CS Seminar

Machine Learning for Real-Time Constrained Optimization

Prof Chen Minghua
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15:30-17:00

Venue:
Tam Wing Fan Innovation Wing Two

Abstract:
Optimization problems subject to hard constraints are common in time-critical applications such as autonomous driving and high-frequency trading. However, existing iterative solvers often face difficulties in solving these problems in real-time. In this talk, we advocate a machine learning approach -- to employ NN's approximation capability to learn the input-solution mapping of a problem and then pass new input through the NN to obtain a quality solution, orders of magnitude faster than iterative solvers. Today, the approach has achieved promising performance and exciting development for an essential optimal power flow problem in power system operation by us and a number of teams globally. A fundamental issue, however, is to ensure NN solution feasibility with respect to the hard constraints, which is non-trivial due to inherent NN prediction errors. To this end, we present two approaches, predict-and-reconstruct and homeomorphic projection, to ensure NN solution strictly satisfies the equality and inequality constraints. In particular, homeomorphic projection is a low-complexity scheme to guarantee NN solution feasibility for optimization over a general set homeomorphic to a unit ball, covering all compact convex sets and certain classes of nonconvex sets. The idea is to (i) learn a minimum distortion homeomorphic mapping between the constraint set and a unit ball using an invertible NN (INN), and then (ii) perform a simple bisection operation concerning the unit ball so that the INN-mapped final solution is feasible with respect to the constraint set with minor distortion-induced optimality loss. We prove the feasibility guarantee and bound the optimality loss under mild conditions. Simulation results, including those for non-convex AC-OPF problems in power grid operation, show that homeomorphic projection outperforms existing methods in solution feasibility and run-time complexity, while achieving similar optimality loss.

About the Speaker:
Minghua received his B.Eng. and M.S. degrees from the Department of Electronic Engineering at Tsinghua University. He received his Ph.D. degree from the Department of Electrical Engineering and Computer Sciences at University of California Berkeley. He is a Professor of School of Data Science, City University of Hong Kong. He received the Eli Jury award from UC Berkeley in 2007 (presented to a graduate student or recent alumnus for outstanding achievement in the area of Systems, Communications, Control, or Signal Processing) and The Chinese University of Hong Kong Young Researcher Award in 2013. He also received several best paper awards, including IEEE ICME Best Paper Award in 2009, IEEE Transactions on Multimedia Prize Paper Award in 2009, ACM Multimedia Best Paper Award in 2012, IEEE INFOCOM Best Poster Award in 2021, and ACM e-Energy Best Paper Award in 2023. Storage codes co-invented by Minghua have been incorporated into Microsoft Windows and Azure Cloud Storage, serving tens of millions of users. His recent research interests include online optimization and algorithms, machine learning in power system operation, intelligent transportation, distributed optimization, delay-critical networking, and capitalizing the benefit of data-driven prediction in algorithm/system design. He is an ACM Distinguished Scientist and an IEEE Fellow.

All are welcome!
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