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Probabilistic tractography as distributions over paths: A Gaussian Processes Approach

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Tractography is a family of algorithms that aim to estimate the trajectories of brain fibers from noisy diffusion weighted MRI data. The most typical approach for estimating such trajectories is *fiber tracking*, where the algorithm starts at a pre-selected seed point and keeps walking in an estimated "most likely" direction until a stopping criterion is reached. Many fiber tracking variants exist, some of which are *probabilistic* in the sense that each step is drawn randomly from a distribution of stepping directions. By sending many *walkers*, such methods are able to get a good estimate of the most likely trajectory in spite of the noisy data. However, tracking methods suffer from "path length dependency" which, probabilistically, results in a) propagation of uncertainty with distance to the seed point, and b) decrease in the probability of ever reaching a target point with its distance to the seed point, regardless of whether there is a physical connection or not.

In this talk we present a new and recently developed family of tractography algorithms which output a probability distribution over paths as an estimate of the fiber trajectories. The uncertainty of the distributions give a localized measure of tract uncertainty, which does *not* propagate with distance to the seed point and which does not suffer from path length dependency.

The concrete algorithm returns tracts as Gaussian Processes that represent shortest paths in a random Riemannian manifold estimated from the data, in the special case of diffusion tensor imaging (DTI). However, the approach taken is general, and we will outline ongoing work aiming to apply the same approach to modern high angular resolution diffusion imaging data.