Image Compression Technique For Low Bit Rate Transmission

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ABSTRACT
A novel Adaptive Lossy Image Compression (ALIC) technique is proposed to achieve high compression ratio by reducing the number of source symbols through the application of an efficient technique. The proposed algorithm is based on processing the discrete cosine transform (DCT) of the image to extract the highest energy coefficients in addition to applying one of the novel quantization schemes proposed in the present work. This method is straightforward and simple. It does not need complicated calculation; therefore the hardware implementation is easy to attach. Experimental comparisons are carried out to compare the performance of the proposed technique with those of other standard techniques such as the JPEG. The experimental results show that the proposed compression technique achieves high compression ratio with higher peak signal to noise ratio than that of JPEG at low bit rate without the visual degradation that appears in case of JPEG.

Keywords: Adaptive Lossy Image Compression (ALIC), Discrete Cosine Transform (DCT), Huffman Encoding, JPEG, Lossy Compression

1. INTRODUCTION
As a result of bandwidth and storage limitations, image compression techniques are widely used in data transmission and data storage. The image compression is highly used in all applications like medical imaging, satellite imaging, etc. The image compression helps to reduce the size of the image, so that the compressed image could be sent over a space link or a computer network from one place to another in short amount of time. Also, the compressed image helps to store more number of images on the storage device (Gonzalez & Woods, 2005; Salomon, 2001; Khalifa, Harding, & Hashim, 2008; Singh, Sharma, & Sharma, 2009).

The most popular image compression standard is JPEG (Pennebaker & Mitchell, 1993; Lakhani, 2003); JPEG is described in Appendix B. However it is not an adaptive technique; it is independent on the image to be compressed. In fact, one significant complexity provided by the JPEG technique is the presence of the fixed Huffman tables in JPEG baseline which can be a bottleneck in hardware implementations.

There are many adaptive compression algorithms presented in the literature. In Wu (2002) an adaptive sampling algorithm applied in the spectral domain, achieved by discrete cosine
transform (DCT), is presented. This algorithm records the most significant coefficients as compressed data for transmission or storage. For the decoder operation, the most significant coefficients can be directly retrieved from the compressed data.

In Fillimon (1998) an irregular sampling algorithm was proposed for wavelet compression. In that paper, an adaptive sampling algorithm in the discrete time domain is constructed by finding a univocal relation between the signal samples and the nonzero wavelet transform coefficients. Reconstruction is performed through repeated projections of an approximation of the initial signal based on the arriving samples.

This paper is organized as follows: Section 2 shows detailed description for the proposed ALIC technique in addition to descriptions for the novel quantization techniques. The performance analysis of the ALIC technique is performed using a pool of nine images. A detailed comparative study against JPEG technique is presented in Section 3. The conclusions are presented in Section 4.

2. DESCRIPTION OF THE PROPOSED TECHNIQUE

The process of the proposed ALIC technique can be described by the block diagram that is shown in Figure 1. At the transmitter, the input N×M image (N rows and M columns of pixels) is converted into a vector; the rows of the N×M matrix are concatenated sequentially in one long row that contains all the image pixels using matrix to vector converter. This vector is exposed to DCT to transform the image from spatial domain into frequency domain in which energy of the image information is concentrated in a few number of coefficients. The output of the DCT process is a vector that has the same length of the image (number of pixels in the image), but with many values approximated to zeros. After applying the DCT the output coefficients are arranged in a descending order according to its energy content. The energy content of the coefficients is summed from the beginning of the vector and toward the end till a specific EP% of the image energy is reached. Those coefficients that carry EP% from the total image energy are chosen to be transmitted and the rest of coefficients are neglected since they carry only very small energy that will not affect the visual quality of the recovered image. This EP value depends on image characteristics and it can be varied to achieve the desired compression ratio and the signal to noise ratio according to the channel noise, and the application: As we decrease the EP value, a higher compression ratio is obtained with slightly lower signal to noise ratio. Now the number of the transmitted coefficients (TC) becomes very small. The reduced coefficients

histogram of the image, so they are adaptive techniques. The indices of the selected coefficients are stored to be used later.

The quantized coefficients are ordered according to their stored indices in a new vector that has the same length as the DCT input vector. This new vector is completed by zeros, and then are Run-Length encoded. The resultant vector is processed by Huffman encoder which generates coded output stream. In order to restore the original image again at the receiver, the previous stages are processed in the reverse direction. The following is the detailed description of the ALIC technique.

The input N×M image; an image assumed to be a matrix has length of N rows and width of M columns, is first converted into single vector by concatenating successive rows beside each other to form a long row that contains all the image pixels using matrix to vector converter. This vector is subjected to DCT to transform the image from spatial domain into frequency domain in which energy of the image information is concentrated in a few number of coefficients. The output of the DCT process is a vector that has the same length of the image (number of pixels in the image), but with many values approximated to zeros. After applying the DCT the output coefficients are arranged in a descending order according to its energy content. The energy content of the coefficients is summed from the beginning of the vector and toward the end till a specific EP% of the image energy is reached. Those coefficients that carry EP% from the total image energy are chosen to be transmitted and the rest of coefficients are neglected since they carry only very small energy that will not affect the visual quality of the recovered image. This EP value depends on image characteristics and it can be varied to achieve the desired compression ratio and the signal to noise ratio according to the channel noise, and the application: As we decrease the EP value, a higher compression ratio is obtained with slightly lower signal to noise ratio. Now the number of the transmitted coefficients (TC) becomes very small. The reduced coefficients
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