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REGION BASED MEDICAL IMAGE COMPRESSION WITH BINARY PLANE CODING

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ABSTRACT

Image compression methods which are capable of delivering high reconstruction quality are of great demand in research. Analysis of medical images is very important and crucial in diagnosis .However in medical images, only a portion of it is useful for diagnosis so there is the need to implement region based compression method for these images. This paper proposes one such region based algorithm with only a single approach which can be applied in both lossy and lossless modes. Experiments were conducted on MR brain images and the results were showing improvement with respect to traditional approaches.

Keywords: ROI image compression, MR brain image, skull stripping, binary plane difference coding.

1. INTRODUCTION

Medical imaging devices produce a large amount of data like in computed tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography (PET). This heavy data is stored in picture archiving and communication system (PACS) and using Hospital information system (HIS) which requires storage of about 5-15GB per day [1], storing of this huge data becomes more complex over a period of time. Image compression finds a useful solution for such cases which not only reduces the size but also provides a faster transmission if at any image has to be transmitted over the network. It was assumed that if the image is compressed by 8:1 compression without degrading its perceptual quality then it can increases eight times of its storage capacity [2].

Compression methods are broadly classified as lossy and lossless but in medical image processing employing a lossy scheme with 10 % compression ratio is not desirable since it may lose some important clinical information that may lead to wrong diagnosis. So employing a compression technique for such medical images require three main constraints (i) High lossless compression ratio, (ii) Resolution scalability (represents the ability to decode the compressed image at various resolutions) (iii) Quality Scalability (refers to the ability to decode the compressed image at various qualities or SNRs) [3].

Digital imaging and communications in medicine (DICOM) is the most accepted version of an medical imaging standard, this format apart from the image details it also includes the patient details, so to compress such a DICOM image file special attention has to be given for preserving the header information [4]. Region based compression method are very much useful for this scenario where a part of the image which is treated as region of interest is compressed in lossless mode and the rest which is termed as non region of interest is compressed in lossy mode.

So far many researchers who have focused their research in this area have implemented this with two different compression mechanisms/ methods which make the system computationally complex. So in order to overcome this complexity, in this paper a hybrid approach is provided to apply the compression in both modes with a single binary plane coding approach. This paper is organized as follows:

2. RELATED WORK

Region of interest is a neuro psychological concept which means a particular region which the person may be of interest and it can also be defined as the area which contains some meaningful information. In the medical images, particularly in MR brain images the region where the exact brain is represented is of interest discarding the background.

There are several approaches for extracting ROI in natural images like that are stated in [5] [6], but these techniques are not suitable for medical images. In [7], there are two methods of extracting ROI from medical images which are based on Mean square error and thresholding. But these methods do contains limitation like, the MSE approach require a reference image which is practically not possible and the later involves complexity in determining the specific threshold value for every image.

Another method named Max-shift approach is proposed in [8], in which the scaling is computed in such a way that it makes possible to have arbitrarily shaped ROIs without intimating the shape details to the decoder. However this method provides better results at higher bit rates and provides no information regarding the background [9].

Liu *et al* in [10], proposed a lossy to lossless ROI compression scheme, the scheme is based on SPIHT (set partition in hierarchical trees) and EBCOT (embedded block coding with optimized truncation). The images are segmented into fore ground and background and a chain code based coding scheme is used to code ROI's shape information [11]. Since this approach involves complex algorithm it consumes more time.

Ravi kumar *et al*, in [12], [13], proposed a block based PCA algorithm for implementing lossy and lossless compression for non ROI and ROI. This method uses

canny edge operator for extraction of mask region which produces segmentation blobs and fails to neglect the skull region specifically for MR brain images. So in order to provide a efficient ROI based image compression, in this skull stripping used for extraction of ROI and then binary plane difference coding or binary plane technique is applied in both lossy and lossless modes for Non ROI and ROI regions. This paper is organized as follows, section I presents the introduction of ROI based compression, its need and importance. Section II presents a brief literature survey on the methods and techniques that were proposed so far for ROI based image compression, their limitation and focus on the importance of this work.

3. BINARY PLANE DIFFERENCE CODING

This method can be applied in both modes (i) Lossless and (ii) Lossy.

The loss less compression technique is based on spatial domain of the image and they are very much suitable for the compression of medical images. The Lossy Binary Plane technique introduces little loss to achieve more compression rate.

The Binary Plane Techniques are applied for color images as well as for gray scale images. In all of the techniques the compressed file is maintained in two parts. The first part is bit plane and second is data table. The bit plane is collection of l's and 0's to represent whether a pixel is repeated or not. The second part is data table, which holds only the necessary pixel values. The bit plane and data table are merged into one file. To further compress, another loss less technique Huffman coding is applied and final form of compressed file is generated. [14] [15] [16].

The main objective of this technique is to take advantage of repeated values in consecutive pixels positions. For a set of repeated consecutive values only one value is retained.

In the Binary Plane Technique two codes are used to build the Bit Plane. The codes are as given below

Code 1 (one) is used to indicate that current pixel is different from previous pixel. In this case the current pixel is moved to the Data Table

Code 0 is used to indicate that the current pixel is exactly same as previous pixel. This eliminates the storage of current pixel.

(a) Numerical example for lossless mode

If the image file contains the following pixels
126 79 79 79 250 98 98 198 198 198 198 67 224 92 92 92
then the bit plane file contains 1 1 0 0 1 1 0 1 0 0 0 1 1 1 0 0 and data file is as below:

126 79 250 98 198 67 224 92
At the decoder it uses bit plane to decode the data
126 79 79 79 250 98 98 198 198 198 198 67 224 92 92 92

In the above example there is a change from 126 to 79 , so in bit plane at the first position it is'1' initially since it gone for a changes again it is represented as '1' in second position, there after it can be observed that the intensity value is not changed for third and fourth position , hence in the data table it is represented as '0 ' and '0' in respective position and this is continued for the entire values in the matrix, the same reverse process is applied at the decoder.

(a) Numerical example for lossy mode

This technique is also like Binary Plane technique but quantization is applied to reduce no of possible values of pixel, thereby reducing the number of bits needed to represent it.

Pixels: 128 78 77 79 80 113 119 125 180 188
Threshold Value: 4 which is {-2,-1, 0, 1 }=> [-2 1]

P	PP	Range	BP	DT
129	0	(-2,1)	1	129
78	128	127-130	1	78
77	78	76-79	0	--
79	78	76-79	1	79
80	79	77-80	0	--
113	79	77-80	1	113
119	113	111-114	1	119
125	119	117-120	1	125
180	125	123-126	1	180
188	180	178-181	1	188

Bit Plane: [1 1 0 1 0 1 1 1 1 1]
Data Table: [128 78 79 113 119 125 180 188]

In the above it can be seen that a quantization of value 4 is considered which lies in the interval of [-2 1], initially the first value is taken in data table and '1' is placed in bit plane, from the second value it considers the interval of previous value and the current value lie in that interval '0' is placed in data table if not a '1', and this continued for the entire matrix. It can be observed from the above example that total 10 pixel values are compressed into '8' and the two cannot be restored, that's the reason it is said as lossy mode of operation.

4. PROPOSED METHOD

This work focus on extracting the ROI from MR brain images and apply lossy bit plane technique for Non ROI and lossless BPT for ROI. This involves few steps of operation

(a) Skull stripping

Morphological image processing procedures are applied to extract the skull region from MR brain image. A structuring element of octagon shape is considered and a series of erosion, binarization and dilation process were applied to extract the region. [17].

(a) (b) (c)

Figure-1. (a) Original image (b) ROI mask (c) Extracted ROI.

(b) Partitioning of ROI and non ROI

After the extraction of ROI region from the image, the intensity values within the mask region are considered as ROI intensity values and the rest Non ROI intensity values

(c) Compression

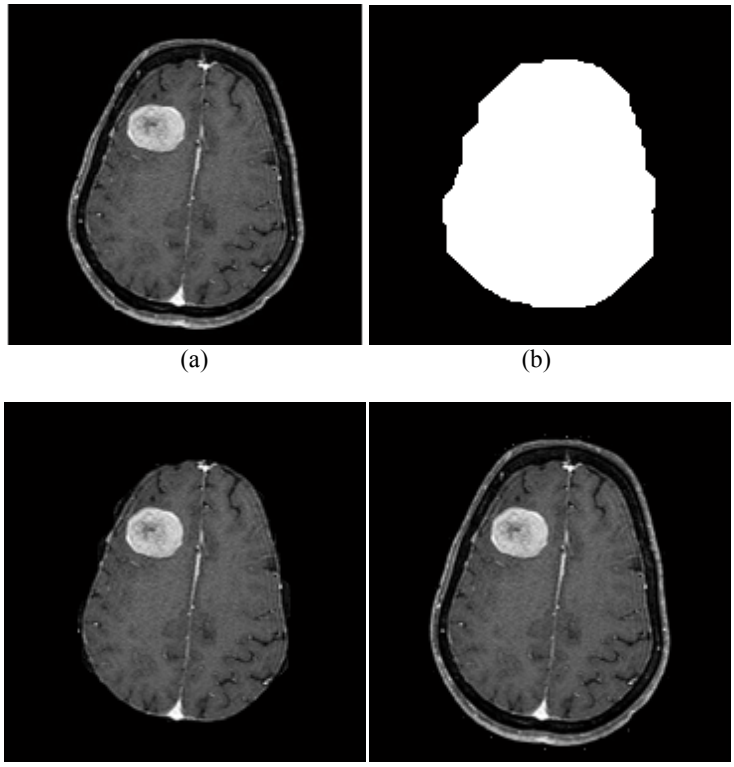
The intensity values within the mask region are compressed with BPT in lossless mode while the rest of the intensities are compressed in lossy mode. Both regions data table are bit planes are merged together to form the compressed data table and bit plane.

(d) Reconstruction

The respective bit planes are data tables are inversely transformed to obtain the reconstructed intensity values, for which the validation metrics like PSNR, MSE, SSIM are calculated.

5. EXPERIMENTAL RESULTS

This work is conducted on both real time and BRATS image database for different subjects from Cancer imaging Archive are used [18]. This method is also compared against with traditional JPEG compression [19], executed and tested on Matlab 2013 a version.



(a) (b)

(c) (d)

Figure-2. (a) Original image (b) ROI mask region (c) Extracted ROI (d) Reconstructed image.

Table-1. PSNR and SSIM values for the proposed approach and JPEG (Lossy Q=20).

Image	Proposed		JPEG	
	PSNR	SSIM	PSNR	SSIM
Patient_1	47.17	0.978	29.62	0.928
Patient_2	43.83	0.972	28.63	0.911
Patient_3	45.98	0.981	30.02	0.932
Patient_4	45.69	0.979	27.99	0.923
Patient_5	44.86	0.982	29.10	0.939

For the validation of the above experiment the proposed approach compressed images were compared with JPEG which are compressed with quality factor of 20 in terms of PSNR and SSIM (structural index metric) [20]. It is observed that the quality of the reconstructed image is 9.5 times better than the traditional approach and 6 times improvement in terms of PSNR however, since this method includes a combination of lossy and loss less modes that requires more time which almost 4.5 times more than the traditional approach.

6. CONCLUSIONS

A ROI based medical image compression is proposed in this paper where the ROLIO is extracted with the help of basic morphological operation which produces excellent results when compared with some edge detector and means square approaches and also involves a simple spatial domain based compression approach which can be operated in both lossy and loss less modes. The quality of the reconstructed images when compared with respect to JPEG shows to be better, however this limits with processing time. In future a better way of coding to be presented that consumes very less time and competes with JPEG coding.

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