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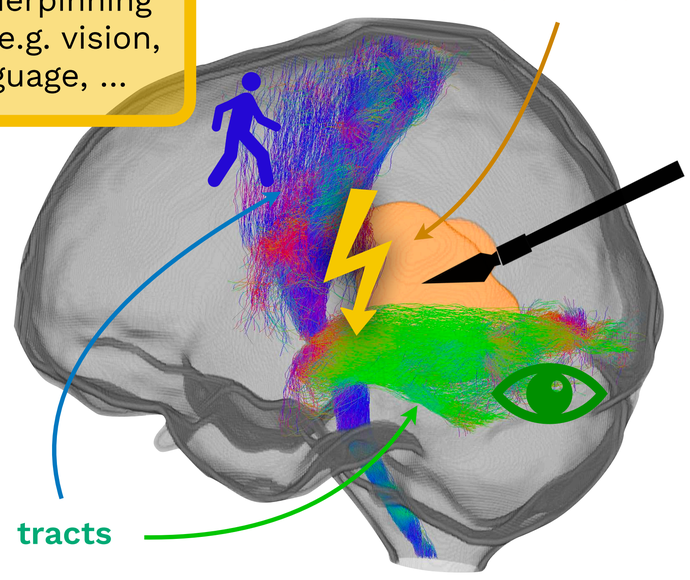
Improving brain surgery with intra-operative MRI

NHS Great Ormond Street Hospital for Children NHS Foundation Trust

Tracts: bundles of fibres in the brain underpinning vital functions, e.g. vision, movement, language, ...



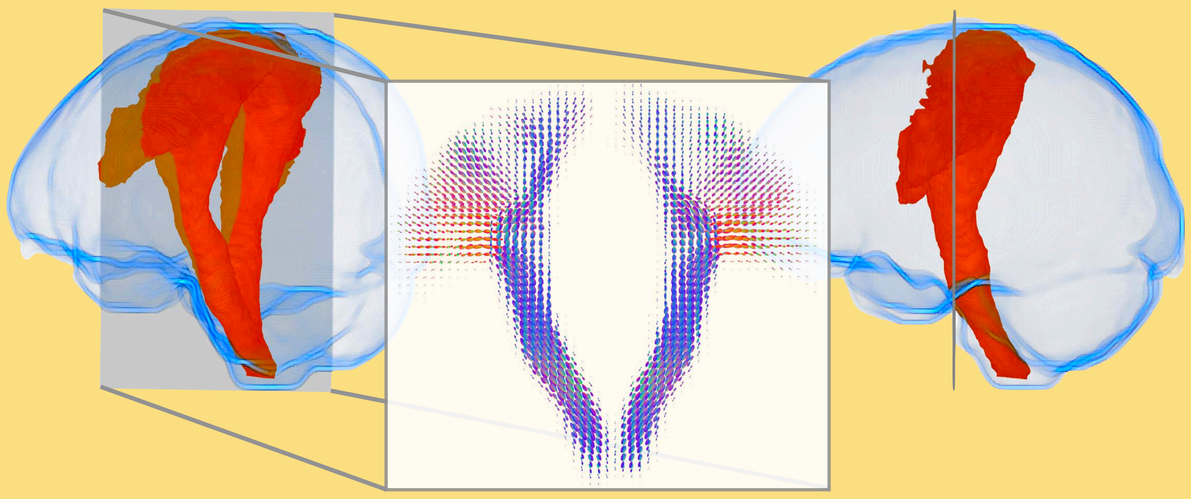
Motivation

- Advanced diffusion MRI techniques can visualise brain fibre tracts to help **avoid injury to healthy tracts during surgery**
- Movement of tissue during surgery renders **pre-operative imaging inaccurate**
- **Intra-operative MRI** can provide updated images
- Existing **tract visualisation** techniques (e.g. tractography) are difficult to implement intra-operatively → **alternative method required**

Step 1: Tract atlas

An atlas is created for each tract encoding **location and orientation expectations** for the tract.

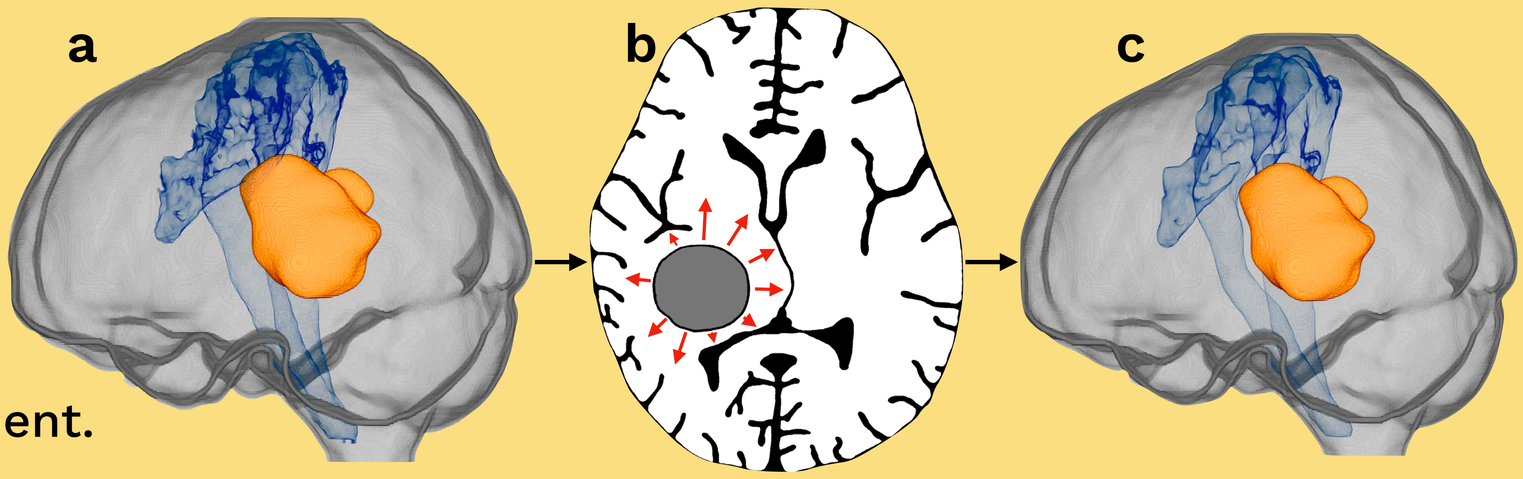
Each voxel of the atlas contains a spatial probability and orientation distribution.[1]



Step 2: Tumour deformation

The tract orientation atlas is registered to the target image (a).

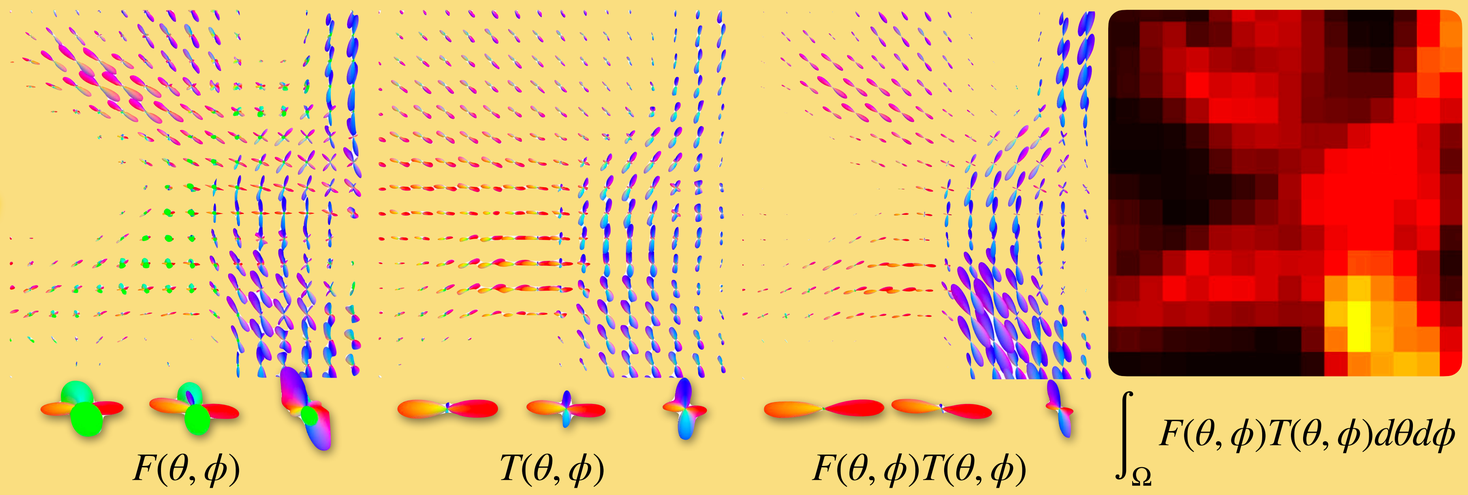
A **tumour deformation field**[2] is computed (b) from the target image and used to **warp the atlas** (c) to account for tumour-induced tissue displacement.

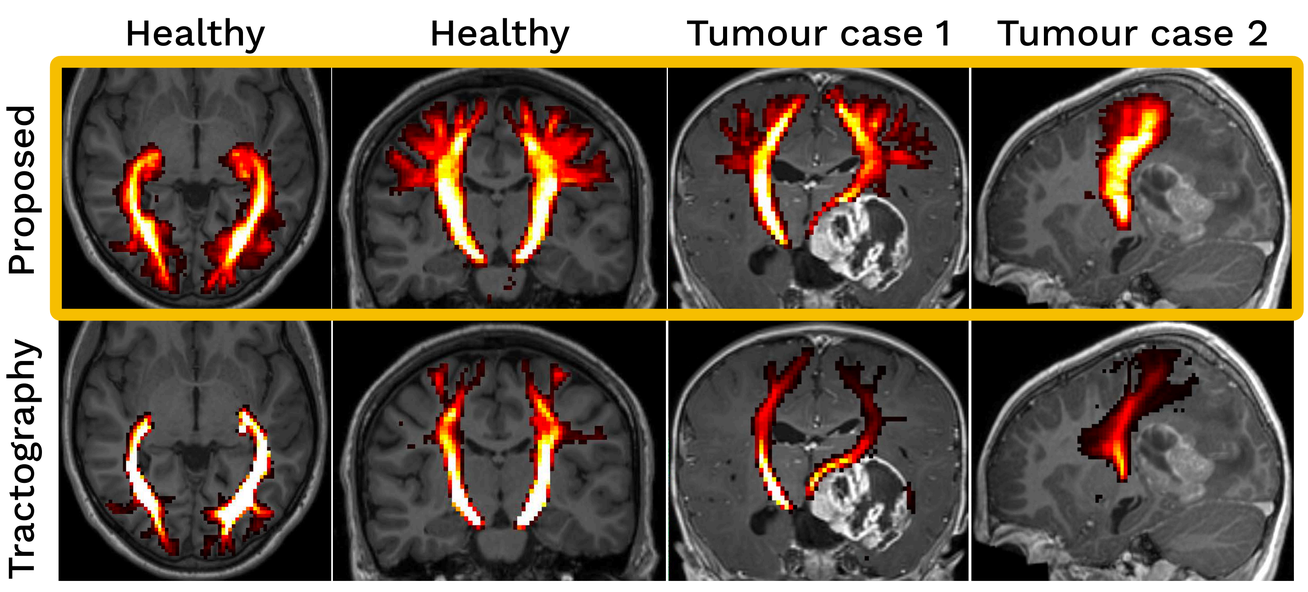


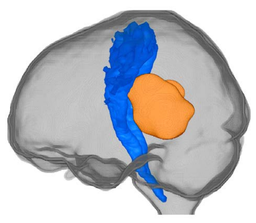
Step 3: Combine atlas and data

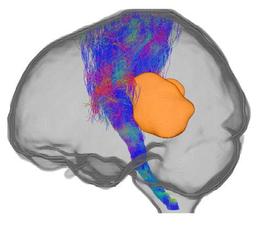
Inner product of the atlas ($T(\theta, \phi)$) and target image fibre orientations ($F(\theta, \phi)$) is evaluated to **determine the degree of agreement:**

$$\int_{\Omega} F(\theta, \phi) T(\theta, \phi) d\theta d\phi$$









Summary

- New tract segmentation method
- Results are **comparable with tractography** (current clincial standard)
- Successful handling of **complex tumour cases**
- Low effort, short processing time, and no expert knowledge required → feasible for intraoperative use

1. Dhollander, T. *et al.* (2014) https://doi.org/10.1016/j.neuroimage.2013.12.047
2. Nowinski, W. L., & Belov, D. (2005) https://doi.org/10.1016/j.acra.2005.04.018