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An Optimized Hybrid Filter Designing for Speckle Noise Reduction in Ultrasound Images

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Abstract: ***Image is a visual perception of some scene or something. Images are set of pixels that have some values and these value appear in the form of colors to view that particular set of pixels as image. An image containes information about whatever is depicted in the picture and hence it can be said as useful source for storing or conveying information. Image noise is most apparent in image region with low signal level, such as shadow region or under expose images. This report presents the concept of noising and denoising in a digital image. Noise is a kind of disturbance occurs in the channel at the time of transmission. For ages researchers have been proposing several techniques that were used to remove the noise from the image. Image denoising is the procedure of improving true image from the noisy image. At the time of such process it is difficult to reduce noise. Owing to this difficulty, numerous denoising models have been proposed [3]. These techniques have been focused on the noise that enters through the channel. So that in the proposed work, the butterworth filters is applied for filtering the noisy image and then the coefficients are optimized by using the firefly optimization mechanism to removes noise that occurs at the time of transmission. Experiments have been performed to check the performance of the proposed technique.***
Keywords: Digital Images, Speckle Noise, Gaussian Noise, Denoising, Butterworth Filters, Firefly Optimization.

I. INTRODUCTION

The digital data travels over the internet in the form of the signals. These signals are very sensitive and can be caught by the noise easily. When signals travels over the network then the signal get distorted due to the occurrence of noise in the signals. Noise is a kind of disturbance occurs in the signals. Noise represents the unwanted sound in the actual data which leads to the loss of data or wrong or irrelevant data to be transferred at the destination [1]. Noise is the kind of thing or interrupts which occurs from outside of the network such as hum. Occurrence of noise is the higher in the case of analog signals but it can also occur in digital signals sometime. Each and every recording or sound consists of some amount of noise always. But noise is considered as a problem in signals only when it increases from a threshold level. But in case when the existence of noise in signals is not recognizable [2] i.e. it is not hearable in the sound then it does not affect the signals.

Image can suffers from assorted types of noise some of them are listed as follows:

A. Gaussian noise
B. Salt and Pepper Noise
C. Shot noise
D. Quantization Noise
E. Film grain
F. Anisotropic Noise
G. Periodic noise

II. TECHNIQUES USED FOR DENOISING

Generally to eliminate the noisy signals from digital images, the filters are used purpose fully. Filtration is one of the major mechanisms that is widely acceptable to de noising and processing the images [3]. Filters are applied to the noisy image in order to obtain the enhanced, noise less image. Various filters have been developed and the selection of the filters relies upon some parameters like format of the information located in image [4], purpose of filters for implementation etc.

A. Butterworth Filter

Butterworth filter helps in maintaining the flat and static output response. The Butterworth LPF operates somewhat in similar manner to the ideal filter without few steps discontinuous model [5]. In Butterworth filter the transfer function with ‘n’ order and

predefined cutoff frequency locus at a distance I0 from the origin can be described with the help of following mathematical equation.

$$H(a,b) = \frac{1}{1 + [\frac{I(a,b)}{I_o}]\text{^}2n} \ldots\ldots (1)$$

$$I(a,b) = (a^2 + b^2)^{1/2} \ldots\ldots (2)$$

B. Firefly Optimization Algorithm

Firefly optimization algorithm is a nature inspired optimization mechanism. It is a met heuristics algorithm. The firefly algorithm was developed by Xin She Yang in late 2007 at Cambridge University. The idea of developing firefly was derived from the concept of particle swarm optimization but the only difference is that the firefly works upon the basis of the flashing pattern and nature of fireflies. It works upon the basis of the following three rules:

1) Fireflies are unisex insects. Therefore a firefly can lure other firefly irrespective to their sex.

2) The property of luring and brightness is direct proportionate to each other thus both of the properties decreases with the increase in distance between them. Consequently the firefly with less brightness move towards the firefly with more brightness if no such firefly is located then the fireflies moves randomly.

3) The brightness of the firefly is diagnosed on the behalf of the landscape of the objective function.

The variation of attractive with the distance can be evaluated by using

$$\beta = \beta_0 e^{-\gamma r^2} \ldots\ldots\ldots (3)$$

The movement of firefly i with the less brightness is towards the another firefly j is determined by

$$x_i^{t+1} = x_i^t + \beta_0 e^{-\gamma r_{ij}^2 \left(x_j^t - x_i^t\right) + \alpha_t \epsilon_i^t} \ldots\ldots\ldots\ldots (4)$$

III. PROBLEM FORMULATION

At the time of acquisition, noise may enter into an image which distorts the actual quality of the signal. Considering this fact, in the existing work, waiver filter has applied to remove the noise from the image [6]. Moreover, the adaptive wavelet thresholding has performed for the filtration purpose. From the applications of this technique, it has concluded that the value of the coefficient remained fixed until the execution. In other words, the best value has acquired and the coefficients remained constant with this value. Accordingly, this method limits the process of filtration and can remove the noise at some extent which means that it does not consider the amount of noise having in the image [7]. Consequently, noise cannot be removed completely from the image. Secondly, the applied wavelet thresholding technique is not capable in reserving the edge of the images due to which the problem of lacking shift invariance occurs. In order to exclude these issues, there is a requirement of replacement of this technique with the advanced methods.

IV. PROPOSED WORK

After understanding the problems in the existing work, a novel approach has introduced in this work where waiver filter has replaced with the Butterworth filter. Because the Butterworth filter designed the coefficients and does not remain them constant [8]. The values of the coefficients varying with each iteration. Furthermore, the acquired coefficient's value will be optimized using the firefly algorithm that rule out the lack of shift invariance in the existing work. The firefly algorithm worked continuously over the values until it does not attained the best optimum solution for the problem and keep on varying the coefficient's value till the deduction of noise from the image. As a result, it can say that proposed algorithm have the capability to retain the process till the removal of noise from the image entirely.

A. Methodology

The methodology of the proposed work is as follows

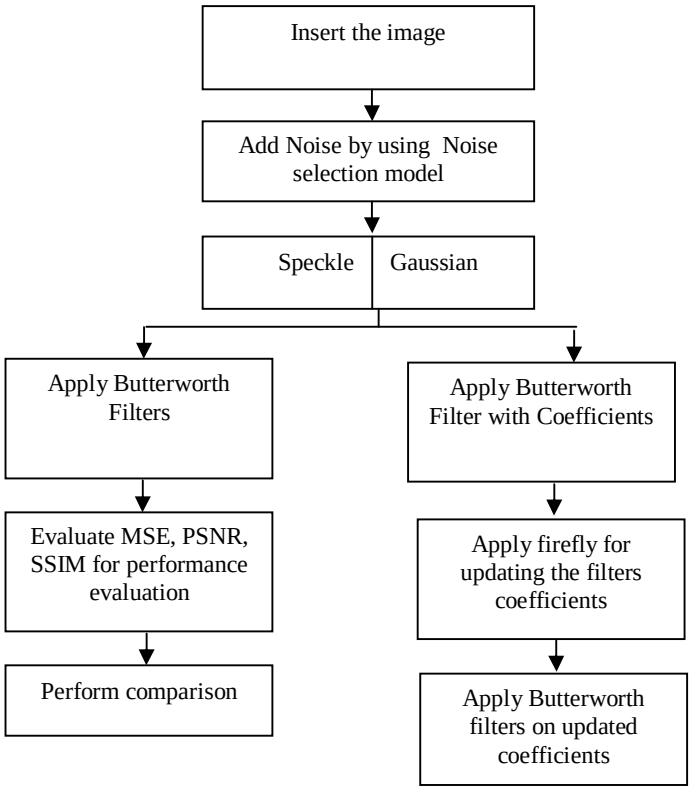

Fig 1 Flowchart of proposed work

1) First step is to insert an image by browsing the image folder. In this work total four images are used for implementation i.e. image of Lena, cameraman, monarch and house.
2) . Next step is to adding the noise to the selected images by choosing the noise selection model. This work uses two kinds of noises i.e. speckle noise and Gaussian noise.
3) . After selecting the type of noise , in this step the filtration is applied to the noisy image in two different manners as below:
4) Apply filtration process by using normal Butterworth filters. And go to step 6
5) Apply Butterworth filtration with defined coefficients.
6) Update filter coefficients by optimizing them by using firefly optimization technique.
7) Apply filtration on updated coefficients again by using Butterworth filters.
8) Next step is to evaluate or measure the performance of the proposed work by evaluating the various performance metrics like MSE, SSIM and PSNR.
9) Last step is to perform a contrast study among proposed and traditional work on the basis of evaluated performance parameters.

V. RESULTS

The present work is comprised of Butterworth filters for denoising the image and along with this the firefly is used for optimizing the obtained results. This section defines the results in the form of graphs that are obtained after implementing the proposed work. The performance is measured in the terms of peak signal to noise ratio, structural similar index and fitness of the system on the basis of the four different images i.e. Lena, cameraman, monarch and house. Then for the purpose of proving the proficiency of the proposed work, the contrast is portrayed among present study, algorithm given by Liu [14] and traditional work [1].

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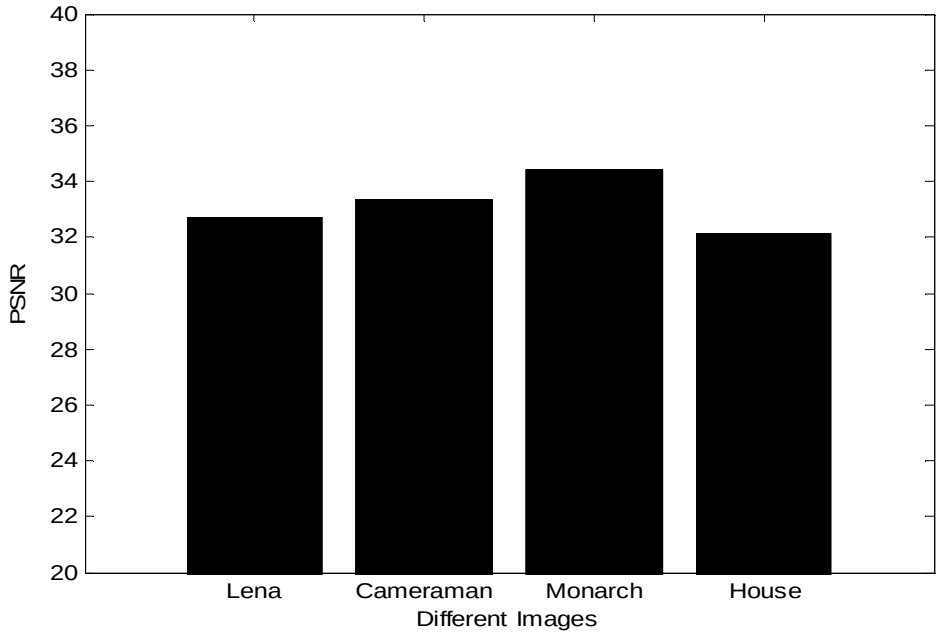

Fig2PSNR of various images in case of proposed work

The graph in figure 2 depicts the PSNR of the proposed work on the basis of the four images. PSNR refers to the ratio of signals and noise in the image. The highest value of PSNR refers to the higher presence of signals in comparison to the noise. Therefore its value should be high. Now from the graph it is observed that the PSNR of the Monarch image is higher one and the PSNR of the image of house is lowest one in case of proposed work. .

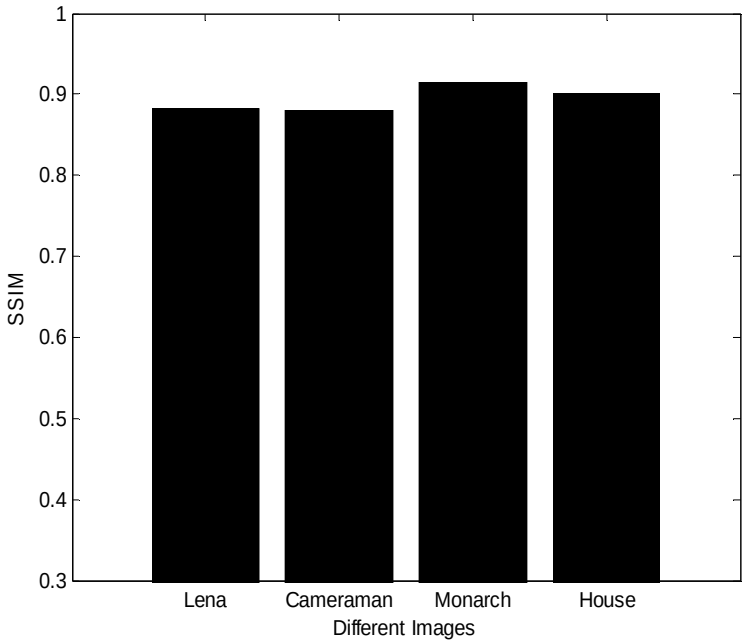

Fig3SSIM of various images in case of proposed work

The SSIM is structural similarity of the images used to measure the similarity among two images. In this the distorted and output image is compared to evaluate the similarity between original and output image with respect to information of the image. The graph in figure 3 portrays that the SSIM of monarch image is higher in comparison to other mechanisms. The higher value of the SSIM depicts that after processing the original image its original content did not get changed.

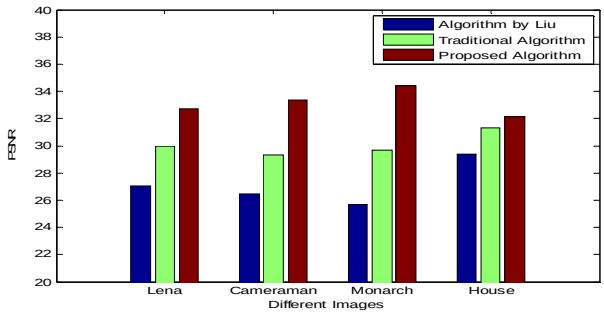

Fig4 PSNR of proposed and traditional work

The graph in figure 4 outlines a contrast study among present work, algorithm of Liu [14] and traditional work [1]. The comparison is drawn on the basis of four images. The graph proves that the PSNR of the proposed work is higher in four cases whereas the PSNR of algorithm by Liu [14] is lowest one in all cases. The table 1 depicts the value of PSNR corresponding to the algorithm of Liu [14], traditional technique [1] and proposed work. The values are obtained on the basis of the graph that has been represented in figure 4.4. The table pretends that the value of PSNR in case of proposed work is measured to 32.7, 33.4, 34.4, 32.1 for image of Lena, Cameraman, Monarch and House respectively. The obtained values are higher values of PSNR in contrast to algorithm by Liu [14] and traditional approach. Hence it is proved that the proposed mechanism is better in terms of PSNR then other two.

Table I
Comparison of PSNR

Techniques	Lena	Cameraman	Monarch	House
Algorithm by Liu [14]	27	26.5	25.7	29.4
Traditional Approach [1]	30	29.3	29.7	31.3
Proposed Approach	32.7	33.4	34.4	32.1

The comparison of SSIM of proposed and traditional work is depicted in figure 5. The SSIM of proposed work is observed to be higher in all cases. The actual values of SSIM on the behalf of graph (figure 5) are depicted in table 2. The table proves that the proposed work outnumbers the Liu's algorithm [14] and traditional technique [1] in terms of structural similarity index. The SSIM of proposed work for Lena image is 0.88, for image of cameraman is 0.88, for image of monarch is 0.91 and for house it is 0.9. The value of PSNR for proposed work is higher from traditional techniques.

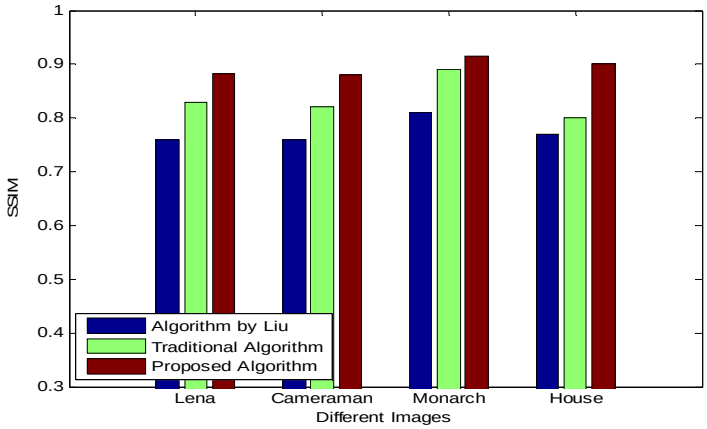

Fig 5 SSIM of proposed and traditional work

TableII
Comparison of SSIM

Techniques	Lena	Cameraman	Monarch	House
Algorithm by Liu [14]	0.76	0.76	0.81	0.77
Traditional Approach [1]	0.83	0.82	0.89	0.8
Proposed Approach	0.88	0.88	0.91	0.9

VI. CONCLUSION AND FUTURESCOPE

In this era of internet the data travels over then networks in the form of signals whether it is digital or analog. All of the communication channels used for internet based communication leads to the addition of some noisy content in the original data. Thus the introduction of the noise in the original data leads to the alterations in data which modify its original meaning. Thus this study focuses on images that travels over the internet and suffers from the issue of noise. The major intention behind conducting this study along with the outcome can be concluded as follows:

1) To analyze the effect of speckle and Gaussian noise on the digital images.
2) To apply the Butterworth filters for denoising the images along with coefficients optimization using firefly algorithm.
3) To obtain the highest PSNR and SSIM of the resultant images.

In future more enhancements can be done in the present work in following manners:Hybrid Filtration can be applied by applying filtration process on both spatial and frequency domain collectively.

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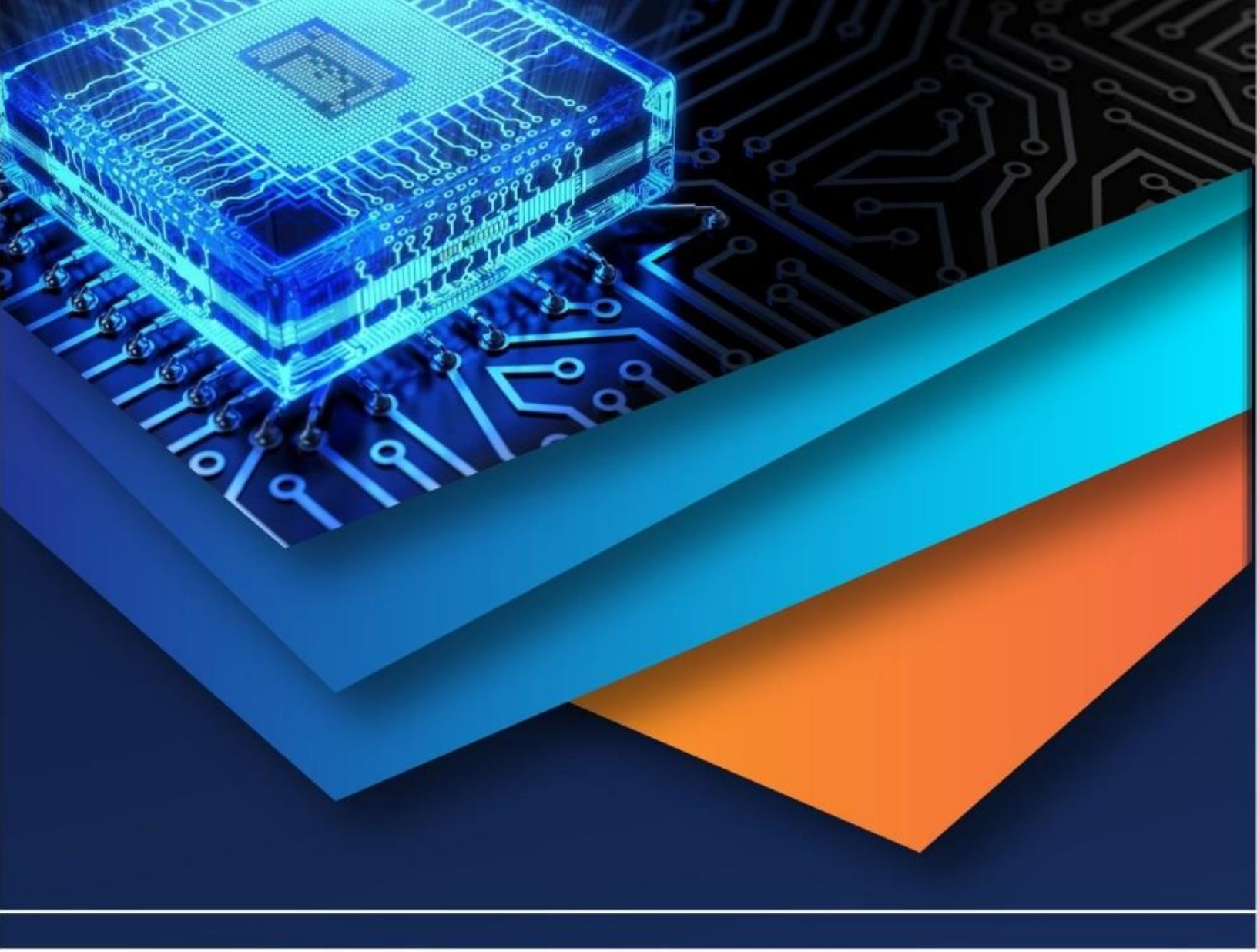

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