Speckle Reduction for US Images using Weighted Median Filter within Adaptive Sized Windows

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1 Introduction
In the diagnostic ultrasound scan images, granular structures appear in the images. These structures are called speckle. The source of speckle is interference of back-scattered signals, which in turn is caused by tissue inhomogeneity. Speckle is a multiplicative noise that corrupts the ultrasound image’s quality, and degrades the visualization of the images. It is necessary to develop more robust despeckling techniques for enhance the ultrasound medical images. However, the removal of speckle may be counterproductive (blurring the original images). In this paper, a new filter that balances between speckle reduction and edge (detail) preservation is proposed. The new approach adjusts the filter’s window size and varying the weights used in median filter by utilizing the local statistics inside the filter. The proposed method improves the effect of speckle reducing while inhibiting blurring the edges.

2 Backgrounds
2.1 Filter Window Size
Although the existing despeckle filters are termed as “edge preserving” and “feature preserving”, there exist major limitation of the filtering approach (sensitive to the size of the filter window). Given a filter window that is too large (compare to the scale of interest), over-smoothing will occur and edges will be blurred. A small window will decrease the smoothing capability of the filter and leave the speckle[1]. Therefore, the ability to adjust the window size according to the texture of the region is desired.

2.2 Weighted Median Filter
The traditional median filter is a simple nonlinear operator that replaces the middle pixel in the window with the median-value of its neighbors. The weighed median of a sequence \( \{ X_i \} \) is defined as the pure median of the extended sequence formed by taking each term \( X_i \), \( W_i \) times, where \( \{ W_i \} \) are the corresponding weight coefficients. For example, if the weight coefficients are \( w_1 = 3 \), \( w_2 = 1 \), \( w_3 = 2 \), the weighed median of the sequence \( \{ X_1, X_2, X_3 \} \) is given by[2]:
\[
y_{WM} = \text{median}\{X_1, X_1, X_1, X_2, X_3, X_3\}
\]
(1)
It is important to notice that if the weight added to the central point is dominant, the ability of the weighted median to suppress noise decreases. But the detail preservation increases.

3 Proposed Method
The method takes the common assumption that the speckle is fully developed, and the multiplicatively corrupted backscattered signal is modeled as
\[
g = f \cdot \eta
\]
(2)
Therefore, we consider two classes of terrain reflectivity, the homogeneous and the heterogeneous. The homogeneous class corresponds to the areas where \( f \) is constant, and the heterogeneous class corresponds to the areas where \( f \) varies, such as in textured areas, along edges, and in the presence of details. Based on the local statistics of the mean and variance of \( g \), we define the coefficient of variation:
\[
C = \sqrt{\frac{\text{Var}(g)}{\mu_g}}
\]
(3)
By using the \( C \) we can determine the window size and the weights in the median filter. If \( C \) is smaller than the threshold (homogeneous area), the next window size increases, and the weights are similar to central weight. Therefore the maximum noise reduction is performed. If \( C \) is larger than the threshold (heterogeneous area), the next window size decreases, and the central weight is dominant. So the details are preserved.

4 Experiment and Conclusion
The proposed method is compared with several standard filters by checking the PSNR. And a diagnostic image is processed by conventional median filter and the proposed method. It is clear that the proposed method reduced the speckle while preserved the edge information.

<table>
<thead>
<tr>
<th>Filtering methods</th>
<th>PSNR</th>
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<tbody>
<tr>
<td>Frost</td>
<td>25.86</td>
</tr>
<tr>
<td>Lee</td>
<td>22.00</td>
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<tr>
<td>Median</td>
<td>16.93</td>
</tr>
<tr>
<td>SRAD</td>
<td>32.93</td>
</tr>
<tr>
<td>Proposed</td>
<td>33.41</td>
</tr>
</tbody>
</table>

Fig.2 Diagnostic imagery result of a tumor in a human’s liver. (a) result of Median. (b) result of Proposed method.

References