WAVELET BASED DENOISING TECHNIQUES FOR ULTRASOUND IMAGES

Ivana Duskunovic, Aleksandra Pizurica, Gjenna Stippel, Wilfried Philips, Ignace Lemahieu

Department for Telecommunications and Information Processing
Ghent University
Sint-Pietersnieuwstraat 41, B-9000 Ghent-Belgium
Tel.: +32 9 264 34 15
id@telin.rug.ac.be

Abstract - Clinical research has shown a clear correlation between white matter disorders of the neonatal brain and neuro-motoric handicap at a later age. The visual interpretation of ultrasound images is a proven method to detect White Matter Damage at an early stage. A problem, common to all medical ultrasound images, is the presence of speckle noise, which not only complicates the visual interpretation of images, but also the quantitative measurements. In this article we compare two wavelet based filtering methods which are applied in order to remove speckle noise and preserve details as well. The first one is a new wavelet-based method for image denoising that applies the Bayesian framework, using prior knowledge about the spatial clustering of the wavelet coefficients. Local spatial interactions of the wavelet coefficients are modeled by adopting a Markov Random Field model. The second one is a new filtering method, based on a recursive filtering of detail images obtained from a wavelet decomposition of the image by using spatial filtering which is based on threshold decomposition and simple spatial rules.

Keywords - Wavelets, denoising, speckle

1. INTRODUCTION

Ultrasound is the perfect means for morphological investigation of the neonatal brain. With real time ultrasound, most of the diseases can be discovered and followed, and this with a harmless non-invasive technique (with normal use of ultrasound). In particular post-asphyctic damage, white matter damage matrix-bleedings, intro-cranial bleedings, hydro-cephally and a big group of congenital malformations can be investigated well by ultrasound. It is logical and desirable to research quantitatively the echo-reflections that come from the neonatal brain. Measuring the echo-density is a means to reach this goal. One of the reasons this method has never been applied before, is the great difficulty to control a large series of variables. In order to make an objective diagnosis it is necessary to perform numerical measurements on ultrasound images, for which we need reliable data. From the forgoing it is already clear that suppression of speckle noise is necessary to get reliable measurements. At the moment we are researching new filtering techniques in order to remove this speckle noise as much as possible and preserve details as well. In this article we compare two new noise removal techniques, based on wavelet decomposition, applied to speckle images. We use a discrete redundant wavelet decomposition with spline wavelets [1]. This decomposition produces at each resolution scale one set of scaling coefficients (low pass image) and two sets of wavelet coefficients containing the band pass information in horizontal and vertical directions. These sets of wavelet coefficients are referred to as detail images. The first method applies Bayesian schrinkage of the wavelet coefficients using MRF model to express the prior knowledge about the statial clustering of the coefficients. The second method recursivelly applies simple spatial rules to detail images in order determine and clean noisy wavelet coefficients.

2. THE FIRST METHOD

First, we introduce the notation, which is similar to the one that is used in [2]. Because the same modification rule is applied at all the levels and orientations in the wavelet decomposition, the wavelet coefficients carry the spatial position as the only index. We adopt a simple numbering of pixels by using a raste,r scanning and assigning a sequence number l to each pixel. The set of all indices l for a given array of pixels is denoted by S. Hence, the set $\mathbf{W} = \{W_l | l \in S\}$ is the set of wavelet coefficients at a given scale and orientation. $\mathbf{X} = \{X_l | l \in S\}$ represents a set of binary labels, which take value 1 if the corresponding wavelet coefficient is meaningful and 0 otherwise. Sets $\mathbf{X}$ of this type are called masks. Finally, the set $\mathbf{M} = \{M_l | l \in S\}$ denotes a set of noise measures, which indicate how noisy the wavelet coefficients are. In particular, we choose $M_l = |W_l|$. Random variables are denoted as capital letters and their realizations as the corresponding small letters. Vectors are denoted as