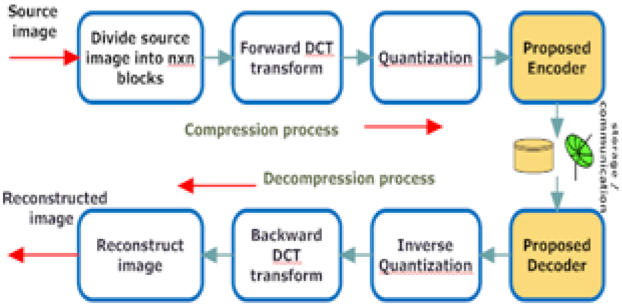

Fig.1 The block diagram of the Compression / Decompression process

II. The Proposed Algorithm

In this paper a simple entropy encoder **algorithm** will be proposed and implemented. It works on quantized coefficients of the discrete cosine transform (see Fig.1). The probability of being nonzero of zig-zag ordered DCT coefficients, as shown in Fig.2, is a decreasing monotonic function of the index. This is estimated and confirmed by the experiment presented by Pennenbaker and Mitchell [5].

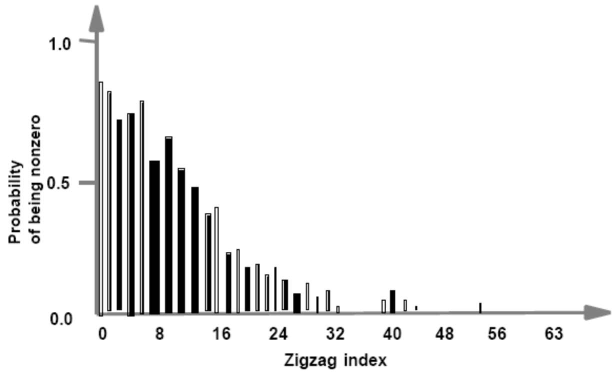

Fig.2 Probability of being non-zero of zig-zag ordered DCT coefficients

The basic idea of the new approach is to divide the image into 8x8 blocks and then extract the consecutive non-zero coefficients preceding the zero coefficients in each block. In contrast to the Run_Length decoder, the output of this encoder consists of the number of the nono-zero coefficients followed by the coefficients themselves for each block. The decompression process can be performed systematically and the number of zero coefficients can be computed by subtracting the number of non-zero coefficients from 64 for each block. Following is a short example of this algorithm. In this example, there are two 8x8 blocks of coefficients as input to the suggested coder. The output of this coder is shown in the right side of Fig.3.

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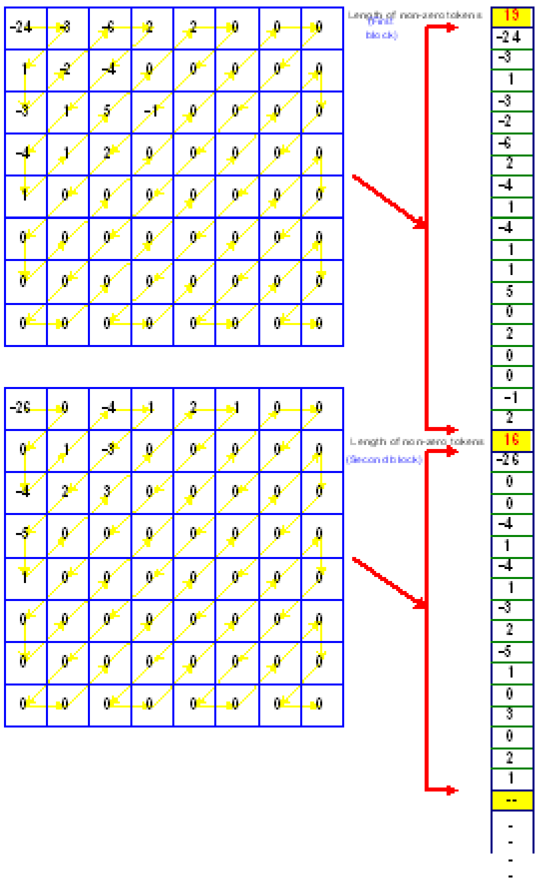

Fig.3 Demonstration example of the proposed algorithm

III. Experimental Measurements

A complete compression process has been implemented to test and demonstrate the proposed coder algorithm and it included the following sub-processes:

Generating nxn blocks: In RGB space the image is split up into red, blue and green images. The image is then divided into 8x8 blocks of pixels and accordingly the image of wxh pixels will contain *W*x*H* blocks. Where $W = w\,/\,8,\ H = h\,/\,8$.

DCT: All values are level shifted by subtracting 128 from each value. The Forward Discrete Cosine Transform of the block is then computed. The mathematical formula for calculating the DCT is:

$$T(u,v) = \sum_{x=0}^{n}\sum_{y=0}^{n} f(x,y)g(x,y,u,v)$$

Where:

$$g(x,y,u,v) = \tfrac{1}{4}\alpha(u)\alpha(v)\cos\left[\frac{(2x+1)u\pi}{2n}\right]\cos\left[\frac{(2y+1)v\pi}{2n}\right]$$

Where:

$$\alpha(u) = \begin{cases} \frac{1}{\sqrt{2}} \ldots\ldots\ldots\ldots for.u = 0 \\ 1\ldots\ldots\ldots\ldots for.u = 1,2,\ldots.., N-1 \end{cases}$$

Quantization: Quantization is the step where the most of the compression takes place. DCT really does not compress the image, as it is almost lossless. Quantization makes use of the fact, that, the high frequency components are less important than the low frequency components. The Quantization Output is: $Q_{DCT} = round(\frac{T(u,v)}{Z(u,v)})$

The *Z(u,v)* matrix could be anything, but the JPEG committee suggests some matrices which work well with image compression. There is a standard Z_{50} matrix. This matrix can used to create other *Z* matrices depending on the amount of compression required.

Entropy Coding: After quantization, most of the high frequency coefficients (lower right corner) are zeros. To exploit the number of zeros, a zig-zag scan of the matrix is used yielding to Long strings of zeros. The current coder acts as filter to pass only the string of non-zero coefficients. By the end of this process we will have a list of non-zero tokens for each block preceded by their count (Fig.3).

DCT based image compression using blocks of size 8x8 is considered. After this, the quantization of DCT coefficients of image blocks is carried out. The new approach of entropy encoding is then applied to the quantized DCT coefficients. A JPEG [6] test image set has been used to compare the performance of the abovementioned algorithm. The efficiency of the proposed encoder is analyzed and compared with that obtained after applying Run-lenth coding method (Fig.4). It has been found that the compression ratio achieved by the new algorithm is about 1.3 of that obtained with the Run-Length method. The compression achieved in this approach is evaluated based on the overall compression ratio (C_R) which is defined as:

C_R =size of the input or original image / size of the output or compressed file

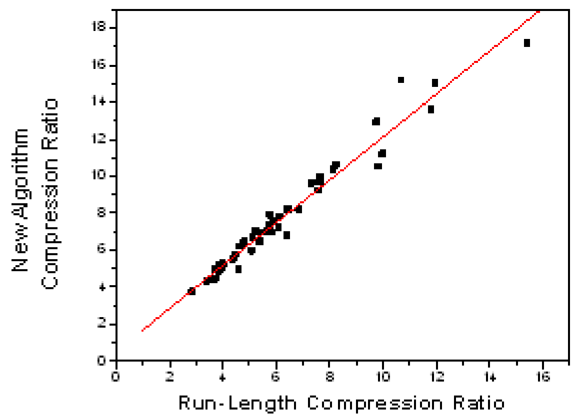

Fig.4 New algorithm's compression ratio versus that of the Run-Length method

Figure 5 shows an image before and after applying the compression algorithm.

a)

b)

Fig.5 a) Before compression b) After compressio

IV. Conclusion

The technique seems to have compression ratio higher than of the prior entropy coding method called Run-Method. The technique is particularly amenable to the design of relatively simple, fast decoders and it can be used as a key component in data compressors for a wide variety of data types, including image, video, audio, and text data.

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