Functional Principal Component Analysis of Spatial-Temporal Point Processes with Applications in Disease Surveillance

Speaker: Yehua Li
Iowa State University
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In disease surveillance applications, the disease events are modeled by spatial-temporal point processes. We propose a new class of semi-parametric generalized linear mixed Cox model for such data, where the event rate is related to some known risk factors and some unknown latent random effects. We model the latent spatial-temporal process as spatially correlated functional data, and propose composite likelihood methods based on spline approximation to estimate the mean and covariance of the latent process. By performing functional principal component analysis to the latent process, we gain deeper understanding of the correlation structure in the point process, and we propose an empirical Bayes method to predict the latent spatial random effects, which can help highlighting the high risk spatial regions for the disease. Under an increasing domain and increasing knots asymptotic framework, we provide the asymptotic distribution for the parametric components in the model and the asymptotic convergence rate for the functional principal component estimators. We illustrate the methodology through a simulation study and an application to the Connecticut Tumor Registry data.

Authors:
Yehua Li, Iowa State University
Yongtao Guan, University of Miami