**Syllabus: The diffusion tensor & derived indices**

Gwenaëlle Douaud (FMRIB Centre, University of Oxford)

**Abstract:** Diffusion tensor imaging is a powerful tool to describe in a meaningful, interpretable way the random motion of water molecules in the brain. It allows probing the underlying tissue microstructural properties and proves to be able to detect subtle changes in healthy or pathophysiological processes, mainly through its most commonly-used indices: the mean diffusivity (which assesses how much the water molecules diffuse) and fractional anisotropy (which assesses how directional this diffusion is). Hence, typically, mean diffusivity is high in “unconstrained” environment, such as in the ventricles, whereas fractional anisotropy is low in these CSF regions, but high in highly-organised tissue, such as in the white matter tracts. Moreover, the neuroscientific community has adopted more recently the parallel and perpendicular diffusivity as surrogate measures for axonal integrity and axonal myelination. Efforts are also being made to validate these measures, using animal models for instance. However, it can sometimes be more difficult to interpret these diffusion indices than previously thought, as these measures can be sensitive to partial volume effects, (motion-related) noise or complex cerebral tissue (such as deep grey matter structures or crossing fibres regions of the white matter).

In this talk, I will cover the following points:

- Historical description of the diffusion tensor (eigenvalues, eigenvectors)

- Diffusion indices: mean diffusivity, fractional anisotropy, relative anisotropy, volume ratio, parallel and perpendicular diffusivity: what do they show, and what are their comparative merits and disadvantages?

- Applications to human brain studies (health/disease)

- Validation of diffusion indices (of mice – rats, giant squids, primates – and men)

- Issues: partial volume effect, noise, crossing-fibres

- Other measures: mode of anisotropy, linear/planar/spherical coefficients, principal diffusion direction/RGB maps

References/preparatory reading:


Further reading: