Session: Imaging Microstructure

Speaker:

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Highlights

- Tractography is widely used to map brain connections but suffers from known pitfalls
- Three key limitations are discussed in this talk
- Novel and innovative methods for addressing these pitfalls are presented

Talk title: Microstructure-informed tractography

- Target audience: anyone interested in either using tractography to study brain connections or working on modelling and developing new tractography algorithms.

- Purpose: The aim of this course is to discuss new avenues in methods development that attempt to address some well-known pitfalls of diffusion MRI tractography.

- Outcome: At the end of the lecture, the audience will be familiarised with three key limitations of most current tractography approaches, but will also have a sense of what research efforts are being deployed to address these pitfalls.

Diffusion MRI tractography is a class of algorithms and techniques for mapping white matter pathways in the brain. These techniques rely on measuring the diffusion coefficient of water along multiple directions, and using these measurements to infer axonal orientations in each imaging voxel. These orientations can then be used to reconstruct trajectories that follow white matter.

Tractography is an indirect method for mapping brain connections, as it relies on linking water diffusion to axonal organisation. This link is done through modelling. A number of different models have been developed for making this link, and thus for estimating the orientation of axon bundles, or groups of axon bundles from the water diffusion profile.

Current diffusion models and tractography algorithms have several limitations and pitfalls. In this course, we will examine the following:

- Modelling asymmetries: The basic diffusion measurement is known to be "central symmetric". This means that measuring diffusion along direction x should give the same value as measuring it along -x. A consequence of such property is that voxelwise models of the diffusion signal cannot be asymmetric, and therefore cannot capture features such as fibre fanning or bending that are inherently asymmetric. I will discuss a few methods that attempt to solve this particular issue.

- Gyral bias: One issue with tractography that is not often highlighted is a tendency for estimated connections to terminate at gyral crowns as opposed to gyral walls or fundi. I will discuss the origin and consequences of such biases, and present a new framework for dealing with gyral biases.

- Quantification: A major limitation of tractography is the difficulty of interpreting connections quantitatively. I will discuss the origin and consequences of such limitation and present recent research that attempts to address this question by combining tractography with microstructural modelling.