Joint Mathematics–Statistics PhD Homecoming

Statistics Talks
S17-04-46
02 Oct 2025–03 Oct 2025

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Abstracts

A two-way heterogeneity model for dynamic networks

2 Oct
9.30–10.10

Jiang Binyan

The Hong Kong Polytechnic University, Hong Kong SAR

Dynamic network data analysis requires joint modelling individual snapshots and time dynamics. This paper proposes a new two-way heterogeneity model towards this goal. The new model equips each node of the network with two heterogeneity parameters, one to characterize the propensity of forming ties with other nodes and the other to differentiate the tendency of retaining existing ties over time. Though the negative log-likelihood function is non-convex, it is locally convex in a neighborhood of the true value of the parameter vector. By using a novel method of moments estimator as the initial value, the consistent local maximum likelihood estimator (MLE) can be obtained by a gradient descent algorithm. To establish the upper bound for the estimation error of the MLE, we derive a new uniform deviation bound, which is of independent interest. The usefulness of the model and the associated theory are further supported by extensive simulation and the analysis of some real network data sets.

Semi-parametric Estimation in Covariate-dependent Dynamic High-dimensional Gaussian Graphical Models

2 Oct
10.30–11.10

Luo Shan

Shanghai Jiao Tong University, China

This study introduces SEDYG, a semi-parametric framework for estimating dynamic graphs influenced by covariates. It aims to detect sparse, high-dimensional graph edges and identify active temporal intervals, as well as significant covariates influencing the graphs. The approach innovates by: (i) assessing functional variable correlations for parallelized neighborhood estimation, (ii) developing a varying coefficient model to quantify edge strength based on covariates, and (iii) ensuring selection consistency for converging to true graph structures. SEDYG outperforms existing methods in accuracy and speed, as demonstrated through numerical analysis and applications to EEG data and NBA statistics, revealing dynamic interconnections in complex, covariate-rich systems.

From Euclidean to Riemannian natural gradient: definition, computation and applications

2 Oct
11.15–11.55

Tran Minh-Ngoc

The University of Sydney, Australia

The natural gradient method is a widely used tool in statistical optimization, but computing it remains a challenging problem. We first introduce a method for efficiently computing the natural gradient by generating a sequence of matrices that converge to the inverse of Fisher information. A notable aspect of our approach is the avoidance of analytically computing the Fisher information matrix and its explicit inversion. The Variational Bayes training procedure, coupled with this matrix inverse-free natural gradient, is provably convergent and achieves a convergence rate of order $\mathcal{O}(\log s/s)$. We then extend the concept of natural gradient and its computation from the Euclidean domain to Riemannian manifolds. Our Riemannian natural gradient is intrinsic and can be computed efficiently. We offer a range of numerical examples to demonstrate the efficiency and reliability of the proposed method.

The general linear hypothesis testing problem for multivariate functional data with applications

3 Oct
9.30–9.55

Zhu Tianming

National Institute of Education, Singapore

As technology continues to advance at a rapid pace, the prevalence of multivariate functional data (MFD) has expanded across diverse disciplines, spanning biology, climatology, finance, and numerous other fields of study. Although MFD are encountered in various fields, the development of methods for hypotheses on mean functions, especially the general linear hypothesis testing (GLHT) problem for such data has been limited. In this study, we propose and study a new global test for the GLHT problem for MFD, which includes the one-way multivariate analysis of variance for functional data (FMANOVA), post hoc, and contrast analysis as special cases. The asymptotic null distribution of the test statistic is shown to be a chi-squared-type mixture dependent of eigenvalues of the heteroscedastic covariance functions. The distribution of the chi-squared-type mixture can be well approximated by a three-cumulant matched chi-squared-approximation with its approximation parameters estimated from the data. By incorporating an adjustment coefficient, the proposed test performs effectively irrespective of the correlation structure in the functional data, even when dealing with a relatively small sample size. Additionally, the asymptotic power of the proposed test under a local alternative is established. Simulation studies and a real data example demonstrate finite-sample performance and broad applicability of the proposed test.

Weighted Fisher divergence for high-dimensional Gaussian variational inference

3 Oct
10.00–10.25

Linda Tan Siew Li

National University of Singapore, Singapore

Bayesian inference has many advantages for complex models. However, standard Monte Carlo methods for summarizing the posterior can be computationally demanding, and it is attractive to consider optimization-based variational approximations. Our work considers Gaussian approximations with sparse precision matrices which are tractable to optimize in high-dimensional problems. Although the optimal Gaussian approximation is usually defined as the one closest to the target posterior in Kullback-Leibler divergence, it is useful to consider other divergences when the Gaussian assumption is crude, in order to capture important features of the posterior for a given application. Our work studies the weighted Fisher divergence, which focuses on gradient differences between the target posterior and its approximation, with the Fisher and score-based divergences being special cases. We make three main contributions. First, we compare approximations for weighted Fisher divergences under mean-field assumptions for both Gaussian and non-Gaussian targets with Kullback-Leibler approximations. Second, we go beyond mean-field and consider approximations with sparse precision matrices reflecting posterior conditional independence structure for hierarchical models. Using stochastic gradient descent to enforce sparsity, we develop two approaches to minimize the weighted Fisher divergence, based on the reparametrization trick and a batch approximation of the objective. Finally, we examine the performance of our methods for examples involving logistic regression, generalized linear mixed models and stochastic volatility models.

Pigeonhole Stochastic Gradient Langevin Dynamics for Large Crossed Mixed Effects Models

3 Oct
11.00–1125

Zhang Xinyu

National University of Singapore, Singapore

Large crossed mixed effects models with imbalanced structures and missing data pose major computational challenges for standard Bayesian posterior sampling algorithms, as the computational complexity is usually superlinear in the number of observations. We propose two efficient subset-based stochastic gradient MCMC algorithms for such crossed mixed effects models, which facilitate scalable inference on both the variance components and regression coefficients. The first algorithm is developed for balanced design without missing observations, where we leverage the closed-form expression of the precision matrix for the full data matrix. The second algorithm, which we call the pigeonhole stochastic gradient Langevin dynamics (PSGLD), is developed for both balanced and unbalanced designs with potentially a

large proportion of missing observations. Our PSGLD algorithm imputes the latent crossed random effects by running short Markov chains and then samples the model parameters of variance components and regression coefficients at each MCMC iteration. We provide theoretical guarantees by showing the convergence of the output distribution from the proposed algorithms to the target non-log-concave posterior distribution. A variety of numerical experiments based on both synthetic and real data demonstrate that the proposed algorithms can significantly reduce the computational cost of the standard MCMC algorithms and better balance the approximation accuracy and computational efficiency.

Multiplier bootstrap meets high-dimensional sample covariance matrices

3 Oct
11.30–11.55

Xie Jiahui

National University of Singapore, Singapore

In this work, we examine the feasibility and the adaptivity of employing multiplier bootstrap to analyze the asymptotic distributions of the largest eigenvalues of potentially spiked high-dimensional sample covariance matrices. Our findings demonstrate that multiplier bootstrap remains valid , provided the multipliers are appropriately chosen and the bootstrap procedures are applied multiple times with suitable corrections.
