Abstracted Visualization of White Matter Structure with Resampled Weighted Tracts

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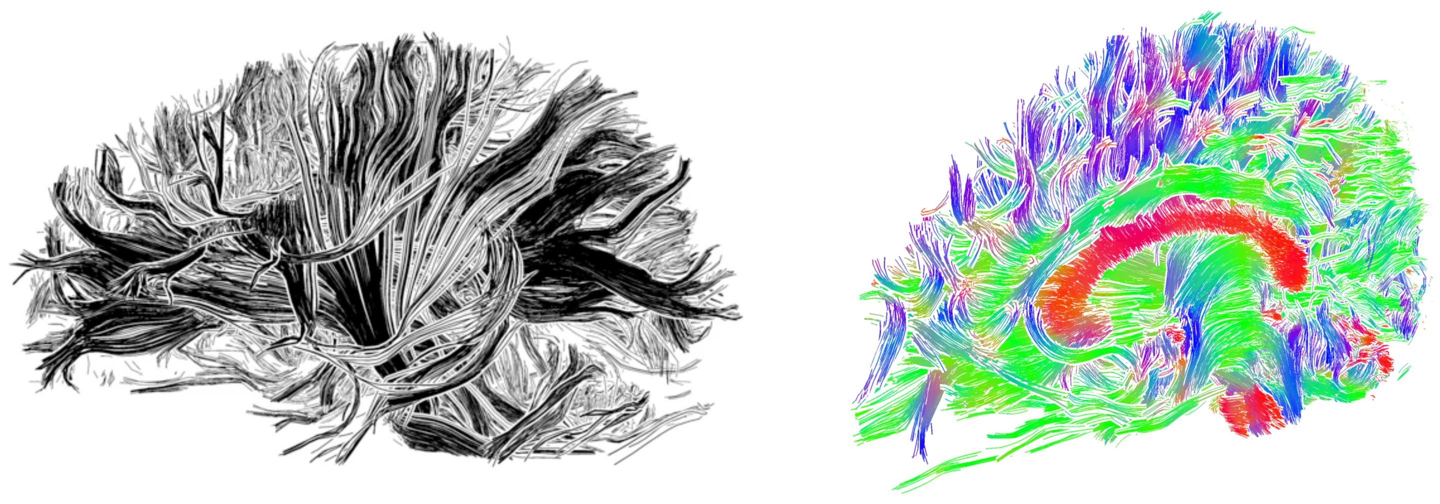
The white matter visualization problem

Fiber tracking applied to Diffusion Tensor Imaging (DTI) data results in a large set of tracts representing white matter fibers in the brain. Due to the large number of tracts and their density it is hard to get insight in 3D global brain structure.



In both visualizations the large number of tracts makes it hard to observe the global 3D white matter structure.

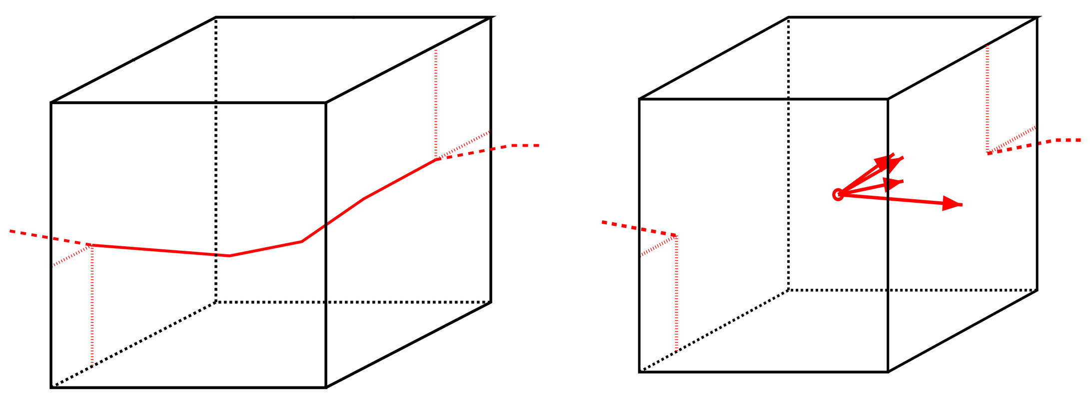
The goal of this project

We want to create an abstracted visualization of white matter using a small number of newly generated *curves* that follow dense tract areas. Curves have to be distributed evenly over the whole brain and the local width of a curve has to represent the local density of tracts running parallel to the curve. These curves may be used to visualize global white matter structure or to serve as context for small sets of tracts.

Our approach

Step 1

We create a uniform grid covering the set of tracts, and grid cells centered at grid points. At every grid point vectors are stored that represent parts of tracts falling in the corresponding grid cell. At a given grid cell vectors may point in various directions as tracts are curved and as a grid cell may be intersected by many tracts. We call the totality of all grid points and vectors **T.**



Left: a grid cell intersected by a curved tract. Right: the vectors representing the curve part falling in the grid cell.

Step 2

Consecutive curves are created by a numerical integration process on **T**. **Every curve starts at the densest point in T and every newly generated curve is subtracted from T immediately after it has been completed.** In this way every curve starts at a new point in **T** and avoids regions where previous curves are located. For every curve segment the local tract density in **T** is stored. In the visualization process the local density determines the local width of the curve.

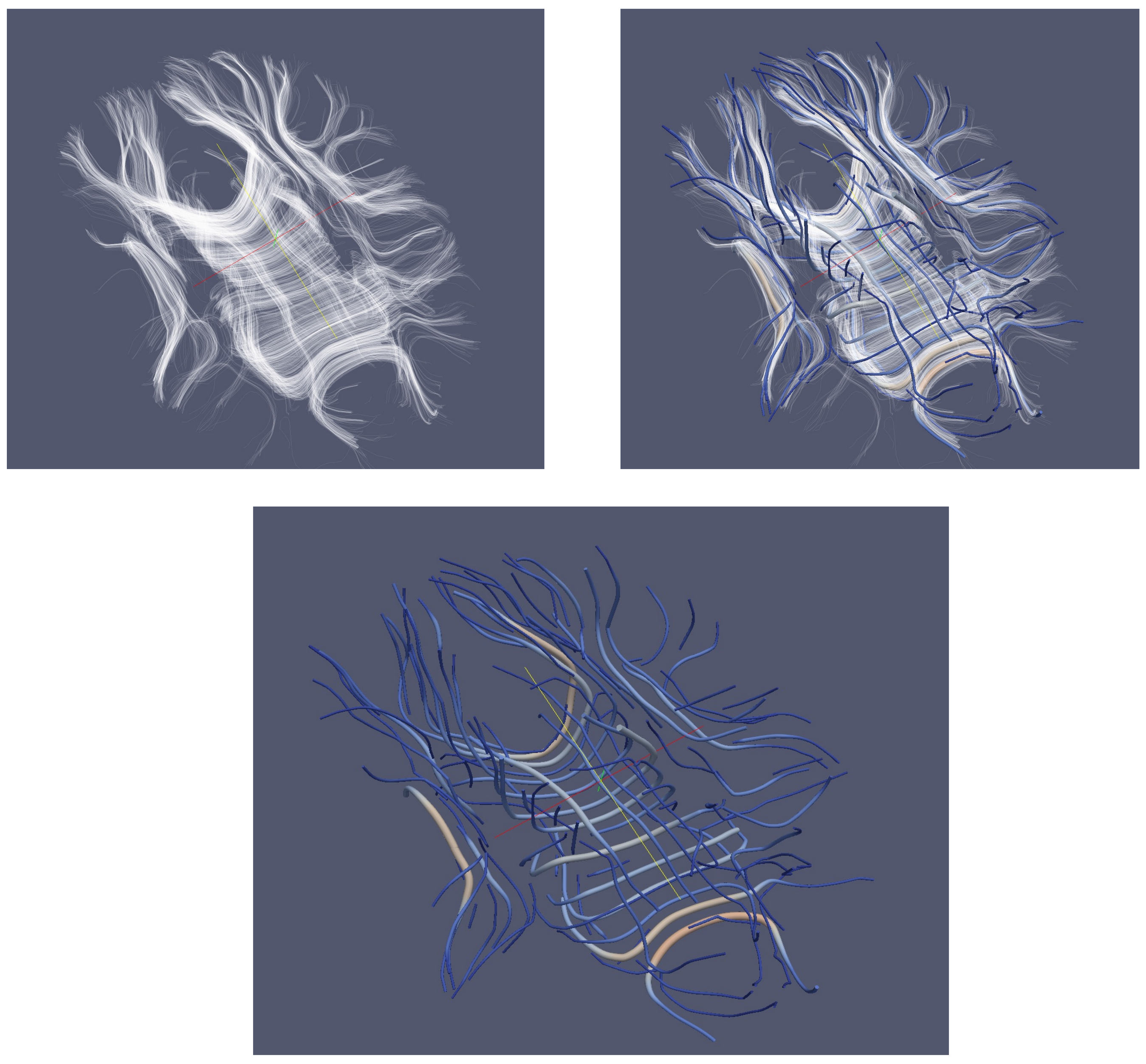
In the integration process a directional filter is used, with the effect that only tracts that are locally approximately parallel to the local integration direction are taken into account.

Subtracting a curve from T

Every curve segment is the result of a weighted sum of vectors of **T** near the curve segment. During the integration process of a curve these weights are stored. After the curve has been completed these weights are used to scale down the vectors that contributed to the curve, thus, **T** is adjusted after a curve has been completed.

Results

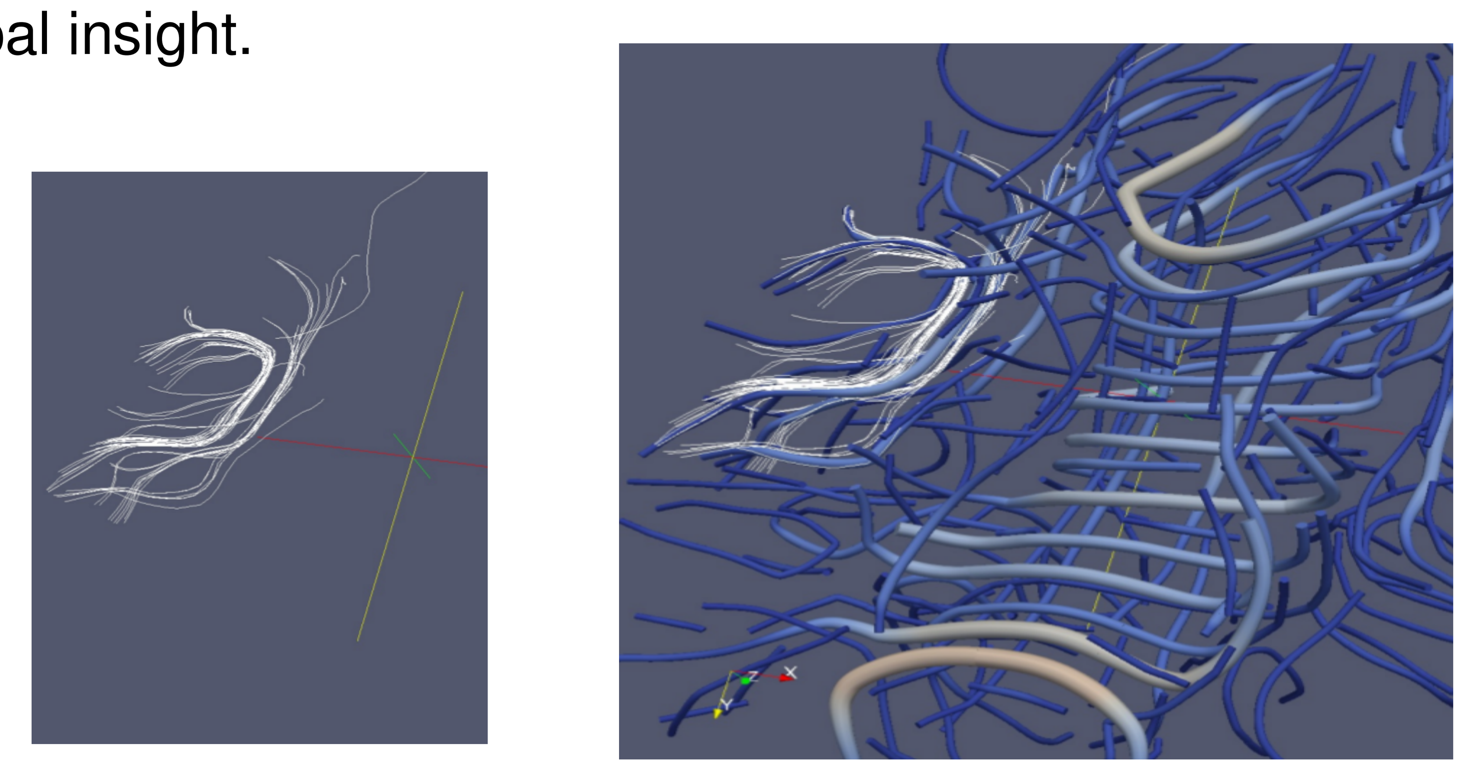
We applied the method to a standard set of DTI tracts using a grid spacing of 3 mm.



Upper left: the original set of 7000 tracts. Upper right: the tracts and the first 100 curves superimposed.
Lower: 100 curves. The local width and color of a curve represent local tract density.

Using curves as context

Curves may be used as context for a small selection of tracts. The two-level granularity gives both detailed and global insight.



Left: 50 tracts. Right: 50 tracts superimposed on 100 curves. This shows well how these tracts curve around dense structures.

Discussion and Conclusion

- Curves are evenly distributed and the whole data set is covered, giving a good global overview of white matter structure.
- For a set of 7000 tracts it takes 3 minutes to generate 200 curves on a standard PC.
- Besides abstracting DTI tracts we consider applying the method to fluid flow data and traffic flow data.