Visualizing and exploring tractograms via two-dimensional connectivity maps

Radu Jianu, Çağatay Demiralp, and David H. Laidlaw

Introduction: Reflecting the intricacy of the connectivity in the brain, 3D brain tractography models are generally visually dense. Therefore, it is often difficult to ascertain tract projections as well as anatomical and functional structures clearly. In this context, we introduce a connectivity ("dependency") map of tract projections in a framework that uses two-dimensional map representations for modeling and exploring the connectivity in the brain. We also describe an anecdotal evaluation with a neuropsychologist to assess the usefulness of our method in exploring anatomical and functional structures in the brain. We build on previous work described in [1] by extending it with a circular graph visualization of tract projection points, which can visualize the connectivity density and profiles in the brain (see Figure 1).

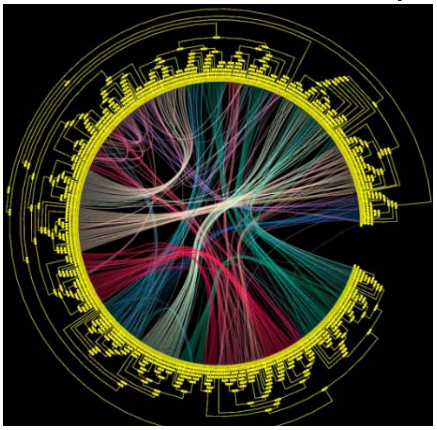

Fig 1: *Circular map of connectivities*.

Methods: For a set of tracts, given as lists of connected points, we create conventional 3D streamtube models and three 2D representations: a planar embedding, a hierarchical clustering tree, and a circular dependency graph visualization based on clustering of tract end points. Both the planar embedding and the hierarchical clustering visualizations are representations of a similarity matrix obtained by computing pairwise "distances" between the fiber tracts [1]. We obtain the dependency graph representation by first clustering tract end points using hierarchical clustering again and setting an implicit dependency between the end points of each tract. We then visualize the resulting hierarchical tree with pair-wise connectivities (or dependencies) using hierarchical edge bundling [2]. We link the views of these representations implicitly through interaction and explicitly through a perceptually uniform coloring. For example, whenever user selects 2D curves in our dependency map, corresponding primitives (i.e., 3D streamtube models, planar embedding points, and clustering tree nodes) in other representations are also selected and vice versa. Similarly, corresponding primitives of representations are given the same color. Figure 2 shows a visualization of fiber tracts (the internal capsule) obtained from a DTI brain data set in our framework. This type of coordinated interaction has the potential to enable faster and more accurate interaction with dense fiber tract collections.

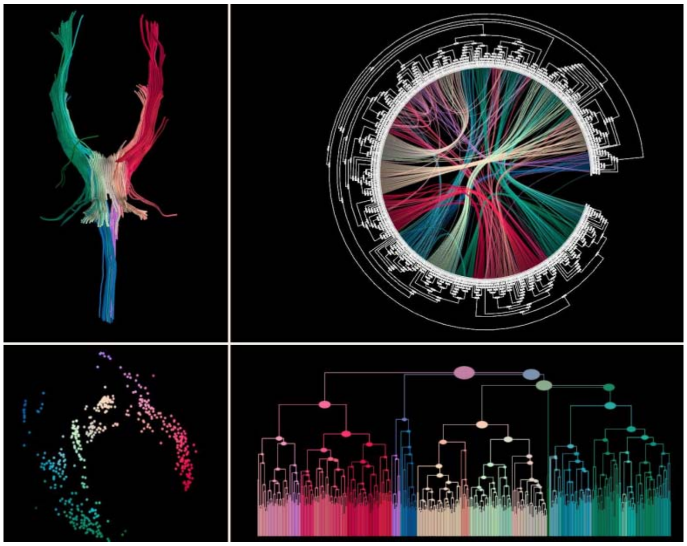

Fig 2: *The internal capsule represented with streamtubes (Upper Left), a set of embedded points (LL), a hierarchical clustering tree (LR), and a connectivity map (UR).*

Expert Feedback: We have obtained anecdotal feedback from a neuropsychologist for the dependency map representation in a prototype of our framework. He found our visualization useful for understanding connectivity densities and profiles. He also pointed that it could take time for a novice user to construct the correspondence between the anatomy and the map, which is an abstract two dimensional space.

Conclusions: We introduce a circular graph visualization of tract projections in a framework that uses two-dimensional map representations for exploring connectivity in the brain. Expert feedback indicates that it can be useful for understanding connectivity densities and configurations.

References: **[1]** Jianu et al. *Exploring 3D DTI fiber-tracts with linked 2D representations*. IEEE TVCG '09. [**2]** Holten, J. *Hierarchical Edge Bundles: Visualization of Adjacency Relations in Hierarchical Data*. IEEE TVCG'06.