SPECKLE REDUCTION OF SAR IMAGES USING SURE-BASED ADAPTIVE SIGMOID THRESHOLDINGS IN THE WAVELET DOMAIN

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ABSTRACT

Synthetic aperture radar (SAR) images are corrupted by speckle noise due to random interference of electromagnetic waves. The speckle degrades the quality of the images and makes interpretations, analysis and classifications of SAR images harder. Therefore, some speckle reduction is necessary prior to the processing of SAR images. The speckle noise can be modeled as multiplicative Rayleigh noise. Logarithmic transformation of SAR images convert the multiplicative noise models to additive *i.i.d.* The speckle noise is suppressed by applying a speckle removal filters on the digital image before display and further analysis. A commonly used filter is the Lee filter [1]. It is based on local variance statistics, but research in this area is still open.

The most straightforward way of distinguishing information from noise in the wavelet domain consists of thresholding the wavelet coefficients. An appropriate thresholding for further reconstruction of denoised image plays a key role in the wavelet decomposition/reconstruction procedure. Since the work of Donoho & Johnstone [2,3] who proposed the most popular strategy, soft thresholding, many alternative methods have come forth. We cite here, hard and semi-soft thresholding, VisuShrink [3], SureSrink [4], BiShrink [5], BayesShrink [6] and SURE-LET [7].

Recently, Sveinsson and Benediktsson [7], proposed an adaptive sigmoid thresholding method in the wavelet domain. It is based on a nonlinear function similar to the activation function commonly used in neural networks. The coefficients thresholding for this method is based on the choice of two parameters in the Sigmoid thresholding function. They were chosen according to a visual appreciation, i.e., by an *ad. hoc* method. We propose in this paper to select these parameters by minimizing an estimate of square error between the clean image and the denoised one. The key point is that we have in our proposal a very accurate, statistically unbiased, MSE estimate – Stein's Unbiased Risk Estimate [8],[9]– that depends on the noisy image alone, not on the clean one. This is suitable in image denoising, because, in practice, we only have access to the noisy image not to the clean image.

In order to evaluate the denoising methods, both a simulated SAR image, based on the well-known Lena image and a real SAR image were used. The real SAR image used in the experiments is 8-bit single-look ERS-1 SAR image which shows a portion of the glacier Kotlujokull in the southern part of Iceland. It is a summertime image showing the glacier and the landscape. The obtained results were excellent both in terms of metrical comparison to other approaches and visual inspection. In particular, the proposed method significantly outperforms the *ad hoc.* method which does not come as a surprise since the proposed approach uses computational methods to select the parameters whereas the *ad hoc.* method is based on visual appreciation.

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