Globally Optimal State Estimation of AC Power Systems Using Semidefinite Programming (20110169, Dr. Georgios Giannakis)

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State Estimation for Power Distribution and to Manage Power Grids

An algorithm uses semidefinite programming (SDP) formulation for state estimation (SE) to find the optimum solution for power distribution and could be used to manage power grids. The improved SE algorithms, which provide greater reliability (e.g., decreased power interruption, greater resilience to malicious attacks) for a regional transmission organization (RTO) or smaller distribution network, could also provide more efficient power generation from a cost perspective and conceivably better integration of renewables. The robust SDP-based SE techniques are resilient to outlying measurements and/or adversarial cyber-attacks, and allow local control areas to solve centralized SDP-based SE problems in a distributed fashion.

Achieves Global Optimality

Within energy management systems used with the electrical power grid, SE is a key step in building real-time network models based on distributed measurements throughout the grid. Current SE implemented in Supervisory Control and Data Acquisition (SCADA) solutions, based on iterative schemes, only attain a local optimum. They face initialization challenges, are computationally intensive and cannot guarantee convergence to the correct state. As a result, power grids are subject to increased risk of power interruption and inefficient power generation. This new technology uses SPR to efficiently estimate the states and potentially achieve a global optimum. The new algorithm enables an energy management system that quickly determines the current optimal state of power needed in the grid and contributes towards real-time distribution of energy. The technology provides a faster, more accurate estimation of the grid, critical in optimizing power flow and determining available transfer capability, thus improving security to counter cyber-attacks and improving load balancing.

BENEFITS AND FEATURES:

- Provide greater reliability (e.g., decreased power interruption, greater resilience to malicious attacks)
- More efficient power generation from a cost perspective
- Better integration of renewables
- Global optimality
- Computational efficiency
- Distributed implementation
- Resilience to malicious attack
- Fast: polynomial time vs. iterative

APPLICATIONS:

- Efficient monitoring of power grid states for system control and economic dispatch with cybersecurity constraints and concerns
- Electrical power grids
- SCADA systems
- SCADA system manufacturers
- Grid optimization software companies
- AC power networks; smart grids
- RTOs or smaller distribution networks

Phase of Development - Proof of concept: algorithm developed, simulated with IEEE data sets

Researchers

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Publications

PSSE Redux: Convex Relaxation, Decentralized, Robust, and Dynamic Approaches
arXiv, Aug 2017

Power System Nonlinear State Estimation using Distributed Semidefinite Programming
IEEEJournal of Selected Topics in Signal Processing, Vol. 8, no. 6, pp. 1039-1050, December 2014

Monitoring and Optimization for Power Grids: A Signal Processing Perspective
IEEE Signal Processing Magazine, Vol. 30, no. 5, pp. 107-128, September 2013

Distributed Robust Power System State Estimation
IEEE Transactions on Power Systems, Vol. 28, no. 2, pp. 1617-1626, May 2013

Multi-area State Estimation using Distributed Semidefinite Programming for Nonlinear Power Systems

Proc. of 3rd Intl. Conf. on Smart Grid Communications, Tainan, Taiwan, November 5-8, 2012
Robust Power System State Estimation for the Nonlinear AC Flow Model
Proc. of 44th North American Power Systems Symposium, Univ. of Illinois at Urbana-Champaign, September 9-11, 2012
Estimating the State of AC Power Systems using Semidefinite Programming
Proc. of 43rd North American Power Systems Symposium, Northeastern Univ., Boston, MA, August 4-6, 2011

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