High Density Noise Removal for Magnetic Resonance Imaging by Modified Median Filter

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Abstract: In MRI images noise removal techniques have become an essential exercise in medical imaging applications, for the study of anatomical structures. MRI images are affected by Rician noise due to the magnitude image formation. Presence of Rician noise can significantly affect the image quality and contrast ratio of an image. In this paper Modified Median Filter technique is used for de-noising Rician noise. Rician noise displays varying distribution characteristic depending on the SNR of the image. Based on the probability distribution function of noise and SNR information obtained from the image, the proposed filter uses selection of filtering window of size 3X3 to perform de-noising. The proposed filtering technique has been implemented on MRI images. The efficiency of the proposed filtering technique is verified with a study of the PSNR characteristic of the de-noised and noisy image with respect to the true image. The proposed de- noising technique shows an improvement in the contrast ratio and PSNR of the noisy image.

Keywords: Rician Noise, Median Filter, De-noising.

Introduction

A straightforward middle channel [1] works pleasantly to denoising rash commotion of low thickness and is anything but difficult to execute. Yet, the cost paid for it is twists edges and fine subtle elements of a picture. The contortion increment as the sifting window size is expanded to smother high thickness commotion. Middle Filter is a nonlinear sifting procedure broadly utilized for expulsion of motivation commotion [2]. In spite of its adequacy in smoothing commotion the middle channel tends to evacuate fine subtle elements when it is connected to a picture consistently. Be that as it may, some specific middle channels, for example, Weighted Median Filter [3] and Recursive Weighted Median Filter RWMF [4], Center Weighted Median Filter are proposed in writing to enhance the execution of the middle channel by giving more weight to some chose pixels in the sifting window.

The area images processing the two principal applications are the improvement of pictorial information for human interpretations. The way toward getting and investigating visual data by advanced PCs is called computerized picture preparing. A picture might be depicted as a two dimensional capacity f(p, q) where p and q are spatial directions. Sufficiency off at any combine of co- ordinates (p, q) is known as the force or dim level of the picture by then. The picture made out of a limited number of components each of which has a specific area and qualities. That implies the components of picture are pixels. Pixel is the term most broadly used to mean the components of computerized picture.

Performing some mechanical operation (robot motion) is the goal of the Image processing. In the Figure 1 typical blocks diagram of image processing system. This consists of the center part is the computer system, one image acquisition, image processing software, storage devices, transmitters and display devices. Advanced picture preparing has many preferences over simple picture handling. It permits a much more extensive scope of calculations to be connected to the info information, and can stay away from issues, for example, the development of clamor and flag contortion amid preparing [5].

Noise is caused due to various sources which include many external causes in transmission system and environmental factors which includes noise like Gaussian, Poisson, Blurred , Speckle and salt-and- pepper noise. Noise removing method has become an important factor in medical imaging applications and the most commonly used filters are Median filter, Gaussian filter, Weinerfilter which gives the best result for the respective noises. The need for the smoothening of images has becomes essential whichis required to remove the noise and for that best filters or standard filters are used in most of the image processing applications. The property of a de-noising model is to remove the noise from the image and also preserve the edges. There are two types of models which are used for de-noising linear model and non- liner model. Most of the time linear models are experimented because of its speed even though it has the limitation of not able to preserve the edges of an image in a efficient way.

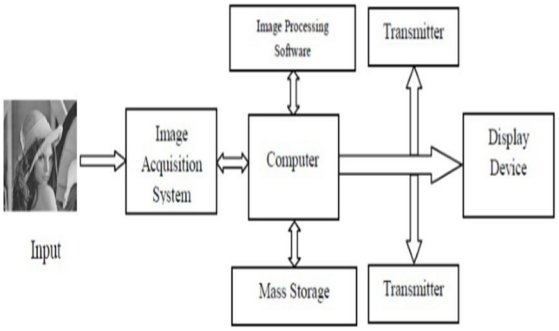

Figure 1: Typical Image Processing System

Literature Review

B Deepa et al. [1], Noise removal techniques have become an essential exercise in medical imaging applications, for the study of anatomical structures. The most commonly affected noises in medical image are salt and pepper, Gaussian, Speckle and Brownian noise. In this paper, the medical images taken for comparison include MRI brain images, in gray scale and RGB. The low quality of medical images causes difficulty for the Surgeons at the time of diagnosis or interpretation. A quality image is needed by Biometric Identification and Authentication Systems to aim at consistent and exact outcomes so that it can be helpful for universalperson trained in medical science to study the prodrome of the patients. The quality of the MRI and brain imageis obtained by the noise free images to get the better result and increased in accuracy of the result. Many filters are applied to get the best possible result for the noises present in the image like Weiner filter, Median filter etc.

Babu G et al. [2], Noise is an ingrained phenomenon in the medical images which may increase the root mean square error and reduce the peak signal to noise ratio. NLM filter is used for the removal of speckle noise and shrinkage rule is used to shrink the content of noise present in the brain images by means of the thresholding technique.
Priyanka Punhani et al. [3], Magnetic Resonance Imaging is most popularly used techniques in clinical diagnosis. During acquisition, image quality is degraded by certain noise and artifacts. Due to which, it is difficult to interpret important details of user. So it becomes necessary to denoise image. There are various denoising methods available now days.

L. Ramya et al. [4], Image Denoising and Image Segmentation are the two major areas of the medical image processing. The main objective of this paper is to develop a robust segmentation algorithm inorder to detect tumor in 2D MRI brain images. Here we use image denoising as the pre-processing step as noise plays an important role in case of accuracy of affected area of the image, especially in medical diagnostics. Noise reduction is a very essential step in digital image processing for getting better quality images. Medical imaging is a valuable tool in the field of medicine. Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultra Sound imaging (USI) and other imaging techniques provide more effective information about the anatomy of the human body, during the diagnosis process9 . In the medical field the Surgeons always desire for enhanced medical images for the diagnosis because most of the time the images are not perfect and are deteriorated by many internal and external factors.

Table 1: Summary of Literature Review

Entitle of paper	Approached used	Software	Parameter	Published Year
Comparative Analysis of Noise Removal Techniquesin MRI Brain Images	Design Noise Removal by median filter	MATLAB 12.1R	PSNR = 32 dB, MSE = 124.34	IEEE 2015
Design of Spatial Filter for Fused CT and MRI Brain Images	Salt and Pepper noise removal by adaptive filter	MATLAB 10.1R	PSNR = 31.3 dB, MSE=134.65	IEEE 2015
Noise Removal in MR Images using Non Linear Filters	Noise Removal by nonlinear filter	MATLAB 9.1R	PSNR = 30.3 dB, MSE =154.65	IEEE 2015
A Robust Segmentation Algorithm using Morphological Operators for Detection of Tumor in MRI	Segmentation Algorithm using Morphological	MATLAB 9.1R	PSNR = 29.3 dB, MSE =184.89	IEEE 2015

Various Sorces of Noise in Images

Noise is introduced in the image at the time of image acquisition or transmission. Different factors may be responsible for introduction of noise in the image. The number of pixels corrupted in the image will decide the quantification of the noise. The principal sources of noise in the digital image are: a) The imaging sensor may be affected by environmental conditions during image acquisition. b) Insufficient Light levels and sensor temperature may introduce the noise in the image. c) Interference in the transmission channel may also corrupt the image. d) If dust particles are present on the scanner screen, they can also introduce noise in the image.

Different Noise Types

Noise is the undesirable effects produced in the image. During image acquisition or transmission, several factors are responsible for introducing noise in the image. Depending on the type of disturbance, the noise can affect the image to different extent. Generally our focus is to remove certain kind of noise. So we identify certain kind of noise and apply different algorithms to remove the noise. Image noise can be classified as Impulse noise (Salt-and-pepper noise), Amplifier noise (Gaussian noise), Shot noise, Quantization noise (uniform noise), Film grain, on- isotropic noise, Multiplicative noise (Speckle noise) and Periodic noise.

Impulse Noise (Salt and Pepper Noise)

The term impulse noise is also used for this type of noise [5]. Other terms are spike noise, random noise or independent noise. Black and white dots appear in the image [6] as a result of this noise and hence salt and pepper noise. This noise arises in the image because of sharp and sudden changes of image signal. Dust particles in the image acquisition source or over heated faulty components can cause this type of noise. Image is corrupted to a small extent due to noise. Show the effect of this noise on the original image (Fig 2).

Figure 2: Original image without noise, Image with salt & pepper noise

Gaussian Noise

Gaussian distribution which is also known as normal distribution whose Probability Density Function is equal to statistical noise known as Gaussian Noise.

This noise is removed from the digital images by smoothening of the image pixels which helps in reducing the intensity of the noise present in the image which is caused due to acquisition but the result may be sometime undesirable and also which can result in blurring edges of the high-quality images. The formula of adding the Gaussian Noise to an image is: g = imnoise (I,'Gaussian', m, var), where I is the input image, m is mean and var is variance.

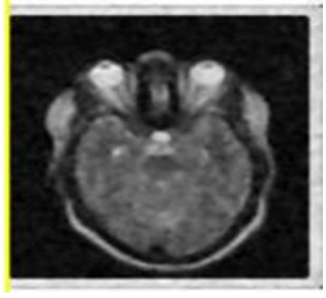

Figure 3: Image after Gaussian Noise

Speckle Noise

The Speckle Noise is defined as a noise which is present in the images and which degrades the quality of an image. Speckle Noise is a incident that convoys all rational imaging model quality in which images are formed by inquisitive echoes of a mediate waveform that originate from diversity of the studied objects5.

These are the granular noises that are fundamentally present in the image and reduce the quality of the active radar and Synthetic Aperture Radar (SAR) images or Magnetic Resonance6 .Imaging (MRI) images is referred to as Speckle Noise. If Speckle Noise is present in the images then it results in the random variations of the return signal which increases the grey level in an image.

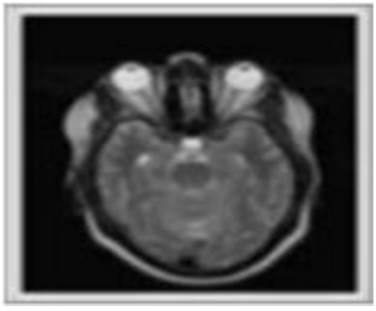

Figure 4: Image after Speckle Noise

Poisson Noise

Poisson Noise is a electronic noise which is a form of ambiguity related with the quantity of the light. This occurs in an image when the limited number of particles that carry energy, such as electrons which is small enough to give rise to measurable variations. Consider a light combination of photons coming out of a source and striking a point which creates a evident spot, the physical process which governs the light emission are such that those photos which are emitted from the light source hits the point many times but to create visible spot billions of photons are needed. However, if the source is not able to emit handful number of photons which hits the point every second then this noise is caused. The formula of adding the Gaussian Noise to an image is: J = imnoise (I,'poisson') where I is double precision, then input pixel values are interpreted as means of Poisson distributions.

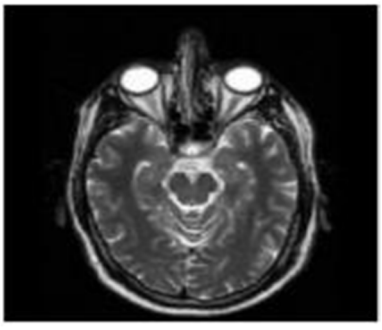

Figure 5: Image after Poisson Noise

Blurred Noise

Blurred Noise is caused due to the light intensity and external factors. Capturing reasonable photos under low light conditions using a handheld camera can be annoying experience. Often the photos taken are blurred or noisy. These kinds of images containing hazy and blurred pixels are referred to as Blurred Noise which is present in the image.

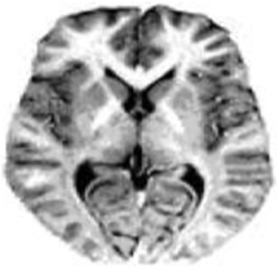

Figure 6: Image after Blurred Noise

Removal Techniques

Image de-noising is asset for image noise processing which includes filtering techniques which includes different ways to de-noise an image. It is solved by using different algorithms. Accordingly, noises are spotted with neighboring information and are removed using best filtering techniques without affecting the image quality and reinforce the smoothness of the image taken for examination.

Median Filter

In sign processing, it's far often proper that allows you to carry out some type of noise reduction on a photograph or sign. The middle sift through is a nonlinear advanced separating system, every now and again used to evacuate commotion. Such clamor rebate is a normal pre-handling venture to enhance the results of later preparing (for instance, side location on a picture). Middle sifting could be generally utilized as a part of computerized photo processing due to the fact, beneath certain situations, it preserves edges even as doing away with noise (however see dialogue under).

The guideline idea of the middle get out is to gone through the sign section through get to, supplanting every passage with the middle of neighboring passages. The example of colleagues is known as the "window", which slides, access with the guide of access, over the total flag. For 1D sign, the most extreme clear window is essentially the essential couple of past and taking after sections, while for 2d (or higher-dimensional) cautions including photos, more intricate window examples are reasonable (which incorporate "holder" or "go" designs). Know that if the window has an odd wide assortment of passages, then the middle is anything but difficult to characterize: it is essentially the inside esteem after every one of the sections inside the window is sorted numerically. For an even wide assortment of passages, there is several suitable middle, see middle for additional data.

See that, in the case above, in light of the fact that there is no get to past the principal esteem; the essential expense is rehashed, as with a definitive charge, to procure adequate passages to fill the window. This is one method for adapting to lacking window passages at the hindrances of the flag, yet there are diverse plans that have outstanding houses that may be fancied particularly examples:

- Avoid handling the limits, with or without trimming the flag or picture limit a while later,
- Fetching sections from different places in the flag. With pictures for instance, sections from the far flat or vertical limit may be chosen,
- Shrinking the window close to the limits, so that each window is full.

Noise is added inside the picture at the time of photograph acquisition or transmission. Different factors may be accountable for introduction of noise inside the photo. The wide variety of pixels corrupted in the picture will decide the quantification of the noise. The fundamental assets of noise within the virtual image are:

a) The imaging sensor may be stricken by environmental conditions at some stage in picture acquisition.

b) Inadequate mild degrees and sensor temperature may additionally introduce the noise in the picture.

c) Interference in the transmission channel may also corrupt the photo.

d) If dirt debris is gift at the scanner display screen, they also can introduce noise inside the photograph.

Noise is the undesirable results produced within the picture. For the duration of photo acquisition or transmission, numerous elements are chargeable for introducing noise in the photo. Depending at the sort of disturbance, the noise can have an effect on the picture to special volume. Commonly our cognizance is to cast off sure kind of noise.

So we become aware of sure type of commotion and apply one of a kind calculation to get rid of the clamor. Picture commotion can be sorted as Impulse clamor (Salt-and-pepper clamor).

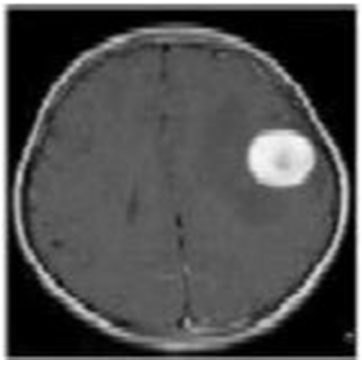

Figure 7 (a): Original Image

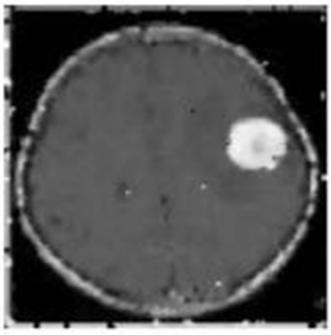

Figure 7 (b): Original Image and Median Filter

Weiner Filter (WF)

The goal of the Weiner filter is to filter out the noise present in an image which possess corrupted signal in it. This filtering technique uses statistical approach to filter the noise from each pixel of an image. This filtering technique uses different angle in an image to modify the corrupted signal in it. Original image signal has spectral properties and noise present in it so to start with experiment one should have the knowledge of the properties of it, one seeks the LTI filter (Linearity and Time-Invariance) whose outcome will be closer to the original signal present in the image as achievable. Wiener filter is a technique which performs optimal trading involving opposite filtering and noise smoothing. It removes the blurring and additional noise present in the image and it is also very optimal in relation to the mean squared error where it minimizes the overall Mean Square Error in the operation of the filtering technique for noise removal1. Wiener filters are usually defined by the following: a. Hypothesis: additive noise and image signal are inactive linear random processes containing spectral characteristics. b. Necessity: The filter must be able to achieve and can be accessed. c. Performance criteria: It depends on minimum Mean Square Error.

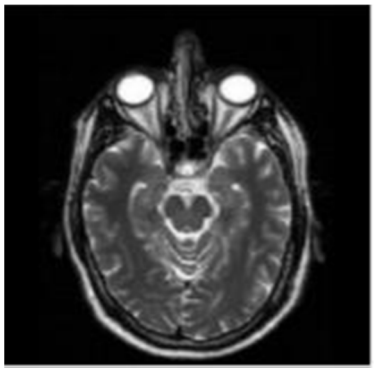

Figure 8 (a): Original Image

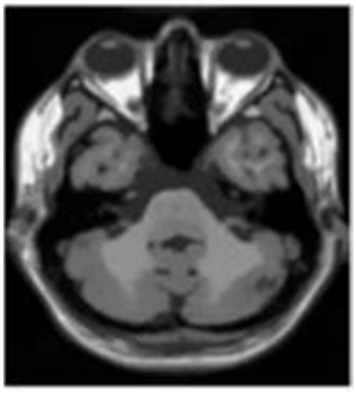

Figure 8 (b): Original Image and Weiner Filter

Gaussian filter

Speckle Noise is typical noises which is caused due to internal or external factor and are generally present in the digital images and MRI images. Gaussian filter is implemented to remove the Speckle Noise present in ultra sound images or MRI brain images. In this technique, the average value of the surrounding pixel or neighboring pixels replaces the noisy pixel present in the image which is based on Gaussian distribution.

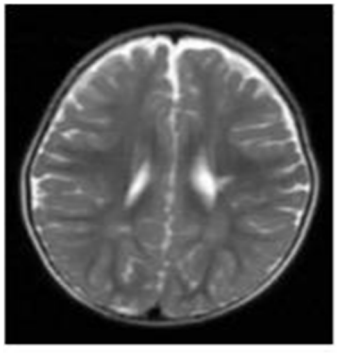

Figure 9 (a): Original Image

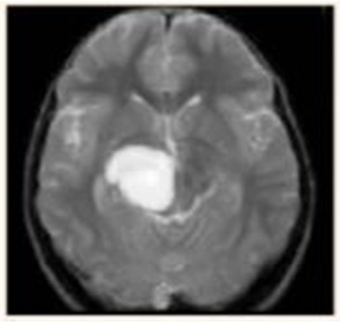

Figure 9 (b): Original Image after Gaussian Filter

Comparative Study

Among various types of filters, each has different characteristics and working of each one is different for different types of images. Various filtering technique are applied on the MRI brain image which help for the comparative study among different types of filters.

Table 1: Comparative Result

Filters	Effects
KSL filtering	Noise removal in different types of MRI brain images like low SNR MRI, partially parallel MRI and so on
Median filtering	Remove the outlier without reducing the sharpness of the image. So performs better result in MRI brain for noise removal.
Wiener filter	Involves noise smoothing and inverse filtering.
Adaptive filter	Requires less computation time
Mean filter	Removing grain noise from an image

Proposed Methodology

The Modified Median Filter calculation is the point at which a chose window contains just 0 and 255 esteem then the reestablished esteem is either 0 or 255(again uproarious), drives us to proposed. In this calculation we chose pixel esteem 0 and 255 values then the preparing pixel is supplanted by mean estimation of the chose window. The detail of the calculation is given underneath.

Algorithm:

Step 1: Select a 3 x 3 matrix size according to the 2-D window size. Assume that the processing pixel is Pij, which lies at the

center of window.
Step 2: If 0 < Pij< 255, then the processing pixel or Pij is uncorrupted and left unchanged.
Step 3: On the off chance that Pij = 0 or Pij = 255, then it is considered as tainted pixel and four cases are conceivable as given underneath.
Case 1: In the event that the chose window has all the pixel esteem as 0, then Pij is supplanted by the Salt clamor (i.e. 255).
Case 2: On the off chance that the chose window contains all the pixel esteem as255, then Pij is supplanted by the pepper commotion (i.e. 0).

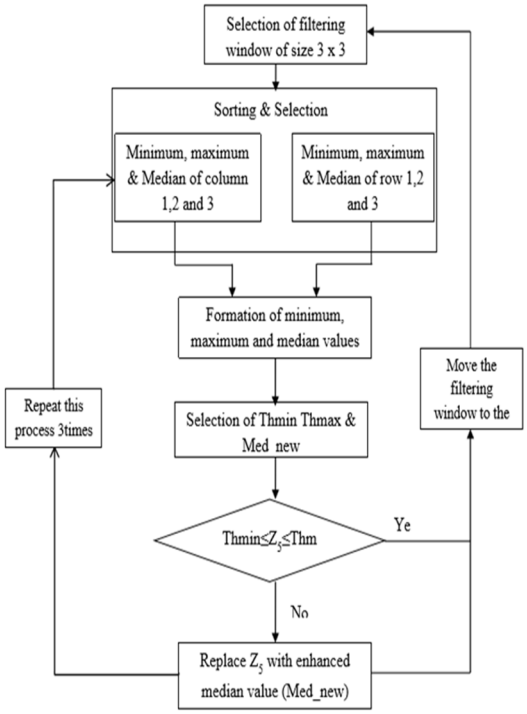

Figure 10: Flow Chart of Proposed Method

Case 3: In the event that the chose window contains all the esteem as 0 and 255 both. At that point the handling pixel is supplanted by mean estimation of the window.
Case 4: On the off chance that the chose window contains not all the component 0 and 255. At that point dispose of 0 and 255 and locate the middle estimation of the rest of the component. Supplant Pij with middle esteem.
Step 4: Rehash step 1 to 3 for the whole picture until the procedure is finished.

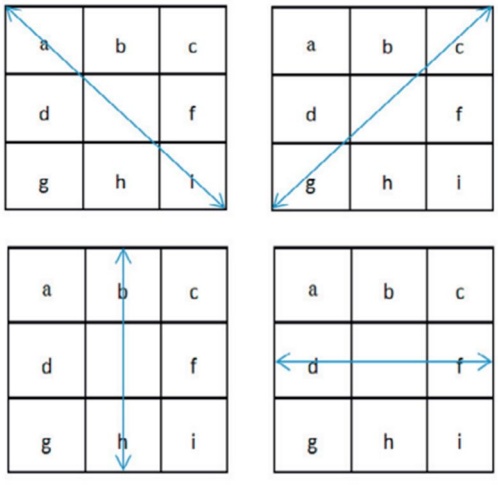

Figure 11: Read the Matrix

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 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).

Mean Square Error (MSE)

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

Peak Signal to Noise Ratio (PSNR) in dB

$$= 10 \times \log_{10} \left(\frac{255}{\text{MSE}} \right) \qquad (2)$$

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.

Rician noise image is also knows as Gaussian noise. Rician noise is statistical noise having a probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed.

$$P(Z) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(z-\mu)^2}{2\sigma^2}} \qquad (3)$$

Conclusion

The proposed filter has proved that it is very efficient for random valued impulse noise because practically noise is not uniform over the channel. In this dissertation is used concept of maximum and minimum threshold to detect both positive and negative noise. It produces improve PSNR (Peak Signal to Noise Ratio) and very small MSE (Mean Square Error) for highly corrupted images, especially for more than 50% noise density.

we present a simple and efficient technique to remove noise from the medical images which combines both median filtering and mean filtering to determine the pixel value in the noise less image. Experimental results show that our proposed method performs much better than the other filtering methods. The proposed method has been compared with smoothing, median, and midpoint filter using quantitative parameters like PSNR, SNR and RMSE. It has been found that the proposed method performs better than all other methods while still retaining the structural details. Although smoothing filter shows better result, it suffers from blurring effect. Because in the mean filtering techniques each pixel is considered for calculating the mean and also every pixel is replaced by that calculated mean. So affected pixels are considered for calculating the mean and unaffected pixels are also replaced by this calculated mean.

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