Image Compression and Various Approaches –A Review

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Abstract: Medical images are very much important in the field of medical science for the future reference of the patients, needs to be stored. These images require the process of compression before storing it. Compression is a process of encoding the image and to reduce the size of image, storage and transmission. In this paper comparative analysis of different medical images compression techniques and performance results has been discussed. However, the medical image compression has intense scope in future but it also has lot of difficulties and challenges to achieve necessities of the medical field.

Keywords: *Compression techniques, medical images, Lossy and Lossless image compression techniques, Compression Ratio.*

I. INTRODUCTION

The usage of medical images became necessary for the diagnosis of patients and hence large numbers of images are produced and used. Due to the large generation of medical images, it is very much essential to process the compression of images. Henceforth compression of medical images plays a vital role for storage and transmission. There are different compression techniques uses different medical images like Magnetic resonance images (MRI) and X-ray angiograms (XA) etc. DICOM (digital imaging and communications in medicine) is used for storing, transmitting and viewing of the medical images. However, even with such advancement in medical science, there is a gap between the medical science and technologies available to support it with an anticipated goal. It is very important that while performing compression on the medical images, the effectiveness of resolution as well as perceptual quality be restored. It is also known that compression is also accompanied by certain loss of significant information if the data are massive and channel capacity is highly limited for transmission purpose. Nowadays there are many applications where the image compression tools used to effectively increased efficiency and performance. Applications like Health Industries, Retail Stores, Federal Government Agencies, Security Industries, Museums and Galleries etc.

II. LITERATURE SURVEY

An effort has been done to provide effective storage of medical images with patient medical record for future use and also for effective transfer between hospitals and health care centers. In the following, the most important medical image compression techniques that have been proposed are revised: In [8], a method has been developed for a 3-D image compression. It uses a separable non-uniform 3-D wavelet transform. The non-uniform 3-D transform applies one wavelet filter bank in the x and y directions, and a second wavelet filter bank in the z direction. The second wavelet filter bank is selected for image sets at various slice distances according to the best compression performance. In [9] Rodet et al., make use of steps named decomposition, quantification and un-compression based on Fourier decomposition. Hashimoto et al., [10] proposed a system of lossless compression by using the Region of Interest (ROI) method by means of optimal degree, motion remunerated and lossless compression in additional areas. The process works by first applying the segmentation process to the input image. After that motion compensated coding is applied. The next step involves the utilization of entropy minimizing coding of motion vector. The method is tested on CT images. The experimental results showed that 2.5% rate can be achieved by this compression method.

Ref.	Advantages	Limitations	Results
[8]	Image quality is preserved by removing the noise factor	A bit slow system	Compression rate was enhanced by 70% for MRI and by 35%CT
[9]	Handle the compression ratio and limitations of signal quality	Excellence of signal	A great compression rate with minimization of the processing time
[10]	Can handle both 2D and 3D medical image	Involves too many processes	Compression ratio of 2.5% is achieved
[11]	Noise removal	Quality of image is affected	Acceptable and promising compression rates are achieved
[12]	Image quality is preserved	Coding is activated only when inter frame correlation is high enough	Compression gains: 13.3% and 26.3%
[13]	Image quality is preserved	Expensive system	improvement of more than 40% incompression ratio without deterioration in image quality
[14]	Image quality is good	has better performance than JPEG with low and high bit rates.	
[15]	success rate of 80 percent	Small average distortion can result in a damaging visual artifact	compression ratios are in the range of 40"s and the PSNR values in the range of 50"s

In [11] Kanoun et al, makes use of DCT which is the most common method among the compression methods. The results indicate that it can be applied to different medical modalities together with the feature of image quality preservation factor. A lossless compression method for medical image sequences using JPEG-LS and inter-frame coding is presented in [12]. Another lossless medical images compression method was introduced by Tzong-Jer and Keh-Shih [13]. This method is based on eliminating the noise factor without damaging the image quality. The results of this method show that the use of Haar wavelet transform in the slice direction gives the optimum results in the majority of cases except for the CT image set with 1-mm slice distances. In 2012, Dubey and Singh, have proposed 3D medical image compression using Huffman encoding technique, by converting colour image into grey level image. Then the symbols that represent pixel values which is non-repeated are defined. Then the probability of each symbol is calculated and arranged in deciding order. Then this probability is divided into groups of two which each group merged into one. This procedure is continued until reaching only two probabilities. The codes are then assigned according to the rule "the highest probable symbol will have a shorter length code". Thus, Huffman encoding is performed [14]. In [15] image compression technique is performed using bi-orthogonal filters for implementing the wavelet decomposition. The decomposed images are then passed through an m channel analysis-synthesis filter and the compression is done using FIR-IIR filters [9]-[10].This analysis leads to the horizontal, vertical, approximation and diagonal details. The analysis-synthesis filters are based on the Quadrature Mirror Filters (QMF). Table 1 summarizes the above-mentioned medical image compression techniques.

III. IMAGE COMPRESSION TECHNIQUES

The need for data storage capacity and transmission bandwidth continues to exceed the capability of available technologies. The process of obtaining a compact representation of an image while maintaining all the necessary information important for medical diagnosis is referred to as image compression. Image compression is basically a process of reducing the size in bytes of images deprived of demeaning the superiority and quality of the image to an objectionable level. The decrease in image size permits further images to be deposited in a specified quantity of disk or memory space, in order to present a part of human body in digital form. The image compression methods are generally categorized into two central types: Lossless and Lossy methods

Fig1 : Difference between Lossless and Lossy Image

The major objective of each type is to rebuild the original image from the compressed one without affecting any of its numerical or physical values [2].

A. Lossless Compression Techniques

In lossless compression scheme, shown in Fig. the reconstructed image, after compression, is numerically identical to the original image.It is used in many applications such as ZIP file format & in UNIX tool gzip.It is important when the original & the decompressed data be identical. Some image file formats like PNG or GIF use only lossless compression. Most lossless compression programs do two things in sequence: the first step generates a *statistical model* for the input data, and the second step uses this model to map input data to bit sequences in such a way that "probable" (e.g. frequently encountered) data will produce shorter output than "improbable" data. Lossless compression is therefore a demand however, due to the cost, it is used only for a few applications with stringent requirements such as medical imaging.

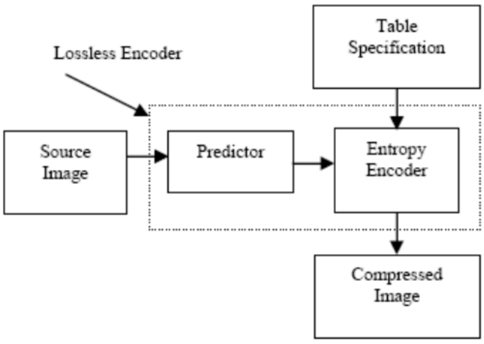

Fig 2: Block Diagram for Lossless Compression Various lossless compression techniques are as follows.

1) Run Length Encoding:

Run length Encoding (RLE) is basically based on the idea of encoding a consecutive occurrence of the same symbol. This is achieved by replacing a series of repeated symbols with a count and the symbol. That is, RLE finds the number of repeated symbols in the input image and replaces them with two-bytes code. The first byte for the number and the second one is for the symbol. For a simple illustrative example, the string AAAAAABBBBCCCCC" is encoded as A6B4C5"; that saves nine bytes (i.e. compression ratio =15/6=5/2). However in some cases there is no much consecutive repetition which reduces the compression ratio. An illustrative example, the original data “12000131415000000900”, the RLE encodes it to “120313141506902”(i.e. compression ratio=20/15=4/3). Moreover if the data is random the RLE may fail to achieve any compression ratio [4]-[5].

2) Entropy encoding:

An entropy encoding is a coding scheme that involves assigning codes to symbols so as to match code lengths with the probabilities of the symbols. Typically, entropy encoders are used to compress data by replacing symbols represented by equal-length codes with symbols represented by codes proportional to the negative logarithm of the probability. Therefore, the most common symbols use the shortest codes. Entropy is a lower bound on the average number of bits needed to represent the symbols (the data compression limit). Entropy coding methods, aspire to achieve the entropy for a given alphabet. A code achieving the entropy limit is optimal

$$\text{Bits Per Symbol (BPS)} = \frac{|\text{Encoded Message}|}{|\text{Original Message}|}$$

3) Huffman encoding:

It is the most popular technique for removing coding redundancy. When the symbols of an information source are coded individually, Huffman coding yields the smallest possible number of code symbols per source symbols. This method is started with a list of the probabilities of the image data elements. Then, take the two least probable elements and make them two nodes with branches (labeled “0” and “1”) to a common node which represents a new element. The new element has a probability, which is the sum of the two probabilities of the merged elements. The procedure is repeated until the list contains only one element [6]. Thus statistical occurrence frequencies (probabilities) to carry out the process are used. Each pixel of the image is treated as a symbol. Then histogram then computed to count the frequency occurrence of each symbol.

4) LZW coding:

LZW (Lempel- Ziv – Welch) is a dictionary based coding which can be static or dynamic. In static coding, dictionary is fixed during the encoding and decoding processes. In dynamic coding, the dictionary is updated on fly. LZW is widely used in computer industry and is implemented as compress command on UNIX [4].

5) Area coding:

Area coding is an enhanced form of RLE, reflecting the two dimensional character of images. This is a significant advance over the other lossless methods. For coding an image, it handles the image as an array of sequences building up a two dimensional object. The algorithms for area coding try to find rectangular regions with the same characteristics. These regions are coded in a descriptive form as an element with two points and a certain structure. This type of coding can be highly effective but it bears the problem of a nonlinear method, which cannot be implemented in hardware. Therefore, the performance in terms of compression time is not competitive, although the compression ratio is in comparison with RLE that deals with two dimensional characters of images [6].

B. Lossy Compression Techniques

Lossy compression technique provides higher compression ratio than lossless compression. In this method, the compression ratio is high; the decompressed image is not exactly identical to the original image, but close to it. Different types of lossy compression techniques are widely used, characterized by the quality of the reconstructed images and its adequacy for application.

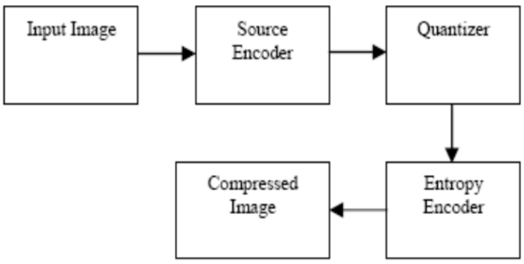

Fig 3: Block Diagram for Lossy Compression

In the following subsections, several Lossy compression techniques are reviewed:

1) Transformation coding:

Another approach to image compression is the use of transformations that operate on an image to produce a set of coefficients. A subset of these coefficients is chosen and quantized for transmission across a channel or for storage. The goal of this technique is to choose a transformation for which such a subset of coefficients is adequate to reconstruct an image with a minimum of discernible distortion. The Fourier Transform (FT) is not a practical approach to represent boundaries and edges of objects of an image. However, Wavelet Transform (WT) provides multi resolution analysis in which edges and boundaries can be represented. Since WT and cosine transform have become the most popular technique for image compression, we devote this subsection to review them.

2)* Discrete Cosine Transform (*DCT):

The DCT process is applied on blocks of 8 * 8 or 16 * 16 pixels, which will convert into series of coefficients, which define spectral composition of the block. The Transformer transforms the input data into a format to reduce interpixel redundancies in the input image. Transform coding techniques use a reversible, linear mathematical transform to map the pixel values onto a set of coefficients, which are then quantized and encoded. The key factor behind the success of transform-based coding schemes is that many of the resulting coefficients for most natural images have small magnitudes and can be quantized without causing significant distortion in the decoded image.DCT Attempts to decorrelate the image data after decorrelation each transform coefficient can be encoded without dropping off compression efficiency.

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 DWT represents the image data into a set of high pass (detail) and low pass (approximate) coefficients. The image is first divided into blocks of 32×32. Each block is then passed through the two filters: the first level decomposition is performed to decompose the input data into an approximation and detail coefficients. After obtaining the transformed matrix, the detail and approximate coefficients are separated as LL,HL, LH, and HH coefficients. All the coefficients are discarded except the LL coefficients that are transformed into the second level. The coefficients are then passed through a constant scaling factor to achieve the desired compression ratio.

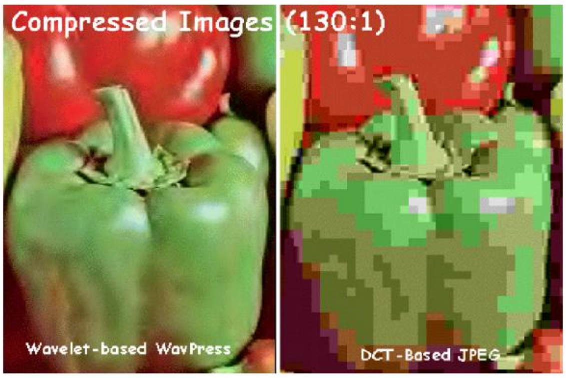

Fig 4: Compressed Image of DWT and DCT

4) Fractal coding: Fractal image compression is a process to find a small set of mathematical equations that can describe the image. By sending the parameters of these equations to the decoder, we can reconstruct the original image. In general, the theory of fractal compression is based on the contraction mapping theorem in the mathematics of metric spaces [6].

5) Block truncation coding:

In block truncation coding, the image is divided into non overlapping blocks of pixels. For each block, threshold and reconstruction values are determined. The threshold is usually the mean of pixel values in the block. Then a bitmap of the block is derived by replacing all pixels whose values are greater than or equal and less than to the threshold by a 1 and 0, respectively. Then for each segment there are groups of 1s and 0s in the bitmap, the reconstruction value is determined as the average of the values of the corresponding pixels in the original block [17].

6) Sub band coding:

In this scheme, the image is analyzed to produce the components containing frequencies in well-defined bands, the sub bands. Subsequently, quantization and coding is applied to each of the bands. The advantage of this scheme is that the quantization and coding well-suited for each of the sub bands can be designed separately [17].

C. Compression Ratio

The compression ratio (that is, the size of the compressed file compared to that of the uncompressed file.

$$\text{Compression ratio} = \frac{\text{original data size}}{\text{compressed data size}}$$

If the compression and decompression processes induce no information loss, then the compression scheme is lossless; otherwise, it is lossy.

1. Video can be compressed immensely (e.g. 100:1) with little visible quality loss

2. Audio can often be compressed at 10:1 with imperceptible loss of quality[18]

3. Still images are often lossily compressed at 10:1, as with audio, but the quality loss is more noticeable, especially on closer inspection. Lossy compressors generally obtain much higher compression ratios than do lossless compressors. Say 100 vs. 2. Lossy compression is acceptable in many imaging applications[19]. Lossless compression is essential in applications such as text file compression. In video transmission, a slight loss in the transmitted video is not noticed by the human eye.

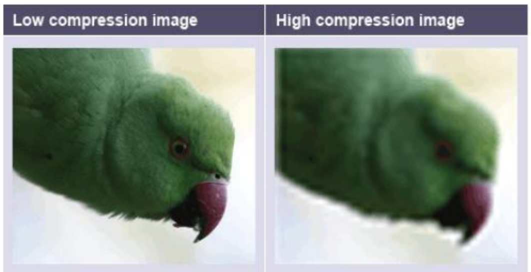

Fig 5: Comparison of low compression and high compression image

CONCLUSION

Even though there exists abundant research work on medical image compression considering lossy and lossless types, but the need of medical images to be compressed efficiently with optimal compression ratio is yet a question mark. Also it has been found from previous research work that most of the work was intended to the 2D medical images. So, there is need to develop effective compression algorithm for 3D medical images.

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