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 in preparation for *Operation Research*).
- **Zihan Zhu**, Xin Gai, Anru Zhang. **Functional Post-Clustering Selective Inference with Applications to EHR Data Analysis**, manuscript, in preparation for *Biometrika.*
- Jing Lei, Anru Zhang, **Zihan Zhu** (alphabetical order). **Computational and Statistical Error Bounds in Multi-Layer Stochastic Block Models**, *Submitted to Annals of Statistics.* Link: https://arxiv.org/pdf/2311.07773.pdf.

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 that models decision-dependent distributions of the observed data. Derived sufficient conditions under this parametric framework that ensures a unique Nash equilibrium.
- 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 parametric model and projected gradient descent to learn the Nash equilibrium.
- Provided theoretical guarantees of convergence rate and estimation error under mild assumptions. Studied the estimation error under the power norm and extended the classical result of online stochastic approximation under the RKHS norm into a continuous scale. Derived novel proof steps to obtain the error bounds.

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 coerce the functional data into low-dimensional tensors. 2. Leveraged sample covariance estimator to evaluate the covariance matrices and conduct the whitening transformation. 3. Defined the selective p-value based on the clustering output.
- Derived theoretical guarantees for the proposed selective inference framework. Proved that the framework controls the selective type-I error and is asymptotically powerful under mild assumptions.
- Applied the selective inference framework to phenotyping based on Electronic Health Records (EHR).

Computational and Statistical Thresholds in Multi-Layer SBM — May 2023 - Dec 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).
- Leveraged the low-degree polynomial method to establish the computational hardness by deriving the regime that the second moment of the low-degree likelihood ratio (LDLR) is bounded. Studied the Sum-of-square (SOS) hierarchy.
- Established the informational-theoretical hardness by deriving Le Cam's contiguity. Derived the regime that contiguity holds by calculating the 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.

Additional Information

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