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Advanced medical image compression with 2-D maximum entropy method and hybrid compression concepts

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Abstract

Objective: In medical image processing, storage and transmission of image pixels is a vital problem since diagnosis is a continuous process.
Methods: The 2D maximum entropy method segmentation followed by compression provides good results in the field of Medical image processing which has storage and transmission problems.The proposed algorithm is created using 2-D maximum entropy method segmentation and followed by Hybrid image compression.This proposal introduces an advanced compression method which combines both lossy and lossless image compression techniques. The clinical part of the image is segmented with 2-D maximum entropy thresholding and lossless techniques are applied to compress this part. Lossy image compression technology is implemented in other part of the image that is with the background picture. Run Length Encoding is applied to the resultant data to produce the compressed image.
Findings: The Advantage of using 2-D Maximum entropy method is that it considers both the grey information and neighbouring information. It can be able to produce good results even the image's signal to noise ratio (SNR) is low. Among lossy and lossless image compression methods lossless method is preferred in medical image processing since it has to protect important clinical information. Lossless compression can be able to produce lower compression ratio than lossy because it reduces the size of image only to certain limit. The experimental result shows that the proposed method provides good compression ratio and PSNR measures**.**
Novelty/Improvements: Future enhancement of this algorithm is that the neural network algorithm such as self-organizing feature map can be used to find out the threshold value automatically.

Keywords: Segmentation, 2-D Maximum Entropy Thresholding, Losslessimage Compression, Lossy Image Compression, Decompression

1. Introduction

To diagnose different diseases and to provide a treatment, medical images in digital format taken from radiographs are utilized in hospitals. Such as Tomography(CT) images, Magnetic resonance imaging(MRI) images and Digital subtraction Angiography(DSA) images.This digital format of images facilitates transferring of images and it allows for its visual diagnostic information to be manipulated. The potential problem of working with these digital images is that large number of bits are required for their representation.The main aim of this proposed method is that the image pixels are classified into two groups: required image part and the background image pixels. There are many methods have been proposed to select a better threshold value in the field of image segmentation. But it can be divided into two groups: Global thresholding and Local thresholding [1]. The Global thresholding may be dependent on either a point or an area. If it is point dependent, it considers the grey value of a particular pixel and not the neighbouring pixel. According to gray level histogram, if it is 00, it may be black, 10 means boundary, 01 represents the pixel origin, 11 denotes white colour. In the case of Area or region dependent thresholding technique, the neighbouring pixels also took part in selecting thresholding value. On the other hand, the local thresholding method partitions the given image into sub images and finds threshold value for each and every image. Though point dependent thresholding is simple, the global thresholding technique is applied to segment the image which uses both grey-level distribution and spatial information. This paper explains about segmentation concepts, how the hybrid compression technique is applied to medical images and experimental results and discussion.

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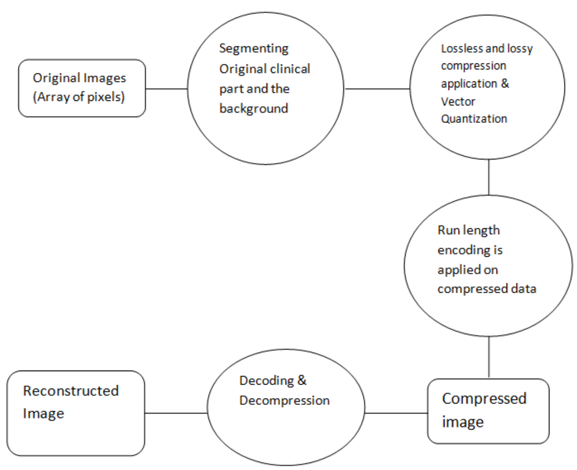
2.Materials and Methods

Image compression can be categorised as a reversible compression and non-reversible compression.In reversible compression also known as bit preserving or lossless, the reconstructed image is similar to the original image on a pixel by pixel basis.In non-reversible compression also known as lossy,the reconstructed image is identical to the original image with little loss of information which is not essential part. The compression ratio can be much higher in non-reversible compression as compared to reversible compression. In the case of medical imaging applications, reversible compression must be used to achieve efficient compression ratio. The compression scheme includes image decomposition or image transformation, quantization, Encoding. Edge detection and feature extraction algorithms are also applied for pre-processing the image to increase compression ratio with improved picture quality which is essential for medical imaging applications.The image decomposition or transformation is a reversible process and it reduces the dynamic range of the signal to eliminate redundant information of the signal [2]. The reversible compression and non-reversible compression differs in the compression step quantization. The numbers of possible output image pixels are reduced after quantizing the data. After encoding the quantized data the input image is compressed. For decompression, the reverse process is applied [3].

2.1 Hybrid image compression

A new hybrid compression approach [4] is treated in medical images as significant regions and non-significant regions. That is, significant regions are clinically relevant areas and non-significant regions are not clinically important. The diagnostics or physicians are going to work with clinically relevant regions and therefore these regions may be compressed using lossless compression scheme. Most lossy compression algorithms such as JPEG may be applied with clinically not relevant areas [5]. Figure 1 represents Schematic diagram of proposed compression steps.

Figure 1. Schematic diagram of proposed compression steps



2.2.Segmentation

To make image compression effective, the important clinical information of an Image is to be segmented from its background without affecting the required image pixel values [6].There are different methods to segment the original image. In Grey scale medical images the background pictures are black in colour. But the image pixels are grey, light grey, white or black. Most probably the background pixels are black in colour. 01 and 10 represents the gray values. The gray value 10 represents the boundary of the image. 01 denotes the starting pixel of the image part. If there is no fault in segmentation, it will provide simple, uniform and homogeneous regions, with simple not ragged boundaries which are spatially accurate [7]. The medical image part is segmented after calculating the threshold vectors(s*,t*)[8]. The calculations are explained with 2-D maximum entropy method which provides better result compared to 1-D maximum entropy method[9].

2.3. 2-D Maximum entropy method

The images with uneven illumination cannot be segmented using a histogram; so, the original image is partitioned into sub images using the threshold value and the process is implemented in each of the sub images[9].

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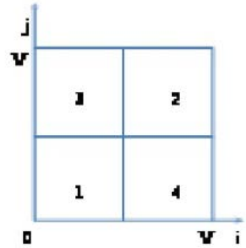
Figure 2.Histogram plane



The two dimensional maximum entropy method is explained with the two dimensional histogram of the image as shown in Figure 2; where the area 1 and 2 denote objects and background respectively, and 3 and 4 denote edges and noise. Threshold vector (*t*, *l*) defines, *t* is a threshold for pixel intensity and *l* is another threshold for the local average of pixels[10]. Figure 2 explains Histogram planefor the segmented image. According to 2-D maximum entropy principle, the calculated threshold vector should make area 1 and area 2 which results maximum information[11].Suppose the area 1 and area 2 has different probability distributions. According to the threshold vector (*t*, *l*), we denote *P*1 and *P*2 as:

$$P1=\sum_{i=0}^{l-1}\sum_{j=0}^{t-1}P_{ij}------------(1)$$

$$P2=\sum_{i=l}^{V-1}\sum_{j=l}^{V-1}P_{ij}------------(2)$$

Then the 2-D discrete entropy can be defined as:

$$H=-\sum_{i}\sum_{j}P_{ij}\lg P_{ij}--------(3)$$

The 2-D entropy of area 1 can be derived as follows:

$$H(1)=\lg(P1)+\frac{H1}{P1}--------(4)$$

The entropy of area2 can also be defined as follows:

$$H(2)=\lg(P2)+\frac{H2}{P2}------(5)$$

WhereH1 and *H*2are described as,

$$H1=\sum_{i=0}^{l-1}\sum_{j=0}^{t-1}P_{ij}\lg P_{ij}-----------(6)$$

$$H2=-\sum_{i=l}^{V-1}\sum_{j=1}^{V-1}P_{ij}\lg P_{ij}----------(7)$$

Where H(1) and *H*(2) are described in the formula (4)and (5).

$$O(l,t)=H(1)+H(2)------(8)$$

According to the maximum entropy principle, thethreshold vector (*l**, *t**) should be satisfied to

$$\phi(l*,t*)=\max\{\phi(l,t)\}-----(9)$$

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The improved method of 2-D maximum entropy threshold segmentation is 2D. The value attributes gray histogram which increases the segmentation speed and efficiency. The experimental results show that this proposed algorithm can able to provide segmentation threshold value quickly and accurately; also the cost and time of solving optimum threshold is of short period[12].

2.4. Methodology

Step 1: Convert the given medical image into array of pixels

Step 2: Using 2-D Maximum entropy threshold method, the threshold value is defined.

Step 3: The original image is segmented with the threshold value.

Step 4: The clinical part of the medical image is compressed with lossless compression since; lossless compression gives the reconstructed image as original image.

Step 5: The background which are irrelevant of the clinical part of the image are compressed with lossy compression.

Step 6: The pixel coefficients are quantized into nearest integer values. Vector Quantization is implemented in this step to increase the accuracy ofquantization mechanism[13].

Step 7: Run length encoding is applied to get compressed file data[14].

Step 8: The decoding and Decompression steps are applied to get the reconstructed image that is similar to the original data.

3. Results and Discussion

X-ray images, MRI images and CT scan images have been applied to the proposed algorithm to find out the results. A better compression ratio and PSNR value is obtained for all the images given. The results of Hybrid compression ratio is compared with traditional lossless compression ratio for medical images. From the results it is identified that Hybrid compression ratio provides better result than the traditional method.Figure3 is an X-ray1 image.Figure 4denotes X-ray2 image,Figure5 represents MRI brain1,Figure 6 is a MRI nerve andFigure7denotes CT Pelvic scan1 image.The Quality measures like compression ratio and PSNR (Peak signal noise ratio) are calculated using the proposed compression algorithm. Compression ratio is derived from the ratio between the original given image and resultant compressed image. PSNR is calculated from the ratio between the maximum possible value of a signal and the value of distorting noise that creates impacts on the quality of its representation. The PSNR is derived in terms of logarithmic decibel scale.Table 1 displays the values of Quality Measures like Peak signal to Noise Ratio (PSNR) and Compression ratio (CR) for the given five images.Table 2 shows the values of Compression ratio (CR) of the proposed method and lossless compression of medical images and it is compared. From Table 2, it is understood that combining lossless and lossy compression provides better result than compressing medical images only with lossless compression. Figure 8 compares the proposed method's CR with traditional lossless method.From the above comparison chart, it is found that the Hybrid compression ratio seems to provide better result than the ordinary lossless compression ratio.

Figure 3. X-ray1

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Figure 4. X-ray2

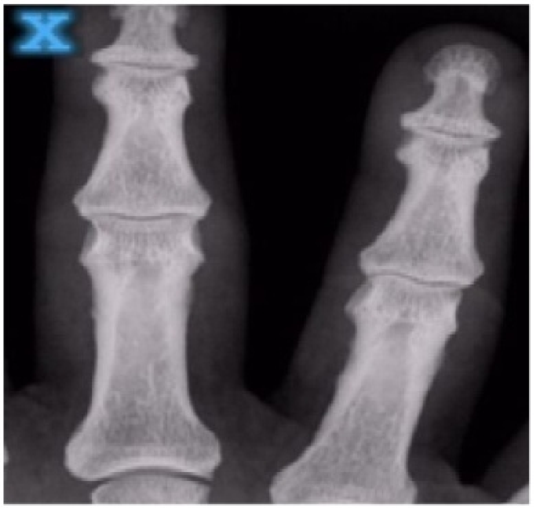

Figure 5. MRI brain1

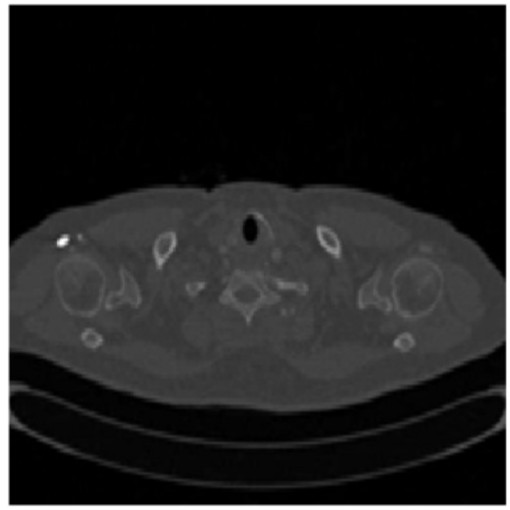

Figure 6. MRI nerve

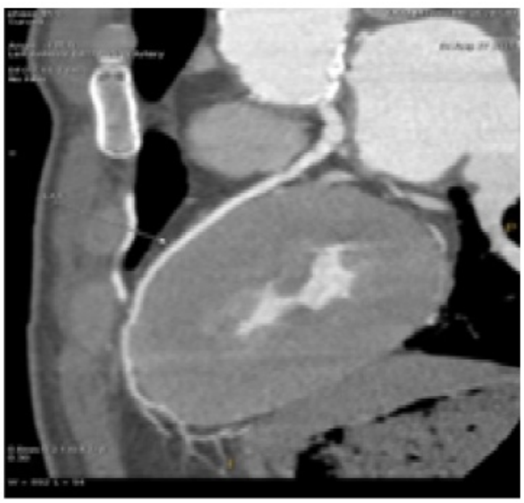

Figure 7. CT Pelvicscan1

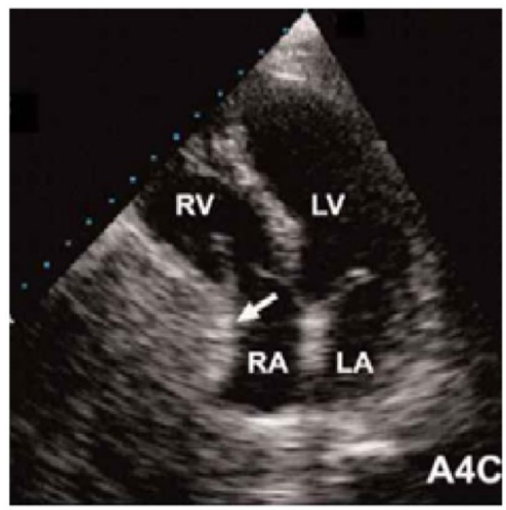

Figure 8. Comparison of proposed method's compression ratio with traditional lossless method

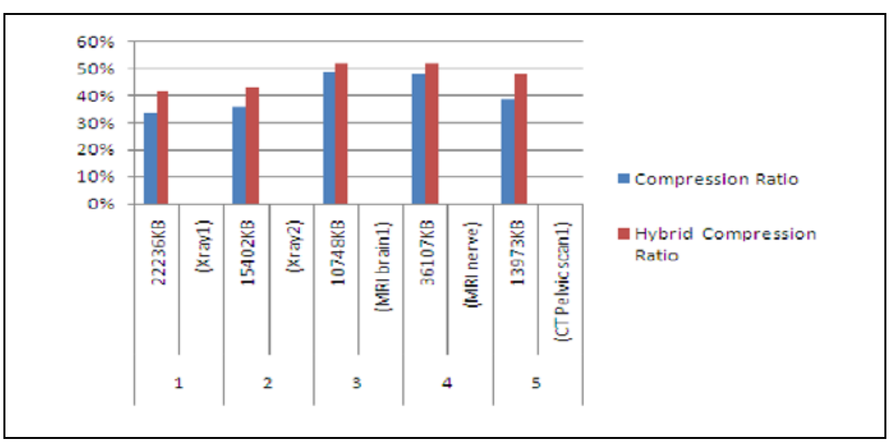

Table 1. Quality Measures-Peak signal to Noise Ratio (PSNR), Compression ratio (CR)

S.No	Raw size	Compression time	PSNR	CR
1	22236KB(Xray1)	149 sec	22.02	34%
2	15402KB(Xray2)	57sec	22.11	35.9%
3	10748KB(MRI brain1)	73sec	23.94	48.7%
4	36107KB(MRI nerve)	450sec	22.44	48%
5	13973KB(CT Pelvic scan1)	41sec	26.06	39%

Table 2. Comparison of Compression ratio (CR) of the proposed method and lossless compression of medical images

S.No	Raw size	CR	Hybrid CR
1	22236KB(Xray1)	34%	42%
2	15402KB(Xray2)	35.9%	43.4%
3	10748KB(MRI brain1)	48.7%	52%
4	36107KB(MRI nerve)	48%	51.9%
5	13973KB(CT Pelvic scan1)	39%	48%

4. Conclusion

Since 2-D maximum entropy is a time consuming thresholding process, neural network concepts may be applied to find out the thresholding value. Particularly, self organizing feature Map can be used to identify accurate threshold value. From the experimental results, it is shown that for all types of images, PSNR value is 22 to 40.It is proved that if the PSNR value is between 22-40 it can provide good compression ratio. Compressing medical images using this proposed method considerably reduces the computation cost[15].

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