The effect of computation strategy on fiber tractography metrics: A focus on fractional anisotropy and corpus callosum

Citation for published version (APA):

Zhylka, A., Leemans, A. L. G., Pluim, J. P. W., & De Luca, A. (2020). *The effect of computation strategy on fiber tractography metrics: A focus on fractional anisotropy and corpus callosum*. S126-S127. Abstract from ESMRMB 2020 Online, 37th Annual Scientific Meeting. <https://doi.org/10.1007/s10334-020-00876-y>

DOI:

[10.1007/s10334-020-00876-y](https://doi.org/10.1007/s10334-020-00876-y)

Document status and date:

Published: 01/10/2020

Document Version:

Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

The effect of computation strategy on fiber tractography metrics: A focus on fractional anisotropy and corpus callosum

A. Zhylka, A. Leemans, J. Pluim, A. De Luca

Introduction

The analysis of diffusion MRI metrics along pathways reconstructed with fiber tractography¹ (FT) (tractometry²) is becoming increasingly popular and reaching clinical application³. This kind of analysis requires, however, several computational steps and user choices, whose effect on the analysis step remains unknown.

In this work, we showcase the effect of two interpolation approaches and of three ways of assigning metrics to the points along a pathway on the reconstruction and quantitative analysis of the corpus callosum (CC) (Fig. 1a).

Subjects/Methods

Thirty subjects from the Human Connectome Project⁴ were used for the analysis consisting of 18 volumes at $b=0\text{s/mm}^2$ and 90 volumes at $b=1000\text{s/mm}^2$.

Deterministic whole-brain DT-based FT was performed with a range of FA thresholds $\{0.1, 0.15, 0.2, 0.25, 0.3\}$, 1mm step size, 45° angle threshold, then the CC was delineated⁵. For each setting, FT was performed twice, calculating the FA at each point with DT- and FA-based interpolation. The FA was computed by averaging the FA values of each of pathways' points (denoted as "*plain*"), and by calculating the average and the weighted average FA on a voxel-basis. In the latter case, the weights were defined as the numbers of the unique pathways visiting each voxel, and the voxel assignment was performed both directly and using a Bresenham-like discretization algorithm⁶ ("*Bresenham map*", Fig. 1b). Statistical testing was performed using the two-tailed Wilcoxon test with confidence level $\alpha=0.05$.

Results/Discussion

From the FA profiles (Fig. 2a) it can be seen that different approaches to averaging FA values as well as using a different interpolation strategy (DT vs FA) provide different results. Fig. 2b shows that DT-interpolated FA values significantly differ from FA-interpolated FA values in most cases. The correlation between all the approaches is high (Fig. 2c), which is in line with the observed similarity in shape for the FA profiles (despite the offset). When zero-centering each bundle FA set, we did not observe significant differences between any pair of bundle FA sets, independently from the choice of the averaging and interpolation approaches (Tab. 1).

Our results suggest that FA values computed with different interpolation methods have near-identical sensitivity to physiological changes along the reconstructed pathways. However, the presence of an offset between the methods hampers the comparability of the results obtained with different settings, and suggests the need to report the chosen interpolation method along with other user-defined settings of FT.

Acknowledgements

Andrey Zhylka is supported by funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No 765148.

References

1. Jeurissen,et al. *NMRBiomed*2019
2. Bells, et al *ISMRM*2011
3. Cousineau,et al. *NeuroImage*2017
4. Van Essen,et al, *NeuroImage*2013
5. Wasserman,et al. *BrainStructFunct*2016
6. Rheault,et al. *FrontNeuroinform*2017

Figure 1

Figure 1 (a) Using either FA or DT volume for FA calculation along the pathway might lead to different results. (b) Using Bresenham-like approach voxels passed by pathways but not containing their points are included into the bundle-wise computations.

Figure 2

Figure 2 Despite similar shapes of the bundle FA profiles(a) mainly significant difference was reported by the Wilcoxon test(b). However, the bundle FA correlation is high(c) which is in conformity with the profiles' shapes.

Table 1

Table 1 Two-tailed Wilcoxon test results (p -values) on centered bundle averages of a subset of compared pairs of bundles where one is tracked with FA values inferred from DT and FA ([DT]-, [FA]-marked) volumes, showing insignificant differences ($\alpha = 0.05$).

FA Threshold	0.1	0.15	0.2	0.25	0.3
[DT] Plain Average vs [FA] Visitation Weighted Averaged Map	0.9181	0.8693	0.9672	0.8050	0.9344
[DT] Plain Average vs [FA] Averaged Map	0.8855	0.9836	1.0000	0.9836	0.9181
[DT] Plain Average vs [FA] Visitation Weighted Bresenham Map	1.0000	0.9672	0.9018	0.7892	0.5372
[DT] Plain Average vs [FA] Averaged Bresenham Map	0.9508	1.0000	0.9836	0.8855	0.9018
[DT] Visitation Weighted Averaged Map vs [FA] Averaged Map	0.9181	0.9836	0.9508	0.9508	1.0000
[DT] Visitation Weighted vs [FA] Visitation Weighted Bresenham Map	0.8855	0.8531	0.6658	0.9672	0.9508
[DT] Visitation Weighted Averaged Map vs [FA] Averaged Bresenham Map	0.9836	0.9672	0.9672	0.9836	0.9344
[DT] Averaged Map vs [FA] Visitation Weighted Bresenham Map	0.9836	0.9836	0.8693	1.0000	0.9836
[DT] Averaged Map vs [FA] Averaged Bresenham Map	0.9344	0.9508	1.0000	0.8531	0.9018
[DT] Visitation Weighted Bresenham Map vs [FA] Averaged Bresenham Map	0.9836	1.0000	0.8531	0.8693	0.9672