



New Hybrid Filtering Methods To Remove Noise From Digital Images

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Abstract

Using hybrid digital filtering techniques reduces the amount of time a patient is exposed to radiation. If the patient is exposed to radiation for an extended length of time, his life will be jeopardized. Noise reduction in the photos is necessary when asked to lower the high radiation dosage and time it takes, which hides some of the right information from the physician and makes it difficult for him to appropriately analyze it. As a consequence, pre-processing has become the most significant item in digital image processors, and in this research, we offer a novel hybrid technology approach to decrease noise caused when photos are captured with medical equipment or when they are transferred. While respecting the image's edges, the resulting noise of the salt and pepper type. The statistical quantity measurements, Peak Signal-to-Noise Ratio (PSNR) and Root Mean Square Error (RMSE) are used to assess the enhanced picture quality. To illustrate this method, take 0.08 salts and pepper noise and compute it as Mean Square Error (MSE) it becomes 2.58 and PSNR 202.67, which indicates that this method is better than others at removing higher noise.

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1. Introduction.

Digital images have grown more common in a variety of fields in recent years, including medicine, scientific experimentation, education, and so on. As part of their everyday operations, hospitals, and medical institutions generate a large number of magnetic resonance imaging (MRI), digital pictures such as x-rays, and mammograms [1]. Several digital image applications are extensively or regularly utilized, including x-rays, magnetic resonance imaging, ultrasound, computed tomography, and ceroscopy images (DI) [2]. Unfortunately, a number of noises can cause problems with medical imaging. Gaussian, Pepper and Salt noise, Poisson noise, and Impulse noise are among the harmful noises [3].

These noises are made up of two fixed values that are dispersed evenly throughout the image [4]. A variety of causes can produce noise. Due to the architecture of the equipment that takes the medical picture, noise might be introduced into the image. We won't be able to extract the required information even if the medical picture becomes noisy since the noise obscures the true content. As a result, the noise that results must be carefully controlled. Image noise rises during transmission and reception, potentially masking the true content. The fuzzy algorithms are among the suggested noise-reduction filtering techniques in the literature [5, 6], and mean, and median filter [7].

There's a lot of interest in creating a way to assist examiners identify illness using a computer-aided design (CAD) system. The data in the image is kept while the noise is removed using a basic approach for noise reduction. To remove the damage caused by corrupted pixels, two-step filtering approaches [8, 9] are applied. When someone is suffering from a life-threatening ailment and their medical records have become crowded, it's not easy to save their life. Getting rid of noise It has become a highly significant topic in both biomedical engineering and image processing, with MRI wipe pictures being a focus of inquiry. Because noise comprises worthless and excessive information, it has an influence on medical imaging in general. This information has the potential to skew the truth and hide the image's quality and uniqueness. In contrast, the imaging device's limited sensitivity, and insufficient lighting may all contribute to image quality loss. In X-Beam imaging, the time of the individual's exposure to the beam and the number of X-Ray doses given to the affected persons are both important factors.

The only thing that matters in MRI imaging is the amount of time it takes to record the picture. When the X-Ray dose higher than normal, but the patient will still be at danger in the interval. In a similar way, when the imaging duration is extended, the noise level in the MRI picture is reduced, but this poses a danger to the patient. For further sickness study and data collection, medical images must be de-noised. The objective this project is to propose improved hybrid filtering methods and evaluates their efficiency of images used in medical area. There's also a method for detecting and removing pepper and salt sounds. When the image is not noise-free, the examiner will not be able to evaluate it with maximum accuracy and precision. As a result, it's critical to remove noise from medical images. We must first filter the MRI picture noise before we can begin detecting disorders [10]. This paper is organized as follows. The second section discusses the many types of noise that may be seen in medical imaging. The main topics are introduced in the third segment. Section 4 presents the several de-noising filtering methods for medical pictures. Sections 5 and 6 address the suggested hybrid filtering algorithms for minimizing Gaussian noise in medical images, as well as the approach, was chosen. The experimental findings are presented in Section 7. The RMSE of the recommended approach is evaluated in Section 8. In Section 9, the study's major themes are summarized.

2. X-Ray.

X-rays are a widely utilized imaging technology all over the world. X-rays have saved many lives and led to numerous key discoveries since they were first used to scan bones over a century ago. X-rays are a form of electromagnetic radiation that occurs naturally. When charged particles hit with a high-energy material, they create it [11].

3. Digital image.

A digital image is consist of image pixels, also called pixels, each with a non-related numerical representation of its intensity or gray level, which are formed using spatial coordinates given by the x and y on the x and y axes by 2D functions [12].

4. Issues with Image Noise.

During the coding, transmission, image capture, and processing steps, noise concerns were discovered in medical pictures. Without prior knowledge of the noise model, noise is extremely difficult to remove from medical images [13].

Many researchers have investigated and presented strategies to eliminate noise from medical images, however, these methods alone are insufficient to deliver actual outcomes. Noise removal from medical

pictures is tough, according to an MRI approach. Because our predicted outcomes are grayscale, and the intensity among the pixels is barely affected, they are difficult to analyze [14]. To minimize the noise in medical imaging, many strategies have been used.

5. Scenarios for New Techniques Proposed.

This part covers some general concepts and discoveries on digital topology that will be utilized throughout the article.

Definition (A)

The two-dimensional function $f(x, y)$ is used to describe a digital image, here x and y are coordinates and $f(X, Y)$ is the pixel intensity at the (X, Y) position. The brightness values in grayscale photographs range from 0 to 255, whereas binary images have brightness values ranging from 0 to 1 [15].

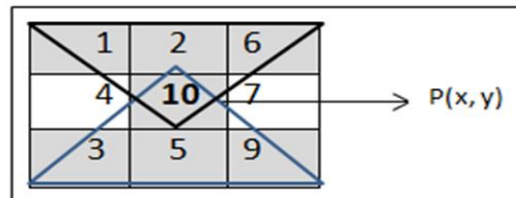
Definition (B)

A subgroup of (X) consist of a set of item and the pixel p , denoted by $N. (p)$, is the pixel of the neighbor $P \in X$.

Definition (C)

Neighbors -6 is N_6 and represents the six horizontal adjacent of the point P at $p(x, y)$. The center pixel $p(x, y)$ is 10, and the 6-neighbors of the point $p(x, y)$ are 1, 2, 6, 3, 5, and 9. $(x-1, y-1), (x-1, y), (x+1, y+1), (x+1, y-1), (x+1, y)$ and $(x+1, y+1)$ are its six horizontal point p , and is denoted by $N_6(p)$. Three points above with the center point that creates the upper triangle, and the three points below with the center point that creates the lower triangle, and the center point represents the intersection of two neighborhoods, and the remaining two points from the right and left of the center's point have no role during the operation.

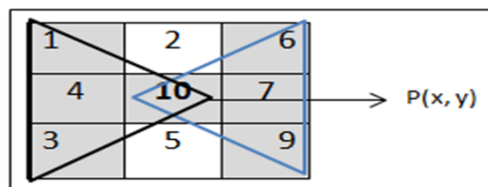
Table 1. Explains the definition (c)



Definition (E)

Neighbors -6 is N_6 and represents the six vertical adjacent of the point P at $p(x, y)$. The centre pixel $p(x, y)$ is 10, and the 6- adjacent of the point $p(x, y)$ are 1, 4, 3, 6, 7, and 9. $(x-1, y-1), (x, y-1), (x+1, y-1), (x-1, y+1), (x, y+1)$ and $(x+1, y+1)$ are its six vertical point p and is denoted by $N_6(p)$. Three points from left with the center point that create the left triangle, the three points from the right with the center point that create the right triangle, and the center point represents the intersection of two neighborhoods and the remaining two points from above and below the center's point have no role during the process.

Table 2. Explains the definition (E)



5.1 Techniques for filtering

The definitions of a number of existing filters may be found in this section. In a spatial domain, the image analysis function may be stated as follows:

Result (p)=T[f(P)] (1) The value of the pixel (brightness or grey of value level) of the input image's nearest location P(x, y) is f(p), and the pixel value of the processed image's nearest location P(x, y) is Result (p). The symbol T represents the transformation function [16].

5.2 Filter at its most extreme (Maximum Filter)

Within an ordered frame of pixel values, the maximum filter identifies the biggest value. Pepper noise is generated by a sequence of black pixels. The intensity of all of the hues is lower than that of black. The maximum filter reduces pepper noise by replacing the center pixel value with the biggest value in the vicinity. Due to the same reason, this filter tends to brighten the image. The pepper noise level is lowered by using the maximum filter. These filters have the following transfer function:

$$T(x, y) = \max(f(x, y)) \quad (3)$$

The x and y coordinates of nearby pixels are xi, yi. The brightness of the neighbors is represented by f(xi, yi). The value of I, which ranges from 1 to the mask's dimension, determines the mask's size. The value fluctuates between 1 and 9 for a 3 x 3 mask [17].

5.3 Median filter

In the same manner that the mean filter lowers noise, the median filter does as well. By comparing each pixel in the picture to its neighbors, the median filter determines if it is typical of its surroundings. Instead of utilizing the mean of neighboring pixel values, the median of those values is used to adjust the value of each pixel. The median is identified by numerically rating all of the value of the pixel in the immediate vicinity, then replacing the middle pixel value for the pixel in question. The median filter, like the mean filter, reduces noise. The median filter compares each pixel in the image to its neighbors to see if it is typical of its surroundings. The median of neighboring pixel values is used instead of the mean to adjust the value of each pixel. The median is determined by numerically evaluating all of the neighboring pixel values and then substituting the problematic pixel with the middle pixel value [18].

$$\text{Result}(p) = \text{median}\{f(p), \text{where } P \in N_6(p)\} \quad (2)$$

6. The PROPOSED HYBRID FILTERING Methods.

The proposed hybrid filters will be defined in this section. To reduce noise in Pepper, Salt, Gaussian, and ultrasonic medical imaging, researchers have yet to use these filters.

6.1 Hybrid median Cross Triangle filter (Hmct₁F)

The Hybrid Median filter is a type of nonlinear filter that eliminates impulsive noise fast while keeping the edges intact. The hybrid median filter is critical in image processing and vision. The corner preservation properties of the hybrid version of the median filter are better than those of the basic version. The filter definition is as follows:

$$\begin{aligned} &\text{Result}(p) \\ &= \text{median}\left\{ \begin{array}{l} f(p), \\ P \in N_{3ut}(p), \\ \text{median}\{f(p), P \in N_{3dt}(3)\}, f(p) \end{array} \right\} \text{ And } N_{3ut}(p) + N_{3dt}(p) \text{ equal to } P \\ &\in N_6(p) \end{aligned} \quad (5)$$

In comparison to a median filter, a mongrel median filter maintains rimming much best. The number of pixels in a point p is modified by the median of its median pixel value. 3-neighborhood, cross-neighbors' median pixel value, and a pixel value of ('p') in a hybrid median filter 6-neighborhood, a pixel value of ('p') in a mongrel median filter 6-neighborhood, and the values of pixel ('p') in a hybrid median filter 6-neighborhood.

6.2 Hybrid median cross triangle filter (Hmct₂F)

The nonlinear Hybrid Median filter removes impulsive noise fast while maintaining edges. The hybrid median filter is significant in image processing and vision. The hybrid media filter's latest iteration has better corner preservation qualities than the basic version. The following is the filter definition:

$$\begin{aligned} &\text{Result}(p) \\ &= \text{median}\left\{\text{median}\left\{\begin{array}{c} f(p), \\ p \in \text{Nrt}(p), \end{array}\right\} \text{ And } \text{N3rt}(p) + \text{N3lt}(p) \text{ equal to } p \right. \\ &\left. \in \text{N6}(p) \right\} \end{aligned} \quad (6)$$

A hybrid cross median filter replaces the value of pixel a point p with the median of the median pixel value of (RT) neighbors of a point 'p', the median pixel value of (LT) neighbors of a point 'p', and the pixel value of 'p'. 6-neighborhood, the median pixel value of a point 'p' across adjacent, and the pixel value of 'p'.

7. Proposed Algorithm

In this paper, propose a unique method for minimizing noise from medical images produced with various equipment and then relocated from one site to another. This study also shows how to enhance the image once the noise is eliminated, allowing for a cleaner visual perspective, which is crucial for effective sickness diagnosis. The phases of the proposed algorithm are as follows:

Algorithm's name (Hmcs₂F)

Input: MRI image

Output: a noise-free image

Initial

Step (1): Assume the input is an MRI image.

Step (2): is to create a gray scale representation of the image.

Step (3): Noise is added to the MRI image.

Step (4): Improve your work by employing morphological processes.

Step (5): Obtain the histogram equalization. .

Step (6): To keep the image's edges, use the Adjusted New Techniques Median Filter.

Step (7): Use the Median Filter to create a noise-free image.

End

8. Methodology of research.

In this part, we'll go through the full strategy for our proposed new algorithm. The technique is seen in its entirety in Figure 1. An MRI picture is fed into the system. The proportions of the picture are determined. Obtain the measurements of an image in a certain file. Grayscale-picture Following that, the supplied picture is converted to grayscale. For further processing, the gray-scaled image is required. The fundamental reason for this is that we now have ranges spanning from 0 to 255, and

every integer between these two numbers represents a unique picture point. Noise is introduced to every image at random. We're guessing there's some noise in the image you've provided.

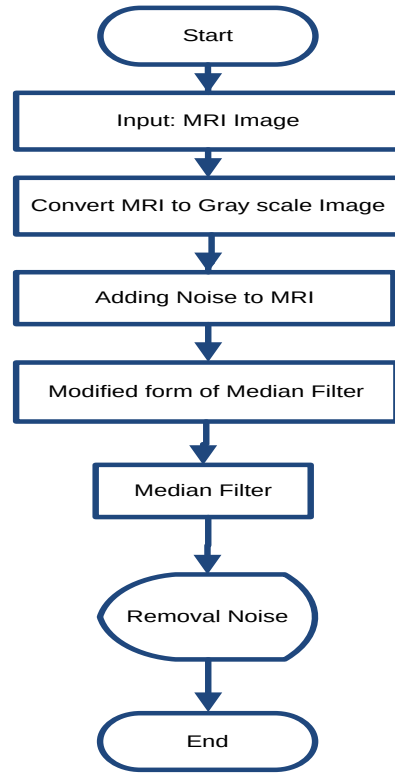


Figure 1. The suggested algorithm's flow chart

Adjusted Median Filter. Non-linear filters are a type of non-linear filters, such as the median filter. It's a highly effective nonlinear filter. It decreases the amount of a difference between neighboring pixels. The primary concept is to use rather than the pixel value, used the median value. The value of the median may be determined via ordering the image pixels from smallest to greatest and then determining the middle value. For pepper and salt noise, the median filter is utilized. The median filter's operation Table describes it.

Table 3. Shows how the Median Filter works

11	3	1
8	15	6
2	5	9
2	5	9

The pixel values must be rebuilt in ascending order first and foremost.

1, 2, 3, 5, 6, 8, 9, 11, 15

In this example, the median number is 6; hence the marked value must be changed to an intermediate value. We determined the median using a modified mean filter with similar window dimensions but in a diverse manner. Figure 2 shows the optimized operation of the media filter. The mean value was determined using a modified mean filter with a cross mask. The average filter set with a cross mask was performed again, yielding a new mean value. The average of the two median values coming first is combined with the real value in the enhanced version of utilizing the median filter. The refined median filter is illustrated in the diagram below. Moreover, it shows very well how to determine the average value. Rather than relying on a single operator.

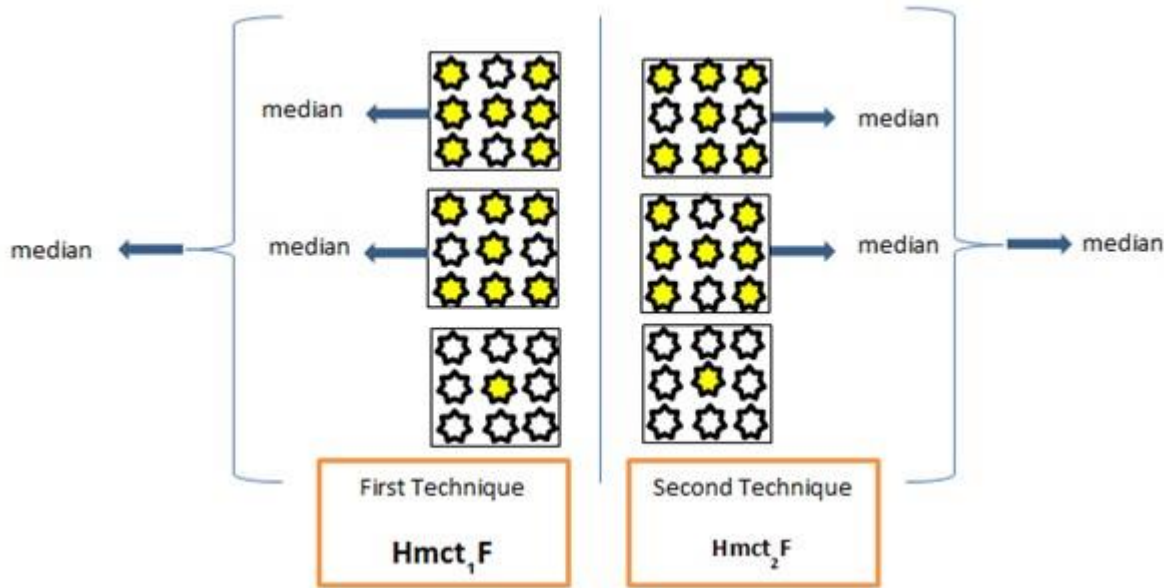


Figure 2. shows enhanced version of the Median filter applied on the intersection of the two Triangle at the center point

The modified median filter was attached to the median filter after establishing the image's median. Below is a list of the phases of the enhanced variation of the median filter algorithm.

Modified New Median Filter Techniques Algorithm

Input: Digital image or MRI image

Output: image without noise

Initial:

Step (1): On the item, choose the filter size and window.

Step 2: Choose the pieces according to the filter's size.

Step 3: Rearrange the items you've selected.

Step (4): Pick a value that's halfway between the two extremes (like in the case of a standard median filter).

Step (5): Assign the two triangular values to the objects you've chosen.

Step (6): Select the items based on the size of the filter.

Step (7): Rearrange the items.

Step (8): Select the intermediate value.

Step (9): Make a list of everything you learned in stages 4 and 8 as well as the element itself.

Step (10): Rearrange these four items in a new order.

Step (11): The median value should be updated and assigned to the middle value.

End

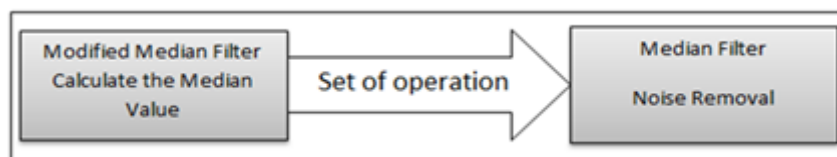


Figure 3. The suggested filter combination

To cancel noise from medical images, a number of filters can be applied. However, because of its advantages and endurance, we picked the median filter above other nonlinear filters in our investigation.

To minimize the amount of noise in the images, the Median filter is utilized. It is centered on the idea of doing things as efficiently as possible. It is determined what the mean square error is. For noise reduction, the received signal is compared to the intended noiseless signal. The median filter factor is affinity-based and has no values or mask. When the size of the local neighborhood is given, the value of the central point is substituted with the median value or the center of the neighbor values, not the mean. It's utilized to increase the photo blur effect's linearity. Helps to reduce the signal-to-noise ratio (SNR) .

9. Experimental Results.

The experimental results are included in this section. The photos obtained after each stage are used to calculate the experimental findings. The original picture may be seen in Figure 4(A). We transform the picture to gray scale after acquiring it. Figure 4(B) shows the result of the gray image. The outcome of adding noise to the medical picture is shown in Figure 4(C). pepper and Salt noise is seen in medical images such as optical CT scans and ultrasounds, and it degrades the clarity of the images. We changed the low-resolution picture to a grayscale image to improve the results. The grayscale image's outcome is shown in the figure below. We utilize the edge detection approach after transforming the noisy picture to a grayscale image. The edges of the input picture were detected using this approach. The development of an algorithm is our goal that reduces noise and improves the original image's visibility. As a consequence, we came up with the idea of a mongrel filter.

The Modified Median Filter and the Median Filter are combined in a hybrid filter technique. To eliminate the noise, the median filter is utilized. It's similar to the mean filter, except it maintains the picture's edge data. It also keeps the image's info, which is required for further processes. The adjusted median filter's result is shown in Figure 4 (D).

To filter out the noise, use a median filter in the final step, resulting in a noise-free image with the edges maintained owing to the Gaussian low pass filter. When removing noise from a medical image, the median filter is utilized. As a result of the unwelcome communications, that image has been tarnished. Some filters work on the principle of frequency response; although, because it employs a statistical method, the median filter requires a different perspective and has a unique point of view.

The median filter's result is shown in Figure 4(D). We apply a median filter to remove noise from a picture in the final step, resulting in a noise-free image with edges retained owing to the Gaussian low pass filter. To completely reduce noise from a medical image, the median filter is applied.

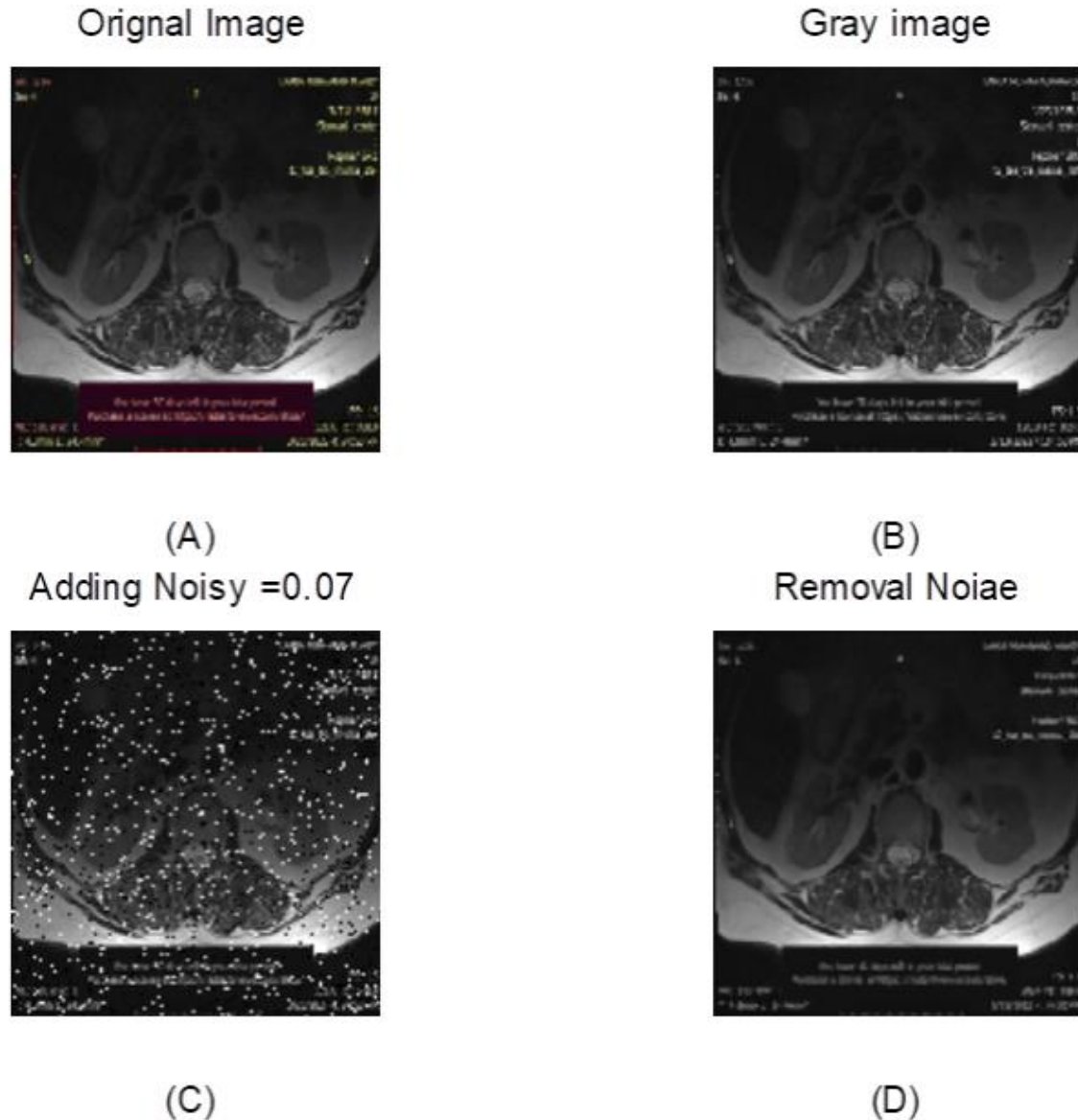


Figure 4. displays the outcomes of the proposed noise removal strategy for medical images with image size (280 x 272). Image in its original color (A), Image in Gray (B), The image contains noise (C), and (D) The enhanced median filter.

We took some MRI images of different dimensions, then added noise to them, and then tested the proposed hybrid filtering technique on them and saw the result. We used a hybrid median filtering algorithm on magnetic resonance imaging (MRI) of the human brain. After converting images to grayscale images, we added noise to it, and we observed the performance of this algorithm with some other filtering algorithms, which is a pre-processing process, before segmentation and classification. This is a necessary step as shown in figure 5 and figure 6.

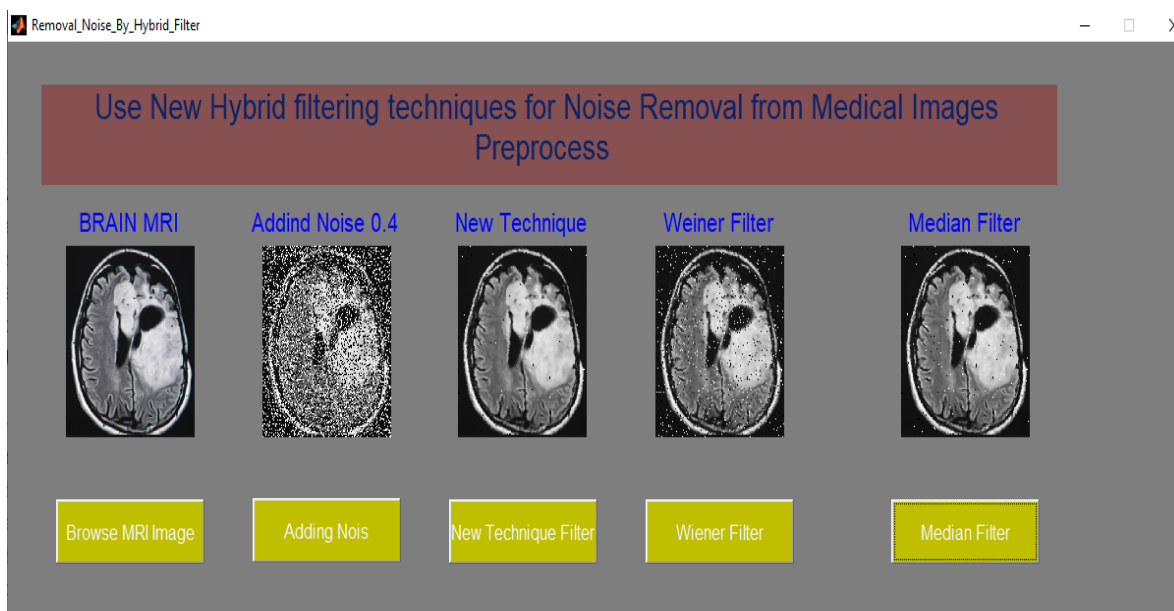


Figure 5. Result of the proposed noise removal strategy for brain medical image compared to a Wiener filter and a traditional median filter.

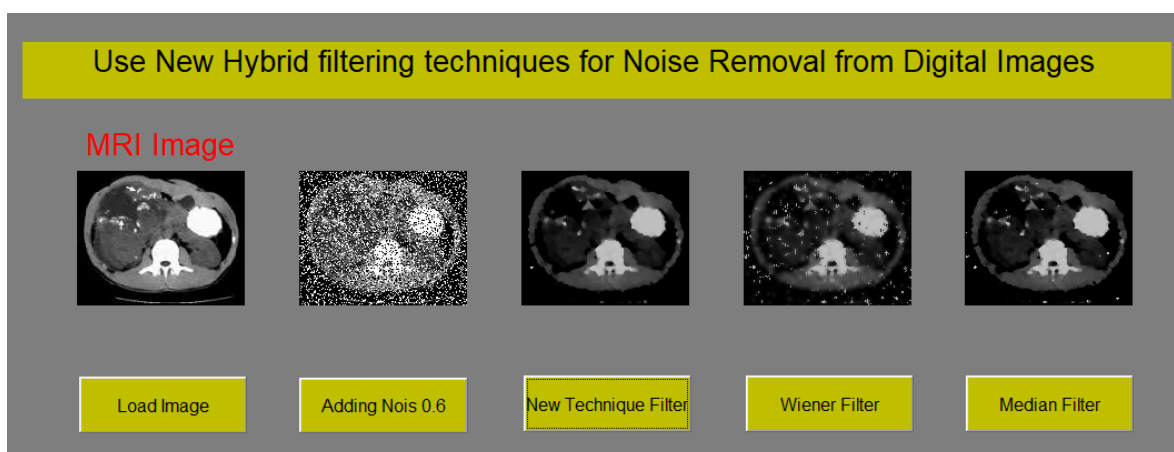


Figure 6. Result of the proposed Gaussian noise removal strategy from Medical image (MRI), compared to a Wiener filter and a traditional median filter.

10. Analysis and Performance

Mean Square Error (MSE), Signal to Noise Ratio (SNR), Peak Signal to Noise Ratio (PSNR), Root Mean Square Error (RMSE), and Maximum Absolute Error [MAE] are the most often utilized methods for objective assessments. We calculated all of the above-mentioned Figure s. The following equations are used to compute the outcomes of the above-mentioned values.

$$MSE = \frac{1}{N * M} \sum_{i=1}^{N-1} \sum_{j=0}^{M-1} [|f(i, j) - \hat{f}(i, j)|^2] \quad (5)$$

$$\sqrt{\text{MSE}} = \text{RMSE} \quad (6)$$

$$\text{MAE} = \text{MAX} |f(i, j) - f'(i, j)| \quad (7)$$

$$\text{SNR} = 10 \log \left\{ \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} f(i, j)^2 / \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} [f(i, j) - f'(i, j)]^2 \right\} \quad (8)$$

$$\text{PSNR} = 20 \log \left\{ \frac{(255)^2}{\text{MSE}} \right\} \quad (9)$$

The result of the (PSNR) and (SNR) tests are provided in decibels (dB). Following the process of Median filter, the initial image and final image are denoted by $f(i, j)$ and $f'(i, j)$. The results of the PSNR, SNR, MSE, and RMSE testing are shown in Table 4. It makes pepper and salt noises in this case. And at almost the same time, we're altering the image size and noise strength level.

Table 4. Illustrates the results of the estimation of the technique that is suggested in terms of PSNR, SNR, MSE, and RMSE, (Variable Noise Level and Fixed Image Size).

Noise Level	Image Dimensions	PSNR- dB	SNR- dB	MSE	RMSE
0.03	297 x 286	191.33	102	4.55	2.13
0.06	297 x 286	188.38	101	5.27	2.29
0.11	297 x 286	184.11	100	6.53	2.55
0.15	297 x 286	181.73	100	7.35	2.71
0.19	297 x 286	178.38	99	8.70	2.94
0.22	297 x 286	175.98	98	9.80	3.13

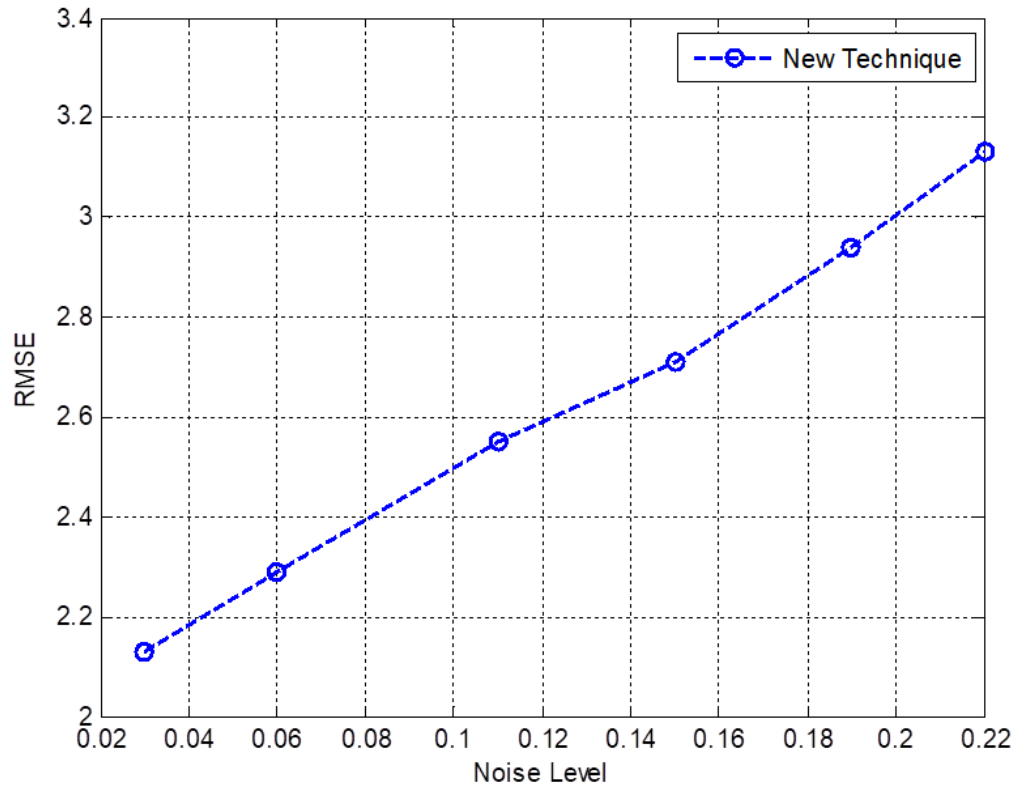


Figure 7. Depicts the relationship between RMSE and Variable Noise Level vs. Fixed Image Size.

Table 5, illustrates the results of a single image's PSNR, SNR, MSE, and RMSE. Choose a noise level of 0.08. And calculated the values above after modifying the pixel images.

Table 5. illustrates the results of the evaluation of the recommended method in terms of PSNR. , SNR, MSE, and RMSE, (Constant Noise Level and Variable Image Size).

Noise Level	Image Dimensions	PSNR- dB	SNR- dB	MSE	RMSE
0.08	492 x 472	202.67	111	2.58	1.60
0.08	482 x 464	201.45	110	2.74	1.65
0.08	432 x 414	198.68	108	3.15	1.71
0.08	372 x 340	192.22	105	4.35	2.08
0.08	297 x 286	186.79	101	5.71	2.39
0.08	280 x 272	185.42	100	6.11	2.47

The Gaussian distribution of noise is identified by the mean and standard variations. The graph's midpoint is identified by the mean, while the graph's height and breadth are identified by the standard deviation.

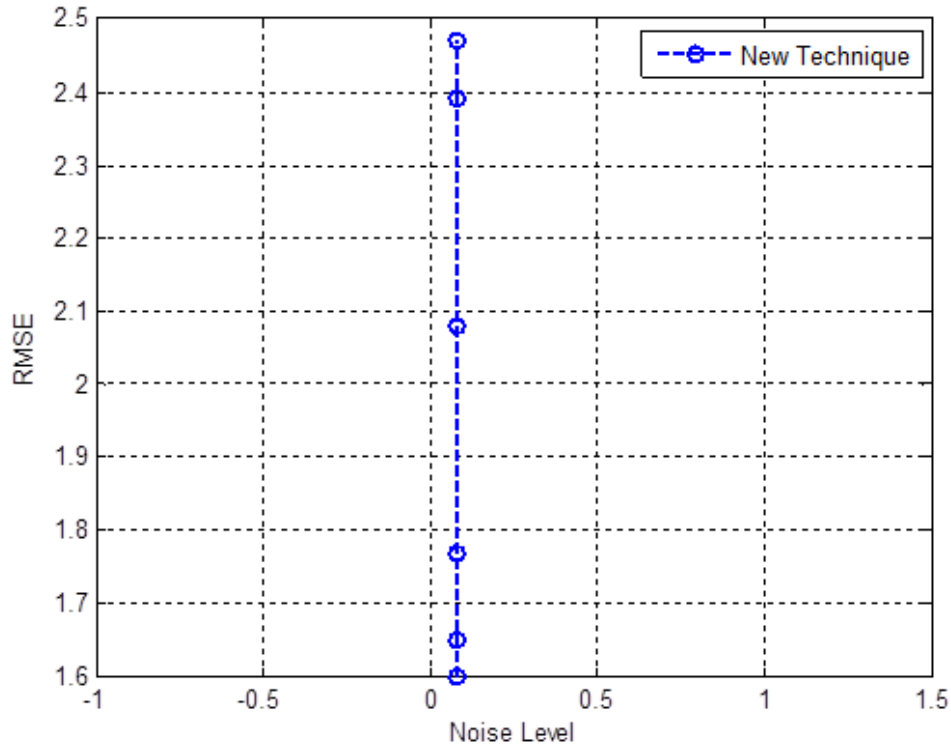


Figure 8. Depicts the relationship between RMSE and Fixed Noise Level vs. Variable Image Size.

11. Comparison of three filter methods.

The traditional median filter method, the hybrid median filter method 2020, and our proposed method after adding 0.6 noise, and through that, our methods are much better than the others. As shown in figure 7.

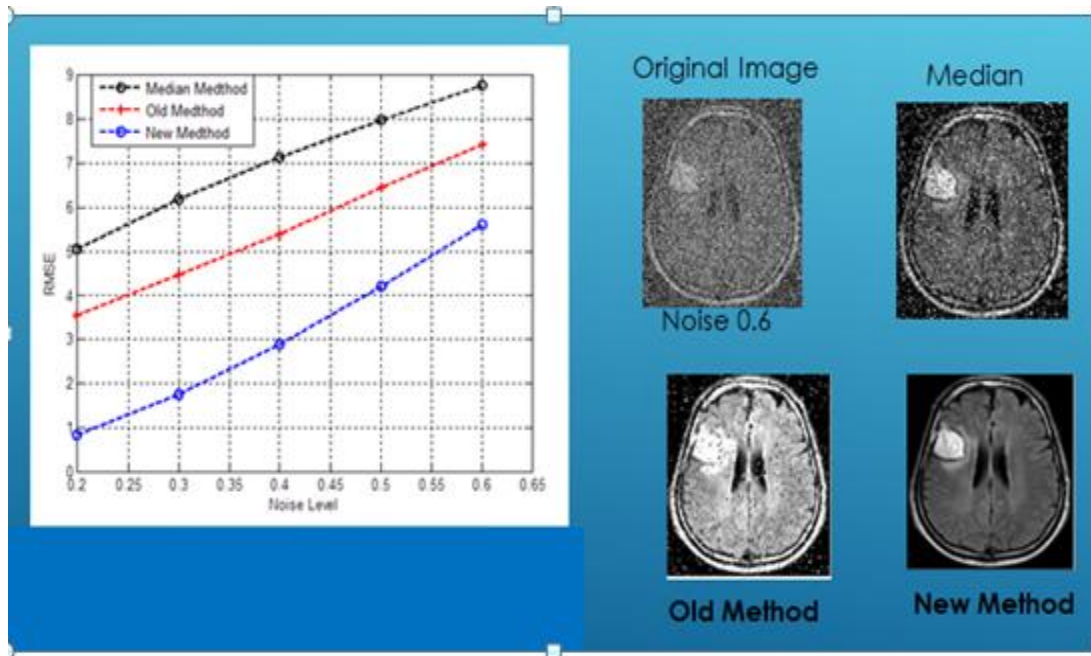


Figure 9. Flowchart comparing the three technologies.

12. Conclusions

In this study, we used an MRI picture and added the noise salt and pepper that have mean and variance. We executed our recommended strategy after introducing the noise. These findings indicate that the proposed approach has a great capacity for image noise reduction. The hybrid image, on the other hand, has no influence on the image's quality. As a result, we expect that by modifying medical imaging technology, we will be able to substantially cut the time it takes to identify illnesses. When compared to any other version of the median filter, the modified form produces better results by leaving the edges intact. A suggested the filter of the median produces good results the edges are kept intact. As can be seen in the output images, the median filter produces the desired picture results. In our studies, we discovered that the result is superior than that of other hybrid filters when the noise level is more than 0.5. For example, if we choose 0.07 noise for a 280 x 172 picture, the MSE value becomes 5.95, but the MSE value is significantly higher in other ways, which is not optimal in this situation. As a result, the suggested technique outperforms previous methods owing to its low MSE.

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