

Multivariate Spline Estimation and Inference for Image-on-scalar Regression

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Abstract: Motivated by recent work of analyzing data in the biomedical imaging studies, we consider a class of image-on-scalar regression models for imaging responses and scalar predictors. We propose to use flexible multivariate splines over triangulations to handle the irregular domain of the objects of interest on the images and other characteristics of images. The proposed estimators of the coefficient functions are proved to be root-n consistent and asymptotically normal under some regularity conditions. We also provide a consistent and computationally efficient estimator of the covariance function. Asymptotic pointwise confidence intervals (PCIs) and data-driven simultaneous confidence corridors (SCCs) for the coefficient functions are constructed. Our method can simultaneously estimate and make inferences of the coefficient functions while incorporating the spatial heterogeneity and spatial correlation. A highly efficient and scalable estimation algorithm is developed. Monte Carlo simulation studies are conducted to examine the finite-sample performance of the proposed method. The proposed method is applied to the spatially normalized Positron Emission Tomography (PET) data of Alzheimer's Disease Neuroimaging Initiative (ADNI).