Denoising Multi-coil Magnetic Resonance Imaging Using Nonlocal Means on Extended LMMSE

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Abstract Denoising plays key role in the field of medical images. Reliable estimation and noise removal is very important for accurate diagnosis of the disease. This should be done in such a way that original resolution is retained while maintaining the valuable features. Multi-coil Magnetic Resonance Image(MRI) trails nonstationary noise following Rician and Noncentral Chi(nc-χ) distribution. On using the modern techniques which make use of multi-coil MRI like in GRAPPA would yield nc-χ distributed data. There has been lots of research done on the Rician nature but only few for nc-χ distribution. The proposed method uses Nonlocal Mean(NLM) on extended Linear Minimum Mean Square Error(ELMMSE) for denoising multi-coil MRI having nc-χ distributed data. The performance of the nonlocal scheme on multi-coil MRI is evaluated based on PSNR, SSIM and MSE and the result indicates proposed scheme is better than the existing scheme including Non local Maximum Likelihood(NLML), adaptive NLML and ELMMSE.

1 Introduction

Noise is an important factor which decreases the quality of the image. It is an unwanted information that comes along the required data during the image acquisition and image transmission. Medical image plays an important part for diagnosing the disease. Medical images shows visual representation of the interior body which will be helpful for the medical analysis. Major medical imaging modalities include Radiography, MRI, Nuclear Medicine, Computed Tomography(CT), Ultrasound. For studying the soft tissues CT and MRI can be used.

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MRI provides higher details of soft tissues and is also preferred greatly for tumor detection. Even though the scanning duration is lesser for CT, it uses x-rays to construct the image and radiation from these are harmful. Presence of noise in medical images like MRI will result in poor visual quality and physician won't be able to diagnose the disease correctly. These noise can also affect the MRI post processing algorithms.

In single coil MRI the noise distribution will be stationary and magnitude data is coped with Rician, Gaussian and Rayleigh distribution. It is on an assumption that only single σ value featuring the complete data. Modern techniques make use of multi-coil MRI in which noise varies with position in the image i.e. nonstationary data. Multi-coil magnitude data follows Rician and nc-χ distributed. Systems like Generalized Auto calibrating Partially Parallel Acquisitions(GRAPPA) trails nc-χ distributed magnitude data. There has been a lot of literature work done on the Rician nature of the noise but very few for the nc-χ distribution.

The objective of the MRI denoising technique is to remove the noisy information from the original image. Raw data acquired from MRI scanning are complex values and it can be represented in Fourier transform as:

$$M = x + iy \tag{1}$$

The noise added to the MRI can be expressed as:

$$M = (x + n_{re}) + i(y + n_{im}) \tag{2}$$

The magnitude of the noisy raw data can be given as:

$$|M| = \sqrt{(x + n_{re})^2 + i(y + n_{im})^2} \tag{3}$$

In order to reduce noise, methods like acquiring MR data repeatedly and then averaging these data can be used. But this technique increases the capturing time. Another way to reduce noise is, by utilizing post processing techniques. The denoising technique needs to be selected in such a way that it should not modify the original features of the MRI.

In Sections 2, the related work of multi-coil MRI denoising methods for nc-χ distributed data are discussed, section 3 explains the theory behind proposed method. In Section 4, experiments and results are discussed. Finally, conclusions are drawn in Section 5.

2 Related Work

Several Rician noise removal techniques are available in the literature for denoising MRI. For example linear estimators [1], Partial Differential Equations (PDE) [2, 3],