Web-based tractogram observer for inspection and virtual tract-tracing.

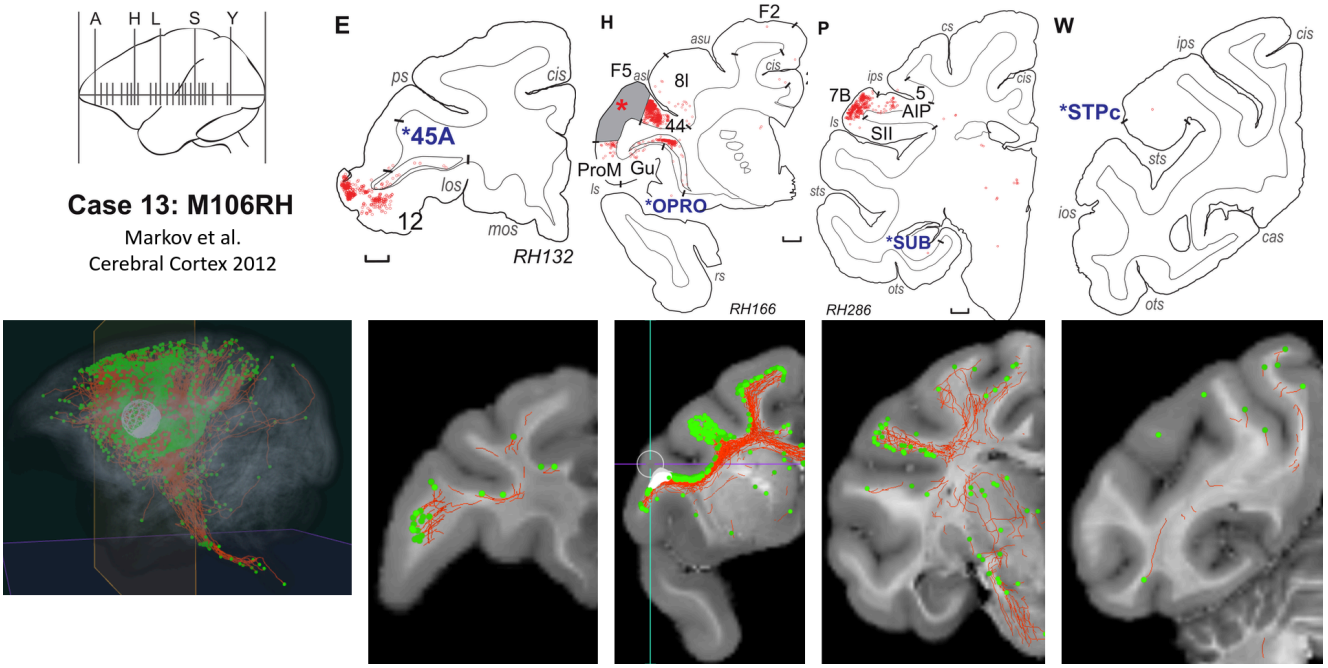
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Introduction Comparisons between Diffusion-Weighted-Imaging (DWI)-derived tractograms and tract-tracing studies in macaque typically measure overlap between connectivity matrices at the brain area level. A more in depth comparison between tracer injections and DWI-derived streamlines will yield better insights in tractogram accuracy. As an example we take Case 13 from the seminal tract-tracing study by Markov et al. 2012 (see figure). Can we find streamlines that connect the injection site in area F5 with cell bodies labelled in area 7B? And with the sparse label found in area STPc? To answer these questions, we need (1) high quality macaque tractograms and (2) a tool that can selectively display streamlines that terminate at a given probe location.

Methods We present a new web-app (https://tractogram.observer) that takes a tractogram and anatomical brain image as input and displays all streamlines that start/end within a spherical probe. The probe and selected streamlines are displayed in a 3d overview picture and in coronal, sagittal and axial slices. The interface allows for easy comparison with literature-published tract-tracing studies. Brain orientation can be adjusted (pitch, yaw, roll) to match published slice pictures. The open source tool (https://github.com/rbakker/tract-tracer) operates client-side and is suitable for privacy-sensitive human data. We use high quality, multishell 0.45mm ex-vivo DWI data from the MacBNA project (Lu et al. 2024) to construct macaque tractograms. Five-tissue-type anatomically-constrained tractography is performed with seeding from the gray-white matter boundary, using an mrtrix3-based pipeline (Tournier et al. 2019).

Results The figure below compares the Case 13 example tracing experiment to a tractogram derived from the MacBNA-M03 subject. Tractogram.observer was used to select a probe location that matches the tracer injection location (asterisk in subplot H, area F5) and to show streamline endpoints in slices that best match the published sections. The most notable discrepancy is the strong connectivity to area 8l suggested by the tractogram but only weakly present in the experiment. It could be that a strong link exists in the opposite direction (tracer injections are uni-directional), or that the connection strength is over-estimated. More tractograms and case studies are in preparation.



Conclusion The new tractogram.observer tool facilitates the comparison between DWI-derived tractograms and tract-tracing experiments, without the need to parcellate the brain. It can help to find better tractogram-producing algorithms by comparing them to ground-truth data, while keeping these limitations in mind: tractograms reveal whether two regions are connected by white matter fibers, tract-tracing experiments show the precise use of these fibers including directionality and targeted cortical layers.

1. Markov et al. (2012) Cerebral Cortex 24(1). doi: 10.1093/cercor/bhs270.
2. Lu et al. (2024). Science Bulletin 69(14). doi: 10.1016/j.scib.2024.03.031
3. Tournier et al. (2019) *NeuroImage* 202. doi 10.1016/j.neuroimage.2019.116137.

Acknowledgement: Funding from the Dutch Research Council (NWO) grant number KICH1.ST03.21.004.