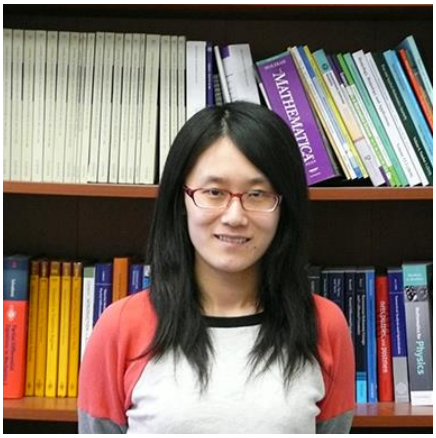
WPI MATHEMATICAL SCIENCES

Hong Yan

PhD Candidate

Mathematical Sciences



Tuesday, October 30, 2018

Campus Center
Chairman's Room, 129

10:00am

Dissertation Committee:

Professor Jian Zou, WPI
Professor Zhongqiang Zhang, WPI
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PhD Dissertation Presentation

Hybrid Hierarchical Spatio-Temporal Methodologies: Model Reduction and Filtering

Abstract: The spatio-temporal analysis is emerging and imperative with the increasing volumes of available databases and development of computing technology. Such analysis involves investigations of both space and time dimensions and often leads to high complexity, but both high accuracy and low computational cost are desired. To deal with these issues, we developed a family of hybrid Bayesian hierarchical methods to reduce the computational burden and to improve the accuracy. These methodologies essentially consist of two stages. The first stage is designed to scale down the program execution time by dimension reduction techniques. The second stage is to apply nonlinear filtering to achieve more accurate predictions.

Specifically, we developed two series of methodologies: the Dirichlet process particle filter (DPPF) models and the restricted Gaussian process particle filter (ReGPPF) models. DPPF models combine a Dirichlet process mixture (DPM) structure and nonlinear filtering to reduce data dimension and improve prediction. ReGPPF models utilize the principal component analysis (PCA) and particle filter to reduce the parameter dimension in a Gaussian process model and improve the model fittings and predictions.

We have applied our methodologies to multiple applications including syndromic surveillance and urban transportation surveillance. Numerical results show that our novel methodologies improved the predictive accuracy over the non-hybrid models, especially when the signal-to-noise ratio is low. Moreover, the computational cost is acceptable and competitive in the real-world applications, benefiting from the dimension reduction procedure we employed. With the capacity of incorporating online updating scheme for data streaming applications, both of the DPPF and ReGPPF methodologies have the potential to accommodate other longitudinal studies with high-dimensional data structures.