

TAO JIANG

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EDUCATION

Cornell University, United States

September 2020 - present

- Ph.D. in Operations Research, School of Operations Research and Information Engineering *CGPA: 4.096/4.0*

- Thesis advisor: Prof. Damek Davis

- Committee members: Prof. James Renegar, Prof. Adrian Lewis, Prof. Anil Damle, Prof. Katya Scheinberg

University of Waterloo (UW), Canada

September 2018 - August 2020

- Master of Mathematics (Thesis), Department of Combinatorics and Optimization *CGPA: 95/100*

- Thesis advisor: Prof. Stephen Vavasis

- Committee members: Prof. Levent Tunçel, Prof. Henry Wolkowicz

- Thesis: Sum-of-norms clustering: theoretical guarantee and algorithms

Singapore University of Technology and Design (SUTD), Singapore

May 2015 - August 2018

- Bachelor of Engineering, Summa Cum Laude, Engineering Systems and Design *CGPA: 4.79/5.00*

- Majors: Operations Research, Business Analytics

University of California, Berkeley, United States

June - August 2016

- Summer exchange program, Department of Applied Mathematics

CGPA: 3.85/4.00

INDUSTRY EXPERIENCES

Research Scientist Intern, FAIR lab, Meta AI, United States

June - present 2023

- Mentor: Lin Xiao

- Design and analyze an efficient optimizer LLM and vision transformers.

Data Science Analyst, GIC Private Limited, Singapore

July - September 2017

- Forecast NAREIT Index price value performance using Regression and Tree Ensemble on a monthly basis with 50,000 public data points, producing prediction results with a 2% MAPE.

Client Services Analyst, Goldman Sachs, Singapore

May - July 2017

- Enhanced client onboarding process and web application with 3 hours reduced per request

- Assisted client services for the trading of listed derivatives and advisory of trade discrepancies.

RESEARCH INTEREST

Mathematics of learning, especially the interplay of optimization, statistics, machine learning and numerical linear algebra.

PUBLICATIONS AND WORKING PAPERS

I. Machine learning: mathematics for clustering

(i) Sum-of-norms clustering

Jiang, T., Vavasis, S., & Zhai, C. W. (2020). Recovery of a Mixture of Gaussians by Sum-of-norms Clustering. *Journal of Machine Learning Research*, 21(225), 1-16. Sum-of-norms clustering is a method for assigning n points in R^d to K clusters using convex optimization. Recently, Panahi et al.(2017) proved that sum-of-norms clustering is guaranteed to recover a mixture of Gaussians under the restriction that the number of samples is not too large. The purpose of this

note is to lift this restriction, showing that sum-of-norms clustering can recover a mixture of Gaussians even as the number of samples tends to infinity.

Jiang, T., & Vavasis, S. (2020). Certifying clusters from sum-of-norms clustering. arXiv preprint arXiv:2006.11355.

All algorithms for sum-of-norms clustering yield approximate solutions, even though an exact solution is demanded to determine the correct cluster assignment. This paper aims to close the gap between the output from existing algorithms and the exact solution to the optimization problem. We propose a clustering test that identifies and certifies the correct cluster assignment from an approximate solution yielded by any primal-dual algorithm. Moreover, we show the correct cluster assignment is guaranteed to be certified by a primal-dual path-following algorithm after sufficiently many iterations.

Jiang, T., Tan, S., & Vavasis, S. (2023). Re-embedding data to strengthen recovery guarantees of clustering. arXiv preprint arXiv: 2301.10901.) We propose a clustering method that involves chaining four known techniques into a pipeline yielding an algorithm with stronger recovery guarantees than any of the four components separately. Given n points in R^d , the first component of our pipeline, which we call leapfrog distances, is reminiscent of density-based clustering, yielding an $n \times n$ distance matrix. The leapfrog distances are then translated to new embeddings using multidimensional scaling and spectral methods, two other known techniques, yielding new embeddings of the n points in $R^{d'}$, where d' satisfies $d' \ll d$ in general. Finally, sum-of-norms (SON) clustering is applied to the re-embedded points. Although the fourth step (SON clustering) can in principle be replaced by any other clustering method, our focus is on provable guarantees of recovery of the underlying structure. Therefore, we establish that the re-embedding improves recovery SON clustering, since SON clustering is a well-studied method that already has provable guarantees.

(ii) Spectral clustering

Singh, A., Jiang, T., & Damle, A. (2023). Filtering for spectral clustering. (Working paper)

We propose a new filtering method to boost the performance of spectral clustering.

II. Optimizers and solvers for learning, signal processing and decision making

(i) PDHG solvers for conic programs

Jiang, T., Moursi, W., & Vavasis, S. (2023). Range of the displacement operator of PDHG with applications to quadratic and conic programming. arXiv:2309.15009. We develop a novel formula for the range of PDHG using monotone operator theory. The analysis is then specialized to conic programming and further to quadratic programming and second-order cone programming. A consequence of our analysis is that PDHG is able to diagnose infeasible or unbounded instances of QP and of the ellipsoid-separation problem, a subclass of SOCP.

(ii) Nonsmooth and nonconvex optimizers for signal processing

Davis, D., & Jiang, T. (2022). A linearly convergent Gauss-Newton subgradient method for ill-conditioned problems. ArXiv:2212.13278. We analyze a preconditioned subgradient method for optimizing composite functions $h \circ c$, where h is a locally Lipschitz function and c is a smooth nonlinear mapping. We prove that when c satisfies a constant rank property and h is semismooth and sharp on the image of c , the method converges linearly. In contrast to standard subgradient methods, its oracle complexity is invariant under reparameterizations of c .

(iii) Nonconvex optimizers for portfolio management

Jiang, T., Wang, S., Zhang, R., Qin, L., Wu, J., Wang, D., & Ahipasaoglu, S. D. (2019). An inexact l2-norm penalty method for cardinality constrained portfolio optimization.

The Engineering Economist, 64(3), 289297. doi: 10.1080/0013791x.2019.1636169

We analyze and solve a single-period portfolio optimization problem with non-convex constraints, which address practical concerns of investment such as the active share weights of sectors and the number of stocks held in a portfolio. We reformulate the problem to simplify the computation and propose an inexact l2-norm penalty method to solve the problem.

SERVICES

Reviewer for ICML, SIAM Journal on Optimization, Machine Learning

Co-chair for minisymposium *Mathematics for sum-of-norms clustering* in SIAM Conference on Mathematics of Data Science 2022

TALKS

Recovery of a mixture of Gaussians by sum-of-norms clustering August 2019
ICCOPT 2019, Berlin, Germany

Certifying clusters from sum-of-norms clustering July 2022
ICCOPT 2022, Bethlehem, PA, USA

Leapfrog distance strengthens recovery guarantees of SON clustering September, October 2022
SIAM MDS22, San Diego, CA, USA

Informs Annual Meeting 2022, Indianapolis, IN, USA

HONORS AND AWARDS

Ministry of Education, Singapore: SM2 Undergraduate Scholarship

SUTD: SRX Operations Research Award, top student in Operations Research, SUTD Honors List for all academic terms

UW: William Tutte Postgraduate Scholarship, Sinclair Graduate Scholarship, MATH Senate Graduate Scholarship, UW Graduate Scholarship, TA, RA fellowship, Travelling Research Assistantship for ICCOPT

Cornell: Eleanor and Howard Morgan PhD 68 Graduate Fellowship

SIAM: SIAM Student Travel Awards

TEACHING EXPERIENCES

Graduate Teaching Assistant, Cornell University, USA

ORIE 5380 Optimization Methods 2022 Fall

ORIE 4740 Statistical Data Mining 2022 Spring

ORIE 4741 Big Messy Data 2021 Fall

ORIE 3310 Optimization II 2021 Spring

Graduate Teaching Assistant, UW, Canada

CO 671 Semidefinite Programming 2020 Spring

CO 663 Convex Optimization and Analysis 2020 Winter

CO 250 Introduction to Optimization 2019 Winter, Spring, Fall

Math 114 Linear Algebra for Science 2018 Fall

Undergraduate Teaching Assistant, SUTD, Singapore

10.007 Modelling the Systems World 2017 Winter, 2018 Spring

40.002 Optimization 2017 Fall

10.004 Advanced Mathematics II (Linear Algebra) 2016 Fall

SKILLS AND SELECTED PROJECTS

- Proficient in Python, PyTorch, R, Julia, Matlab, AMPL, Latex
- Bilingual and biliterate in English, native in Chinese
- Built an interactive web application for a financial institution which takes satellite images and other auxiliary data sources, to perform automated retail catchment analysis by machine learning
- Performed revenue maximization for Wind Flower Florist, with tools of statistics, Newsvendor model, dynamic pricing and data of sales and supply in the past 24 months
- Developed an algorithm for a car-sharing company, Car Club, which dynamically recommends the best plan to allocate vehicles across 78 stations weekly, boosting usage rate by 12%

PERSONAL INTEREST

- 8-year flutist with grade nine in Arts Grade Examination of China
- 1-year fencer with a specialty in foil
- Owner of 3 patents; Slippers with an embedded massaging function, kitchen knives that provide a cleaner cut on vegetables and foldable toothbrush incorporating four useful tools