# Guest Editorial: State Estimation for Future Cyber-physical Power and Energy Systems: Challenges and Solutions

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LARGE-SCALE renewable power plants and distributed generators are integrated in the electric power systems on the generation side, meanwhile new demand-response technologies are being deployed on the demand side, such as electric vehicles and energy storage, controllable building energy and integrated energy system of industry park. Thereby the system dynamic characteristics become more complicated. To address this issue, advanced sensing, monitoring, communication, computation and control technologies are widely adopted. The power systems are evolving to tightly coupled cyber-physical power and energy systems, where the two-way flows of both electricity and information spread. As a result, there is an urgent need for the development of new state estimation algorithms for the modeling, situational awareness, operation and control of the integrated cyber-physical energy system. This special section focuses on some of the new techniques to solve the current challenges and solutions for future cyber-physical power and energy system state estimation. Eleven articles included in the special section are summarized as follows:

In the paper entitled "Multi-period Power System State Estimation with PMUs under GPS Spoofing Attacks", the authors present a dynamic and robust network state model to provide state estimation solution under global positioning system (GPS) spoofing attacks of phasor measurement units (PMUs). The paper develops an efficient algorithm with closed-form updates to collectively estimate the network state and time-varying attacks. The improved performance of the proposed algorithm is validated with simulations compared with static method.

In the paper entitled "Physics-guided Deep Learning for Power System State Estimation", the authors describe a physics-guided state estimation approach based on deep learning technique. Deep neural networks are employed to learn the temporal correlations and then the result is tested against physical power flows. Case studies are reported to validate the robustness and accuracy of the proposed method.

In the paper entitled "Tracking Power System State Evolution with Maximum-correntropy-based Extended Kalman Filter", a power system state tracking method based on Maximum correntropy criterion is introduced. The presented method firstly demonstrates the estimation process by the maximum-correntropy-based Extended Kalman filter and then properly adjusts the kernel bandwidth to maintain the accuracy during unexpected circumstances. IEEE test systems and the real Brazilian interconnected system are used to prove the efficiency and accuracy of the proposed method under normal and abnormal situations.

In the paper entitled "Fully Distributed State Estimation for Power System with Information Propagation Algorithm", a novel state estimation in fully distributed manner based on weighted least square method and graph theory is introduced. Unlike conventional distributed method, the proposed method does not require the area partition of the systems. The distributed implementation is realized by a novel information propagation algorithm. Extensive case studies are conducted to show the advantage of the proposed strategy compared with traditional methods.

In the paper entitled "A Hybrid State Estimation Approach for Integrated Heat and Electricity Networks Considering Time-scale Characteristics", a two-stage iterative hybrid state estimation method for integrated heat and electricity networks is proposed. The time delay of heat power transportation is considered and estimated through the proposed method. Case studies indicate that the hybrid state estimator has good performance in both steady and dynamic processes.

In the paper entitled "Decentralized State Estimation of Combined Heat and Power System Considering Communication Packet Loss", a decentralized state estimation method for combined heat and power systems is proposed based on a relaxed alternating direction method of multipliers. The proposed decentralized method can also handle communication failures. The validity and advantage of the decentralized state estimation method is demonstrated through case studies.

In the paper entitled "Measurement Sensitivity and Estimation Error in Distribution System State Estimation Using Augmented Complex Kalman Filter", generalized augmented complex Kalman filter framework is proposed to enable in-

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corporation of scalar and complex-valued measurements. Then, the framework is employed in sensitivity analysis of error covariance to optimize measurement locations. Case studies demonstrate the accuracy and performance of the proposed method compared with weighted least squares (WLS) method.

In the paper entitled "Cyber-attack Detection Strategy Based on Distribution System State Estimation", the authors develop a three-phase interval state estimation model and efficient iterative solution method to address unbalancing and uncertainties in distribution networks. Based on the state estimation model, a cyber-attack detection strategy is investigated to cope with fake data injection attack and validated by Monte Carlo simulation.

In the paper entitled "Complex Variable Multi-phase Distribution System State Estimation Using Vectorized Code", the authors derive a compact formulation of multiphase distribution system state estimation using Wirtinger calculus. The novel formulation facilitates unified handling of PMUs and other measurements and efficient code implementation by exploiting vectorized instruction set. Numerical tests reveal that the vectorized implementation achieves two-fold performance improvement on large distribution networks.

In the paper entitled "Dynamic State Estimation of Medium-voltage DC Integrated Power System with Pulse Load", the dynamic state estimation of medium-voltage DC integrated power system is studied against the periodic disturbance of pulse load. The extended Kalman filter with fictitious process noise is utilized in the proposed dynamic state estimation method. Numerical simulations on the studied system support the feasibility and effectiveness of the proposed model and method.

In the paper entitled "Secure Market Operation in Presence of Critical Model Parameters in State Estimation", the authors study on the impact of network parameter errors on the electricity markets. It is pointed out that casual meter placements can lead to undetectable parameters and undesirable operation and management. Moreover, the authors propose quantification methods and meter placement strategies which are justified by numerical simulations.

We would like to thank all the participating authors for submitting their works to this special section. We really appreciate the anonymous reviewers' valuable efforts.

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