# Performance Enhancement of Blurred and Noisy Medical Images using Curvelet Transformation

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**Abstract— Medical images are contaminated with Gaussian noise and blur which are some of the major sources of image quality degradation during acquisition or transmission. In this we propose an improved technique to reduce blur and noise in medical images (MRI and Ultrasound) based on curvelet transform using median filter. Curvelet transform has better directional properties. Experimental results shows that our method gives comparatively higher peak signal to noise ratio (PSNR) are much more efficient and have less Mean square error (MSE). It acquires a good denoisy effect and visual effect, and preserves image edge well.**

**Keywords—Noise, Blur, MRI, Ultrasound, Denoising, Curvelet Transform, Median filter, PSNR, MSE**

## I. INTRODUCTION

Digital image acquisition and processing techniques plays very important role in current-day medical diagnosis. Medical images are generally of low contrast and they often have a complex type of noise due to various acquisitions, transmission storage and display devices and also because of application of different types of quantization, reconstruction and enhancement algorithms. All medical images contain visual noise. Images of living objects are taken using different modalities like Ultrasound, Computed Tomography (CT), and Magnetic Resonance Imaging (MRI) etc. A medical image is a window to the body. But there is no perfect window. Medical images are contaminated with Gaussian noise and blur which are some of the major sources of image quality degradation. Image restoration [1] is the removal or reduction of degradations that are incurred while the image is being obtained. Degradation comes from blurring as well as noise due to electronic and photometric sources [2] [3]. A noise is introduced in the transmission medium due to a noisy channel, errors during the measurement process and during quantization of the data for digital storage [4] [5]. Image denoising finds applications in medical imaging where the physical requirements for high quality imaging are needed for analyzing images of unique events. Magnetic resonance imaging (MRI) is increasingly being used in medical settings because of its ability to produce, non-invasively, high quality images of the inside of the human body. MRI systems in clinical diagnosis are becoming a standard tool for detecting a variety of tumors, lesions and abnormalities [6].

Ultrasonography is a diagnostic imaging technique that is used for visualizing human body structures including tendons, muscles, joints, vessels and internal organs. It is based on ultrasound. Ultrasound is a cyclic sound pressure wave with a frequency greater than the upper limit of the human hearing range [7]. Gaussian noise significantly degrades the image quality and hence, makes it more difficult for the observer to discriminate fine detail of the images in diagnostic examinations. The standard model of amplifier noise is additive, Gaussian, independent at each pixel and independent of the signal intensity. Additive white Gaussian noise is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density and a Gaussian distribution of amplitude [8]. Blurring limits visibility of detail. There is some blurring in all medical images. There are three specific effects of blurring in medical imaging [9] reduced visibility of detail, image unsharpness and reduced spatial resolution. Denoising plays an important role in signal processing. An image is often corrupted by noise in its acquisition or transmission. The aim of denoising is to remove the noise from the corrupted image and retain as much as possible the important information. Curvelet transform is a multiscale geometric wavelet transforms, can represent edges and curve-singularities much more efficiently than traditional wavelet. Curvelet combines multiscale analysis & geometrical ideas to achieve the optimal rate of convergence by simple thresholding [2]. In soft thresholding scheme, if the absolute value of the input X is less than or equal to $\lambda$ then the output is forced to zero. In the hard thresholding scheme, the input is kept if it is greater than the threshold $\lambda$, otherwise it is zero. The hard thresholding procedure removes the noise by thresholding only the wavelet coefficients of the detailed sub-band, while keeping the low-resolution coefficients unaltered. Median filter [10] follows the moving window principle and uses 3×3, 5×5 or 7×7 window. The median of window is calculated and the center pixel value of the window is replaced with that value. This paper presents the image de-blurring and de-noising on ultrasound and MRI images embedded in Gaussian noise and motion blur based on curvelet transformation using median filter. The performance assessment parameters used are Peak-signal-to-noise-ratio (PSNR) and Mean square error (MSE).

## II. RELATED WORK

Several researchers have proposed measures for image de-noising with different methods. Image degradation is a universal problem in imaging system for the hardware restriction. Digital image processing can be used to enhance resolution and noise reduction effectively; thus to improve image quality with less cost. Multiscale geometric denoising methods based on curvelet transform are used and compared with wavelet based methods. The simulated results show that cycle spinning based curvelet transform method outperforms the wavelet based methods not only for the suppression of noise but also for preservation of fine details and edges and allow the use of a low dose brain Computed Tomography (CT) images [1]. The soft-threshold denosing method in curvelet domain, which may cause edges blurred, a new denoising method based on the edge features of the given image is proposed. In this method, make full use of the anisotropic advantages of curvelet are used to extract the detail and edge information from the low-frequency domain and restore it, which can prevent the destruction of the soft-threshold [3]. The USFFT Curvelet transform is used to the noisy image, the global threshold value is estimated in the Curvelet domain. The window technique is used to compute the shrinkage factor corresponding to pixel value. The de-noised image signal is obtained by using inverse USFFT Curvelet transform. It acquires a good de- noisy effect and visual effect, and preserves image edge well [4]. A new method for image denoising based on the curvelet transform using cycle spinning. The curvelet transform, a new multiscale transform with the character of anisotropy, was developed from the wavelet transform. Experimental results show that the proposed image denoising method based on curvelet transform yields denoised images with higher PSNR and exhibits better perceptual quality than the ones denoised by wavelet transform [11]. The images usually bring different kinds of noise in the process of receiving, coding and transmission. Two digital implementations of the Curvelet transform (a multiscale transform) viz the Unequally Spaced Fast Fourier Transform (USFFT) and the Wrapping Algorithm are used to de-noise images degraded by different types of noises such as Random, Gaussian, Salt and Pepper, Speckle and Poisson noise. A signal to noise ratio as a measure of the quality of de-noising was preferred. The experimental results show that the conventional Curvelet shrinkage approach fails to remove Poisson noise in medical images [12]. But with all the work that has been done yet has not reached much higher results for de-blurring and de-noising of images.

## III. PROPOSED WORK

Curvelets was proposed by E. Candes and D. Donoho (2000). Curvelet transform is a multiscale transform with strong directional character in which elements are highly anisotropic at fine scales. The idea of Curvelets is to represent a curve as a superposition of functions of various lengths and widths obeying the scaling parabolic law: width ≅ $(\text{length})^2$. Curvelet transform wrapping algorithm is used with hard thresholding to denoise medical images of ultrasound and MRI images. In this proposed work, concept of sampling is the main concentration because to get more good quality of images after denoising first up sampling and at last down sampling is done for images of size more than 256x256 pixels of gray scale. A median filter belongs to the class of nonlinear filters unlike the mean filter. The median filter also follows the moving window principle similar to the mean filter. A 3×3, 5× 5, or 7× 7 kernel of pixels is scanned over pixel matrix of the entire image. The median of the pixel values in the window is computed, and the center pixel of the window is replaced with the computed median. Median filtering is done by, first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. Note that the median value must be written to a separate array or buffer so that the results are not corrupted as the process is performed. In methodology shown in figure 1, the algorithm works like this

Step 1: Load an original image of gray scale I (x, y).

Step 2: Apply up sampling of the inputted image.

Step 3: Motion Blur is added to the standard image read in above step. Gaussian adds additive noise to the image.

Step 4: Compute threshold value from the original image.

Step 5: Apply Fast Discrete Curvelet Transform on original images with computed threshold value.

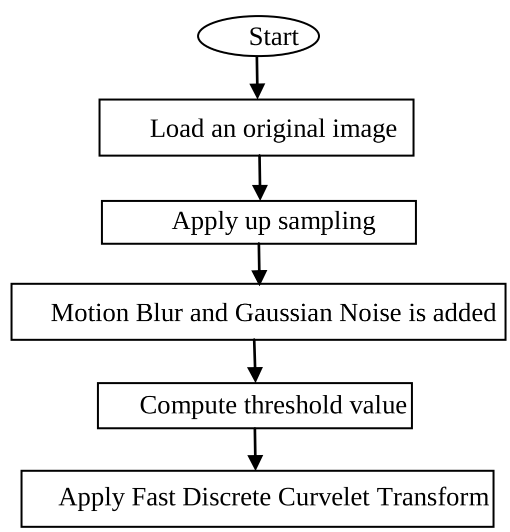
Step 6: Computed all norms of Curvelet for the estimation of noise level in image.

Step 7: Apply Curvelet Transform on Noisy images with computed threshold value.

Step 8: Apply Inverse Curvelet Transform on Noisy images to get resorted image.

Step 9: Apply down sampling.

Step 10: Load the denoise image.



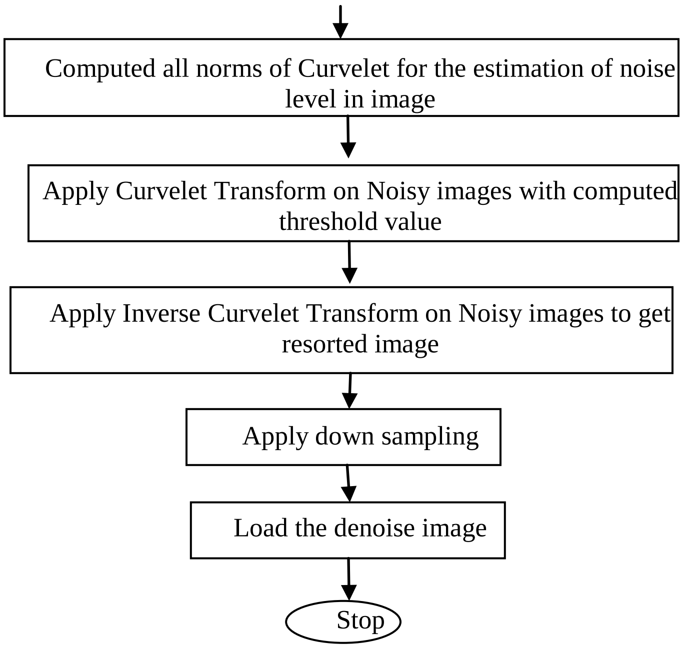
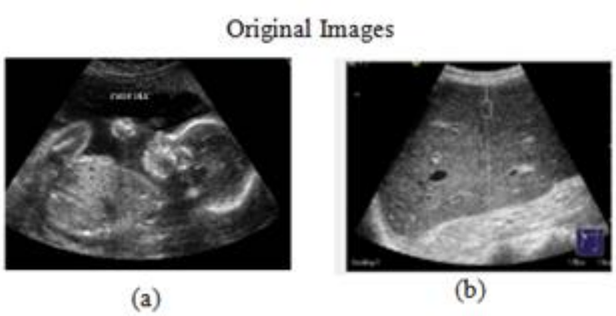
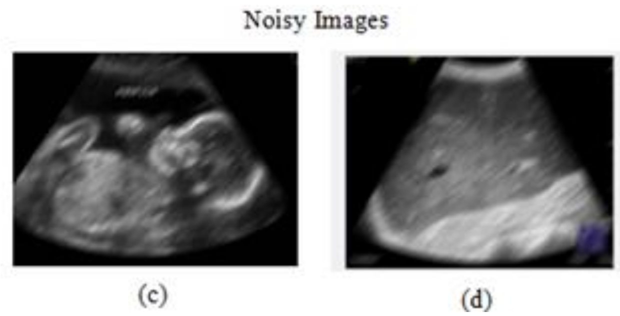



Fig. 1 Methodology

## IV. RESULT & DISCUSSIONS

In our work, the algorithm described in above section such as Curvelet transform and well known method such as, Median filter have been applied on standard images. The results were evaluated both qualitatively and quantitatively. First, Multi-Dimensional filter is applied to Ultrasound images then it is applied to MRI images to calculate MSE as shown in Fig. 2 and Fig. 3 which contains Original images, Noisy images and Denoised images, respectively to understand basics of denoise method.



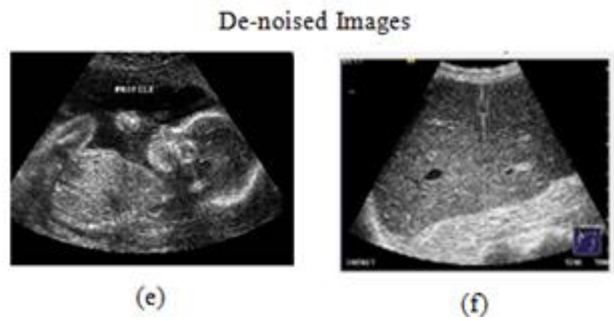




Fig. 2 Original image (a) 2d_ultrasound (b) liv_trans_ul
Noisy Image (c) 2d_ultrasound (d) liv_trans_ul
Denoised Image (e) 2d_ultrasound (f) liv_trans_ul

**TABLE I**

RESULTS OF MSE FOR ULTRASOUND IMAGES

| SNo | MSE | | |
|---|---|---|---|
| | **Image** | **Multi_Dimensional _Filter** | **curvelet_t_ Median_Filter** |
| 1 | 2d_ultrasound | 9.18 | 5.11 |
| 2 | liv_trans_ul | 11.89 | 7.4 |

**TABLE III**

RESULTS OF MSE FOR MRI IMAGES

| SNo | MSE | | |
|---|---|---|---|
| | **Image** | **Multi_Dimensional _Filter** | **curvelet_t_ Median_Filter** |
| 1 | Baby-in-womb_MRI | 8.8 | 6.08 |
| 2 | ankle-mri | 11.96 | 8.2 |

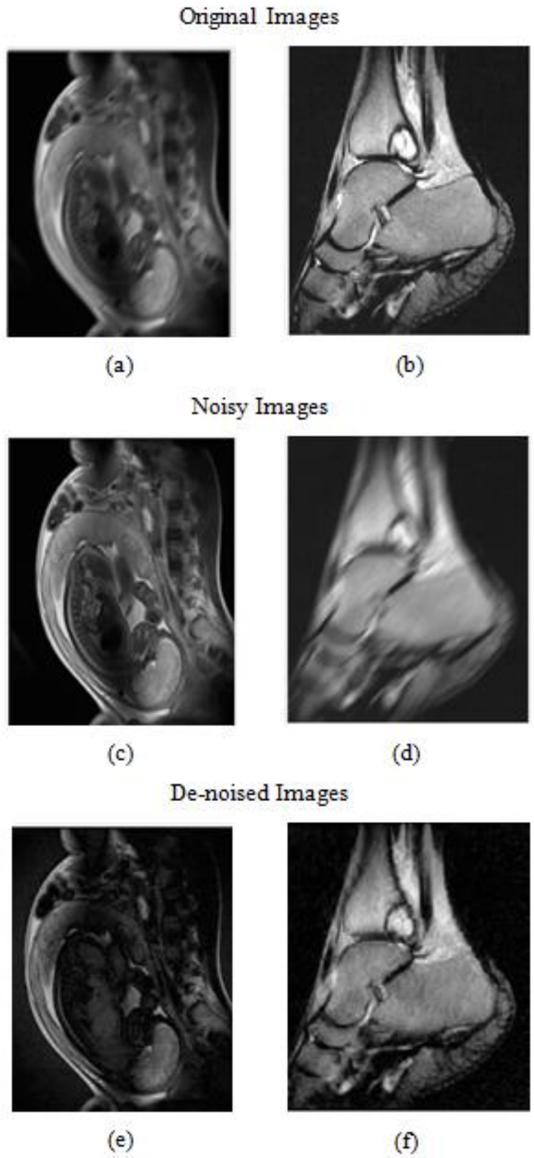



Fig. 3 Original image (a) Baby-in-womb_MRI (b) ankle-mri
Noisy Image (c) Baby-in-womb_MRI (d) ankle-mri
Denoised Image (e) Baby-in-womb_MRI (f) ankle-mri

We evaluated both quantitatively and qualitatively result of the algorithms and comparisons of their evaluated results with the help of graphs and discussion about results are shown in the form of tables. Table I and II shows the MSE parameters values for the Ultrasound and MRI images for multi dimensional filter and curvelet transform denoising. Now apply curvelet transformation using Median filter for image denoising for same ultrasound and MRI images to calculate PSNR as shown in Fig. 4 and Fig. 5 which contains Original images, Noisy images and Denoised images, respectively.

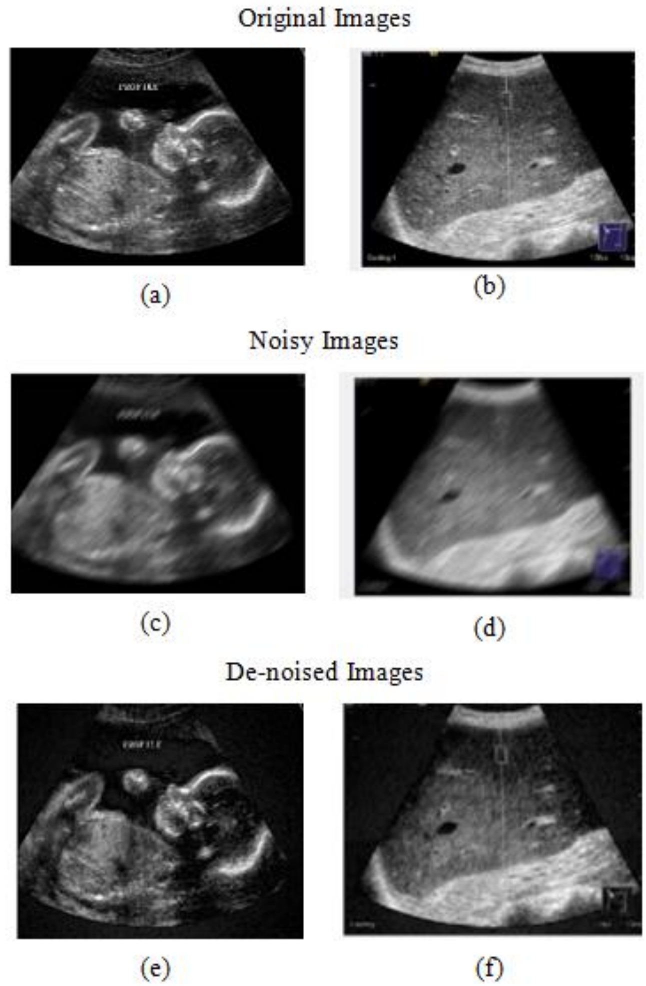



Fig. 4 Original image (a) 2d_ultrasound (b) Brachial-cleft-cystultra
Noisy Image (c) 2d_ultrasound (d) Brachial-cleft-cystultra
Denoised Image using CT (e) 2d_ultrasound (f) Brachial-cleft-cystultra

TABLE IIIII

RESULTS OF PSNR FOR ULTRASOUND IMAGES

| SNo | PSNR | | |
|---|---|---|---|
| | **Image** | **Multi_Dimensional _Filter** | **curvelet_t_ Median_Filter** |
| 1 | 2d_ultrasound | 38.5 | 41.05 |
| 2 | liv_trans_ul | 37.38 | 39.44 |

TABLE IVV

RESULTS OF PSNR FOR MRI IMAGES

| SNo | PSNR | | |
|---|---|---|---|
| | **Image** | **Multi_Dimensional _Filter** | **curvelet_t_ Median_Filter** |
| 1 | Baby-in-womb_MRI | 38.69 | 40.29 |
| 2 | ankle-mri | 37.36 | 38.99 |

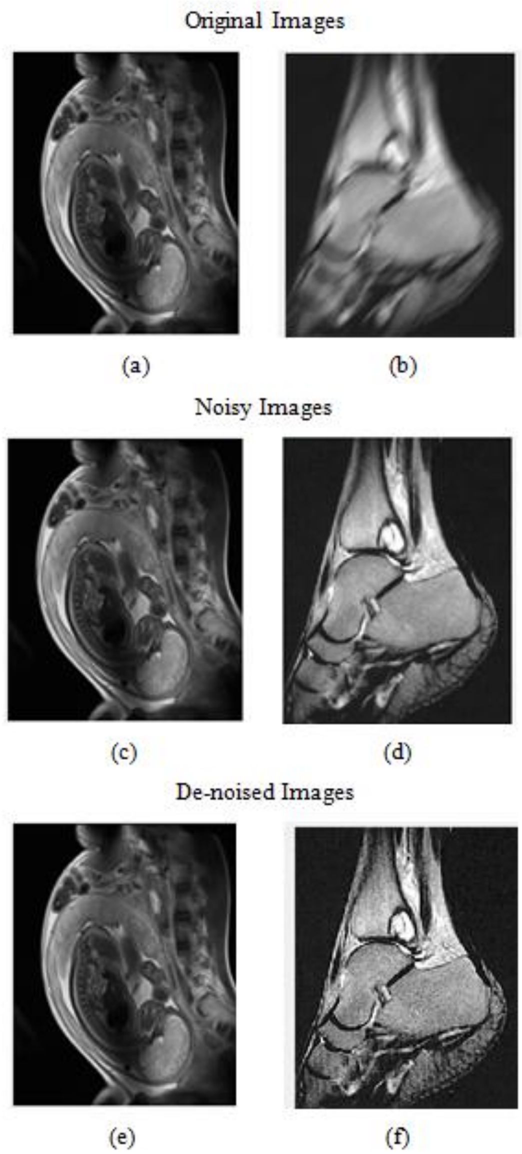
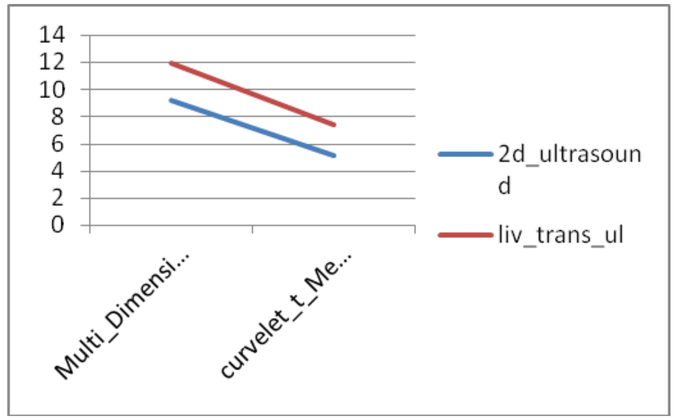


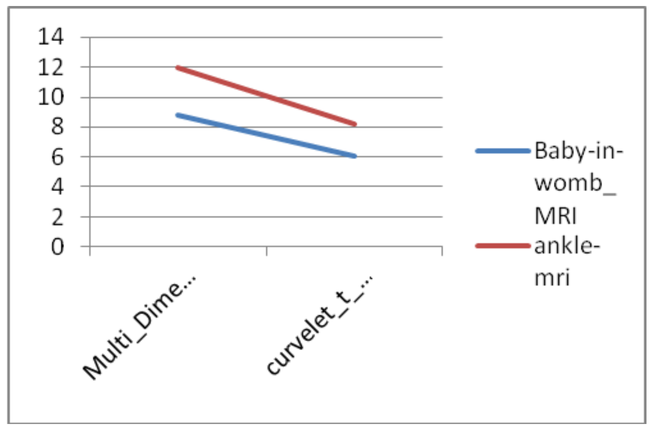

Fig. 5 Original image (a) Baby-in-womb_MRI (b) ankle-mri
Noisy Image (c) Baby-in-womb_MRI (d) ankle-mri
Denoised Image using CT (e) Baby-in-womb_MRI (f) ankle-mri

Graph 1.1 represent the MSE parameter values applied on multi dimensional filter and Curvelet transform for various images of ultrasound. On X-axis various images for denoising is represented and on Y-axis range is represented under which values of MSE lies.



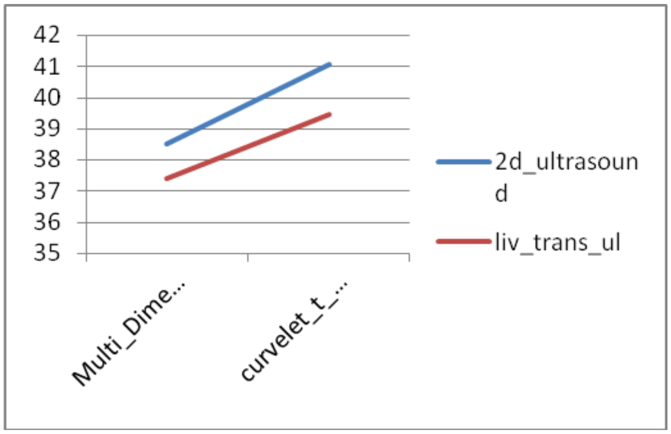

Graph 1.1 MSE Value Graph for Ultrasound images

Graph 1.2 represent MSE parameter values applied on multi dimensional filter and Curvelet transform for various images of MRI. On X-axis various techniques for denoising is represented and on Y-axis range is represented under which values of MSE lies.

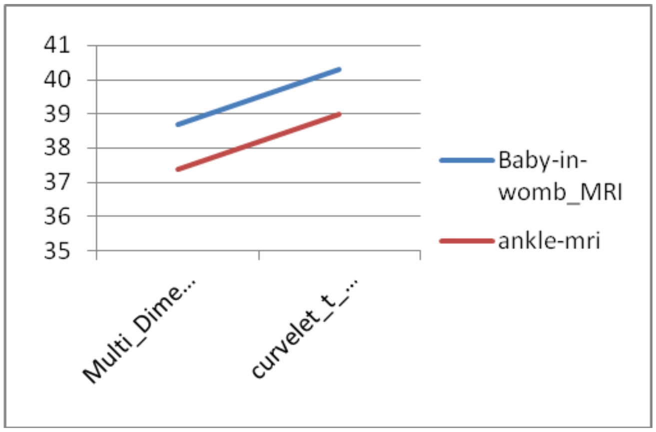



Graph 1.2 MSE Value Graphs for MRI images

Graph 1.3 represent the PSNR parameter values applied on multi dimensional filter and Curvelet transform for various images of ultrasound. On X-axis various images for denoising is represented and on Y-axis range is represented under which values of PSNR lies. Graph 1.4 represent the PSNR parameter values applied on multi dimensional filter and Curvelet transform for various images of MRI. On X-axis various images for denoising is represented and on Y-axis range is represented under which values of PSNR lies.




Graph 1.3 PSNR Value Graphs for Ultrasound images




Graph 1.4 PSNR Value Graphs for MRI images

The results for Fig. 2 and Fig. 3 are seen in Graph 1.1 and Graph 1.2, and quantitative results are shown in Table I and Table II respectively. By analyzing these results, it is seen that curvelet transform median filter results, as measure MSE is lower for ultrasound and MRI images respectively. Whereas multi dimensional filter transform algorithm have higher MSE. The results for Fig. 4 and Fig. 5 are seen in Graph 1.3 and in Graph 1.4, and quantitative results are shown in Table III and Table IV respectively. By analyzing these results, it is seen that curvelet transform median filter results, as measure PSNR is higher for ultrasound and MRI images respectively whereas multi dimensional filter transform have lower PSNR.

## V. CONCLUSION & FUTURE WORK

In our work, we make use of curvelet for denoising of grayscale images. This presents a comparative analysis of various image denoising techniques such as multi dimensional filter and Median filter based Curvelet transform as to remove motion blur and noise. In comparison of multi dimensional filtering methods and Curvelet transform method, a novel multi scaled nonlinear method for motion blur and noise suppression in ultrasound and MRI images is presented. Curvelet denoising method is more efficient in denoising blurred and Gaussians ultrasound and MRI images due to the ability of curvelet to recover signals in different directions as compared with the previous work done using other methods. The work, up to the current stage has shown how Curvelet transform can be implemented to scale and translate motion blur and Gaussian noise images into a multi-resolution analysis representation. Subsequently, various wavelet shrinkage techniques were used to reduce noise motion blur and Gaussian noise at different resolution levels. The results obtained have shown significant motion blur and Gaussian noise reduction but the images tend to smear with more decomposition levels. Hence, there are still areas that can be done to improve this work. The threshold procedures can be used in the algorithm to further improve noise reduction.

## REFERENCES

**[1]** Gajanand Gupta "Algorithm for Image Processing Using Improved Median Filter and Comparison of Mean, Median and Improved Median Filter" International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1, Issue-5, November 2011.

**[2]** E. Malar, A.Kandaswamy, S.S.Kirthana, D.Nivedhitha "A Comparative Study on Mammographic Image Denoising Technique Using Wavelet, Curvelet And Contourlet Transforms", 2012. 978-1-4673-2322-2/12/$31.00 ©2012 IEEE.

**[3]** H. S. Bhadauria and Dr. M. L. Dewal, "Performance Evaluation of Curvelet and Wavelet based Denoising Methods on Brain Computed Tomography Images" Proceedings of ICETECT 2011, 978-1-4244-7926-9/11/$26.00 ©2011 IEEE

**[4]** Jing Ji, Shan Gai in 2011 "New Image De-noising Method Using Curvelet Transform" 978-1-61284-459-6/11/$26.00 ©2011 IEEE

**[5]** Ms. Jignasa, M. Parmar, Ms. S. A. Patil "Performance Evaluation and Comparison of Modified Denoising Method and the Local Adaptive Wavelet Image Denoising Method" 2013 International Conference on Intelligent Systems and Signal Processing (ISSP) 978-1-4799-0317-7/13/$31.00©2013 IEEE.

**[6]** D. Mary Sugantharathnam, Dr. D. Manimegalai "The Curvelet Approach for Denoising in various Imaging Modalities using Different Shrinkage Rules" International Journal of Computer Applications (0975 – 8887) Volume 29– No.7, September 2011.

**[7]** N. K. Ragesh, A. R. Anil2, Dr. R. Rajesh "Digital Image Denoising in Medical Ultrasound Images: A Survey" ICGST AIML-11 Conference, Dubai, UAE, 12-14 April 2011.

**[8]** Gnanambal Iango and R. Marudhachalam “New Hybrid Filtering Techniques for Removal of Gaussian Noise from Medical Images” ARPN Journal of Engineering and Applied Sciences VOL. 6, NO. 2. FEBRUARY 2011, ISSN 1819-6608

**[9]** Zohair Al-Ameen, Ghazali Sulong and Md. Gapar Md. Johar “Fast Deblurring Method for Computed Tomography Medical Images Using a Novel Kernels Set”, International Journal of Bio-Science and Bio-Technology Vol. 4, No. 3, September, 2012.

**[10]** Jappreet Kaur, Manpreet Kaur, Poonamdeep Kaur, Manpreet Kaur “Comparative Analysis of Image Denoising Techniques” International Journal of Emerging Technology and Advanced Engineering.

**[11]** Jyotsna Patil1, Sunita Jadhav “A Comparative Study of Image Denoising Techniques”, International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 3, March 2013, ISSN: 2319-8753.

**[12]** J. Umamaheswari, Dr.G. Radhamani “Hybrid Denoising Method for Removal of Mixed Noise in Medical Images” (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 3, No. 5, 2012