ISAAC LIAO

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EDUCATION

Massachusetts Institute of Technology *Sep 2023 - Present*
Master of Engineering expected in June 2024, Electrical Engineering and Computer Science
Massachusetts Institute of Technology GPA: 5.0/5.0 *Sep 2019 - Jun 2023*
Bachelor of Science, Double major in Computer Science and Physics
Earl Haig Secondary School *Sep 2015 - Jun 2019*
Ontario Secondary School Diploma (OSSD)

RELEVANT COURSEWORK

Graduate Bayesian Modeling and Inference, Graduate Statistical Learning Theory, Graduate Information Theory, Quantum Physics I-III, Computer Vision, Statistical Mechanics I, Experimental Physics I. Built superfluid simulator using split-step method on Gross-Pitaevskii equation, with visualizations used to teach MIT Classical Mechanics II class.

RESEARCH PUBLICATIONS

Liao, I., Dangovski, R. R., Foerster, J. N., and Soljačić, M. Learning to optimize quasi-newton methods. In *Submitted to Transactions on Machine Learning Research*, 2023. URL https://openreview.net/forum?id=Ns2X7Azudy

Introduces a novel machine learning optimization algorithm which blends learn to optimize (L2O) meta-learning techniques with quasi-Newton optimization methods using sparse neural networks. Theoretical results regarding convex and nonconvex stochastic convergence and sparse neural network expressiveness, with experimental support.

INDEPENDENT PROJECTS

Hypernetworks for Mechanistic Interpretability
Advisor: Max Tegmark
Introduction of a novel hypernetwork architecture for generative modeling of neural network weights. Architecture is a merge of Pareto hypernetworks, hierarchical VAEs, and graph transformers. Reverse-engineering of learned algorithms, with algorithmic phase transitions using order parameters and visualization via force-directed graph drawing. Currently in progress.

Bayesian Recommender Systems
Final project in graduate Bayesian modeling and inference class
Probabilistic reformulation of the alternating least squares algorithm for low rank approximations for large matrix completion, as a special case of coordinate ascent variational inference for a mean-field approximation. Extension of algorithm from within the Bayesian framework to accommodate an expanded posterior class. Experiments to support a $> 2\%$ improvement in Netflix Prize Dataset RMSE, and ablative analyses of structures in the learned posterior.

Parameter-Efficient Approximation by Exploitation of Sparsity
Final project in graduate statistical learning theory class
Novel representation theorems regarding sparse neural network architectures and their ability to parameter-efficiently replicate any other sparse architecture. Proof ideas drawing from Pinsker inequality, Cheeger inequality, card shuffling, algrebraic connectivity, and transposition graphs. Experimental evaluation of the ability of sparse architectures to perform compositionally sparse linear operations.

Few Shot Learned Image Compression
Final project in computer vision class
Ideation, refinement, theoretical analysis, and empirical testing of neural image compression techniques. Use of information theory to develop channel codes for compression resembling the forward passes of VAEs and BNNs. Reinvented reparameterization gradients, hierarchical depth, and KL annealing schedules in the process, without prior knowledge of variational inference.

A Perturbative Approach to Random Matrix Spectra
Final project in quantum physics III class
Rederivation of joint eigenvalue distribution of random Hermitian matrices, using a combination of second-order quantum perturbation theory, Metropolis-Hastings, and Brownian motion. Rederivation of Wigner semicircle law. Connections to chaotic quantum billiards and application to emission spectra of quantum dots.

Swarm Intelligence for MIT Battlecode Competition
Development of novel swarm intelligence algorithms to play multi-agent competitive zero-sum games. Pathfinding, heuristics, minimax searches, bytecode optimization, network information compression and redundancy, encryption, emergent behavior, resource management and decision making, distributed algorithms, domain knowledge of real time strategy games. Manipulation of floating point computation structures to optimize restricted BFS search. Swarm construction and management of large-scale structures with topological properties using only local information.

AWARDS AND HONORS

International Physics Olympiad: *Silver Medal* — *Tel Aviv, Israel, July 2019*
International Physics Olympiad: *Honorable Mention* — *Lisbon, Portugal, July 2018*
MIT Battlecode Competition: Champion, solo — *Cambridge, MA, Jan 2022*
MIT Battlecode Competition: 7th place, solo — *Cambridge, MA, Jan 2021*
MIT Battlecode Competition: Champion of Newbie division, solo — *Cambridge, MA, Jan 2020*

EXTRACURRICULARS

Poker, piano, ice skating, polyphonic whistling