A Virtual Analysis on Effective Speckle Noise Removal Techniques in Medical Images by Various Filtering Methods

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Abstract:
Acquiring a cost effective and efficient method of removing speckle noise from the images is an extraordinary questioning for the researchers and Scientists. Change of magnitude of speckle noise is the most essential processes to improve the quality of consistent and coherent images. Speckle Noise is a farinaceous noise that integrally exists in and aggrades the quality of the progressive in Medical Images. In Medical image processing, image de-noising is essential work all through make a diagnosis. Intercession between the upholding of useful diagnostic knowledge and noise repression must be cherished in medical related images. In Ultrasound medical images, the noise can pin down information which is expensive for the medical practitioner. At the same time medical images are very contradictory, and it is decisive to operate from initial state to Final state. These Medical images may be multi - dimensional representations of the object. Here the Speckle noise is to be removed for the fine quality of an image objects. Noise can aggrade the image at the time of acquiring or transmittance of an image. Before applying image processing techniques to an image, Speckle noise removal from the images is to be done. Wide and Wise algorithms are available and accessible, but they have their own postulates, virtues and disadvantages. Filtering is one of the communal methods which is used to cut down the speckle noises. Here a beam of light is thrown on speckle noise and an analysis is carried forward for the removal of speckle noise . Also Multi-Speckle noise reduction filters are considered on the conditional Images such as real or artificial Images for this analysis. This research paper projects the effects of different applied noise image models and de-noising the selected image noise with the help of different filter models and studies the results of applying various Speckle noise reduction techniques with the help of Images and Diagrams.

Keywords: *Speckle noise, Medical Images, Medical imaging, De-noising*

I. Introduction

In the previous decades, numerous non-invasive original imaging techniques have been discovered such as, SPECT, CT scan, spectroscopy, ultrasound, magnetic resonance imaging (MRI), digital radiography, and others. The above mentioned techniques have revolutionized diagnostic investigative radiology, provided that the clinician with innovative information about the internal of the human body that is not available before. Among those medical imaging techniques, we are fascinated on the ultrasound medical imaging which is a accepted and admitted non invasive and minimum cost process to observe the behavior of human organs. This process utilizes ultrasonic waves which are created from the transducer and pass through through bodily tissues. The return sound wave vibrates the transducer which converts into electrical pulses that pass through to the ultrasonic scanner which they are processed and changed into a digital image [1]. The resolution of the provided image will be best by using advanced frequencies but this limits the intensity of the penetration. However, the observance of noise is looming due to the loss of suitable contact or air slit between the transducer investigation and body [2]. Speckle noise is a certain type of noise that degrades the fine information and edges characterization and confines the contrast resolution by assembling it more difficult to investigate low and small contrast lesion in human body. The confront is to invent methods which can particularly minimise noise without varying edges and losing significant features. More methods have been projected to eliminate speckle noise including temporal averaging homomorphic Wiener filtering [18]. Temporal averaging [3], median filtering[4], adaptive speckle reduction [5] and wavelet Thresholding [6]. Adaptive filters [7][8][9] have the more advantage that they take into account that the local arithmetical properties of the image in which speckle noise can be more reduced but small information tends to be vanished. In the past few years, the use of non-linear PDEs models linking anisotropic diffusion has notably grown and becomes an significant tool in contemporary medical image processing. The key idea behind the anisotropic diffusion is to integrate an adaptative and smoothness control in the de-noising image process. That is, the smooth is expected in a homogeneous section and depress across borders, in order to protect the discontinuities of the medical image. One of the most victorious tools for image de-noising is the Total Variation (TV) Process proposed by Rudin and al [10] [11][12] and the anisotropic smoothing model projected by Perona and Malik [13], which has been extended and enhanced upon [14][15]. Over the years, other very motivating de-noising methods have been emerged such as: Bilateral filter and its derivatives [16]. In our work, we address ultrasound images de-noising by using nonlinear diffusion tensor derived from the structure tensors which have proven their efficiency in several areas such as: Motion laboratory analysis, texture segmentation, and angle detection. The structure tensor gives a more prevailing explanation of restricted patterns images better than a undemanding gradient. Based on its eigen -values and the corresponding eigen vectors, the tensor categorizes the principal directions of the gradient in a selected neighbourhood of a selected point, and the point to which those directions are consistent.

2. Assorted varieties of Noise

Noise is initiated in the image at the clip of image representation of transmission. Different elements may be answerable for launching of noise in the image pattern. The number of image pixels corrupted in the image pattern will determine the measurement of the noise. The main sources of image noise in the digital image representation are that the imaging representational process sensor might be impressed by environmental states during image learning acquisition, due to insufficient light coloured beam luminious levels and sensing element temperature might produce the noise in the image, intervention of light transmission impression might also damage the image and dust particles any appears on the scanner projection screen might also produce noise in the image pattern. Noise is the unwanted effects initialized in the projected image pattern. During image learning acquisition, various elements are answerable for producing noise in image pattern. Based on the type of activity of disturbance, the noise can spoil the image to various extent. Mostly our concentration is to take away the definite type of noise. So we determine the kind of image noise and employ algorithms to reject the image noise level. Image noise can be categorized as Impulse noise which can be also termed as Salt-and-pepper noise, Amplifier noise or Gaussian noise, Shot attemptable noise, Quantization noise or homogeneous noise, Film grain motion picture noise , on-isotropic image noise, Periodic noise and Multiplicative noise which is mainly considered noise called as Speckle noise taken for our analysis purpose.

3. Speckle Noise

This type of noise can be modeled by random assessment of multiplicative with pixel standards of the image and can be expressed as

$$\mathbf{SP_n = I + U_n * I}\ SP_n$$

is the speckle noise statistical distribution image

I is the input noise image

U_n is the uniform noise image by mean M and variance V.

This noise degenerates the attribute of operational medical images. This noise is developed because of consistent processing of back-scattered signals from multiple apportioned points. This kind of noise is detected when the returned communicative signal from the physical object having the size lower than or equal to a individual image processing portion, displays sudden variations. Mean filters are better for Gaussian noise and uniform noise $U_{n.}$ The below mentioned image shows the affected with speckle noise

Speckle noise is a farinaceous noise that integrally exists in and degrades the quality of the progressive medical images . Images are damaged by speckle image noise that impacts all consistent imaging systems. Inside each resolution cell a multi number of primary scatters indicate the parenthetical waves. Due to the back-scattering techniques of of consistent and coherent motions at various phases , outcomes in creative or devastating interference of wave in a unselected mode. The acquired image is damaged by a granular design pattern that postpones the interpretation of the noise image data and decreases the noise features of interest.

4. Speckle Noise in different Forms of Images

Ultrasound Images

Ultrasound imaging instrumentation is used as characteristic tool[6] for modern medical image diagnosis. It is utilized for the visualization of muscles, Internal human body structure and the area has been affected. Obstetric sonography is utilized during pregnancy analysis. In an ultrasound image speckle noise displays its existence while proceeding the visualization process. An built-in distinctive of ultrasound imaging is the existence of speckle noise. Speckle noise is a unselected and deterministic in an represented image. Speckle noise has negative effect on ultrasound imaging, Revolutionary change of magnitude in contrast resolution may be accountable for the poor impressive resolution of ultrasound image as compared to MRI. In case of medical image diagnosis, speckle noise is also known as tactile property. Generalized model of the speckle noise is depicted as,

$$Ob_{image}(x,y) = C(x,y)*M(x,y) + A(x,y)$$

$Ob_{image}(x,y)$ is Observed Image

C(x,y) is Constant Term

M(x,y) is Multiplicative Component

A(x,y) is Additive Component of Speckle noise

x,y represents the axial and lateral indices of the denoted image .

For the ultrasound image process, only multiplicative component of the noise is to be considered and preservative element of the noise is to be ignored. Hence, above equation can be updated as

$$Ob_{image}(x,y) = C(x,y)*M(x,y) + A(x,y) - A(x,y)$$

i.e. $Ob_{image}(x,y) = C(x,y)*M(x,y)$

Medical Images

Speckle noise in systematic process is to be referred as the deviation between a valid measurement and the genuine mean value. aggraded image with image speckle noise in ultrasound image is represented by the equation

$$D(a,b) = O_{image}(a,b)*SN(a,b)$$

D(a,b) is the aggraded image

$O_{image}(a,b)$ is Original Image

SN(a,b) is the Speckle Noise

a,b denotes the Pixel allocation

Image processing is fundamentally and essentially the use of algorithms to execute physical image processing on digital designs or images. Image processing has multi important benefits over analog image processing. Image processing permits a wider range of algorithms to be applied to the input image data and can avoid issues such as the constructive noise and image distortion noise during process of taken images. Wavelet transforms have turned a very powerful tool for de-noising an image. One of the most favorite methods is wiener filter. In this process Speckle noise is used and image de-noising performed by Mean filter, Median filter and Wiener filter .Further statistical analysis have been compared for all noises. In various applications, it might be necessary to examine a given impressive signal. The structure and features of the given signal might be better understood by transforming the collection of information into another domain. There are various transforms available like the Hilbert transform and Fourier transform, wavelet transform, etc. The Fourier transform is credibly the most favorite transform. Nevertheless the Fourier transform yields only the frequency amplitude dictation of the raw image signal. The detailed time information is much lost. So we cannot proceed with the Fourier transform in various applications which involves both time as well as detailed frequency information at the very same time. The advanced Short Time Fourier Transform (ASTFT) was formulated to overcome this disadvantage.

5. Speckle Noise Filtering

In speckle based filtering a kernel is stimulated over every pixel in the image and applying a quantity of mathematical computation by means of these pixel standards below the kernel and replaced the middle pixel with designed or computed value. This kernel is stimulated down the image with only one pixel at a instance until the whole image is covered. By applying these designed filters smoothing result is achieved and speckle noise has been minimized to certain point [21].

5.1 Median filter [23]: The most excellent notorious ordered based statistics filter is the median factored filter in image technical processing. The median filter is the most simpler practice and it also eradicates the speckle noise from an given image and also reduces pulse or spike noise[22]-[23].

5.2 Lee filter [24]: The lee filter is utilized for speckle noise minimization. The lee filter is based on the hypothesis that the mean and variance of the pixel of the concern is equal to the local mean and variance of all pixels within the evolving kernel[24]

5.3 Kaun filter [25]: In this filter the multiplicative noise model is first altered into a signal reliant preservative noise model. Then they said MMSE standard was modified to this model.[25]

5.4 The SRAD filter [26]: SRAD filter is acknowledged as speckle minimizing anisotropic dissemination. The SRAD can eradicate speckle exclsively distorting useful image details and without damaging the important image edges. The SRAD PDE exploits the immediate coefficient of dissimilarity in minimizing the speckle noise. The output received are given below to mention that the SRAD set of rules provides greater performance in assessment to the predictable techniques like frost, lee, kaun filters in terms of preserving and smoothing the edges and salient features.

5.5 Wiener filtering [22]-[23]: Wiener filter was proposed by the year of 1942, after N.Wiener. Wiener filter (a type of linear filter) is functional to an image *adaptively*, tailoring itself to the confined image variance. If the variance is too large, then Wiener filter develops little smoothing. If the variance is too small, Wiener develops additional smoothing. This approach comes forward to produces good results than linear type of filtering. This adaptive filter technique is more discriminatory than a analogous linear filter, preserving all edges and other high-frequency organs of an provided image. Nevertheless, wiener filter technique requires more computational time than linear filtering models.

6. Arithmetic Model of Speckle Noise

Arithmetically the image noise can be shown with the help of these equations as shown below

$$V(x, y) = g[u(x, y)] + ŋ(x, y)$$

$$g[u(x,y)]= \iint h(x, y; x', y')u'(x', y')dx'dy'$$

$$Ŋ(x, y)=f\ [g(u(x, y))]\ ŋ1(x,y) + ŋ2(x, y)$$

Here u(x, y) denotes the objects (means the original innovative image) and v(x, y) is the experimental image. Here h (x, y; x', y') denotes the inclination response of the image acquiring process. The term ŋ(x, y) represents the additive noise has an image reliant indiscriminate components f [g(w)]ŋ1 and an image self-regulating random component ŋ2. A different type of noise in the rational imaging of objects is called speckle noise. Finally Speckle noise can be developed as

$$V(x, y) = u(x, y)\ s(x, y) + ŋ(x, y)$$

Also the speckle noise concentration is given by s(x, y) and ŋ(x, y) is a white Gaussian noise [17]-[18]. The main objective of image-de-noising techniques is to eliminate such noises while retaining as much as possible the important signal appearances. One of its main short-comings is the reduced quality of images, which are exaggerated by speckle noise. The continuation of speckle is unpleasant since it disgraces image quality and affects the work of individual elucidation and diagnosis finding. An suitable method for speckle diminution is one which enhances the signal-to-noise ratio conserving the lines and edges in the image. Weiner filter was introduced for filtering in the spectral domain, but the minute classical Wiener filter is not enough as it is designed first and foremost for additive noise repression. In recent times there have been many challenges to decrease the speckle image noise using wavelet transformation as a poly-resolution image-processing technical realization. Speckle noise is a high-frequency element of the image and reflects in defined wavelet coefficients. One universal method exploited for speckle reduction is wavelet reduction [19].

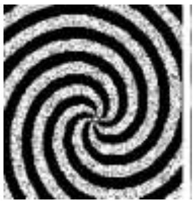
Wavelets transforms are essentially possible scientific functions[4] which break up the information data into different frequency factors, and then we study each element with a resolution compatible to its scale. Wavelets have some benefits over conventional Fourier methods in examining physical conditions where the image includes separations, sharp spikes and discontinuities. Wavelets transforms are the best proficiency technique to manage the different variety of image noises which is available in an depicted image. There are different wavelet transform colonies that show multi results when images are applied in image processing. The wavelets statistical analysis is applied in the image de-noising technique because of its much more multi-resolution and internal locality property.

7. Image De-Noising

Image de-noising[12] is an critical image processing process itself as well as a component in other processes. There are many different ways to de-noise an defined medical image[5] . The essential property of an image de-noising model is that it must entirely take away noise to preserve edges. Conventionally, there are two forms of models i.e. first linear model and secondly non-liner model. Broadly, linear models are utilized. The public presentation of linear noise removal technique [9] is the fastness and the disadvantage of the linear models is that the linear models are not capable to preserve finite edges of the images in a cost-efficient manner. Non-linear models can manage edges in a better way than firstly mentioned linear models. The nonlinear models related image can be denoised with the help of selective filters. Here we can have a study on different filters such as Mean Filter, Median Filter, and Wiener Filter.

8. Output Result

The test is conducted for the proposed algorithm with a given image having many tilting curves sized 256x256 pixels figure (i). A speckle noise with variance $\sigma * \sigma$ is added to the original image to obtain a noisy version Figure (ii). The model's parameters are fixed to Nb iter =10 ,C= 0.6 $\sigma = 1.3$,$\rho = 5.6$ Compared to the other methods, the restored image in figure (viii) shows a fine quality enhancement with a appreciably improved edges and a good repression of noise. The dissemination tolerably follows the track of curving lines.

(i) Original image (ii) Degraded image


(iii) Lee method (iv) Median filter


(v) Total Variation (vi) Kaun Method


(vii) Frost Method (viii) Proposed model

To calculate the quality of image, we utilize two measures that peak signal-to-noise-ratio (PSNR) and the mean structural similarity (MSSIM) index [20] which compares the arrangement of two images after subtracting luminance and normalizing variance. The PSNR is defined by:

$$PSNR = 10 \log_{10} N_{maximum}/MSE$$

where $N_{maximum}$ is the maximum variation in the input image

$N_{maximum} = (2^n-1)$, $N_{maximum} = 255$, when the components of a pixel are encoded on 8 bits; MSE denotes the mean square error, mentioned as below

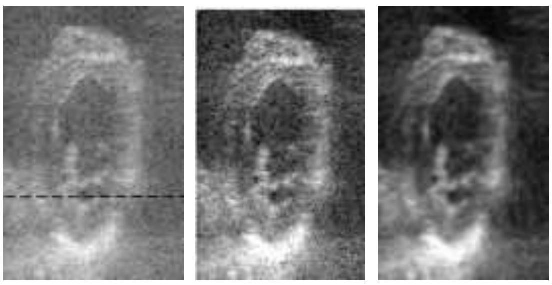
$$MSE = 1/MN \, \Sigma^{N}_{i=1} \Sigma^{M}_{i=1} |(f(i,j) - F(i,j)|^{2}$$

where f(i,j) is the original image and F(i,j) is restored image

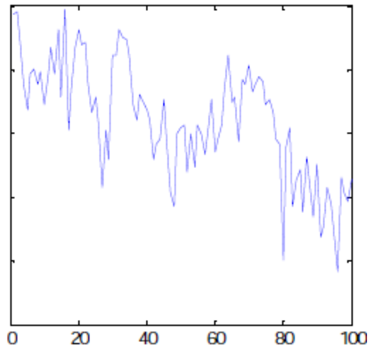
Table of Comparison

Model	PSNR	MSE	MSSIM
Lee	16	0.032	0.80
Median	13.65	0.044	0.72
Total Variation	14.05	0.040	0.74
SRAD	14.07	0.041	0.75
Kaun	13.55	0.047	0.76
Wavelet Based	13.57	0.049	0.78
Weiner	14.70	0.048	0.79
Frost	14.60	0.049	0.77
Proposed	17.20	0.026	0.84

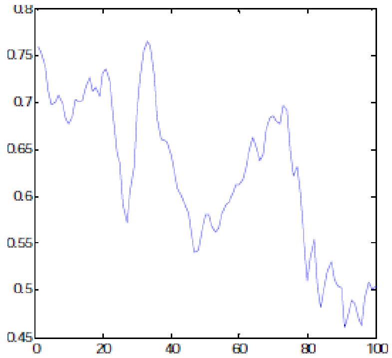
We note that the MSSIM approximates the supposed image quality of an image is better than PSNR. It takes standard values in [0,1] and increases as the quality of the image increases. Table represents the efficiency of our model with the uppermost score of MSSIM. In the another analysis, we apply the proposed set of rules on a real cardiac ultrasound medical image from a medical database sized 150x100 pixels . The Models parameters are fixed to Nb itr = 10 , c= 1.4, $\sigma = 1.3$,$\rho = 5.6$. This image of medical appears worst value, minimized resolution and very much noisy as shown in below figures . It can be noted that the restored illustration of image as shown in figure shows a noteworthy development with a best encircled cardiac void . Discontinuities and Edges have been well improved and conserved.



(a)Original (b) Adjusted (c) Restored



(a) Original Image



(b) Restored Image

9. Conclusion

The continuation of speckle noise in the Medical image is disagreeable since it discredit the image quality by distressing image edges and confined details between assorted parts which are the most much fascinating part for image diagnosis. In this research paper, we have projected a de-noising approach that combines homomorphism conversion and dissemination tensors. The design is to permit dissemination along the direction of greatest consistency beneath circumstance of additive preservative noise. Nevertheless, the usefulness of the planned approach intends on the option of the dissemination mass functions that organize the dissemination along the direction of finest consistency. The investigational analysis on a authentic Medical images are very much capable in terms of dropping speckle noise on preserving the manifestation of prepared regions and entire surface. This will be very much mutual to support radiologist in their expedition and investigation. Future works will be carried forward with real time speckle reduction on multi-dimensional medical images for the purpose of de-noising for the best output.

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