# A SURVEY ON SPECKLE NOISE SUPPRESSION TECHNIQUES FOR MEDICAL IMAGES

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## *Abstract*

*The treatment of patients is heavily dependent on diagnosis of diseases. Most of digital diagnosis used these days affected with some kind of noises. Most commonly used medical images are Ultrasound images, Magnetic Resonance Imaging, Computed Tomography, X-ray and Ultrasound images. These images are often affected with different types of noises such as random noise, speckle noise, Gaussian noise, uniform noise, impulse noise/salt and pepper noise. The noise can be defined as unwanted information in image which degrades the quality of the image. The speckle noise is one of the most frequently noise available in ultrasound images. The speckle noise hinders the medical image diagnosis procedure. It is multiplicative in nature and produces granular pattern formation. Due to speckle noise, image becomes blurry from edges. The contrast deterioration, blurring of edges, dilution of fine details are problems raised due to presence of speckle in the ultrasound images. It is a hard job to remove speckle noise as it itself is intermixed with important information of the image. The speckle noise needs to be suppressed in order to enhance the visual quality of medical images.*

*The objective of present study is to analyze different techniques and methods used in the past to remove speckle noise from medical images. The several methods and techniques have been found in literature which addresses the problems of speckle noise in the ultrasound images. Every method has its own strength and weakness but these methods are subjective in nature.*

**Keywords:** *Speckle noise, Arithmetic mean filter, Geometric mean filter, Harmonic mean filter, Median filter, Salt and pepper noise.*

## Introduction

Ultrasonography is a medical diagnosis technique widely used in medical science. As compared to computed tomography (CT) or magnetic resonance imaging (MRI), it is a harmless technique as it is non invasive, portable, inexpensive, safer and versatile (Gupta Nidhi et al. 2015). It is used to measure abnormality in the size, shape and appearance of soft tissues and organs like kidney, heart, liver and brain. But the presence of various noises in the ultrasound images makes the diagnosis process complicated and tedious especially when the stone size is marginally small. The speckle noise is the most prominent noise which not only degrades the visual quality but also intermixed with the small objects in the image (Saini Kalpana et al.2010).

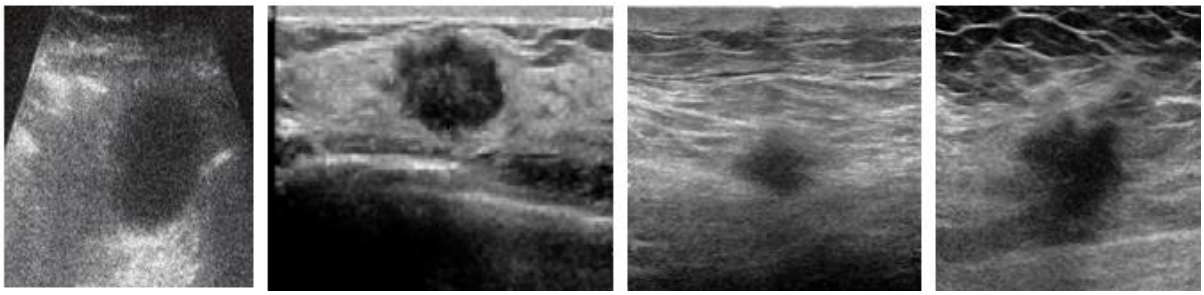

Figure: Sample images of ultrasound

*Source: onlinemedicalimages.com*

The speckle noise disorders the edges and fine details of the image which degrades the contrast resolution. Due to it, image becomes blurry from edges. It is a hard job to remove speckle noise as it itself is intermixed with important information of the image.

## LITERATURE REVIEW

Several methods and techniques have been found in literature which addresses the problems of speckle noise in the ultrasound images. All these methods are specific to the problem under taken. This means method suitable for one type of medical image may not be suitable for other type of medical image. For an instance method suitable for MRI images may not suitable for ultrasound images. The various studies related to denoising, segmentation, feature extraction and classification have been discussed below:

In 2003, **Shi Hairong et al. [21]** have implemented wiener filter, anisotropic diffusion filter, k-distribution based adaptive filter and wavelet filter on ultrasound images to remove speckle noise. The Wiener filter improved the image qualities. The Anisotropic diffusion used to suppress speckle noise based on some parameters. One more filter was used which was k-distribution based adaptive filter. Many other filters were also studied and compared with these filters.

In 2004**, Chinrungrueng Chedsada et al. [4]** developed a noise suppression filter named as Anisotropic Savitzky - Golay filter. It was the two dimensional weighted filter which enhanced methods for managing both the direction and degree of the smoothing. It reduced the speckle noise more effectively as compared to the adaptive speckle filter and adaptive weighted median filter. The filter was used for real-time speckle reduction and coherence enhancement of ultrasound images.

**In 2006, Liu Haihua et al. [14]** have proposed the fuzzy clustering technique for the segmentation of ultrasound images. The proposed method was divided into two parts. The first part was local contrast enhancement and second part was segmentation. An alternative fuzzy c-mean algorithm was used to segment the ultrasound images. The features emphasized the basic requirement of local contrast enhancement and suppressed the speckle noise.

**In 2006, Tsao Jenho et al. [23]** have introduced an algorithm for detection and identification of renal stone in ultrasound images. The image features such as target shape and contrast were used for stone detection and identification. These features of ultrasound kidney images for renal stone detection and identification were studied based on statistical characteristics.

In 2007, Yu Jin-Hua et al. [29] have proposed a segmentation method based on fuzzy logic. It simultaneously reduced the speckle noise as well as compensated the intensity in

homogeneities. A two dimensional fuzzy C-means algorithm with spatial constraints was developed. The results were compared with gradient vector field (GVF).

**In 2009, Coupe Pierrick et al.** [5] have proposed a modified Bayesian Nonlocal Means filter to suppress the speckle noise from ultrasound images. The synthetic images as well as clinical ultrasound images were used to carry out the study. In the experiments, quantitative measurements were used to compare with various well established methods. The filter preserved the edges and structural details of the image accurately as compared to the other methods. In the similar study, Zhu **In 2009 Zhu Changming et al. [30]** developed a technique used in image segmentation and compare with previously existing techniques. The bibliographic survey elaborated various merits and demeris of the segmentation methods.

**In 2011, Abrahim Banazier A. et al. [3]** have proposed non local means filter. The filter was implemented on real ultrasound images for suppression of speckle nosie. With the help of evaluation metrics such as visual results and image quality, the study concluded that the non local means filter worked better than another filters. The method also preserved the edges, textures and structural details while removing the speckle noise from ultrasound images.

**In 2013, Rahman Tanzila et al.** [19] have developed a method which segment kidney regions from the ultrasound images. Two segmentation techniques i.e. cell segmentation and region based segmentation were used to segment the human kidney from ultrasound images. The region based segmentation was used to extract kidney regions from the ultrasound images. The method removed the speckle noise from image and also enhanced the image quality. After restoration phase the speckle noise was removed with Gabor filter to smooth the images. The histogram equalization was also used to enhance the image quality. In the same year, **Suganya R et al. [22]** have compared the twelve features with the selected features from GLCM to classify liver based on texture. Three models were included preprocessing, feature analysis and classification modules. Image was processed by anistropic diffuse speckle reduction method. The results obtained with five features i.e. contrast, auto correlation, angula second momentum, cluster shade and cluster prominence were better than the feature extraction by other methods.

**In 2013 Wilson Beshiba et al. [27]** studied a various filtering techniques and compare results for speckle noise reduction from ultrasound images. The results of many filtering techniques were compared with statistical parameters, whereas Non local (NL) means filter removed the speckle noise without degrading its resolution and enhanced the edge information of ultrasound image.

**In 2014, Gupta Rishu et al. [7]** attempted to suppress speckle noise from musculoskeletal images using anistropic diffusion and non local (NL) means methods. The measurement parameters were MSE and PSNR used for quantitative analysis. For qualitative analysis, visual inspection was also carried out. It was concluded that the non local means method was superior both qualitatively and quantitatively and yielded better results for despeckling of ultrasound images. In the same year, Gupta **Gupta Sheifali et al. [8]** provided a review of different techniques of removing speckle noise from ultrasound images. Author explained the wavelet based techniques to denoise and enhance the image quality of ultrasound images. Region based processing and discrete wavelet transform (DWT) technique was used to remove speckle noise for providing better noise rejection in ultrasound images. **Hajare Vikas**

**D et al. [9]** have presented the various techniques of speckle noise reduction from ultrasound images to detect the chronic kidney diseases. Median filter, Ideal filter and Butterworth filter were used to remove speckle noise. Ideal filter was much simpler than any other filter because it took only one parameter Median filter with window size (4x4) provided better results than other filters. Butterworth filter takes order of filter and cutoff frequency as two parameters. **Jaiswal Ayushi et al. [10]** have developed linear and non linear filtering algorithms. Linear filtering was used to remove the additive noise. Non linear filtering was used to remove the speckle noise. This new approach solved the purpose by filtering and wavelet thresholding methods. The proposed method preserved the edge details during denoising process. The standard measurement parameters such as (PSNR) Peak signal to noise ratio and MSE (Mean Square Error) was used to evaluate the performance. **Park Jihoon et al. [16]** have used speckle reduction spatial compounding technique with laplacian pyramid-based nonlinear diffusion for speckle noise reduction in ultrasound images. In this method, the sub images were acquired at different beam orientations at the expense of temporal resolution. These techniques were clubbed together to reduce the speckle noise. The study concluded with a comparison of three well known techniques: speckle reduction frequency compounding, speckle reduction spatial compounding, and post filtering and also compare their own strengths and weaknesses. **Viswanath et al. [26]** has explained the preprocessing method to remove speckle noise from ultrasound images. In preprocessing, speckle noise was reduced with image restoration. Then denoised image was smoothening with the Gabor filter. The histogram equalization enhanced the image. Level set segmentation method was used to segment the preprocessed ultrasound image.

**In 2015, Gupta Nidhi et al. [6]** have compared ten filters that are Lee, Frost, Median, SRAD, PMAD, SRBF, Bilateral, Adaptive Bilateral and Multiresolution. The parameter peak signal to noise ratio (PSNR) was used to measure the performance of mentioned ten filters. The comparison concluded that the multi resolution filter provide better results as compared to other mentioned filter. In the same year, **Khusna Dina Arifatul et al. [13]** have studied the performance of various speckle noise reduction filters such as Adaptive median filter, Frost's filter, detailed preserved anisotropic diffusion filter and Wiener filter. These filters were evaluated on the basis of PSNR, MSE, Average Difference, Mean, and Variance as second order texture operator to analyze their ability to preserve the edges and fine details of ultrasound images. **Mitra Pabitra et al. [15]** introduced a methodology for speckle noise reduction of intravascular ultrasound (IVUS). The quality of IVUS image was improved by applying Non local (NL) means filter in wavelet domain to smooth out the speckle noise. The efficiency of this methodology was evaluated by peak signal to noise ratio (PSNR) and Mean squared error (MSE). **Rekha Ch Kranthi et al. [20]** have discussed various speckle noise removal researches based on ultrasound images. Various parameters such as Signal to Noise Ratio (SNR), efficiency etc. were discussed to find out which method was best in removing speckle noise from ultrasound images. Authors also proposed an approach to reduce speckle noise from ultrasound images.

**In 2016, Kang Jinbum et al. [11]** have proposed a feature-enhanced speckle reduction method for ultrasound B-mode imaging. Five speckle reduction methods were used to develop the reconstructed B-mode images. This method was based on multi-scale analysis and feature enhancement filtering to improve ultrasound B-mode imaging. The proposed

method showed improvements in edge preservation, speckle signal to noise ratio, contrast to noise ration and mean structure similarity. **Porwal Shrusti et al. [17]** have compared the different filtering techniques such as Hybrid wiener- H filtering technique, LSH- frequency domain filtering technique and Advance Mexican hat linear spatial filtering technique. These techniques were used to remove the speckle noise from ultrasound images and enhanced the image quality. Standard measures like PSNR (Peak signal to noise ratio) and RSME (Root mean square error) were used to compare the different filtering techniques. Advance Mexican hat linear spatial filtering technique gave better results as compared to Hybrid wiener- H filtering technique and LSH- frequency domain filtering technique. **Vinoth R et al. [25]** have introduced the enhanced medical decision support system which helped the medical practitioners for decision making. The quality of image was improved by removing speckle, salt and pepper noise. These noises were removed by using fuzzy c-means filter and the Gray Level co-occurrence Matrix (GLCM).

## CONCLUSION

It has been observed from the literature review that there are various methods available in literature that shows performance of demonising methods are subjective in nature to the problem in hand. A few studies in literature reviewed regarding kidney stone detection methods. It is also noted that over suppression of noise results loss of information such as edges, deformation of small objects. On the other hand under suppression itself degrade the quality of the image. Moreover, noise suppression is adaptive in nature which means that suppression required to get desired results for particular objective may differ to address for other objective. For instance method used for suppression of noise to detect boundaries of an organ in ultrasound may not be suitable to detect presence of kidney stone in the images.

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