Cluster Computing (2019) 22:S3835–S3840
https://doi.org/10.1007/s10586-018-2430-6

A hybird filtering approach for mri image with multiresolution

K. Murugan[1] · V. P. Arunachalam[2] · S. Karthik[3]

Received: 11 January 2018 / Revised: 2 March 2018 / Accepted: 6 March 2018 / Published online: 15 March 2018

Abstract

In a modern medical technology Magnetic Resonance Imaging (MRI) is widely used to capture the structures of organs inside the body. It uses magnetic field and pulses of radio wave energy to capture the images. The images captured using MRI systems are often corrupted by various kinds noises like Gaussian, Salt & pepper, Speckle…etc. while transferring through communication network. Obtaining the clear image from corrupted images and improve the performance of the computing system is an important goal of image processing. A Hybrid filtering approach is proposed to remove the Salt & Pepper noise in the MRI images with Multiresolution. It consist of Dual Threshold median filter and verge distance filter. The classification of pixels into noisy or nose free plays a vital role in denoising. The Proposed Multi-resolution Hybrid filter out performs the existing methods while improving the resolution of the reconstructed image.

Keywords MRI · Dual threshold · Verge distance · Multi-resolution · Computing system

1 Introduction

Magnetic Resonance Imaging (MRI) system uses non-ionizing radiation to create images. In initial stages it was used in chemical analysis and named as Nuclear Magnetic Resonance Imaging system. A MRI scanner consist of large magnet and radio wave antenna. The radio waves are passed through the patient's body and received by the antennas attached to the scanner. By using the computers attached to the scanner the radio waves are converted into an image. Any part of the body can be imaged using this method.

During this acquisition and transmission process MRI images are affected by various kinds of noises like Gaussian, Rician, Poisson and Impulse noise. Impulse is the more important type of noise present in the MRI images. Salt & Pepper and Random values are two classification of Impulse noise. In this removal of Salt & Pepper noise plays a vital role in the MRI image denoising techniques. It is a important pre-processing step in a image processing [1–3, 5].

Various filtering techniques have been proposed for the removal of Salt & Pepper noise from MRI images. The edge preservation is a important feature of a filtering techniques. Filters likes Median Filter [7] and its variations are used widely in the processing. The Median filter removes the Salt & pepper noise well, but the edge preservation quality of median filter is low. So different variations are done in the Median filter to improve the edge preservation quality of it. High Speed Median Filter [10], switching filters [9], Adaptive Mean Filter [11], Modified Median Filter [8] are the example of variations of Median filter. These filters are efficiently removes the Salt & pepper noise while preserving edges. Here a new approach is proposed to remove the Salt & Pepper noise with increased resolution while preserving edges. It consist of Dual Threshold Median Filter [4] and Verge Filter [6].

Using this proposed Hybrid Multi-resolution filter MRI images are obtained with different resolution. These different images can be used based on the application.

✉ K. Murugan
murugan88.kumar@gmail.com

V. P. Arunachalam
drvparunachalam@yahoo.com

S. Karthik
profskarthi@gmail.com

1 Department of ECE, Tamilnadu College of Engineering, Karumathampatti, Coimbatore, Tamil Nadu, India

2 SNS College of Technology, Coimbatore, India

3 Department of CSE, SNS college of Technology, Coimbatore, India

2 Dual threshold median filter

Median filter replaces the corrupted center pixel in a processing window by the median value of the pixels in that processing window. Identification of noisy pixels plays a vital role in the performance of the filtering algorithms used for removing Salt & Pepper noise. Wrong identification of noisy pixels leads to blurring of an image.

A dual threshold median filter is proposed to reconstruct the corrupted pixels after the proper identification of it. A 3 × 3 processing window is used in this method. The neighboring pixels corresponding to the center pixels in the processing window are used to identify the nature of the center pixel (Noisy of Noise free). The identification is done using two threshold values TH_1 and TH_2. Where TH_1 represents the threshold values in-terms of Minimum values in the Processing window, TH_2 represents the threshold values in-terms of columns in the Processing window and they are calculated as follows. Figure 1 shows the processing window.

Fig. 1 Processing window

P(1,1)	P(1,2)	P(1,3)
P(2,1)	P(2,2)	P(2,3)
P(3,1)	P(3,2)	P(3,3)

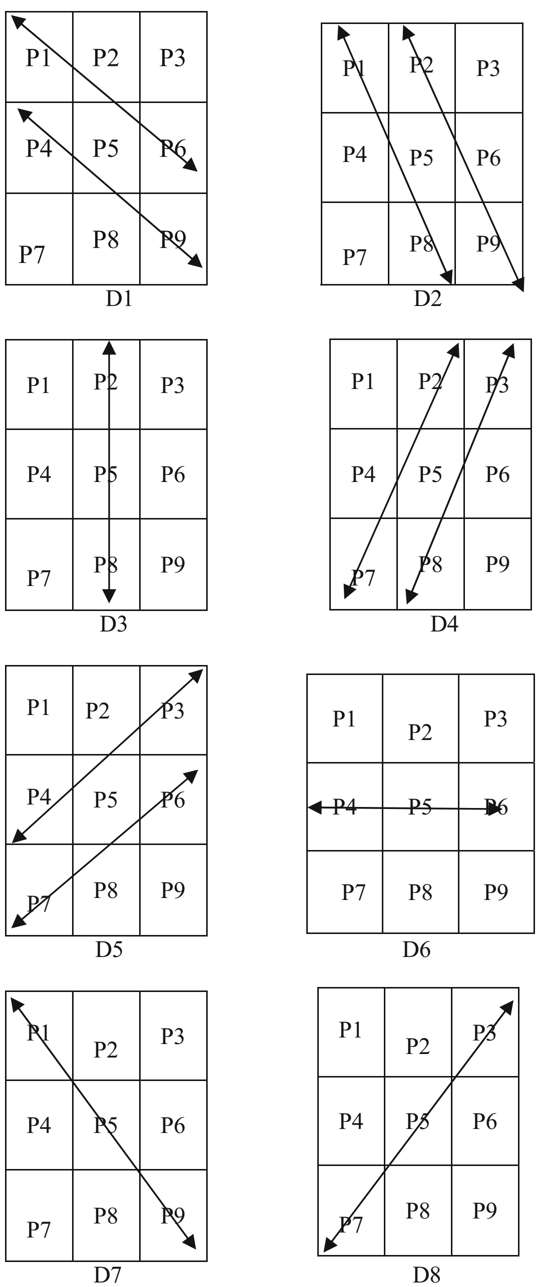

Fig. 2 Verge distance calculation

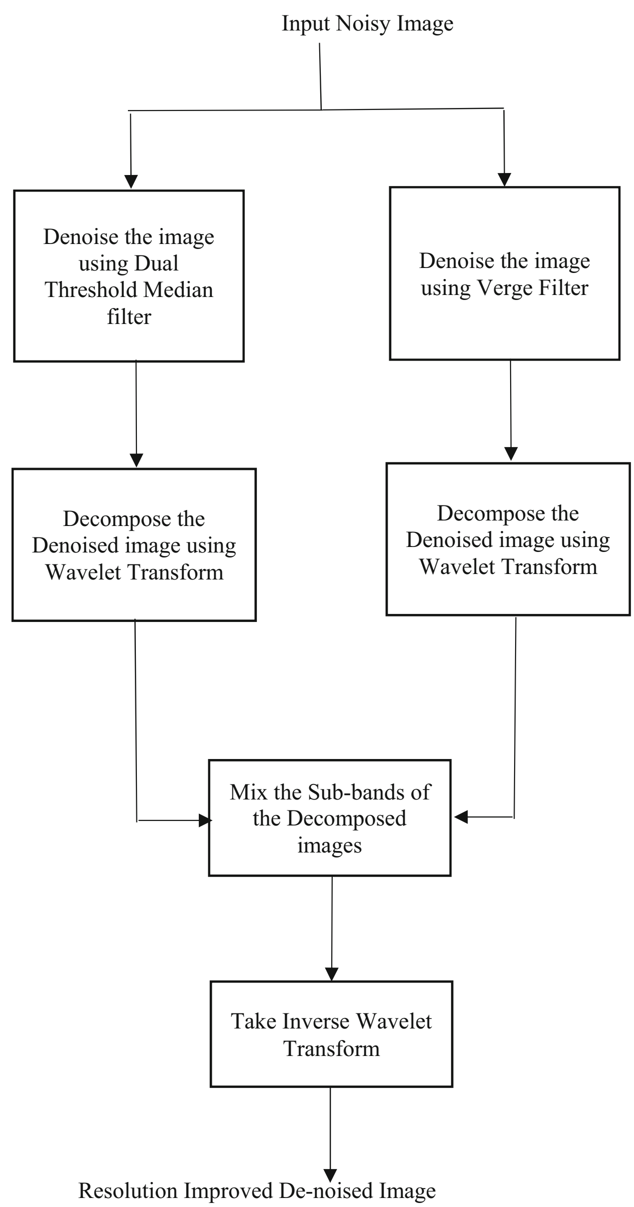

Fig. 3 Proposed approach

The TH_1 and TH_2 values are calculated using minimum and maximum values in each row, each column and diagonal values. Minimum and maximum values are calculated as follows,

$$\mathrm{MinthR}_i = \min(\mathrm{R}_i) \quad (1)$$

$$\mathrm{MaxthR_i} = \max(\mathrm{R_i}) \quad (2)$$

$$\mathrm{MinthC_i} = \min(\mathrm{C_i}) \quad (3)$$

$$\mathrm{MaxthC_i} = \max(\mathrm{C_i}) \quad (4)$$

$$\mathrm{MinthD_i} = \min(\mathrm{D_i}) \quad (5)$$

$$\mathrm{MaxthD_i} = \max(\mathrm{D_i}) \quad (6)$$

where i = 1,2,3. R_i represents row values, C_i represents column values and D_i represents diagonal values. There will be three rows, three columns and two diagonals (left diagonal and right diagonal) in a processing window.

The threshold values are given as,

$$\mathrm{TH_1} = \min(\mathrm{MinthR_i},\ \mathrm{MinthC_i},\ \mathrm{MinthD_i}) \quad (7)$$

$$\mathrm{TH_2} = \max\left(\mathrm{MaxthR_i},\ \mathrm{MaxthC_{i,}MaxthD_i}\right) \quad (8)$$

The threshold values indicates the minimum and maximum value of pixel in a processing window. If there is a noisy pixel in a processing window, then the value of threshold will be either 0 or 255. If the central pixel in a processing window equals the TH_1 or TH_2, then it is classified as a noisy pixel and it is reconstructed using the modified median value as mentioned below

$$\mathrm{MedthR_i} = \mathrm{med}(\mathrm{R_i}) \quad (9)$$

$$\mathrm{MedthC_i} = \mathrm{med}(\mathrm{C_i}) \quad (10)$$

$$\mathrm{MedthD_i} = \mathrm{med}(\mathrm{R_i}) \quad (11)$$

$$\mathrm{X'} = \mathrm{med}(\mathrm{MedthR_i},\ \mathrm{MedthC_i},\ \mathrm{MedthD_i}) \quad (12)$$

The function med represents the median value.

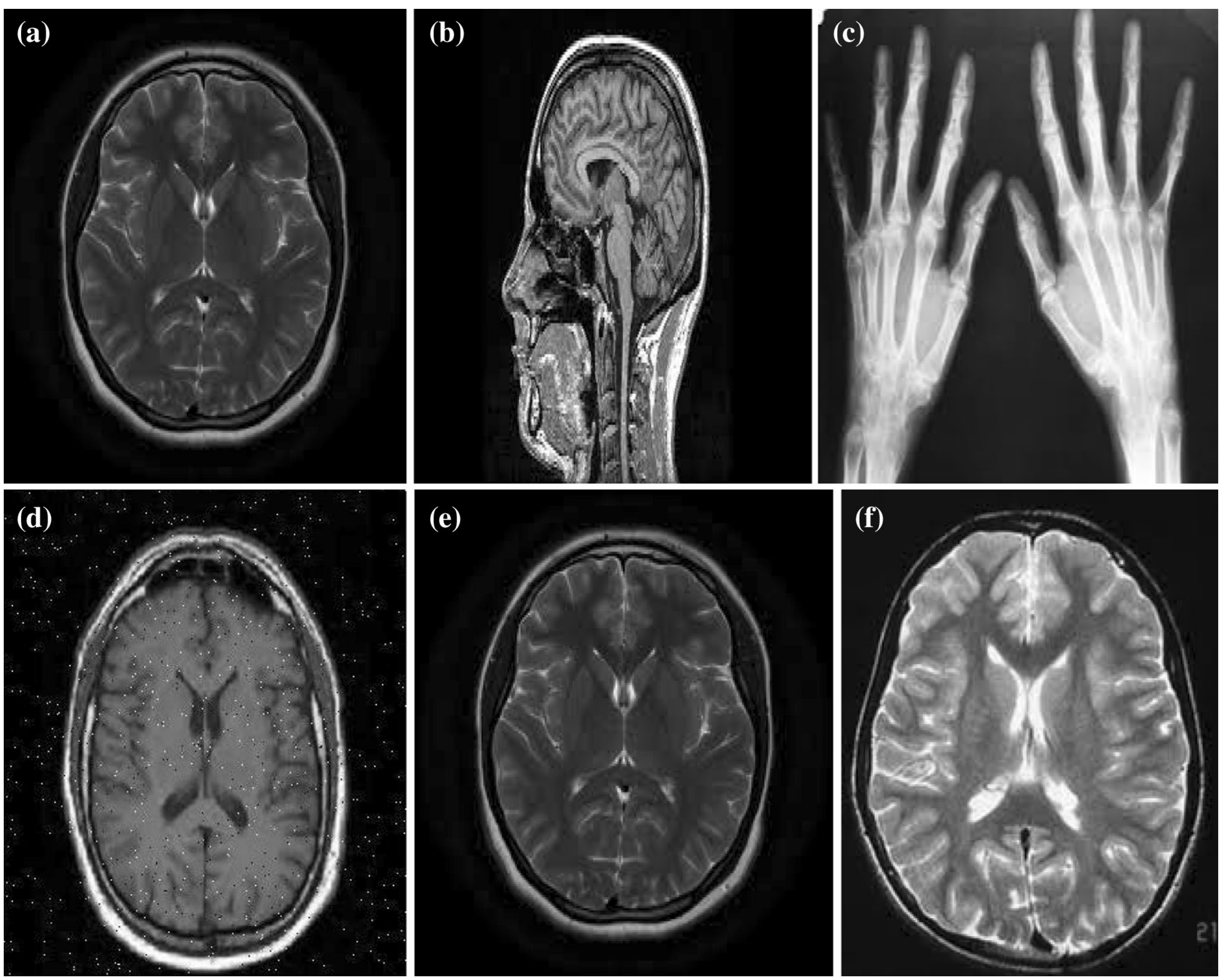

Fig. 4 **a**, **b**, **c** Original images **d** Noise affected image **e** denoised image **f** Resolution improved image

Table 1 PSNR (db) comparison

Image	Method/noise density in %	10	20	30	40	50	60	70	80	90
Sectional view of brain	DTMF	35.93	34.39	32.77	31.59	29.87	28.69	26.51	25.12	23.56
	DTBM	34.34	32.56	31.87	29.76	28.11	26.54	24.43	23.98	21.65
	WF	35.25	32.78	30.87	29.20	27.80	26.54	25.36	24.38	23.47
	MF	41.42	38.31	35.92	33.89	31.61	29.27	26.27	22.28	21.79
	AMF	42.32	39.45	37.25	34.92	32.80	30.66	27.75	23.18	22.81
	Proposed	44.56	40.87	38.55	36.72	35.96	33.28	31.64	29.88	25.45
Upper view of hands	DTMF	36.91	35.38	33.25	31.78	29.84	28.22	26.74	24.96	22.87
	DTBM	32.00	30.66	29.35	28.52	27.87	26.98	25.44	24.78	23.83
	WF	33.20	30.71	29.4	28.54	27.92	27.46	26.05	24.78	24.53
	MF	39.69	38.26	36.50	34.30	31.55	28.26	26.32	25.88	24.61
	AMF	40.21	39.30	37.51	35.61	31.98	30.12	29.54	28.91	27.12
	Proposed	40.55	39.66	38.12	35.98	32.54	31.65	30.14	29.65	28.42
Lateral view of brain	DTMF	40.68	37.83	35.03	32.13	30.02	28.37	26.79	25.02	23.74
	DTBM	40.65	36.66	33.25	31.45	29.87	27.55	25.99	24.22	21.66
	WF	42.92	39.79	37.91	34.98	31.61	29.53	27.93	26.27	24.07
	MF	41.10	40.21	38.92	37.50	36.11	33.94	31.53	28.25	26.95
	AMF	42.11	40.95	39.83	38.55	37.10	35.14	32.45	30.11	27.14
	Proposed	42.99	41.56	40.28	39.33	38.56	36.72	33.45	32.45	28.41

3 Verge filter

The verge filter is an another type of filter applied to reconstruct the noisy pixels by considering verge distance values. The small verge value corresponds to high correlation between the pixels. With respect to the central pixel eight verge distances are calculated. The Calculation of Verge distance is shown in Fig. 2

The verge distance values are given by,

$$\begin{aligned} D1 &= |P1 - P6| + |P4 - P9| \\ D2 &= |P1 - P8| + |P2 - P9| \\ D3 &= |P2 - P8| * 2 \\ D4 &= |P2 - P7| + |P3 - P8| \\ D5 &= |P3 - P4| + |P6 - P7| \\ D6 &= |P4 - P6| * 2 \\ D7 &= |P1 - P9| * 2 \\ D8 &= |P3 - P7| * 2 \end{aligned} \tag{13}$$

The verge distance indicates correlation between center pixel and pixels along the different direction. Minimum verge distance corresponds to high correlation between center pixel and pixels along that verge. The noisy pixels are reconstructed based on the verge distance as follows,

$$\begin{aligned} P5' &= (P1 + P6 + P4 + P9) \quad \text{if Dmin} = D1 \\ &= (P1 + P2 + P8 + P9) \quad \text{if Dmin} = D2 \\ &= (P2 + P8)/2 \quad \text{if Dmin} = D3 \\ &= (P2 + P3 + P7 + P8) \quad \text{if Dmin} = D4 \\ &= (P3 + P4 + P6 + P7) \quad \text{if Dmin} = D5 \\ &= (P4 + P6)/2 \quad \text{if Dmin} = D6 \\ &= (P1 + P9)/2 \quad \text{if Dmin} = D7 \\ &= (P3 + P7)/2 \quad \text{if Dmin} = D8 \end{aligned} \tag{14}$$

where Dmin represents the minimum of verge distances. If the central pixel in a processing window is classified as noisy pixel using the TH_1 and TH_2, then it is replaced by Eq. (14).

After Denoising the images by Dual Threshold Median filter and Verge filter, wavelet transform is applied on the denoised images. The application of wavelet transform decompose the images into different sub-bands. The sub-band contains LL, LH, HL and HH bands. The high frequency band contains edge information. By combining the different sub-bands of the two denoised images, an image with different resolution can be obtained. Figure 3. Shows the proposed approach.

The flow of proposed algorithm is given as,

Step1: Get noisy image

Step1: Apply Dual Threshold Median filter to get denoised image.

Step3: Apply verge filter to get denoised image.

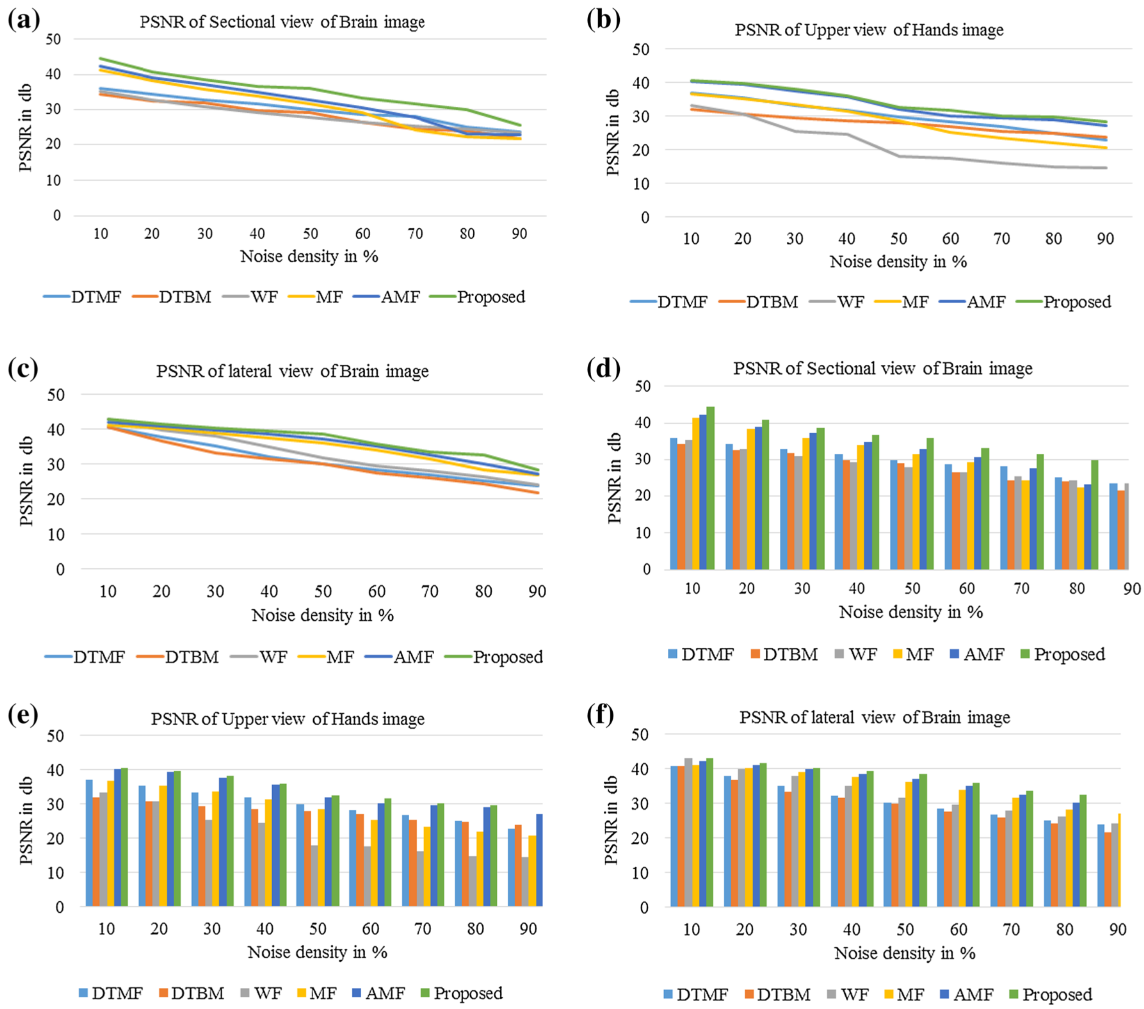

Fig. 5 **a, d** PSNR comparison of sectional view of brain image. **b, e** PSNR comparison upper view of hands image. **c, f** PSNR comparison of lateral view of brain image

Step4: Apply wavelet transform on denoised images

Step5: Mix the different Sub-bands of the Decomposed Images

Step6: Apply inverse wavelet transform of get resolution improved image.

Input Noisy Image

4 Results and discussion

The performance of the proposed approach for denoising the MRI images are evaluated in-terms of quantitative and visual analysis.

Peak Signal to Noise Ratio (PSNR) is used as a quantitative performance analysis metric and it is given by

$$\mathrm{PSNR\ (db)} = 10.\log_{10}\frac{MAX}{MSE} \tag{15}$$

where MAX is the maximum gray value in an image (255), MSE is mean square error which is given by

$$\mathrm{MSE} = \frac{1}{P.Q}\sum_{i=0}^{P-1}\sum_{j=0}^{Q-1}\left|A_{i,j} - B_{i,j}\right|^2 \tag{16}$$

P and Q are size of an images, A represents an input image, B represents the restored image. The visual analysis is shown in Fig. 4.

The results of the Multiresolution Hybrid filter approach is compared with the Dual Threshold Median Filter (DTMF), Decision Tree Based Method (DTBM), Wiener Filter (WF), Median Filter (MF) and Adaptive Median

Filter (AMF). Table 1 and Fig. 5 represents the PSNR comparison of the proposed method with above mentioned methods. It shows that the proposed method produces high PSNR values when compared to other methods when the noise level is too high.

5 Conclusion

This paper presents a Hybrid Multi-resolution filter for MRI image denoising in computing systems. It consists of Dual threshold Median filter and Verge filter. The classification of pixel into noisy or noisy free is done in a deterministic way. The experimental results shows that the proposed filter removes the Salt & Pepper noise in MRI images while improving the resolution of an image. It produces high PSNR values when the noise level is too high. Using this method, images with different resolutions can be obtained by mixing different sub-bands of the images using wavelet transform.

References

1. Brownrigg, R.K.: The weighted median filter. Commun. ACM **27**(8), 807–818 (1984)
2. Chen, T., Wu, H.: Adaptive impule detection using centre weighted median filters. Signal Process. Lett. **8**(1), 1–3 (2001)
3. Esakkirajan, S., Veerakumar, T., Subramaniyam, A.N., Premchand, C.H.: Removal of high density salt and pepper noise through modified decision based un-symmetric trimmed median filter. IEEE Signal Process. Lett. **18**(5), 287–290 (2011)
4. Gupta, V., et al.: Random Valued impulse noise removal using adaptive dual threshold median filter. J. vis. Commun. **26**, 296–304 (2014)
5. Lien, C.Y.: Chen, P.Y: An efficient edge preserving algorithm for removal of salt and pepper noise. IEEE signal process. Lett. **15**, 833–836 (2008)
6. Rajesh, R., Malathi P.: An Effective Denoising and Enhancement Technique for Removal of Random Impulse Noise in Images. In: Proceedings of International Conference on Advances in Electrnoics, Communication and Computer Technology, (2016)
7. Sharama, A., Chaurasia, V.: Removal of high density saltand pepper noise by recursive enhanced median filtering. In: Proceedings of 2nd International Conference on Emerging Trends in Electronics, Communication and Networking, IEEE, pp 1–4 (2014)
8. Veerakumar, T., Esakkirajan, S., Vennila, I.: Salt and pepper noise removal in video using adaptive decision based median filter, In: Proceedings of International Conference on Multimedia, Signal Processing and Communication Technologies, (2011)
9. Vishaga, S., Das, S.L.: A survey on switching median filters for impulse noise removal. In: International Conference on Circuit, Power and Computing Technologiies (ICCPCT), pp1–6 (2015)
10. Li, Y., Su, G.: Design of high speed median filter based on neighborhood processor", software engineering and service science (ICSESS), In: Proceedings of 6th IEEE International Conference, pp.648–651 (2015)
11. Zheng-yang, G., Le, Z.: Improved adaptive medin filter. In: Proceedings of 10th International Conference on Comptational Intelligence and Security, IEEE, pp 44–46 (2014)

K. Murugan received his Bachelor of Engineering (ECE) from Tamilnadu college of Engineering. He completed his Maters in Engineering from Anna University Regional centre, Coimbatore. Currently Working as a Assistant professor in Tamilnadu College of Engineering Karumathampatti. He is pursuing his research in Ann University. Published Various papers in International journals.

V. P. Arunachalam completed his B.E in Mechanical Engineering at Coimbatore Institute of Technology, Coimbatore, Tamilnadu, India and he received his masters in Machine Tool Engineering at PSG College of Technology, Coimbatore. He completed his Doctor of Philosophy (Ph.D.), in Mechanical Engineering at Government College of technology, Coimbatore. At present he is a professor and director of SNS College of Technology, Coimbatore. He has published more than 100 Research Papers in the International Reputed Journals. His main research interests are MANET, WSN, Data Mining and Image Processing.

S. Karthik received his Masters in Engineering from KSR College of Technology, Anna University, Chennai, India. He completed his Doctor of Philosophy (Ph.D.), in Computer Science and Engineering from Anna University, Coimbatore. Currently working as Professor and Dean in the Department of Computer science and Engineering at SNS College of Technology, Coimbatore, India. His main research areas are Network security and Distributed Computing. He has published more than 90 Research Papers in the International Reputed Journals. Coordinator-AICTE and AU Proposals, ISO Quality Management System Auditor, Reviewer for 7 International Journals.