EE 574 PROJECT PROPOSAL

FIBER TRACTOGRAPHY USING BRAIN DT-MRI DATA AND VTK VISUALIZATION

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INTRODUCTION

Diffusion Tensor Imaging (DTI) is an MRI technique that gives information about the random thermal motion of water molecules in the human brain. The diffusion of water molecules in the human brain is different in white and gray matter regions. In white matter regions, where axons are similarly aligned, diffusion is mostly anisotropic in the direction of axons of the neurons whereas in gray matter regions, where less ordered tissue structure is observed, it is mostly isotropic. This property enables to distinguish between white and gray matter regions and with DTI, pathological changes such as those occurring in multiple sclerosis, tumors etc. can be observed. [1]

Despite the fact that DTI data gives information about the direction of each voxel, it gives no information about the connections between different voxels. Different techniques are employed in constructing this connection, which will be the main idea of this project. Tensor data assigns a matrix to each point to the 3D brain image. The eigenvalues of these matrices give information about the amount of diffusion and the eigendirections are associated with the directions of the diffusion. Two methods will be employed in tracting fiber trajectories :

The first method assumes the dominancy of one of these eigenvalues relative to the others, which means that the other eigenvalues have values 0 and the diffusion is anisotropic exactly in the direction of the eigenvector corresponding to the highest eigenvalue. These eigenvectors corresponding to the highest eigenvalues will be tracted using Euler's and 4th order Runge-Kutta methods. The stopping criteria in this method are reaching the image boundaries or anisotrophy falling under a specific threshold. [2] & [3]

Fast marching algorithm will be implemented as the second step of the project. The fast marching algorithm utilizes rules of the level set theory and includes the evolution of a closed region up to the boundaries of the structure which it's in over time. The boundary of this region (which is also called the front) propogates in the direction where the eigenvector corresponding to the highest eigenvalue and the normal to the front at that point are most similar (i.e. are in the same direction). By starting from many seed points and propogating according to these rules, every voxel in the image is assigned an arrival time, which can be used as a measure for the connectedness of these points and the seed such that, points that have smaller arrival times are more related to the seed points than those that have higher arrival times. The connection between these points within the arrival time and the seeds points are established by minimizing the arrival time T between these points by steepest descent method. [4]

B-Spline interpolation will also be implemented to provide smoothess of the fiber tracts.

After segmenting the fiber tracts, they will be presented to the user in an interactive program. A windows executable will be created using Visual C++ and WIN32 API. Visualization will be accomplished by VTK 4.0 C++ Library. Axial, sagital and coronal views and their corresponding 3D form will be presented to user.

REFERENCES

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[2] Peter J Basser, Sinisa Pajevic, Carlo Pierpaoli and Akram Aldroubi, "Fiber Tract Following in the Human Brain Using DT-MRI Data", IEICE Trans . Inf. & Syst. Vol E85-D January 2002

[3] C.R. Tench, P.S. Morgan, M. Wilson, and L.D. Blumhardt, "White Matter Mapping Using Diffusion Tensor MRI", Magnetic Resonance in Medicine 47:967–972 (2002)

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