School of Electrical, Computer and Energy Engineering

PhD Final Oral Defense
A Data Analytics Framework for Smart Grids: Spatio-temporal Wind Power Analysis and Synchrophasor Data Mining

by
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Abstract
Under the framework of smart grids – enhanced electrical power grids by leveraging advanced information, communication and control technologies, a primary objective of this study is to develop novel data mining and data processing schemes for several critical applications that can enhance the reliability of power systems. Specifically, this study is broadly organized into the following two parts: 1) data mining and information fusion of synchrophasor measurements toward secure power grids, and 2) spatio-temporal wind power analysis for wind generation forecast and integration. Part 1 focuses on incorporating the emerging synchrophasor technology into the security assessment and the post-disturbance fault diagnosis of power systems. First, a data-mining framework is developed for on-line dynamic security assessment by using adaptive ensemble decision tree learning of real-time synchrophasor measurements. Under this framework, novel on-line dynamic security assessment (DSA) schemes are devised, aiming to handle various factors (including variations of operating conditions,
forced system topology change, and loss of critical synchrophasor measurements) that can have significant impact on the performance of conventional data-mining based online DSA schemes. Then, in the context of post-disturbance analysis, fault detection and localization of line outage is investigated using a dependency graph approach. It is shown that a dependency graph for voltage phase angles can be built according to the interconnection structure of power system, and line outage events can be detected and localized through networked data fusion of the synchrophasor measurements collected from multiple locations of power grids. Along a more practical avenue, a decentralized networked data fusion scheme is proposed for efficient fault detection and localization.

Part 2 is centered around wind farm generation forecast and integration. First, a spatio-temporal analysis approach for short-term wind farm generation forecasting is proposed. Specifically, using extensive measurement data from an actual wind farm, the probability distribution and the level crossing rate of wind farm generation are characterized using tools from graphical learning and time-series analysis. Built on these spatial and temporal characterizations, finite state Markov chain models are developed, and a point forecast of wind farm generation is derived using the Markov chains. Then, multi-timescale scheduling and dispatch with stochastic wind generation and opportunistic demand response is investigated.