

hybrid version of both adaptive median and fuzzy switching filters, has given the highest PSNR of all the five filters.

3.3 Segmentation methods

Image segmentation is an indispensable technique in image processing to spot the area of interest, especially in medical imaging to reason out the defect or malfunctioning of vital parts. It is the process of partitioning an image into a number of segments, so as to precisely locate the objects and their boundaries. Many techniques have been developed for image segmentation, depending on the application, but for congenital heart disease analysis, a familiar and most commonly used Threshold segmentation is applied. Another segmentation that is used in this study is the watershed segmentation. The filtered images taken from Non Adaptive Fuzzy Switching Method were given as input to this segmentation process and the output images were collected to further apply morphological operations. This paper holds only the filtered images and the segmented images to carry out further analysis over these congenital heart images.

3.3.1 Threshold Method

A non-parametric and unsupervised thresholding method was introduced by Nobuyuki Otsu in 1979 [4], where an optimum threshold is chosen using the discriminant criterion between the gray levels of the image. It is a simple process where it calculates from the zeroth a first order aggregate moments of the gray-level histogram. In this, an optimum threshold is being selected not based on the local property but on the global property of the histogram.

In this method, threshold is expected to minimize the intra-class variance, which is defined as a sum of weights of variances of two classes and is represented by Eq. (4),

$$\sigma_w^2(t) = \omega_0(t)\sigma_0^2(t) + \omega_1(t)\sigma_1^2(t) \quad (4)$$

Where ω_0, ω_1 are probabilities of two different classes separated by a threshold t and σ_0^2, σ_1^2 are variances of these two classes.

3.3.2 Watershed Method

Conventional Watershed segmentation transformation is a commonly used segmentation method which is defined on gray scale images. It is basically a region based segmentation approach initially proposed by Digabel and Lantuejoul in 1977 [15] and was later enhanced by Li, et al., in 2003 [16]. NAFSM filtered cardiac MRI images are given as inputs to this watershed algorithm and the segmented images are taken as output images for further applying some morphological transformations.

Both threshold segmented images and watershed segmented images are taken as inputs to further analysis by applying morphological transformations to make the region of interest achieve more clarity for the doctor's decision to be more appropriate.

4 Experimental Results

The collected cardiac MRI images were given as inputs and were subjected to various filters and studied which filters were more suitable for the enhancement of images using a metric called PSNR. The PSNR for an image is computed as the ratio between maximum strength of the original signal to that of noise that disturbs its representation and is usually expressed in decibel scale. Often it is used to estimate the reconstructed images for their quality. Noise is referred to as the error introduced into the original signal through compression. PSNR approximates human perception of reconstructed quality, especially when compressed images are compared. Higher the value of PSNR better is the reconstruction quality. PSNR is a computational measure to find the quality of the image based on pixel difference between pixels between two images. The Signal to Noise Ratio (SNR) computes the quality of a recreated image when compared to that of the original image. The PSNR would be same as SNR when all pixel values are equal. The filtering techniques were applied and tested on Cardiac MRI images. Median Filter, Average Filter, Wiener Filter, Gaussian Filter and Noise Adaptive Fuzzy Switching Median (NAFSM) Filters were applied and NAFSM filter enhanced the MRI Cardiac Images. The comparison was made on Filtered Images for quality and depicted those enhanced images in the following Table-2. The comparison metric PSNR values for quality of the images were also mentioned in the last column of the Table-2. It is evident from the Table-2 that NAFSM filter has enhanced the Image quality compared to all other filter techniques. Next to the NAFSM filter, Gaussian filter proved to be good, which then followed by Wiener filter. The same was evident from the graph represented in Fig.1. Segmentation of Images was done using two methods Threshold and Watershed shown in Table-3 and performance evaluation was made using PSNR metric

values shown in Table-4. It is found that the Threshold segmentation method was found to be good when compared with watershed segmentation. Fig.2 shows the comparison graph. The Tables are showing few MRI images results, but it was carried on all 33 images.

Table 2. Sample of 10 MRI filtered images with their respective PSNR values



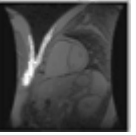
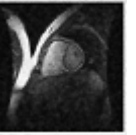
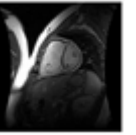
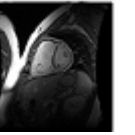

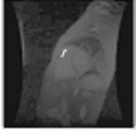
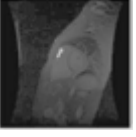
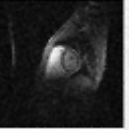


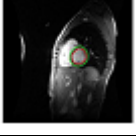
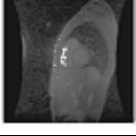
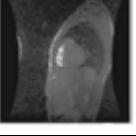
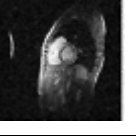
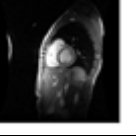
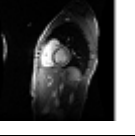

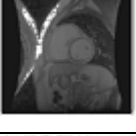




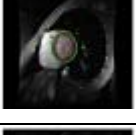
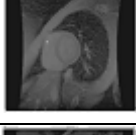






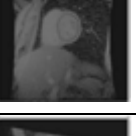
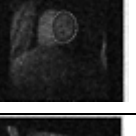
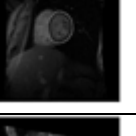

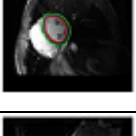
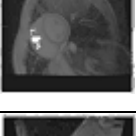
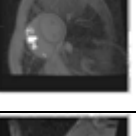


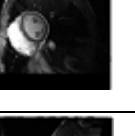
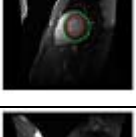
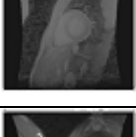
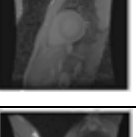
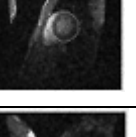


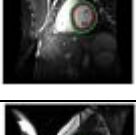
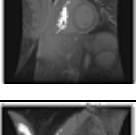
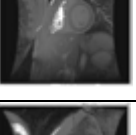

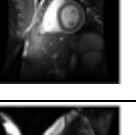


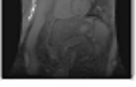



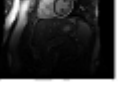
Original Image	Median filtered	Average filtered	Wiener filtered	Gaussian filtered	NAFSM filtered	PSNR
						med = 18.1394 avg = 17.6229 wien = 23.1523 Gauss = 23.2720 NAFSM = 28.9906
						med = 16.9278 avg = 16.4961 wien = 23.3653 Gauss = 23.6441 NAFSM = 29.0063
						med = 17.0316 avg = 16.6623 wien = 22.9988 Gauss = 23.1590 NAFSM = 26.5736
						med = 17.4943 avg = 17.0933 wien = 22.9889 Gauss = 23.0604 NAFSM = 27.9424
						med = 17.4991 avg = 16.9791 wien = 23.3346 Gauss = 23.6110 NAFSM = 26.5527
						med = 17.2458 avg = 16.7177 wien = 23.5411 Gauss = 23.7270 NAFSM = 26.8404
						med = 17.5475 avg = 17.0176 wien = 23.3279 Gauss = 23.6610 NAFSM = 30.1076
						med = 17.1683 avg = 16.6682 wien = 23.2778 Gauss = 23.4288 NAFSM = 27.2619
						med = 18.5658 avg = 17.9629 wien = 23.2871 Gauss = 23.4222 NAFSM = 28.0004
						med = 17.5281 avg = 17.1190 wien = 23.1601 Gauss = 23.5148 NAFSM = 28.7978

Table 3. Sample of 10 NAFSM filtered images being segmented using two different methods Threshold and Watershed Segmentation

Original Image	NAFSM filtered Image	Threshold segmented Images	Watershed Segmented Images	PSNR	
				Threshold	Watershed
				19.1818	14.2647
				21.3082	15.5509
				19.8675	14.1695
				19.9323	14.0255
				20.1542	14.7456
				22.9316	15.2529
				19.9094	14.7979
				21.3351	15.3704
				18.7359	14.3961
				20.0680	14.4714

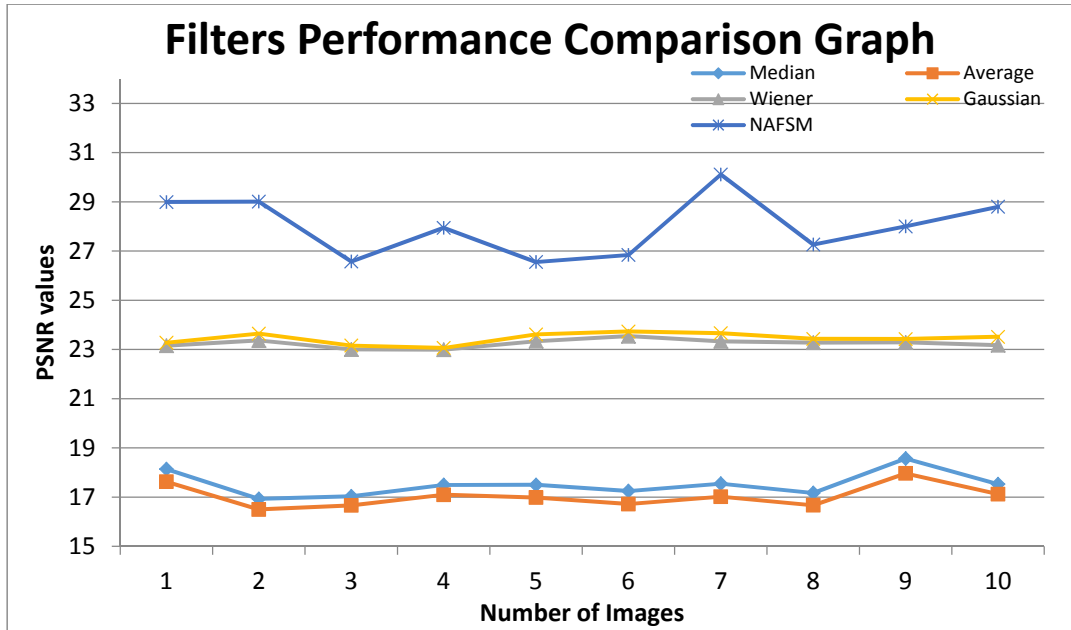


Fig.1: Performance based comparison of Filters on Images using PSNR metric

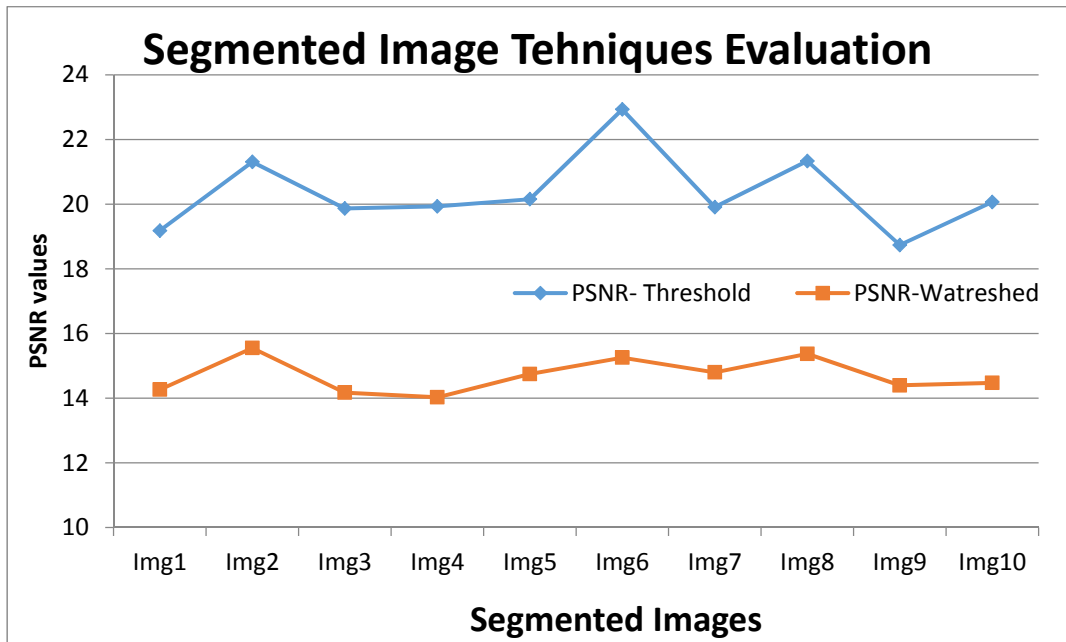


Fig.2: The Comparison graph of two segmentation methods

Table 4. The PSNR values of two segmentation methods

Segmented Images \ Metric	PSNR- Threshold	PSNR-Watreshed
Img1	19.1818	14.2647
Img2	21.3082	15.5509
Img3	19.8675	14.1695
Img4	19.9323	14.0255
Img5	20.1542	14.7456
Img6	22.9316	15.2529
Img7	19.9094	14.7979
Img8	21.3351	15.3704
Img9	18.7359	14.3961
Img10	20.068	14.4714

5 Conclusions and Future work

In this paper, cardiac MR images from 33 subjects with heart ailments were pre-processed using five types of filters viz., Median filter, Mean Filter, Wiener filter, Gaussian filter and NAFSM filter. Their peak signal to noise ratios were found out and the Noise Adaptive Fuzzy Switching Median filter resulted in a better PSNR values than that of other filters. Mean filter and Median filter proved to be not suitable for enhancement of MRI images. Gaussian and wiener filters performance are almost same, but NAFSM filter outperforms all the filters in the enhancement of image quality. Two segmentation methods were carried on refined MRI images obtained by NAFSM filter and their performance evaluation was done and it is found that Threshold segmentation was good when compared to Watershed segmentation. Further we perform morphological operations to figure out the exact location of heart ailment in the next course of our research work.

References

- [1] Christine GUILLEMOT, Patrick RAULT, Patrice ONNO. (1998): Time-invariant and time-varying multirate filter banks: application to image coding, pp. 192-218.
- [2] V. Behar and V. Bogdanova. (2015): Pre-Processing of Hyperspectral Images Using Nonlinear Filters, Information Technologies and Control.
- [3] Prodip Biswas, Abu Sufian Sarkar and Mohammed Mynuddin. (2015): Deblurring Images using a Wiener Filter, International Journal of Computer Applications (0975 – 8887) Volume 109 – No. 7.
- [4] OTSU N, IEEE Trans. Syst. Man Cybern. (1979): A Threshold Selection Method from Gray-level Histograms, 9: 62-66.
- [5] P. D. Honawadajkar and Dr. Prof. Y. S. Angal (2015): Image Segmentation Based on OTSU Method with a New Iterative Triclass Thresholding Technique, International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 5, Issue 9.
- [6] Ch. Hima Bindu and K. Satya Prasad. (2012): An Efficient Medical Image Segmentation Using Conventional OTSU Method, International Journal of Advanced Science and Technology Vol. 38.
- [7] Malik Sikandar Hayat Khiyal, Aihab Khan, and Amna Bibi. (2009): Modified Watershed Algorithm for Segmentation of 2D Images, Issues in Informing Science and Information Technology, Volume 6.
- [8] Nassir Salman. (2006): Image Segmentation Based on Watershed and Edge Detection Techniques, The International Arab Journal of Information Technology, Vol. 3, No. 2.
- [9] Yan M. X. H. and Karp J. S. (1995): Segmentation of 3D Brain MR Using an Adaptive K-means Clustering Algorithm, in Proceedings of the 4th IEEE Conference on Nuclear Science Symposium and Medical Imaging, San Francisco, USA, vol.4., pp. 1529-1533.
- [10] Kenny Kal Vin Toh and Nor Ashidi Mat Isa. (2010): Noise Adaptive Fuzzy Switching Median Filter for Salt-and-Pepper Noise Reduction, IEEE SIGNAL PROCESSING LETTERS, VOL. 17, NO. 3.
- [11] Alexander Andreopoulos, John K. Tsotsos. (2008): Efficient and Generalizable Statistical Models of Shape and Appearance for Analysis of Cardiac MRI, *Medical Image Analysis*, Volume 12, Issue 3, Pages 335-357.
- [12] Mahdi Hajiaghayi, Elliott M. Groves, Hamid Jafarkhani and Arash Kheradvar. (2017): A 3-D Active Contour Method for Automated Segmentation of the Left Ventricle From Magnetic Resonance Images, IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 64, NO. 1.
- [13] H. Ibrahim, N. S. P. Kong, and T. F. Foo. (2008): Simple adaptive median filter for the removal of impulse noise from highly corrupted images, IEEE Trans. Consumer Electron., vol. 54, no. 4, pp. 1920–1927.
- [14] K. K. V. Toh, H. Ibrahim, and M. N. Mahyuddin. (2008): Salt-and-pepper noise detection and reduction using fuzzy switching median filter, IEEE Trans. Consumer Electron., vol. 54, no. 4, pp. 1956–1961.
- [15] Digabel, H., & Lantuejoul, C. (1977). Iterative algorithms, In J.-L. Chermant (Ed.), Actes du Second Symposium Europeen d'Analyse Quantitative des Microstructures en Sciences des Materiaux, Biologie et Medicine, Caen, 4-7, pp. 85-99.
- [16] Li, H., Elmoataz, A., Fadili, J. & Ruan, S., In H. Lu & T.Zhang (Eds.). (2003) An improved image segmentation approach based on level set and mathematical morphology, Proceedings of the Third International Symposium on Multispectral Image Processing and Pattern Recognition, volume 5286, pp. 851- 854.