PSERC Power Systems Engineering Research Center

PSERC WEBINAR

Power System State Estimation by Phase Synchronization and Eigenvectors

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To estimate accurate voltage phasors from inaccurate voltage magnitude and complex power measurements, the standard approach is to iteratively refine a good initial guess using the Gauss–Newton method. But the nonconvexity of the estimation makes the Gauss–Newton method sensitive to its initial guess, so human intervention is sometimes needed to detect convergence to plausible but ultimately spurious estimates. In this talk, we make a novel connection with the phase synchronization in signal processing to yield two key benefits: (1) an exceptionally high quality initial guess over the angles, known as a spectral initialization; (2) a correctness guarantee for the estimated angles, known as a global optimality certificate. These are formulated as sparse eigenvalue-eigenvector problems, which we efficiently compute in time comparable to a few Gauss-Newton iterations. Our experiments on the complete set of Polish, PEGASE, and RTE models show, where voltage magnitudes are already reasonably accurate, that spectral initialization provides an almost-perfect single-shot estimation of n angles from 2n moderately noisy bus power measurements (i.e. n pairs of PQ measurements), whose correctness becomes guaranteed after a single Gauss–Newton iteration. For less accurate voltage magnitudes, the performance of the method degrades gracefully; even with moderate voltage magnitude errors, the estimated voltage angles remain surprisingly accurate.

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LINK TO WEBINAR

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Richard Y. Zhang is an Assistant Professor in the Department of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign. He received the B.E. (hons) degree with first class honours in Electrical Engineering from the University of Canterbury, Christchurch, New Zealand, and the S.M. and Ph.D. degrees in Electrical Engineering and Computer Science from MIT. Before joining the University of Illinois, he was a Postdoctoral Scholar at the University of California, Berkeley. His research interests are in optimization and machine learning, and applications in power and energy systems. He is particularly interested in theoretical foundations and practical algorithms for nonconvex low-rank matrix optimization and convex semidefinite programming. He is a recipient of the NSF CAREER Award in 2021.