SIGNIFICANCE OF ROI BASED CODING ON LOSSY AND LOSSLESS MEDICAL IMAGE COMPRESSION

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***Abstract*— As there is an increasing demand for telemedicine services, the need for the development of efficient compression standards is essential to reduce the storage requirement of the medical Images. In medical image compression, it is necessary to reduce the storage size of the image by preserving the diagnostic information. ROI-based compression methods becoming a promising tool in recent years to preserve the important information in the Medical Image. In this paper, we analysed the significance of ROI based coding on Lossy and Lossless medical image compression. The comparative analysis is made between two popular compression standards such as Huffman (Lossless) and JPEG (Lossy) on Region of Interest (ROI) versus whole image compression. The results are analysed using the metrics Compression Ratio (CR) and Peak Signal to Noise Ratio (PSNR).**

Keywords — *Medical Image Compression, ROI-Coding, Huffman, JPEG.*

I. INTRODUCTION

In the health care sector, medical images play a vital role in disease diagnosis, treatment and further surgical planning. There are various imaging modalities available in the market which produces different types of medical images. Some of the most widely used imaging modalities are Computed Tomography (CT), Magnetic Resonance Imaging (MRI), X-Ray, Ultra Sound (US), Positron Emission Tomography (PET). Due to the extraordinary evolution in the field of medical imaging technology, there is a huge volume of medical images produced in modern hospitals and scan centres every day. Those huge volume of images are used for diagnosis and further treatment. Presently they are stored in the Picture Archiving and Communication Systems (PACS) for further reference in the future [1]. Imaging communication standard like DICOM are being used to provide platform independent methods of interconnecting different types of digital imaging devices via computer networks. DICOM provides a variety of functions to PACS [2]. It requires a huge amount of storage space and consumes a high data when the image is being transmitted. This is due to the remarkable development in the medical imaging technology which produces high quality images which obviously consumes high storage space [3]. To overcome these storage and transmission complexity the image compression techniques are introduced and various compression techniques had been developed and still new techniques are under development. Image compression targets at reducing the amount of information required to represent a digital image. Image compression techniques have a chief role to play in the telemedicine services. Modern hospitals are using telemedicine services to monitor patients remotely and also to get remarkable suggestions from the experts around the world to treat the patients efficiently. In telemedicine services, transmission of the medical images takes very long time due to the huge image size [4]. To improve this service, medical image compression is required which can bring in a remarkable growth in remote health care service. The data transmission rate can be remarkably improved by applying the compression techniques to the medical images [5-11]. Compression techniques are generally bifurcated into two categories based on their nature of compression

- Lossless image compression techniques
- Lossy image compression techniques

a) Lossless Image compression techniques

In lossless compression technique, the quality of the original image is retained. The lossless compression techniques compresses the original image by encoding the complete information so that when the image is decompressed, an exact match of the original image can be obtained [12]. Literally no data is lost during compression. This type of compression is used in the Medical image compression as important information for diagnosis is preserved efficiently. E.g.: Run Length Encoding, Huffman Encoding.

b) Lossy Image compression techniques

In lossy compression technique, the size of the image can be reduced much better than that of the lossless technique but it demands the loss of information from the image [13]. Loss of information in medical images is not acceptable because important information may be lost from the image which may lead to wrong diagnosis. But still lossy compression can be used up to a certain extent in telemedicine services. E.g.: JPEG, BTC

Most of the medical image compression is done using Lossless compression techniques to preserve the information present in the image. In some cases Lossy algorithms are also

used. Both cases, the Region of Interest (ROI) based image compression techniques produce much better results than compressing the whole image. The ROI based compression is efficient because the removal of background information helps in reducing the size of the image effectively. However if required the background can be reconstructed during the decompression stage. This paper discuss the comparative analysis of ROI and non-ROI based medical Image compression over lossy and lossless methods.

II. METHODOLOGY

1) Huffman encoding

Huffman coding is a lossless data compression algorithm which was proposed by David Huffman in 1951. Huffman algorithm creates a frequency sorted binary tree in a bottom up approach. The core idea behind this algorithm is to represent the less frequently occurring symbols using more bits and frequently occurring symbols using fewer bits of data [14]. To achieve this it uses variable length encoding. This algorithm is very effective when there is a high variation in symbol probability.

The steps involved in Huffman coding is given below:

Step 1: Read a medical image from the workspace.

Step 2: Compute the probability of the each symbol of the image.

Step 3: Arrange the probabilities of the symbols in decreasing order and merge the symbols which have the lowest probability.

Step 4: The previous step is repeated until only two probabilities are left and generate a Huffman tree.

Step 5: Based on the Huffman tree, assign the codes to the symbols based on their probability. High frequency symbol will have smaller code and vice versa.

Step 6: Decompression of the image is done by using the Huffman decoding to get back the original image. This is done by traversing the Huffman tree node by node and separating the prefix codes to match the corresponding samples.

2) JPEG Compression

JPEG compression was developed by a committee known as the Joint Photographic Experts Group (JPEG). JPEG provides both lossy and lossless image compression techniques which was developed to compress still images. It works well with the continuous-tone images, where the adjacent pixels tend to have similar colours [15]. JPEG allows the user to adjust the amount of data lost during compression which allows to adjust the compression ratio. JPEG lossy variant is a DCT-based method which is known as the Baseline method.

The following are the steps involved in JPEG Compression technique:

Step 1: Read the medical image from the workspace.

Step 2: Segment the image into 8 × 8 blocks of pixels from top left.

Step 3: Apply Discrete Cosine Transform (DCT) to each block segmented earlier from the top left block to the bottom right block.

Step 4: Now compress every single block in the image by using quantization.

Step 5: The compressed blocks are preserved as array which contains the compressed data to represent the image.

Step 6: The Inverse Discrete Cosine Transform (IDCT) is used to decompress the image whenever required.

3) ROI Extraction

Region of Interest (ROI) in this study refers to the region except to the background present in the medical image. Background of medical image is mostly occupied by black pixels which are not really necessary. Even when it is necessary, it can be reconstructed during the decompression. So by eliminating the background as much as possible we can improve the compression ratio of the image. There are various techniques to extract the Region of Interest from the background. Bounding box is one of the techniques used to extract the ROI from the background [16]. The extracted ROI is compressed using the algorithms discussed above.

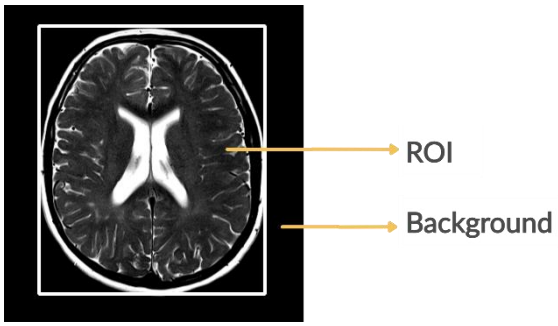


Fig 1: Medical Image and the Selected ROI

In this proposed method, we applied the selected Lossless (Huffman Coding) and Lossy (JPEG) compression technique for both ROI and non-ROI (whole) image separately, and computed the compression metrics such as compression Ratio (CR), Peak Signal to Noise Ratio (PSNR) and Encoding time to analyse the performance of Lossy and Lossless compression on ROI and whole Image compression as detailed below.

Huffman Coding for Whole Image

The whole medical image is taken and compressed with Huffman coding. The encoded data is preserved for decompression of the image. This compressed image size is taken for the computation of the compression metrics such as Compression Ratio (CR) for comparison with other methods.

Huffman ROI based Coding

ROI of the medical image is extracted by eliminating the background pixels using the bounding box method and the ROI alone is compressed with the Huffman coding algorithm and the CR is calculated for comparison.

JPEG for Whole Image

Entire medical image is taken and compressed with JPEG lossy algorithm with the required compression quality. This compressed image size is taken into consideration to compute the CR for further comparison with other methods.

JPEG for ROI

The ROI is extracted from the medical image using the bounding box technique and then the ROI alone is subjected to the JPEG Lossy compression algorithm and the results of the compressed ROI image is preserved for comparison with the above discussed methods.

stream and control system for parking. Despite the fact that there are a few points of interest, there are likewise a few shortcomings in the RFID based parking System. An RFID reader can check a tag as long for what it's worth inside recurrence go. It doesn't have any line of sights limitations. A few materials may make signal issue. Establishment procedure needs significant expense. Sometimes, it neglects to read. To conquer every one of these disadvantages, there is a need to proceed onward web camera based parking system.

III. MATERIALS AND EVALUATION PARAMETERS

The medical image data collected from different sources such as Internet Brain Segmentation Repository (IBSR) and Radiopaedia were used to conduct the compression study. The metrics used for compression evaluation are compression ratio (CR) and Peak Signal to Noise Ratio (PSNR) [17]. CR (1) is the ratio between the Size of the original image and the size of the compressed image.

$$\mathbf{CR} = \frac{\mathbf{n1}}{\mathbf{n2}} \qquad \mathbf{(1)}$$

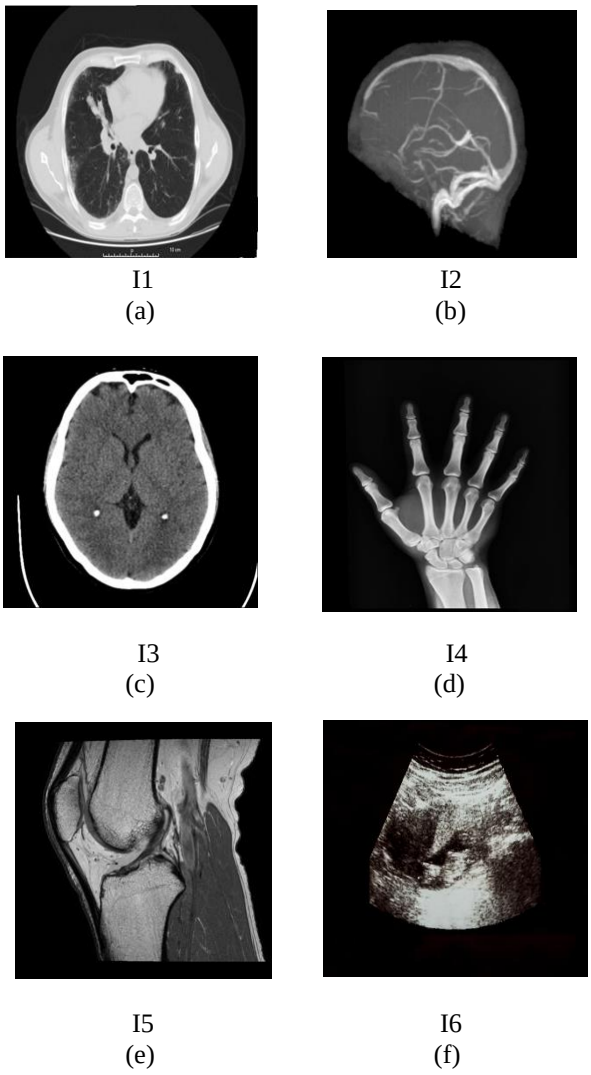
where n1 and n2 represents the number of bits required to represent the original image and compressed image respectively. The PSNR is the ratio between the maximum possible powers of a signal to the power of corrupting noise that affects the fidelity of its Mean Squared Error (MSE). The PSNR (db) is given in Eqn. (2)

$$\boldsymbol{PSNR = 10.log_{10}\left(\frac{MAX_I^2}{MSE}\right)} \qquad \mathbf{(2)}$$

where, MAX_I is maximum fluctuation in an image and

$$\boldsymbol{MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I(x,y) - I'(x,y)]^2} \qquad \mathbf{(3)}$$

where, $I(x,\ y)$ is the original image, $I'\ (x,\ y)$ is the approximated version (decompressed image) and M, N are the dimensions of the image. A higher value of PSNR is appreciable because it means that the ratio of signal to noise is higher. Here Signal is the original image and noise is the error in the reconstructed image. Given below are the medical image samples from CT, MRI and few others modalities used for the comparative study of the above discussed methods.



I1 (a) I2 (b) I3 (c) I4 (d) I5 (e) I6 (f)

Fig 2: Sample Medical Images (a) CT- Chest (b) MRV – Brain (c) CT- Brain (d) X-ray - Hand (e) MRI - Knee (f) Ultra Sound - Fetus

IV. RESULTS AND DISCUSSION

The results of the analysed methods are given in Table I to Table IV. The Table I show the compression results of the Huffman coding method which shows an average compression ratio (CR) of 1.43 with an average compression percentage of 28.77% while compressing the entire medical image using this method. However, the Table II displays the and relegates them a class name. Together, these issues are alluded to as object recognition. Results of the compression of ROI, eliminating the background data using the same

Huffman coding. Here it clearly indicates that the average compression ratio is higher than the whole image compression. This gives us an average compression ratio (CR) of 1.80 with average compression percentage of 42.99 % which will save a huge amount of space required to store the medical image and also increases the transmission speed of the images. The same improvement is also observed in the encoding time of the Lossless Huffman coding method while implementing Background elimination in medical images.

TABLE I: Huffman Coding

I_ID	Comp_ Ratio	Comp_ Per (%)	Encoding Time(Sec)
I1	1.30	23.07	1.58
I2	1.17	14.52	1.70
I3	1.84	45.65	1.70
I4	1.50	33.33	1.73
I5	1.37	27.00	1.63
I6	1.41	29.07	1.75
Average	**1.43**	**28.77**	**1.68**

TABLE II: Huffman Coding for ROI

I_ID	Comp_ Ratio	Comp_ Per (%)	Encoding Time(Sec)
I1	1.66	39.75	0.68
I2	1.99	49.74	0.66
I3	2.13	53.05	0.79
I4	2.08	51.92	0.70
I5	1.48	32.43	0.70
I6	1.45	31.03	0.78
Average	**1.80**	**42.99**	**0.72**

On the other hand, Table III and Table IV illustrates the results obtained from the lossy JPEG algorithm, implementing both whole image and ROI-based compression in the lossy JPEG algorithm. In Table III the average Compression Ratio (CR) of the entire image is 1.72 with an average compression percentage of 41.77% and also with 30.07 PSNR average. This when compared to the Table IV, the ROI separated compression in Lossy JPEG, the average CR is 2.05 with the average Compression percentage of 50.02% which is well above the previous whole image compression, but with a slightly lower PSNR average of 29.56 which indicates the quality of the compressed image comparing with the original image.

TABLE III: JPEG Compression

I_ID	Comp_ Ratio	Comp_ Per(%)	PSNR	Time (Sec)
I1	1.70	41.17	33.70	2.41
I2	1.77	43.50	30.39	1.47
I3	1.70	41.17	31.45	1.79
I4	1.72	41.86	31.63	1.86
I5	1.76	43.18	23.40	1.63
I6	1.66	39.75	29.87	2.12
Average	**1.72**	**41.77**	**30.07**	**1.88**

TABLE IV: JPEG Compression for ROI

I_ID	Comp_ Ratio	Comp_ Per(%)	PSNR	Time (Sec)
I1	2.15	53.48	32.25	1.72
I2	2.76	63.76	30.07	1.82
I3	2.01	50.24	29.71	2.20
I4	1.95	48.71	33.63	2.10
I5	1.77	43.50	22.66	1.84
I6	1.68	40.47	29.08	1.54
Average	**2.05**	**50.02**	**29.56**	**1.87**

Finally, when comparing all the four methods analysed above the ROI based compression methods provides better results for medical image compression reducing a lot of space for storage and increasing the transmission speed in both lossy and lossless compression. Since the medical images possess highly valuable information which cannot be lost at any cost, the lossless compression method is preferred for medical image Compression. The lossy image compression is also used in medical image compression for compressing the background data compression or non-ROI regions.

V. CONCLUSION

In medical image compression, the ROI based compression technique is efficient but in some cases the Background is also equally important for the identification of the location of the Region of Interest accurately in the image. However, the background can be reconstructed during the time of decompression by using the size of the image and coordinates of the ROI. The comparative analysis made in this paper shows the significance of ROI based image compression for telemedicine services and also the advantage of removing the background data from the image to achieve better compression ratio, the ROI based Lossless coding is very efficient for remote health care services.

Edge put together calculations depend with respect to the brokenness in the enlightenment found in the continuous world. For constant applications to succeed a method for utilize strength to the framework is obviously conceivable through edge-based instruments.

References

[1] M.J.Zukoski, T.Boult and T.Lyriboz, “A Novel Approach to Medical Image Compression”, International Journal of Bioinformatics Research and Applications, Vol.2, no.1, pp. 89-103, 2006.

[2] [2] B.Vinayak, A.N.Gaikwad, M.Kanaskar “DICOM Medical Data Compression for Telemedicine in Rural Areas” Advances in Engineering Science Sect. C (2), April-June 2008.

[3] [3] David Salomon, “A Concise Introduction to Data Compression”, Springer International Edition, 2011.

[4] [4] M.A.Ansari and R.S.Anand,” Recent Trends in Image Compression and its Applications in Telemedicine and

Teleconsultation", XXXII National Systems Conference, NSC 2008, December 17-19, 2008.

[5] [5] J.Strom and P.C.Cosman, "Medical Image Compression with Lossless Regions of Interest", Signal Processing, Vol.59, no.2, pp.155-171, June 1997.

[6] [6] S.Boopathiraja and P.Kalavathi, "A Near Lossless Three-Dimensional Medical Image Compression Technique using 3D-Discrete Wavelet Transform", International Journal of Biomedical Engineering and Technology, 2019.

[7] [7] S.Boopathiraja, P.Kalavathi and and C.Dhanalakshmi, "Significance of Image Compression and its Upshots – A survey", International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 2019.

[8] [8] S.Boopathiraja, P.Kalavathi and S.Chokkalingam "A Hybrid Lossless Encoding Method for Compressing Multispectral Images using LZW and Arithmetic Coding", International Journal of Computer Sciences and Engineering, May 2018.

[9] [9] S.Boopathiraja and P.Kalavathi, "A Near Lossless Multispectral Image Compression using 3D-DWT with application to LANDSAT Images", International Journal of Computer Sciences and Engineering, ISSN: 2347-2693, Vol.06, No.04, pp.332-336, May 2018.

[10] [10] P.Kalavathi and S.Boopathiraja, "A Medical Image Compression Technique using 2D-DWT with Run Length Encoding ", Global Journal of Pure and Applied Mathematics. ISSN: 0973-9750. Vol.13, no.5, pp. 87-96. September 2017.

[11] [11] P.Kalavathi and S.Boopathiraja, "A Wavelet Based Image Compression with RLC Encoder", Proceedings of the National Conference on Computational Methods, Communication Techniques and Informatics (NCCVNI), pp.68-74. January 2017.

[12] [12] Ming Yang and Nikolaos Bourbakis, "An overview of Lossless Digital Image Compression Techniques", IEEE, pp. 1099-1102, 2005.

[13] [13] V.K.Padmaja and Dr. B.Chandrasekhar," Literature Review of Image Compression Algorithm", IJSER, Volume 3, pp.1-6, 2012.

[14] [14] J.H.Pujar and L.M.Kadlaskar, "A new Lossless method of Image Compression and Decompression using Huffman Coding Techiniques", Journal of Theoretical and Applied Information Technology, Vol.15, pp. 18-23, 2010.

[15] [15] Muzir Shaban AL-Ani, "The JPEG Image Compression Algorithm", IJAET Vol.6, pp.1055-106, May 2013.

[16] [16] Manpreet Kaur and Vikas Wasson, "ROI based Medical Image Compression for Telemedicine Application" Procedia Computer Science 70 (2015), pp.579 - 585

[17] [17] P.C.Cosman, R.M. Gray and R.A. Olhsen, "Evaluating Quality of Compressed Medical Images: SNR, Subjective Rating, and Diadnostic Accuracy", Proceedings of the IEEE, Vol. 82, no. 6, pp.919-931, 1997.