ProbtrackX outputs

Known white matter tracts

Connectivity matrices

ROI by ROI

voxel by ROI

voxel by voxel
Diffusion Tractography

- Goal of tractography
- Estimating Fibre Orientations - BEDPOSTX
- Probabilistic Tractography - PROBTRACKX
- ProtrackX outputs
- Tractography limitations
What is a quantitative measure of connectivity?

- Number of axons connecting 2 areas?
- Proportion of axons from a seed that reach a target?
- “Integrity” of the connecting white matter ...
  - Effective conductivity?
  - Degree of myelination?
  - Packing density?
- What are we measuring?
  - The probability that the dominant path through the diffusion field passes through this region.
Connection Probabilities

- They may reflect “Connection Strength”

- But they do also reflect other uninteresting factors, such as:

  **Connection length**: Longer connections have smaller probability than shorter ones

  **Geometric complexity**: Probabilities of connections that go through regions of complex structure will be smaller than connections that go through more coherent regions

  **Resolution of the spatial grid**: Probabilities change if we change the size of “bins” for displaying the spatial histogram
Can we trust tractography?

Is the direction of least hindrance to diffusion a good proxy for fibre orientation?

Mapping between axon geometry and diffusion profile can be ambiguous

Jbabdi & Johansen-Berg (2011)
White matter organisation can be surprising

Whole mouse brain Electron Microscopy!
Mikula Binding Denk, Nature Methods 2012
Can we trust tractography?

In the white matter: jumping between tracts

Near the cortex ambiguities/biases

Jbabdi & Johansen-Berg (2011)
Many false positives in tractography

25 synthetic WM tracts (based on real data)  Simulated diffusion data

Bundle detection

Maier-Hein et al. (Nat. Comm., 2017)
Validation: comparison with classical chemical tracing

Jbabdi et al, Journal of Neuroscience, 2013
Functional validation: meta-analysis of FMRI activations within thalamus
That's all folks