A Robust and Reliable Processing Pipeline on the Cluster for Quantitative Pediatric Neuroimaging

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Background/Problem Being Solved

Pediatric neuroimaging is essential for identifying brain anomalies in clinical practice. Quantitative measures from magnetic resonance imaging (MRI) have shown potential in detecting subtle brain abnormalities. However, integrating these quantitative MRI measures into clinical workflows faces significant challenges: 1) non-biological variance due to diverse processing methods across different age groups, and 2) long processing times, delaying clinical decision-making and impacting patient care.

Intervention(s)

To address these limitations, we developed a robust and fast neuroimaging processing pipeline for structural and diffusion MRI applicable across all pediatric age groups (Figure 1). FreeSurfer and ACAPULCO were applied to structural MRI for obtaining morphological measures in cortical, subcortical, and cerebellar parcellations. Diffusion tensor imaging (DTI) is processed by FSL and DSI Studio to derive regional diffusion measures, such as fractional anisotropy and fiber tracking.

Barriers/Challenges

The primary challenges include ensuring consistency in processing methods across different age groups and reducing the processing time to facilitate timely clinical assessments. Implementing the pipeline on a high-performance computing (HPC) cluster, comprised of multiple nodes with 56 CPU cores, 768GB of RAM, and Nvidia T4 GPUs, was crucial to overcoming these barriers.

Outcome

Using our pipeline, MRIs from in-house 165 normative pediatric subjects aged 2 to 18 years were successfully processed. On HPC cluster, average processing time per patient was 5 hours and 33 minutes. This demonstrates that our pipeline is a reliable approach for analyzing MRI and DTI data across a wide age range, offering fast processing times that assist clinical workflows.

Conclusion/Statement of Impact/Lessons Learned

Our neuroimaging processing pipeline provides a robust and valuable resource for performing quantitative MRI in clinical practice. The fast-processing time is particularly beneficial in clinical settings where timely diagnosis and treatment can

significantly impact patient outcomes. Future work will focus on validating the pipeline with larger datasets and exploring its potential integration into clinical workflows.

Figure(s)

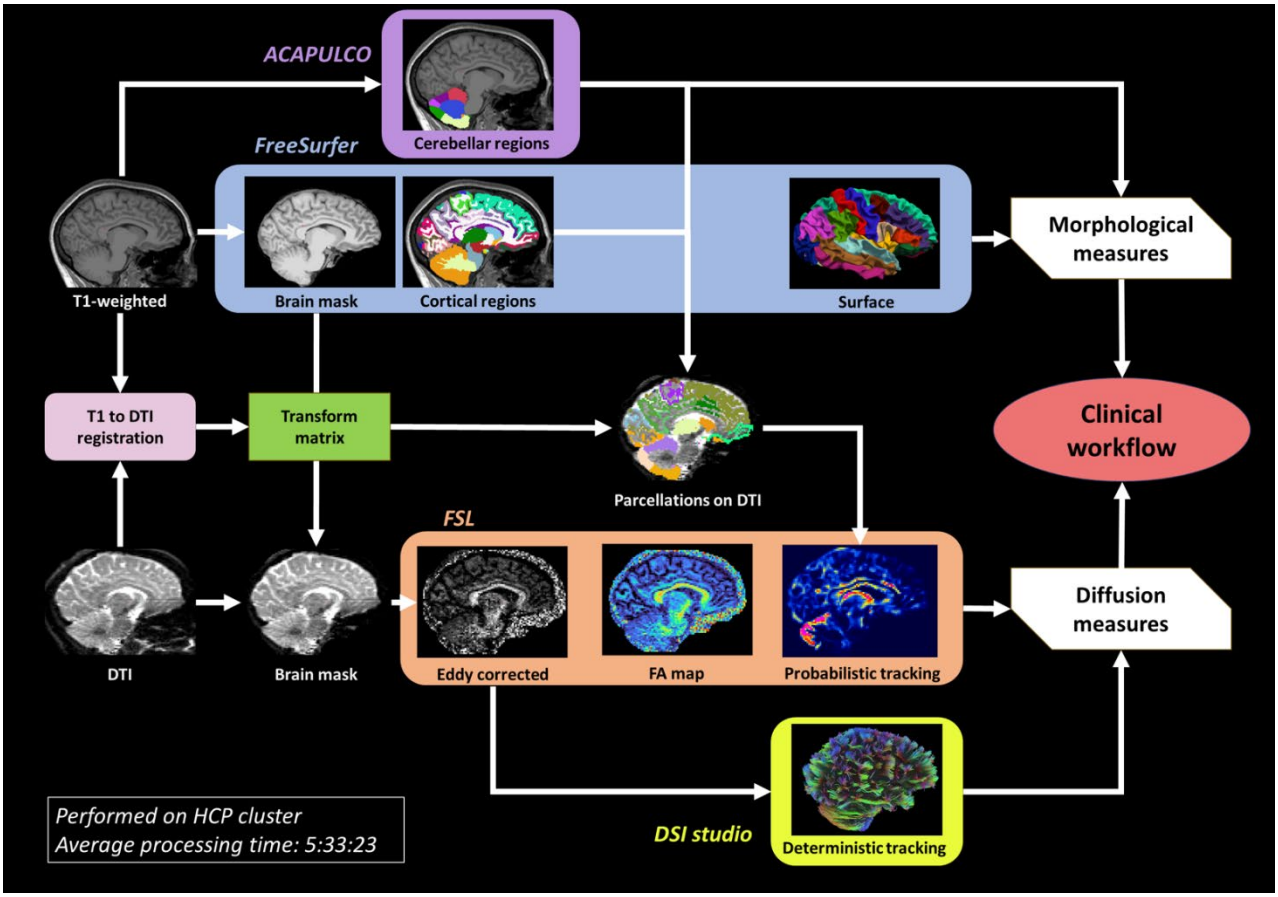

Figure 1. Processing flowchart for quantitative MRI. ACAPULCO: automatic cerebellum anatomical parcellation using U-Net with locally constrained optimization, DSI: diffusion spectrum imaging, DTI: diffusion tensor imaging, FSL: FMRIB software library, FA: fractional anisotropy, and HPC: high performance computing. Average processing time of 165 normative pediatric subjects is 5 hours, 33 minutes, and 23 seconds on HCP cluster.

Keywords

Applications; Clinical Workflow & Productivity; Emerging Technologies; Imaging Research