Chapter 31
Denoising Ultrasound Medical Images: A Block Based Hard and Soft Thresholding in Wavelet Domain

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ABSTRACT

Medical ultrasound imaging has revolutioned the diagnostics of human body in the last few decades. The major drawback of ultrasound medical images is speckle noise. Speckle noise in ultrasound images is because of multiple reflections of ultrasound waves from hard tissues. Speckle noise degrades the medical ultrasound images lessening the visible quality of the image. The aim of this paper is to improve the image quality of ultrasound medical images by applying block based hard and soft thresholding on wavelet coefficients. Medical ultrasound image transformation to wavelet domain uses debauchee's mother wavelet. Divide the approximate and detailed coefficients into uniform blocks of size 8×8, 16×16, 32×32 and 64×64. Hard and soft thresholding on these blocks of approximate and detailed coefficients reduces speckle noise. Inverse transformation to original spatial domain produces a noise reduced ultrasound image. Experiments on medical ultrasound images obtained from diagnostic centers in Vijayawada, India show good improvements to ultrasound images visually. Quality of improved images in measured using peak signal to noise ratio (PSNR), image quality index (IQI), structural similarity index (SSIM).

1. INTRODUCTION

Medical ultrasound imaging (Hennersperger, Baust., Waelkens, Karamalis, Ahmadi & Navab, 2014) ;(Rabinovich, Friedman & Feuer, 2013);(Anquez, Angelini, Grange & Bloch, 2013) is extensively used to diagnostics of internal human body parts invasively. Ultrasound imaging tool has been cost-effective, portable and time saving. Computed Tomography (CT), Magnetic Resonance Imaging (MRI) produce

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quality images compared to ultrasound imaging. Drawbacks include high operating costs along with dangerously harmful electromagnetic radiations. With the advent of signal processing algorithms demand for ultrasound image enhancements are on the high among the research communities around the world (Hacini, Hachouf & Djemal,2014);(Müller, Viaccoz, Kuzmanovic, Bonvin, Burkhardt, Bochaton & Sztajzel,2014); (Deep Gupta, Anand & Tyagi,2014);(Mace, Montaldo, Osmanski, Cohen, Fink & Tanter,2013).

Image quality is the primary concern in ultrasound imaging due to the presence of speckle signals that are picked up by the receiver from the hard tissues in the human body (Liang, Yung & Yu, 2013); (Donati, Martini & Tambosso, 2013). To understand and investigate ultrasound images in order to obtain quantitative information from them is a daunting task even for a trained eye. Safety and inexpensive nature of ultrasound technology is the reason behind their extensive use in many clinical applications. The challenge before researchers is to appendage medical ultrasound images for legitimate and accurate information for diagnosis (Mauldin, Dan Lin & Hossack, 2011); (Asl & Mahloojifar, 2012);(Chengpu, Zhang & Lihua Xie, 2012).

Medical ultra sonographic images are meagerly visible as the scanning process results in speckle noise (Tay, Garson, Acton & Hossack, 2010) which occurs especially in the images of fetus of pregnant woman, whose underlying structures are too small to be resolved by large wavelengths (Rueda, Fathima, Knight, Yaqub, Papageorghiou, Rahmatullah,; Foi, Maggioni, Pepe, Tohka, Stebbing, McManigle, Ciurte, Bresson, Cuadra, Changming Sun, Ponomarev, Gelfand, Kazanov, Ching-Wei Wang, Hsiang-Chou Chen, Chun-Wei Peng, Hung & Noble, 2014). Thus speckle reduction (de-speckling)is an important characteristic for analysis of ultrasound images. Many algorithms have been developed on despeckling in spatial (Abd-Elmoniem, Youssef & Kadah, 2002) and transformed (Rabbani, Vafadust, Abolmaesumi, & Gazor, 2008) domains in last decade. The algorithms in literature offer good denoising leaving their effect on the edges of the objects in the image.

Spatial filters have been generally used for eliminate noise from images (Charles & Rozell, 2014). Spatial filters typically soften the intensity levels of pixels to reduce the noise. Though spatial filters are good at reducing noise to a large extent, they suffer by inducing blur to the edges of objects in the image. Numerous new techniques have been reported in the last few years which improve on spatial filters by removing the noise more effectively while preserving the edges in the data. Some of these techniques use the concepts of partial differential equations and computational fluid dynamics such as level set methods(Estellers, Zosso, Rongjie, Osher, Thiran & Bresson, 2012), total variation methods(Drapaca,2009), nonlinear isotropic and anisotropic diffusion(Elmoniem, Youssef & Kadah,2002). Various other techniques combine impulse removal filters with local adaptive filtering in the transform domain to remove not only white and mixed noise, but also their mixtures (Rabbani, Vafadust, Abolmaesumi, & Gazor, 2008). In order to reduce the presence of noise in medical images many techniques are available from the past such as linear filtering (Simon,VanBaren & Ebbini, 1998) adaptive filtering (Weiner Filters) (Hasegawa, Kageyama & Kanai, 2013) and median filtering (Czerwinski, Jones & O'Brien, 1995). However, digital filters, linear filters and adaptive filters proved to reduce noise in stationary signals. For reducing noise from non-stationary signals, wavelet transform has been proven to be a useful tool for signal and image analysis (Michailovich & Adam, 2002). Researchers have proposed many de-noising algorithms on wavelet framework effectively but they suffer from shortcomings such as oscillations, shift variance, aliasing, and lack of directionality.

The most widely used techniques for denoising in image processing are wavelet transform based hard and soft thresholding (Jing, Yipeng, Qiang & Shen Yi, 2012); (Chen & Zhou, 2012). These two