Regularized Bundle-Specific Axon Caliber Estimation with Micro-Structure Informed Tractography

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Abstract

Axon diameter helps to determine the capacity Axon diameter distribution helps to determine the capacity of nervous transmission in the nervous systems. Axon diameter is directly associated with nerve response as it is proportional to its velocity conduction. Thus, having a good estimation of the axon-caliber becomes essential in medical applications.

The COMMIT framework is a powerful and novel tool, which estimates axon density and diameter by combining tractography and tissue micro-structure. The utility of COMMIT has been proved in several situations. COMMIT has been used by many research groups around the world to study the white matter microstructure. However, COMMIT has limitations estimating axon diameter distribution. COMMIT also requires an excessive amount of total system memory as well as high computational burden.

This work presents an extension of the COMMIT framework. It is focused on the addition of a regularization term to the original formulation of the mathematical model used by COMMIT to model the diffusion MRI data. This regularization is introduced to improve the axon diameter estimation. This work shows a set of experiments and practical situations where the regularization term improves on the estimation of axon-caliber. As secondary contribution, this works changes the half-sphere sampling scheme used in another framework called AMICO. This new sampling scheme provides an optimized memory management for both AMICO and COMMIT frameworks because COMMIT uses AMICO to generate a lookup table of synthetic diffusion MRI signals.