Spatially Dependent Functional Data: Covariance Estimation, Principal Component Analysis, and Kriging

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Abstract: We consider spatially dependent functional data collected under a geostatistics setting, where locations are sampled from a spatial point process and a random function is observed at each location. The functional response is the sum of a spatially dependent functional effect and a spatially independent functional nugget effect. Observations on each function are made on discrete time points and contaminated with measurement errors. Under the assumption of spatial stationarity and isotropy, we propose a tensor product spline estimator for the spatio-temporal covariance function. If a coregionalization covariance structure is further assumed, we propose a new functional principal component analysis method that borrows information from neighboring functions. Under a unified framework for both sparse and dense functional data, where the number of observations per curve is allowed to be of any rate relative to the number of functions, we develop the asymptotic convergence rates for the proposed estimators. Advantages of the proposed approach over existing methods are demonstrated through simulation studies and a real data application to the home price-rent ratio data in the San Francisco Bay Area.