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Automated Imaging Post Processing for MRI DTI Fiber Tracking

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ABSTRACT

Diffusion tensor imaging (DTI) fiber tractography is a valuable technique for visualizing white-matter pathways but is often labor-intensive and operator-dependent. We developed and validated a fully automated MRI DTI post-processing tool that interfaces directly with the MRI scanner, PACS, or DICOM database to perform automated image import, distortion correction, image registration, region-of-interest identification, and reconstruction of five major white-matter fiber tracts: the corticospinal tract (CST), cingulum (CG), inferior longitudinal fasciculus (ILF), superior longitudinal fasciculus (SLF), and anterior thalamic radiation (ATR), using only T1-weighted anatomical and DTI datasets. The automated system was validated against manual tractography in five healthy subjects, with 30 fiber tracts evaluated. Twenty-six of the 30 tracts demonstrated excellent agreement with manual results. While manual processing required approximately 2 hours per subject to reconstruct all fiber tracts, the automated pipeline completed the analysis in approximately 10 minutes, substantially improving workflow efficiency while maintaining comparable reconstruction quality. This automated DTI fiber-tracking tool provides rapid, reproducible, and accurate tract reconstruction, reducing operator dependence and post-processing time. The method has the potential to enhance both clinical and research workflows. Future work will focus on validation in larger patient cohorts, including tumor and other neurological diseases, and the integration of artificial intelligence (AI) techniques to further improve the accuracy and robustness of automated white-matter fiber tract identification.

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INTRODUCTION

Diffusion tensor imaging (DTI) fiber tracking is a noninvasive magnetic resonance imaging (MRI) technique that enables three-dimensional visualization and reconstruction of white-matter pathways by characterizing the directional diffusion of water molecules within neural tissue. It has become an important tool in both clinical practice and neuroscience research for evaluating structural brain connectivity, supporting presurgical planning, and assessing a wide range of neurological disorders. However, conventional DTI fiber tracking typically requires extensive manual intervention, including the selection of regions of interest (ROIs) and adjustment of tracking parameters, making the process time-consuming, operator-dependent, and subject to inter- and intra-observer variability. These limitations reduce workflow efficiency and may affect the reproducibility and consistency of tractography results across users and institutions. To address these challenges, this work presents the development and validation of an automated MRI DTI fiber-tracking post-processing tool designed to streamline tract reconstruction, minimize user dependence, and improve the efficiency and reproducibility of white-matter pathway visualization while maintaining high agreement with conventional manual approaches.

METHODS AND MATERIALS

We developed an automated post-processing system that connects directly to the scanner PACS, MRI scanner, or DTI DICOM imaging database. The tool processes DTI DICOM images with fully automated distortion correction and image registration. It automatically identifies regions of interest (ROIs) and reconstructs five major white-matter fiber tracts: corticospinal tract (CST), cingulum (CG), inferior longitudinal fasciculus (ILF), superior longitudinal fasciculus (SLF), and anterior thalamic radiation (ATR), using only the input DICOM images of T1 structure and DTI functional data. The basic workflow is shown in Fig.1.

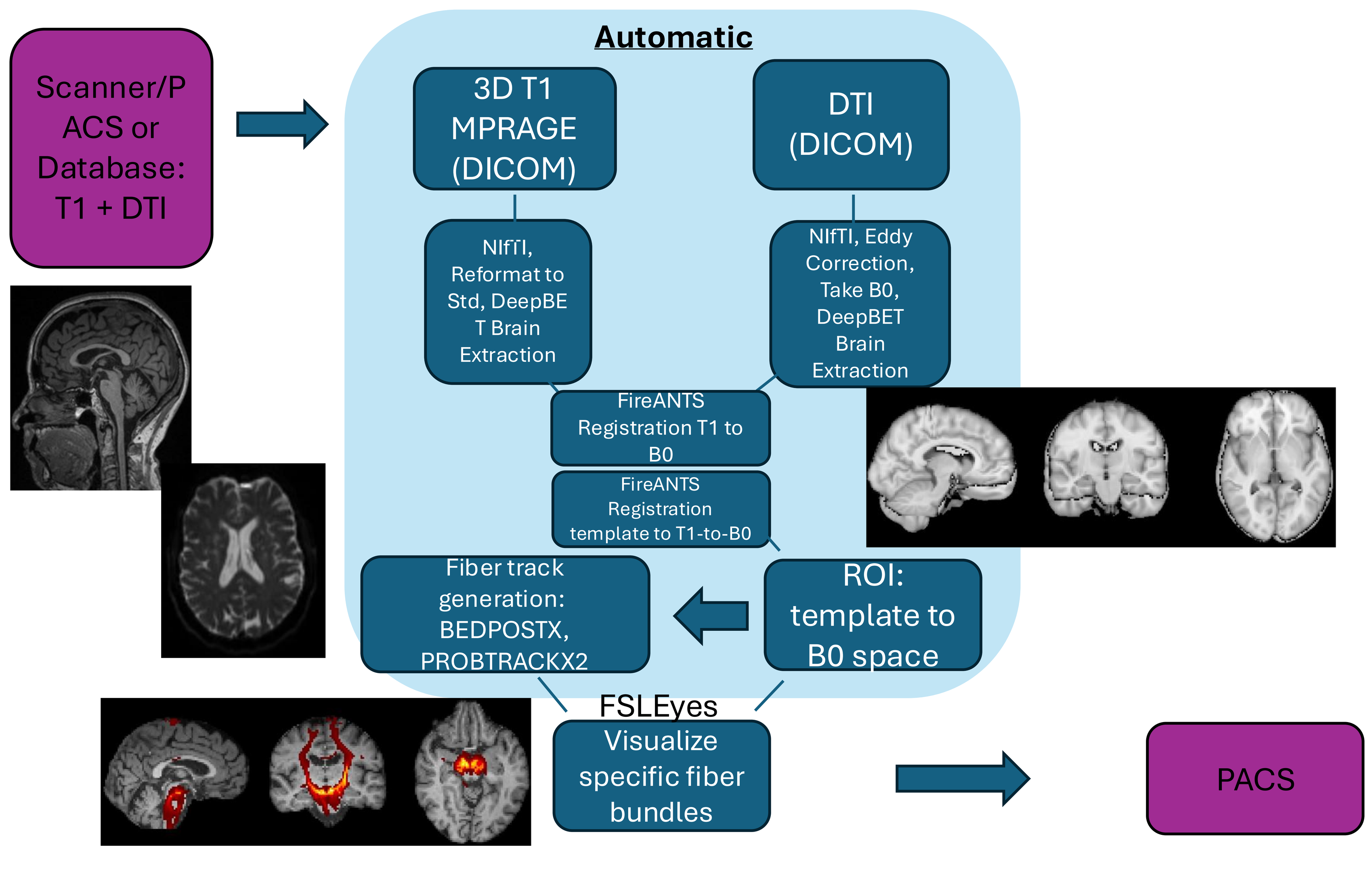

Fig.1. An automated post-processing system for brain fiber tracking that connects directly to the scanner PACS, MRI scanner, or DTI DICOM imaging database.

RESULTS

To validate the automated processing results, fiber tracking was also performed manually in 6 health subjects for the 5 fibers (CST, CG, ILF, SLF and ATR) . A total of 30 fiber tracts were compared between the manual and automated methods. Of these, 26 fibers demonstrated very good agreement. Manual processing required approximately 2 hours per case to generate all fiber tracts, whereas the automated system completed the same processing in approximately 10 minutes.

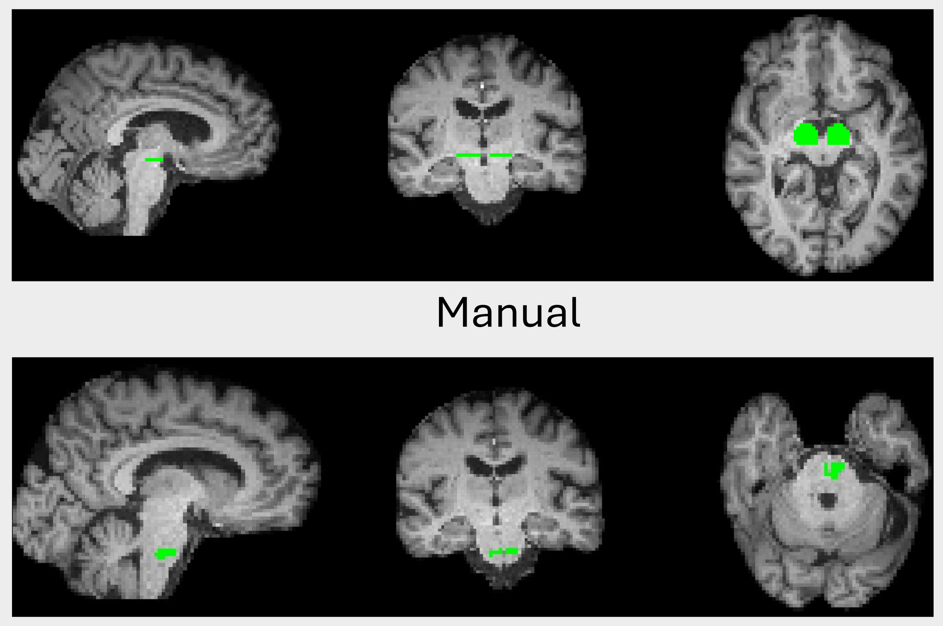

Fig. 2. Comparison of ROIs for CST Fiber Tracking performed with manually delineated technique versus automatically generated tool.

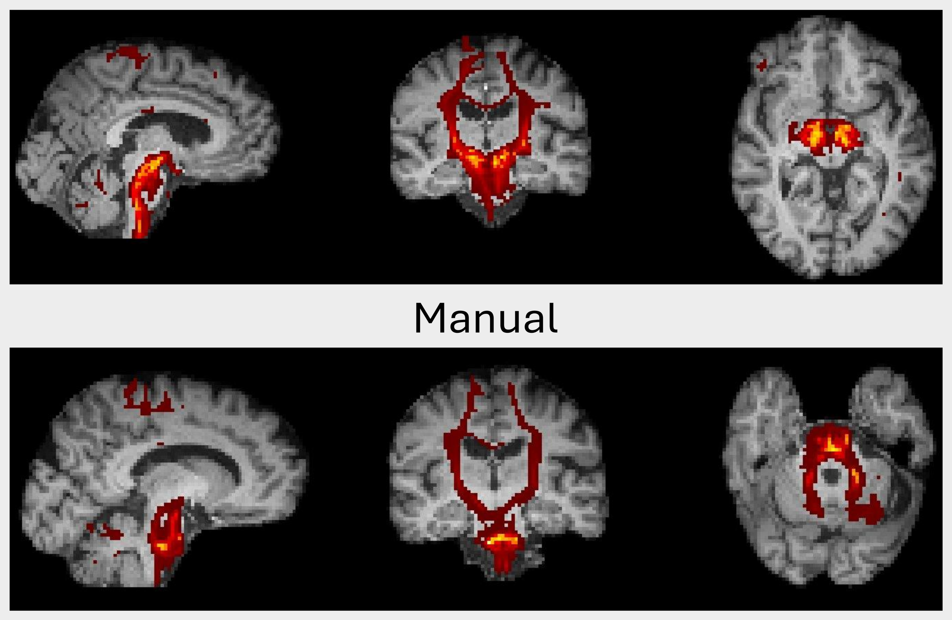

Fig. 3. Comparison of MR DTI fiber tractography performed with manually delineated ROIs versus automatically generated ROIs for CST Fiber Tracking.

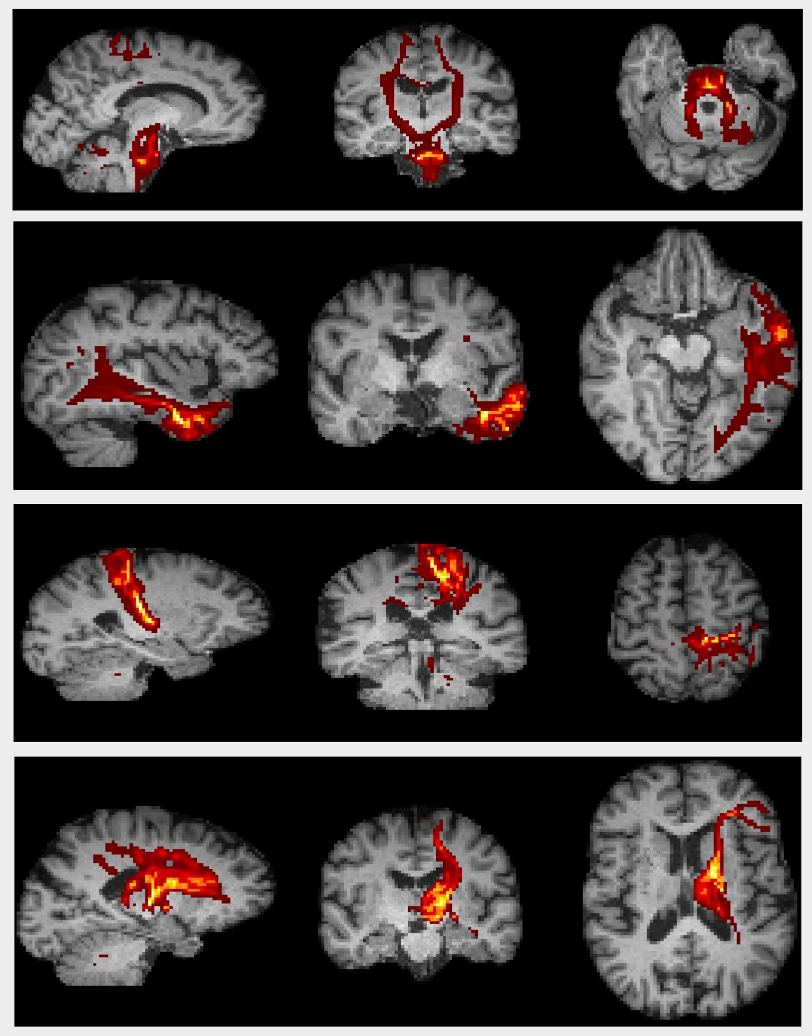

Fig. 4. Representative example of MR DTI fiber tractography generated by our automated tool.

DISCUSSION

The automated DTI post-processing tool demonstrated high efficiency by significantly reducing processing time while producing reproducible fiber tractography results that closely matched those obtained with manual fiber tracking. These findings suggest that the proposed approach can improve the efficiency and consistency of both clinical and research workflows. However, further validation using a larger dataset is required to fully assess its robustness and generalizability. Future studies will also evaluate the tool in disease-specific populations, including patients with brain tumors and other neurological conditions. In addition, artificial intelligence (AI)-based techniques will be incorporated in future versions to enable more accurate and robust identification of human brain fiber tracts.

CONCLUSIONS

The proposed automated DTI post-processing tool provides a fast, reproducible, and reliable approach for MR DTI fiber tractography, with performance comparable to manual fiber tracking. It has the potential to streamline DTI post-processing and facilitate broader clinical and research applications. Continued validation and the integration of AI-based fiber tract identification are expected to further enhance its accuracy and clinical utility.

REFERENCES

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