Title: Assessing the reliability and reproducibility of an automated tool for clustering diffusion tractography

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Structured Abstract:

Introduction: White matter fibres comprise the brain's structural connections. Neurological conditions and disorders may be associated with abnormalities of these pathways. Diffusion tractography offers a non-invasive technique to probe structural connectivity [1]. A number of manual or automated techniques exist to identify unique pathways from tractography [2]. Additionally, quantitative MRI can further quantify identified connections. With any technique, it is imperative to assess the reliability and reproducibility of the output. We aim to assess the reliability and reproducibility of the NeuroBundle Extraction and Evaluation Resource. This tool identifies unique pathways from geometric similarities and can extract short-ranged U-shaped fibres, which have been implicated in neurological conditions.

Methods: Preprocessed diffusion MRI (dMRI) data (n=100) from the Human Connectome Project [3] was used to create a whole-brain tractography template. Data was acquired on a customized Siemens Skyra 3T scanner [4,5] at 1.25mm isotropic resolution, b-values=1000, 2000, 3000 s/mm^2 and 270 total diffusion-encoding directions. Additionally, multiple sessions (n=16) of dMRI from a single subject released from the MyConnectome Project [6] was used to assess the reliability of identified pathways. Data was collected on a separate Siemens Skyra 3T scanner at 1.74x1.74x1.7mm^3 resolution, b-values=1000, 2000 s/mm^2 and 60 total diffusion-encoding directions. Preprocessing was performed using in-house pipelines and whole-brain tractography was generated for each session. Unique fibre bundles were clustered using our developed tool. Output reproducibility was assessed by computing average Euclidean distances between each session to the template. Intraclass correlation was also computed for fractional anisotropy (FA) measurements to identify reliability of quantitative measurements. Assessment was performed on five identical clusters in each hemisphere and five additional clusters along the corpus callosum.

Results: Average Euclidean distance was computed for identified clusters between sessions and the template from tracts identified using the NeuroBundle Extraction and Evaluation Resource. Computed distance were found to be within 4.5mm. Intraclass correlations of FA ranged from 0.83 to 0.99 in corresponding clusters.

Discussion: Reliability and reproducibility of results was assessed for our developed tool. Quantitative assessments show the tool’s ability to identify similar tracts and extract reliable quantitative metrics. Future work includes creating a unique white matter atlas inclusive of short-ranged, U-shaped fibres using our tool and to investigate structural connectivity of patient populations.