A Review on Region of Interest (ROI) based compression Techniques for Medical Images

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Abstract :

In various sectors of image processing, the compression of images plays a vital part to store and communication. In this work handles the compression of image, the needs of comparison, and varied methods of compression. This paper also provides Region of Interest (ROI) based coding techniques which overcome the limitations of lossy and lossless compression techniques. ROI based coding technique is mainly introduced for medical images.

I. INTRODUCTION

Image Compression

The foremost goal of 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. The use of computer graphics is advertising and entertainment is widespread, and its use in scientific visualization and engineering applications is growing at rapid pace. The reason for this interest in digital images is clear as representing images in digital form allows visual information to be easily manipulated in useful and simple ways. Compression is achieved by the removal of one or more of the three basic data redundancies:

1. Coding Redundancy: It arises when less than optimal code words are used. A code contains symbols (bits, letters, numbers) used to represent information or set of events. Each piece of information or events is assigned a sequence of code symbols, called a code word. The number of symbols in each code word is its length.

2. Interpixel Redundancy: It is also known as spatial redundancy or temporal redundancy. Because the pixels of image are correlated spatially, information is unnecessarily replicated in the representations of the correlated pixels. In video sequence, temporally correlated pixels also provide replicate information.

3. Psychovisual Redundancy: Most data/arrays contain irrelevant information that is ignored by the human visual system and unrelated to the anticipated use of the image. It is redundant in the sense that it is not used. Image compression research aims at reducing the number of bits needed to represent an image by removing the spatial and spectral redundancies as much as possible.

Need of Image Compression:

- Reduce the execution time as less data is transferred.
- Reduce the probability of transmission errors as fewer bits are transferred.
- To minimize the memory footprint of image data so that storage and transmission times are minimized.
- Reduce the cost as less data is transferred.
- Reducing the memory image data will correspondingly reduce internet bandwidth consumption.

Techniques of Image Compression

1. Lossless Compression Method.

2. Lossy Compression Method.

An image compression system is shown in Fig. 1. The data reduction, or compression, is performed by a device known as the encoder. The encoder reduces the data size of the original image X. The compressed image Y is the output which passes through a channel (usually an actual transmission channel or a storage system) to the decoder. The decoder reconstructs, or decompresses, the image Z from the compressed data. The ratio of the size (amount of data or bandwidth) of the original image to the size of the compressed image is known as the compression ratio or compression rate. The compression ratio can also be expressed in bpp (bits per pixel). The term bit rate is a general term for bpp. The higher the compression rate, the greater is the reduction of data [2]. Depending on the application, the channel may be affected by noise which results in distortion of the compressed image during transmission. If so, the channel is known as an error-prone channel; otherwise, it is errorless.

Lossless Compression Method:

In this method, the exact original data can be recovered. These are also called noiseless since they do not add noise to the signal/image. It is also known as entropy coding since it use statistics/decomposition techniques to minimize redundancy. Lossless compression is used only for a few applications with stringent requirements such as medical imaging.

Lossy Compression Method:

In this method, only close approximation of the original data can be obtained. A reconstructed image contains degradation relative to the original image. Often this is because the compression scheme completely discards redundant information. However, lossy schemes are capable of achieving much higher compression.

ROI based Image Compression:

ROI concept is introduced owing to limitations of lossless and lossy compression techniques Medical imaging has a great impact on the diagnosis of diseases and surgical planning. However, imaging devices continue to generate more data per patient, often 1000 images. These data need long-term storage and efficient transmission. Most of the lossless compression techniques, the compression ratio are near to 80% of original size, whereas for lossy encoders the compression ratio is much higher (up to 5-30 %) but there may be significant loss in data. This loss may hamper effective treatment, losing diagnostically important parts of the medical image. Hence, there is a need for that compression technique which will preserve image diagnostically.

The functionality of ROI is important in medical applications where certain parts of the image are of higher diagnostic importance than others. In such a case, these regions need to be encoded at higher quality than the background. During image transmission for telemedicine purposes, these regions are required to be transmitted first or at a higher priority. Usually, the wavelet transform is applied to the image at the encoder side and the resulting coefficients not associated with the ROI are scaled down (shifted down) so that the ROI-associated bits are placed in higher bit planes. The mask in the wavelet domain is a map pointing out all the related coefficients for the reconstruction of the ROI. The corresponding locations of the coefficients in the next scale are calculated from the current scale.

Different ROI based techniques are applied on the medical image compression for producing better results, as higher compression ratio, high peak-signal-to-noise ratio values, less mean square error, less processing time and so on. For better results transform coding schemes such as Principal Component Analysis (PCA) and Discrete Cosine Transform (DCT), SPIHT (set partitioning in hierarchical trees), MAXSHIFT, are used. ROI coding schemes developed for two-dimensional (2-D) still medical images, ROI coding in the case of volumetric images, A prototype ROI encoder for compression of angiogram video sequences is presented. ROI coding schemes give best results for two-dimensional medical images.

Need of ROI

ROI technique mainly introduced for medical images where more loss of information is not allowed, especially in the fields of diagnosis and surgical planning. As imaging devices continue to generate large amounts of data per patient, which require long-term storage and efficient transmission. Current compression schemes produce high compression rates if loss of quality is affordable. However, in most cases physicians may not afford loss in important regions of images; called regions of interest (ROIs). So an approach that brings a high compression rate with good quality required ROI compression. The general theme is to preserve quality in diagnostically critical regions, applying lossless encoding technique on important region (ROI- Region) while allowing lossy encoding on the other regions (Non-ROI-Region).

II. QUALITY FACTORS

Quality Factors for an image judge the usability of an image. These facts also describe the necessary details about differences in original image and compressed image. The calculations based upon these facts help to justify the best suitable image, as per requirement. A number of quality factors are available, but the major seven factors have been defined as following:

- Mean Square Error:

The MSE is the cumulative squared error between the compressed and the original image,

- Signal-to-noise ratio:

SNR is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power, often expressed in decibels.

- Peak Signal to Noise Ratio:

PSNR is a measure of the peak error. PSNR is the difference between original image and compressed image. As PSNR values increases, the result is best.

- Data compression ratio:

It also known as compression power is a computer science term used to quantify the reduction in data representation size produced by a data compression algorithm. The data compression ratio is analogous to the physical compression ratio used to measure physical compression of substances.

- Quantization

Quantization allows passing from a continuous to a discrete set; therefore it is the main step in image digitalization. Typically one byte is used for each chromatic component.

- Transmission Rate

Transmission rate is defined as compressed image takes quite less time to transmit.

III. OVERVIEW OF SOME EXISTING COMPRESSION ALGORITHMS

"Charalampos Doukas And Ilias Maglogiannis" proposed in their paper several methods enabling ROI coding image compression in distributed telemedicine systems for various types of medical image modalities. As presented, the general scaling, the MAXSHIFT and the ROI-VQ methods require additional coefficients to decode the object, whereas RB-IWT, OB-SPIHT and OB-SPECK methods using the same number of coefficients as the entire image for background and the ROI region. From these methods, only general scaling method requires the ROI shape information to be incorporated into the bit stream, whereas most of them support arbitrary ROI coding. The exact decoding of the object feasibility refers to the ability of the method to preserve the entire ROI without pixel-blending artefacts. Finally, these methods are summarized in Table 1 with PSNR (Peak-Signal-to-Noise-Ratio) values, and relieved OB-SPIHT and OB-SPECK method has higher PSNR values without extra shape information and coefficients. Given table is comparing the PSNR values of discussed methods:

Methods for Compression	**Results (PSNR Values in db)**
General Scaling	44.91
MAXSHIFT	44.90
ROI-VQ	31.58
RB-IWT	35
OB-SPIHT, OB-SPECK	54.2

Table 1: PSNR values for Different

"Deepak.S.Thomas" in his paper provides solutions for efficient region based image compression for increasing the compression ratio with less mean square error at minimum processing time based on fast discrete curvelet transform with adaptive arithmetic coding, Lifting wavelet transform with set partitioning Embedded block coding. This project heavily utilized for compressing medical images to transmit for telemedicine application. To minimize the information loss, arithmetic entropy coding was used effectively. It will be enhanced by combining speck coding for compressing the secondary region and this hybrid approach was increased the CR and reduce the information loss. MRI brain image was used to measure the quality results and performance will be analysed through determining the image quality after decompression, compression ratio, correlation and execution time. Given table calculating the output factors for this paper:

Calculated Parameters	Results
Compression Ratio	20
PSNR values	65db
Mean Time	15Sec

Table 2: Resulting Parameters

"Lavanya. M" presented his paper for providing better image compression quality by applying lossy and lossless compression over multiple region of interest to obtain high compression ratio and good quality in primary region (ROI) and edges are detected and combined by fusion techniques. For providing faster rate of encoding and decoding process, SPIHT method is combined with discrete wavelet transform method. After that Lavanya compared the PSNR values of input and output image. Given table calculating the output factors for this paper:

Calculated Parameters	Results
I/P image size	654kb
O/P image size	14.8kb
Compression Ratio	44:1
PSNR values	51.9301db

Table 3: Resulting Parameters

V. COMPARATIVE REVIEW OF ALGORITHMS DISCUSSED

Quality of the image mainly depends upon two factors: Peak Signal to Noise Ratio (PSNR) values and Mean Square Error (MSE). For compressing the image, SPIHT method is applied by all discussed papers. Charalampos Doukas used extended OB-SPIHT and OB-SPECK method with same number of coefficients, in his paper, to compress the size of image. Deepak.S.Thomas used SPECK coding with arithmetic entropy coding to minimize the information loss. Lavanya. M used SPIHT method combined with discrete wavelet transform method for providing faster rate of encoding and decoding process.

Algorithm	PSNR values
Charalampos Doukas	54.2db
Deepak.S.Thomas	65db
Lavanya. M	51.93db

Table 3: Comparison of discussed Algorithms

VI. CONCLUSION

This paper presents various types of image compression techniques. There are basically two types of compression techniques. One is Lossless Compression and other is Lossy Compression Technique. Some of these techniques are obtained good for certain applications like security technologies. Lossy compression techniques provide higher compression rates as compared to lossless compression techniques, but lossless compression techniques do not add noise to image and lossy compression techniques lost the information more. But in certain systems, physicians may not allow any deficiency in the required area. So to overcome the limitations of lossy and lossless compression techniques, ROI based coding technique is used to provide best results for medical images where need to store images for long time with higher PSNR values and higher compression ratio. Existing algorithms also discussed in this paper and compare the results of these algorithms. From these algorithms, SPIHT method provides better results.

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