Estimation of integral curves from noisy diffusion tensor data

Abstract

Consider a tensor field in a bounded subset in R^d. Its components are slopes in a certain system of regression equations. The problem is to estimate the integral curve starting at a given point and driven by the principle eigenvector field corresponding to this tensor field. We develop a three-step estimation procedure based on a kernel estimator for the tensor field, followed by a plug-in estimator for the vector field and a plug-in estimator for the integral curve. Our work utilizes ideas of Koltchinskii, Sakhanenko and Cai (2007) in a more complicated, more general and more realistic than theirs model. The resulting estimator for the integral curve is asymptotically normal. We derive the differential and integral equations for the mean and the covariance of the limiting Gaussian process. This provides a method for tracking the integral curve together with its mean and covariance and allows to construct confidence ellipsoids for fixed points on the curve. This problem is motivated by Diffusion Tensor Magnetic Resonance Imaging (DT-MRI), a popular brain imaging technique. We provide a statistical framework for assessing uncertainty in images based on diffusion tensor data.