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Efficient quality analysis and enhancement of MRI image using Filters and Wavelets

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Abstract: Pre-processing techniques in image processing are efficiently used to improve the quality of the image before using into any real time application. These pre-processing techniques uses neighborhood pixels in the input image to get new brightness values of the desired output image .These pre-processing techniques hire filtration and resolution enhancement in to it .noise and resolution are the main quality parameters in medical images.

The main objective is to improve the image quality by denoising and by resolution enhancement. Noise is the main factor that degrade most of the medical imaging techniques .So to preserve the edges and contour information of the medical images, an improved image enhancement technique and the efficient denoising is required. In this we concentrate on the average filtering, median filtering, wiener filtering and wavelet denoising for image denoising and an interpolation based Discrete and stationary Wavelet Transform technique for resolution enhancement. These technique performance is evaluated using Peak Signal to Noise Ratio (PSNR). From the results, it reveals that the efficient denoising and resolution enhancement technique is essential for image pre-processing.

Keywords: Pre-processing , Filtering, Denoising, PSNR, Noise, Resolution enhancement.

I. INTRODUCTION

(MRI) is a test that uses a magnetic field and pulses of radio wave energy to make pictures of organs and structures in the body and in many cases, MRI give different information about structures in the body than can be seen with an ultrasound or CT(computed tomography), X-ray scan. MRI [24], also show problems that cannot be seen by other methods. Many type of MRI are there that may be ordered by doctors for example head MRI, chest MRI, Magnetic resonance angiography(MRA), pelvis [22] and abdomen MRI bone and joint and spine MRI[23].

The magnet used in an MRI is really powerful but there are no known special effects from it. The magnet may affect artificial limbs, pacemakers, and other medical devices that contain iron even stopping a watch that is close to it. The patients who are having any type of metallic materials within their body must notify their physician or the MRI staff prior to the test[26]. Patients with simulated heart valves, metallic ear implants and chemotherapy or insulin pumps bullet fragments, should not have to do MRI scanning.

In order to improve the quality of image filters have to be applied. there are different types of filters to remove the noise from the image like mean, median and wiener filters. Mean filter [5],[6] belong to the class of linear spatial filters. Mean filter is basically convolution filter which consists of mask or kernel to produce the smooth image. Kernel represents the size and shape of the neighborhood to be sampled when calculating the mean. Generally 3×3 square shaped kernel or mask is used. Even though larger kernels like 5×5 can be used for more severe smoothing.

Median filter is like mean filter but better in Reducing noise without blurring edges of the image that is preservation of sharp edges. The median value [3] is much like neighborhood pixels and will not affect the other pixels significantly. The response of the median filter is based on median value of pixels contained in the image area encompassed by the filter or mask and then replaces the center value of pixel with that calculated median value. Wiener filters are mainly characterized by three important factors. Assumption: The stationary linear stochastic processes of image and noise with known spectral characteristics. Spectral properties like power functions for both original and noise images. Requirement: The filter must be physically realizable [11],[12],[13],[19].Performance criterion: minimum mean-square error (MMSE) or least square error.

Image interpolation is the process of transferring image from one resolution to another without losing image quality. Interpolation is the process of using known data values to estimate unknown data points in [30]. Interpolation of an image is way through which images are improved. Interpolation has been widely used in many image processing applications such as facial reconstruction, multiple description coding, and resolution. Transformation [7] of signal is representation of signal in another domain.

The transformation does not change the information associated with the signal. It will give more detailed information. It does same in case of images also. in the proposed method the combination of wavelet transform [7] and interpolation and filters in order to have

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highly resolution enhanced image [7] with high supression of noise [8],[12],[14],[27].

II. LITERATURE REVIEW

The original concept of MRI was proposed by Damadian in the year of 1969, he has requested to the Health Research Council of the City of New York proposing the MR (NMR) body scanner and requesting the funds to pursue it . In March 1971 Damadian first published Article on his work. Scanning method for MRI is proposed by the same named Damadian on spring 1971.Damadian and coworkers, Minkoff and Goldsmith, achieved the first scan (image) of the human body on 1977.Damadian and FONAR introduce first commercial MRI scanner utilizing voxel method of patent on 1980 and finally High Court on U.S Patents and U.S Supreme Court enforce Damadian '832 patent on 1997[20].

Mona Mahmoudi and Guillermo Sapiro [2005] made improvements to the nonlocal means of image denoising method. The original nonlocal method replaces a noisy pixel by the weighted average of pixels with correlated adjacent neighborhoods. While producing up to date denoising results,they concluded that this method is computationally unrealistic. In order to accelerate the algorithm, they introduce filters that eliminate unrelated neighborhoods from the weighted average. These filters are based on the local average gray values and gradients, reclassifying neighborhoods and thereby reducing the original quadratic complexity to a linear one and reducing the influence of less-related areas in the denoising of a wanted pixel. They have presented the underlying framework and experimental results for gray level and color images as well as for video [4]**.**

L. Sahawneh and B. Carroll [2009] explore the derivation of inverse filter and Wiener filter. They looked that their efficiancy in restoring has also investigated the ability to estimate the parameters of unknown noise by analyzing the histograms of uniform regions of interest in the corrupted image. Inverse filter functions extremely well when the point spread function is known and there is no noise. The inverse filter seeks to undo the blurring, which smoothes over sudden changes in intensity in the original image. The Wiener filter, does a good job of approximating the original image. It is capable to do this by attenuation of the frequencies with poor signal to noise ratios that dominated the image produced by the inverse filter. The Wiener filter also perform practically well with uniformly distributed noise and a Gaussian blur. We showed that the noise power spectrum can be effectively estimated by analyzing a relatively uniform region of interest in the degraded image. Obtaining the spectrum of the original signal is more difficult. This necessity make Wiener filter less useful in many practical application and the Wiener filter provides a sound theoretical foundation upon which other restoration techniques are based [5].

JianhuaLuo and Yuemin Zhu [2009] proposed a novel denoising approach that is based on averaging reconstructed images. This approach divides the spectrum of image to be denoised into different parts. Every sub spectrum is then reconstructed an image using a 2D singularity function analysis model. By collecting each of the reconstructed images as a sum of the different smaller noise and same noise free image, the denoising is obtained through averaging the reconstructed images. The theoretical formulation and untried results on both simulated and real images consistently demonstrated that the proposed approach can efficiently denoised high image quality and presents significant advantages over conventional denoising methods.

NING Chun-yu, LIU Shu-fen and QU Ming [2009] proposed that Traditional median filter and an adaptive median filter for removing salt-and-pepper noise in medical images. Research and analyze the influence of the filter window size and the spatial density of noise on the quality of denoised image also. The results of simulation based on Matlab show that the two methods can eliminate the salt-and-pepper noise in CT and MRI medical images and preserve the edges and detail information of the entity. Both the two methods have been used in the virtual endoscope system, and the filtering performance is very satisfactory12].

Bhaskar Gupta, Anil Kumar Singh and Vikash Kumar Chauhan [2010] explained the Performance Comparison of Median and Wiener Filters in Image denoising for Gaussian noise, Salt & Pepper noise and Speckle noise. They said that Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Image noise may also be generate in film grain and in the unavoidable shot noise of an ideal photon detector. Image noise is generally considered as an undesirable by-product of image capture. Finally they concluded that the performance of the Wiener Filter after denoising for Speckle and Gaussian noisy image is better than Median filter and the performance of the Median filter after denoising for Salt & Pepper noisy image is better than Wiener filter.

ZeinabA.Mustafa and Banazier A. Abrahim [2012] a critical issue in image restoration is the problem of Gaussian noise removal while keeping the integrity of relevant image information. Clinical magnetic resonance imaging (MRI) data is normally corrupted by rician noise from the measurement process which reduces the accuracy and reliability of any automatic analysis. The quality of ultrasound (US) imaging is degraded by the presence of signal dependant noise known as speckle. It practically tend to reduce the resolution and contrast and to degrade the diagnostic accuracy of this modality. For these reasons, denoising methods are often applied to increase the: Signal-to-Noise Ratio (SNR) and improve image quality. They proposed a statistical filter, which is a modified version of Hybrid Median filter for noise reduction, which computes the median of the diagonal elements and the mean of the diagonal, vertical and horizontal elements in a moving window and finally the median value of the two values will be the new pixel

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value. The results show that their proposed method outperforms the classical implementation of the Hybrid Median filter, median and mean filter in terms of denoising quality. It has been found that quality evaluation metrics the proposed method performs better than all other methods while still retaining the structural details and experimental results show that not only remove speckle noise but also preserve the details and edges of the image and is better than all other in quantitative terms as well as visual quality of the image.

GurmeetKaurand Jagroop Singh [2012] said that the process of removing noise from the original image is still a demanding problem for researchers. There are several algorithms and each has its assumptions, merits, and demerits. The prime focus is related to the pre processing of an image before it can be used in applications. The preprocessing is done by de-noising of image. The de-noising algorithms, filtering approach and wavelet based approach are used and perform their comparative study. Different noises Gaussian, salt and pepper and speckle noise are used. The wavelet based approach has been proved to be the best in de-noising images corrupted with Gaussian, salt and pepper and speckle noise A quantitative measure of comparison is provided by the parameters like, Entropy, Correlation, Peak signal to noise ratio, Root mean square error of the image[28].

ToranLalSahu and Mrs. DeeptyDubey [2012] Digital images are noisy due to environmental disturbances. To ensure the quality of an image, image processing of noise reduction is a very important step before analyzing or using images. Data values collected by image sensors are generally infected by noise. The denoising of image is a serious task for medical imaging, satellite and areal image processing, micro vision systems, robot vision, space exploring etc. The noise is characterized by its pattern and by its probabilistic characteristics. Most wide variety of noise types which we focus on the most important types of noises and denoise filters been developed to reduce noise from corrupted images to enhance image quality [27].

III. OVERVIEW OF PROPOSED WORK

In general the image quality analysis consist of two major parts one is mainly denoising and the other one is image enhancement or simply resolution enhancement and this resolution enhancement or the image enhancement is followed by the denoising part. The denoising part is the initial part of the entire system. Denoising as in [29],[28] part is again having two parts like one is pre-processing the MRI image and the second one is filtration part to reduce the noise [3],[5] that is in the MRI image.

The pre-processing techniques are like first take the image that is MRI raw image and convert the raw image to gray scale image because the processing of gray scale image is very easy and fast when compared to that of RGB image and after conversion of the image to gray scale image add Gaussian noise to that image to filter that noise through filter techniques that are like mean, median and wiener filter and then denoise as in [27] the image using this filters as shown in Fig 1. After this evaluate the image by calculating the mean square error and peak signal to noise ratio for each filter and then compare the results in terms of MSE and PSNR.

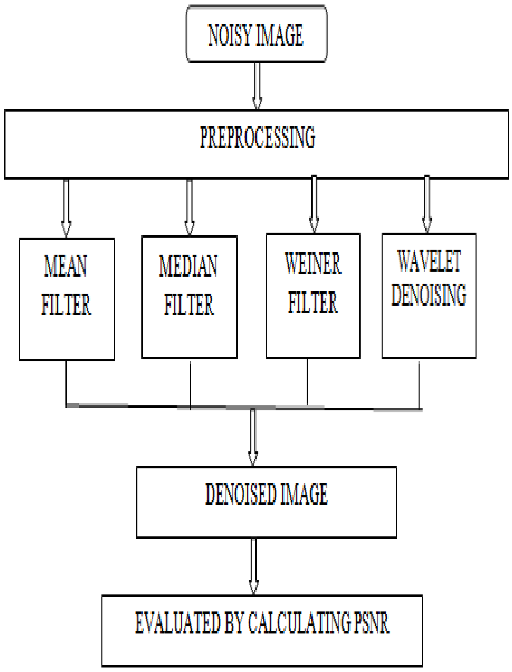

Fig 1: Flowchart for denoising technique

A wavelet transform as in [7],[15] decomposes signal into set of basic functions called wavelets. One level DWT is used to decompose an input image into different sub band images as shown in Fig 2. Three high frequency sub bands contain the high frequency components of the input image and these sub band images are referred to low-low (LL), low-high (LH), high-low (HL) and high-high (HH) and one low frequency sub band contains low frequency components referred to as low-low (LL).

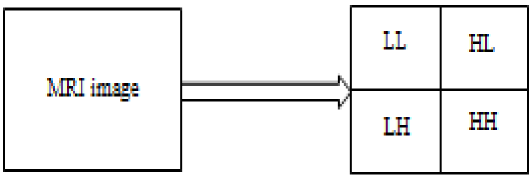

Fig 2: One level decomposition of DWT

The 2D DWT is computed by passing the input image through series of low pass filters to analyze low frequency components and through series of high pass filters to analyze high frequency components of the discrete time domain signal. The 2D DWT [7] is shown in Fig 3.

At each level of decomposition, the high pass filter produces detail information, and the low pass filter associated with scaling function produces coarse approximations. The filtering operation determines the

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image resolution meaning the quality of detail information.

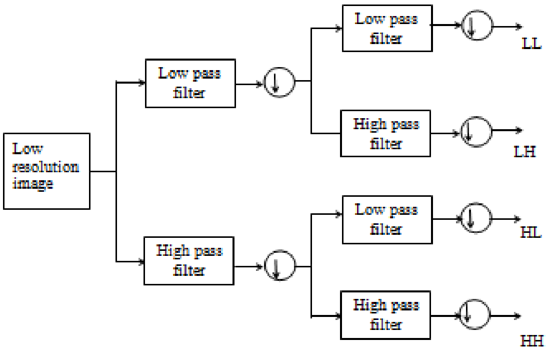

Fig 3: 2D DWT block diagram

SWT has been used in several image processing applications which is the another recent wavelet transform. We can say, SWT is similar to DWT but it does not use down sampling, s the sub-bands will have the same size as the input image. The SWT has translation invariance or shift invariance property. Thus the SWT [15] gives the larger amount of information about the transformed signal as compared to the DWT. Large amount of information especially important when statistical approaches are used for analysing the wavelet coefficients. The shift invariant property is important in feature extraction applications, denoising and detection.

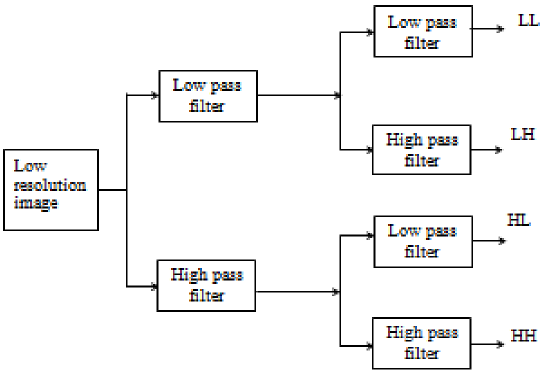

Fig 4: Block diagram of SWT

To obtain the required image after DWT and SWT has been performed; one can go for IDWT as shown in Fig 5.

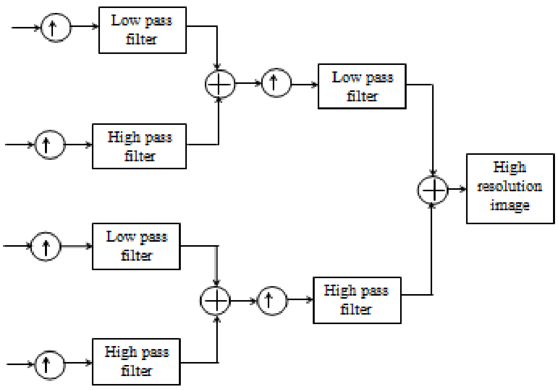

Fig 5: Block diagram of IDWT

A process by which components can be assembled back into the original image without loss of information is called reconstruction. In the proposed technique, the corrected interpolated high frequency sub bands and involution interpolated low resolution image are combined by using IDWT to obtain high resolution image. The following figure illustrates the IDWT.

In the proposed technique, bi-cubic interpolation with enlargement factor of 2 is applied to high frequency sub band images of DWT to make sub bands equal to SWT sub bands for addition. Down sampling in each of the sub bands in DWT causes information loss in the respective sub bands. Hence, SWT is used to minimize this loss.
Finally, the interpolated high frequency sub bands and the SWT high frequency sub bands have the same size which means they can be added together. The new estimated high frequency sub bands can be interpolated further for higher enlargement.

In wavelet domain we can say, low frequency sub band having the low resolution than the image which is used as input for resolution enhancement. Therefore, instead of using low frequency sub band, and that contains less information than the obtained denoised image of having low resolution, we are using the input image for the interpolation of low frequency sub band image. Using denoised [8] image instead of low frequency sub band increases the quality of the super resolved image.

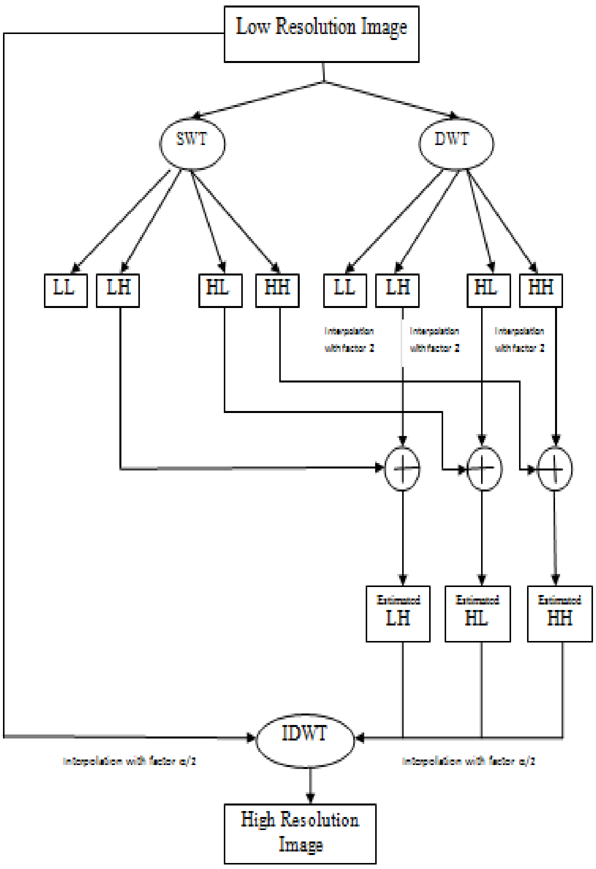

Fig 6: Flow chart for resolution enhancement

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By interpolating low resolution image by $\alpha/2$ and high frequency subbands by $\alpha/2$ in the intermediate and final interpolation stages respectively and then by applying IDWT, the output image will contain sharper edges than the interpolated image obtained by interpolation of the input image directly. This is due to the fact that, the interpolation of isolated high frequency components in high frequency sub bands and using the corrections obtained by adding high frequency sub bands of SWT [15] of the low resolution image will preserve more high frequency components after the interpolation than interpolating low resolution image directly.

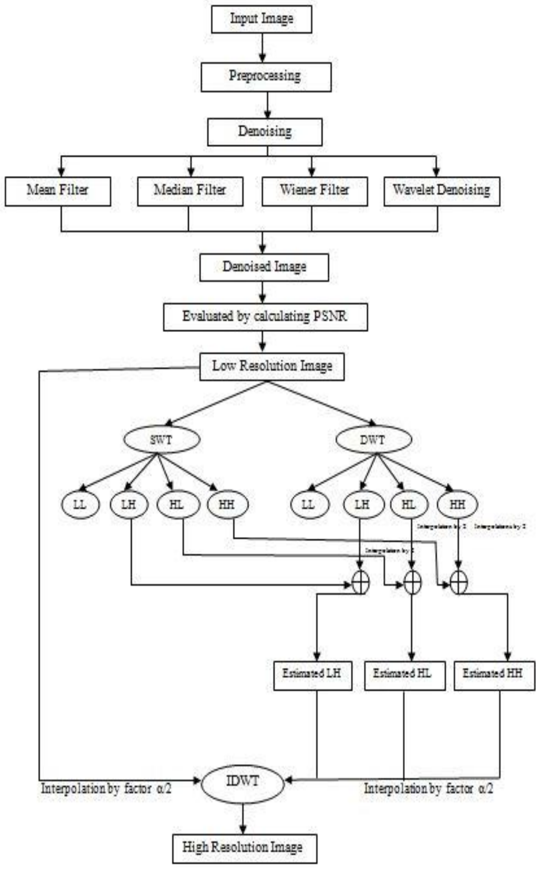
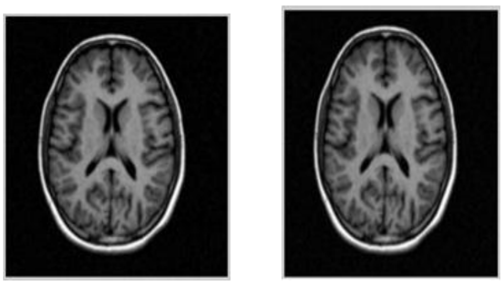


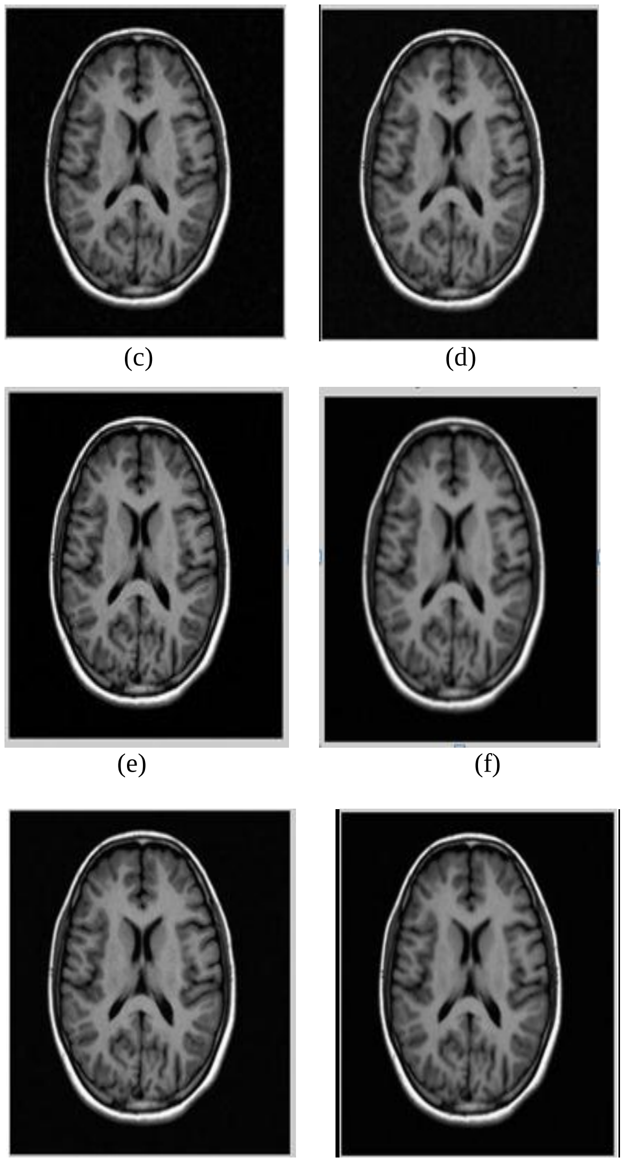
Fig 7: Final flow chart of proposed method

Following figure shows the proposed resolution enhancement technique. The proposed resolution enhancement scheme using wavelet transforms performs well compared to the resolution enhancement based on interpolation technique and it avoids the disadvantages of interpolation technique.

IV. EXPERIMENTAL RESULTS



(a) (b)

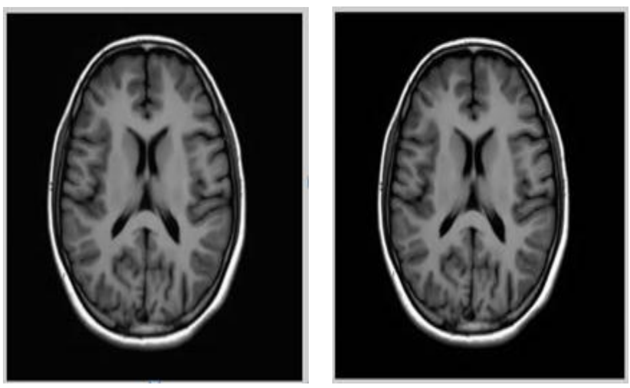


(c) (d)

(e) (f)

(g) (h)

Fig 8: (a) (b) (c) (d) Represents respected existing output of mean median and wiener filter and (e) (f) (g) (h) represents the DWT and SWT based denoised and mean median and wiener filter



(a) (b)

Fig 9: Existing method (a) Input and (b) Respective output

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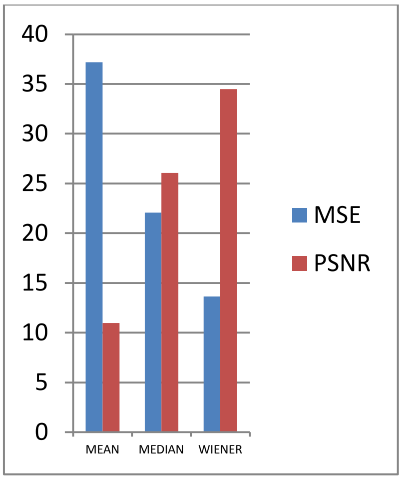
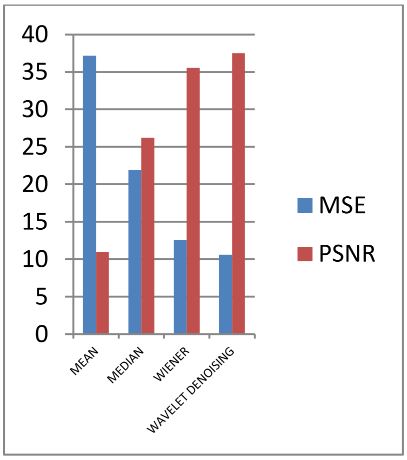
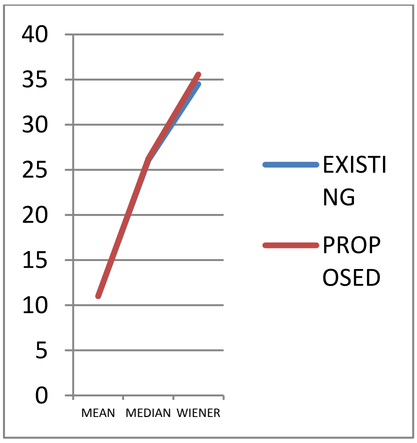


(a)



(b)



(c)

Fig 10: PSNR vs MSE value graph for (a) With DWT (b) With both DWT & SWT (c) comparison of both existing and proposed methods

V. FUTURE SCOPE

Till now the denoising part is over where the image noise is removed and the quality check of the different filters like mean filtering, median filtering and wiener filtering is checked using the PSNR. Later the image denoised is to be enhanced using wavelet transforms. The wavelets transform is like Discrete wavelet transform in which the denoised image is taken and then the process of splitting image to LL(Low-Low), LH(Low-High), HL(High-Low), HH(High-High) parts is performed and then again by taking the interpolation and inverse discrete wavelet transform is applied to get the enhanced image.

VI. CONCLUSION

The MR brain image is pre-processed by denoising in order to improve the quality of an image. In denoising [12], the noise gets reduced better by wiener filtering rather than the mean or median filter. Thus the MSE is rapidly reduced in wiener filter than the mean or median filters that make the PSNR got increased in wiener filter. So, thus wiener filter is good for removing the Gaussian noise rather than mean and median filter.

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