ABSTRACT

The advent of medical imaging technologies such as computed tomography (CT), ultrasound, magnetic resonance imaging (MRI), and molecular imaging has revolutionized the diagnostics in modern medicine. Medical imaging provides the useful information like physiological and anatomical condition of the patients to the clinicians which help in diagnosis and further for treatment phases. Among other imaging modalities such as X-ray, CT, and molecular imaging, MRI plays an important role in modern medical diagnosis and clinical applications because of accurate representations and functional characterization of the internal human body and its non-invasive technology. Magnetic resonance (MR) images are affected by random noise during the acquisition process either by single-coil or multi-coil acquisitions. Such a noise not only degrades the diagnostic quality of the images but also affects the performance of other image processing and analysis tasks. Therefore, denoising is used to improve the image quality for more accurate diagnosis. Also, it is used as a preprocessing step in many image processing procedures such as segmentation and registration. An efficient denoising method should remove as much as noise possible while preserving the image anatomical structures.

It has been shown that the noise in magnitude MR images follows a Rician distribution, which is signal dependent. It is particularly difficult to

remove the random fluctuations and bias introduced by Rician noise. A variety of techniques have been presented in the literature for denoising MR images with Rician noise and each technique has its own assumptions, merits, and demerits. A trade-off between noise reduction and preservation of the useful image features still persists and is a challenging problem in MR image denoising. Hence, a lot of research is being done in the estimation and removal of noise.

In this thesis, new methodologies are proposed and analyzed for denoising MR images acquired using both single-coil and multi-coil acquisition based on Neutrosophic Set (NS) theory to achieve a balance between noise reduction and structure preservation. Three different denoising methods such as Neutrosophic set approach of median filtering (NS median), Neutrosophic set approach of Wiener filtering (NS Wiener), and Nonlocal neutrosophic set approach of Wiener filtering (NLNS Wiener) are proposed for single-coil acquired MR image which introduces a uniformly distributed Rician noise. For denoising multi-coil acquired MR image which introduces a spatially varying noise level, the nonlocal neutrosophic set approach of spatially adaptive median filtering (NLNSAM) is proposed.

Performance of the proposed denoising methods are evaluated based on the ability of noise removal and structure preservation by using both the simulated MR images from Brainweb database and clinical MR images

and compared with the state-of-the art methods in terms of qualitative and quantitative measures. For noise removal, different performance metrics such as peak signal to noise ratio (PSNR), structural similarity index (SSIM), Bhattacharyya coefficient (BC), and the mean absolute difference (MAD) are used. To ensure structure preservation, the denoised image is compared with the original (noise-free) image and the residual image by visual inspection.

In general, the experimental results demonstrate that the proposed denoising methods exhibit better performance in removing the noise and preserve the anatomical structures of MR images. For automated brain tumor segmentation, the proposed NLNS Wiener method is used as the pre-processing step for denoising, to enhance the performance of segmentation.