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Survey on Speckle Filtering Techniques of the Ultrasound Images

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Abstract- Today, ultrasound and magnetic resonance images are the essential tools for non-invasive medical diagnosis. One of the fundamental problems in this area is speckle noise, which is a major limitation on the image quality particularly in ultrasound imaging. Ultrasound images contain speckle noise that affects the quality of images. The presence of speckle noise affects image interpretation by human and the accuracy of the computer-aided diagnosis techniques. Low image quality is an obstacle to an effective feature extraction, analysis, identification and quantitative measurements. Speckle is a granular noise that is naturally present in and degrades the quality of medical images. Eliminating such noise is an important pre-processing task. This paper presents a review of some important work for removing stains from ultrasound images.
Index terms - Image denoising, ultrasound images, speckle noise, standard speckle filters, wavelets transform.

I. INTRODUCTION

Ultrasound imaging is one of the mostly used techniques in medical field. The speed, low cost imaging and the transferability of scanning engine power is used very popular for imaging soft tissue in organs such as liver, kidney, spleen, uterus, heart, brain. The common problem in the ultrasound image is speckle noise used by the imaging technique which may be based on coherent waves, as acoustically caused by laser imaging [8] [9]. Ultrasound is a sound wave having a frequency exceeding 20 kHz. It transports energy and propagates through various means such as a pulsating pressure wave. It is described by a number of wave parameters such as print density, direction of propagation and particle displacement. The shaft is referred to as longitudinal or compression wave when the particle displacement is parallel to the propagation direction. When the particle displacement is perpendicular to the, direction of propagation, there is a shear or shear wave.

The interaction of ultrasonic waves with the tissue subjects to the laws of geometrical optics which includes reflection, refraction, scattering, diffraction, interference and absorption. Except the disorders, all other interactions reduces the intensity of the ultrasound beam. Ultrasound technology is mainly based on the measurement of a medium to transmit it as echoes. In the echo pulse ultrasonic technique of ultrasonic wave interacts with the tissue and parts of the transmission power returns to the transducer by the instrument are determined. The use of ultrasound imaging in medical diagnostics is known because of its noninvasive nature, ability to form real-time imaging and continuous improvement of the image quality. However, it suffers from a number of deficiencies, and these include: acquisition of noise from the equipment, the ambient noise from the environment, the presence of background tissues, other organs and anatomical factors such as body fat, and respiratory motion. Therefore, noise reduction is very important because different types of noise generated limit the effectiveness of medical image diagnosis.

II. SPECKLE NOISE IN ULTRASOUND IMAGES

Today, the US medical imaging is a common method of diagnosis over the other imaging methods such as positron emission tomography (PET), magnetic resonance imaging (MRI) and computed tomography (CT), due to its low cost and availability. Monochromatic radiations such as the USA and laser, the radiation scattered by a surface with a roughness in the order of a wavelength produce speckle interference pattern.

A speckled image is commonly modelled as $\nu 1 = f 1 \upsilon$: where

$f = \{f1, f2, f3 \ldots fn\}$

$\nu = \{\nu1, \nu2, \nu3 \ldots \nu n\}$

$\upsilon = \{\upsilon1, \upsilon2, \upsilon3, \ldots\ldots \upsilon n\}$ in which ‘ f ’ represents a noise-free ideal image, ‘ν’ represents speckle noise and ‘ υ ‘represents unit mean random field[2].In section 2 different standard speckle filters will be explained: The paper is organized as follows. Section 3 contains a description of the wavelet based filtering techniques. Paper concludes with Section 4 contains discussion of various

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despeckling techniques.

III. SPECKLE FILTERING TECHNIQUE

There are many filters for speckle reductions with better visual interpretations, while other good noise suppression or smoothing capabilities. Some of the best known speckle reduction filters are Lee Kuan, median, standard Frost, Enhanced Frost, Weiner, Gamma MAP and SRAD filter. Some of these filters have unique speckle reduction approach, spatial filtering in a square - move window as known kernel performs. The filtering is based on the statistical relationship between the center pixel and the surrounding pixels are calculated. The typical size of the filter window can range from 3-mal 3-33 -by -33 rich, but the size of the window to be odd. If the size of the filter window is too large, important information will be lost by over-smoothing. On the other hand, if the window size is too small, speckle reduction may not produce good results. In general, a 3-by-3-or 7- used by -7 windows is accepted to give good results [3].

A. Median Filter

The median filter [4] is about calculating the median value of all the pixels. After calculation it replaces the centre pixel with this median value in the local window. Median filtering is the one among the non-linear filtering technique. This method is effective in cases where the noise pattern consists of strong end points in the ultrasound images and features are edges. The main disadvantage of the median filter is the additional calculation time needed to sort the intensity value of each set.

B. Wiener Filter

The Wiener Filter [5], also known as Least Mean Square filter, is given by the following expression: H (x, y) is the degradation function and H (x, y) * is the conjugate complex. G (x, y) is the image deteriorated. Sf functions (x, y) and Sn (x, y) are power spectra of the original image and the noise. Wiener filter accepts noise and power spectra object a priori.

C. Lee Filter

Lee filter [6] is based on speckle multiplicative model and it can use local statistics to preserve edges effectively. This filter is based on the approach that if the variance of an area is low, or constant, smoothing is not performed on the basis, otherwise the smoothing can be carried out, if the variance is high (close to edges).

$$Img(i,j)=Im+W*(Cp-Im) \qquad (1)$$

D. Frost Filter

The frost filter [6] maintains a balance between averaging and the all-pass filter. In this filter, the balance is achieved by formation of an exponentially shaped filter core which varies from a basis filter an identity adaptive filter. The result of the filter will vary locally with the coefficient of variation. The filter is average at similar low coefficient of variation, and in cases of high coefficient of variation the filter sharp features are not preserved. The resulting filter after some simplifications can be written as:

$$Mn=\exp(-DAMP*(S/Im)2)*T) \ (2)$$

Where K is a constant controlling the damping rate of the impulse response function, and shows the pixel to be filtered. It can be seen that if the coefficient of variation I CT is smaller, the filter behaves like an LP filter smooth the speckles, and when I CT large is a tendency that has received original observed image.

E. Enhanced Frost Filter

The extension of the frost filter is the Enhanced Frost Filter [9].It is a different filtering technique with exponential weighting factor M in the equation to each region. Depending on the comparison between the local coefficient of variation C in a defined window size and the variations of efficient Cu the output of the filter divides the image into three classes. If Ci is smaller than Cu speckle is by replacing the value of the filtered pixel with the intensity mean in the filter window removed. This represents the homogeneous or uniform class. In the second grade, when Ci falls between the lower and upper speckle variation coefficient of the value of the filtered pixel is replaced by the weighted equation .

$$Img(i,j)=\Sigma Pn*Mn/\Sigma Mn \qquad (3)$$

This provides the heterogeneous class when the speckle reduced, but not eliminated, so as to maintain the quality of the image. In

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the last class, Ci is greater than the upper threshold Cmax. In this case, the value of the filtered pixel is replaced with the center pixel in the window filter. This is due to the consideration that isolated points to keep up with high reflectivity for analysis. The Enhanced frost filter as compared to the frost filtering better preserves the edges and the texture of an image.

F. Kuan Filter

Kuan filter [4] is used for the statistical distribution of pixels in the sliding window to determine the value of the pixel of interest. Provided that the multiplicative noise can be considered as additional ones. Kuan filter is based on the assumption that the mean and variance of the pixel of interest with the local mean and the variance of all the pixels within the moving window is calculated. Kuan filter is described as follows:

$$R(t) = I(t) + W(t)(I(t) - I(t)) \qquad (2)$$

Where R (t) is the filtered pixel value. I (t) is noisy and average pixel value in the moving window.

IV. WAVELET FILTERS

A. Wavelet Thresholding

A high frequency component of the image is speckle noise and is in wavelet coefficients. A method for speckle reduction is proposed wavelet thresholding. Basic procedure for all thresholding method is

Calculate DWT if the Image.

Thresholding the wavelet components.

Compute IDWT to obtain denoised estimate.

There are two commonly used thresholding functions. Fixed thresholding function retains the entry, if it is greater than the threshold; otherwise it is set to zero. Soft sleepers function takes the argument and it shrinks to zero by the threshold. Soft-threshold rule is decided on hard sleepers. The soft thresholding method yields visually pleasing images on hard thresholding. One result can still be noisy. Large thresholds alternatively produce the signal with a large number of zero coefficients. This leads to a smooth signal. To choose an optimal threshold, much attention must be paid. Achim et.al, Thitimajshima.P et.al proposed speckle reduction through wavelet transform on Bayesian approach by the statistical models based on both noise and signal [9]. Wavelet based noise reduction with Hidden Markov Trees, originally proposed by Crouse, et. al., Romberg, et. al., has been quite successful, and led to a series of other HMT and used the minimum mean square error (MMSE) **-** like estimators to suppress the noise.

B. Universal Threshold

Universal threshold $TT = \sigma\sqrt{2}$login, where n is equal to the size of the image is noise variance σ. This was determined in a perfect setting for soft thresholding with random Gaussian noise. This is easy to implement, but provides a threshold value is greater than with other methods, resulting in a smoother reconstructed data. This assessment will depend on the data size n only, not for the content of the data. For large values of M to allow, even sleepers tends to be high, killed many signal coefficients together with the noise. Thus, the threshold is not well applied at discontinuities in the signal.

V. DISCUSSION

The comparative study of different speckle reduction filter for ultrasound images shows that the wavelet filters outperforms other standard speckle filter. Although all standard speckle filters perform well on ultrasound images, but they have some limitations with respect to resolution degradation. These filters work by On a fixed window smoothing and it is produce artifacts around the object and sometimes causes over smoothing Wavelet transformation is best suited to the performance because of its properties as sparsity, multi-resolution and multi-scale nature. The discrete wavelet used easiest to implement.

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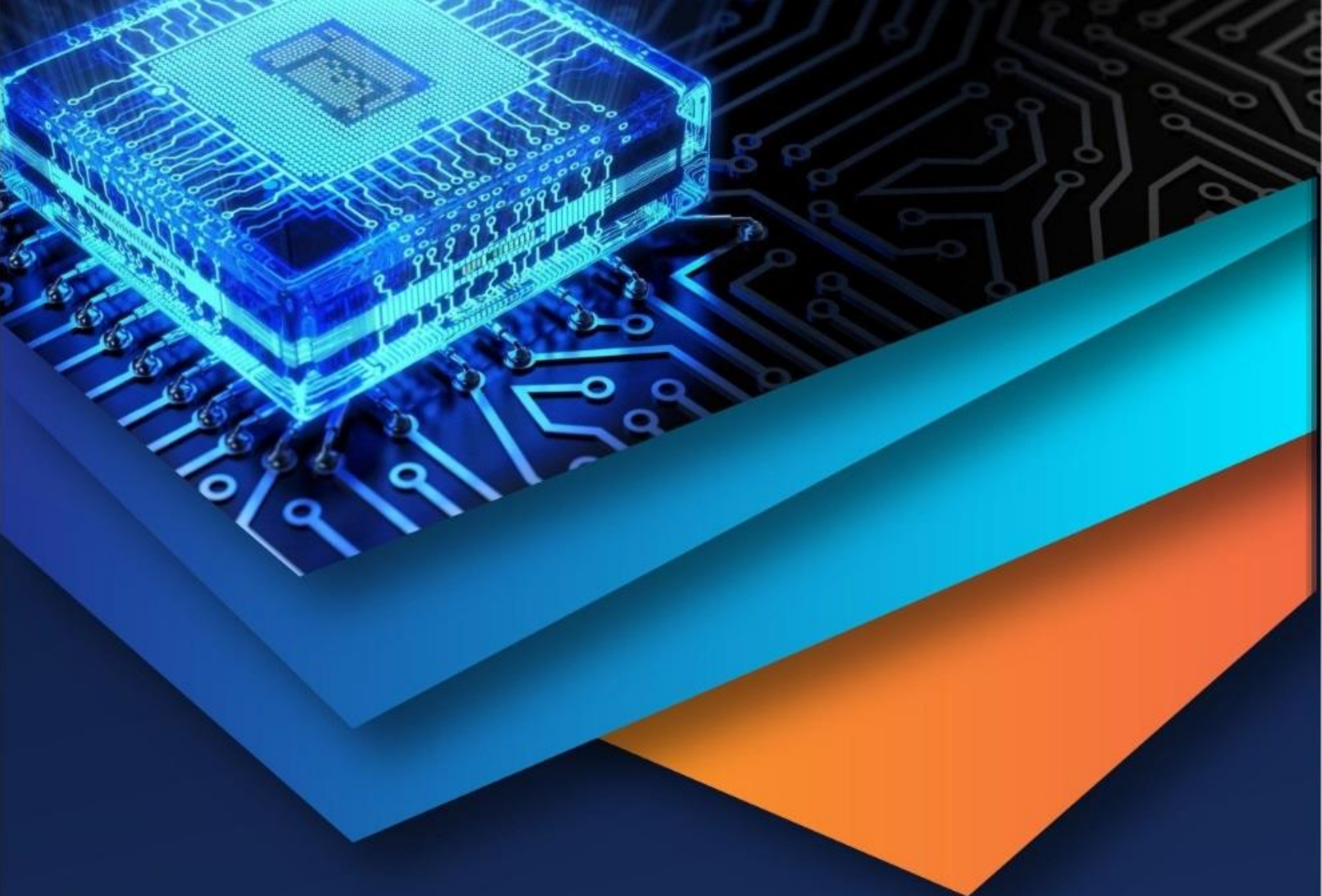

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