DESPECKLING OF MEDICAL ULTRASOUND IMAGES BASED ON WAVELETS AND ITS VARIANTS

Abstract

With the advent of digital image processing techniques, many medical image modalities like Computer Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), Ultrasound, etc. have been developed recently. Among them ultrasound is widely used because it is non-invasive, comparatively safe, portable, and economical. However, due to the coherence of backscattered echo signals, medical ultrasound images suffer from speckle noise. The presence of speckle degrades the image quality and destroys finer details, thus making it difficult for human diagnosis and interpretation. So, speckle removal is an important issue for analysis of ultrasound images. In despeckling, the main challenge is to remove the speckle noise by retaining edge details and other information content in an image. The main objective of this research is to supress the speckle noise while preserving the edge details in the medical ultrasound images. A comprehensive literature review has been presented on spatial domain and frequency domain filters. Some of the spatial domain filters are LEE filter, KUAN filter, Frost filter, Non Local Means (NLM) filters and diffusion filters. Frequency domain filters are based on wavelets and their variants which include wavelet packets, contourlets, Dual Tree Complex Wavelet Transform (DTCWT) etc. Some innovative techniques for edge preserving noise cleaning filters such as Symmetric Nearest Neighbor (SNN) filter, Locally Adaptive Regression Kernels (LARK) filter have been already developed in the recent years. Several wavelet based methods have been proposed for the purpose of image denoising. The wavelet shrinkage method iv is used to eliminate the noise by shrinking the wavelet coefficients in the wavelet domain. The main focus of this thesis is to reduce the speckle noise in ultrasound images and to preserve all the relevant features of the image. Four approaches investigated in this thesis work are summarized below:

- Adaptive wavelet packet transform along with adaptive thresholding.
- Direction sensitive wavelet packet along with shrinkage techniques.
- Directionally decimated wavelet packets with adaptive clustering.
- DTCWT with fuzzy based thresholding.

The first method proposes a Discrete Wavelet Packet Transform (DWPT) and bilateral filter along with adaptive thresholding for the despeckling of medical ultrasound images. The speckled ultrasound image is a first log-transformed to convert multiplicative noise into additive noise. Then, the image is subjected to wavelet packet decomposition, which results in a rich set of sub-bands, from which the best sub-bands are selected by Singular Value Decomposition (SVD) technique. The band with the highest singular value is subjected to bilateral filtering, whereas all other bands are thresholded using a modified NeighShrink technique. The proposed Adaptive Wavelet Packet Transform (AWPT) performs better than some of the existing state-of-the-art filters like SNN, NLM, and LARK filter. The PSNR value of the proposed method out-performs the SNN filter by 14%, the Lee filter by 1.4%, the Frost filter by 4.8%, the NLM filter by 1.2%, the LARK filter by 2.5% and wavelet thresholding by 0.75% respectively. v The second method attempts to minimize the impact of speckle noise through wavelet packet decomposition and Iterated Directional Filter Bank (IDFB) along with shrinkage techniques. Wavelet packet decomposition is performed on the image and best subbands are selected using singular value decomposition. The low frequency subband is preserved as it has the maximum information content. IDFB is applied on all other selected subbands. The vertical cells of the IDFB in the horizontal subbands and horizontal cells of IDFB in vertical subbands are eliminated because of their minimum edge information and maximum noise. Shrinkages are also applied on the

remaining cells which are to be evaluated. The PSNR of proposed technique is 8.2% better than AWPT, 15.6% better than WT, 11.9% better than NLM, 21.4% better than SNN, 14.1% better than FROST, and 14.2% better than LEE. The third method proposes a double filter bank structure using discrete wavelet packet transform and Directional Filter Bank(DFB) along with fuzzy based clustering techniques for the despeckling of ultrasound images. Wavelet packet transform can efficiently reject noise based on gray scale relational thresholding and DFB can efficiently preserve edge information. Decimation using DFB and clustering based on intensity of gray scale values is done to segregate noise out of the information. The algorithm provides consistent improvement over the competing state-of-the-art speckle reduction algorithms due to the improved ability to preserve geometric features while rejecting speckle noise. The PSNR value of the proposed method is 3.3% better than AWPT, 9.71 % better than SNN, 9.26% better than FROST and 5.48% better than LEE filter respectively. The MSSIM of the proposed technique achieved 2.15% better than AWPT, 6.97% better than NLM, and 14.81 % better than SNN filter respectively. vi The fourth method attempts to despeckle ultrasound images using Dual Tree Complex Wavelet Transform (DTCWT) and Possibilistic Fuzzy C-Means (PFCM) clustering. The increased directionality and shift invariance makes the DTCWT a good sample for speckle reduction. PFCM is employed for separating the information from noise. The PSNR value of the proposed method provided 6.79% better than AWPT, 31.37 % better than SNN, 15.97% better than FROST, and 11.87% better than LEE filter respectively