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Comparative Study of Different Image Compression Techniques

Hiroj Naik

Electronics and Telecommunication Engineering Department, Goa College of Engineering, Goa, India

Abstract: Image processing field has been revolutionized by advancements in imaging technologies. Due to increasing requirements for transmission and storage of images in computer and mobile devices, the research in image compression has increased significantly. Digital images in their uncompressed form require a large amount of storage space and transmission bandwidth. Image compression reduces the storage space required and reduces the required transmission bandwidth. There are various techniques of image compression developed. This paper gives the study of various image compression techniques.

Keywords: Image Compression, DCT, VQ, Fractal

I. INTRODUCTION

Compression is important because it decreases the time and cost required for image transmission and it decreases storage requirements. Compression algorithms can be either lossless (reversible) or lossy (irreversible).Higher degrees of compression are only possible using lossy or irreversible techniques and therefore lossy compression has been subject of considerable investigation. Algorithms for lossless compression include run length encoding, Huffman Encoding and Lempel-Ziv and variants. Various types of lossy encoding algorithms have been investigated including, discrete time cosine (DCT), vector quantization, wavelets, fractal and others [1].

The image compression techniques can be categorized into two fundamental groups: reversible and non reversible. In reversible (also known as bit reversing or lossless),the reconstructed image after compression is numerically identical to the original image on a pixel-by-pixel basis. Obviously reversible is ideally desired since no information is compromised. However only modest compression ratio are possible with reversible compression. In non reversible compression (also known as lossy), the reconstructed image contains degradations relative to the original. As a result, much higher compression ratios can be achieved as compared to reversible compression. In general more compression is achieved at the expense of more distortion. It is important to note that these degradations may or may not be visually apparent [2]. A typical still image contains a large amount of spatial redundancy in plain areas where adjacent picture elements have almost the same values. It means that the pixel values are highly correlated. In addition, a still image can contain subjective redundancy, which is determined by properties of a human visual system (HVS). An HVS presents some tolerance to distortion, depending upon the image content and viewing conditions [3]. Consequently, pixels must not always be reproduced exactly as originated and the HVS will not detect the difference between original image and reproduced image. The redundancy (both statistical and subjective) can be removed to achieve compression of the image data.

In general, three types of redundancy can be identified:

Coding Redundancy

A code is a system of symbols (letters, numbers, bits and the like) used to represent a body of information or set of events. Each piece of information or events is assigned a sequence of code symbols called code word. The number of symbols in each code word is its length. The 8-bit codes that are used to represent the intensities in the most 2-D intensity arrays contain more bits than are needed to represent the intensities.

Spatial and temporal redundancy

Because the pixels of most 2-D intensity arrays are correlated spatially, information is unnecessarily replicated in the representations of the correlated pixels.

Irrelevant information

Most 2-D intensity arrays contain information that is ignored by the human visual system and extraneous to the intended use of the image. It is redundant in the sense that it is not used [4].

The general framework for compression scheme includes three components: image decomposition or transformation, quantization and symbol encoding. The relative importance of each component varies from one technique to another and not all components are necessarily included in a particular technique. The image decomposition or transformation is usually a reversible operation and is performed to reduce the dynamic range of the signal, to eliminate redundant information or in general to provide a representation that is more amenable to efficient coding. The primary difference between reversible and non-reversible techniques is the inclusion of next stage, quantization, in non-reversible techniques. By quantizing the data, the number of possible output symbols is reduced. The type and degree of quantization has a large impact on the bit rate and quality of a non-reversible scheme. The final stage, symbol encoding, may be as simple as using fixed-length binary code-words to represent the symbols resulting from the decomposition or quantization stages, or it might use a variable-length code as a means of achieving rates close to the fundamental information-theoretic limits.

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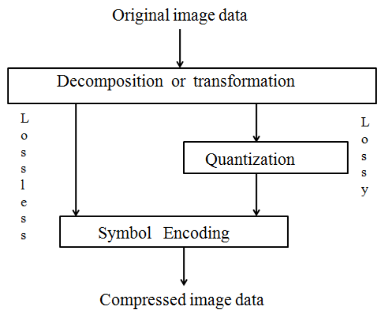

Fig. 1 General Compression Framework

II. LOSSLESS COMPRESSION TECHNIQUES

A. Run Length Encoding

One of the simplest forms of data compression is known as Run Length Encoding (RLE).Images with repeating intensities along their rows (or columns) can often be compressed by representing runs of identical intensities as run-length pairs, where each run-length pair specifies the start of a new intensity and the number of consecutive pixels that have that intensity. Compression is achieved by eliminating a simple form of special redundancy-groups of identical intensities. Run length encoding is particularly effective when compressing binary images. Because there are only two possible intensities (black and white), adjacent pixels are more likely to be identical.

B. Huffman Coding

A more sophisticated and efficient lossless compression technique is known as Huffman Coding in which the characters in a data file are converted to a binary code. Huffman coding is a method for the construction of minimum redundancy code. Huffman code is a technique for compressing data. Huffman's greedy algorithm looks at the occurrence of each character and it as a binary string in an optimal way. Huffman coding is a form of statistical coding which attempts to reduce the amount of bits required to represent a string of symbols. The algorithm accomplishes its goals by allowing symbols to vary in length. Shorter codes are assigned to the most frequently used symbols, and longer codes to the symbols which appear less frequently in the string. Code word lengths vary and will be shorter for the more frequently used characters[5].

C. Limpel Ziv Welch Coding

Lempel-Ziv-Welch (LZW) is a category of a dictionary-based compression method. It maps a variable number of symbols to a fixed length code. LZW places longer and longer repeated entries into a dictionary. It emits the code for an element, rather than the string itself, if the element has already been placed in the dictionary. In a dictionary-based data compression technique, a symbol or a string of symbols generated from a source alphabet is represented by an index to a dictionary constructed from the source alphabet. When a new symbol or string is found and that is contained in the dictionary, it is encoded with an index to the dictionary. Or else, the new symbol is not in the dictionary, the symbol or strings of symbols are encoded in a less efficient manner [6]. A dictionary is initialized to contain the single character strings corresponding to all the possible input characters. The algorithm works by scanning through the input string for successively longer substrings until it finds one that is not in the dictionary. When such a string is found, the index for the string without the last character (i.e., the longest substring that is in the dictionary) is retrieved from the dictionary and sent to output, and the new string (including the last character) is added to the dictionary with the next available code. The last input character is then used as the next starting point to scan for substrings. In this way, successively longer strings are registered in the dictionary and made available for subsequent encoding as single output values. The algorithm works best on data with repeated patterns, so the initial parts of a message will see little compression. As the message grows, however, the compression ratio tends asymptotically to the maximum. The decoding algorithm works by reading a value from the encoded input and outputting the corresponding string from the initialized dictionary. At the same time it obtains the next value from the input, and adds to the dictionary the concatenation of the string just output and the first character of the string obtained by decoding the next input value. The decoder then proceeds to the next input value and repeats the process until there is no more input, at which point the final input value is decoded without any more additions to the dictionary. In this way the decoder builds up a dictionary which is identical to that used by the encoder, and uses it to decode subsequent input values.

III.LOSSY IMAGE COMPRESSION TECHNIQUES

D. DPCM

The Differential Pulse Code Modulation (DPCM) is transformation for increasing the compressibility of an image. It consists of scanning the image and predicting the next pixel's value. There are several modes to predict the next pixel's value [7]. In a lossless coding scheme, the original image is reproducible by storing the pixels at the beginning of the scan and decoding in the same scan order. The set of differences between each pixel and its predicted value is the residual image. The residual distribution is typically zero-mean and much more compact than the distribution of the original image. A more compact distribution results in lower entropy which determines the minimum average codeword length that is attainable without information loss.

E. Vector Quantization

Vector quantization (VQ) is a useful scheme for grayscale image compression. It can also be used for speech compression. VQ can be applied to the multimedia applications that having a limited computation power because it has low bit rate and simple image decoding procedure [8]. In general, VQ can be divided into three parts: codebook generation, image encoding, and image decoding. The goal of codebook generation procedure is to generate a set of representative codewords to form the codebook. From the literature, the LBG algorithm is the

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most commonly used algorithm for codebook design. The LBG algorithm is a clustering based algorithm. Typically, a good codebook can be designed by using the LBG algorithm when the initial codebook is well selected. In the image encoding procedure, each greyscale image to be compressed is first divided into a set of non-overlapped image blocks of n x n pixels. Each image block can be viewed as an image vector of k dimensions where k = n x n. To compress the image, each image block is processed in the left to right and top to bottom order. Given one image block x and a codebook of N codewords, the closest codeword in the codebook for x is to be determined. In the image decoding procedure, the compressed image of VQ is to be reconstructed. Here, the same codebook of N code words as that was used in the image encoding procedure is used. To recover each compressed block x , the $\log_2 N$ bits index of the closest codeword in the codebook for x is extracted. Then, the corresponding codeword of this index is employed to recover the compressed block x. When each compressed block is sequentially reconstructed in the same way, the decoded image of VQ is obtained.

F. DCT

Discrete Cosine Transform (DCT) represents an image as a superposition of cosine functions with different discrete frequencies. The transformed signal is a function of two spatial dimensions, and its components are called DCT coefficients or spatial frequencies. DCT coefficients measure the contribution of the cosine functions at different discrete frequencies. DCT provides excellent energy compaction, and a number of fast algorithms exist for calculating the DCT. Most existing compression systems use square DCT blocks of regular size. The image is divided into blocks of samples and each block is transformed independently to give coefficients. For many blocks within the image, most of the DCT coefficients will be near zero. DCT in itself does not give compression. To achieve the compression, DCT coefficients should be quantized so that the near-zero coefficients are set to zero and the remaining coefficients are represented with reduced precision that is determined by quantizer scale. The quantization results in loss of information, but also in compression. Increasing the quantizer scale leads to coarser quantization ,which gives high compression and poor decoded image quality.

The 2D-DCT can not only concentrate the main information of original image into the smallest low frequency coefficient, but also it can cause the image blocking effect being the smallest, which can realize the good compromise between the information centralizing and the computing complication . Two dimensional discrete cosine transform (2D-DCT) is defined as

$$F(jk)=a(j)a(k)\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} f(mn)\cos\left[\frac{(2m+1)j\pi}{2N}\right]\cos\left[\frac{(2n+1)k\pi}{2N}\right]$$

G. Wavelet Transform

The basic idea of discrete wavelet transform (DWT) in image process is to multi-differentiated decompose the image into sub-image of different spatial domain and independent frequency district .Then transform the coefficient of sub-image. After the original image has been DWT transformed, it is decomposed into 4 frequency districts which is one low-frequency district(LL) and three high-frequency districts (LH,HL,HH).If the information of low-frequency district is DWT transformed, the sub-level frequency district information will be obtained. The low-frequency district information also can be decomposed into sub-level frequency district information of LL2, HL2, LH2 and HH2.By doing this the original image can be decomposed for n level wavelet transformation [9]. The information of low frequency district is a image close to the original image. Most signal information of original image is in this frequency district. The frequency districts of LH, HL and HH respectively represents the level detail, the upright detail and the diagonal detail of the original image[10].

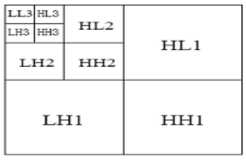

Fig. 2 Sketch map of Image DWT decomposed

H. Fractal Image Compression

Fractal image compression is a relatively recent image compression method which exploits similarities in different parts of the image. Fractal Image Compression (FIC) is a field of intensive research. It not only considers the interrelation between local data, and also between global data and local data [11]. So fractal image compression is suitable for images with self-similar or self-affine. There are a lot of self-similar or the self-affine image in natural world, fractal image compression is used in many fields. The technique works on the basis of the observation that as fractals can produce fairly realistic images, then, it must be probable to store a given image as just a few basic fractal patterns, coupled with the specification of reconstructing the image from those fractals. The FIC algorithm initially begins with the complete image, and partitions the image into a number of smaller blocks. In addition, FIC offers faster decoding and the code is resolution independent. However, the method experiences a major deficiency of longer encoding times. Fractal compression and fractal encoding makes use of the self-similarity property of fractal objects. Exact self-similarity means that the fractal object is constituted by scaled down copies of itself that are translated, stretched and rotated based on a transformation. Such a transformation is called affine transformation.

IV. CONCLUSION

The paper presents different image compression techniques. Image Compression plays a significant role in reducing the transmission and storage cost. Image compression techniques are mainly classified into lossless and lossy techniques. In lossless compression, the image is compressed and decompressed without any lose of information. In lossy compression there is some loss of

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information. Lossless techniques are used in text and clip art while lossy compression techniques are used in multimedia applications.

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