A Review: Medical Image Compression Methods and their Characteristics

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Abstract— Medical images are employ for disease detection. The problem faced by the physician and the team is to store them using less space. A large numbers of patients come in a day even in small hospitals and this become necessary to store the health data of each of the patient. Medical images including radiography, magnetic resonance (MR), mammography and ultrasonic images, brain MRI, CT images and so on, this images are big size data and having such numerous amount of patient the storage this kind images occupies more area in storing devices. So there is need is to compress the medical images for storage. The another requirement of medical image compression is the transmission of medical images for second opinion of the specialist doctors who is far away from the patient. So there is need to compress the images to be resolve the verity of problem related to storage and transmission, so this long term rapid transmission is not prohibited without image compression. To make the medical images more useful and process-able and also to reduce the transmission time the image must be compressed. By compression appearance of image become more visual too and compression it will help to reduce the transmission error as less data will transmit.

Key words: Image Compression, PSNR, CR

I. INTRODUCTION

Image is collection of small size pixels. A digital image Consisting of both layout and intensity information of an image. So images can be considered as discrete representation of data. We can also treating an image as multidimensional signal. The image can be considered as a collection of pixels and each pixel having different colour intensity. In simple case each pixel location contains only a one numerical value represented the signal level or colour intensity at particular point of an image. The image size may be varies according to the type of image is used may be large or small in size. The Compressing an image is mean that removing the replicating or redundant data from the image. Replication of data in an digital image is meant that removing of such pixel having same intensity value.

There are two type of compression techniques are use known as lossy compression method and lossless compression method. Lossy compression operates by removing replicating information from an image and it degrades visual quality of image, where as in loss-less compression it is possible to remove some information from image without any apparent change visual appearance. If such information is visually redundant then its transmission is unnecessary for appreciation of the image.

There are two major parameters which define the quality of the image after processing is performed on image one is power to noise ratio (PSNR) and another is compression ratio (CR).

The medical image for example CT or MRI images etc are medical images that produces a digital form of human body pictures, and this images are big size image and need to be compressed to make them process-able.

This medial image can be divided into two part which are the important part in respect of diagnosis, known as medically Region Of Interest (ROI) or and the other than region of interest is Non Region Of Interest (NROI).

Both the ROI and NROI can be related in terms of peak signal to noise ratio and Compression Ratio. The higher PSNR shows the no degradation or lower changes in image appearance quality of reconstructed image after compression, which is required in the area of region of interest (ROI PART) or the image appearance quality at ROI can be calculated in terms of compression ratio which must be as low as possible. And for the NROI area the quality of image appearance that means the PSNR should be low and compression ratio should be high as much as possible of reconstructed image. Various compression methods have been invented for the medical image compression taking concentration on both ROI and NROI.

II. LITERATURE SURVEY

A. Fast Lossy compression Algorithm for Medical Image, 2016

Sadchenko, And O. Kushnirenko and O. Plachinda [1] in this paper the pre-processing is performed converted in required width after that uniform error is added to an images decimation unit. After that the uniform error is added to an image in decimation unit. The Huffman coder provides lossless compression at the expense of non-uniform probabilistic encoding. After the Huffman decoding, array re-indexing and averaging the values of neighbouring image elements by rows and by columns we get the restored image. Comparison of original and reconstructed images shows that the loss of some tiny details does not affect the medical diagnosis quality if the size of the details does not exceed the resolution of the algorithm. The MSE is $\sigma = 3.9$ and PSNR is 42.90 when the compression ratio equals to 4. Wavelet processing of this image at the same value of the compression ratio allows obtaining a value of $\sigma = 2.1$. However, the computational efficiency of the discrete wavelet transform is significantly lower.

B. Image Compression Based upon Wavelet Transform and a Statistical Threshold, 2016

Ahmed A. Nashat, N. M. Hussain Hassan [2] uses method in compression are Haar wavelet DWT, Huffman encoding, threshold. A non medical image was used in this paper and

simulation shows that the CR, the RMSE, and the PSNR do not change much above the fifth level. This suggests that instead of decomposing the image to its highest level, which is on approximation coefficient, they stopped at level six and found that the compression ratio for applied methods with universal threshold (wavelet and haar CR=63.5 with universal threshold) as compared to wavelet CR=88.83.

C. Hybrid Medical Image Compression Method using SPIHT Algorithm and Haar Wavelet Transform, 2016

Dr. Monisha Sharma and Mr. Chandrashekhar Kamargaonkar [3] the medical image is first pre-processed then the segmentation is applied and in ROI part of image the SPIHT method applied for compression and NROI is compressed with HAAR WAVELET transform. Then image is reconstructed and the reconstructed image, compressed image quality with different bit rate values (number of bits per pixel). In this paper the authors They have varied the bits per pixel from 0.25-2.00 BPP and PSNR is calculated in compared manner with SPIHT alone and SPIHT with HAAR WALET transform and it's found that the value of PSNR in SPIHT alone is lesser then(41.1850 with BPP=2) SPIHT+HAAR WAVELET (42.0153).

D. Medical Image Compression using Wrapping Based Fast Discrete Curvelet Transform and Arithmetic Coding, 2016

P. Anandan and R. S. Sabeenian [5] using methods Discrete curvelet transform, fast discrete curvelet transform, arithmetic coding, Vector quantization and found the method for image compression is based on the wrapping based fast discrete curvelet transform This method gives improvement in performance parameter like PSNR= 40 dB, CR=74.3%

E. Dicom image compression based on spatial fuzzy clustering using wavelet based contourlet transform 2016

Rupa sajani [4] methods applied were Spatial fluffy C implies bunching (SFCM), WBCT, Modified SPIHT and found in the result In the proposed paper WBCT based medical image compression for different DICOM images are implemented with modified SPIHT encoding algorithm. MSPIHT algorithm is based on traditional SPIHT algorithm but WBCT coefficients are repositioned before encoding with spatial orientation tree. PSNR obtain in this method is approximately 34.86 dB.

F. Lossless Compression Based on Hierarchical Extrapolation for Biomedical Imaging Applications, 2015

G.Vallathan and Dr.K.Jayanthi [7] using methods YCoCg Transform, Haar transform, SPIHT, CALIC, Huffman coding**,** and found the simulation analysis is performed with five different sizes of imaging modalities like CT image, And found that the overall CR(compression ratio), MSE and PSNR are 7.32, 7.11, and 38.94 respectively.

G. Segmentation and compression of Medical image using MSPIHT in Telemedicine application, 2014

Sathiya Lakshmi and M.Vanitha Lakshmi [9] represented a paper on medical image segmentation and compression applying methods SPIHT, MSPIHT, LZW, DCT and found that the image compression using MSPIHT gives high PSNR & CR.

H. MRI Brain Image Compression using Spatial Fuzzy Clustering Technique, 2014

S. Rupa et. Al [10] in this paper medical image compression for different MRI brain images are implemented based on curvelet transform with modified SPIHT algorithm. MSPIHT algorithm is based on the same principle as SPIHT algorithm. The main focus of the proposed work is that it uses curve let transform with anisotropy capability to represent singularities along arbitrarily y-shaped curves. The result found in this method the CR (compression ratio) is found 9.22, PSNR is 32.059 and BPP is 1.6854 which is slightly greater than other applied method like JPEG and WAVELET (bi-orthogonal-SPIHT and HAAR-SPIHT).

I. De-noising and wavelet compression of X-ray image for tele-radiology, 2014

Anita Thakur, Anupama Bhan, and Garima Vyas [11] in this paper, the de-noising is done by median filter and for compression SPIHT wavelet method is used. This work gives encouraging results with rate of 0.5, high PSNR 34.5199 and low entropy 0.0772 and optimum compression ratio of 50% achieved.

J. Image Compression Using Lifting based Wavelet Transform Coupled With SPIHT Algorithm, 2013

Md. Ahasan Kabir et al [16] lossy compression methods based on 2Dwavelet transforms because their properties are interesting. applied the proposed algorithm on test image 'Brain Axial slice' of size 512×512 encoded by 8 BPP To show the performance of the proposed method, we make a comparison between these different types of transform. For each application we vary the bit-rate from 0.125 to 2, we calculate the PSNR and MSSIM the following result found maximum at BPP=2 as listed below

1) CDF Lifting Based (WT + SPIHT) =>PSNR=53.88 & MSSIM=1.00(identical image)
2) CDF9/7(Lifting)+SPIHT=>PSNR=55.17& MSSIM=>1.00(identical image)
3) CDF9/7(Filter Bank)+SPIHT=>PSNR=52.19, & MSSIM=0.99(non-identical image)
4) CDF9/7 (Lifting)+EZW => PSNR=46.77, & MSSIM = 0.99

K. A secure fast 2d - discrete fractional fourier transform based medical image compression Using hybrid Encoding technique, 2013

P. Vasanthi Kumari & Dr.K.Thanushkodi [20] Wavelet Transform with SPIHT and D2 Transform Modified SPIHT is high Lung image 1 with 2.0 BPP, the PSNR obtained for the approaches like wavelet Transform with SPIHT, D2 wavelet transform with Modified SPIHT and Fractional Fourier transform with BSP SPIHT is 36.62, 37.29 and 38.20 respectively. But, the PSNR obtained For the proposed approach is 40.90.The MSE value of the proposed Fast 2D-dfrft approach Is very less when compared with the existing transformation Approaches.

L. A ZEROTREE Coding for Compression of ECG Signal Using EZW and SPIH, 2012

S. Ktata and H. Mahjoubi [22] in this paper on medical image compression the comparative performance of two algorithms for high fidelity compression of ECG data, The other main advantage of the presented EZW and SPIHT

method is the simplicity of the ZEROTREE coding. The simulation results show that the EZW method provided higher percent root mean square difference (PRD) but the SPIHT method provides lower PRD in compression CR(EZW)=16:1,CR(16:1) is higher than any other applied method in this paper.

M. Near Lossless Compression Method for Medical Images, 2012

M.Moorthi and R.Amutha [26] applying method Wavelet decomposition fuzzy logic, SPIHT and found that in this paper near Lossless compression algorithms was used for compressing non ROI. The SPIHT algorithm has the advantages of not requiring codebook design and it is not limited in the size of the blocks used for classification. The results proved to be better in compression Performance provided by ROI based algorithms in terms Of visual quality and higher PSNR. This method improves both CR & PSNR values.

III. CHARACTERISTICS

Medical images are become boon to monitor the health of person's. The physician encounters the problem related to storing such large size image. By using the appropriate image compression method in which the image is compressed without any degradation in visual quality of an image by just reducing the space required to store them. The problem related to storage of such big and important data can be resolved using compression technique, So there is need to compress the image to be resolved in a storage problem in variety of medical images. Fast and reliable transmission and storage of the medical images is tremendous boon in practice i n medical treatment.

To make the medical images more useful and reliable the image should be transmitted less time and should occupy low space. The reconstructed image become more visual and compression will help to reduce the transmission error as less data will transmit or say only adequate amount of data would be transmitted.

The medical images is divided into two parts which are the medically important region known as region of interest and its known as ROI part of images and its desired that the this part of image does not loss any appearance quality while appear after the compression perform , another part of medical images is the region which is not medically interest is known as non-region of interest known as the NROI part of the image.

As we have discussed the both part of image its already known that the both part will compressed with two distinct method are well known as loss less compression method and lossy compression method. Majority of compression techniques lacks in low compression ratio in loss less compression method and low PSNR in lossy compression method. The survey is performed taking concentration on both the image quality (measured in terms of PSNR dB) for ROI and compression ratio (CR) for NON-ROI both Should be high.

A. Peak signal to noise ratio and min square error

The peak signal to noise ratio of the reconstructed image is given by

$$\text{PSNR} = 10 \log 10 \frac{(\text{MAX})^2}{\sqrt{\text{MSE}}} \qquad (1)$$

Where "MAX" is the maximum gray value of the image and where "MSE" is min squared error between original and reconstructed and given by

$$\text{MSE} = \frac{1}{\text{MN}} \sum_{\text{M}=0}^{\text{M}-1} \sum_{\text{N}=0}^{\text{N}-1} |\text{X}(\text{M},\text{N}) - \bar{\text{X}}(\text{M},\text{N})|^2 \quad (2)$$

Where $\text{X}(\text{M},\text{N})$ is original image and $\bar{\text{X}}(\text{M},\text{N})$ of reconstructed image and M*N is size of original image. Equation (1) shows that the lower MSE gives higher PSNR.

B. Compression Ratio

Compression ratio of reconstructed image is given by

$$\text{CR} = \frac{\text{RECONSTRUCTED IMAGE SIZE}}{\text{ORIGIONL IMAGE SIZE}} = \frac{\text{N2}}{\text{N1}} \quad (3)$$

The survey shows various methods which have both higher and lower PSNR and CR Because it is essential the image quality should be unchanged during the reception at another end so the it's required to use such method in which the PSNR is high and lower CR for ROI respectively And such methods which provide lower PSNR and higher CR for NON-ROI.

C. Structural Similarity (SSIM) Index

Structural similarity index is a method for predicting the perceived quality of image SSIM measure the similarity between the two images the SSIM index is a full reference matrix. SSIM measure the image quality is based on initial uncompressed image and compressed image.

The basic deference between the previously defined method like PSNR and MSE in these Approaches the estimation is based on the absolute error on other hand the SSIM is perception based model that consider image degradation as perceived change in structural information including both luminance masking and contrast making.

D. Image Formats

In the real word, we need to effectively display images, store them, transmit them over the network and recognize bodies of numerical data as corresponding to image. This lead the development of standard digital image formats. Below table shows the various image formats and properties.

Acronym	Name	Properties
GIF	Graphic Interchange format	Limited only 256 colours (8 bit) Colour less compression
JPEG	Joint photographic expert group	In most common use today. Lossy compression. Lossless variant exist.
BMP	Bit map picture	Basic image format. Limited (generally) lossless compression. Lossy variant.
PNG	Portable network graphic	New lossless compression formats. Designed to replace GIF
TIF/TIFF	Tagged image (file) format	Highly flexible Detailed and adapted format Compressed/uncompressed variant exist

Table 1: Various image formats and properties

The literature survey has been performed taking concentration on medical image compression based on the

characteristics values like PSNR and CR. The method listed in the table has different PSNR and CR values.

Applied methods for compression	**PSNR dB**	**CR%**
Huffman coding+ Array re-indexing +averaging Wavelet transform [1]	For MSE= 3.9 PSNR is 42.22, when MSE= 2.1 PSNR is 44.90	40
Haar wavelet+ DWT +Huffman encoding +threshold (Statistical, Hard, Soft, Universal) [2].	Considering only universal threshold PSNR= 17	63.5
Discrete curvelet transform+ fast discrete curvelet transform+arithmetic coding+ Vector quantization[5]	40	72.3
YCoCg Transfor+ Haar transform+ SPIHT + CALIC+ Huffman coding.[7]	38.9	7.3
Discrete Wavelet + transform and SPIHT +ENTROPY ENCODING	34	50
SPIHT + Haar wavelet transform + Binary Thresholding + median filter[3]	42.01	~60
Spatial fluffy C implies bunching + WBCT+ Modified SPIHT[4]	34.02	~70

Table 2: Literature Survey

IV. SUMMARY

The review paper show that the importance of both part of the medical image. The characteristic values of the both part varies according the method applied on individual part of the images, as previously mentioned the ROI part should be compressed with either the method which is loss-less or with a method which gives higher PSNR value, similarly for the NROI part of image is compressed with lossy method or such method which gives higher compression ratio.

The latest method the MODIFIED SPIHT gives appreciable PSNR. The lossy method DCT and DWT are very well known lossy compression methods and the hybrid of DCT and DWT would results in good compression ratio.

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