Tracking of CE-MR-Angiography data using established approaches in DTI

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Introduction

MR angiography is routinely used to examine the vascular system of different body parts like the human head or the extremities. Typically, volume data sets are acquired with and without contrast agent from which subtraction images and maximum intensity projections are computed, which then highlight the vascular system. However, no quantitative data can be derived from such a dataset since the MIP-images are 2D images only, which do not contain any information about the vessel paths in the projection direction. To obtain such information one has to perform further post processing on the data set to segment the vascular system which is, in general, model dependent and either adapted and optimized to find large or small vessels. The idea of this study was to exploit the tremendous advances made with diffusion tensor tracking and to these techniques to MR angiography data in order to obtain a 3-dimensional model of a vascular system.

Materials and Methods

High resolution 3D MR data of the left leg of a healthy volunteer was acquired on a 3T MR-Scanner (Siemens, Erlangen Germany) with an isotropic resolution of 0.45 x 0.45 x 0.45 mm³. Two volumes were acquired with and without an intravascular contrast agent (Vasovist, Bayer-Schering). Starting from the subtraction images the Hessian matrix was calculated at different scales [1]. The particular Hessian matrix which show the largest deviations among its separate elements between the different scales was chosen to generate an artificial tensor data set within each voxel for the complete data set. The conversion from the Hessian matrix to a pseudo diffusion tensor is necessary, since the shape of the Hessian matrix is complementary to the tensor shape which is required for tracking the vascular structure. Subsequently this created tensor data set was used for deterministic tracking by using the diffusion toolkit [2]. The seed points for the streamline tracking were derived from the so-called vesselness function [1], which ranges from 0 to 1. Voxel in which the vesselness exceeded 0.3 were selected as seed points. In addition, the same threshold was chosen to mask and limit the tracking procedure. Memory limitations of the program required partitioning of the data set, which actually limits the application of the technique to the whole data set *en bloc* currently. The tractograms were finally composed to a complete data set and visualized employing Trackvis [2].

Results

As shown in Fig. 1 the pseudo diffusion tensor data are suited to generate fiber tracts which model the vascular system. The major vessels are reconstructed even if they branch. Small vessels are also visible and it is nicely shown how the tracts are aligned with respect to each other.

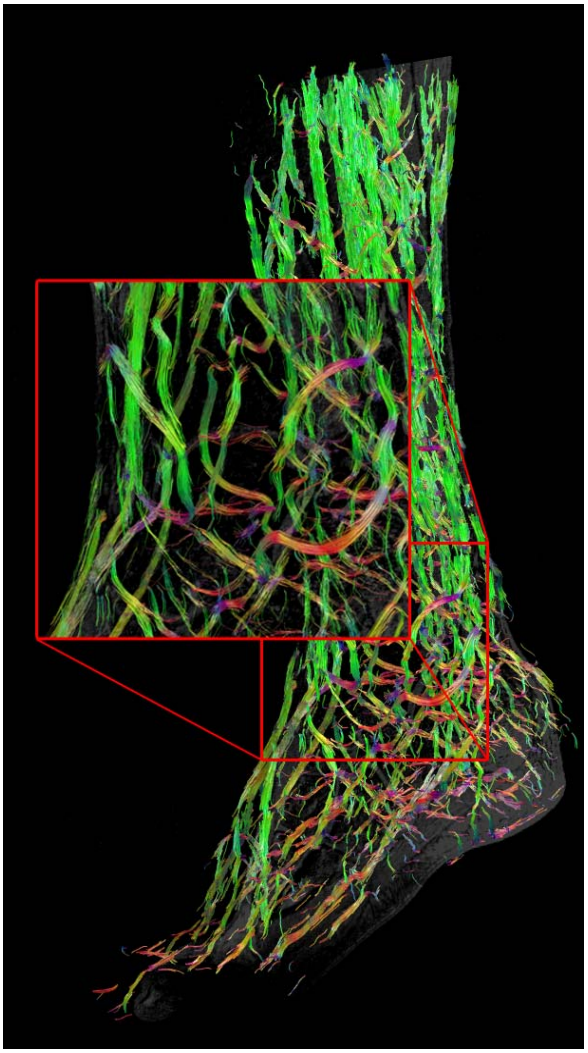

Fig. 1 – Streamline tracking results of pseudo diffusion tensor data derived from a subtraction MR angiography volume of the left leg of a healthy volunteer. The color encoding reflects the direction of the fiber segments (green – inferior-superior, red – left-right, blue – anterior-posterior)

Discussion

We were able to demonstrate that it is possible to generate artificial diffusion tensor data from MR angiography data sets in order to create fiber tracts by employing existing DTI tools. This approach is not limited to CE-MR angiography data. It should be easily adaptable to DSA or MR ToF data. In fact, almost any tracking tool for DTI data can be used to generate the tracts. Although branching of vessels was detected it can also result in interrupted tracts. This limitation should be overcome by applying probabilistic tracking methods. Clustering algorithms should then easily distinguish between different vessels and vessel trees and should be able to separate arteries from veins.

References

[1] Jackowski M, et al, MICCAI Int Conf. 2005; 8(Pt 2): 701-8

[2] Ruopeng Wang, Van J. Wedeen, Diffusion Toolkit, http://www.trackvis.org, 2007