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Introduction

With diffusion MRI (dMRI) based fiber tractography (FT), brain white matter fiber pathways can be reconstructed in vivo and noninvasively[2]. Recent work has shown that reliable and consistent computation of these fiber trajectories is challenging as there are various algorithms with different user-defined settings[4]. In particular, it is well known that probabilistic FT approaches can produce more false positive reconstructions than the deterministic ones. On the other hand, while deterministic FT approaches can sample dominant peak orientations from the fiber orientation distribution (FOD) in a robust way, they typically produce more false negative pathways (Fig. 1).

We developed a novel way to reconstruct pathways by considering a peak selection strategy that also integrates the orientations with a higher angular deviation. By incorporating prior knowledge of the location of seed and target regions of interest (ROI) while maintaining a deterministic view of FT, we can provide a more balanced tradeoff between true and false positive reconstructions.

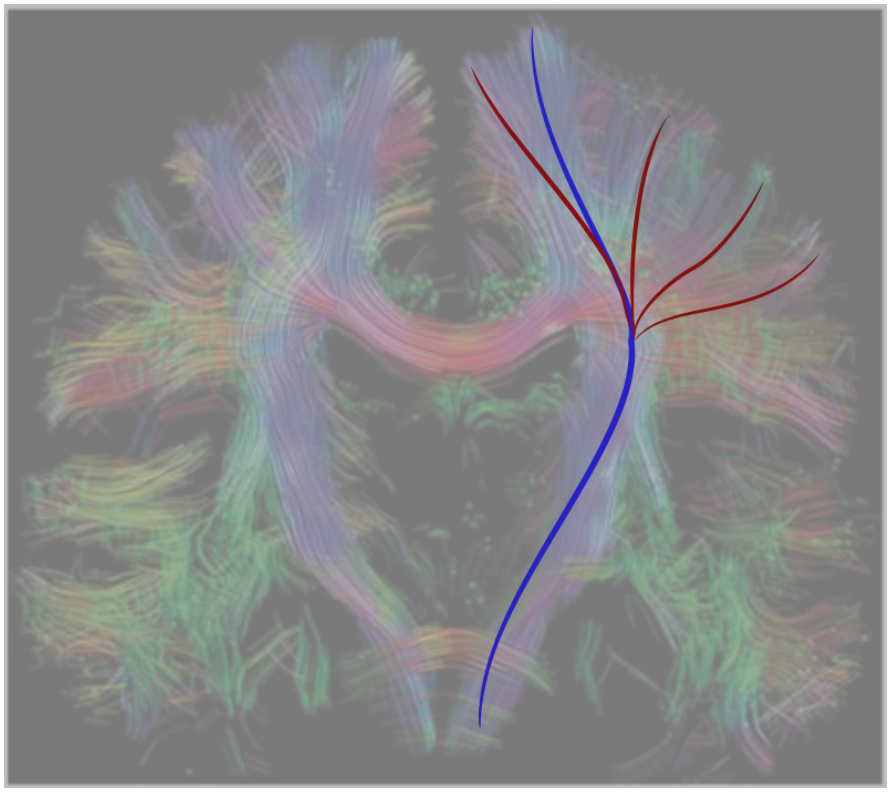

Fig. 1: Current FT methods only use a part of the FOD peak information, reconstructing a subset of the pathways (blue). We aim to use the neglected information, to reconstruct the missing branches (red). Background image is from [5] (with permission).

Methods

The peak selection strategy introduced in this work is implemented for the constrained spherical deconvolution (CSD) based FT method[1] and consists of the following steps. Firstly, conventional CSD FT is performed (with FOD threshold of 0.1 and angular deviation threshold of 45°). Secondly, every point of each pathway that has more than one FOD peak is considered as a new seed, but now with the other peak orientations as the initial directions for reconstructing new pathways. This procedure can be performed recursively with predefined convergence criteria. Finally, the resulting pathways are selected based on prior knowledge of the anatomical location of the ROI in combination with the topology of the fiber tracts.
The dMRI data used in this work were acquired with a 3T MRI system: 60 volumes at b=3000s/mm^2, 6 volumes at b=0s/mm^2; 2.5mm isotropic voxel size. Visualizations are performed with *ExploreDTI*[3].

Results

In Fig. 2a, a conventional pathway is reconstructed with the seed point defined in the spine area (only one seed point is taken). Fig. 2b shows the "unconstrained" result with the additional seed definition according to proposed strategy. Fig. 2c shows the final result with target ROI selected. Fig. 3 shows the results in a more realistic scenario with more seeds.

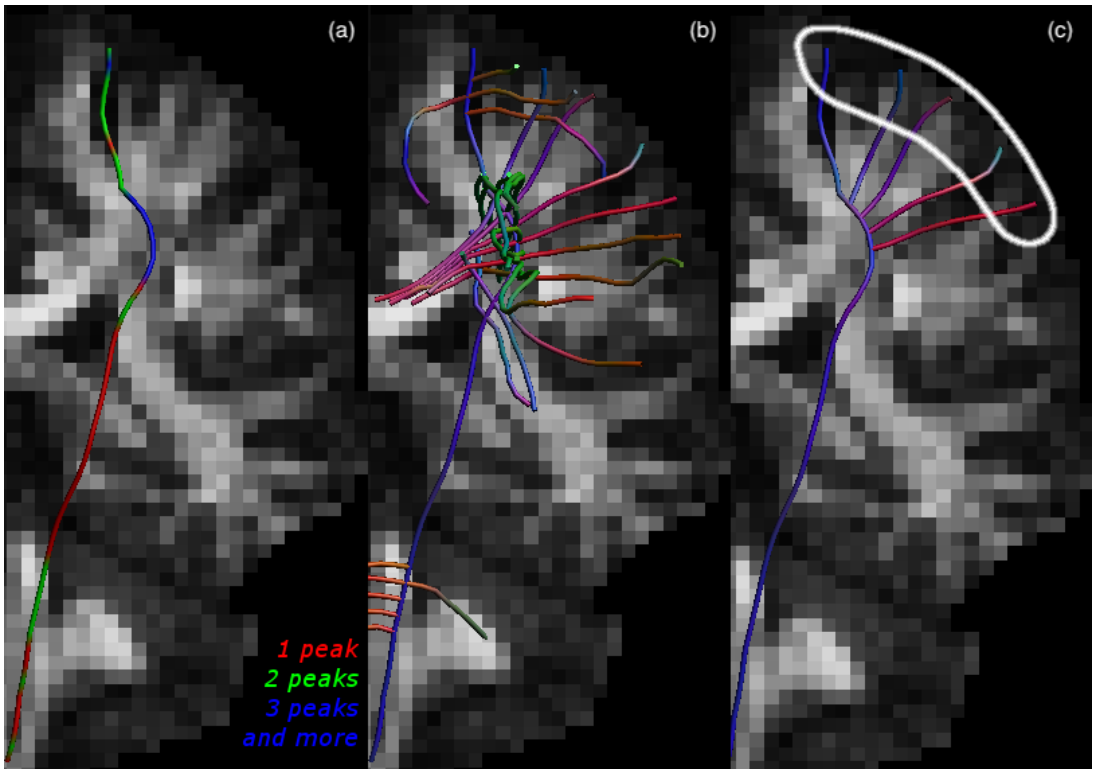

Fig. 2: (a) Example pathway with color-encoding according to number of fiber peaks along its trajectory. (b) pathways crossing the original pathway in (a). (c) Final result showing the additional branches (see white target ROI).

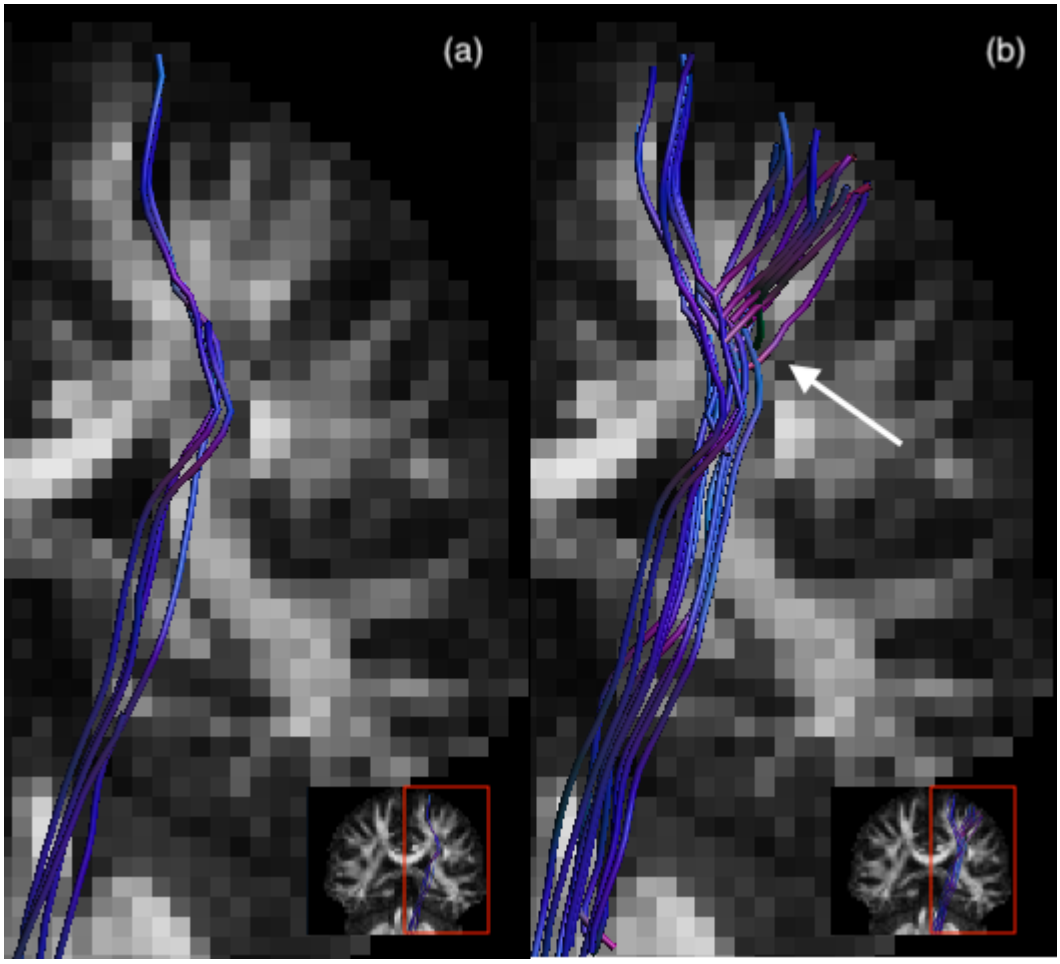

Fig. 3: (a) Conventional FT result (similar as Fig. 2(a), but more seed points). (b) The final result after including our proposed peak selection strategy. Notice the increase of true positives (lateral tract branching as indicated by the white arrow).

Conclusion

We developed a novel way to perform FT by considering a peak selection strategy that also integrates the orientations with a higher angular deviation and that incorporates prior knowledge of fiber tract anatomy. In doing so, we can obtain a more complete representation of brain pathways.

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