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Medical Image De-Noising Using Discrete Wavelet Transform and Threshold Filter

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Abstract
Medical imaging plays a critical role in diagnosis and treatment planning. However, during acquisition and transmission, medical images such as MRI, CT, or X-rays are often corrupted by noise, which may degrade the image quality and affect diagnostic accuracy. Effective de-noising is therefore essential to preserve important structural details while removing noise artifacts. This research presents an efficient de-noising method for medical images using Discrete Wavelet Transform (DWT) combined with threshold-based filtering. The DWT is employed to decompose the image into various subbands representing different frequency components. Since noise primarily affects the high-frequency subbands, appropriate thresholding techniques are applied to suppress these components while retaining the significant low-frequency details. The inverse DWT is then used to reconstruct the noise-reduced image. Performance metrics like Peak Signal-to-Noise Ratio (PSNR) and mean square error (MSE) are used to evaluate the quality of de-noised images.
Experimental results on standard medical image datasets demonstrate that the proposed DWT and threshold-based method effectively removes noise while preserving anatomical features. This method can be highly beneficial for pre-processing in automated diagnostic systems, improving clinical accuracy and reducing false diagnoses.
Keywords: MRI image, Various Noise, PSNR, MSE

1. INTRODUCTION

Nowadays, a lot of the information used in computer preparation is handled online. The capacity and correspondence requirements for this online material, which is either graphical or pictorial in nature, are enormous. As a result, information packing techniques prior to transmission and capacity are extremely valuable and commercially interesting. Reducing the repeating amount of information needed to speak to an advanced picture is known as picture pressure. The transformation of a 2-D pixel show by picture into a factually uncorrelated informational collection is a way to describe the digital picture pressure in numerical structure. The alteration is related to the digital image data's capability and transport. The process of decompression transforms the packed image into a unique image. A decompressed image may be an estimate of the original image or a unique image. The invention for addressing the enlarged spatial objectives of current imaging sensors and evolving communication TV standards is picture pressure. In many important and diverse applications, such as televideo conferencing, remote detection, archival and medical imaging, copy transmission, and the operation of remotely guided vehicles in space, military, and hazardous waste management applications, picture pressure plays a crucial role.

The application list is continuously improving the efficient management of the storage and transfer of different types of computerized images, such as paired images, dim scale images, shading images, and so on [1], [2]. Even though the Internet is still young, it continues to grow and have an impact on our personal and professional life. For these and many other uses, a vast amount of additional space and communication capacity are required for digital images. Creative methods are then used to convince computerized media to make efficient use of additional space and correspondence data transfer capacity by applying pressure to sophisticated images [3], [4]. Lossless pressure and lossy pressure plans are the two broad categories into which picture talking pressure systems may generally be divided. Information protection with lossless compression: As the name implies, no information is lost throughout this process. The compressed information can be used to precisely recover the first piece of information.

A CT scan is a type of special x-beam exam that uses a computer and x-beams to create cross-sectional images of the body. Using CT filter images of organs such as the liver, pancreas, digestive system, kidney, bladder, adrenal organ, lung, and heart, it connects a notable job detecting pharmaceutical infections and is used to know subtleties of the human body such as the chest, paunch, pelvis, arm, leg, and so on. The MRI uses a large amount of attractive and radio waves to provide a decent image of the organs.

It will be used to consider the mind and spinal line and to assess a variety of diseases, from malignancies to tendons. De-noising images is a crucial task in restorative photo handling in order to obtain precise images for subsequent discovery. Many sensors collect therapeutic images, and they are also subjected to a wide range of mutilation, stockpiling, pressure, procurement, preparation, propagation, and transmission that defiles them. These images are then removed using channels because they can produce the best results depending on their parameters. The choice of channels is based on the type of noise since different types of noise can be eliminated using different types of noise. This work considers a noisy image, filters it using the Wiener channel and median, and examines the results on various parameters. The calculation of the Wiener and middle channels will be modified. There are various cries as well as noises like salt and pepper. The intermediate channel and Wiener channel are designed to remove extraneous material noise, which is present in MRI and CT filters that can also gradually add thickness. The cooling system and fluid helium siphon in the superconductive scanner are responsible for the "pound" sound, which also irritates patients and causes temporary hoop misery.

II. MRI IMAGE

Protons in the body align with the solid attracting field created by the incredible magnets used in X-rays. The protons become energized and lose equilibrium when a radiofrequency current is sent through the patient, exerting pressure against the attractive field's pull.

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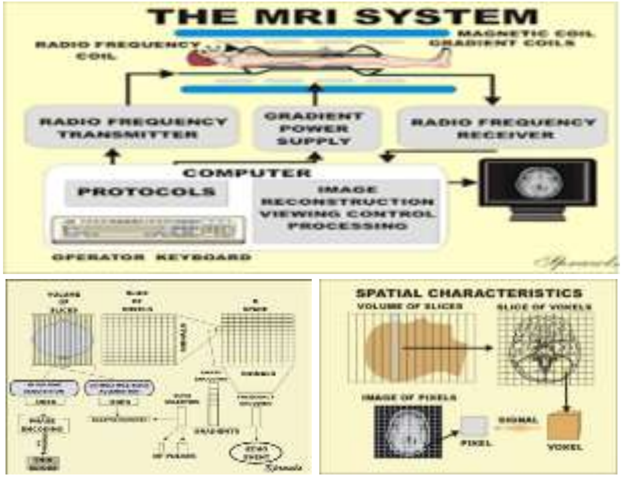

Figure 1: Working of MRI Image

The liveliness expelled as the protons realign with the attractive field can be detected by the MRI sensors at the moment when the radiofrequency field is killed.

Polarization that is appealing extremely strong, consistent magnet excitation. Excellent RF transmitter acquisition; inclination attractive fields are used to encode location. Very innovative Audi amplifiers Proton polarization and its enticing minute rotations resemble pivoting magnets. There are many protons in the body.

III. PROPOSED METHODOLOGY

We have developed the simple algorithm in which we perform the noise detection & noise removal process simultaneously. We use the smallest window size which preserves the fine details of image. The window of size 3x3 chooses for noise detection and noise removal. The window contains total 9 elements which are as follows: Z1, Z2, Z3, Z4, Z5, Z6, Z7, Z8, Z9. First step selects the maximum, minimum and median values of columns and rows. Second step stores these values and selects minimum threshold, maximum threshold and final median value. Third step use threshold values for noise detection and final median value for noise removal. We can divide the complete process into no. of steps as follows:

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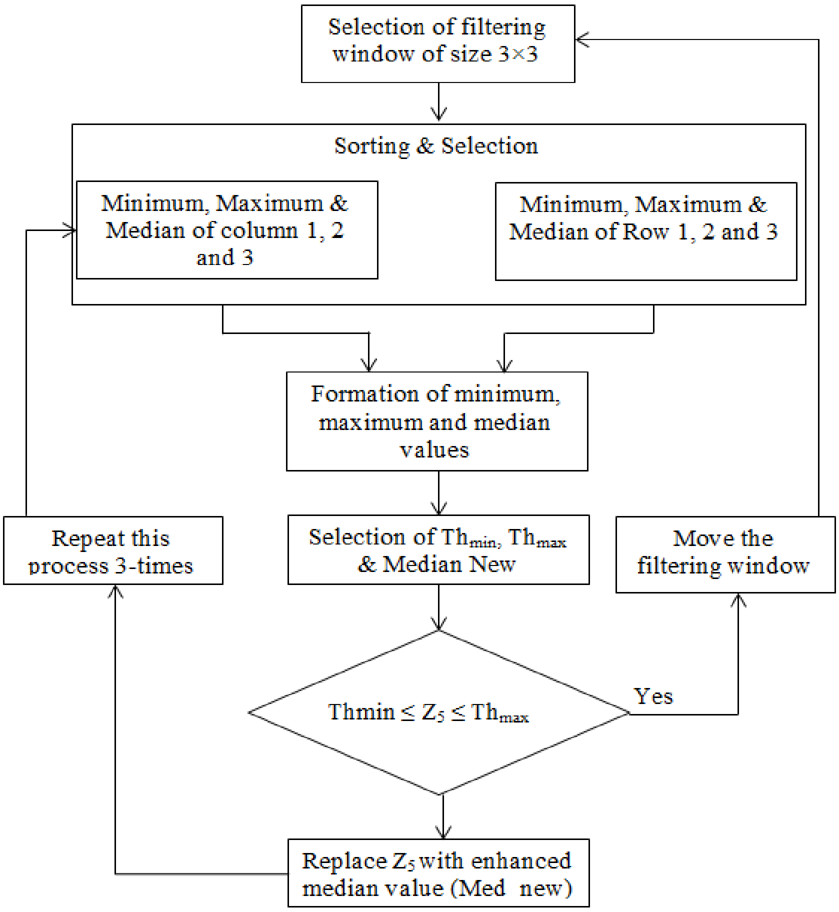

Figure: 2: Flow chart of proposed method for filtering window size 3x3

Step-1:-

First we select all columns of filtering window one by one and then we find three values i.e. Maximum, Minimum and Median in each column. The mathematical expression can be shown as follow: The minimum values of rows and columns are represented as

Min (cln1) = min { Z1, Z4, Z7}
Min (cln2) = min { Z2, Z5, Z8}
Min (cln3) = min { Z3, Z6, Z9}
Min (row1) = min { Z1, Z2, Z3}
Min (row2) = min { Z4, Z5, Z6}
Min (row3) = min { Z7, Z8, Z9}

The maximum value of rows and columns are represented as

Max (cln1) = max { Z1, Z4, Z7}
Max (cln2) = max { Z2, Z5, Z8}
Max (cln3) = max { Z3, Z6, Z9}
Max (row1) = max { Z1, Z2, Z3}
Max (row2) = max { Z4, Z5, Z6}

Max (row3) = max { Z7, Z8, Z9}

The median value of the rows and columns are represented as
Med (cln1) = med { Z1, Z4, Z7}
Med (cln2) = med { Z2, Z5, Z8}
Med (cln3) = med { Z3, Z6, Z9}
Med (row1) = med { Z1, Z2, Z3}
Med (row2) = med { Z4, Z5, Z6}
Med (row3) = med { Z7, Z8, Z9}

Step-2:-

Now we have total nine values (three maximum, three minimum and three median). We will use these values to calculate threshold values (maximum threshold and minimum threshold) and median value. For these calculations, we make three different groups of these nine elements.
Max_group = (Max (cln1), Max (cln2), Max (cln3) Max (row1), Max (row2), Max (row3))
Min_group = (Min (cln1), Min (cln2), Min (cln3) Min (row1), Min (row2), Min (row3))
Med_group = (Med (cln1), Med (cln2), Med (cln3) Med (row1), Med (row2), Med (row3))
First we will calculate max_min by choosing maximum value in min_group and min_max by choosing minimum value in max_group. Then we choose minimum threshold by choosing minimum value in max_group.
max_min = Max (Min (cln1), Min (cln2), Min (cln3) Min (row1), Min (row2), Min (row3))
min_max = Min (Max (cln1), Max (cln2), Max (cln3) Max (row1), Max (row2), Max (row3)} median_med = Med {Med (cln1), Med (cln2), Med (cln3) Med (row1), Med (row2), Med (row3))
Now these three values (max_min, min_max, median_med) will be furhter sorted and finally we get minimum threshold, maximum threshold and final median value as follows:
Thmax = max {min_max, median_med, max_min}
Thmin = min {min_max, median_med, max_min}
Final_med= med { min_max, median_med, max_min }
These two threshold values will be used for noise detection and final median will be used for noise removal.

Step-3:-

Now we will perform noise detection and noise removal operation using these three values i.e. Thmax, Thmin, and Med_new. We compare the central pixel with threshold values. If the central pixel is in between the Thmin and Thmax, then the pixel will be considered as noise free, then pixel will remain unchanged and window will move or slide to the next pixel. Otherwise pixel will consider as noisy and it will be replaced by median value.
If Thmin ≤Z5≤ Thmax
Then Z5 is unchanged.
Else Z5= Med_new.

Here we are parallelly calculating the threshold values and median value. So there is no need to perform noise detection and noise removal separately.

Discrete Wavelet Transform

Multiresolution analysis (MRA) is a characteristic feature of sub-band and it is used for better spectral representation of the signal. In MRA, the signal is decomposed for more than one DWT level known as multilevel DWT. It means the low-pass output of first DWT level is further decomposed in a similar manner in order to get the second level of DWT decomposition and the process is repeated for higher DWT levels [7]. Some algorithms have been suggested for computation of multilevel DWT. One of the most important algorithm are pyramid algorithm (PA), this algorithm are proposed Mallet for parallel computation of multilevel DWT. PA for 1-D DWT is given by

$$Y_l^j(n) = \sum_{i=0}^{k-1} h(i) Y_l^{j-1}(2n-i) \qquad (1)$$

$$Y_h^j(n) = \sum_{i=0}^{k-1} g(i) Y_h^{j-1}(2n-i) \qquad (2)$$

Where $Y_l^j(n)$ is the n[th] low-pass sub band component of the j[th] DWT level and $Y_h^j(n)$ is the n[th] high-pass sub band component of the j[th] DWT level. Two-dimensional signal, such as images, are analyzed using the 2-D DWT as shown in Figure 1. Currently 2-D DWT is applied in many image processing applications such as image compression and reconstruction [8]. The 2-D DWT is a mathematical technique that disintegrates an input image in the multi-resolution frequency space [9]. The 2-D DWT disintegrate an enter photo into four sub bands called low-low (LL), low-excessive (LH), high-low (HL) and high-excessive (HH) sub band.

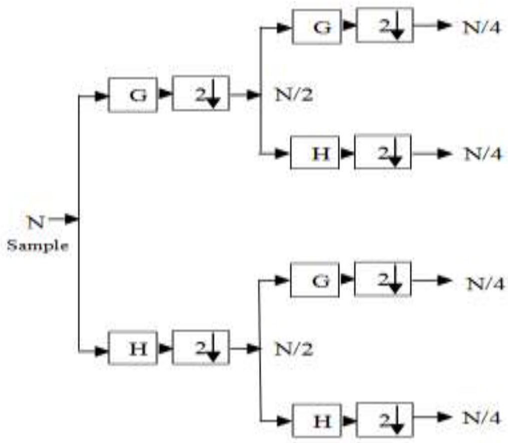

Figure 3: Two Level Diagram of Discrete Wavelet Transform

IV. SIMULATION RESULT

The proposed calculations are tried utilizing 256x256 8bit/pixel picture bike.jpg. In the reproduction, pictures are tainted by Salt and Pepper commotion. The commotion level shifts

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from 10% to 90% with augmentation of 10% and the execution is quantitatively measured by Mean square Error (MSE) and Peak Signal to Noise Ratio (PSNR).

Normalized Absolute Error (NAE)

$$= \frac{1}{N_1 N_2} \sum_{j=1}^{N_2} \sum_{i=1}^{N_1} (f(i,j) - g(i,j)) \quad (1)$$

Mean Square Error (MSE)

$$= \frac{1}{N_1 N_2} \sum_{j=1}^{N_2} \sum_{i=1}^{N_1} (f(i,j) - g(i,j))^2 \quad (2)$$

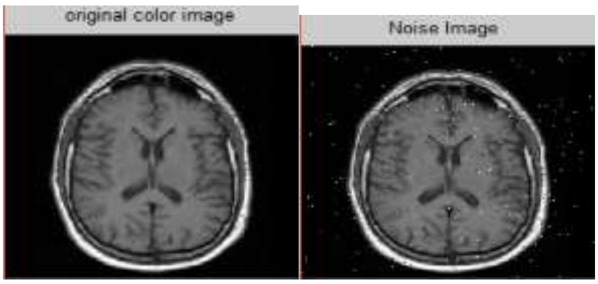
Root Mean Square Error (MSE)

$$= \sqrt{MSE} \quad (3)$$

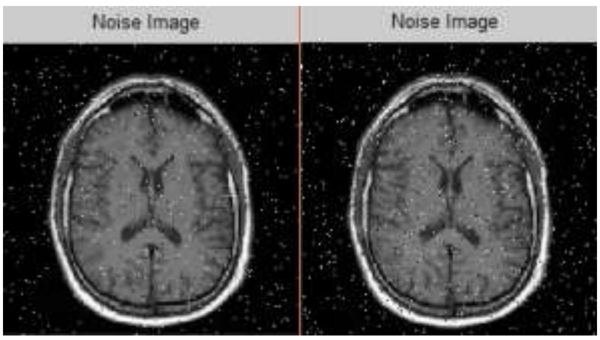
Peak Signal to Noise Ratio (PSNR) in dB

$$= 10 \times \log_{10}\left(\frac{255^2}{MSE}\right) \quad (4)$$

Where MSE remains for Mean Square Error, PSNR remains for Peak Signal to Noise Ratio. From the reproduction result appeared in Table I to II, it is watched that the execution of proposed calculation is enhanced PSNR than the current calculations at medium and high clamor level.



(a) Original Image (b) 0.01 Noise Density



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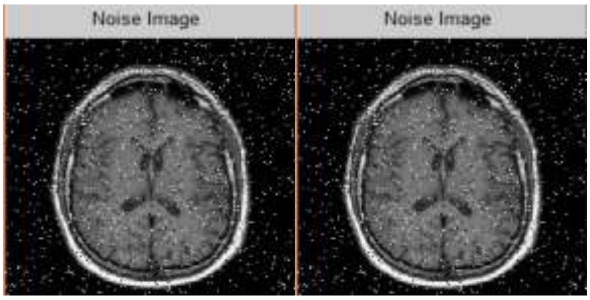
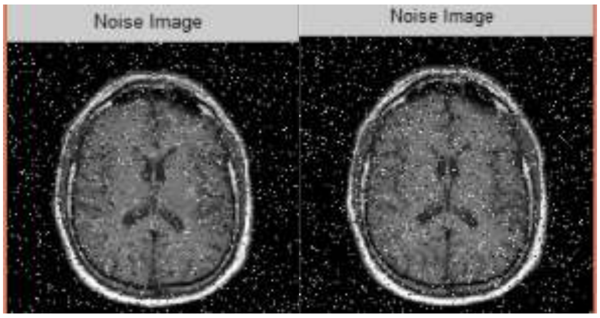
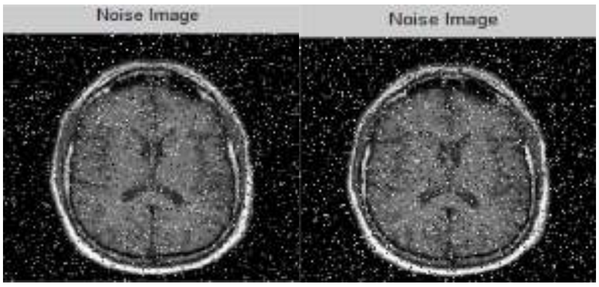
(c) 0.02 Noise Density (d) 0.03 Noise Density



(e) 0.04 Noise Density (f) 0.05 Noise Density



(g) 0.06 Noise Density (h) 0.07 Noise Density



(i) 0.08 Noise Density (j) 0.09 Noise Density

Figure 4: Experimental Salt & Pepper Noise Image for Different Noise Density

Table 1: PSNR and MSE Value for Different Noise Density

Image Density	NAE	MSE	RMSE	PSNR (dB)
0.01	0.019	1.9275	0.354	45.2808
0.02	0.037	3.2818	0.495	42.9696
0.03	0.057	5.0253	0.608	41.1192
0.04	0.077	6.9567	0.713	39.7068
0.05	0.096	8.4989	0.795	38.8372
0.06	0.114	10.0549	0.861	38.1070
0.07	0.136	11.8962	0.942	37.3767
0.08	0.153	13.4730	1.009	36.8362
0.09	0.169	16.1479	1.052	36.0496

V. V. CONCLUSION

In this work, it can be watched that the execution of the proposed channel is better than the current channels. The fundamental commitment of the paper is a strategy that is fit for reestablishing pictures debased by speckle noise commotion with to a great degree high clamor proportion. Light is additionally tossed on the reasons for these commotions and their real sources. In the second area we introduce the different sifting systems that can be connected to de-commotion the pictures. Trial comes about displayed, demands us to finish up middle channels performed well. Adjusted middle channel is the best decision of expelling the speckle noise commotion. In this paper is utilized changed middle channel and enhanced PSNR (crest flag clamor proportion) and decreased mean square mistake (MSE) for dim and shading picture.

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