Valarmathy K / Afr.J.Bio.Sc. 6(5) (2024). 9525-9533 **ISSN: 2663-2187**

https://doi.org/10.48047/AFJBS.6.5.2024. 9525-9533

AfricanJournalofBiological Sciences

AN EFFICIENT HYBRID FILTERING APPROACH TO IMPROVE THE QUALITY OF MEDICAL IMAGES

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Article History
Volume 6, Issue 5, 2024
Received: 22 May 2024
Accepted: 03 Jun 2024
doi:*10.48047/AFJBS.6.5.2024. 9525-9533*

Abstract:

Noises in the image results from the scanned image have a serious impact on the final decision made by the Expert. Globally, huge millions of decision made based on the scanned results. This paper focuses on the noise replacement aspect by an image filtering algorithm to perform noise removal automatically. The application has developed based on the fusion of both median and modified Discrete Wavelet Transform (mDWT) filtering algorithm and it is tested on variegated dataset images. Such a de-noised image performance has been analysed by the various performance measures such as Peak Signal to Noise Ratio (PSNR), Normalized Absolute Error (NAE), Structural Context (SC), Normalized Absolute Error (NAE), Structural Similarity Index Measure (SSIM), Normalized Cross correlation (NK) and Maximum Difference (MD). The fused filtering algorithm plays a key role in image processing, since it acts as a pre-processing step.

Keywords: Median Filter, modified DWT filter, MRI images, Rician noise

1. Introduction:

The World Health Organization reported that several millions of people got infected with variegated health issues. In order to identify such issues; initial scanning plays a key role. Such scanning has been performed by MRI, CT, X-ray and fMRI scanning. After scanning, noise replacement plays a crucial role. Since, image has been captured with noise during the image acquisition time. Such noise has to be replaced by an efficient noise replacement algorithm. In the previous literature by Guhathakurta, wavelet gains a greater performance. It utilizes the multi resolution analysis. By using wavelets and wavelet packets, a comparison was made with variegated approaches. Furthermore, a hybrid model by Benabdelkader and Soltani has been utilized in image denoising technique. It estimates the standard deviation for the entire image. It is then utilized for the threshold calculation in the wavelet coefficient shrinkage. Lahmiri and Boukadoum proposed that for filtering first order local statistics (FOLS) and the fourth order PDE were combined. Its performance was evaluated on the images in the presence of Gaussian, salt and pepper, poisson and speckle noise. Rekha and Samundiswary introduced a method called Double density wavelet transform. It is nothing but the combination of the Fast Bilateral Filter (FBF) with double density wavelets. It reduces the noise present in the image which acquires during the image acquisition and it degrades the noise at any levels. Remya et al. proposed a novel thresholding approach utilized in the discrete wavelet transform filtering to denoise the image. It yields better accuracy than the other similar works. To measure the filtering performance, PSNR and SSIM were utilized. Igor proposed in his work that for filtering, fusion of a centre- weighted median filter and block matching 3D filtering technique have been utilized. It removes both impulsive and Gaussian noise.

Such combined filter yields greater effective result. Panda et al. utilized two stages of filtering in their work. Initially impulse noise added image is allowed to pass through Artificial Neural Network (ANN) detector to identify the corrupted pixel by considering its surrounding neighboring pixels. It is then passed to the DWT filter. Furthermore, it is allowed to subject to ANN detector to identify the corruption. Even with high noise content, the proposed algorithm achieves better noise reduction and edge preservation capability. Devasena et al. proposed that an improved impulse decision based filtering technique. It includes three various modules. It reducesthe noise by a hybrid wiener adaptive centre weighted median filtering approach. It reduces the noise intensity by 90%. Chang et al. proposed that a Back propagation network using texture image features to evaluate the Bilateral filter parameters. In another work proposed by Li et al. an adaptive hybrid filter has been utilized to replace the speckle noise in the ultrasound images. It has four filters, which includes Guided Filter (GF), Speckle Reducing Bilateral Filter (SRBF), Rotation Invariant Bilateral Non Local Means filter (RIBNLM) and Median Filter (MF). The novelty method adapted here is the selection of the optimal filter coefficient by the Bayesian based neural network. The training model of the Bayesian based neural networkwith the optimal coefficient. Also, the optimal filter coefficient is analyzed with Firefly update in the Lion algorithm.

The major contribution of the proposed work is that

- The images were utilized from BRATS, TCIA, ISIC, and ADNI datasets for testing.
- Effectively reduces the noise by preserving the important feature: edge
- Enhance the image quality; make it as more reliable and efficient method for a wide range of applications.
- Robust against artifacts.

With the improvement, in this paper we estimate the noise filtering by an efficient proposed algorithm for the dataset images. The proposed work is arranged as section 2 portrays the strategy; section 3 spotlights on the simulation outcomes of filtering. At last, section 4 portrays the conclusion part.

2. Methodology:

In this section, we present the image filtering algorithms to reduce the noise from either MI or CT scan images. The block schematic of the current work is given in figure 1. Initially, the input images were converted into gray scale image. Then the inputs images were added with Rician noise. Afterwards, denoising has to be done by median and proposed modified DWT filtering approach. Both outputs got fused, finally the output fused image is better than the other approaches such as DWT, and enhanced DWT. The effectiveness of the approach has estimated by various performance metrics.

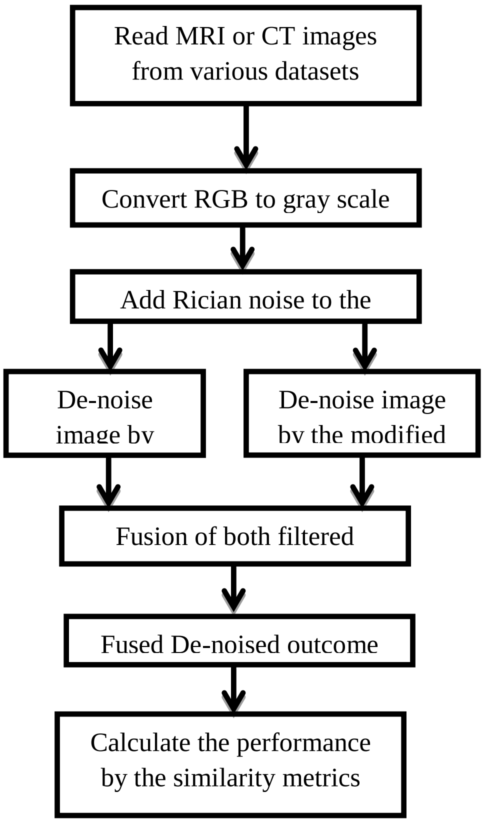

Fig. 1: Proposed workflow

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2.1. Image filtering:

The flowchart to be utilized for image filtering is charted in figure 1. It depicts that initially images were pre-processed by converting the input RGB images into gray scale images. Afterwards, it adds Rician noise to the images; in order to estimate the replacement algorithms performance. Then it performs the image filtering operation, for that it utilizes both median and modified DWT filtering algorithm. So such filtering algorithm has to be applied separately on the same images. Afterwards, the earned outcome has to be fused. The outcome is free from the noise. Such filtered output has to be compared against the various other similar works.

2.1.1. Median filtering:

It reduces the noise content from the image. It is regarded as a more efficient one, when the image is corrupted with salt and pepper and impulse noise, whereas few pixels have extreme values when contrasted to the neighboring pixels by Li et al.. The working of the median filtering is explained herewith;

Selection of window: Window is nothing but a kernel, which moves along the entire image pixel by pixel. Its size may be 3×3 or 5×5.

Sorting of pixel: While moving the window or kernel over the image, the pixel values get sorted within that window.

Calculation of median: After sorting, the median value in that particular window has been chosen as the new value being processed.

A similar process is followed for each pixel in the image. Unlike other filtering methods such as weighted average, average; it replaces the pixel value by the same pixel value present in the window itself. So it has the ability to reduce the effect of noise level present in the image. Also, it is suitable for limited noise only, it is not suited all varieties of noise, since it introduces some blurring effect. The estimation of the median value for a 3×3 matrix is explained in figure 2. Initially, it sort the pixels present in the 3×3 matrix as 1, 2, 3, 4, 5, 6, 7, 8, 9. Here the total count is 9, the center value is considered as the median value. For this example, the median value is 5.

1	3	5
7	9	2
4	6	8

Fig. 2: A 3×3 window for Median filtering procedure.

2.1.2. Modified DWT filtering:

The Discrete Wavelet Transform (DWT) is regarded as a powerful tool in image analysis, denoising, and compression. In this paper, a modified approach is carried out here to remove the noise present in the image. Also, it retains the relevant information present in the imageDeivediet al.. The procedures to be followed in the modified DWT are explained below:

i. Decomposition: DWT is applied to noisy image to attain low frequency and high frequency components, whereas it contains various wavelet coefficients such as horizontal, vertical, diagonal, and approximation coefficients.
ii. Thresholding: It is regarded as the major step in filtering approach. It sets the small coefficient value to zero to improve the quality of the frequency bands. For thresholding operation, various techniques are used. It includes soft thresholding, hard thresholding, adaptive thresholding, and Bayesian thresholding.
    a. Soft thresholding: It involves shrinking the coefficient to a zero, if it is below the threshold value. Otherwise, it linearly reduces the coefficient. It produces the smoother output.
    b. Hard thresholding: It sets the coefficient to zero value, if it is below the threshold value. Else it retains the same value. As a result of this it holds the sharp edge features. At the same time, it introduces artifacts.
    c. Adaptive thresholding: It uses various thresholds at variegated decomposition levels to upgrade the denoising performance. It uses Steins' Unbiased Risk Estimate to reduce the error.
    d. Bayesian thresholding: It utilizes Bayesian estimation to estimate the optimal threshold value. It utilizes the properties to estimate the threshold.

In this work, hard thresholding has been identified as the optimal thresholding approach to hold the features present as in the input image. The equation utilized for hard thresholding 'ht' is given in equation (1)

$$ht = \begin{cases} 0 & i'(y,z) \geq t \\ i'(y,z) & i'(y,z) < t \end{cases} \quad (1)$$

In equation (1), t denotes the threshold value used for optimization, 'i'' points out the input image, y and z be the row and column size of the image 'i''. The outcome of the above equation is that, it makes the pixel value as '0', if its value is greater than the value of 't'. Else, it will retain the same value. The value of 't' is estimated by the equation (2).

$$t = \frac{1}{y'z'} \sum_{y=1}^{y'} \sum_{z=1}^{z'} [i'(y,z)]^{\frac{1}{y-1} \times \frac{1}{z-1}} \quad (2)$$

Here y' and z' as the size of the image. After estimating the hard thresholding value for the wavelet coefficients, inverse DWT is performed to do the reconstruction.

iii. Reconstruction: It reconstructs the signal based on the modified coefficient, that is, it utilizes inverse DWT. The modified DWT is represented as md_f.

After that, fusion of both filtering approaches such as median filter and modified DWT filter had done to enhance the visual quality of the image. The fusion of both algorithms has been done by the following equation (3)

$$\text{fused output} = \text{median filter} + \text{modified DWT filter}$$

$$f_o = m_f + md_f$$

$$m_f = \text{sort}(p'1, p'3, p'5, p'7, p'9, p'2, p'4, p'6, p'8) = p'1, p'2, p'3, p'4, p'5, p'6, p'7, p'8, p'9 = p'5$$

3. Experimental results:

The simulated outcome of the proposed work is outlined in this part. Here the examination is done on three different set of datasets include BRATS, TCIA, ISIC, and ADNI. After examining the images, the performance is estimated by various metrics.

TCIA dataset: The Cancer Imaging Archieve dataset includes cancerous image in Magnetic Resonance Imaging, Computerized Tomography (CT), and Positron Emission Tomography (PET), and so on by Prior et al.

BRATS dataset: It has been used in the medical field for segmenting brain tumor by Menzeet al.. It comprises of T1 weighted, T1-c contrast enhanced, T2 weighted, and Fluid Attenuated Inversion Recovery (FLAIR) images. All these are available in MRI scanned format.

ADNI: Alzheimers' Disease Neuroimaging Initiative holds scanned images in MRI and PET form, which was introduced by Thibeau-Sutreet al.. Its aim is to keep on tracking Alzheimer disease progression by collecting the data over time. It holds the information from various phases includes ADNI1, ADNI2, ADNI-GO, ADNI3, and it has the data from various collaboration and sites.

ISIC: International Skin Imaging Collaboration dataset is a group of skin cancer images. It contains 900 dermoscopic and its ground truth imagesby Kassenet al..

PSNR (Peak Signal to Noise Ratio): It is a measure to analyze the quality of filtered image, which was proposed by Hore and Ziou. It compares among the input image and filtered/enhanced/reconstructed image to identify how much quality gets affected. The equation for PSNR is given as in equation (3)

$$PSNR = 10\log_{10} \frac{[\text{maximu m value (255)}]^2}{mse} \quad (3)$$

'mse' is the average of squared variation among the input and enhanced/filtered/reconstructed image. Higher the PSNR means higher the image quality.

SSIM (Structural Similarity Index Measure): It estimates the similarity among the input and filtered image. It mainly focuses on the pixel wise difference. It compares various aspects such as luminanace, contrast, and structure. Its value lies between - 1 and 1. In the event that SSIM is '1', which demonstrates an ideal likeness exists among the input and filtered images and it is depicted in equation (4).

$$SSIM(y,z) = \frac{(2L_y L_z + O_1).(2C_{yz} + O_2)}{(L_y^2 + L_z^2 + O_1)(V_y^2 + V_z^2 + O_2)} \quad (4)$$

Here O_1 and O_2 are constants, which is used to avoid the instability problem happening near '0', L_y and L_z be the luminance value of the images y and z respectively. V_y^2 and V_z^2 are the variance in the images y and z.

NAE (Normalized Absolute Error): It estimates the similarity among the input and filtered image by using the equation (5), which was utilized by Remya et al.

$$N(y,z) = \frac{1}{y'z'}\sum_{y=1}^{y'}\sum_{z=1}^{z'}\left|\frac{i_{y,z}-F_{y,z}}{\max(i_{y,z},F_{y,z})}\right| \quad (5)$$

Here ‘i’ and ‘F’ as the input and filtered image, $|.|$ points out the absolute value.

MD (Maximum Difference): It finds the maximum deviation among the input and filtered image and it is given in equation (6).

$$MD = \max\left|i_{y,z} - F_{y,z}\right| \quad (6)$$

Structural Content (SC): It is the ratio of the sum of the square of the input image pixels to the sum of square of the filtered image pixels. The estimation of SC has done as in equation (7).

$$SC = \frac{\sum_{y=1}^{y'}\sum_{z=1}^{z'} {i_{y,z}}^2}{\sum_{y=1}^{y'}\sum_{z=1}^{z'} {F_{y,z}}^2} \quad (7)$$

Normalized Cross-Correlation (NK): It is the ratio of the sum of distinction among the input and filtered image to the sum of square of the distinction among the input and filtered image. The value of NK has estimated as in equation (8).

$$NK = \frac{\sum_{y=1}^{y'}\sum_{z=1}^{z'}(i_{y,z}-F_{y,z})^2}{\sum_{y=1}^{y'}\sum_{z=1}^{z'} {F_{y,z}}^2} \quad (8)$$

3.1. Simulation outcomes:

Selection of window size in median filter: The selection of window/ mask size plays a major role. For example, if the window size 3×3, the PSNR value if of 57.089. If it is of 5×5, the PSNR value got reduced to 55.8584. In this work, the window size is chosen as 3×3 to attain high PSNR value. The experiment is conducted on various set of dataset images to analyze the performance. The workflow of the proposed algorithm is that, initially it performs denoising as a pre-processing step by median and the modified DWT filtering algorithm. Afterward, the attained outcome of both algorithms has been combined. Its performance has been tested in various dataset images and it is given in the following sections.

3.1.1. Simulation outcomes of TCIA dataset images:

The experiment is conducted on variegated images; the figure 3 depicts the simulation outcomes of six different images. In this experiment, the filtering is done by a fusion of median and modified DWT filtering approach. First row shows the input image, second row shows the noise added image (Rician noise), and third row shows the noise free image using the proposed algorithm (de-noised image). The quality of the image is analyzed by variegated performance metrics.

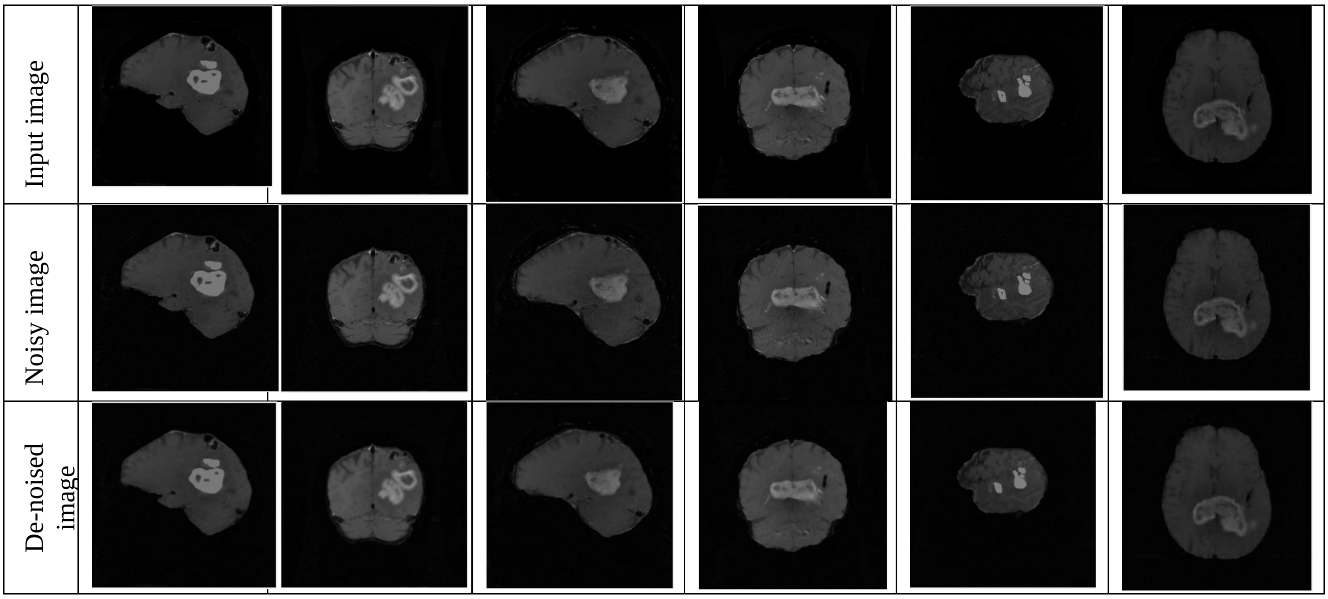

Fig. 3: Simulated outcomes of TCIA dataset images.

Table 1 depicts the quantitative information about the image when it is tested on various approaches such as Unequally Spaced Fast Fourier Transform (USFFT) by Hammouche and ElBahry, fuzzy rule with genetic algorithm (FGA) by Gharraf et al., enhanced DWT, modified DWT, and median along with the modified DWT algorithm. The value attained for PSNR for the hybrid (Median+modified DWT) filtering is that 56.8545, which is 2.4%, 2.2%, 1.7%, and 3.2% better than USFFT, FDCT, enhanced DWT, and modified DWT respectively. For SSIM, hybrid filtering approach is 0.9999, which is 0.01%, 0.3%, 0.4%, and 2.8% higher USFFT, FDCT, enhanced DWT, and modified DWT respectively. Similarly for NK, the proposed approach value is 0.9994, which is 0.2%, 0.19%, 0.26%, and 0.23% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively. For SC, the proposed approach value is 0.006%, 0.008%, 0.3%, and 0.75% greater than USFFT, FDCT, enhanced DWT, and modified DWT respectively. For MD, 56.2%, 53.5%, 80.4%, and 28.09% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively. Finally, for NAE, 93.53%, 82.6%, 82.32%, and 38.89% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively.

Table 1: Quantitative information of TCIA dataset images

	USFFT [20]	FGA[21]	Enhanced DWT [5]	**Proposed Modified DWT**	**Median+ Modified DWT**
PSNR	38.8157	47.1452	44.2965	55.4869	**56.8545**
SSIM	0.9717	0.9958	0.9970	0.9998	**0.9999**
NK	1.0018	1.0006	0.9994	0.9991	**0.9968**
SC	0.9942	0.9985	1.0009	1.0011	**1.0018**
MD	0.0199	0.0187	0.0443	0.0121	**0.0087**
NAE	0.0681	0.0253	0.0249	0.0072	**0.0044**

3.1.2. Simulation outcomes of Kaggle dataset:

The evaluation has done on different images from the kaggle dataset; the figure 4 portrays the simulation results of six different images. First line shows the input image, second row shows the Rician noise added one, third row shows the noiseless image utilizing the proposed calculation (de-noised image). The image quality is examined by the variegated quality measurements.

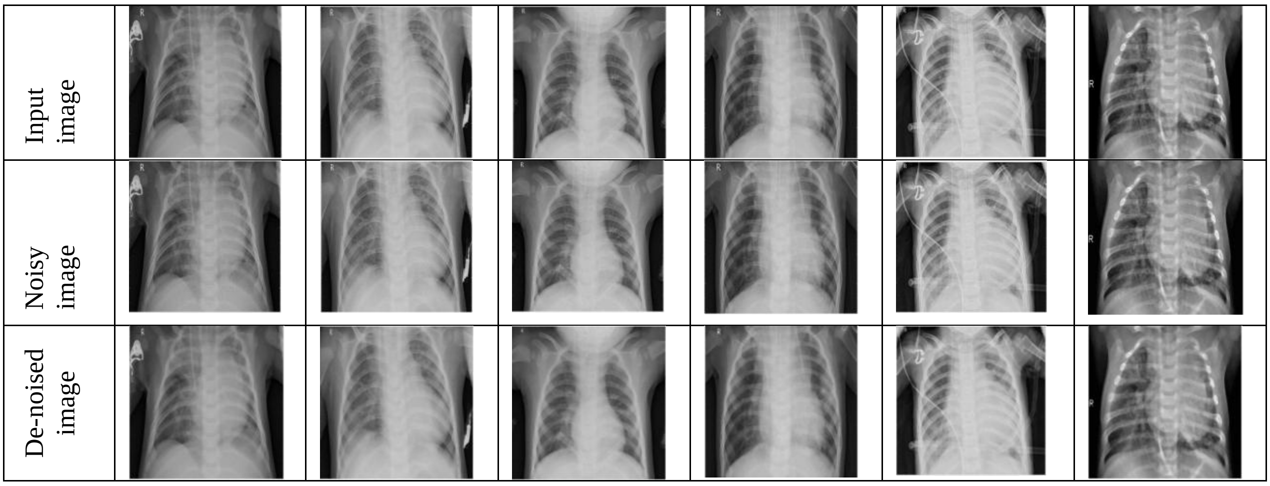

Fig. 4: Simulated outcomes of Kaggle dataset images.

Table 2 depicts the quantitative information about the image when it is tested on various approaches such as USFFT, FDCT, enhanced DWT, modified DWT, and median along with the modified DWT algorithm. The value attained for PSNR for the hybrid (Median + modified DWT) filtering is that 56.9941, which is 3.3%, 22.54%, 43.05%, and 47.72% better than USFFT, FDCT, enhanced DWT, and modified DWT respectively. For SSIM, hybrid filtering approach is 0.9998, which is 0.0003%, 0.6%, 7.6%, and 0.3% higher than USFFT, FDCT, enhanced DWT, and modified DWT respectively. Similarly for NK, the proposed approach value is 0.9992, which is 0.08%, 0.08%, 0.007%, and 0.0006% lesser thanUSFFT, FDCT, DWT, and modified DWT respectively. For SC, the proposed approach value is1.0012, which is 0.06%, 0.09%, 0.29%, and 0.43% greater than USFFT, FDCT, enhanced DWT, and proposed DWT respectively. For MD, 96.8%, 96.18%, 87.52%, and 58.33% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively. Finally, for NAE, 96.24%, 94.42%, 84.94%, and 48.14% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively.

Table 2: Quantitative information of Kaggle dataset images.

	USFFT [20]	FGA [21]	Enhanced DWT [5]	**Proposed Modified DWT**	**Median+ Modified DWT**
PSNR	29.7947	32.4565	44.1457	55.0833	**56.9941**
SSIM	0.9968	0.9237	0.9936	0.9995	**0.9998**
NK	1.0000	1.0000	0.9999	0.9998	**0.9992**
SC	0.9968	0.9982	1.0002	1.0005	**1.0012**
MD	0.4893	0.4054	0.1242	0.0372	**0.0155**
NAE	0.0372	0.0251	0.0093	0.0027	**0.0014**

3.1.3. Simulation outcomes of ISIC dataset:

Here the experiment evaluation has conducted on various images from the ISIC dataset; the figure 5 depicts the simulation outcomes of six various images. First row shows the input image, second row shows the Rician noise added image, third row shows the noise free image using the proposed algorithm (de-noised image). The quality of the image is analyzed by the variegated performance metrics.

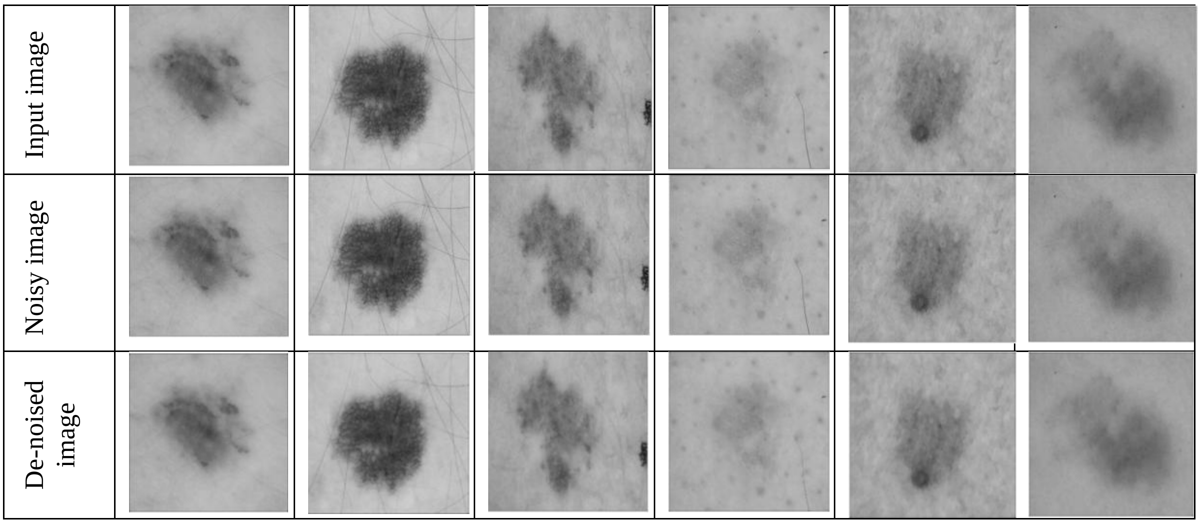

Fig. 5: Simulated outcomes of ISIC dataset images.

Table 3 depicts the quantitative information about the image when it is tested on various approaches such as USFFT, FDCT, enhanced DWT, modified DWT, and median along with the modified DWT algorithm. The value attained for PSNR for the hybrid (Median + modified DWT) filtering is that 57.5192, which is 0.83%, 24.31%, 27.25%, and 36.59% better than modified DWT, enhanced DWT, FDCT, respectively. For SSIM, hybrid filtering approach is 0.9998, which is 0.0001%, 0.36%, 2.5%, and7.8% higher than modified DWT, enhanced DWT, FDCT, and USFFTrespectively. Similarly for NK, the proposed approach value is 0.9964, which is 0.37%, 0.36%, 0.36%, and 0.36% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively. For SC, the proposed approach value is 1.0064, which is 0.62%, 0.62%, 0.66%, and 0.70% greater than modified DWT, enhanced DWT, FDCT, and USFFTrespectively. For MD, the proposed approach attains the value as 0.0056, which is 86.57%, 78.29%, 88.64%, and 36.36% lesser than USFFT, FDCT, DWT, adaptive DWT, enhanced DWT, and modified DWT respectively. Finally, for NAE, the current fused approach holds the value as .000702, which is 95.30%, 91.25%,97.48%, and 36.09% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively.

Table 3: Quantitative information of ISIC dataset images

	USFFT [20]	FGA [21]	Enhanced DWT [5]	**Proposed Modified DWT**	**Median+ Modified DWT**
PSNR	36.4697	41.8461	43.5383	57.0379	**57.5192**
SSIM	0.9213	0.9747	0.9962	0.9997	**0.9998**
NK	1.0002	1.0001	1.0000	1.0000	**0.9964**
SC	0.9993	0.9997	1.0001	1.0001	**1.0064**
MD	0.0417	0.0258	0.0493	0.0088	**0.0056**
NAE	0.0149	0.0080	0.0279	0.0011	**7.0229e-04**

3.1.4. Simulation outcomes of ADNI dataset:

Here the experiment has conducted on various images from the ADNI dataset; the figure 6 depicts the simulation outcomes of six various images. First row shows the input image, second row shows the Rician noise added image, third row shows the noise free image using the proposed algorithm (de-noised image). The quality of the image is analyzed by the various performance metrics.

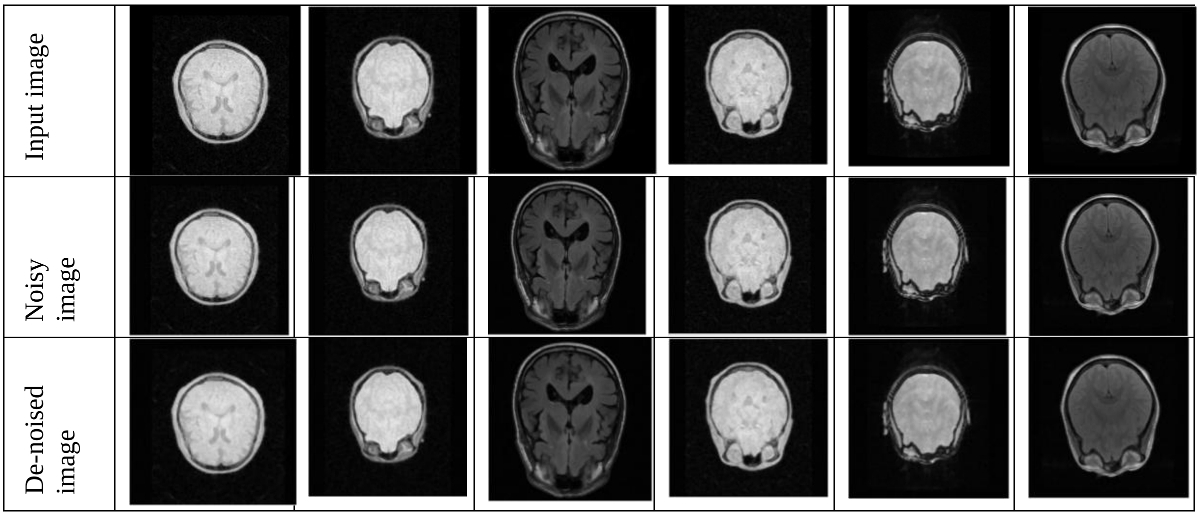

Fig. 6: Simulated outcomes of ADNI dataset images.

Table 4 depicts the quantitative information about the image when it is tested on various approaches such as USFFT, FDCT, enhanced DWT, modified DWT, and median along with the modified DWT algorithm. The value attained for PSNR for the hybrid (Median + modified DWT) filtering is that 54.1781, which is 28.44%, 7.95%, 10.03%, and 22.51% better than modified DWT, enhanced DWT, FDCT, and USFFT respectively. For SSIM, hybrid filtering approach is 0.9997, which is 0.0001%, 0.45%, 0.57%, and 3.33% higher than modified DWT, enhanced DWT, FDCT, and USFFT respectively. Similarly for NK, the proposed approach value is 0.9927, which is 0.95%, 0.83%, 0.69%, and 0.52% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively. For SC, the proposed approach value is 1.0134, which is 0.92%, 1.24%, 1.54%, and 1.89% greater than modified DWT, enhanced DWT, FDCT, and USFFTrespectively. For MD, the proposed approach attains the value as 0.0128, which is 57.19%, 9.22%, 82.95%, and 42.08% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively. Finally, for NAE, the current fused approach holds the value as 0.0038, which is 92.06%, 80.61%, 86.85%, and 54.22% lesser than USFFT, FDCT, enhanced DWT, and modified DWT respectively.

Table 4: Quantitative information of ADNI dataset images.

	USFFT [20]	FGA [21]	Enhanced DWT [5]	**Proposed Modified DWT**	**Median+ Modified DWT**
PSNR	41.9852	48.7425	49.8718	52.7050	**54.1781**
SSIM	0.9664	0.9940	0.9952	0.9996	**0.9997**
NK	1.0023	1.0010	0.9996	0.9979	**0.9927**
SC	0.9942	0.9977	1.0008	1.0041	**1.0134**
MD	0.0299	0.0141	0.0751	0.0221	**0.0128**
NAE	0.0479	0.0196	0.0289	0.0083	**0.0038**

4. Conclusion:

This paper investigated the image filtering outcomes of variegate dataset images includes BRATS, TCIA, ADNI, and ISIC. Based on the results, the proposed fused filtering algorithm yields better image quality compared withUSFFT, FGA, enhanced DWT, and modified DWT filtering approaches The overall filtering accuracy of the proposed hybrid filtering algorithm has attained greater accuracy for all the dataset images such as TCIA, ADNI, Kaggle, and ISIC thanall other filtering approaches in terms of PSNR, SSIM, NK, SC, MD, and NAE metrics. We observed that the filtering performance improves when the fused method has been utilized in the image filtering approach. So such fused image filtering algorithm will act as a better alternative in removing the noise from the scanned images.

References:

1. Guhathakurta. R, (2017) "Denoising of images: A wavelet based approach" 8th industrial automation and electromechanical engineering conference, pp. 194-197, doi:10.1109/IEMECON.2017.8079587.
2. Benabdelkader. S, Soltani. O, (2016) "Wavelet image denoising based spatial noise estimation" 2015 signal processing and intelligent systems conference, pp. 83-87, doi: 10.1109/SPIS.2015.7422317.
3. Lahmiri.S, Boukadoum. M, (2017) "A comparison of four PDE- spatial denoising systems for molecular images", LASCAS 8th IEEE latin American symposium on circuits and systems, R9 IEEE CASS flagship conference proceedings, doi:10.1109/LASCAS.2017.7948084.
4. H. Rekha and P. Samundiswary, (2017) "Double Density Wavelet with Fast Bilateral Filter based Image Denoising for WMSN," 2017 Ninth International Conference on Advanced Computing (ICoAC), Chennai, India, pp. 315-320, doi: 10.1109/ICoAC.2017.8441198.
5. Remya. R, Geetha. K. Parimala and Sundaravadivelu. S., (2019) "Enhanced DWT filtering technique for brain tumor detection", IETE Journal of Research, vol.62, pp. 1-10.
6. Djurović, I. (2016) "BM3D filter in salt-and-pepper noise removal", J Image Video Proc. Vol.13. https://doi.org/10.1186/s13640-016-0113-x.
7. S. Panda, G. Panda, (2020) "Fast and improved back propagation learning of multilayer artificial neural network using the adaptive activation function", Expert System, https://doi.org/10.1111/exsy.12555
8. D. Devasena, Y. Dharshan, B. Sharmila and K. Srinivasan, (2022) "Improved Decision Based Filtering algorithm for impulse noise removal in Digital Images," 2022 International Conference on Intelligent Innovations in Engineering and Technology (ICIIET), Coimbatore, India, pp. 323-328, doi: 10.1109/ICIIET55458.2022.9967693.
9. Herng Hua Chang, Yu ju Lin, Audrey Haihong Zhuang, (2019) "An automatic parameter decision system of bilateral filtering with GPU- based acceleration from brain MR images", Journal of digital imaging, vol. 32, no.1, pp. 148-161.
10. S L SS, M S. (2021) "Bayesian Framework-Based Adaptive Hybrid Filtering for Speckle Noise Reduction in Ultrasound Images Via Lion Plus FireFly Algorithm", J Digit Imaging. 2021 Dec;34(6):1463-1477. doi: 10.1007/s10278-021-00517-3. Epub Oct 1. PMID: 34599464; PMCID: PMC8669092.
11. X. Li, J. Ji, J. Li, S. He and Q. Zhou, (2021) "Research on Image Denoising Based on Median Filter," 2021 IEEE 4th Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC), Chongqing, China, pp. 528-531, doi: 10.1109/IMCEC51613.2021.9482247.
12. X. Li, J. Ji, J. Li, S. He and Q. Zhou, (2021) "Research on Image Denoising Based on Median Filter," 2021 IEEE 4th Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC), Chongqing, China, pp. 528-531, doi: 10.1109/IMCEC51613.2021.9482247.
13. S. Dwivedi, R. N. Yadav and L. Gupta, (2021) "Restoration of Image using Discrete Wavelet Transform with Filtering Technique," 2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT), Kharagpur, India, pp. 1-6, doi: 10.1109/ICCCNT51525.2021.9579573.
14. F. W. Prior et al., (2013) "TCIA: An information resource to enable open science," 2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Osaka, Japan, pp. 1282-1285, doi: 10.1109/EMBC.2013.6609742.
15. B. H. Menze et al., (2015) "The Multimodal Brain Tumor Image Segmentation Benchmark (BRATS)," in IEEE Transactions on Medical Imaging, vol. 34, no. 10, pp. 1993-2024, Oct. doi: 10.1109/TMI.2014.2377694.
16. E. Thibeau-Sutre, B. Couvy-Duchesne, D. Dormont, O. Colliot and N. Burgos, (2022) "MRI Field Strength Predicts Alzheimer's Disease: a Case Example of Bias in the ADNI Data Set," 2022 IEEE 19th International Symposium on Biomedical Imaging (ISBI), Kolkata, India, pp. 1-4, doi: 10.1109/ISBI52829.2022.9761504.
17. M. A. Kassem, K. M. Hosny and M. M. Fouad, (2020) "Skin Lesions Classification Into Eight Classes for ISIC 2019 Using Deep Convolutional Neural Network and Transfer Learning," in IEEE Access, vol. 8, pp. 114822-114832, doi: 10.1109/ACCESS.2020.3003890.
18. A. Horé and D. Ziou, (2010) "Image Quality Metrics: PSNR vs. SSIM," 2010 20th International Conference on Pattern Recognition, Istanbul, Turkey, pp. 2366-2369, doi: 10.1109/ICPR.2010.579.
19. R. Remya, B. P. Shan, K. Umamaheshwari, D. J. Derwin and D. Lavanya, (2022) "Improved DWT Algorithm for Filtering of MRI Images for an Efficient Diagnosis," 2022 Second International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT), Bhilai, India, pp. 1-8, doi: 10.1109/ICAECT54875.2022.9807955.
20. Abdhullah M Hammouche, Hazem M ElBahry, (2017) "A new FDCT-USFFT and FDCT wrap algorithms for image contrast enhancement", International journal of artificial intelligence and mechatronics, vol. 5, no. 5, pp. 31-37.
21. H. S. Gharraf, G. Cansever and A. S. Ahmed, (2022) "Image Filtering of Impulsive Noise Using Biologically Inspired Algorithms," 2022 International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), Ankara, Turkey, pp. 58-65, doi: 10.1109/ISMSIT56059.2022.9932802.