A Spatially Adaptive Filter Reducing Arc Stripe Noise for Sector Scan Medical Ultrasound Imaging

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Abstract

This paper analyzes the source and characteristics of the arc stripes, and then proposes an adaptive filter based on the geometrical properties of these arc stripes. The proposed filter is the weighted summation of radially adaptive filter and common Gaussian filter. The radially adaptive filter aims to reduce the arc stripe noise. The common Gaussian filter is used to counteract the radial stripe artifact produced by the radial filter and suppress the randomly directional noise as well. The weights of the radially adaptive filter and common Gaussian filter are adapted to the proportion between the arc stripe noise and non-directional noise. The results show that the combined filter obviously enhances the image quality and is superior to common Gaussian filter.

Method

The proposed filter is based on the geometric characteristics of these arc stripes, and it consists of two filtering components:

1. Radially Adaptive Filtering Operators
   1) Basic Radially Filtering Operators at Special Directions
   
   \[ \omega_{m} = \sum_{k=0}^{\pi/4} \theta_{m} \omega_{k} \theta_{m} \]
   
   \[ \omega_{k} = \begin{cases} 1 & \text{if } \theta \in [0, \pi/4) \text{ or } \theta \in [3\pi/4, \pi] \text{, otherwise.} 
   \end{cases} \]
   
   2) Radially Filtering Operators at Arbitrary Directions
   
   \[ \omega_{m} = \omega_{g} \omega_{m} + \omega_{m} \sum_{k=0}^{\pi/4} \theta_{m} \omega_{k} \theta_{m} \]
   
   The weight \( \omega_{g} \) and \( \omega_{m} \) are determined by the ratio of non-directional and arc stripe noise components
   
   The Gaussian standard deviations \( \sigma_{g} \) of \( \omega_{g} \) and \( \omega_{m} \) are determined by the size of non-directional and arc stripe noise respectively
   
   The size of filter mask is determined by noise size

2. Weighted Summation of the Radial Filtering Operator and Gaussian Filtering Operator

Result

Example 1: Transrectal ultrasound image of prostate

Example 2: Ultrasound image of fetus

Conclusion

- This paper identifies a significant noise, the arc stripes in sector scan medical ultrasound image; and generalizes the characteristics of the arc stripe noise.
- The proposed filtering algorithm deals with the arc stripe noise through utilizing the geometric characteristics of the special noise.
- The parameters of the filter are adapted with the radial depth in order to effectively smooth noise and deburr the useful image detail.
- The results show that the proposed filter obviously enhances image quality and is superior to common smoothing filter.