White Matter Multi-Resolution Segmentation Using Fuzzy Set Theory

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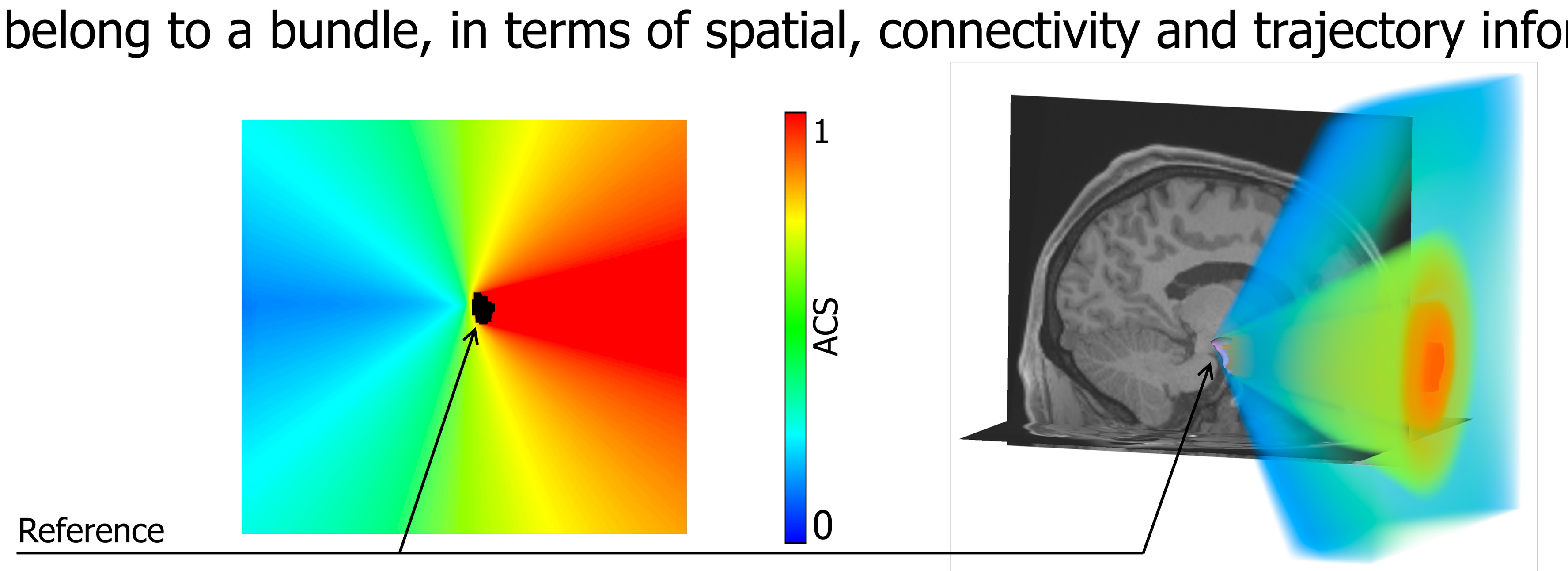
INTRODUCTION / OBJECTIVE

We propose a method for white matter segmentation exploiting spatial relations between brain regions. We model the relations inherent incertitude relying on the spatial fuzzy set theory [1,2]. We complement this approach introducing an interactive navigation and exploration technique based on a multi-resolution brain fiber representation [3].

SPATIAL RELATIONS MODELING

Clinicians often describe white matter fiber bundles using spatial indication in relation to known brain references. These descriptions are intrinsically vague, thus needing an appropriate modelling framework. We apply the fuzzy set theory to represent the uncertainty of fibers to belong to a bundle, in terms of spatial, connectivity and trajectory information (e.g. anterior of Amygdala).



We assign to every fiber an anatomical coherence score (ACS) combining, in a conjunctive way, the satisfaction degrees for all the provided descriptions. Users are able to interactively select the bundles of interest, via an ACS based thresholding operation, with the level of precision that best fit their applications.

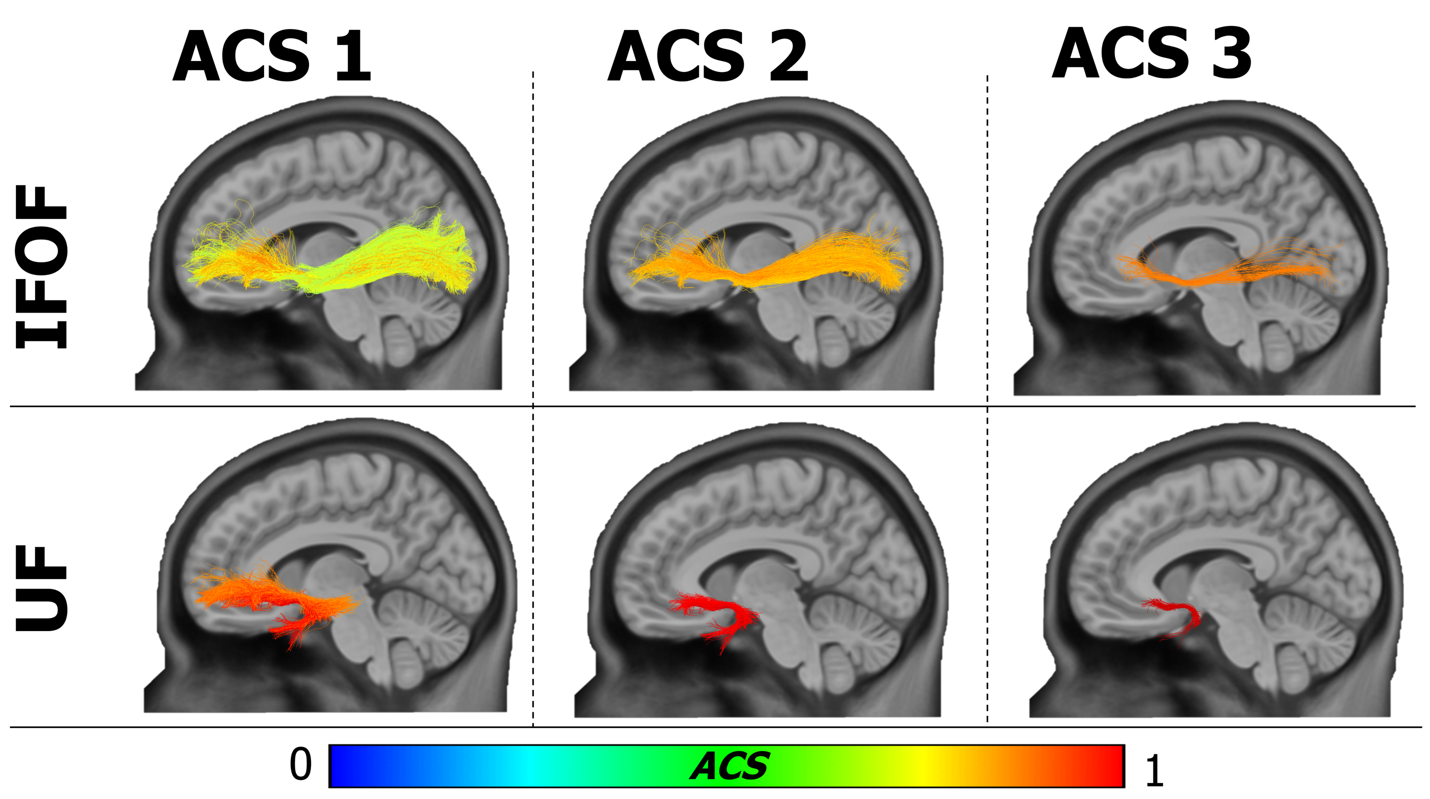


Fig. 1: Thresholding IFOF and UF

MULTI-RESOLUTION REPRESENTATION

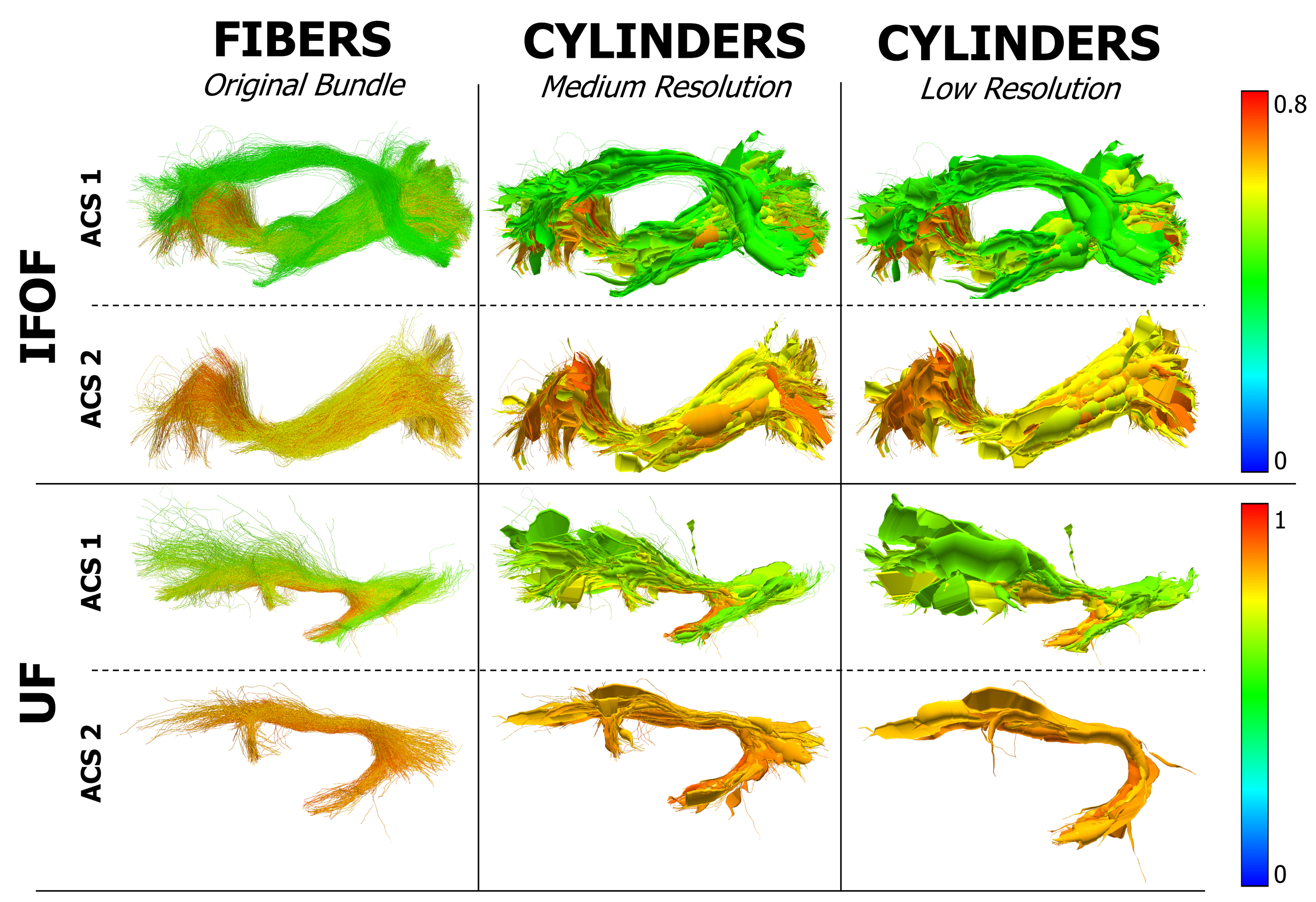
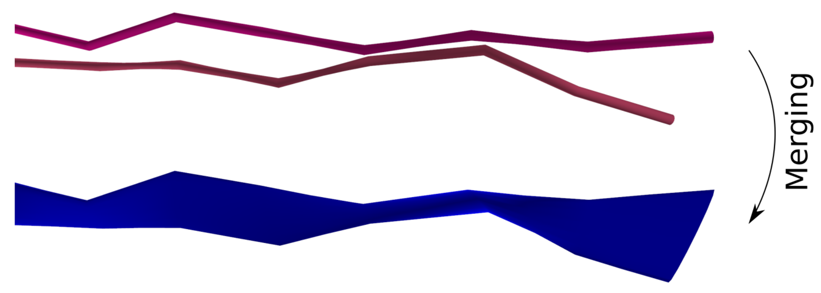


Fig. 2: Multi-resolution visualization of fiber bundles

In order to facilitate brain navigation and to add interactivity to the segmentation process, we introduce a white matter multi-resolution representation based on [3]. Fibers are progressively merged together according to their similarity.

We introduce a new term to the similarity measure (WC_{ext}) to take into account the ACS difference between two fibers X and Y, using a gaussian kernel K to regulate this effect:



$$WC_{ext} = K(|ACS_X - ACS_Y|) * WC \quad [4]$$

The interactive multi-resolution and thresholding allow for an easier understanding of the bundle as well as a better determination of the threshold at which fibers are all part of it.

RESULTS

- We validated our results on 5 unrelated healthy adults subjects from the *HCP* dataset.
- Compared to *WMQL* [4] and manual segmentation, our technique presents less scattered fibers, especially in the areas connecting the temporal and frontal lobe, as shown in the dispersion colormap of figure 3.
- The interactive analysis allowed neurosurgeons to better identify ACS thresholds producing the results that best represented the clinical reality.
- ACS segmentation thresholds were reproducible among different subjects.

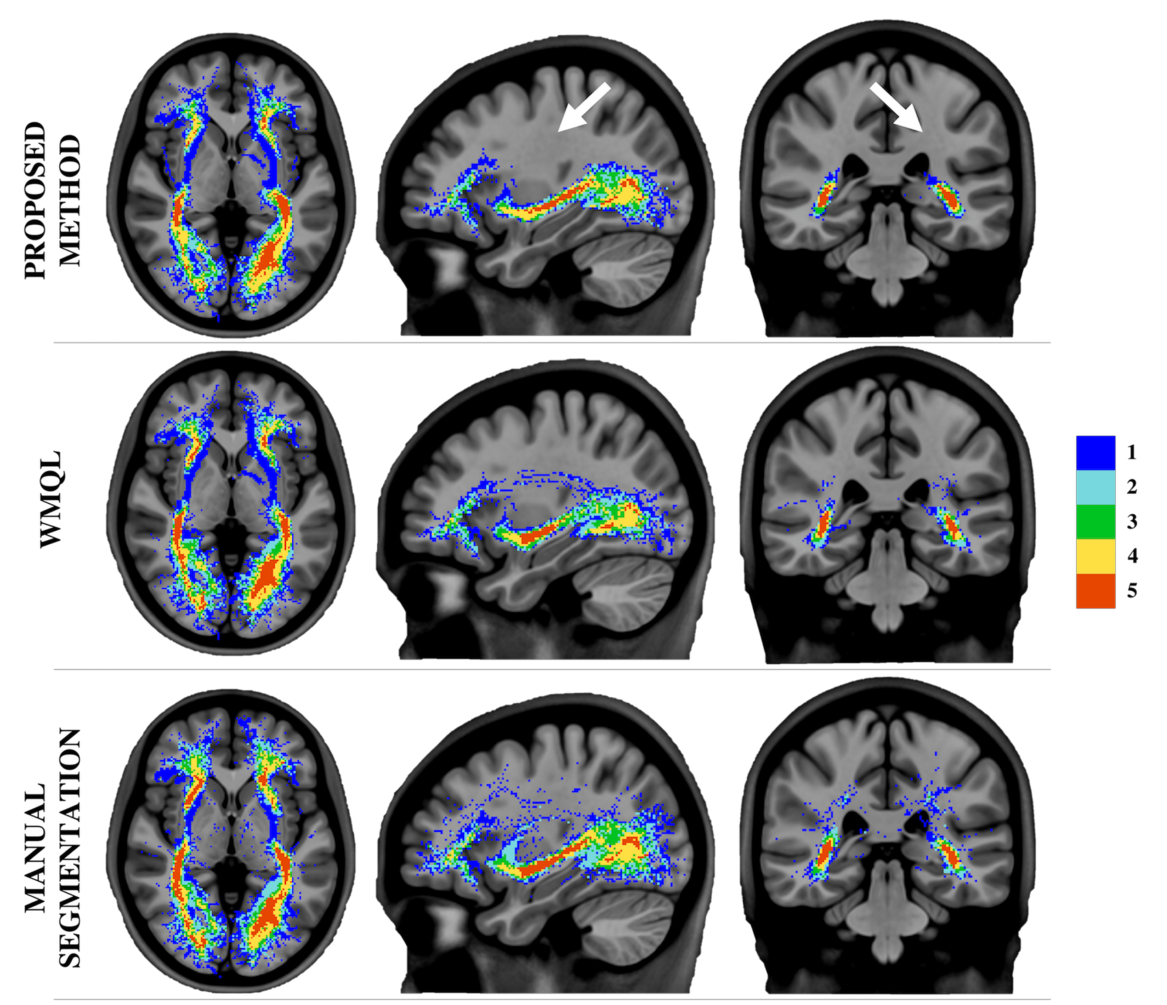


Fig. 3: Tracts dispersion map

FUTURE WORKS

We plan to extend the proposed technique to more tract bundles, implementing more fuzzy relations, and perform statistical analyses.

References
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Poster n°**582**

https://github.com/CorentinMercier/FBTS

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