Multimodal modelling of the human brain

Abstract

There are many ways to model properties of the brain from magnetic resonance imaging (MRI) data. One acquisition technique, known as diffusion-weighted imaging (DWI), can map the speed and direction of water diffusion within the brain. This work explores the quantitative potential of DWI, in combination with other neuroimaging modalities, for *in vivo* modelling of the human brain.

Fiber tractography from DWI can be used to construct a wiring diagram of the brain (or *connectome*) and identify connectivity patterns between regions. To explore the utility of connectome modelling, we constructed brain networks from healthy subjects carrying known genetic variations. Using machine learning, we demonstrated high classification accuracy between subjects with different genotypes using only their connectomes.

Next, we tested whether fiber track density images could be used to detect early pathological effects in patients with Parkinson's disease. We found increases in track density in disease-relevant regions of the white matter, including the nigrostriatal pathway, used unbiased whole-brain statistical testing. This result is extremely encouraging, as axonal degeneration within this area is challenging to identify with standard magnetic resonance imaging contrasts.

Finally, a finite element modelling (FEM) approach was developed for solving the electroencephalography (EEG) forward problem. Electrical conductivity tensors were estimated from DWI in order to represent the heterogeneous conductivity profile of the white matter. When tested against the analytical solution, this FEM method proved more reliable than the current state-of-the-art alternative.

Advanced brain modelling from DWI can clearly provide lucrative results. These methods have been open-sourced for use by the community.