SPECKLE NOISE REMOVAL

Problem Statement:

Ultrasound imaging is an incontestable vital tool for diagnosis, it provides in a non-invasive manner the internal structure of the body to detect eventually diseases or abnormalities tissues. Unfortunately, the presence of speckle noise in these images affects edges and fine details which limit the contrast resolution and make diagnosis more difficult. It also becomes hard to differentiate between speckle noise and clinical information because speckle-noise behaves like information. So it is necessary to overcome this problem by reducing noise.

Objective:

- To implement an algorithm based on discrete wavelet transform to remove speckle noise with the aid of guided and frost filters
- To remove speckle noise from an ultrasound image
- To evaluate the performance of the proposed algorithm using metrics namely – peak signal-to-noise ratio, mean square error, and structural similarity

References:

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- Wang S., Zhou J., Li J., Jiao L. (2012) Speckle Noise Reduction for Ultrasound Images via Adaptive Neighborhood Accumulated Multi-scale Products Thresholding. In: Zhang Y., Zhou ZH., Zhang C., Li Y. (eds) Intelligent Science and Intelligent Data Engineering. IScIDE 2011.
- Wang, S., Huang, TZ., Zhao, XL. *et al.* Speckle noise removal in ultrasound images by first- and second-order total variation. *Numer Algor* 78, 513–533 (2018).
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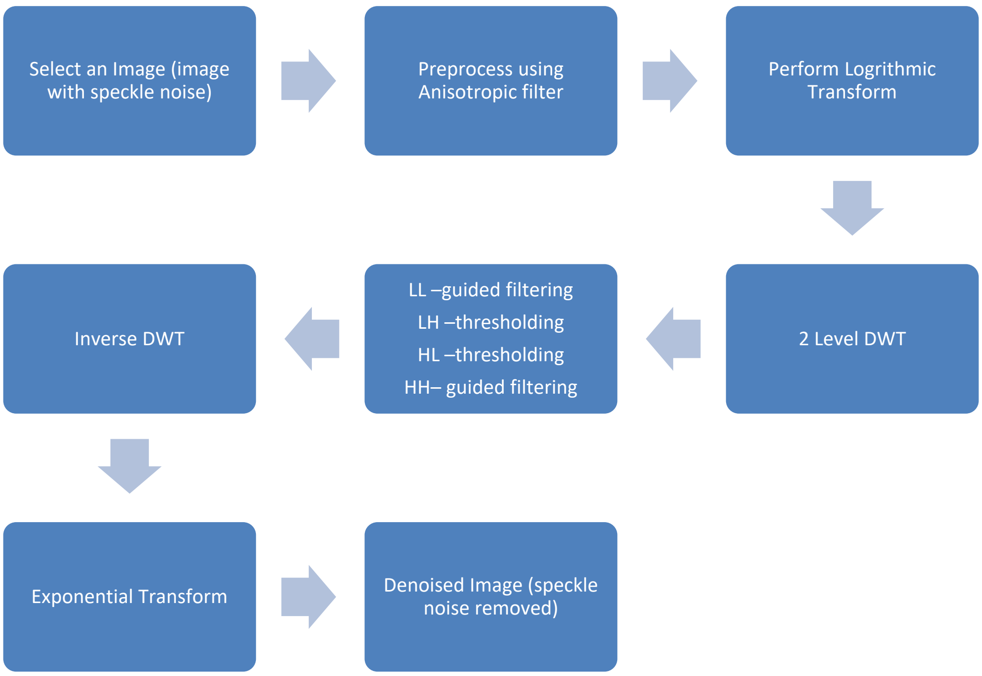
Block Diagram:



Methodology:

The utilization of ultrasound imaging in medical diagnosis is grounded due to its non-invasive nature, minimal effort, and the ability to form real-time imaging, and with good image quality. Be that as it may, it experiences a few weaknesses and these include securing noise from the instrument, environmental noise, and the presence of adipose tissue/fatty tissue, different organs, and anatomical impacts, for example, muscle to fat ratio, and breathing movement. Hence, noise reduction is significant, as different kinds of noise are produced to restrict the adequacy of medical diagnosis.

The essential objective of speckle noise reduction is to eliminate the speckle without losing a lot of information contained in the image. To accomplish this objective, the wavelet transform can be utilized which can then successfully decrease the speckle in the sub-bands as per the local neighborhood statistics within those bands. The major advantage of the wavelet transform is that the image constancy after reconstruction is typically lossless.

A wavelet is a mathematical function used to decompose a given function or continuous-time signal into different frequency components and study each component with a resolution that matches its scale. A wavelet transform is the representation of a function by wavelets. The wavelets are scaled and translated copies (known as daughter wavelets) of a finite length or fast decaying oscillating waveform (known as mother wavelet).

In ultrasound images, the major noise content is multiplicative. Such noise is for the most part harder to eliminate than additive noise clamor because the intensity of the noise varies with the image intensity. To change the multiplicative noise into additive noise, a logarithmic transform is applied to the speckle noise affected image. The noise component is then approximated as additive noise The Discrete Wavelet Transform (DWT) is then applied to the log-transformed image and the wavelet transformed image is subjected to thresholding and filtering with guided filters and frost filters. The guided filter is a kind of edge-preserving smoothing filter. The guided image filter can also filter out noise or texture while retaining sharp edges. While the frost filter based on the local statistics in a sliding window works on preserving the edges while suppressing the noise. After applying the inverse DWT, the processed image is subjected to an exponential transformation, which is the inverse logarithmic operation, which yields a denoised image.

Algorithm:

1. The noisy image is taken as the input
2. Preprocessing is done using an Anisotropic diffusion filter over the multiplicative speckle noise
3. Converting the multiplicative noise into additive noise using Logarithmic transform
4. Perform two-level Discrete Wavelet Transform which splits the image into LL (approximate), LH (vertical), HL (horizontal), and HH (diagonal) components
5. To the individual components perform the following:
    a. LL – approximate component apply guided filtering
    b. LH – vertical component performs thresholding
    c. HL – horizontal component performs thresholding
    d. HH – diagonal component apply guided filtering
6. Reconstruct image from the four components using Inverse Discrete Wavelet Transform
7. Perform Exponential transform to the reconstructed image to obtain the de-noised image