Zihan Zhu

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Education

Duke University **Sep 2022 - May 2024 (expected)**
Master of Science, Department of Statistical Science

Peking University **Sep 2018-Jul 2022**
Bachelor of Science, School of Mathematical Science

Publications & Manuscripts

- **Zihan Zhu**, Ethan X. Fang, Zhuoran Yang. **Online Performative Gradient Descent for Learning Nash Equilibria in Decision-Dependent Games**, *37th Annual Conference on Neural Information Processing Systems (NeurIPS), 2023.* Link: https://openreview.net/forum?id=IdF7VT6eEs. Long version (manuscript): https://zzh1024.netlify.app/uploads/OPGD.pdf, in preparation for *Operation Research*.
- Jing Lei, Anru Zhang, **Zihan Zhu** (alphabetical order). **Computational and Statistical Thresholds in Multi-layer Stochastic Block Models**, submitted to *Annals of Statistics*. Link: https://arxiv.org/pdf/2311.07773.pdf.
- **Zihan Zhu**, Xin Gai, Anru Zhang. **Functional Post-Clustering Selective Inference with Applications to EHR Data Analysis**, manuscript, in preparation for *Biometrika*.

Working Paper

- **Inverse Game Theory for Entropy-Regularized Two-Player Zero-Sum Markov Games**, with Prof. Ethan X. Fang and Prof. Zhuoran Yang.

Honors and Awards

- Dean's Research Award, Duke University 2023
- The Elite Undergraduate Training Program of Pure Math, Peking University 2019-2022
- Academic Excellence Award, Peking University 2018-2019
- China Mathematical Olympiad (CMO), Gold Medalist 2017
- China Western Mathematical Olympiad, Gold Medalist 2017

Research Experience

Online Learning of Nash Equilibria in Decision-Dependent Games Jul 2022 - Oct 2023
Advisor: Prof. Zhuoran Yang and Prof. Ethan X. Fang

- Proposed a parametric framework to model the decision-dependent data. Derived sufficient conditions for strong monotone games under the parametric framework.
- Formulated the learning problem into a bi-level optimization. Derived an online algorithm (OPGD) to find the Nash equilibrium under linear and kernel parametric models. OPGD leverages online stochastic approximation to estimate the unknown parametric model and projected gradient descent to learn the Nash equilibrium. Extended the algorithm into the bandit feedback setting.
- Derived theoretical convergence guarantees for the proposed algorithm. Main technical innovation: Derived the estimation error of the parametric model under the power norm, which extends the classical result of online stochastic approximation under the RKHS norm into a continuous scale.

Post-Clustering Selective Inference for Functional Data **Nov 2022 - Nov 2023**

Advisor: Prof. Anru Zhang

- Proposed a post-clustering selective inference framework for functional data under the Gaussian distributional assumption. Main steps: 1. Leveraged low-dimensional embedding to transform the functional data into low-dimensional tensors. 2. Estimated the covariance matrices and conduct the whitening transformation. 3. Defined the selective p-value for tensor data.
- Derived theoretical guarantees for the proposed selective inference framework. Proved that the framework controls the selective type-I error and is asymptotically powerful.
- Applied the selective inference framework to phenotyping based on Electronic Health Records (EHR).

Computational and Statistical Thresholds in Multi-Layer SBM **May 2023 - Nov 2023**

Advisor: Prof. Anru Zhang and Prof. Jing Lei

- Derived computational lower bound and information-theoretic lower bound of the detection problem in the multi-layer stochastic block model (MLSBM).
- Studied the techniques to establish computational hardness, including the low-degree polynomial method and the Sum-of-square (SOS) hierarchy. Leveraged the low-degree polynomial method to establish the computational lower bound.
- Studied the techniques to establish information-theoretical hardness and derived the informational-theoretical lower bound through the calculation of chi-square divergence.

Inverse Game Theory for Regularized Two-Player Zero-Sum MGs **Jul 2023 - Present**

Advisor: Prof. Zhuoran Yang and Prof. Ethan X. Fang

- Reformed the non-linear QRE constraints into a linear system. Proposed sufficient conditions for strong identification of the payoff matrix under the linear parametric assumption. Derived a finite-sample error bound for the estimation error in the strong identification case.
- Constructed confidence sets covering the identified set with high probability in the partial identification case. Proved that the Hausdorff distance between the confidence set and the identified set converges to zero in probability as the sample size increases.

Poster Presentations

Post-Clustering Selective Inference for Functional Data

- Duke Health Data Science poster showcase — Durham, Dec 2023

Online Learning of Nash Equilibria in Decision-Dependent Games

- 37th Annual Conference on Neural Information Processing Systems — New Orleanian, Dec 2023

Additional Information

- **Reviewer:** ICLR 2024
- **Programming Skills:** R, Python, C, Matlab, Latex
- **Language:** Chinese (native), English (fluent)