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Review on Image Compression Techniques

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ABSTRACT

Image compression is the type of data compression on digital images. The main objective is to reduce redundancy of the image. In image compression, we do not only concentrate on reducing size but also concentrate on doing it without losing quality and information of image. The survey summarizes the major image compression techniques that maybe lossy and lossless, advantages, disadvantages and research possibilities. This paper attempts to give a review of run length coding, Huffman coding, DCT, fractal and Talbot effects. We discuss advantages and disadvantages of these algorithms.

Keywords: Image Compression; RLE; Huffman; DCT; Fractal;

I. INTRODUCTION

Digital images are used for the processing, storage and transmission in computer applications, which is a Two-dimensional array of pixels. Image compression analyses a technique that allow it to reduce the amount of data that describe the information content of image. A gray scale image that is 256*256 pixels has 65536 elements to store & downloading these files takes time. Therefore, development of efficient technique for image compression has become necessary. The objective of image compression is to reduce irrelevance and redundancy of the digital image data in order to store or transmit data in an efficient form. For this purpose two major principles redundancy and irrelevancy is used [1]. Every image will have redundant data. Redundancy means the duplication of data in the image. Either it may be repeating pixel across the image or pattern, which is repeated more frequently in the image. The image compression occurs by taking benefit of redundant information of in the image. Reduction of redundancy provides helps to achieve a saving of storage space of an image. Image compression is the most important technique required for the storage, processing and transmission of digital images[2]. Compression is achieved by the removal of these basic data redundancies i.e. coding redundancy, Interpixel redundancy, Psycho visual redundancy, temporal redundancy and Spatial and Spectral redundancy. Compression plays an important role in many other areas, teleconferencing, video conferencing, remote sensing document and medical imaging and facsimile transmission (FAX).

II. METHODS AND MATERIAL

1. Types of Redundancy

Image compression works on the principle of removing data redundancy. There are 6 types of redundancy:

A. Spatial and Spectral redundancy

Spatial redundancy is due to correlation or dependence between neighboring pixel values. The correlated pixels contain information that is unnecessary replicated. And spectral redundancy is due to correlation between color planes or spectral bands [4].

B. Temporal redundancy

Temporal redundancy is present because of correlation between different frames in images. For a video sequence, temporally correlated pixels have same or duplicate information.

C. Coding redundancy

Coding redundancy is also called variable length coding. It uses code words with different lengths to losslessly represent symbols. It is present when less than optimal code words are used and when some pixel values are more common than others. Image compression can be achieved by reducing coding redundancy, which is done by assigning fewer bits to more probable gray levels than less probable gray levels. Thus the shortest code words are assigned to most frequent gray levels and longest code words are assigned to least frequent gray levels.

D. Interpixel Redundancy

Interpixel redundancy is related with the interpixel correlations within an image. The larger is the correlation more is the interpixel redundancy. Image compression is achieved by reducing interpixel redundancy.

E. Psychovisual redundancy

Psycho visual redundancy is due to data that is ignored by human visual system that is visually non-essential information. It occurs when some color differences are imperceptible. Elimination of this redundancy data results in a loss of quantitative information called quantization. i.e. lossy data compression. E.g. quantization is gray levels, line interfacing in TV.

2. Image Compression Models

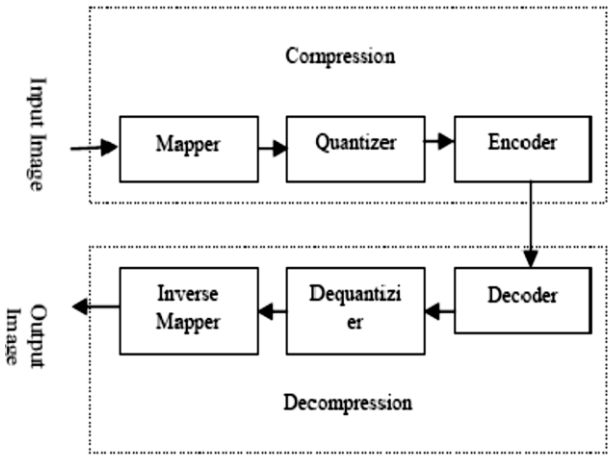

Figure 1. Image Compression Model

The source encoder reduces/eliminates any coding, interpixel and psycho visual redundancies. Source encoder contains 3 processes:-

- Mapper – it transforms the image into arrays of co-efficient reducing Interpixel redundancies. This is reversible process which is not lossy.
- Quantizer – This process reduces the accuracy and hence psycho visual redundancies of a given image. This is irreversible process and therefore lossy.
- Encoder – this is source encoding process where fixed or variable length cod is used to represent mapped and quantized data sets. This is reversible process.
- Decoder - this is inverse of symbol encoder and reverse of variable length coding is applied.
- De-quantizier – De-quantizer is one which receives the output levels of a quantizer and converts them into normal data, by translating each level into a 'reproduction point' in the actual range of data.
- Inverse mapper –Inverse of removal of the Interpixel redundancy.

The only lossy element is the quantizer which removes the psycho visual redundancies causing irreversible loss. Every lossy compression method contains the quantizer module. If error free compression is desired, then quantizer module is removed [4].

3. Benefits of Compression

- It provides an efficient cost saving by sending less data over the network where cost is based on duration of time.
- It reduces execution time as well as memory requirements.
- It reduces the probability of transmission errors since fewer bits are transferred through the transmission media
- Compression can reduce transmission time.

4. Types of Compression

It is divided in 2 depending on whether or not exact replica of original image can be reconstructed using the compressed image :

- Lossless compression.
- Lossy compression.

A. Lossless compression

Optical image can be perfectly recovered from compressed image. It is also called noiseless because they do not add noise to signal or image. it is said to be entropy coding since it uses statics/decomposition technique to reduce/eliminate redundancy. It is used only for few applications like medical imaging. it is reversible compression and reduces the amount of source information. When compressed information is decompressed no loss of information occurs. It has higher quality[5]. Lossless techniques:-

- Run length encoding
- Huffman encoding

Run Length Encoding

It is a standard compression approach in FAX coding. The images that have repeated intensities along their rows(or column) can be compressed by representing runs of identical intensities as run-length pairs, where each run length pair specifies the start of new intensity and number of consecutive pixels that have that intensity. This technique is called as RLE. It results in data expansion when there are few or no runs of identical pixels.

Huffman Encoding

It is the most important technique to remove coding redundancy. It yields the smallest possible number of code symbols per source symbol. It construct Huffman tree according to the source symbol probabilities. First Huffman tree is coded and then source entropy, average code length and code efficiency are computed. It is a block code each symbol is mapped to a fixed sequence of bits and decodes without referencing succeeding symbols. This result in high speed. It is uniquely decodable that is any code word is not a prefix of another.

B. Lossy compression

It provides higher compression ratios than lossless. It is widely used because the quality of reconstructed image is adequate for most applications. Decompressed image is not identical to original image, but reasonably close to it. This compression is suitable for natural images such as photos in applications where minor loss of fidelity is acceptable to achieve a substantial reduction in bit rate. Lossy compression that produces unpredictable differences can be called visually lossless [3].. It reduces the amount of source information. When compressed information is decompressed loss of information occurs. They have lower quality [5]. Lossy techniques:-

- Discrete cosine transform(DCT)
- Fractal compression
- Fractional Talbot effect

Discrete Cosine Transform

It is a lossy compression technique and is used for transformation of 2D matrix of pixel values into a equivalent matrix of spatial frequency components. It would be too consuming to compute the transformed value of each position of total matrix representing the image [6]. Matrix is divided into smaller 8*8 sub matrices. Each is known as a block. It separates image into parts of different frequency and are used to retrieve the image during decompression. DCT is advantageous [7] because

- It has been implemented in single integrated circuit.
- It has ability to pack most of the information in fewer coefficients.
- It minimizes the block like appearance called blocking artifacts that result when boundaries between sub images become visible.

Fractal Compression

This is also a lossy compression technique. It was introduced in late 1980's and early 1990's.it is used for encoding decoding images in Encarta/Encyclopedia. This is based on collage theorem and the fixed point theorem [8]. In this compression technique image is first partitioned into 8*8 non overlapping blocks. These blocks are called range blocks. These blocks consist of 16*16 overlapping blocks called domain block. A fractal compressed code for a range block consist of quantized coefficients in the affine transform, an offset which is mean of pixel gray levels in the range block. The decoding is to find the fixed point and the decoded

image based by starting with any initial image. The procedure is repeated iteratively until it converges. The problem faced by fractal compression is the computational demands and the existence problem of best range-domain matches [9]. The important feature of this technique is the resolution-independent decoding property. The image can be enlarged by decoding an encoded image of smaller size so that the compression ratio may increase it exponentially [10].

Fractional Talbot Effect Compression

It is a lossy compression technique that uses Fresnel transforms which include Fourier transform. It is based on the fractional Talbot effect. This effects has been applied in various fields such as optical computing, image processing and synthesis, optical testing. The Talbot effect consists of reproducing the periodic wave field at periodic spatial intervals along the axis of propagation. The period along the propagation axis is called "Talbot distance". Diffraction of the periodic object at a fraction of the Talbot distance is referred to as fractional Talbot effect [11].

Compression is also divided into two depending on coding techniques:

Predictive coding

The information already sent or available is used to predicate future values and different is coded. It is done in spatial or image domain, therefore it is simple to implement and adapted to local image characteristic. Instead of representing amplitude by large code words, a set of smaller code words can be used each of which indicates only the difference in amplitude between current values. E.g.: differential pulse code modulation (DPCM).

Transform Coding

It is first transforms the image from its spatial domain representation to differential type of representation using some well-known transform, and then codes the transformed values. This coding provides greater data compression as compared to predictive methods, but it requires greater computational requirements. There is no loss of information associated with the transformation.

III. RESULTS AND DISCUSSION

Comparison of Compression Techniques

There are some advantages and disadvantages of various algorithms as shown below:

Table1. Advantages and Disadvantages

Method	Advantages	Disadvantages
Run-length	Useful on data that contain many runs of data.	Not useful for files that don't have many runs as it could greatly increase file size
Huffman	Simple, high speed	Code words of Huffman code can only have an integer no. of bits
DCT	Can be implemented in single integrated circuit.	Blocks cannot be de-correlated at their boundaries using DCT.
Fractal	Image can be enlarged by decoding an encoded image of smaller size	Computational demands and existence problem of best range domain matches.
Talbot	Useful in optical computing, image processing and synthesis, optical testing.	Not useful for general computing images.

IV. CONCLUSION

In this paper we have reviewed about image compression, types of redundancy and basic image compression model. We also deal with different types of compression method lossless and lossy. Comparing the performance of compression technique. After study of all techniques it is found that lossless image compression techniques are most effective over the lossy compression techniques. Lossy provides a higher compression ratio than lossless.

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