A Review of lossless and lossy image compression techniques

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Abstract - *Image compression is mainly used to reduce storage space, transmission time and bandwidth requirements. Compression of the image is achieved using image compression techniques that remove information that is not perceived by the human eye. In this paper, general image compression schemes and image compression techniques that are available in the literature are discussed.*

Key Words: Digital imaging, Image compression, Coding methods, Discrete wavelet transforms.

1.INTRODUCTION

Image compression can be accomplished by the use of coding methods, spatial domain techniques and transform domain techniques [1]. Coding methods are directly applied to images. General coding methods comprise of entropy coding techniques which include Huffman coding and arithmetic coding, run length coding and dictionary based coding. Spatial domain methods which operate directly on the pixels of the image, combine spatial domain algorithms and coding methods. Transform domain methods transform the image from its spatial domain representation to a different type of representation using well-known transforms.

There are two types of image compression schemes, namely: Lossless compression and Lossy compression. In lossless compression schemes, the reconstructed image is exact replica of the original image. In lossy image compression, the reconstructed image contains degradation relative to the original. In lossy compression, higher compression can be achieved when compared to lossless compression scheme.

2.LOSSLESS COMPRESSION TECHNIQUES

Lossless image compression techniques can be implemented using coding methods. Huffman coding is an optimum prefix code [2]. It assigns a set of prefix codes to symbols based on their probabilities. Symbols that occur more frequently will have shorter codewords than symbols which occur less frequently. Also less frequently occurring two symbols have codewords with same maximum length. Huffman coding is inefficient when the alphabet size is small and probability of occurrence of symbols is highly skewed.

Arithmetic coding [3,4] is more efficient when the alphabet size is small or the symbol probabilities are highly skewed. Generating codewords for sequences of symbols is efficient than generating a separate codeword for each symbol in a sequence. A unique arithmetic code can be generated for a particular sequence without generating codewords for all sequences of that length. This is unlike for Huffman codes. A single tag value is assigned to a block of symbols, which is uniquely decodable. Arithmetic coding provides better compression ratios than Huffman coding.

Run-length encoding technique is the simplest compression technique [5]. It is efficient only when the data to be compressed consists of long runs of repeated characters or symbols. It encodes runs of characters into two bytes, namely a count and a symbol, i.e., it stores these runs as a single character, preceded by a number representing the number of times this character is repeated in the run. Dictionary-based coding reads input sequence and looks for groups of symbols that appear in a dictionary [6]. The symbols are coded using a pointer or index in the dictionary. This technique will be more useful with sources that generate a relatively small number of patterns quite frequently [7]. Images will not generate the same pattern of symbols frequently. So more number of bits are required for image coding. Lempel-Ziv-77 (LZ77) and Lempel-Ziv-Welch (LZW) are dictionary based compression techniques.

3.LOSSY COMPRESSION TECHNIQUES

In general, a lossy compression is implemented using spatial domain encoding and transform domain encoding methods. Spatial domain techniques generally make use of the prediction function, in which value of the current pixel is determined by the knowledge of the previously coded pixel. Delta modulation and pulse code modulation are examples of predictive coding.

In transform domain technique, image transforms are used to decorrelate the pixels. Thus, the image information is packed into a small number of coefficients. The coefficients in the transform domain are then quantized to reduce the number of allocated bits. The error or loss in information is due to quantization step. The resulting quantized coefficients are of different probabilities and an entropy coding scheme can further reduce the number of required bits. Transform coding is commonly adopted method for lossy image compression as it provides greater data compression compared to predictive methods [8].

The transforms used to decorrelate the image pixels are Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT), Walsh- Hadamard Transform (WHT), Karhunen-Loeve Transform (KLT) and Discrete Wavelet Transform (DWT). Among these transforms, DCT [9] and DWT [10] are the most popular transform techniques.

In DCT, most of the energy is compacted into lower frequency coefficients. Due to quantization, most of the higher frequency coefficients become small or zero and have a tendency to be grouped together. In DCT based Joint Photographic Experts Group (JPEG) compression standard [11,12] the image is partitioned into non-overlapping 8x8 blocks. DCT is performed on the blocks, and the resulting coefficients are quantized and coded. The main drawback of DCT is that blocking artifacts is noticeable at lower bit rates.

The wavelet transform decomposes the image into different frequency subbands, namely lower frequency subbands and higher frequency subbands, by which smooth variations and details of the image can be separated. Most of the energy is compacted into lower frequency subbands. Most of the coefficients in higher frequency subbands are small or zero and have a tendency to be grouped together and are also located in the same relative spatial location in the subbands. Thus image compression methods that use wavelet transforms are much efficient in providing good quality images than DCT-based methods [13, 14]. Embedded Zero tree Wavelet (EZW) [15], Set Partitioning In Hierarchical Trees (SPIHT) [16], and JPEG2000 [17,18] which uses Embedded Block Coding with Optimized Truncation (EBCOT) are the most popular wavelet-based compression methods.

4. COMPARITIVE ANALYSIS

DCT and DWT are the popular image transforms. DCT-based compression method suffers from blocking artifacts at low bitrates. DWT-based compression is superior to DCT based method. Wavelet-based compression methods such as JPEG 2000, EZW and SPIHT have multiple levels of wavelet decomposition. Arithmetic coding provides better compression ratios than Huffman coding.

5. CONCLUSIONS

An overview of lossless and lossy image compression techniques carried out by previous researchers is presented. The salient features of transform coding, Huffman coding, Arithmetic Coding, medical image coding, JPEG, JPEG 2000, EZW and SPIHT are also presented.

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