Local Analysis of Tract Density Imaging for the Detection of White Matter Alterations

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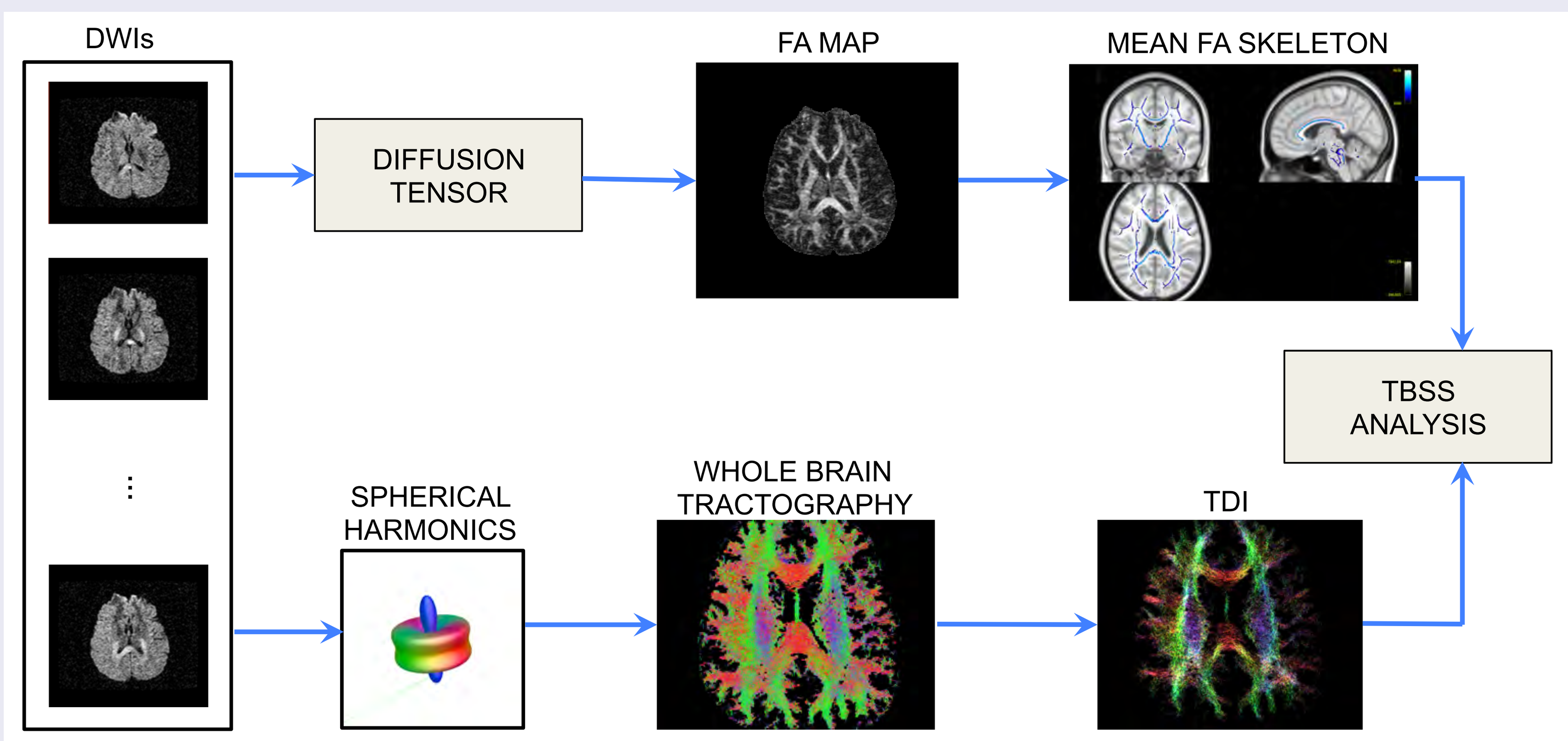
Track-Density Imaging (TDI) can provide super resolution images of the white matter of the brain. As it is based on the results of a whole brain tractography process, it comprises information from different features of the white matter diffusion. We exploit this information by proposing a local analysis approach for TDI, and test it on two different datasets where conventional TBSS analysis using FA did not yield any significant differences. Results revealed the proposed method to be extremely sensitive in the detection of white matter abnormalities, making it a promising tool for white matter group studies.

Purpose and Motivation

- Local analysis performed on Track Density Imaging (TDI)[1] can reveal subtle differences in the white matter architecture that are not easily detected using conventional diffusion MRI analysis tools.
- TDI has been employed to investigate anatomical features and histopathologic correlations have been made but, to the best of our knowledge, it has almost never been used to discover white matter abnormalities related to pathological conditions in group studies (with the exception of Ziegler et al.[2]).

Methods



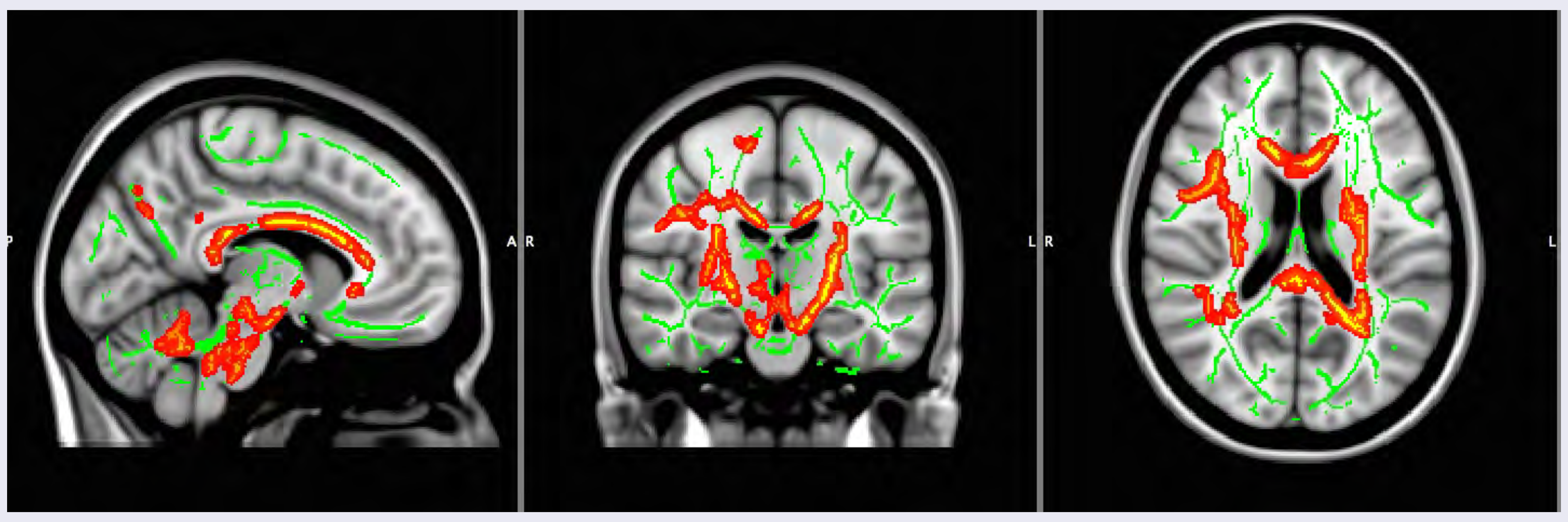
- After DWI data acquisition, fiber-tracking was performed using MRtrix. Spherical harmonics were computed using constrained spherical deconvolution[3] and fed into the fiber-tracking algorithm in order to model multiple fiber orientations.
- FA maps of all subjects were also computed and resampled to the same resolution as the TDI maps. Tract-Based Spatial Statistics (TBSS) were then employed[4]. Comparisons, which are restricted to this FA skeleton, were then made on the FA maps and the TDI maps.
- Two different group studies were carried out, using two different datasets:

Healthy controls Vs Mild Alzheimer's Disease: 17 healthy controls (10 female, 74.5 $\pm$ 3.5 years) and 19 patients (12 female, 76.1 $\pm$ 2.7 years). Patients diagnosed according to NINCDS-ADRDA Alzheimer's Criteria.

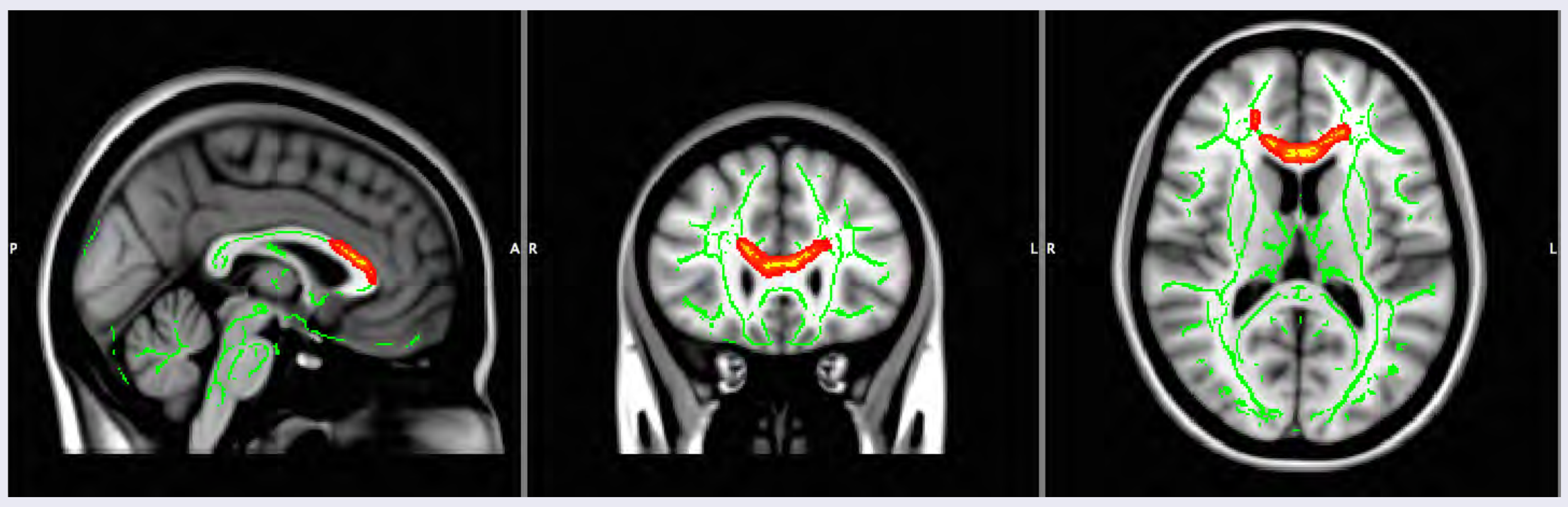
Episodic Vs Chronic Migraine: 18 patients (17 female, 36.6 $\pm$ 11.8 years) with chronic migraine and 10 patients (6 female, 33.5 $\pm$ 7.7 years) with episodic migraine were selected, having been diagnosed according to ICHD III edition.

Results

- No significant differences in the FA maps were found between groups in both experiments.
- For the Alzheimers disease group study, local analysis of TDI was able to locate differences in widespread areas within the white matter. Patients showed a decrease in the track density in the areas depicted in the figure.
- For the migraine group study, local analysis of TDI located a decrease in the track density at the anterior part of the corpus callosum in patients with chronic migraine with respect to those with episodic migraine. There is very few literature analyzing differences between different types of migraine patients using dMRI but, remarkably, our results are consistent with those in[5], where a different approach was employed.



HEALTHY CONTROLS VS MILD ALZHEIMER'S DISEASE



EPISODIC VS CHRONIC MIGRAINE

Conclusions

- Local analysis of Track Density Imaging can reveal subtle differences in white matter group studies.
- A processing pipeline combining TDI and TBSS was proposed and tested on two different datasets where conventional TBSS analysis on the FA did not yield any findings.
- Results showed the proposed approach to be able to detect subtle changes in the white matter, with increased sensitivity with respect to FA analysis.

References

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