Graph Algorithms for Fast Preview of Global Brain White Matter Structure

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1. DTI data as a weighted graph

Diffusion Tensor Imaging (DTI) data can provide information about directional diffusion of water molecules in biological tissue.

How to derive a weighted graph from DTI data:

- Each brain voxel is represented by a vertex in a graph
- Each vertex (voxel) has weighted edges to its neighboring voxels (26-connectedness)
- Edge weights are determined from tensor data: high connectivity between voxels $\rightarrow$ low edge weight

2. Shortest path fiber tracking algorithm

Representing DTI data by a weighted graph allows usage of graph algorithms such as *Dijkstra's shortest path algorithm*.

Dijkstra's algorithm:

Input

- weighted graph
- source vertex s

Output

- For every vertex the shortest path to s, represented by a *shortest path tree*
- Weight of the shortest paths

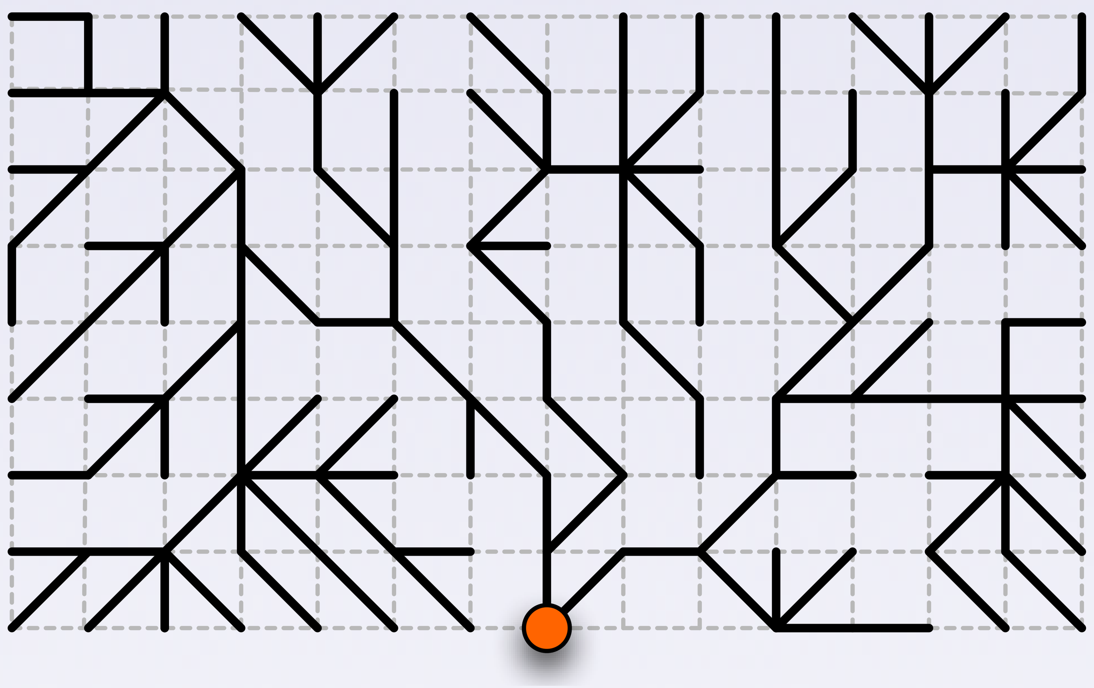
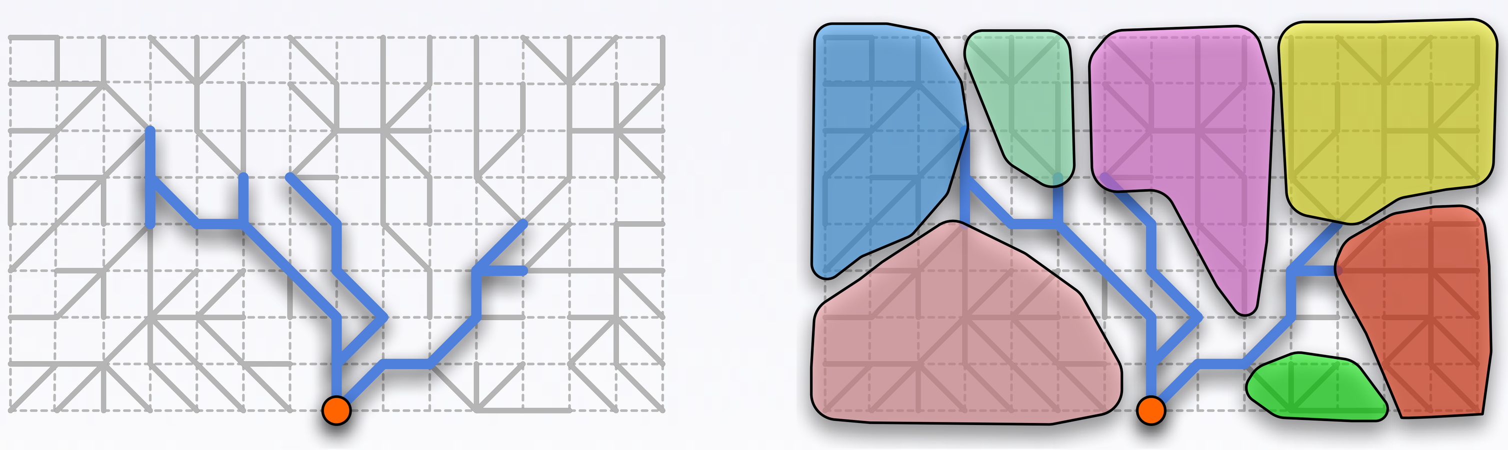


Figure 1: *2D illustration of a shortest path tree*

Our assumption is that these shortest paths have neuroanatomical meaning and allow for new and interesting analysis and visualization of DTI data.



(a) (b)

Figure 2: *2D illustrations of (a) pruning of the shortest path tree and (b) clustering with the shortest path tree.*

3. Results

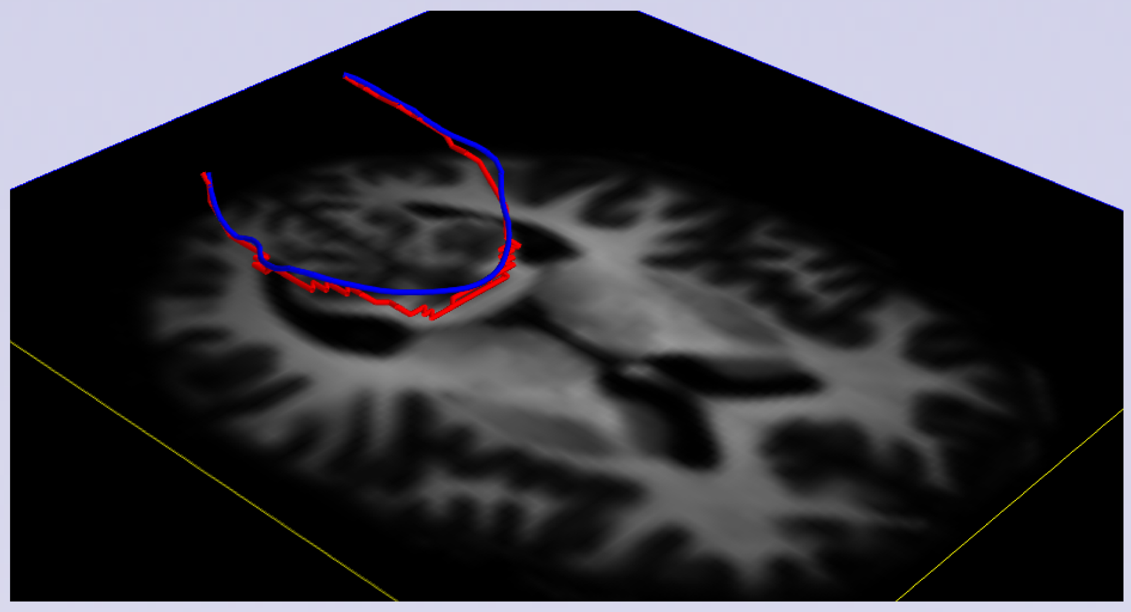
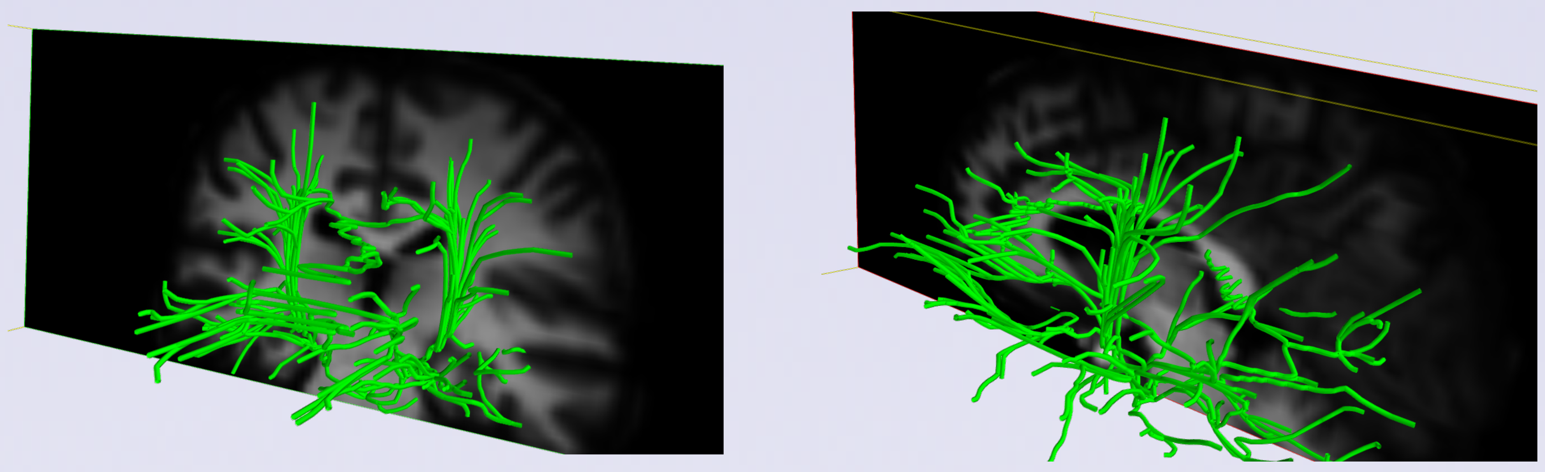


Figure 3: *A shortest path (red) combined with a fiber tract from tradiational deterministic fiber tracking (blue) seeded from the same voxel, shown together with a transverse plane showing fractional anisotropy for context. For the most part the tracts follow the same path.*



(a) (b)

Figure 4: *Pruned shortest path trees combined with (a) a coronal plane and (b) a sagittal plane showing fractional anisotropy.*

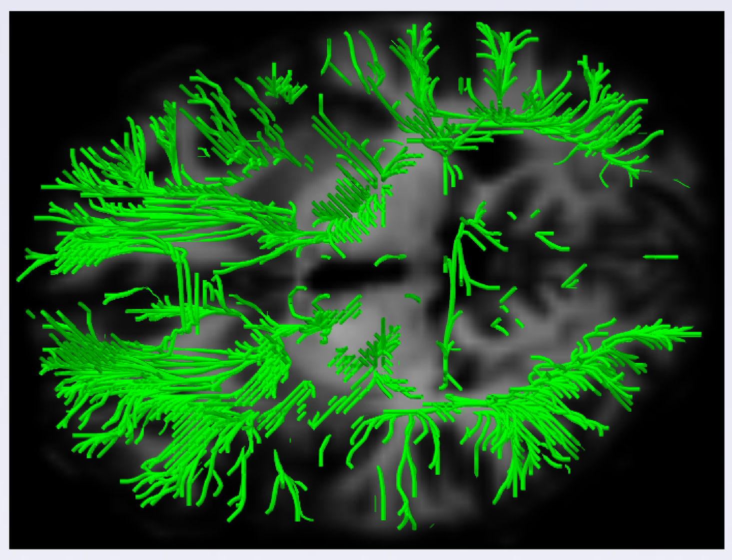


Figure 5: *A four-voxel thick transverse slice of a minimally pruned tree combined with a plane showing fractional anisotropy information.*

4. Performance

- Implementation in C, running on a single core of an AMD Dual Opteron 280 (2.40 Ghz)
- Input: $128 \times 128 \times 51$ tensor field
- Graph building: on average 1.2 seconds
- Shortest path calculation: on average *0.37 seconds*

5. Conclusion

- New fast method for analyzing and visualizing DTI data based on Dijkstra's shortest path algorithm.
- Method uses *global* information.
- Future work includes improving edge weight calculation and extensive validation.

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