ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

PROBABILISTIC DISTRIBUTION SYSTEM STATE ESTIMATION (DSSE)

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This is a summary of the research conducted on Bayesian based state estimation for distribution systems and data analytic methods for exploring probabilistic relations in electricity networks during the ELECTRA REX Researcher Exchange

I. CAPS Host Institute

The Center for Advanced Power Systems has strong emphasis on real-time modeling and simulation, as well as experimental capabilities and test facilities. This research exchange focused on data analytic methods for real time measurements and processing from networked sensor for distribution power system applications like state estimation.

Figure 1: Research group at CAPS

II. Research Exchange

Estimation methods based on the "statistical" Bayesian method utilize measurement data to extract information of prior statistics of the unknown random state as well as the statistical relation between the random state and data. Existing probabilistic approaches of distribution system state estimation (DSSE) have demonstrated the advantage over conventional "classical" approaches like the weighted least square estimation. Based on these works and the linear power flow equations for unbalanced networks, the linear minimum mean square estimation (LMMSE) has been extended to three phase unbalanced networks, including additional to voltage measurements also phasor angles [1]. In a successive step the DSSE algorithm will be implemented in an urban medium voltage network, for validation purposes and to gain performance insight. Extension of implementation in rural medium and low voltage networks is also planned.

III. Collaboration

Our research collaboration further focused on estimation inherent and signal processing related topics. These are namely existence of power flow linearization, Fisher-Rao metric for probability distribution dissimilarity; uncertainty, accuracy and performance analysis of estimation; as well as implementation and application of DSSE. The statistical estimation approach requires data-driven methods and technologies for descriptive analysis and inference statistics of the measurement data (e.g. smart meter, PMU). These data analytic methods are also relevant to related fields and applications like fault identification, and topology detection, as well as predictive applications like load and photovoltaic generation forecast. In particular a Fisher-Rao metric induced shape based feature analysis methods have been explored on PMU based event fault classification [2].

Furthermore, topology detection and identification is very important for state estimation and has a strong impact on validity of results. Data analytics based topology detection, which is based on correlation and measurement matrix Eigenvalue analysis, has been discussed in this context.

Aligned to this topic a special session at the IEEE PowerTech 2017 in Manchester (UK) with the title: 'Data Analytic Applications and Methods for Distribution Systems' was proposed and accepted. Contributions from the collaborative research as well as from industry and other academics will be presented. Additionally a chapter for a book on 'Data Analytics Application' - edited by the host researcher and published by Elsevier - has been contributed by the visiting researcher. In addition, it is planned to contribute a full day tutorial on data-driven statistical models, methods and applications at the next Grid Analytics Europe conference in 2017.

The need and application of networked sensors for monitoring are not restricted electricity networks and can be found in many domains and applications. Networked system science and the technology of Internet of Things (IoT) is becoming increasingly relevant. Not only the improved interoperability and reliability of measurement networks, but also the interconnection between domains is seen as a big advantage to improve applications. Relations and effect of additional sensor data, e.g. temperature, weather, events and even transportation system and electricity systems applications, like state estimation have been investigated.

IV. Future Collaborations

Further collaboration is planned and already proposed in form of a transnational access within the ERIGrid project. Researcher from CAPS group will conduct µPMU (PMU for distribution systems) data-based real-time analysis and processing experiments at the AIT SmartEST laboratory.

Additionally a research project proposal on PMU for distribution system together with CAPS, Technical University of Graz and Austrian based manufacturer of high resolution PMUs will be be submitted at the national call "Beyond Europe".

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References

[1] M. Stifter, R. Arghandeh, J. Cordova, Bayesian Linear State Estimation for Three Phase Unbalanced Distribution Systems, (working paper, to be submitted)

[2] J. Cordova, R, Arghandeh, Y. Zhou, S. Wesolowski,, W. Wu, M. Stifter, Shape-based Data Analysis for Event Classification in Power Systems, IEEE PowerTech 2017, Manchester, 2017 (accepted).