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Conceptual Framework Strategies for Image Compression: A Review

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Abstract— **Image compression plays an important role in digital image processing, it is also very crucial for efficient transmission and storage of images. In image compression, does not only concentrate on reducing size but also concentrate on doing it without losing quality and information of image. This paper summarizes the image compression techniques that may be lossy and lossless and research possibilities.**

Keywords- *Image Compression; Lossy Techniques; Lossless Techniques*

I. INTRODUCTION

An Image is nothing more than a two-dimensional signal processed by the human visual system. The signals representing images are usually in analog form. In order to store an analog signal infinite memory is required to store it and since that is not possible so they are converted from analog to digital form and then store it in digital computer and then performs operations on it.

The digital image is represented as a matrix of pixel value and each pixel for each color is represented in integer value ranging from 0 to 255 occupying 8bits. The RGB image has 3 planes representing three primary colors namely Red, Green and Blue color as components of an image. Image compression is to reduce irrelevance and redundancy of the image data in order to be able to store or transmit data in an efficient form.

There are many applications requiring image compression, such as multimedia, internet, Satellite imaging, remote sensing, and preservation of art work, etc. Image compression may be lossless or lossy. Lossless compression is a class of data compression algorithms that allows the original data to be perfectly reconstructed from compressed data. On the other hand in lossy compression permits reconstruction only of an approximation of the original data, this usually improves compression rates.

II. IMAGE COMPRESSION

The main idea in image compression is to reduce the data stored in the original image to a smaller amount of data. Compression is achieved by the removal of one or more of the three basic data redundancies [1]:

a. Coding Redundancy
b. Interpixel Redundancy
c. Psych visual Redundancy

Coding redundancy is present when less than optimal code words are used. Interpixel redundancy results from correlations between the pixels of an image. Psych visual redundancy is due to data that is ignored by the human visual system (irrelevant information).In Figure 1, outline of image compression where each block in the implementation phase applies a discrete algorithm, That is contingent upon the application, approach and the type and level of desired compression. Any digital image is viewed just as a two-dimensional matrix in a spatial domain. The compression algorithm transforms the image, or frame, to a different dimension and domain, in which individual components of the image can be analyzed. Post analysis, redundant image components are quantized and the image matrix is encoded by using lossless or lossy compression techniques. The encoded image stream is converted into compressed (encoded) digital bit streams, which are used for transmission or storage [2].

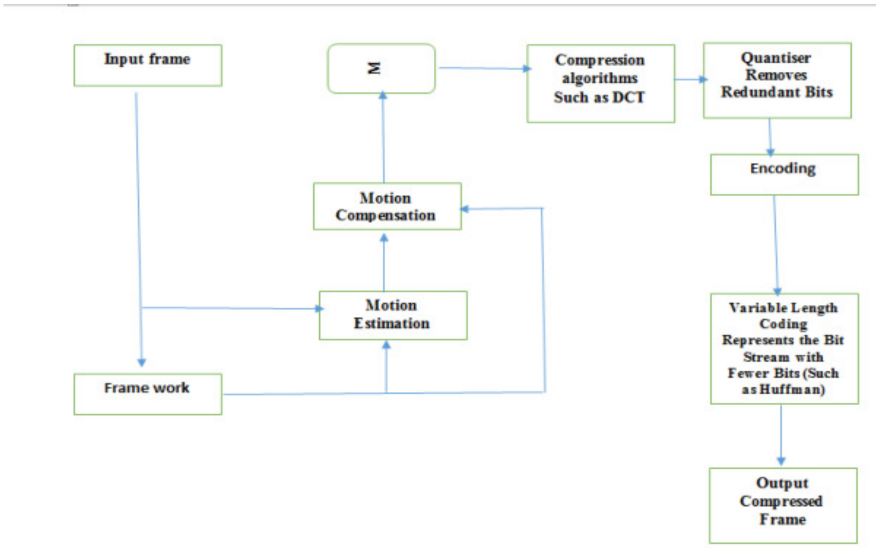

Figure1. Out Line of an Image

A. Advantages of Image Compresion

- Among the prime advantages of image/video compression is size reduction. Based on the application, an image/video stream can be compressed to the required size, which can eventually save storage space. Therefore, it is cost-effective. For situations that involve large amounts of data, this generates significant impact, optimizing archiving and producing appreciable cost savings.
- Another advantage is the variable quality retrieval procedure. This is also referred to as progressive resolution encoding. Some image/video playback devices do not support high-resolution data streams or may restrict the bandwidth through which the content is delivered. This prevents streaming of uncompressed high-quality data over such devices. In such cases, image decoder (decompression) can be tuned to deliver appropriate data quality from the compressed stream.
  - Transmission of compressed digital media content between electronic devices or Web hosts and the device's retrieval rate is faster, thereby improving the workflow of the process.
  - To reduce the time taken for transmission of an image to be sent over the internet or download from the web pages.
  - Image Archiving :Satellite Data
  - Image Transmission: Web Data
  - Multimedia Applications: Desktop Editing

III. IMAGE COMPRESSION TECHNIQUES

The image compression techniques are broadly classified into two classes: lossy or lossless compression. The appropriate type of compression that is followed is based on the nature of the application.

A. Lossless compression technique

Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics. Applications that mandate zero loss in the quality of images and videos upon archiving require the lossless compression technique. Examples are found in healthcare industries which deal with radiographic images and manufacturing industries which use machine drawings images and whose intricate details are significant. Similarly, images of circuit diagrams, etc. are another example that demands zero loss in quality and hence use the lossless compression technique. In figure 2 outline of lossless compression[3][4].

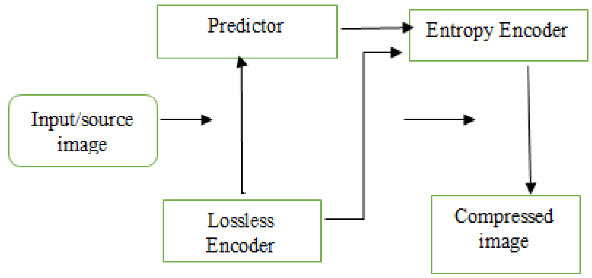

Figure 2: Lossless Compression

Following techniques are included in lossless compression:

1. Run length encoding
2. Huffman encoding
3. Area coding

1) Run Length Encoding

Run length encoding is a lossless data compression technique which replaces data by a (length, value) pair, where value is the repeated value and length is the number of repetitions. It can be used to compress data made of any combination of symbols. It does not need to know the frequency of occurrence of symbols and can be very efficient if data is represented as 0s and 1s [5].

Original Data: BBBBBAAAACCC.
Compressed Data: B05A04C03.

2) Huffman Encoding

Huffman Coding is an entropy encoding algorithm used for lossless data compression. Huffman Coding utilizes a variable length code in which short code words are assigned to more common values or symbols in the data, and longer code words are assigned to less frequently occurring values. The Huffman's algorithm is generating minimum redundancy codes as compared to other algorithms. The Huffman coding has effectively used in text, image, video compression, and conferencing system such as, JPEG, MPEG-2, MPEG-4, and so on [6].

The pixels in the image are treated as symbols. The symbols that occur more frequently are assigned a smaller number of bits, while the symbols that occur less frequently are assigned a relatively larger number of bits. Huffman code is a prefix code. This means that the (binary) code of any symbol is not the prefix of the code of any other symbol [7][8][9].

a) Huffman Coding and Decoding Algorithm

Step1 - Read the image on to the workspace.
Step2- Convert the given color image into grey level image.
Step3-Call a function which will find the symbols (i.e. pixel value which is non-repeated).
Step4-Call a function which will calculate the probability of each symbol.
Step5- Probability of symbols are arranged in decreasing order and lower probabilities are merged and thisstep is continued until only two probabilities are left and codes are assigned according to rule that the highest probable symbol will have a shorter length code.
Step6- Further Huffman encoding is performed i.e. mapping of the code words to the corresponding symbols will result in a compressed data.
Step7- The original image is reconstructed i.e. decompression is done by using Huffman decoding.
Step8- Generate a tree equivalent to the encoding tree.
Step9- Read input character wise and left to the table until last element is reached in the table.
Step10-Output the character encode in the leaf and return to the root, and continue the step9 until all thecodes of corresponding symbols are known.

b) Area coding

The gray value image is divided into m*n large blocks which are black, white or mixed. The most probable type of block gets the 0, the other get codes 10 and 11 and mixed blocks are followed by a bit pattern of it.
Area coding is an enhanced form of run length coding, reflecting the two dimensional characters of images. This is a significant advance over the lossless methods. For coding an image it does not make too much sense to interpret it as a sequential stream, as it is in fact an array of sequences, building up a two dimensional object. Therefore as a two dimensions are independent and of same importance, it is obvious that a coding scheme aware of this has some advantages. The algorithms for area coding try to find rectangular regions with the same characteristics. These regions are in a coded in descriptive form as an element with two points and a certain structure.

B. Lossy compression technique

Lossy methods are especially suitable for natural images such as photographs in applications where minor (sometimes imperceptible) 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. In figure 3 outline of lossy compression
.
Following techniques are included in lossy compression:

1. Transform Coding
2. Discrete Cosine Transform (DCT)
3. Discrete Wavelet Transform (DWT)
4. Fractal Compression

1) Discrete Cosine Transform (DCT)

DCT is a lossy Compression technique which is widely used in area of image and audio compression. Example: JPEG Images. DCTs are used to convert data into the summation of series of cosine waves oscillating at different frequencies. These are very similar to Fourier Transforms, but DCT involves use of Cosine functions and real coefficients, Fourier Transforms use both sine and cosine functions and complex Numbers. For compression, Cosine functions are much more efficient as fewer functions are needed to approximate a signal. Both Fourier and DCT convert data from a spatial domain into a frequency domain and their respective functions [10] [11] [12][13].

Algorithm

The basic operation of the DCT algorithm is as follows:
Step 1: The input image is N by M;
Step 2: f (x, y) is the intensity of the pixel in row x and column y;
Step 3: g (u, v) is the DCT coefficient in row k1 and column k2 of the DCT matrix.
Step 4: For most images, much of the signal energy lies at low frequencies; these appear in the upper left corner of the DCT.
Step 5: Compression is achieved since the lower right values represent higher frequencies, and are often small enough to be neglected with little visible distortion.
Step 6: The DCT input is an 8 by 8 array of integers. This array contains each pixel's gray scale level.
Step 7: 8 bit pixels have levels from 0 to 255.

2) JPEG Compresion

JPEG Standard is the very well- known ISO/ITU-T standard created in the late 1980s. JPEG standard is targeted for full- color still frame applications. One of the most common compression standard is the JPEG standard. Several modes are defined for JPEG including baseline lossless, progressive and hierarchical.

The most common mode uses the discrete cosine transform is the JPEG baseline coding system, also it is suitable for most compression applications. Despite being developed for low compressions JPEG it is very helpful for DCT quantization and compression. JPEG compression reduces file size with minimum image degradation by eliminating the least important information. But it is considered a lossy image compression technique because the final image and the original image are not completely the same and lossy compression the information that may be lost and missed is affordable. JPEG compression is performed in sequential steps [14] [15] [16].

JPEG Process Steps for color images:

- An RGB to YCbCrcolor space conversion (color specification)
- Original image is divided into blocks of 8 x 8.
- The pixel values within each block range from [-128 to 127] but pixel values of a black and white image range from [0-255] so, each block is shifted from [0-255] to [-128 to 127].
- The DCT works from left to right, top to bottom thereby it is applied to each block.
- Each block is compressed through quantization.
- Quantized matrix is entropy encoded.
- Compressed image is reconstructed through reverse process. This process uses the inverse Discrete Cosine Transform (IDCT).

3) Discrete Wavelet Transform (DWT)

The DWT represents an image as a sum of wavelet functions, known as wavelets, with different location and scale. The discrete wavelet transform usually is implemented by using a hierarchical filter structure. It is applied to image blocks generated by the pre-processor. Two-dimension DWT leads to decomposition of approximation coefficients at level j in four components: the approximation at level j+1, and the details in three orientations (horizontal, vertical, and diagonal).

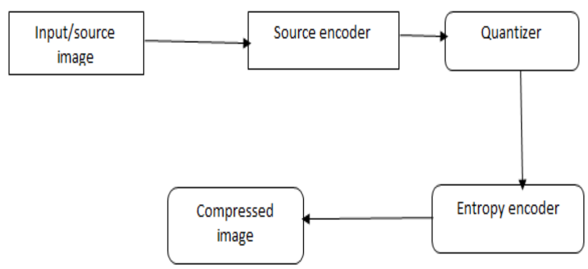

Figure 3. Lossless Compression

IV. CONCLUSION

Image Compression is used for managing images in digital format. In this techniques reduce the number of bits required to represent an image by taking benefits of redundancies. This survey paper has been focused on the fast and efficient lossy and lossless compression technique JPEG for image compression step and decompression step using Discrete Cosine Transform (DCT). The review makes clear that the field will continue to interest researchers in the days to come.

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