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A New Approach in Spatial Filtering to Reduce Speckle Noise

Md. Robiul Hoque, Md. Rashed-Al-Mahfuz

Abstract— **Speckle noise gives a grainy appearance in radar, SAR (Synthetic Aperture Radar), MRI (Magnetic Resonance imaging) images as well as ultrasound medical images. It reduces the image contrast, which has a direct negative effect on texture-based analysis of the imageries. In this paper, a new approach for speckle reduction technique has been proposed and then its performances on simulated (image with artificial speckle noise) imageries with other existing filtering methods has been compared. It has been found that, the proposed technique has better performance than others.**

Index Terms- **Image enhancement, Noise Reduction, Spatial Filter, Speckle Noise.**

I. Introduction

Image enhancement is now very important field of image processing. Specially, for SAR imagery, it is important to reduce noise before trying to extract scene features. Many filters have been developed to improve image quality by conserving what is thought to be intrinsic scene features and texture [1]. However, existing noise reduction techniques, for example, statistical procedure like mean, median-filtering techniques, can reduce speckle to some extend. The resulted image obtained by the techniques mentioned above is not at satisfactory level at all. Therefore, a new technique is necessary which reduce speckle by observing the neighbor pixel values. Because of SAR image form by the reflected signal, which has been sent by radar and speckle noise, is introduced for constructive or destructive interfere of the waves [2]. So it is very efficient to remove noise by selecting a pixel value according to priority of the neighbor pixel value this in turn recover the lost waves by observing the neighbor waves of RADAR.

There is no general theory of image enhancement. When an image is processed for visual interpretation, the viewer is the ultimate judge of how well a particular method works. Visual interpretation of image quality is a highly subjective process, thus making the definition of a “good image” an elusive standard by which to compare algorithm performance. However, evening situations when a clear-cut criterion of performance can be imposed on the problem, a certain amount of trial and error usually is required before a particular image enhancement approach is selected [3]. An important application of image enhancement is in the field of astronomy. In which image averaging carries out enhancement. Further various processes have evolved for enhancement like disk averaging, order-statistics filter such as median filter, max filter, min filter, circular averaging etc.

II. Motivation

In reducing speckle noise from image, median filter is quite popular among various filtering techniques. The response of the mask of median filter is determined by a value that divides the pixel-values into two equal sorted parts[3], each part may contain some groups of equal’s values too. But, as speckle noises is produced by the interference of the received radar waves, it may not comply with that phenomenon, rather it may like that the actual value of the noisy pixel should have the value nearer to some values those are closer to each other surrounding the center of the mask. So it not efficient way to chose the median value as a response of the mask because the actual value may fall either into the lower parts or into the upper parts of the sorted pixel-values.

Another most popular speckle reduction technique is the average filtering. The response of the mask of the average filter is the average value of the mask. It is a good practice to select average value as a response when all the pixel values are closer to each other. But still there is some problem with average-value filleting approach, since average value may be affected by some extreme values, in contrast to that, in real radar image, these extreme values have less contribution to the small region of the image, and considering that reality, in the proposed approach, these extreme value has been assigned the priority 0 (zero).

Finally, the computed average value may not exist in the mask as any pixel’s value. So it needs some suitable procedure to select an existing pixel’s value as a response of the mask that best replaces computed average value. The proposed filtering approach has incorporated that feature where priority of each pixel’s value has been computed, and then selects a pixel’s value having the highest priority as a response of the mask. In the proposed approach, it has been found, selecting the pixels’ value having highest priority instead of always taking the non-existed computed average value has the better filtering performance.

III. Proposed Algorithm

In the proposed algorithm, the pixels values within the mask values have been sorted in ascending order and the average of the pixel values in the mask has been computed.

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Md. Robiul Hoque, Assistant Professor, Dept. of Computer Science and Engineering, Islamic University, Kushtia, Bangladesh, Mobile No. +8801721334168, (e-mail: swapon_cse@yahoo.com).

Md. Rashed-Al-Mahfuz, Lecturer, Dept. of Computer Science and Engineering, Pabna Science and Technology University, Pabna, Bangladesh, Mobile No. +8801723580555, (e-mail: mahfuz1cse@yahoo.com).

The priority of each existing pixels in both higher and lower part of sorted values of pixels in the mask have been computed and normalized by corresponding distance between computed average value and highest or lowest value of the pixels of respective part.

The response of the mask is determined by the value of the pixel that has the highest priority. As though the noisy pixel in the SAR image may have value more likely to the neighbors pixel values, the propose approach always get response of the mask from the pixel values in the mask. The basic task to reduce noise from the image is depicting in Fig. 1.

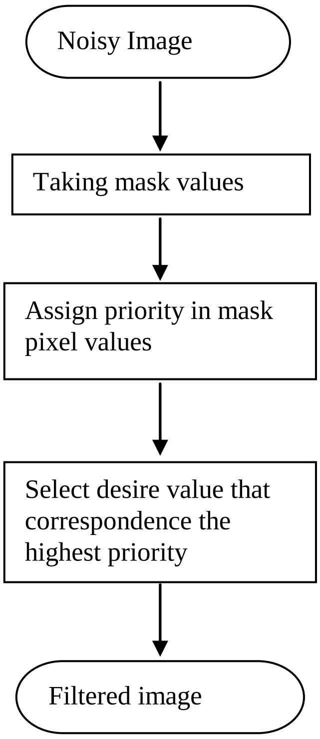

Figure 1. Flowchart of the general image filtering using spatial mask.

The proposed algorithm to reduce the speckle noise is summarized by the following 6 steps:

Step-1: Sort the pixel values of mask area in ascending order.

Step-2: Calculate A_m, the average of the pixel values within the mask.

Step-3: Calculate D_l, the difference between average value and lowest value, and calculate D_h, the difference between average value and highest value.

Step-4: For each value of the mask

a) If the current value, G_c is less than average value then the priority will be $\frac{G_c - G_{\min}}{D_l}$.

b) If the current value, G_c is greater than or equal to average value then the priority will be $\frac{G_{\max} - G_c}{D_h}$,

where $G_{\min}$ and $G_{\max}$ minimum and maximum pixel values in the mask respectively.

Step-5: Make the priority table of the priority value and then select the highest priority.

Step-6: The response of the filter with filter mask is the pixel value corresponding the highest priority.

IV. The Measure of Performance

The measurement of image enhancement is difficult to measure. There is no common algorithm for the enhancement of the image. The statistical measurement could be used to measure enhancement of the image. The Signal-to-Noise Ratio (SNR), Root Mean Square Error (RMSE), and Peak Signal-to-Noise Ratio (PSNR) are used to evaluate the enhancement performance [4].

A. Signal-to-Noise Ratio (SNR)

A common way to evaluate the noise suppression in the case of multiplicative noise in coherent imaging is to calculate the signal-to-noise (*SNR*) ratio, defined as[5]:

$$SNR = 10\log_{10} \frac{\sum f(i,j)^2}{\sum (f(i,j) - F(i,j))^2} \quad \ldots. \quad (1)$$

Here $f(i,j)$ is the original image and $F(i,j)$ is the filtered image.

B. Root Mean Square Error (RMSE)

Root Mean Square Error (RMSE) is also used for performance measurement for real SAR imagery. Root Mean Square Error (RMSE) is defined as [6][7]:

$$RMSE = \sqrt{\frac{\sum (f(i,j) - F(i,j))^2}{MN}} \quad \ldots. \quad (2)$$

Here $f(i,j)$ is the original image and $F(i,j)$ is the filtered image of M×N size.

C. Peak Signal-to-Noise Ratio (PSNR)

Peak Signal-to-Noise Ratio (PSNR): is defined as[6][7]:

$$PSNR = 20\log_{10} \frac{255}{RMSE} \quad \ldots. \quad (3)$$

If the value of RMSE is low and the values of SNR and PSNR are larger then the enhancement approach is better.

V. Experimental Results

The performance of the proposed filtering technique has been compared with the existing techniques for simulated image. The original image is shown in Fig. 2. After introducing multiplicative noise (uniformly distributed random noise with mean 0 and variance 0.04) the noisy image is shown in Fig. 3. The filtered image by filtering new approach is shown in Fig. 4.

For the filtered images all three quantities, i.e., *SNR*, RMSE, and PSNR are computed. The following three figures

Fig. 5, Fig. 6, and Fig. 7 depicts filtering result graphically. X-axis shows the filtering techniques and Y-axis shows the quantity of measurements

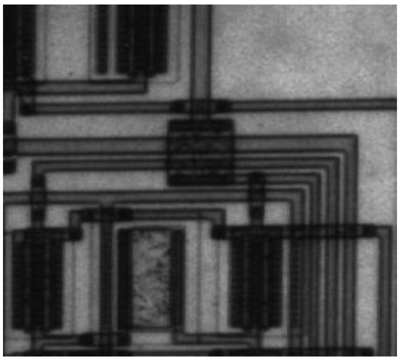

Figure 2. Original image, Source: Matlab7 toolbox.

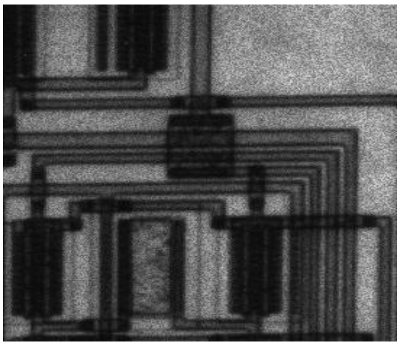

Figure 3. Simulated noisy image

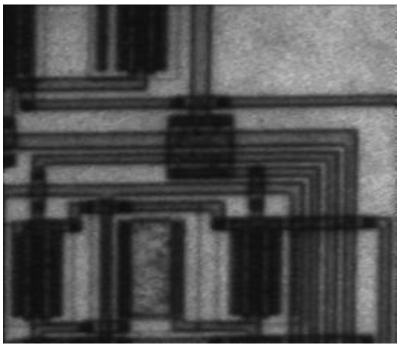

Figure 4. Filter by New approach

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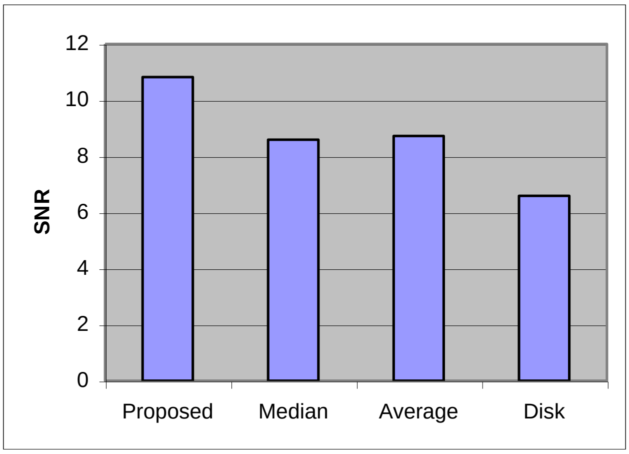

Figure 5. SNR of proposed filter and existing filters.

From Fig. 5 is seen that SNR for proposed filtering is highest.

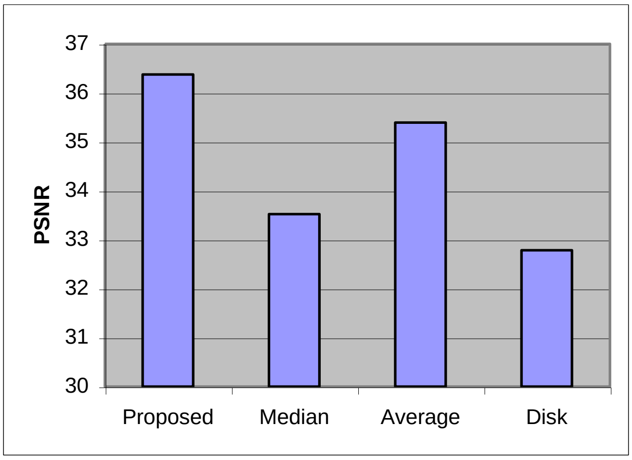

Figure 6. PSNR of proposed filter and existing filters.

From Fig. 6 is seen that PSNR for proposed filtering is highest.

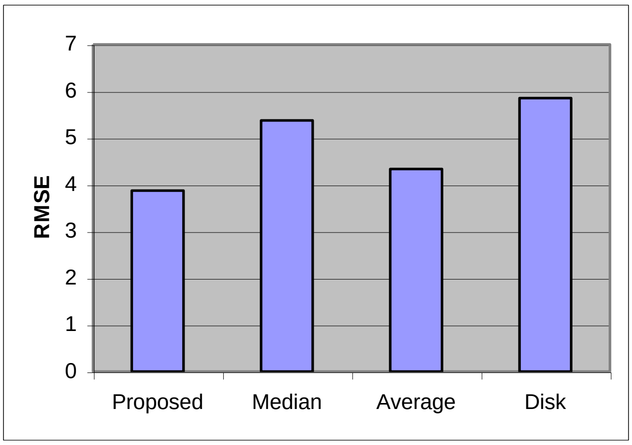

Figure 7. RMSE of proposed filter and existing filters.

From Fig. 7 is seen that RMSE for proposed filtering is lowest.

So the performance of proposed filtering technique is better than other filtering techniques.

VI. DISCUSSION AND CONCLUSION

The speckle noise is modeled as a purely multiplicative noise. The ratio of the standard deviation to pixel value, the “coefficient of variation” is constant at every point in an image corrupted by purely multiplicative noise. The average filtering technique selects a value, as a mask response single value is not able to keep the coefficient of variation either constant or closer for each small region of mask in the whole image. Same situation occurs for both median and disk filtering techniques. The proposed filtering technique selects response of mask based on priority that keeps coefficient of variation among the masks closer. From the above performance measurement we have seen that Signal to Noise ratio is highest for proposed filtering that the standard deviation of the whole image is reduced which implies more elimination of multiplicative noise.

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Md. Robiul Hoque has received B.Sc(Hon’s) and M.Sc. degree in Computer Science and Engineering from the Dept. of Computer Science and Engineering, Islamic University, Kushtia, Bangladesh, in 2000 and 2001 respectively. His current research interests include Image processing; Optical Character Recognition; speech processing, analysis, synthesis and recognition; Natural language processing; Wireless Networking and Robotics.

Md. Rashed-Al-Mahfuz has received B.Sc(Hon’s) and M.Sc. degree in Computer Science and Engineering from the Dept. of Computer Science and Engineering, University of Rajshahi, Rajshahi, Bangladesh, in 2007 and 2008 respectively. His current research interests include Image processing, Enhancement, Medical image analysis; Algorithms and Wireless Sensor Networking.