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MODIFIED KERNEL ANISOTROPIC DIFFUSION DESPECKLE FILTER FOR MEDICAL ULTRASOUND IMAGING

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Abstract: *Speckle is a primary factor which degrades the contrast resolution and masks the meaningful texture information present in an ultrasound image. Its presence severely hampers the interpretation and analysis of ultrasound images. Speckle noise is produced by the mutual interference of a set of scattered wavefronts. Depending on the phase of the wavefronts, the interference may be constructive or destructive resulting in brighter or darker pixels. The proposed filter is based on steps to attenuate the resultant brighter and darker pixels. Anisotropic diffusion minimizes the noise fluctuation while simultaneously preserving the edges of the image.In this paper, a detailed description of Modified kernel Anisotropic diffusion despeckle filter(MKAD) is proposed. MKAD performance is compared with 5 other diffusion filters in medical ultrasound quantitatively and functionally. The proposed filter has presented the greatest structural similarity, 0.95.For better analysis, field II simulation is done on ultrasound images.*

Keywords: ultrasound, speckle noise, diffusion, median, anisotropic diffusion

I.INTRODUCTION

Ultrasound imaging is an important and frequently used diagnostic tool in medical imaging. It uses high-frequency inaudible sound waves to assess images of the soft tissues. The accurate interpretation of ultrasound image is hampered by two signal processing roadblocks. First, subresolution scatterers lead to image speckle that plagues imaging applications by obscuring the underlying tissue properties. Second, the imaging system itself has a point spread function that creates blurring of image features. Both these factors degrade the image quality. As a result, image processing for reducing the speckle noise and blurring is required. Speckle is not truly a noise in the typical engineering sense because its texture often carries useful information about the image being viewed.So speckle reduction should be designed such that it smoothens the image in a controlled fashion without significant loss of information.
Several speckle denoising filters are proposed, of which anisotropic based filters are significant. Several researchers proposed anisotropic diffusion methods based on the original study of Perona and Malik [2], where the anisotropic diffusion equation provides a technique for selective image smoothing. The development of research for anisotropic diffusion via the partial differential equation has taken place in such a way that important structures in the images remain preserved. Speckle reduction method should be a balance between speckle suppression and feature preservation .The Proposed filter enhance objects by suppressing the speckle pattern, while preserving the edges of the objects.

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The organization of the paper is as follows. Section II describes the proposed filter(MKAD).Evaluation methods are detailed in Section III, including filtering of Field II simulated ultrasound images, use of quantitative quality metrics, and functional evaluation based on object segmentation. Results and Discussions are presented in Section IV, and Section V concludes the paper.

II.PROPOSED FILTER

Let speckled image be the B-mode ultrasound image. The Modified Kernel Anisotropic Diffusion(MKAD) Filter can be divided into three steps, namely: median filter, destructive interference suppression and constructive interference suppression and modified kernel anisotropic diffusion.The block diagram of the proposed filter is shown in fig 1,

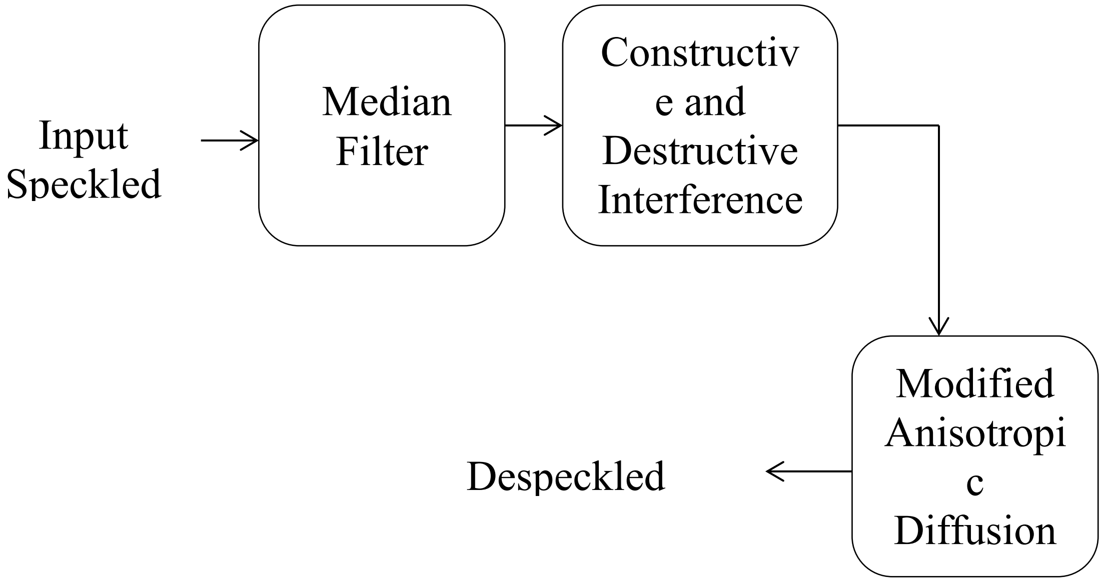

Fig.1.Block Diagram of the MKAD method for Ultrasound Speckle Reduction

Median Filter

A median filter is first applied to the speckled image to smooth the image. Here, a circular window was used rather than a square window to avoid ''blocking'' artifacts. Generally, the larger the window radius, the smoother the image texture becomes. However, to avoid over-smoothing, the selected radius should not be bigger than image structures. Several window radii were tested, ranging from 3 to 40 pixels.

Destructive interference suppression.

The primary purpose of this filter is to smooth an ultrasonography image through the suppression of the gray values caused by destructive interferences, for each position (x, y) , the maximum value between the median filtered image and the speckled image is selected.

$$I_c(x,y) = \max\{I(x,y), I_{med}(x,y)\} \quad (1)$$

where I is the speckled image, I_{med} is the median-filtered image and I_C is the constructive interference only image. For each position (x,y), the brighter pixel between I(x,y) and $I_{med}(x,y)$ is chosen. Hence, step 2 suppresses the darker pixels, which are related to destructive interference (Burckhardt 1978).

Constructive interference suppression.

As only bright speckles remain in the resulting constructive interference image from step 2, a small-windowed (3 pixels radius) median filter is applied to eliminate the remaining extreme single pixels.

Modified Kernel Anisotropic Diffusion Filter

Given the interference suppressed images are good candidates for anisotropic diffusion. The kernel is modified as shown in the fig 2.The discretised filter equation for modified kernel is given in equation (13),

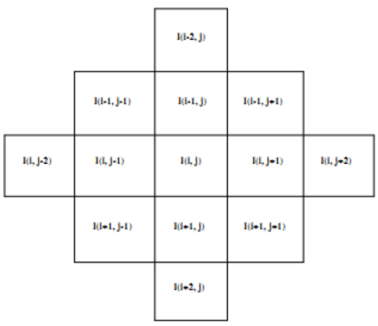

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Fig.2.Kernel of the proposed filter

$$I(x,y,t+1) = I(x,y,t) + \frac{\nabla t.\lambda}{|n_S|}(cN.\nabla I_N + cE.\nabla I_E + cW.\nabla I_W + cS.\nabla I_S + cNE.\nabla I_{NE} + cSE.\nabla I_{SE} + cNW.\nabla I_{NW} + cSW.\nabla I_{SW} + cN1.\nabla I_{N1} + cE1.\nabla I_{E1} + cW1.\nabla I_{W1} + cS1.\nabla I_{S1} \quad (2)$$

where c(x,y,t) represents value of diffusion co-efficient for the pixels in all possible directions. ∇I represents the image gradient in the respective directions.

III EVALUATION METHODOLOGY

The proposed method is compared with five existing diffusion filtering methods which are Perona and Malik filter, MGAD filter, SRAD filter, RTFAD filter and Interference suppressed speckle filter followed by Anisotropic Diffusion(ISFAD) filter. The proposed method of speckle reduction and edge preservation is tested using Field II speckle simulated ultrasound image (Fig.3(a)).The filtered images are functionally evaluated by object segmentation algorithm like level set (Fig.4(a)-4(g)).

Table. 2 summarizes the quantitative results for the simulated ultrasound image.Comparing Fig. 3 and Fig.4 with Table II, we realized that our proposed method successfully improved the speckle reduction and edge preservation and better structural similarity index of 0.95.

IV RESULTS AND DISCUSSION

For experimentation, cyst field II image is taken.The speckled image is be obtained for a scattering distribution of 10,000 and transducer frequeny of 5MHz.The field II speckle simulated medical ultrasound images are subjected to five speckle reducing diffusion filters and the proposed MKAD filter.Level Set object segmentation technique is applied to filtered images .Levelset images shows that the proposed filter preserves the edges and local gray level information of ultrasound image. Table II shows that MKAD filter gives better structural similarity index and reduced error.

CYST PHANTOM –Simulation I

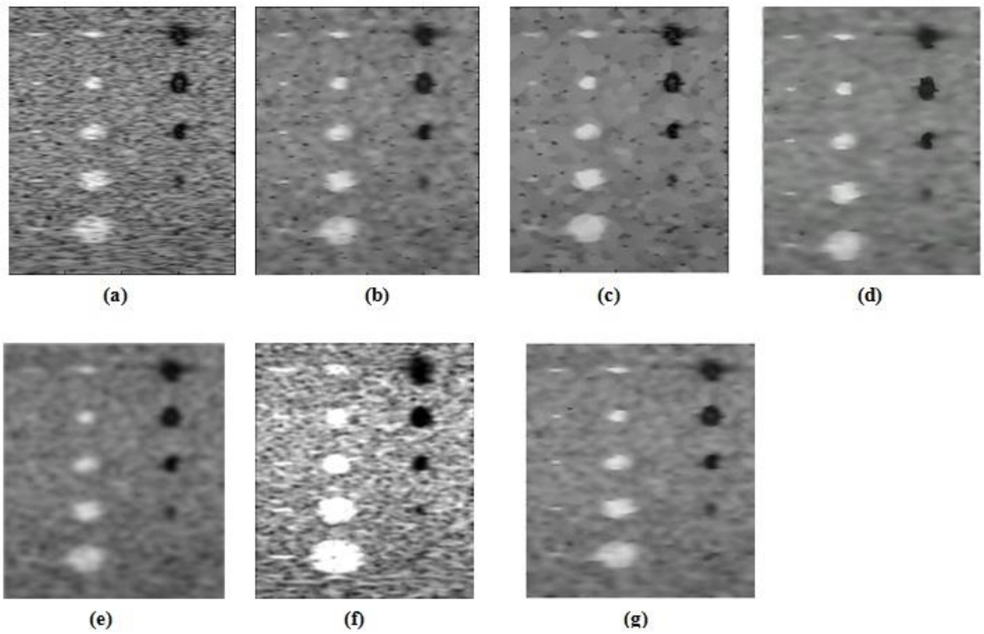

Table II A.Numerical Performances of the filters

Filter	σ	RMSE x 100	SSIM x 100	CSR x 100	Filter	σ	RMSE x 100	SSIM x 100	CSR x 100
Gold Standard	0	0	100	α	MGAD	21.4	81.57	50	837.1
Speckled	12.7	14.46	-64	100	SRAD	22.6	214.0	18	406
					ISFAD	20.6	5.69	90	250.2
AD	24.5	5.70	33.58	88.04	MKAD	63.8	4.06	95	739
RTAD	18.7	0.320	93	0.397					

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CONCLUSION

The experimental results shows that the proposed algorithm can denoise the speckle images more effectively. The main advantage of the MKAD filter is that the image features are retained without any information loss. Median filtering is used to suppress the constructive and destructive interference pixels. Further anisotropic filter with hybrid kernel preserves the edges and the local gray level information. Results reveal that our method performs superior to the other method, indicating it's potential to speckle reduction in ultrasound images.

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