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Performance Comparison of Mean, Median and Wiener Filter in MRI Image De-noising

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***Abstract*—Image filtering algorithms are applied on images to remove the different types of noise that are either present in the image during capturing or injected into the image during transmission. This paper deals with Performance Comparison of Mean, Median and Wiener Filters in MRI Image de-noising for Gaussian noise, Salt & Pepper noise, and Speckle noise. The performance evaluation is done by using Peak Signal to Noise Ratio (PSNR)**

***Index Terms*— Gaussian noise, Salt & Pepper noise, Speckle noise, Mean filter, Median filter, Wiener Filter.**

I. Introduction

The Magnetic Resonance Imaging (MRI) is used to view the internal structures of the body in detail especially for imaging soft tissues and it does not use any radiations. Magnetic resonance imaging has wide uses in the diagnosis, characterization, and planning of treatment for brain tumors. There is no accurate measure for detection of tumor region due to the presence of noise in MRI image. Even small amount of noise can change the classification. So the noise is preprocessed using de-noising techniques. In order to significantly compare the performance of de-noising techniques, the filters are used to eliminate unrelated neighborhoods from the weighted average used to de-noise each image pixel. Most of the imaging techniques are degraded by noise so that the image is preprocessed using de-noising technique to extract the useful information. To analyze the medical image i.e. segmenting the brain tissues, initially the noise must be removed from the MRI image for retaining the original information. Noise in medical imaging is mainly caused by variation in the detector sensitivity, reduced object visibility (low contrast), chemical or photographic limitations and random fluctuations in radiation signal. Initially the MRI image is taken as an input data. The de-noising is performed using averaging filter, median filter and wiener filter. The performance of these de-noising techniques is measured using Peak Signal to Noise Ratio. Fig. 1 shows the overview of the proposed work.

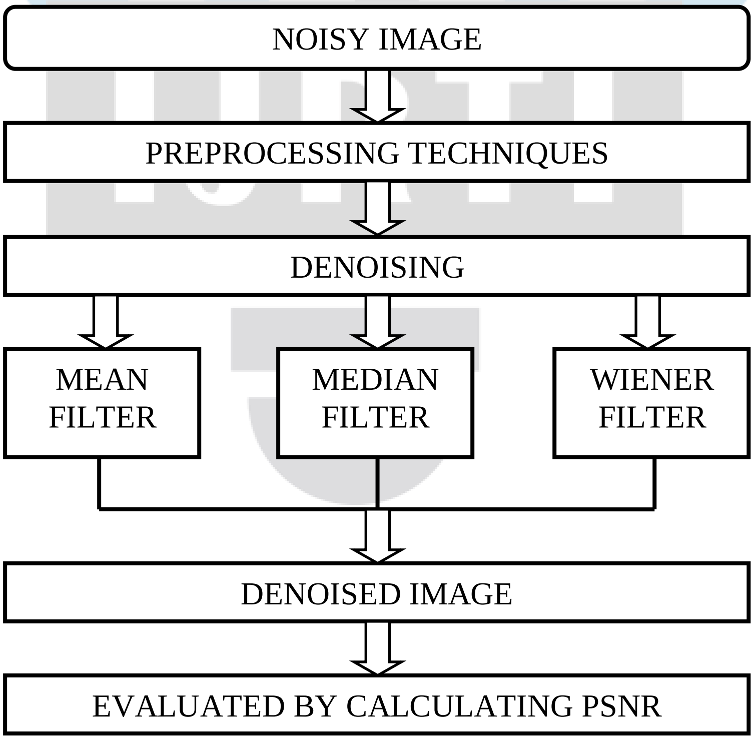

Fig. 1 Overview of the proposed technique

II. Mean filter

Mean filter or averaging filter is a simple linear filter and easy implementation method of smoothing images. Average filter is often used to reduce noise and also reduce the amount of intensity variation from one pixel to another. Here, first take an average that is sum of the elements and divide the sum by the number of elements. Next, replace each pixel in an image by the average of pixels in a square window surrounding this pixel.

III. Median filter

The Median Filter is performed by taking the magnitude of all of the vectors within a mask and sorted according to the magnitudes. The pixel with the median magnitude is then used to replace the pixel studied. The Simple Median Filter has an advantage over the Mean filter since median of the data is taken instead of the mean of an image. The pixel with the median magnitude is then used to replace the pixel studied. The median of a set is more robust with respect to the presence of noise. The median filter is given by

$$Median\ filter(x1 \dots x_N) = Median(\|X_1\|^2 \dots \dots \|X_N\|^2)$$

IV. Wiener filter

The goal of the Wiener filter is to filter out noise that has corrupted a signal. It is based on a statistical approach. Typical filters are designed for a desired frequency response. The Wiener filter approaches filtering from a different angle. One is assumed to have knowledge of the spectral properties of the original signal and the noise, and one seeks the LTI filter whose output would come as close to the original signal as possible [1]. Wiener filters are characterized by the following:

a. Assumption: signal and (additive) noise are stationary linear random processes with known spectral characteristics.

b. Requirement: the filter must be physically realizable, i.e. causal (this requirement can be dropped, resulting in a non-causal solution).

c. Performance criteria: minimum mean-square error.

The Wiener filter is:

$$G(u,v) = \frac{H^*(u,v)P_s(u,v)}{|H(u,v)|^2 P_s(u,v) + P_n(u,v)}$$

Dividing through by **Ps** makes its behavior easier to explain:

$$G(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 + P_n(u,v)/P_s(u,v)}$$

Where,
H(u, v) = Degradation function
H*(u, v) = Complex conjugate of degradation function
Pn (u, v) = Power Spectral Density of Noise
Ps (u, v) = Power Spectral Density of un-degraded image
The term **Pn /Ps** can be interpreted as the reciprocal of the signal-to-noise ratio.

V. Image noise

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector [4]. Image noise is generally regarded as an undesirable by-product of image capture. Although these unwanted fluctuations became known as "noise" by analogy with unwanted sound they are inaudible and actually beneficial in some applications, such as dithering. The types of Noise are following:-

- Amplifier noise (Gaussian noise)
- Salt-and-pepper noise
- Speckle noise

Amplifier noise (Gaussian noise)

The standard model of amplifier noise is additive, Gaussian, independent at each pixel and independent of the signal intensity. In color cameras where more amplification is used in the blue color channel than in the green or red channel, there can be more noise in the blue channel .Amplifier noise is a major part of the "read noise" of an image sensor, that is, of the constant noise level in dark areas of the image [4].

Salt and pepper noise

An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions [4]. This type of noise can be caused by dead pixels, analog-to-digital converter errors, bit errors in transmission, etc. This can be eliminated in large part by using dark frame subtraction and by interpolating around dark/bright pixels.

Speckle noise

Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. Speckle noise in conventional radar results from random fluctuations in the return signal from an object that is no bigger than a single image-processing element. It increases the mean grey level of a local area. Speckle noise is caused by signals from elementary scatterers, the gravity-capillary ripples, and manifests as a pedestal image, beneath the image of the sea waves. One method, for example, employs multiple-look processing [6].

VI. SIMULATION RESULTS

The Original Image is MRI image and it is added by three types of Noise (Gaussian noise, Speckle noise and Salt & Pepper noise) as shown in fig. 2. De-noising is performed using Mean filter, Median filter and Wiener filter. Fig 3, 4, 5 shows the de-noising for Mean, Median and Wiener filters and Fig. 6, Fig 7, Fig. 8 shows performance of the de-noised image.

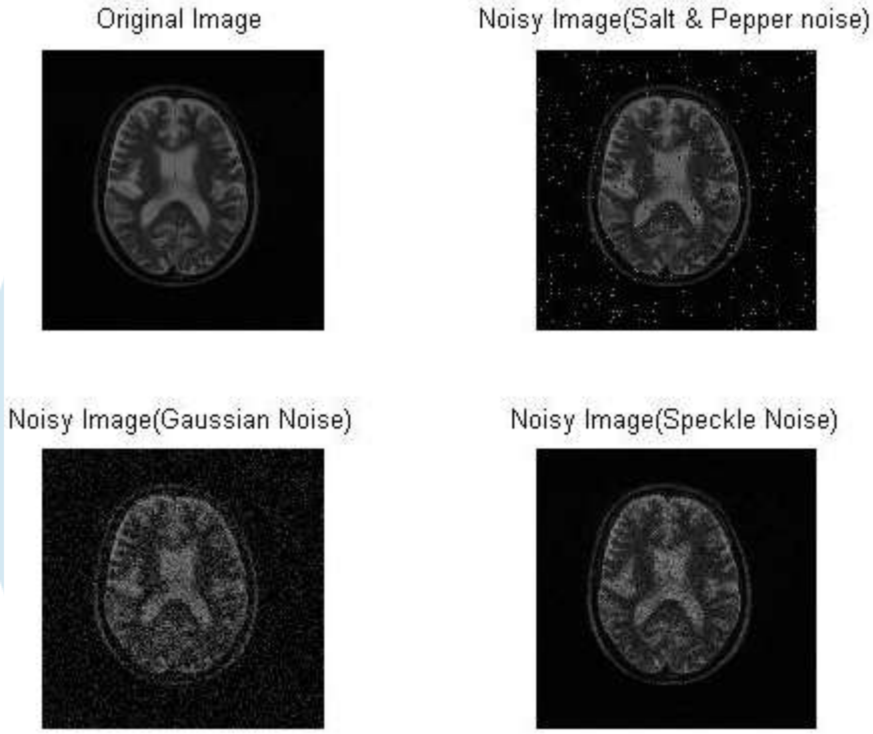

Fig. 2 Original image added with Salt & Pepper, Gaussian and Speckle noise

Fig. 3 De-noising using Mean filter

Fig 4 De-noising using Median filter

Fig. 5 De-noising using Wiener filter

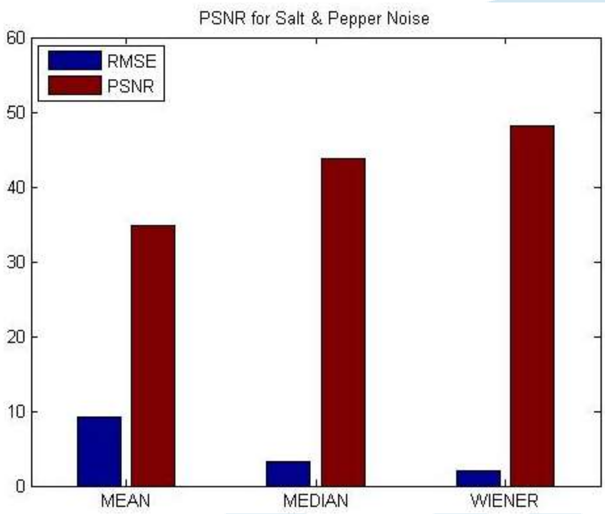

Fig. 6 PSNR Values for Salt & Pepper noise

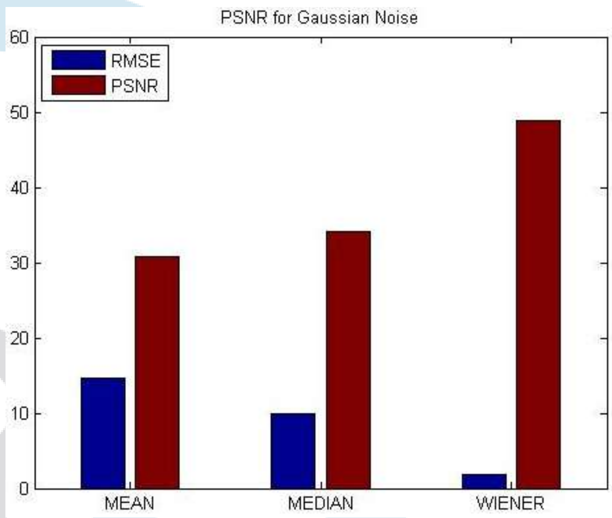

Fig. 7 PSNR Values for Gaussian noise

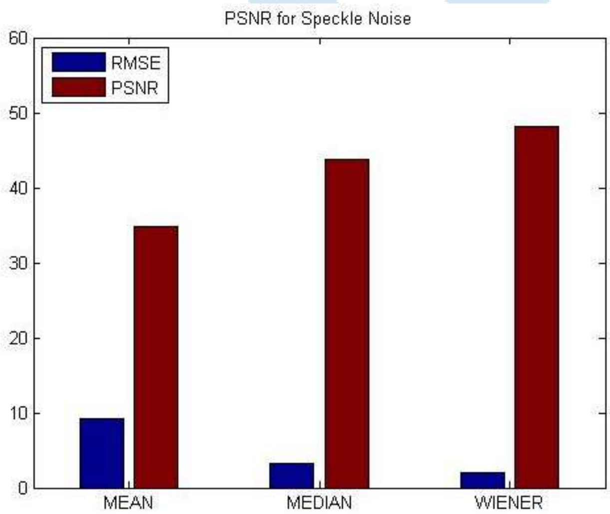

Fig. 8 PSNR Values for Speckle noise

VII. Conclusion

We used the MRI Image (figure 1) in “dcm” format, adding three noise (Speckle, Gaussian and Salt & Pepper) with standard deviation (0.025). In these image (Fig 2 to Fig 4), De-noised all noisy images by all three filters and conclude from the results (Fig 5 to Fig. 8) that:

(a)The performance of the Wiener Filter after de-noising for Speckle and Gaussian noisy image is better than Mean filter and Median filter.

(b)The performance of the Median filter after de-noising for Salt & Pepper noisy image is better than Mean filter and Wiener filter.

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