Scalable and Guaranteed Computation: Optimization and Machine Learning for the Future Electric Grid

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Abstract: Computation promises to greatly enhance the electric grid through optimization and machine learning. However, many computational problems remain unsolved at the scale, speed, and quality necessary for the real world, due to issues of complexity and nonconvexity.

In the first part of this talk, we solve the optimization problem known as optimal power flow in guaranteed near-linear time and linear memory. Our key insight is use domain-specific techniques to exploit the graph theoretic notion of bounded treewidth. We give case studies on real-world electric grids with tens of thousands of vertices. We also extend our insights to solve other important graph-based optimization problems in transportation and medicine.

In the second part of this talk, we make safety-critical guarantees for the learning problem known as power system state estimation. We draw a connection with the nonconvex low-rank matrix recovery problem in recommendation systems, and prove that 1/2-restricted isometry is necessary and sufficient for guaranteed success in both classes of problems. We discuss implications for future work in the industrial applications of artificial intelligence.

Bio: Richard Y. Zhang received the B.E. degree (with first class honors) in electrical engineering from the University of Canterbury, Christchurch, New Zealand, in 2009, and the S.M. and Ph.D. degrees in electrical engineering and computer science from the Massachusetts Institute of Technology, Cambridge, MA, USA, in 2012 and 2017, respectively. From 2017 to 2019, he was a Postdoctoral Scholar with the Department of Industrial Engineering and Operations Research, University of California, Berkeley, CA, USA.

He is currently an Assistant Professor with the Department of Electrical and Computer Engineering, University of Illinois, Urbana–Champaign, Champaign, IL, USA. His research interests include computational mathematics and engineering, particularly in the solution of large-scale nonconvex problems, with applications in electric power systems, power electronics, data science, and machine learning.