The Compression of Digital Imaging and Communications in Medicine Images using Wavelet Coefficients Thresholding and Arithmetic Encoding Technique

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Abstract: - The Image denoising is one of the challenges in medical image compression field. The Discrete Wavelet Transform and Wavelet Thresholding is a popular tool to denoising the image. The Discrete Wavelet Transform uses multiresolution technique where different frequency are analyzed with different resolution. In this proposed work we focus on finding the best wavelet type by applying initially three level decomposition on noise image. Then irrespective to noise type, in second stage, to estimate the threshold value the hard thresholding and universal threshold approach are applied and to determine best threshold value. Lastly Arithmetic Coding is adopted to encode medical image. The simulation work is used to calculate Percentage of Non – Zero Value (PCDZ) of wavelet coefficient for different wavelet types. The proposed method archives good Peak Signal to Noise Ratio and less Mean Square Error and higher Compression Ratio when wavelet threshold and Uniform Quantization apply on Arithmetic Coder.

Key-Words: - Compression Algorithm, Image Filtering Technique, Wavelet Denoising, Wavelet Thresholding, DICOM, PCDZ

1 Introduction

The four major file formats used in medical imaging, Neuroimaging Informatics Technology Initiative (Nifti), Minc, and Digital Imaging and Communications in Medicine (DICOM). The single file contains the metadata and image data. The above configuration store metadata at the beginning of file and image data store in second file. It consists of two binary files. An image file with extension ".img" that contains the voxel raw data and a header file with extension ".hdr" that contains the metadata, such as number of pixels in the x, y, and z directions, voxel size, and data type[1].The characteristics and strengths of the DICOM file format are as follow. It is a worldwide standard that defines how to store, exchange and transmit medical images. The DICOM has variable length binary format header with extension of .dcm. The DICOM supports singed and unsigned data types (8- bit; 16-bit; 32-bit only) [2]. The physician require image compression technique when image transmission is slow due to low internet speed and less storage. It creating a delay to diagnose or treat patients. As well as to deal with the growing size of digital examination files, some degree of compression is required for distribution, especially in teleradiology, and patient data archiving[3]

1.1 Used Compression Algorithms in Medical Imaging

There are two main categories of compression lossless (reversible) and lossy (irreversible). DICOM support lossless compression schemes i.e. low ratio JPEG, run-length encoding (RLE), JPEG-LS. In lossy compression, data are discarded during compression and cannot be recovered some time. Lossy compression achieves much greater compression than lossless compression. Wavelet and higher-level JPEG are the example of lossy compression technique where JPEG 2000 is a progressive lossless-to-lossy compression algorithm [4] [5].

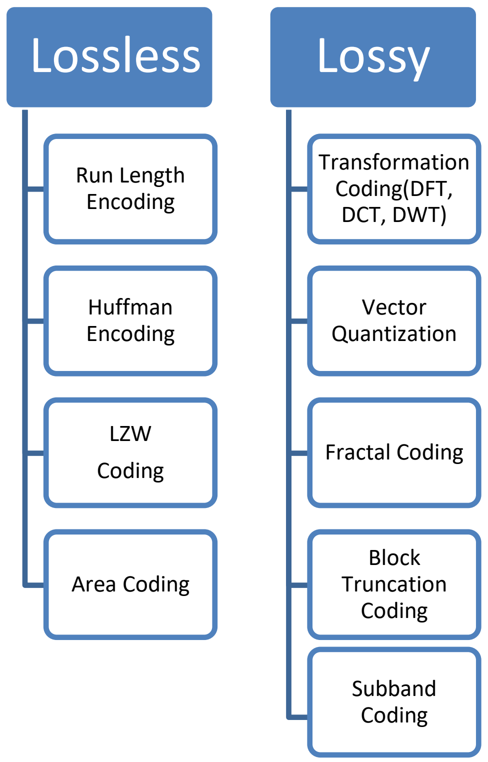

Fig.1 Types of Compression Algorithms in Medical Imaging

2 Related Work

For the medical image processing and compression algorithm input image is obtained by medical input devices such as multislices computed tomography scanners and magnetic resonance imagers. Hence different types of noise got added while image is obtaining from medical input devices. This noise degrades the quality of image. Generally noise will occur due to malfunctioning pixels in camera sensors, faulty memory location in hardware or error in data transmission. There are different types of Noises [6]

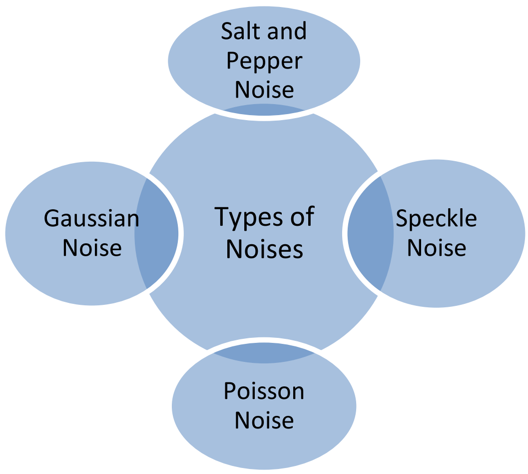

Fig.2 Types of Noises

Noise can be removed by various image filtering techniques. The traditional methods are linear and nonlinear process [7] [8].

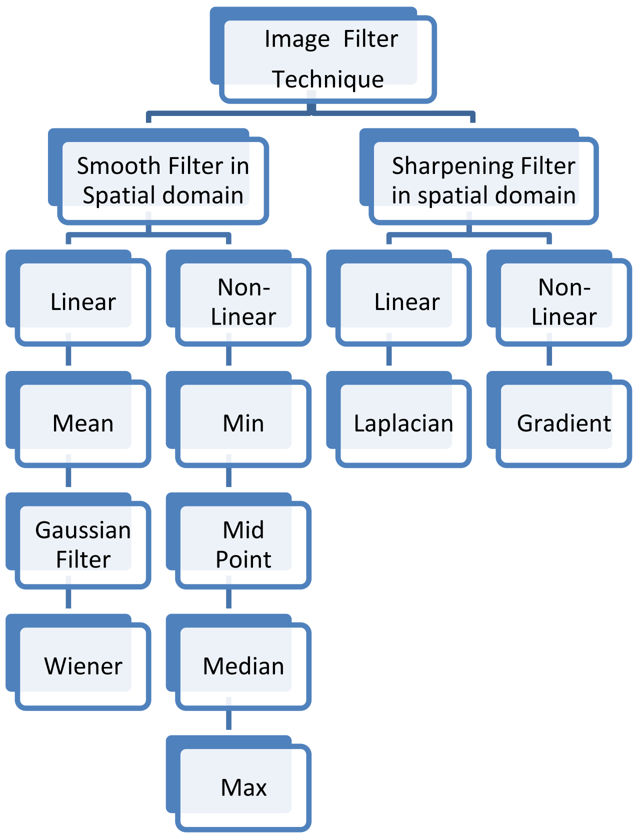

Fig.3 Image Filter Techniques in spatial domain

2.1 Wavelet Denoising

Now a days Wavelet Transform rapidly used in image processing tools, because its includes compression and denoising due to excellent localization property. The wavelet denoising include three steps.

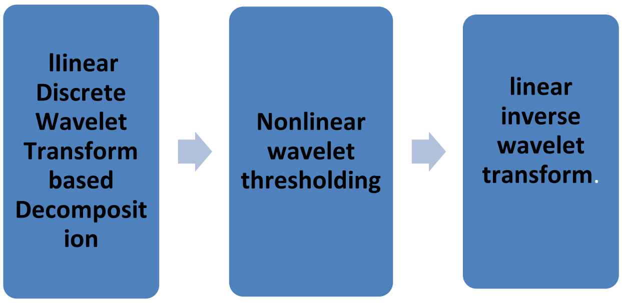

Fig.4 The block diagram of wavelet denoising

2.1.1 Wavelet Decomposition

In the wavelet decomposition, a wavelet function is chosen and decomposed up to level l. The first step the selection of the wavelet function from wavelet family. Then by applying set of function by compression or stretching or translation. The next step is the decomposition levels. The different methods of decomposition of a signal are follows.

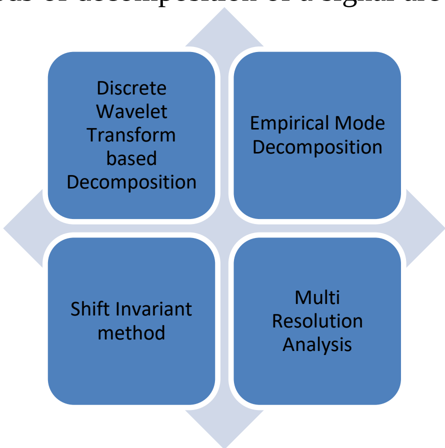

Fig.5 Methods of decomposition

2.1.2 Wavelet Thresholding

In wavelet based denoising, for every level of decomposition, a value is selected and applied to the detail coefficients. This phenomenon is known as thresholding. The basic function of thresholding is as follows: each coefficient value is comparing against threshold value. If the coefficient value is smaller than threshold, it is set to zero; otherwise it is kept. There are two important tasks: how to choose the threshold, and how to perform the thresholding [9]. Many existing methods can determine the threshold value [10]. There are various condition to perform threshold output value [11].

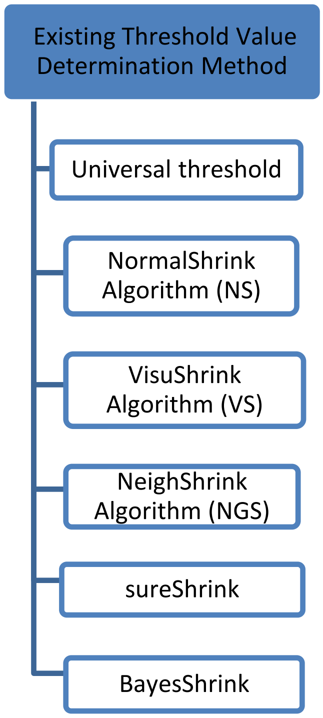

Fig.6 Types of Threshold Value Determination Methods

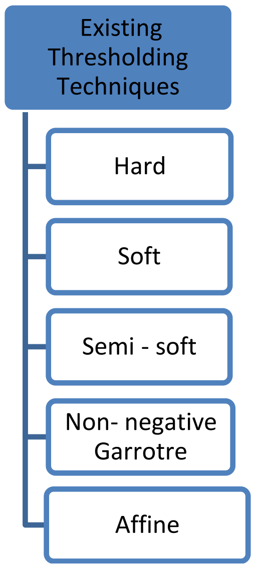

Fig.7 Existing Thresholding Techniques

3. Proposed Methodology

The flow of different used methodologies transformation, thresholding and denoising are draw and summarized in figure .7. The DICOM images is very popular now days because of its various advantages: it integrate patient's data and image details, enhances patients data safety, better compatibility, store rich acquisition and imaging protocol data. The main problem with DICOM images are poor contrast resolution, thus soft tissue cannot be viewed, image noise is also detrimental to image quality.

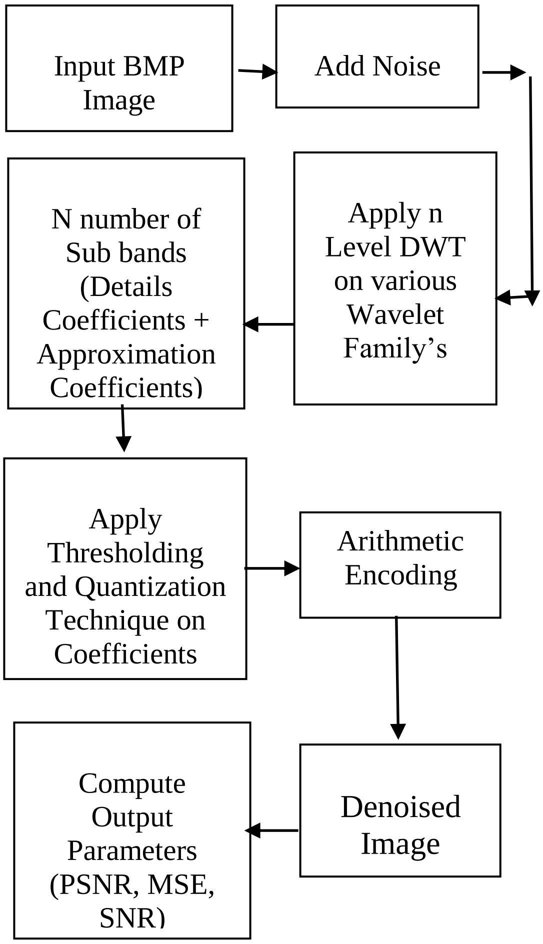

Fig.7 Proposed Block Diagram of image denoising using Wavelet Thresholding Technique

3.1 Acquisition of the .dcm image in bmp format

Input for this above motional methodology is DICOM image which contain image and patient details together [12]. Algorithm steps are as follows.

1. To read the image from specific directory. Choose file class is used for selecting the image.
2. Get the default parameter of file.
3. Create the input stream of DICOM file.
4. Set input stream using reader class.
5. Decode input stream has three part Read metadata of image, read patient data from image, read pixel information from the image.
6. Display the DICOM image.

In DICOM images small differences that may exist between normal and abnormal tissues are confounded by noise and artifacts, so direct analysis of the acquired images difficult. The Discrete Wavelet Transformations are applied in order to denoise the image because it has variable window size.

3.2 The Discrete Wavelet Transform and choice of Wavelet family

We are consider for our implementation, a three-level 2-d DWT decomposition. At each level of decomposition, the LL sub band from the previous level is decomposed, using a 2-d DWT, and is replaced with four new sub bands. Each new sub band is half the width and half the height of the LL sub band from which it was computed. Each additional level of decomposition thus increases the number of sub bands by three but leaves unchanged the total number of DWT coefficients used to represent the image data. Following n levels of 2-d DWT decomposition, the total number of sub bands is therefore 3n+1. If we consider three level, ten sub bands are generated. In this propose work we focus on finding the best wavelet bases and the suitable coefficient selection thresholding technique [12]

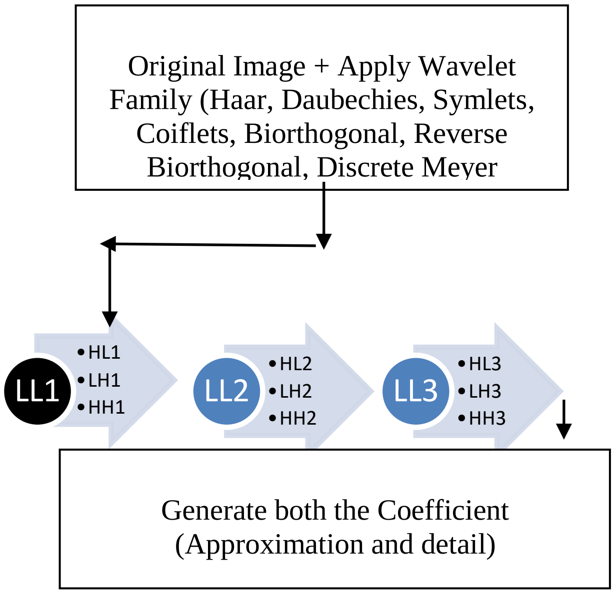

Fig.8 The process of generation of wavelet Coefficients

3.3 Apply Thresholding and Quantization Technique on Generated Coefficients

3.3.1 Thresholding

Let n*n matrix of an original image; noise observation can be written as $s = x + n$; Where s = Noise Observation, x =Original Image, n = Noise. Let s(i), x(i) and n(i) denoted ith sample of pixels. By applying Discrete Wavelet Transform the observed noised image is obtained wavelet coefficients y = θ + z; where y =Ws, θ = Wx and z = Wn respectively. To recover θ and y, y is transformed into wavelet domain that decompose y into many sub bands [13]. Further the coefficients with small value in the sub bands are dominated by noise. Thus replacing noise coefficients by zero. It is denoted by

$$y(i) = \theta(i) + z(i) \qquad (1)$$

If $$\widehat{y(i)} = abs[y(i)] < \lambda \qquad (2)$$

y (i) = 0

Where y (i) = Input and noise wavelet coefficients

λ = Threshold Value

$\widehat{y(i)} =$ *Thresholed Output*

We define the PCDZ parameter, this parameter is required to calculate the percentage of non-zero DWT coefficients.

$$PCDZ = 100 * \frac{NBz}{Ly} \qquad (3)$$

Where NBz = Number of zeros in DWT coefficients

Ly = Number of Coefficients in DWT

3.3.2 Quantization

The quantization of each level permits to put together the set of nearest values. The uniform quantization on resulting DWT coefficients sub bands from thresholding will be transformed in order to be contained in the interval [0 2^Q]. The quantization matrix will be computed as follows: We choose the quantization value Q, (Q represents the number of bits necessary to encode each position of the DWT coefficients sub bands. We determine the MAX and MIN values of the DWT coefficients (DWTmax, DWTmin). The uniform quantization on the resulting DWT coefficients sub bands is formulated by equation [14].

$$DWTQ(i,j) = \frac{(-1+2^Q)(DWT(i,j)-DWTmin)}{DWTmax-DWTmin} \qquad (4)$$

With DWT (i, j) ≠ 0

3.3.3 Arithmetic Coding

We extract the none zero value of quantized DWT coefficients and theirs positions to form two news vectors and matrices NBz (non-zero) and (TAB). TAB indicates by '1' the spatial position of a non-zero DWT (i, j) and by '0' the spatial position of a zero DCT element. TAB is into a new vector (8 bits/ element). The two vectors BNz and TAB are put together in one dimensional vector which is to be statically encoded using arithmetic coding.

4 Result and Discussion

In order to analyze the performance of our proposed method, we take one test images and there information are as follow.

The link: http://dicom.offis.de/dcmtk.php.en

Table 1. Input MR Image for evaluation of various parameters

Image Name	**Size**	**Level of Decomposition(N)**	**noise variance((σ^2)**
1.2.840.1136 19.2.5.17625 83153.21551 9.978957063. 240.dcm	522K B	3	σ = 2, 3, 3.25

The performance of proposed method are based on following parameter like Image Compress Size, Compression Ratio, PSNR, MSE, SNR, compression gain. We have taken the three different values λ (=2, 3 and 3.25) in our experiments. We have compared the experimental results of the proposed method with the various value of the global threshold value that is derived by Donoho[15][16] is given by equation.

$$\lambda = \sigma\sqrt{2\log(N)} \qquad (5)$$

It has also known has a universal threshold method. The compression ratio is the ratio between the size of the compressed image X and the size of the original image Y.

$$CR = \frac{X}{Y} \qquad (6)$$

The Compression Gain is defined as:

$$CG = \left(1 - \frac{1}{CR}\right) * 100 \qquad (7)$$

An efficient compression is represented by a great value of CR and a less efficient compression is represented by a small value of CR.

Table 2. Evaluated values of CR, PSNR, MSE, Image Compressed Size and Compression Gain for different value of Universal Threshold value with Arithmetic Coding applying on Biorthogonal DWT.

Sr. No.	**Evaluated Parameters**	**λ = 2**	**λ = 3**	**λ = 3.25**
1	Image	54 KB	51 KB	48 KB

	Compress Size			
2	Compression Ratio	9.666	10.235	10.875
3	Compression Gain [CG (%)]	89.6545	90.2296	90.80376
4	PSNR	35.8726	35.9039	35.9104
5	MSE	21.1439	21.1752	21.1816
6	SNR	29.578	29.578	29.578

The above Table 2 clear that $\boldsymbol{\lambda} = 3.25$ gives better Compression Ratio and Compression Gain, but PSNR, MSE and SNR are steady for all Universal Threshold value. The selection of $\boldsymbol{\lambda} = 3$ is occur when noise variance (σ) of input MR Image is 3 and level decomposition (N) is also 3 of bio3.1 (Biorthogonal Wavelet Transform).

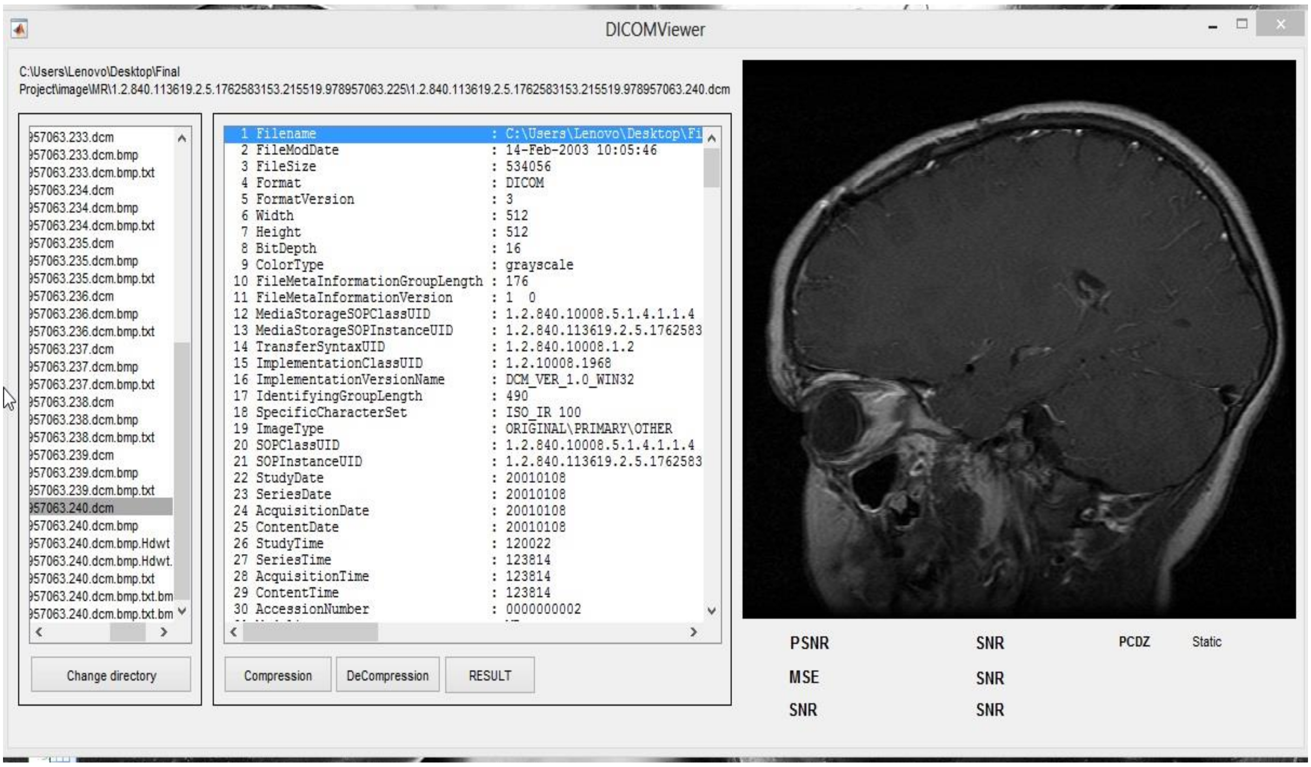

Fig.9 Graphical User interface of DICOM Image (1.2.840.113619.2.5.1762583153.215519.978957063.240.dcm)

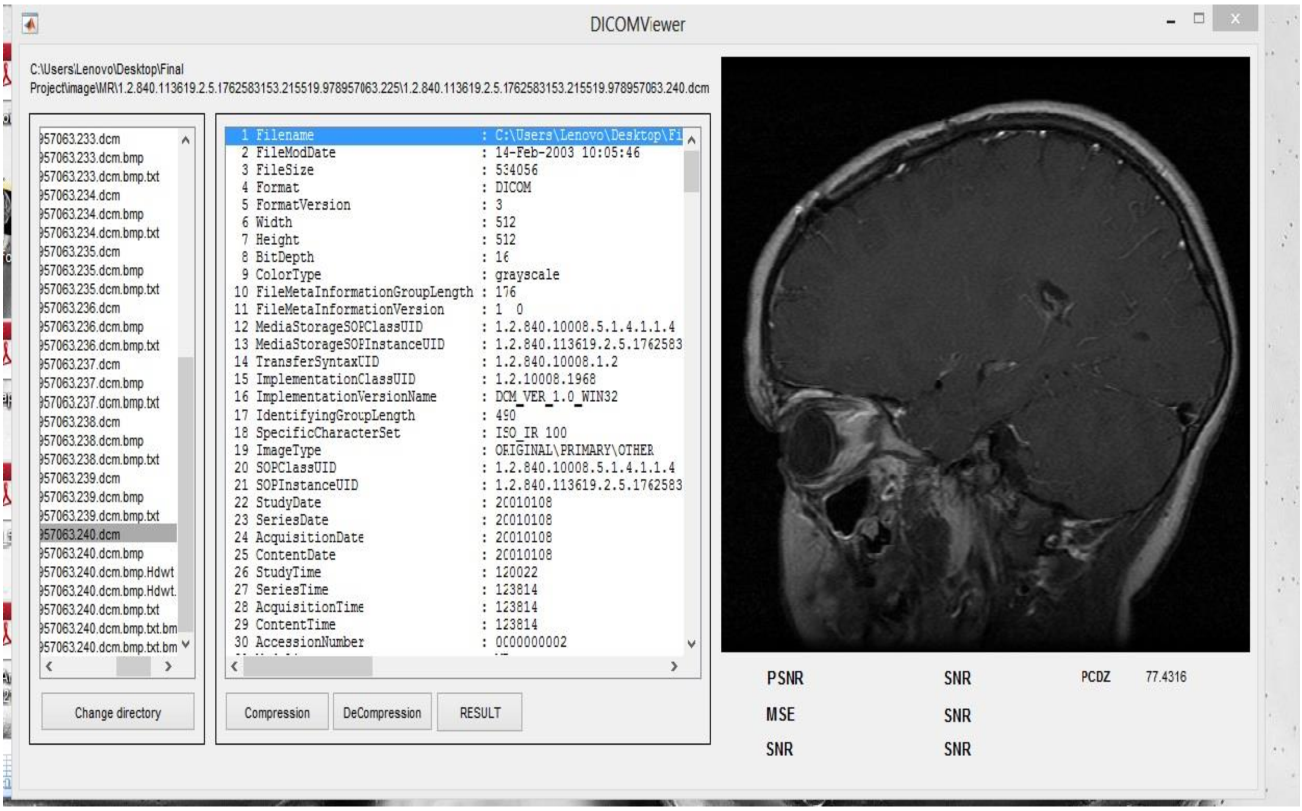

Fig.10 Graphical User interface of DICOM Image (1.2.840.113619.2.5.1762583153.215519.978957063.240.dcm) for Percentage of non-zero DWT Coefficients (PCDZ)

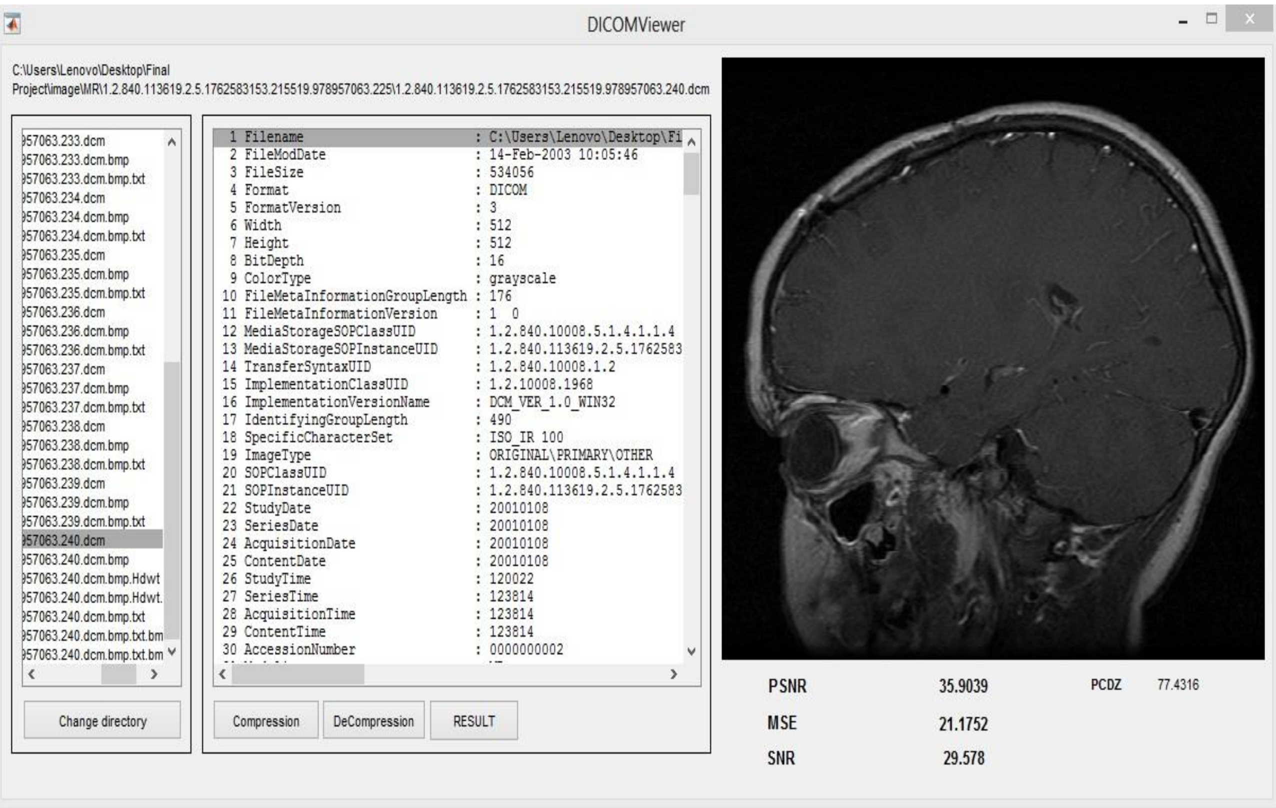

Fig.11 Graphical User interface of DICOM Image (1.2.840.113619.2.5.1762583153.215519.978957063.240.dcm) for PSNR, MSE, SNR, PCDZ

In this implementation we focus on finding the finest wavelet type and the suitable threshold value based on Universal Thresholding technique. The plots are presented for test medical image. Input image information are as follows.

Table 3. Input MR Image for evaluation of PCDZ, PSNR, MSE, SNR

Input Image Name	Size (KB)	For mat Type	Dime nsion (M*N)	Decomp osition Level (N)	Thres hold Value (λ)
brain_ 001.d cm	130	BMP	256 X 256	3	3

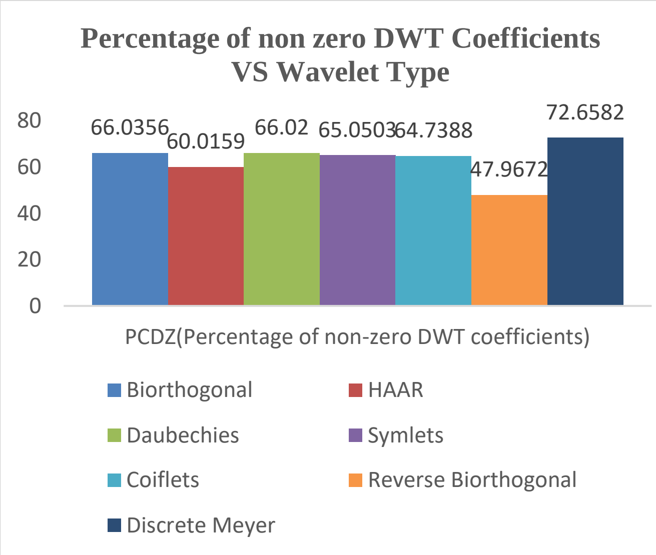

Fig.12 Plot for percentage of non-zero DWT coefficient values for brain_001.dcm

Simulation result for input image brain_001.dcm are shown in Fig. 12. Here we are considering all the wavelet types and it is observed that Discrete Meyer Wavelet gives highest percentage (72.6582%) of PCDZ and Reverse Biorthgonal Wavelet gives lowest percentage (47.9672%) of PCDZ. It is suggested that higher the PCDZ better the Compression Ratio, but more computation time is required for compression and decompression.

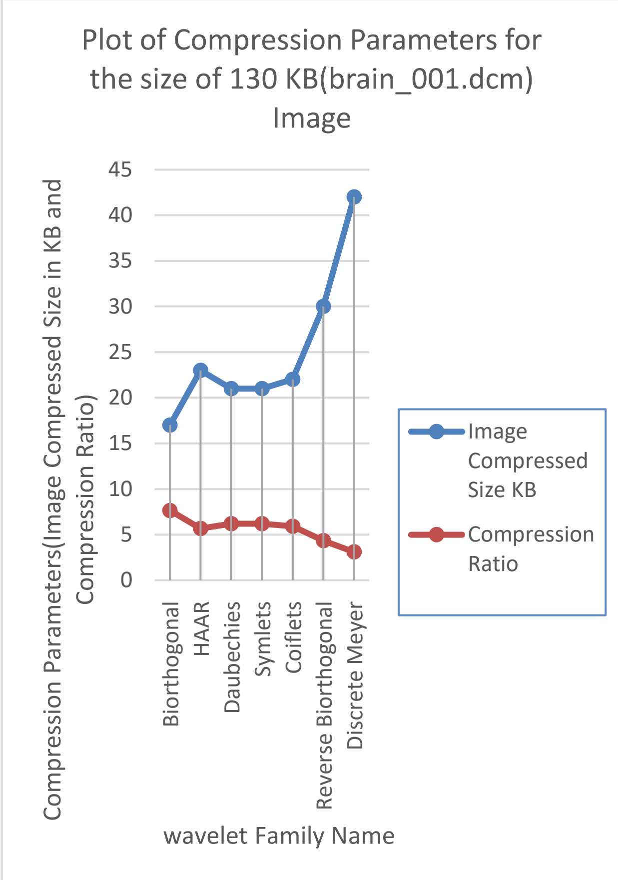

Fig.13 Plot of Compression Parameters for the size of 130 KB (brain_001.dcm) Image

Simulation result for compression parameter for the size of 130 KB (brain_001.dcm) Image are shown in Fig.13. The graph displayed that Biorthogonal DWT give high CR as comparative to another wavelet type

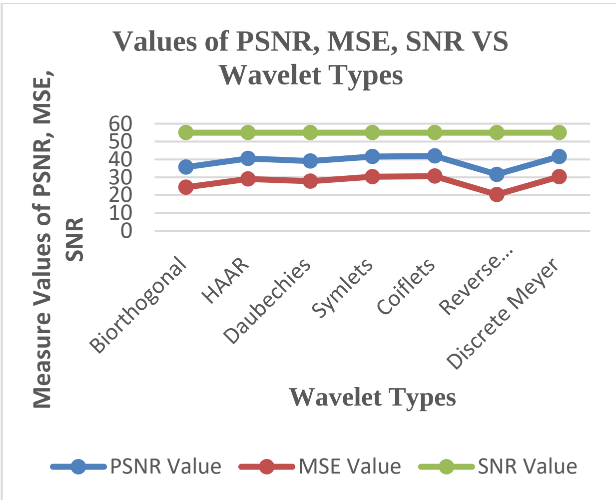

Fig.14 Plot for PSNR, MSE, SNR Values

Simulation result for PSNR, MSE and SNR using image brain_001.dcm are shown in Fig. 12. Here

SNR is constant for all Wavelet Type. The lowest MSE (20.2858) and PSNR (30.5793) evaluate for Reverse Biothogonal wavelet. It is suggested that Coiflets, Symlets and Discrete Meyer DWT wavelet gives better PSNR and MSE and SNR. Those may be suitable for higher image reconstruction.

5 Conclusion

In this paper, we present a comparative analysis of MRI image denoising in wavelet domain using shrinkage approach thresholding techniques. The simulation work was conducted to and analyze the suitability of different wavelet type like Biorthogonal, Haar, Daubechies, Coiflets, symlets, Reverse Biorthogonal, Discrete Meyer. Noises can remove by thresholding the wavelet coefficient. Hence, the universal threshold technique is used. When we compare threshold value for implemented method $\lambda = 3.25$ gives better result for image compress size, compression ratio and compression gain. Where PSNR, MSE and SNR is steady for all threshold values. Quantitative performance measure such as PSNR, MSE and SNR were used to analyze the denoising effect. It is observed that among all wavelet types Biothogonal wavelet performs well in association with hard thresholding with universal threshold at third level of decomposition.

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