Tracking a Physical Phantom by Global Fibre Reconstruction

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1 The Approach

Our method relies on the 'Global Fibre Tracking' approach as proposed in the joint workshop paper [1]. The benchmark setting adapts more to common 'local' tracking approaches that are based on seed points: the organizers published together with the measurement of the physical phantom a set of 16 'seed' voxels. For each voxel the participants have to submit *one* fibre. As our 'global' approach does not have any seed points we had to find a selection strategy to find the most probable fibre passing through the seed voxels based on the global reconstruction. The basic idea is to cluster the fibres going through a seed point into bundles and, then, choose the most probable one by a certain coherence measure.

In the following we shortly explain what parameters were used for the global tracking and how the final fibres were created.

1.1 Global Tracking

We decided for the dataset with $b = 2000$ and $3 \times 3 \times 3\ mm$ resolution, because it seems that our algorithm has no problems with the reduced SNR. We worked directly with the raw data, no preprocessing was done. A mask was created by thresholding the smoothed b_0-image. Conforming to the notation in [1] we have chosen the following parameters $c = 2.5$, $w = 1.2mm$, $\ell = 2.4mm$, $w = 0.001$, $L = 0.4$, $T_{\text{start}} = 0.5$, $T_{\text{stop}} = 0.01$, $its = 5 \cdot 10^8$. The final global reconstruction contains about 5000 fibres. The parameters were manually adjusted to obtain most plausible results. Of course, this is a critical issue.

1.2 Fibre Selection

First, all fibres passing through a seed voxel are selected. Then, a clustering procedure is used to divide the fibres in certain bundles. This was done by a simple hierarchical clustering (the *MATLAB*-function `Z=linkage(X,'complete')`). To compute the distance measure between two fibres the fibres were reparametrized with respect to arclength and and normalized to unit length. We just used the point-by-point squared distances to define the 'fibre distance'. The orientation of the fibres are selected such that this distance is minimized. That is, the distance measure can be written as

$$d^2(f, f') = \min\left(\int_0^1 |f(t) - f'(t)|^2 \, dt, \int_0^1 |f(1-t) - f'(t)|^2 \, dt\right)$$

The expected number of clusters was set such that we have on average 5 fibres in each cluster (the *MATLAB*-function `cluster(Z,'maxclust',N/5)`, where `N` is the number of fibres visiting the seed point). Once the clusters $\mathcal{C} = \{C_i\}$ are obtained we have to decide for the most probable one. Therefore we computed the fitness measure

$$F(C) = \frac{1}{|C|} \sum_{f \in C, f' \in C} e^{-\lambda d^2(f, f')}.$$

which reflects the coherence within the cluster together with the number of the fibres contained in the cluster. The parameter λ was set to $\lambda = 0.5$. The cluster with maximal F is selected. To obtain a fibre representing the selected cluster a simple average over all members is computed, where the correspondence along the fibre is defined by the arc-length parameter t, similar as for the distance computation above:

$$f_{\text{avg}}(t) = \frac{1}{|C|} \sum_{f \in C} f(t)$$

2 Examples

In Figure 1 we show the 16 averaged fibers obtained from the above described procedure. For certain seed points the decisions are a little bit unstable, i.e. the decisions are sensitive to the parameter choice. Especially for seed 6,8,10 and 12 there are no definite 'winners'. The last three are all involved in the 'kissing' configuration. In Figure 2 some the competing clusters are shown for seed 6 and 8.

References

1. Reisert M, Mader I, Kiselev V. Global reconstruction of neuronal fibres. In Proceedings of MICCAI, Diffusion Modelling Workshop. 2009; .

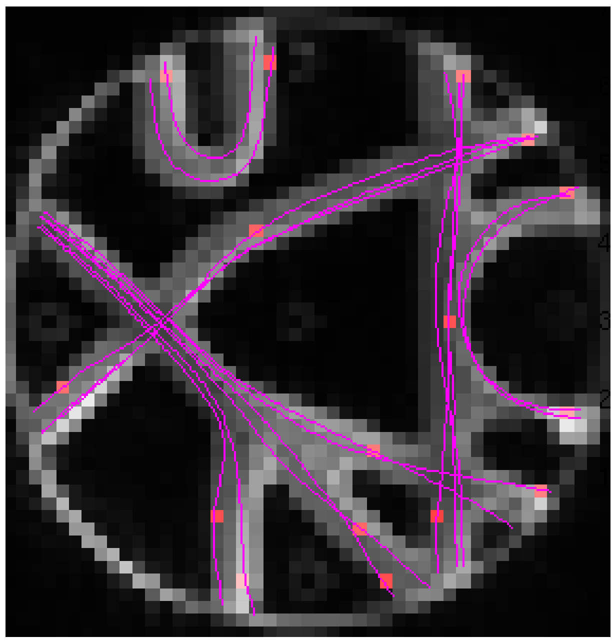

Fig. 1. The sixteen 'average' fibers together with the seed voxels are shown.

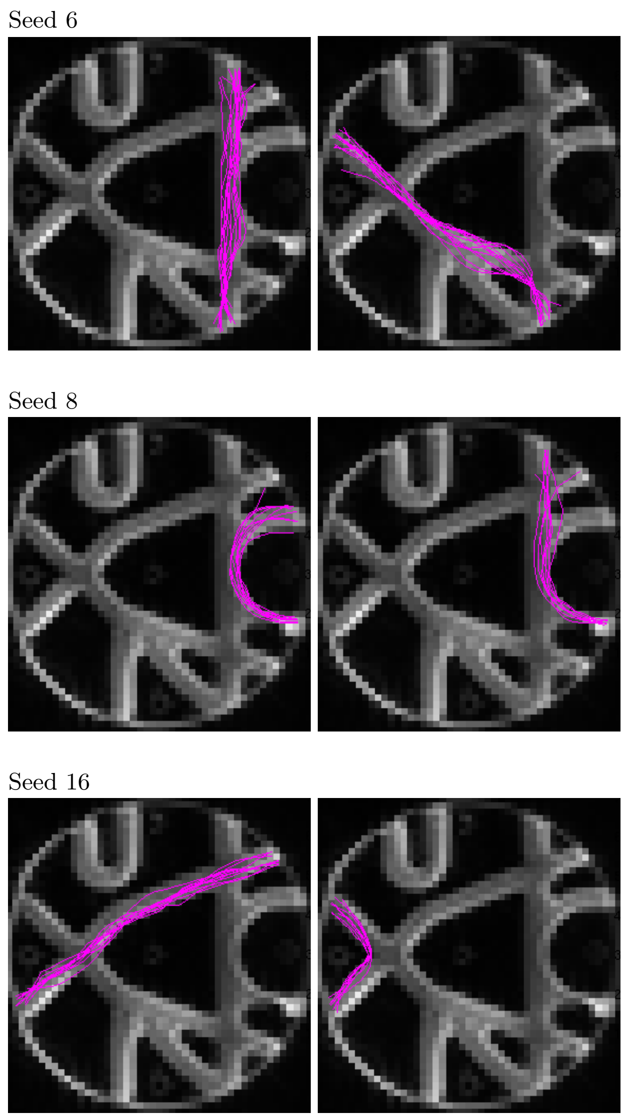

Fig. 2. For each of the seeds 6,8 and 16 two competetive clusters are shown. In particular for seed 6 and 8 the decisions for one of them are unstable.