PROJECT REPORT

Course: **Information Theory and Coding (ECE4007)**

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Slot: C2+TC2

on the topic

Region of Interest Based Medical Image Compression

done under the guidance of

Prof. Kishore V. Krishnan

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CERTIFICATE

This is to certify that the project work entitled **'Region of Interest Based Medical Image Compression'** that is being submitted by Debjeet Basak, Arka Provo Mukhopadhyay and Ritam Sil for **Information Theory and Coding (ECE4007)** is a record of bonafide work done under my supervision. The contents of this Project work, in full or in parts, have neither been taken from any other source nor have been submitted for any other CAL course.

Place: Vellore

Date: 4th April 2018

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INDEX

Contents	Page Number
1. Abstract	5
2. Introduction	6
3. Region of Interest	7
4. Methodology	8-10
5. Experimental results	11 – 17
6.Conclusion	18
7. References	19

ABSTRACT

Many classes of images contain spatial regions which are more important than other regions. Compression methods capable of delivering higher reconstruction quality for important parts are attractive in this situation. For medical images, only a small portion of the image might be diagnostically useful, but the cost of a wrong interpretation is high. Hence, Region Based Coding (RBC) technique is significant for medical image compression and transmission. Lossless compression schemes with secure transmission play a key role in telemedicine applications that help in accurate diagnosis and research. In this project, we have used lossless scalable RBC for Digital Imaging and Communications in Medicine (DICOM) images based on Discrete Wavelet Transform (DWT) and with distortion limiting compression technique for other regions in image. The main objective of this work is to reject the noisy background and reconstruct the image portions lossless. As a part of ROI compression technique algorithm is developed using discrete wavelet transform and SPIHT algorithm. A detailed analysis is carried out on the basis of parameters like compression ratio (CR), mean square error (MSE) and peak signal to noise ratio (PSNR). Advantage of ROI compression over conventional compression scheme is to improve quality of ROI with less value of MSE and PSNR.

INTRODUCTION

Large amount of image data is produced in the field of medical imaging in the form of Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and Ultrasound Images, which can be stored in picture archiving and communication system (PACS) or hospital information system. A medium scale hospital with above facilities produces on an average 5 GB to 15 GB of data. So, it is really difficult for hospitals to manage the storing facilities for the same. This is significant for telemedicine scenario due to limitations of transmission medium in Information and Communication Technology (ICT) especially for rural area.

Image compression is useful in, reducing the storage and transmission bandwidth requirements of medical images. For e.g., an 8-bit grey scale image with 512×512 pixels requires more than 0.2 MB of storage. If the image is compressed by 8:1 compression without any perceptual distortion, the capacity of storage increases 8 times. Compression methods are classified into lossless and lossy methods. In the medical imaging scenario, lossy compression schemes are not generally used. This is due to possible loss of useful clinical information which may influence diagnosis.

Some of the most desirable properties of any compression method for 3D medical images include: (i) high lossless compression ratios, (ii) resolution scalability, which refers to the ability to decode the compressed image data at various resolutions, and (iii) quality scalability, which refers to the ability to decode the compressed image at various qualities or signal-to-noise ratios (SNR) up to lossless reconstruction.

DICOM is the most comprehensive and accepted version of an imaging communications standard. DICOM format has a header which contains information about the image, imaging modality and information about the patient. The header also contains information about the type of media (CT, MRI, audio recording, etc.) and the image dimensions. Body of DICOM standard contains information objects such as medical reports, audio recordings and images. The coding– decoding algorithm must take care of other information in the DICOM file. Also, the algorithms should accept the input image in DICOM format at encoder end and produce DICOM file at decoder end.

REGION OF INTEREST

Basic concept of Region of Interest (ROI) is introduced due to limitations of lossy and lossless compression techniques. For well-known lossless compression technique the compression ratio is approximately 25% of original size, where as for lossy encoders the compression ratio is much higher (up to 1% also), but there is loss in the data. Now this loss may hamper some diagnostically important part of the image. Hence, there is a need of some hybrid technique which will take care of diagnostically important part (ROI) as well as will provide high compression ratio. The functionality of ROI is important in medical applications where certain parts of the image are of higher diagnostic importance than others. For most medical images, the diagnostically significant information is localized over relatively small regions, about 5 to 10% of total area. In such cases, 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.

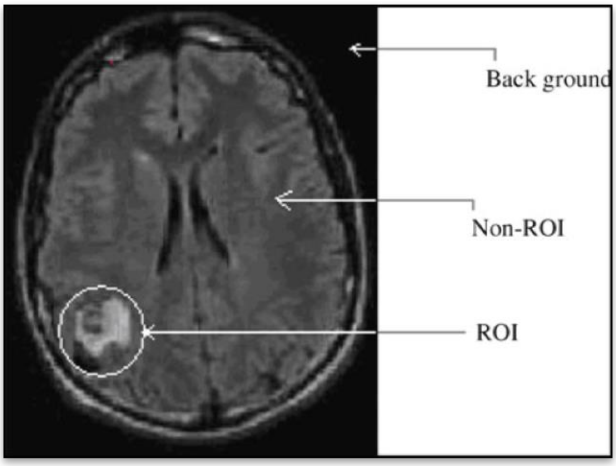

Figure1: *Different parts of the medical image*

METHODOLOGY

A CT or MRI image contains three parts-

i) ROI (the diagnostically important part)
ii) Non-ROI image part
iii) The background (part other than image contents)

Fig 2: Statistical representation of cross-sectional view of medical image

The ROI is selected by expert radiologists. Depending on the selected part ROI-mask is generated in such a way that the foreground is totally included and the pixel values in the background are made zero. The background regions though they appear to be black in colour, they do not have zero grey level values.

The background is made zero using:

$$img[i, j] \leq x_{th}, then$$

$$img[i, j] = 0$$

Here, x_th is the threshold value of background of the image (img). As the background is not required reducing the background contents to zero also accounts for complete lossless compression, producing a ready to process image.

Also, Morphological operations are effectively used, which contain a value of ‘1’ in the foreground and a value of ‘0’ in the background. Then the mask is logically AND-ed with the image to separate-out ROI part (IMG_ROI) and Non-ROI image part.

$$ROI\_mask\&\&img = IMG\_ROI$$

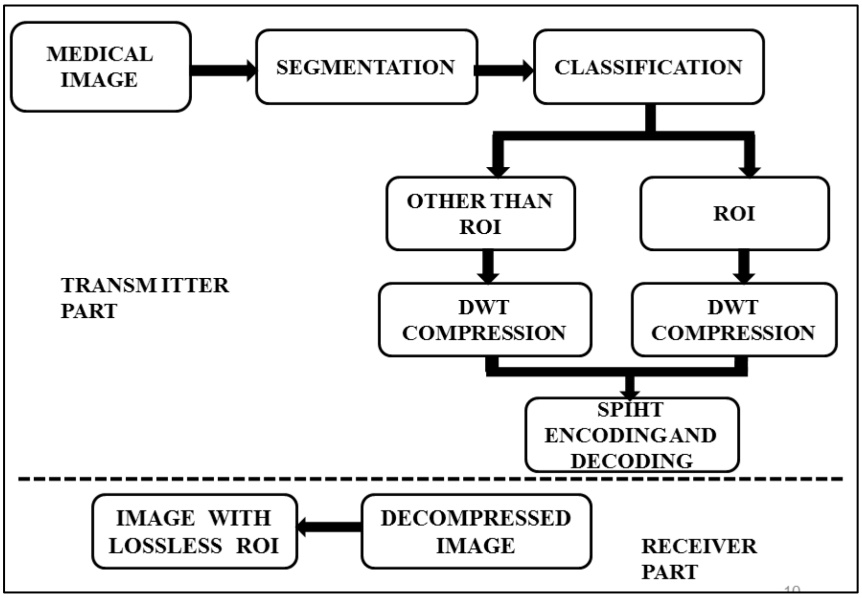

Fig 3: Block diagram of the algorithm

Lossless compression, Progressive transmission and RBC are important functionalities for a compression scheme helpful in telemedicine application. User can select ROI of any arbitrary shape. ROI is compressed with lossless version of compression technique such as Huffman, Arithmetic, RLE, LZW, ZIP, etc., while Non-ROI is compressed by SPIHT algorithm used after wavelet transform. Wavelet-based techniques are the latest development in the field of image compression. It offers multi-resolution capability that is not available in any of the other methods.

The coding algorithm used is presented here-

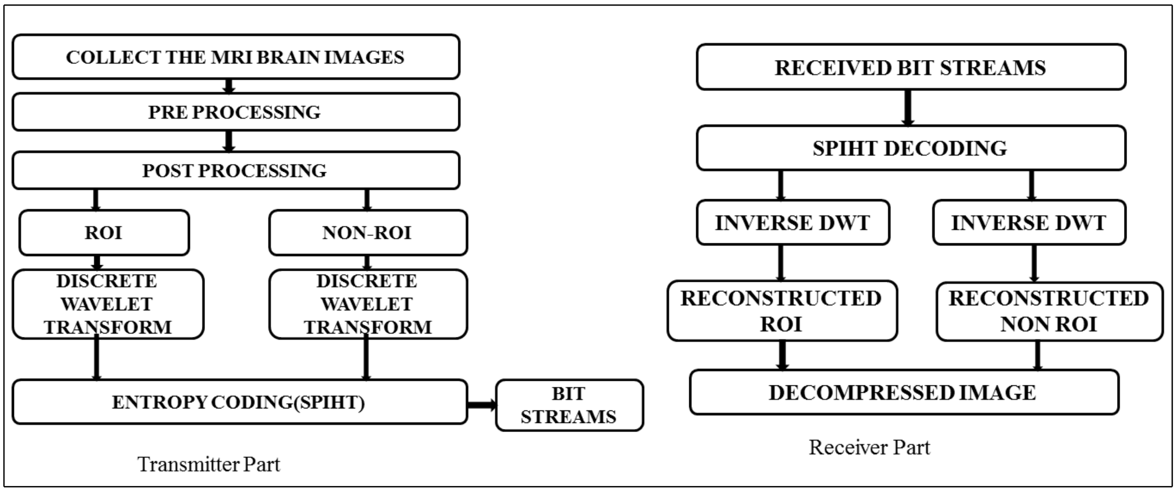

Fig 4: Flow diagram of the coding algorithm

So basically, the steps are-

1. Read image from database and get dimensions.
2. Apply threshold to remove background.
3. Select ROI, and separate out ROI and Non-ROI.
4. Accept compression levels from user.
5. Apply wavelet decomposition for ROI & Non- ROI.
6. Perform operation of wavelet reconstruction recursively combine ROI.
7. Compare the quality of original image with newly reconstructed image with PSNR, MSE ratio.

EXPERIMENTAL RESULTS

The selected image is CT scan of a brain having tumour (downloaded from Radiopaedia.org)

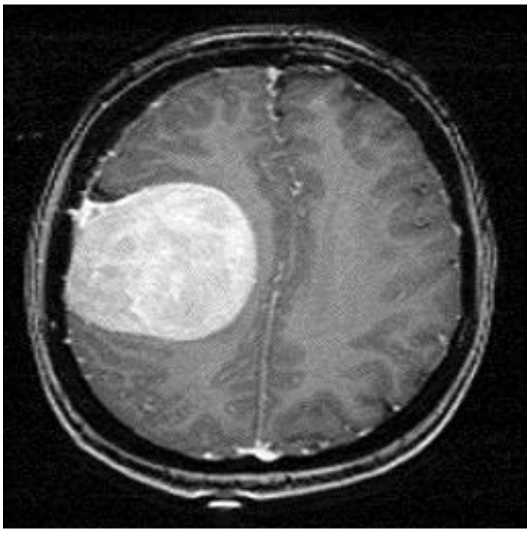

Fig 5: Medical image selected for experiment

After loading the image it's getting pre-processed. Preprocessing images commonly involves-

- Image re-sampling
- Grey scale contrast enhancement
- Noise removal
- Mathematical operations
- Manual correction
- Converting RGB to gray scale image

Then we enhance the gray scale image. Image enhancement is the process of adjusting digital images so that the results are more suitable for display or further image analysis. In enhancement stage, film artifacts such as labels and marks on the MRI image and the high frequency components are removed.

Methods of image enhancement:

- Filtering with morphological operators
- Histogram equalization
- Noise removal using a Wiener filter

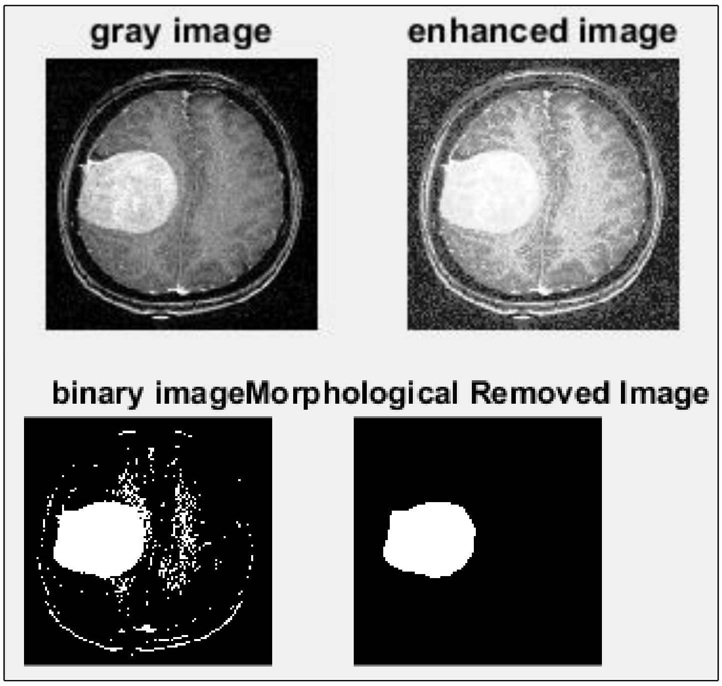

Fig 6: Different stages of developed software for images

Then segmentation of image is performed. Segmentation is the process of dividing an image into regions with similar properties such as gray level, colour, texture, brightness, and contrast.

- Study anatomical structure.
- Identify Region of Interest i.e. locate tumour, lesion and other abnormalities.
- Measure tissue volume to measure growth of tumour.
- Help in treatment planning prior to radiation therapy; in radiation dose calculation.

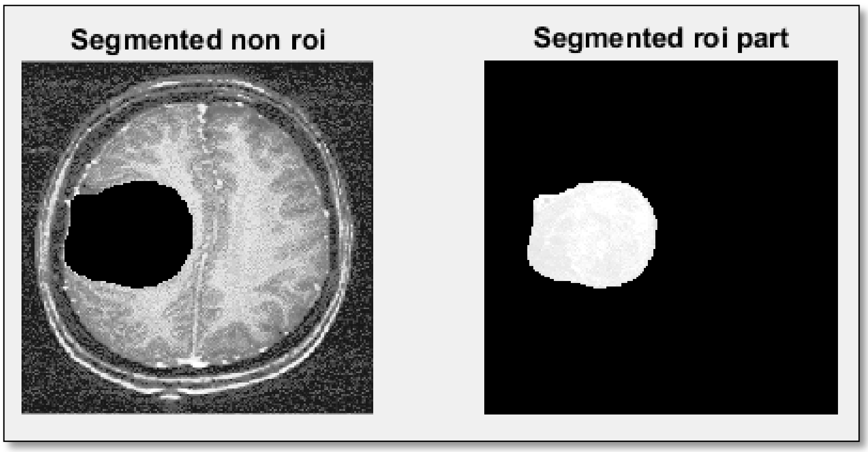

Fig 7: Segmentation of ROI part of the image

After segmentation, discrete wavelets transform is applied for both ROI part and Non ROI part.

The advantages of DWT are

- Faster calculation with respect to traditional CWT.
- No need of temporary memory.
- Generates only filtered number, low computational complexity as compared to CWT which generates floating point numbers.
- Completely reversible, with zero practical loss.

For DWT, different levels can be selected as per the user choice. Here in our project we have selected 4 level transform.

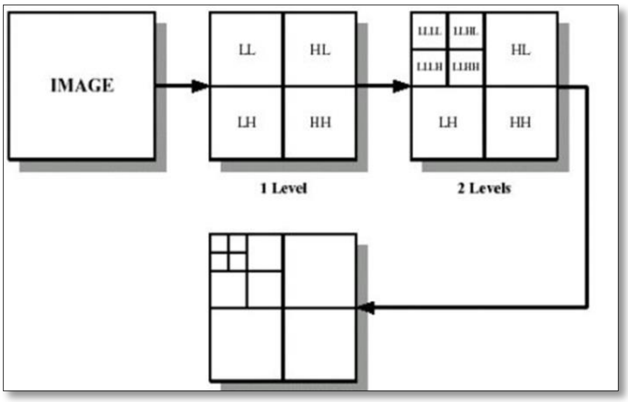

Fig 8: Discrete Wavelet Transform levels

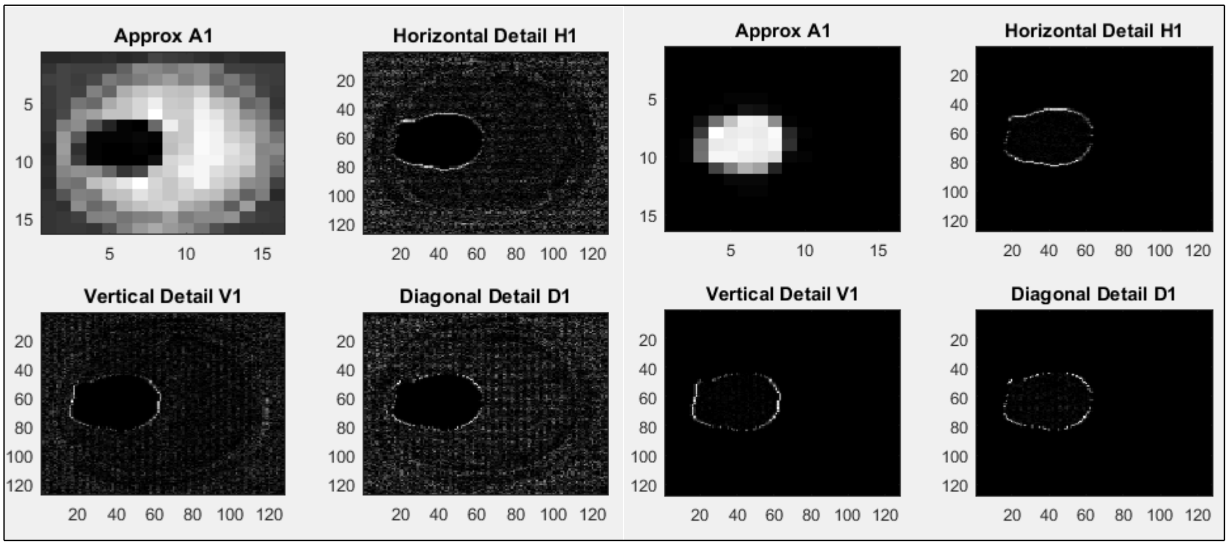

Fig 9: DWT compression

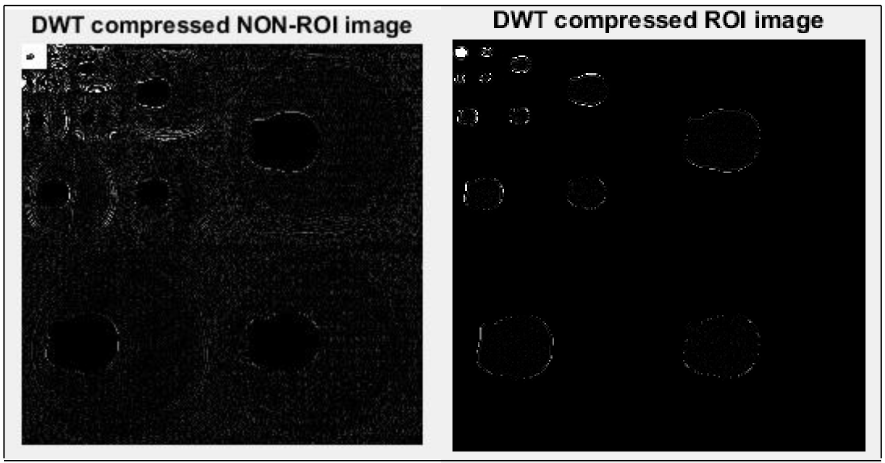

Fig 10: DWT compressed ROI and Non ROI image

After DWT, we perform SPIHT (Set Partitioning In Hierarchical Trees)encoding and decoding. Actually, The SPIHT algorithm is an extension of the EZW algorithm. The SPIHT algorithm significantly improved the performance of its predecessor by changing the way subsets of coefficients are partitioned and how refinement information is conveyed. A unique property of the SPIHT bit stream is its compactness. Two steps are performed in SPIHT. They are- Sorting pass and Refinement pass

In sorting pass the coefficients are sorted into –LIP, LSP & LIS

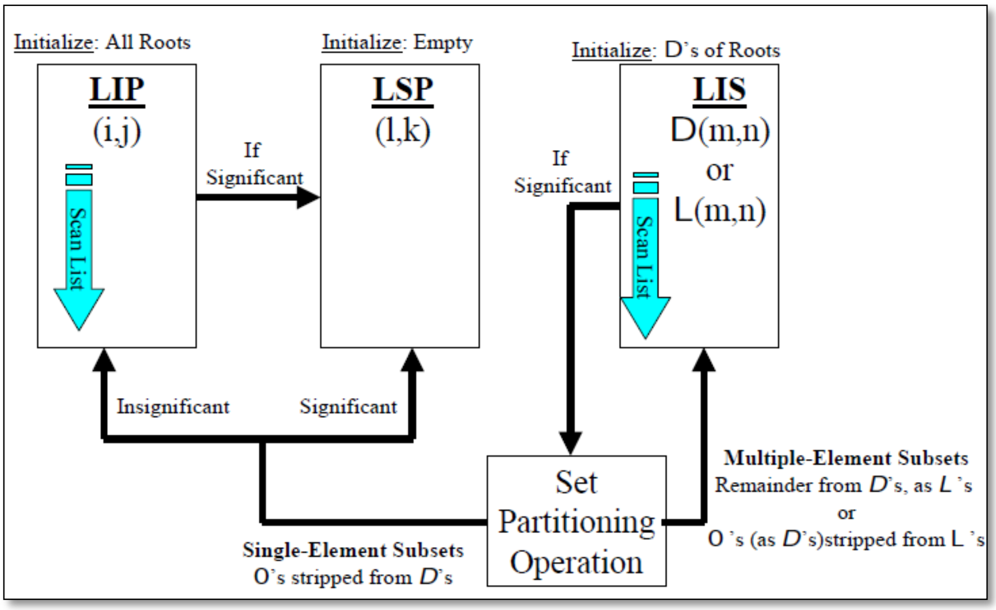

Fig 11: Sorting Pass in SPIHT algorithm

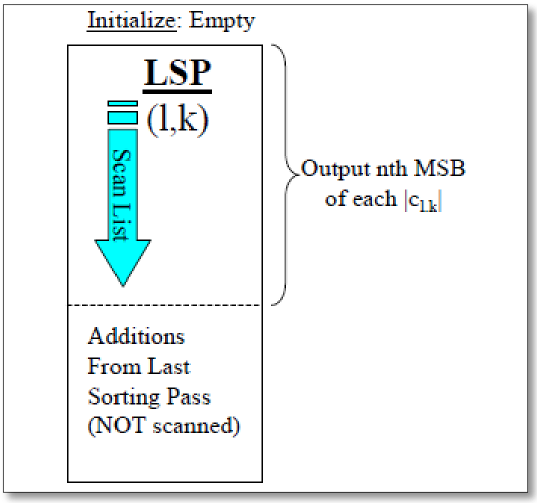

Fig 12: Refinement Pass in SPIHT algorithm

Then we go through decomposition. Decompression is done by first decoding using SPIHT. Non ROI part is reconstructed using inverse DWT. ROI part is reconstructed using inverse DWT.

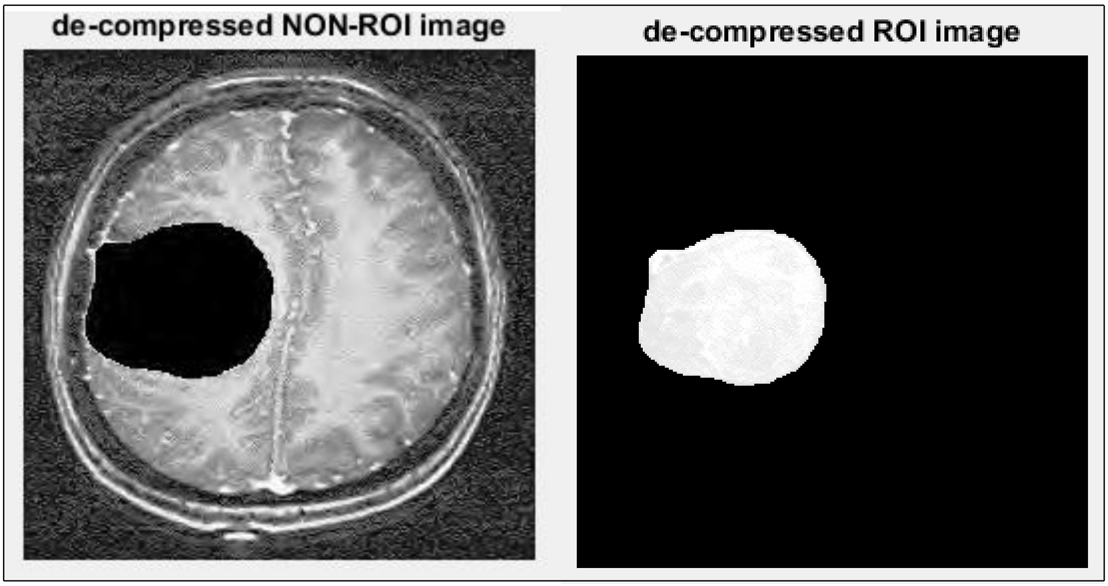

Fig 13: Decompressed images of ROI based encoding with respect to level

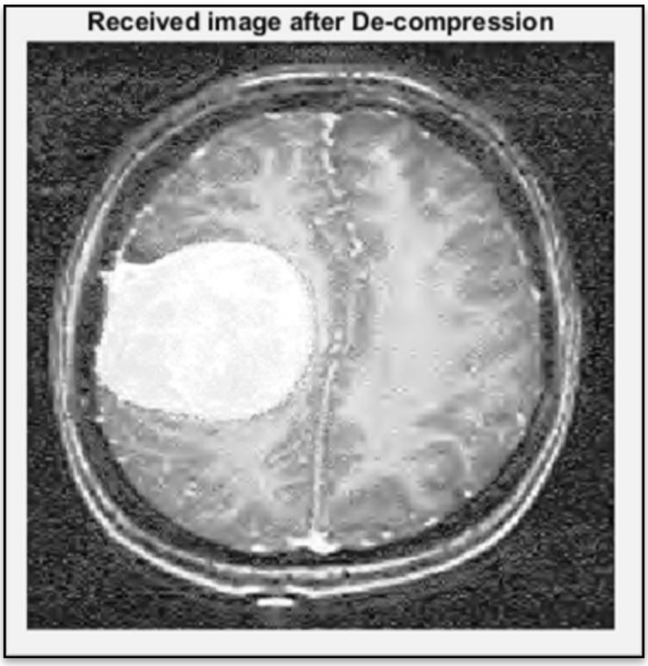

Fig 14: Reconstructed received medical image

After that we calculate MSE and PSNR (dB) and we also get the compression ratio.

$$MSE = \frac{1}{MN}\sum_{j=1}^{M}\sum_{i=1}^{N}\left[\{I'_{ij}\} - \{I_{ij}\}\right]^2$$

$$PSNR\ (dB) = 10\ \log_{10}(255)^2 / MSE$$

We get,

MSE = 74.7052; PSNR= 30.65 dB and Compression ratio= 31.9995%

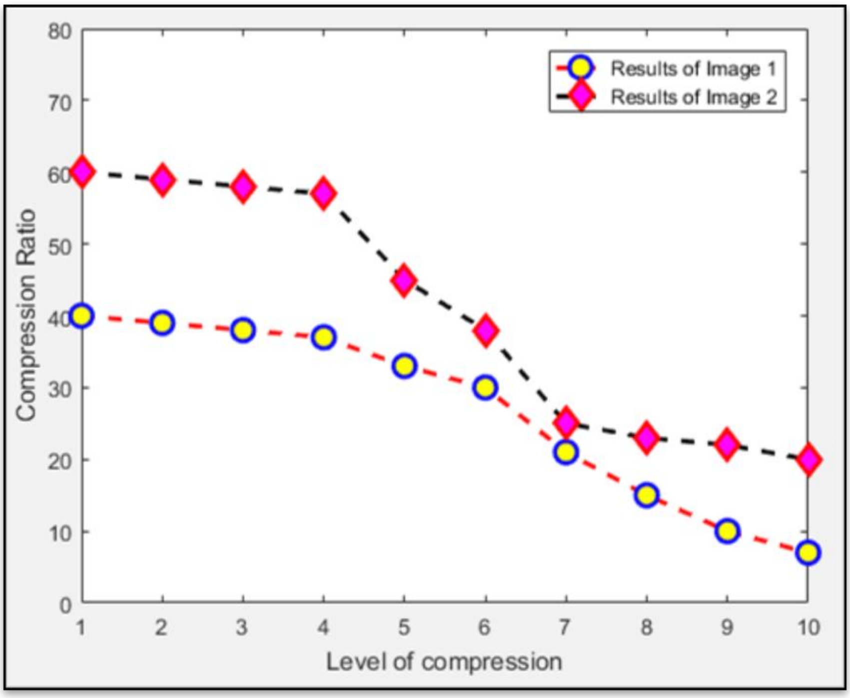

Fig 15: Analysis of compression ratio with respect to level of distortion

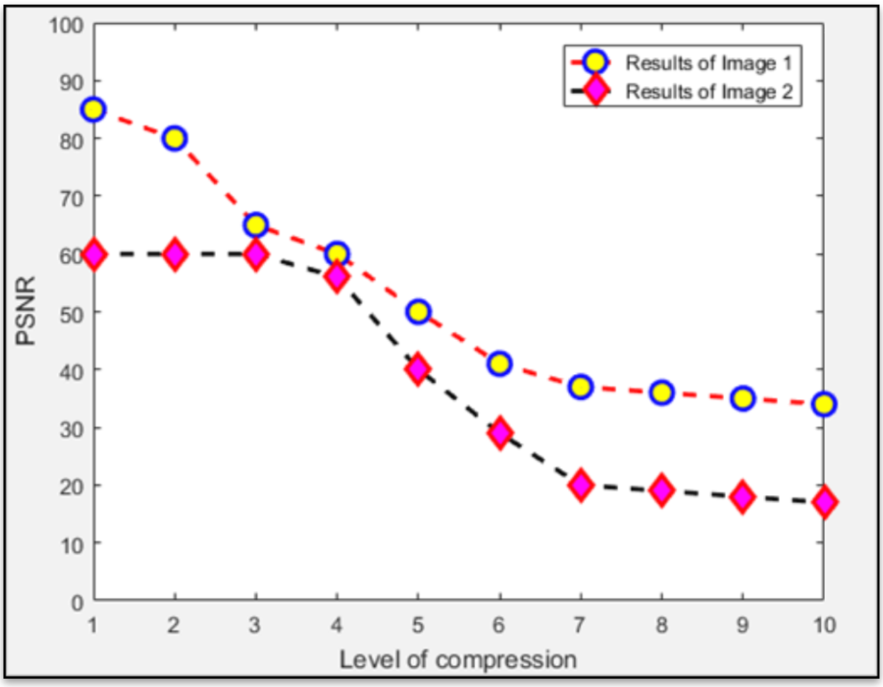

Fig 16: Analysis of PSNR with respect to level of distortion

CONCLUSION

Every image contains some redundant information, which needs to be identified by the user to obtain compression. The floating point representation gives small error in the system. The DWT is recommended for critical medical application because of its perfect reconstruction property. ROI-based compression is providing better results as compared with lossless methods, along with preservation of diagnostically important information. Such method is recommended for telemedicine system especially rural area, where network resources have limitations. Advanced version of the proposed method may include the compression based on the information contents as well as compression based on ROI to be selected automatically. Though for ROI-based compression computational complexity is also one of the important issues to be considered, while addressing real time applications, for MR DICOM images, SPIHT is proved to be the best.

REFERENCES

[1] Ali T J and Akhtar P 2008 *Significance of region of interest applied on MRI and CT images in teleradiology- telemedicine*. Heidelberg: Springer-Verlag Berlin, 151–159

[2] Baeza I and Verdoy A 2009 ROI-based Procedures for progressive transmission of digital images: A comparison. *Elsevier J. Math. Comput. Model.* 50: 849–859

[3] Bairagi V K and Sapkal A M 2009 Selection of Wavelets for Medical Image Compression. *IEEE Int Conf ACT 2009*, Trivendrum, India, 678–680

[4] Bhaskaranarayana A, Satyamurthy L S, Murthy L N R, Sethuraman K and Rayappa H 2009 Bridging health divide between rural and urban areas – Satellite based telemedicine networks in India. *Space Technologies for the Benefit of Human Society and Earth Part II*, P. Olla (ed), Netherlands: Springer Book Series, 160–178

[5]Black P E 2008 *big-O notation, Dictionary of algorithms and data structures*, P E Black (ed),

[6]Doukas C and Maglogiannis I 2007 Region of Interest Coding Techniques for Medical Image Compression.

IEEE Eng. Med. Biol. Mag. 26(5): 29–35