FMEM: Functional Mixed Effects Models for Longitudinal Functional Responses

Abstract

The aim of this paper is to systematically carry out the theoretical analysis of estimation and inference procedure for a class of functional mixed effects models (FMEM). Such FMEM consists of fixed effects that characterize the association between longitudinal functional responses and covariates of interest and random effects that capture the spatial-temporal correlations of longitudinal functional responses. First, we establish the weak convergence of the local linear estimate of refined fixed effect functions, as well as its asymptotic bias and variance. Second, we establish the uniform convergence rate of the estimated spatial-temporal covariance operators and their associated eigenvalues and eigenfunctions. Third, we propose a global test for linear hypotheses of varying coefficient functions, and derive its asymptotic distribution under the null hypothesis and its asymptotic power under the alternative hypothesis. Fourth, we also propose a simultaneous confidence band for each fixed effect curve. Extensive simulations and an application to white-matter fiber skeletons in a national database for autism research are conducted to examine the finite-sample performance of the estimation and inference procedure.