Summer School on Optimisation in Image Analysis 2018

Technische Universiteit Eindhoven University of Technology

Tracking of nerve fibres in brain tumour patients

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IMAG/e TRABIT

Diffusion Weighted Imaging

some optimisation here

1. ***Diffusion Tensor Imaging*** *(signal attenuation equation)*

$$E(q) = \exp(-4\pi^2 \tau q^T D q)$$

where q is gradient direction, D is a second order 3x3 tensor.

2. ***Diffusion Kurtosis Imaging*** *(signal attenuation equation)*

$$\ln(E(q)) = -D_{app}(2\pi)^2 \tau q^2 + \frac{1}{6} D_{app}^2 K_{app} (2\pi)^4 \tau^2 q^4 + O(q^5)$$

where D_{app} and K_{app} refer to apparent diffusion and apparent kurtosis coefficients respectively.

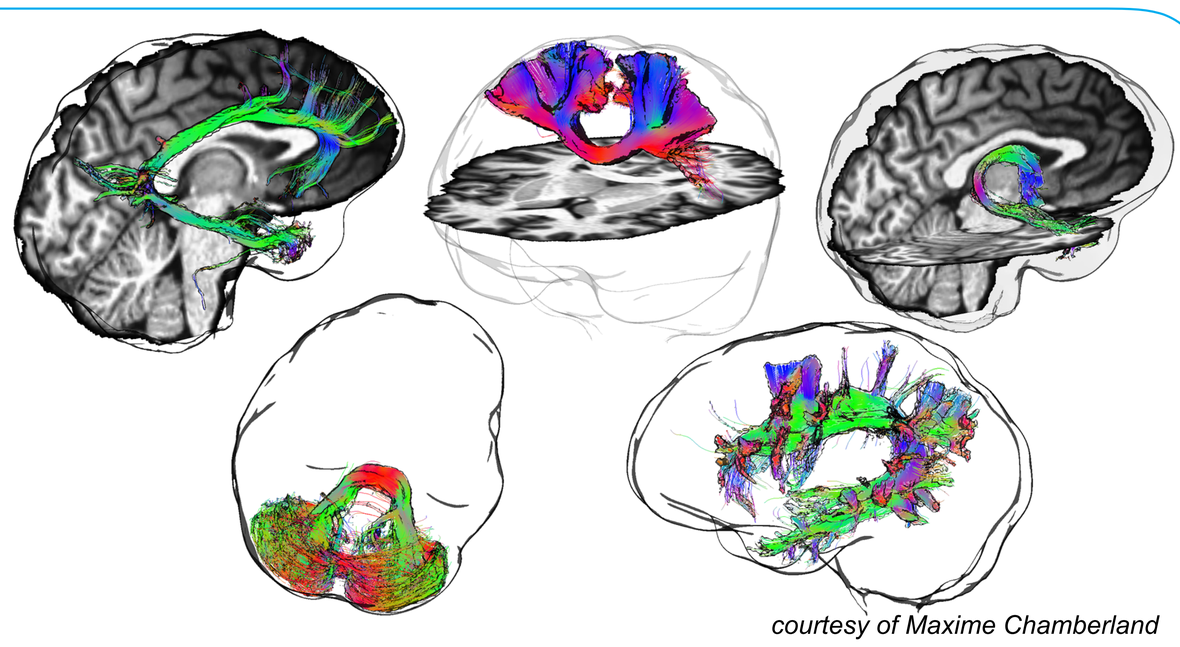
3. ***Q-ball Imaging*** *(signal attenuation equation)*

$$E(q) = \sum_{l=0}^{L} \sum_{m=-l}^{l} a_{lm} y_l^m(u) \delta(q - q')$$

where y_l^m represent a spherical harmonics of order m.

What fibre tracking is all about…

1. ***Opportunities:***
   - to investigate white-matter pathways
   - to perform analysis of specific bundles
2. ***Visualisation:***
   - obtaining information bundles and specific fibres placement
   - showing uncertainty of the tracking results
3. ***Neurosurgery planning***
4. ***Still challenging:***
   - ambiguous tracking in fibre-crossing cases using DTI model



courtesy of Maxime Chamberland

What my plans are…

1. ***Make tool protocol-friendly***
   Any tool needs to be used to be useful. So to make the final prototype as appealing as possible it should be compatible with a variety of scanning protocols. For that sake a harmonization of Diffusion MRI data should be done.
2. ***Make data bigger***
   Currently the simplest diffusion tensor model is the most widely spread one across the sites. More complex models are used less often in clinical routine due to time-consuming acquisition protocols. However, they provide the most accurate information on the brain fibre network. Consequently, in order to benefit from those models, but assuming having the simplest data acquisition scheme at hand, a transformation from, for example, single-shot Diffusion MRI to multi-shot one should be developed.

and some expected here as well

3. ***Make for those who need it most***
   Already making the most of preprocessing of the data by achieving two previous steps robust tractography algorithms should be developed which perform in presence of brain tumours. The need for such algorithms is facilitated by the fact that fibre network may be damaged by the tumor.
4. ***Combine 'em all!***
   Having tractography results ready, they may be combined with results of analysis of other modalities. Thus anatomical and functional information may be taken in consideration. Angiography may be used for path planning. Overall this bullet-point may be summarised as a surgical planning.
5. ***Anything else <u>you</u> may propose***
   Just come by and let's talk!