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Comparison of Three DTI Tractography Algorithms

Introduction

Diffusion tensor imaging fiber tractography is being increasingly integrated in standard neurosurgical navigational systems to aid in preoperative planning. The technique has been shown maintain high degree of correlation with white matter tracks involved in motor, optical, and language pathways. Increased usage in a clinical setting, raises the relevance of the algorithm chosen to generate the fiber tracks as well as operator influence on the final tractography results. Commonly used packages are the Diffusion Toolkit (DT), DiPy library (DP), and MRtrix (MT). Upon tool selection the operator has to carefully select a series of operational parameters that result in the vest final outcome. Careful manual editing and cleaning of tracks is essential to generate clinically useful results. Therefore, selection of algorithms can have an enormous impact on the effort it takes to get good quality results. This report presents preliminary evaluation results of comparing DiPy, Diffusion Toolkit, and MRtrix.

Methods

Evaluation was done for five subjects with Giloma. The algorithms compared were DiPy - using an FA threshold of 0.15, Diffusion Toolkit - HARDI reconstruction and FACT tracking with angle threshold of 60, and MRtrix - iFOD2 using the constrained spherical deconvolution (CSD) with lmax of 8 and step size of 0.1. The same seed and target regions of interest were used for each algorithm. One case was edited and cleaned by a trained operator before being processed with each algorithm. Additional four cases were also processed by each algorithm like the first case. However, they were not edited or cleaned.

Acquired tractography results were converted into binary files and processed using R programming language. Paired evaluation was carried out with each tool to compare the tracks using Sorensen-Dice index. These evaluation processes were repeated for motor, optic and language (Arcuate, SLF 2 and 3, and IFOF) pathways.

Results

Average percent overlap across all tracks using DiPy x MRtrix was 44.2%, DiPy x Diffusion Toolkit was 45.9%, and Diffusion Toolkit x MRtrix was 30.4%. DiPy and Diffusion Toolkit show the higher correlation compared to other algorithms. Across all tools, motor tracks tend to have higher and stable correlation. SLF II and III tend to have the least amount of overlap between tools.

Edited data show lower numbers in all comparisons compared to non-edited data. Average percent overlap across edited tracks using DiPy x Diffusion Toolkit was 44.2%, DiPy x MRtrix was 42.7, and Diffusion Toolkit x MRtrix was 27.6%. However, average percent overlap across non-edited tracks using DiPy x Diffusion Toolkit was 46.3%, DiPy x MRtrix was 44.6, and Diffusion Toolkit x MRtrix was 30.4%. Edited tracks show lower average percent overlaps because some parts of them were removed in the process of cleaning. The difference of edited data and non-edited data is apparently shown in pictures below. Fiber spreads out wider in non-edited data.

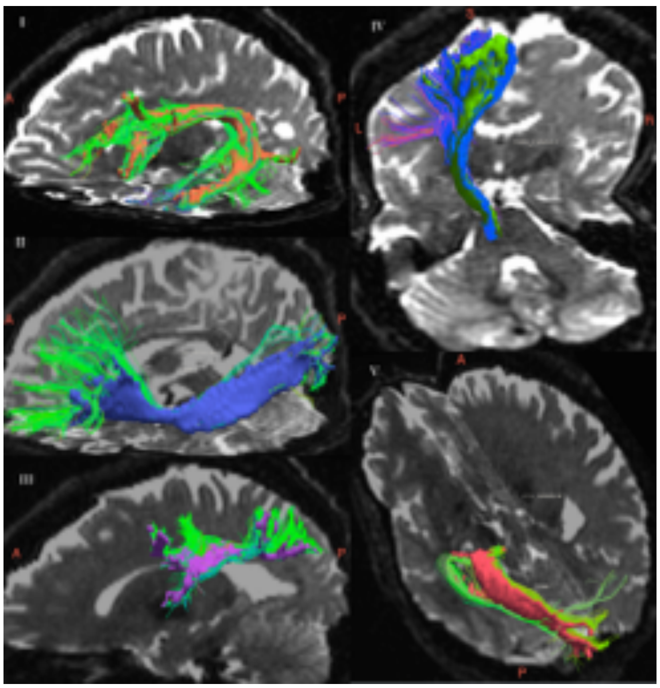

Fig 1. Visualization of each track which were edited by a trained operator then processed with DiPy. Colored regions represent the overlap of three algorithms. I: Arcuate, II: IFOF, III: SLF, IV: Motor, V: Optic.

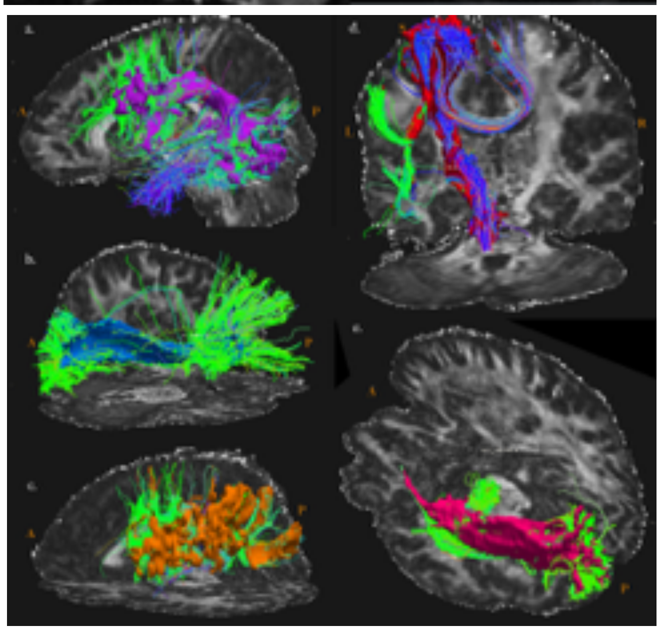

Fig 2. Visualization of each track without being edited processed with DiPy. Colored regions represent the overlap of three algorithms. a: Arcuate, b: IFOF, c: SLF II and III, d: Motor, e: Optic.

Conclusion

MRtrix can provide very fast analysis of an entire brain. However, in the context of clinical usage, location of seed regions of interest can significantly improve the set of tracks to be manipulated by the operator. These preliminary results indicate that DiPy provides better final tracks with less amount of overall manual effort in cleaning.