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Theoretic Study of Various Image Compression Techniques: A Survey

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***Abstract*—** Image compression is widely used term in digital image processing. Image compression main aim is to reduce the redundant data and retaining the important data keeping the image quality as good as possible. The compressed image is represented by less number of bits compared to original. In this paper we review and discuss about the principle of image compression, need of image compression, advantages and disadvantages of image compression, classes of compression and various algorithm of image compression. At last we define what qualities image compression algorithm should contain follows with the discussion and conclusion.

***Keywords*—** Image Compression; Lossy Compression; Lossless Compression; Images

I. INTRODUCTION

The increasing demand for multimedia content such as digital images and video has led to great interest in research into compression techniques. The development of higher quality and less expensive image acquisition devices has produced steady increases in both image size and resolution, and a greater consequent for the design of efficient compression systems [1]. Although storage capacity and transfer bandwidth has grown accordingly in recent years, many applications still require compression.

In general, this thesis investigates still image compression in the transform domain. Multidimensional, multispectral and volumetric digital images are the main topics for analysis. The main objective is to design a compression system suitable for processing, storage and transmission, as well as providing acceptable computational complexity suitable for practical implementation.

The basic rule of compression is to reduce the numbers of bits needed to represent an image. In a computer an image is represented as an array of numbers, integers to be more specific, that is called a ―digital image. The image array is usually two dimensional (2D), if it is black and white (BW) and three dimensional (3D) if it is color image [3]. Digital image compression algorithms exploit the redundancy in an image so that it can be represented using a smaller number of bits while still maintaining acceptable visual quality.

II. PRINCIPLE OF COMPRESSIONS

A common characteristic of most of the images is that the neighboring pixels are correlated and therefore contain redundant information. The foremost task is to find less correlated representation of the image. Two fundamental components of compression are redundancy and irrelevancy reduction [3]. Redundancy reduction aims at removing duplication from the signal source (image). Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System (HVS). In general, three types of redundancy can be identified:

- Spatial Redundancy or correlation between neighboring pixel values.
- Spectral Redundancy or correlation between different color planes or spectral bands.
- Temporal Redundancy or correlation between adjacent frames in a sequence of images (in video applications).

A. Needs of Image Compressions

Need for image compression includes:

- The large storage requirements for multimedia data
- Low power devices such as handheld phones have small storage capacity
- Network bandwidths currently available for transmission
- Effect of computational complexity on practical implementation.

B. Advantages of Image Compressions

Advantages of image compression include:

- It reduces the data storage requirements
- It also offers an attractive approach to reduce the communication cost in transmitting high volumes of data
- Due to the data rate reduction, image compression also increases the quality of multimedia presentation through limited-bandwidth communication channels
- Created new opportunities of creative applications such as digital library, digital archiving, video

teleconferencing, telemedicine and digital entertainment
- An extra level of security can be achieved by making the compression and decompression processes totally transparent to unauthorized users
- by storing the backup of large database files in
- The advantages of image compression will enable more multimedia applications with reduced cost.

C. *Disavantages of Image Compressions*

Disadvantages of image compression include:
- The extra overhead incurred by encoding and decoding
- The compressed data is different from the original data.
- Sometimes loss of quality is also take place

III. COMPRESSION TECHNIQUES

Image compression algorithms can be classified into two categories-
1. Lossless compression

2. Lossy compression

A. *Lossless Compression*

As the name indicates the original image can be perfectly recovered using the lossless compression techniques. They are also known as entropy coding, noiseless compression etc. They will not introduce any noises to the image and they are using statistics or decomposition techniques to reduce the redundancy. As mentioned earlier they are preferred for medical imaging, technical drawing etc. The following are some of the methods which are used for lossless compression.
1. Runlength encoding: This method is a simple lossless compression method. It is mainly used for sequential data {}.This is most useful on data that contains repetitive information. This method will replace identical symbols. These identical symbols are known as runs. They are replaced by shorter symbols. This technique is supported by most bitmap file formats, such as TIFF, BMP, and PCX. RLE is suited for compressing any type of data regardless of its information content, but the content of the data will affect the compression ratio achieved by RLE. Although most RLE algorithms cannot achieve the high compression ratios of the more advanced compression methods, RLE is both easy to implement and quick to execute, making it a good alternative to either using a complex compression algorithm or leaving your image data uncompressed.

2. Entropy encoding: Entropy encoding is another lossless compression technique. It works independent of the specific characteristics of medium. Besides using it as a compression technique it can be also used to measure the similarity in data streams. This method works as follows. It will create a unique prefix code and assign this code to unique symbol in the input. Unlike RLE entropy encoders works by compressing data by replacing the fixed length output with a prefix code word. This is of varying size after creating the prefix code. This will be similar to the negative logarithm of probability. There are many entropy coding methods. The most common techniques are Huffman coding and arithmetic coding. Huffman coding was developed by David A. Huffman. It will use a variable-length code table for encoding a source symbol (such as a character in a file) where it has been derived in a particular way based on the estimated probability of occurrence for each possible value of the source symbol. The prefix code used in this technique is known as prefix-free codes. This technique is similar to block encoding technique and it is optimal for symbol by symbol encoding. But when symbol by symbol restriction is dropped it will not be optimal.

3. Area coding: This method is an enhanced form of run length encoding method. There is some significant advantage of using this technique over other lossless methods .In constant area coding special code words are used to identify large areas of contiguous 1's and 0's.Here the image is segmented in to blocks and then the segments are classified as blocks which only contains black or white pixels or blocks with mixed intensity. Another variant of constant area coding is to use an iterative approach in which the binary image is decomposed into successively smaller and smaller block .A hierarchical tree is built from these blocks. The section stops when the block reaches certain predefined size or when all pixels of the block have the same value. The nodes of this tree are then coded. For compressing white text a simpler approach is used. This is known as white block skipping.

B. *Lossy Compression*

Lossy schemes provide much higher compression ratios than lossless schemes. By this scheme, the decompressed image is not identical to the original image, but reasonably close to it. But this scheme is widely used. Lossy methods are especially suitable for natural images such as photographs in applications where minor loss of fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces imperceptible differences may be called visually lossless. The following methods are used in lossy compression
1. Chroma subsampling: This takes advantage of the fact that the human eye perceives spatial changes of brightness more sharply than those of color, by averaging or dropping some of the chrominance information in the image. It works by taking advantage of the human visual system's lower acuity for color differences than for luminance. It is mainly used in video encoding, jpeg encoding etc. Chroma sub sampling is a method that stores color information at lower resolution

than intensity information. The overwhelming majority of graphics programs perform 2x2 chroma subsampling , which breaks the image into 2x2 pixel blocks and only stores the average color information for each 2x2 pixel group. This process introduces two kinds of errors.

2. Transform coding: It is a type of compression for natural data like photographic images. It will result a low quality output of original image. It is a core technique recommended by jpeg. Transform coding is used to convert spatial image pixel values to transform coefficient values. Since this is a linear process and no information is lost, the number of coefficients produced is equal to the number of pixels transformed. Many types of transforms have been tried for picture coding, including for example Fourier, Karhonen-Loeve, Walsh-Hadamard, lapped orthogonal, discrete cosine (DCT), and recently, wavelets.

3. Fractal Compression: It is a type of compression for natural data like photographic images. It will result a low quality output of original image. It is a core technique recommended by jpeg. Transform coding is used to convert spatial image pixel values to transform coefficient values. Since this is a linear process and no information is lost, the number of coefficients produced is equal to the number of pixels transformed. Many types of transforms have been tried for picture coding, including for example Fourier, Karhonen-Loeve, Walsh-Hadamard, lapped orthogonal, discrete cosine (DCT), and recently, wavelets.

IV. TYPES OF IMAGES

A. TIFF

The TIFF (Tagged Image File Format) is a flexible format which can be used for lossless or lossy Compression [4].In practice, TIFF is used as a lossless image storage format in which image compression is not used. For web transmission TIFF files are not used because TIFF files require large size.

B. GIF

Graphics Interchange Format (GIF) is useful for images that have less than 256 colors, gray scale. GIF is limited to an 8 bit or 256 colors. So that it can be used to store simple graphics, logos and cartoon style images. It uses loss less compression.

C. RAW

RAW file format includes images directly taken from Digital cameras. These formats normally use loss less or lossy compression method and produce smaller size Images like TIFF. The Disadvantage of RAW Image is that they are not standardized image and it will be different for different manufactures. So these images require manufacture's software to view the images.

D. PNG

The PNG (portable Network Graphics) file format supports 8 bit, 24 bit, 48 bit true color with and without alpha channel. Lossless PNG format is best compare to lossy JPEG. Typically, an image in a PNG file can be 10% to 30% more compressed than in a GIF format [5].PNG format have smaller size and more colors compare to others.

E. JPEG

Joint Photographic Expert Group (JPEG) is a lossy compression technique to store 24 bit photographic images. It is widely accepted in multimedia and imaging industries. JPEG is 24 bit color format so it have millions of colors and more superior compare to others[6].it is used for VGA(video graphics Array) display.JPEG have lossy compression and it support 8 bit gray scale image and 24 bit color images.

F. JPEG2000

JPEG 2000 is a compression standard for lossless and lossy storage.JPEG2000 improves the JPEG format. It is nearly same as JPEG.

G. EXIF

The Exif (Exchangeable Image File Format) is similar to JFIF format with TIFF extension. it is used to record and exchange of images with image metadata between the digital camera and editing and viewing software.

H. WEBP

WEBP is a new image format that use lossy image compression. It was designed by Google to reduce image file size to increase the speed when web page is loading. It is based on VP8s infra frame coding.

I. BMP

The Bitmap (BMP) file format deal with graphic file related to Microsoft windows OS. Normally these files are uncompressed so they are large. These files are used in basic windows programming. [7] BMP images are binaryfiles.BMP file does not support true colors.

J. NETPBM

NetPbm format contain three family formats: the PPM (portable Pixel Map), the PGM (portable Gray Map) and the Portable bit map. [8] These files are pure ASCII files or raw binary files.

V. QUALITY OF IMAGES

The best algorithm is measured depends on the following 3 factors:

- The quality of the image
- The amount of compression

• The speed of compression.

A. Quality of the Image

The quality of an image after being compressed depends on usage of two kinds of compression such as:

• Lossless compression
• Lossy compression

B. Amount of Compression

The amount of compression depends on both the compression method and the content of the image.

C. Speed of Compression

The speed of image compression and decompression depends on various factors such as the type of file, system hardware, and compression method

VI. DISCUSSION AND CONCLUSION

We have reviewed and summarized the characteristics of image compression, need of compression, principles behind compression and various image compression algorithms, we also discussed about the types of the images. We got to know about that the best image compression algorithm should contain high quality; high compression and speed of compression should also be fast. In future we will try to mix different approach of image compression algorithm to achieve the desired result.

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