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DT- MRI Noise Reduction based on 2D Anisotropic Diffusion Filtering

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Objectives & Backgrounds : Diffusion Tensor Magnetic Resonance Imaging (DT-MRI) is a new technique that measures water diffusion anisotropy of a tissue. It provides useful information about characteristics of the tissue and is also helpful for fiber tracking since diffusion anisotropy is correlated with fiber orientation in white matter .Recent studies have shown that the abnormalities change water mobility in the brain tissue. Apparent Diffusion Coefficient (ADC) is suggested as a biomarker to distinguish necrosis from recurrence brain tumors. Noise can bias ADC calculation, so reduction of DT-MRI noise necessary. The noise should be removed while preserving tissue boundaries. A nonlinear diffusion filtering based on Perona and Malik [1] (PM) has been used to reduce DT-MRI noise [2]. This method is based on gradient of image and is sensitive to estimated directions. In another attempt, a 3D anisotropic diffusion filter based on Wieckert [3] has been proposed [4]. This method is appropriate when fiber tracking is the goal .It uses the DT-MRI of different directions and slices to construct gradient tensor and remove the noise. In this work, a 2D anisotropic diffusion filtering is proposed to suppress the noise effects on ADC calculation. This method is simpler and faster than 3D anisotropic filtering and is applied to each slice independently.

Materials & Method : The proposed method is based on an anisotropic diffusion filtering technique that smoothes images (I) using the gradient information. At first a gradient tensor (G) is constructed as follows :where G is the product of a Gaussian function with standard deviation convolved with the outer product of gradient intensity. It is an average over different orientations. The Eigen values and eigenvectors of G show the directions of the largest and smallest gradients. A structure tensor (T) is constructed from G by reversing the order of Eigen values and leaving eigenvectors unchanged. Then T is used in: where I is the image intensity, is the image gradient and t is the iteration of the algorithm. Consequently, there is larger (smaller) smoothing along the direction of smaller (larger) gradient ,preserving the boundaries while

removing the noise from homogeneous regions. We have simulated DT-MRI with different b values to evaluate the proposed method .

Results: The input data is the simulated DT-MRI corrupted with Gaussian noises with different standard deviations (SD). Three different filters are tested and compared on the data: The proposed method, a PM filter and a low pass averaging filter. The results show that the proposed method has preserved the boundaries while the averaging filter has blurred the images. In the following table, the SNR results are compared for the three filters applied to DT-MR images with b=1000. N is the iteration of the algorithm. Increasing N will remove noise better while smoothing the image. Noise SD 0.05 0.1 0.15 Elapsed time (Sec (.Proposed Method 73.96 db, N=25 68.07 db, N=50 33.95 db, N=75 0.48 PM filter ۲۶,۰۲ db, N=25 32.76 db, N=50 30.89 db, N=75 0.34 Averaging filter 23.14 db 23.14 db 23.14 db 0.0023 Application of 3D anisotropic diffusion filtering on DT-MRI prepared in 25 directions took

about 8 min. using MATLAB 7. on a PC 1.7GHZ. Discussion & Conclusion In order to denoise DT-MRI, a simple and fast method is proposed based on 2D anisotropic diffusion filtering. According to gradient intensity information, larger smoothing is achieved in the homogeneous regions while preserving the boundaries. For diagnosis applications ,a 2D anisotropic diffusion filter is sufficient to suppress the noise from DT-MRI but for fiber tracking a 3D anisotropy diffusion filter may be needed .The results have shown that the proposed filter is more appropriate than a linear smoothing filter.

Keyword: Diffusion Tensor MRI (DT-MRI) , Anisotropy diffusion filtering , Noise suppression , Edge preserving filter, Apparent Diffusion Coefficient (ADC)

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