Parameter Sensitivity and Uncertainty Visualization in DTI

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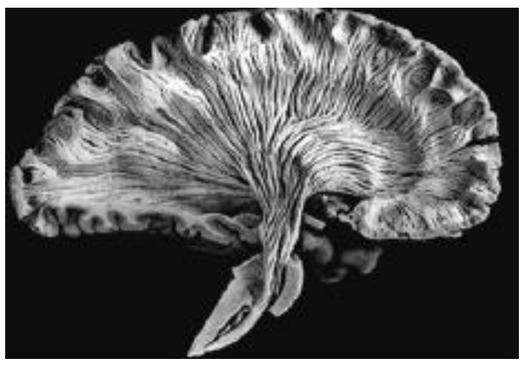
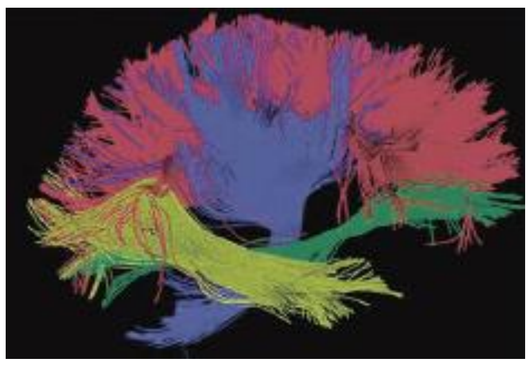
Introduction and motivation

Diffusion Tensor Imaging

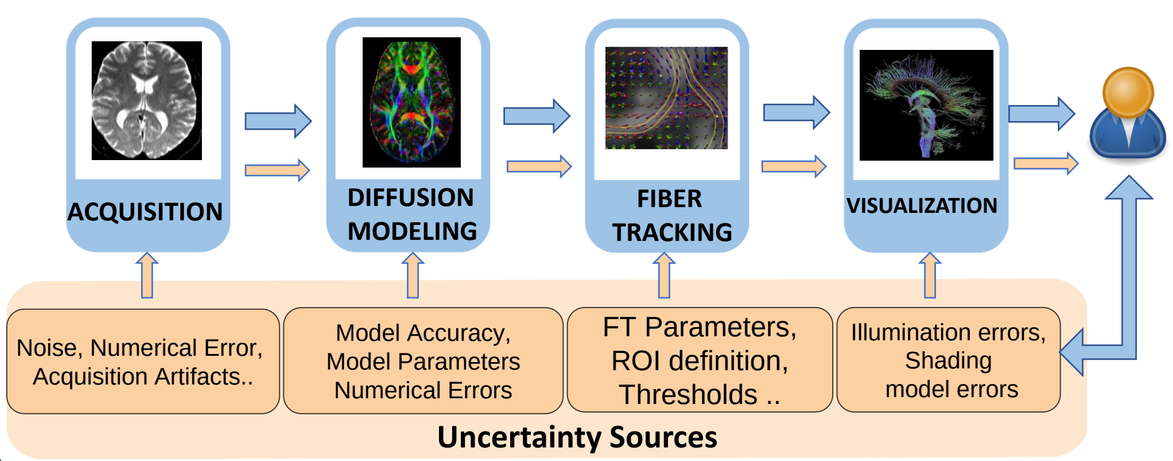
A non-invasive MRI based technique that allows the measurement of the diffusion of the water molecules allows virtual reconstruction of brain white matters.





Uncertainty Visualization Pipeline

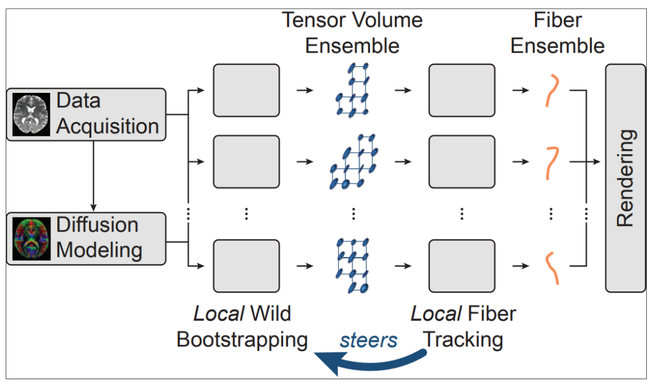
In DTI, the acquired data has to go through a complex transformation and visualization pipeline

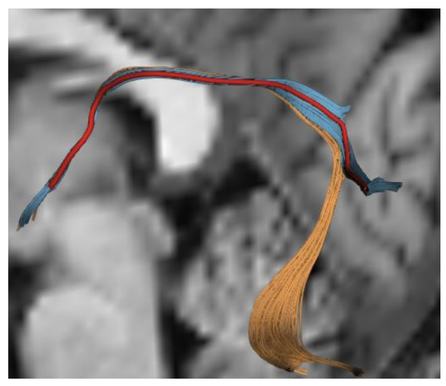


Uncertainties and Sensitivities

Noise and Modeling Uncertainties

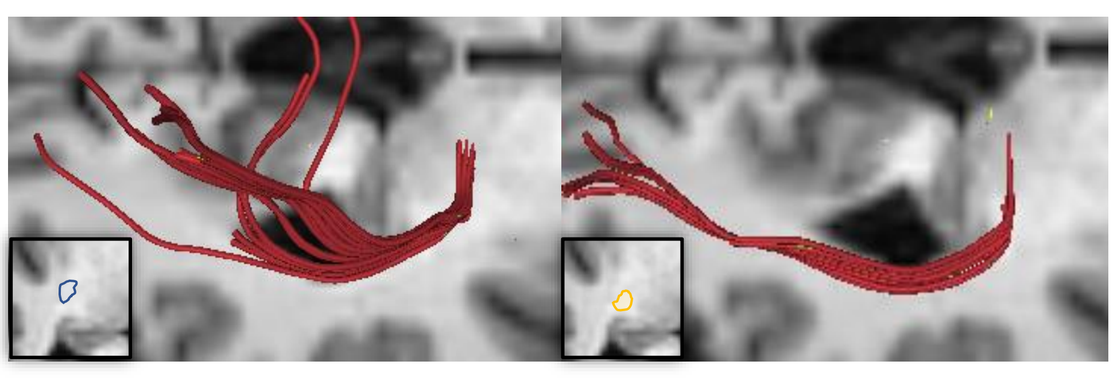
For visualizing the uncertainties due to noise and modeling errors, we developed a progressive visual analytic pipeline that allow the interactive estimation of uncertainty in the tractography [1].





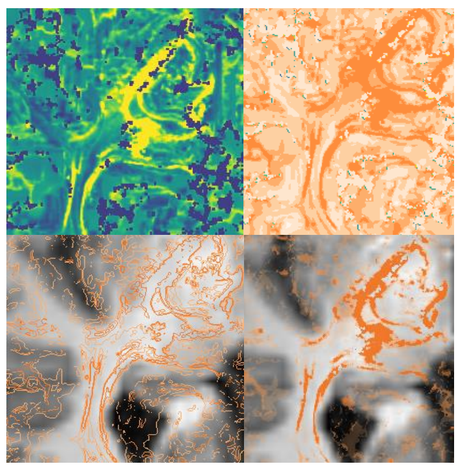
Region Based Parameter Sensitivities

To quantify region-based sensitives, we have defined several region-based sensitivity features based on the shape, length and connectivity of the fiber tracts to guide user in defining the optimal Region of Interests

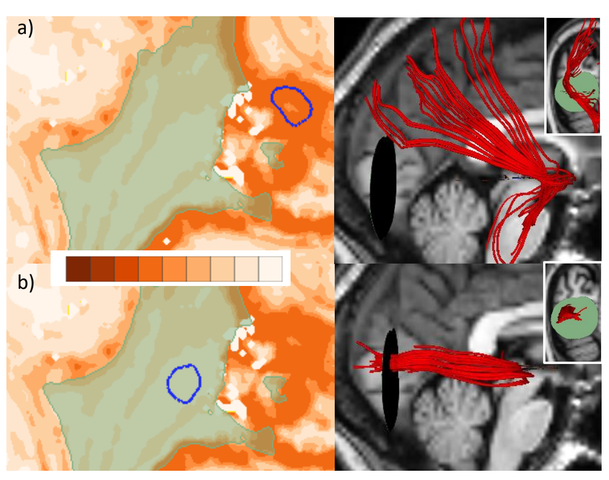


Visualization and Exploration

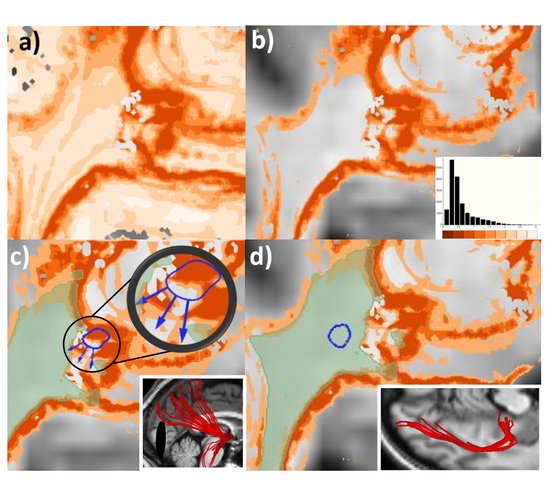
In this system, we proposed a visual analytic solution for the combined visualization and the interactive exploration of the sensitivities and uncertainties involved in the pipeline



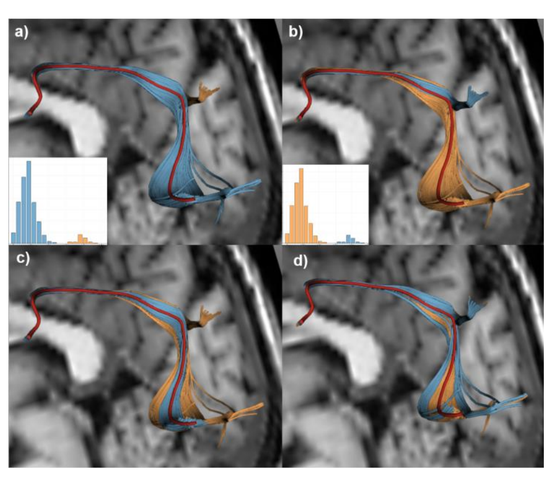
The feature maps are calculated for the preselected region progressively and visualized with binned color map to discretely identify the sensitive regions



The connectivity feature represented with an overlaid transparent surface on the sensitivity map for two cases (a-b). The green region in the figure depicts the projection of the end region



(a-b) Colors map visualization of the controlled with slider and histogram (c) defined ROI with guiding glyphs. (d) Defined ROI and obtained Optic radiation tract



Visualization of the variation of the single. Interactive histogram shows the distribution of the fiber samples based on the distances from the representative fiber

Conclusion

In this project, we propose generating visual analysis solution that allows the interactive estimation and reliable exploration of uncertainties and sensitivities in the DTI visualization and thus make tractography analysis less cumbersome and more reliable, a crucial step towards adoption in the neurosurgical workflow

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References: [1] Siddiqui, F., Höllt, T. and Vilanova, A. (2021), A Progressive Approach for Uncertainty Visualization in Diffusion Tensor Imaging. Computer Graphics Forum, 40: 411-422