DESPECKLING OF RENAL CALCULI IN ULTRASOUND IMAGES

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Abstract - Ultrasound imaging can be used as an initial evaluation method in Urological diagnosis to examine kidney problems. The diagnosis helps doctor to access abnormalities in kidney like abnormality in size and shape of kidneys, presence of swelling, cysts, ulcer and stones. However, the Ultrasound diagnosis is more popular as compare to Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) scanning, but it suffers with speckle noise. The speckle noise is an inherited property of ultrasound images which shows bright particles in the ultrasound images. It not only reduces visual quality but sometimes creates confusion to identity the small objects like stone or ulcer. The presence of speckle also effects decision making while analyzing structural abnormalities like change in size and appearance of kidney organs. To improve the quality of ultrasound imaging, we need to suppress the speckle noise and enhance the visual quality of the image. In this paper, we have analyzed wavelet transform based method to suppress the speckle noise. We have applied median filter, adaptive weighted median filter, non local mean filter, homomorphic ideal filter and wavelet filter. The results show significant improvement in visual quality and can be further used for better diagnosis. We have also performed statistic based method to evaluate the performance. The signal to noise ratio (SNR) and peak single to noise ratio (PSNR) are the parameters used to analyze the performance of these methods.

Key Words: *Ultrasound denoising, Median filter, Adaptive weighted median, Non local mean filter, homomorphic ideal filter, wavelet filter.*

1. INTRODUCTION

Ultrasound imaging is non invasive, low cost and safest method to identify kidney abnormalities. The abnormalities in kidney may be structured in nature like swelling, change in size or appearance, presence of stone [1]. The kidney stone is considered as one of root cause of kidney problems. The stone in kidney may results in other problems like blockage of urine, swelling, and cancerous cell. It is very important to detect stone in early stage. The ultrasound imaging is most preferred method to identify and localize the calculi. As ultrasound image has inherited property of speckle noise which generates small bright particles in image. It not only reduces visual quality but also create confusion to identity the small objects in the image. The presence of small stones is always a challenging take as these stone intermixed with speckle. Here, we need techniques to enhance the visual quality. Sometime over suppression may results in loss of vital information in the image. We need methods which can suppress image ideally to meet the requirement visual quality. There are many methods available in literatures which are used to suppress noise in medical and some of them are: The statistical filters like Weiner filter [2] was used to address primarily for additive noise suppression. To handle the multiplicative nature of speckle noise, Jain developed [3] a homomorphic approach, which first calculate the logarithm of the image then translates the multiplicative noise into additive noise. The Wiener is finally allied on the pre filter image. The wavelet shrinkage Universal threshold that over-smooth images [4]. The same method was later improved by minimizing Stein's unbiased risk estimator [5]. We have applied well known de specking methods to enhance the quality of the images such as wavelet transform based method, median filter, adaptive weighted median filter, non local mean filter, homomorphic ideal filter and wavelet filter. These methods have improved the visual quality and can be further used for diagnosis.

2. MODEL OF THE SPECKLE NOISE

The multiplicative noise [5] is a single dependent form of noise whose magnitude is related to the value of the original pixel. It is generally found in medical images such as Ultrasound images. The following equation defines multiplicative noise:

$w(x, y) = s(x, y) \times n(x, y)$

Where s(x,y) is the original signal, n(x,y) denotes the noise introduced into the signal to produce the corrupted image (x,y), and (x,y) represents the pixel location.

3. DE-SPECKING METHODS

We have implemented well know denoising method to analysis kidney stone images. The denoising methods are applied to enhance the visual quality of the images so that kidney stone can be easily localized.

Median Filter: In median filter [10] a sliding window concept is used in which a square window called mask is used to surround the pixel to be de-noised. Generally, mask size of 3X3 is used. Let us consider (x, y) is a location of pixel to be noised. The pixel value is changed to median of all pixels in the window of locations {(x+1, y), (x-1, y), (x, y-1), (x,y+1), (x+1, y+1), (x-1, y-1), (x-1, y+1), (x+1, y-1)}. It is hardly affected by small number of discrepant values among pixels in neighborhood.

$f(x, y) = \text{median}\{g(s, t)\}$ where $(s, t) \in S$

During the process, the median is calculated by first sorting all pixel values of neighborhood into numeric order and replace pixel being consider with middle value. It has been observed that median filter is good for smoothing purpose and it also preserve small and sharp detail. But it does not preserve small size component as compared to neighborhood pixel values.

Adaptive weighted median filtering: The adaptive weighted median filtering algorithm proposed by Wang Chang-you is applied on Ultrasound image. The method is successively process three process which are (i) Noise detection over the image; (ii) Adaptively determining the window size according to the number of noise pixels within the window; (iii) Adaptively determining the weight of each non-noise point in filtering window and filter off noise points by means of weighted median filtering algorithm.

Non-local means denoising: It is an algorithm in place of taking mean of pixels considered in rectangular region or mask we consider all pixels of the image but we give weight to pixel similar to the group surrounded by the supposed noising pixel. We have applied non local denoising method based Hellier, P .The method proposed is based upon Bayesian framework to derive a NL-means filter adapted to a relevant ultrasound noise mode.

Homomorphic filtering: It is the well-known technique used for removing multiplicative noise from Ultrasound images [12]. In homomorphism filtering first we transform the multiplicative components to additive components by moving to the log domain.

$\ln(I(x,y))=\ln(L(x,y)\, R(x,y))$

$\ln(I(x,y))=\ln(L(x,y))+\ln(R(x,y))$

Then we use a high-pass filter in the log domain to remove the low-frequency illumination component while preserving the high-frequency reflectance component.

Wavelet Transformation: In wavelet transform, we try to express a function in terms of small waves, thus the name wavelet. It consists of eliminating certain frequencies in order to eliminate any existing noise [9]. Since we know that when an image is decomposed, the

HH, LH, and HL images contain most of the image's high frequencies and noise, we can eliminate the noise by eliminating those very images.

Table1: Visual performance of denoising methods

Sr.No.	Method/Technique	Noised Image	De-noised image
1	Median Filter		
2	Adaptive Weighted Median Filter		
3	Non Local Mean filter		
4	Homomorphic Ideal Filter		
5	Wavelet Filter		

Analysis: We have used statistical parameters to analysis the performance of the method which are defined below

PSNR (Peak Signal to Noise Ratio): It is defined as the ratio of peak signal power to average noise power. PSNR looks at how many pixels in the text image differ from Ground truth image values and find quantity of the pixels [6]. Higher the value of PSNR indicates better result .It can be calculated as

$PSNR = 10 \log10 2552*MN / \Sigma i \Sigma j(x(i,j)-y(i,j)2$

Higher the PSNR gives lower the noise in the image i.e. higher image quality.

MSE (Mean Square Error): Mean square error is defined as

$MSE = 1/MN \Sigma mj\Sigma kn(xj,k-x'i,j)2$

SNR (Signal to Noise Ratio): It is defined as ratio of average signal power to average noise power for an image pf size MxN. It may be calculated as

$SNR = 10 \log10 \Sigma i\Sigma jx(i,j) / \Sigma i\Sigma j(x(i,j)-y(I,j)2$

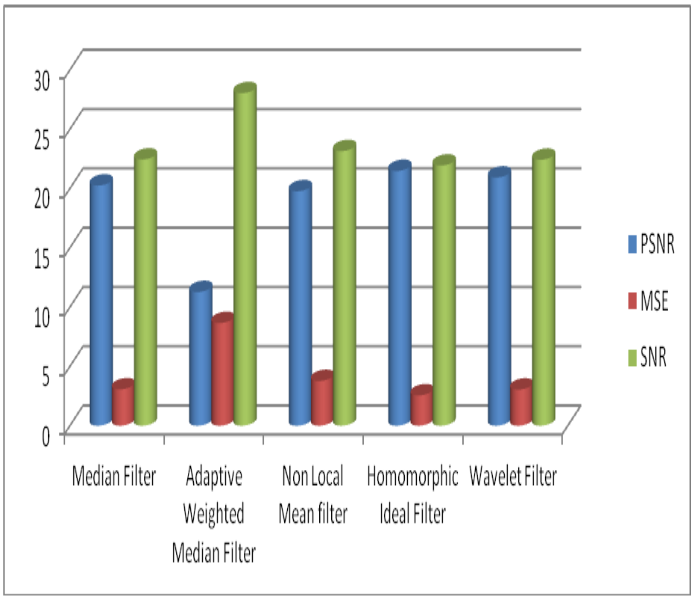
We have also compared all the method in graph form which shows how PSNR, MSE and SNR varies according to methods.

Table2: Statistical analysis of denoising methods

Method	PSNR	MSE	SNR
Median Filter	20.252	3.0612	22.444
Adaptive Weighted Median Filter	11.274	8.6575	28.040
Non Local Mean filter	19.767	3.7714	23.154
Homomorphic Ideal Filter	21.481	2.5551	21.938
Wavelet Filter	20.931	3.0435	22.426

We have also compared all the method in graph form which shows how PSNR, MSE and SNR varies according to methods.

Figure1: Comparison of different of denoising methods



4. CONCLUSION

The study is aimed to explore the use of well-known methods to suppress speckle noise in order to enhance ultrasound kidney images. We have used median filter, adaptive weighted median filter, non-local mean filter and some Fourier / wavelet transformation based filters. These filters perform well to remove speckle noise. The statistical parameters shows adaptive weighted median and wavelet methods are better performed then others. But as we can see all these methods fail to preserve objects small in size whereas a calculus which is large in size is more clearly defined after applying de-noising.

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