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Guest editorial: Special issue on machine learning, data analytics, and advanced optimization techniques in modern power systems

Enabling demand side participation, proliferation of electric vehicles, implementation of (micro) phasor measurement units, integration of renewable energy units, and other emerging smart grid technologies call for advanced analytical techniques for future modern power systems design, operation, planning, and studies. The emerging technologies challenge the traditional methods, however they are ideal for the application of machine learning, data analytics, and advanced optimization techniques. By harnessing their capability in processing complex systems and making better decisions, machine learning, data analytics, and advanced optimization techniques can help in solving emerging problems of modern power systems. The use of these techniques can be the key to realizing potential benefits of the emerging technologies as well as avoiding deleterious outcomes caused by their unsupervised integration and operation. However, yet, insufficient effort has been devoted to applying these techniques to the problems regarding modern power systems.

The focus of this special issue is high quality state-of-the-art technologies and solutions related to machine learning, data analytics, and advanced optimization techniques for solving problems in modern power systems. In particular, the issue showcases the most recent achievements and developments in the application of machine learning, data analytics, and advanced optimization techniques to modern power systems.

In response to the call for papers, 15 manuscripts were received and considered for the peer reviews. Ultimately, 11 high-quality manuscripts were accepted and included in this special issue. These papers are briefly introduced in the following:

1. "*Towards green data center microgrids by leveraging data center loads in providing frequency regulation*" by W. Qi and J. Li presents a heuristic control approach to demand response control in a data center micro grid to regulate system frequency when it is in island mode. By investigation of the operational characteristics of traditional and photovoltaic generation units, uninterruptible power supply units, and power consumption characteristics of IT components and cooling systems, the proposed load control strategy effectively exploits primary frequency capabilities while not compromising data center quality of service requirements.
2. "*Risk-based cooperative scheduling of demand response and electric vehicle aggregators*" by P. Aliasghari, B. Mohammadi-Ivatloo, and M. Abapour focuses on cooperation between demand response and electric vehicle aggregators as an issue in modern power systems. In the proposed model, the driving pattern of electric vehicle owners and the uncertainty of day-ahead prices are simulated via scenario-based and bi-level information-gap decision theory based methods, respectively. The paper uses a metaheuristic optimization approach to optimizing the cooperation.
3. "*Evaluation of online techniques utilized for extracting the transformer transfer function*" by F. Nasirpour, M.H. Samimi, and H. Mohseni focuses on an asset management problem wherein condition of power transformers is to be monitored in an online fashion. To do so, different existing methods have been reviewed and their performance is compared with that of the offline approach (which is the benchmark here). The results of this contribution determine the proper methods for the online frequency response analysis technique which can be used in the transformer monitoring applications.
4. "*A response-based approach to online prediction of generating unit angular stability*" by A.A. Hajnorouzi and H.A. Shayanfar presents a new method to judge stability of a generator during a fault in the system based on the data achieved by a phasor measurement unit installed at the point of common coupling. The method is based on some curve fitting approaches that predict the angular curve of the generator. Using the curve, it can be

judged whether the generator remains stable or not. This may help operators to disconnect the generator from the network and avoid more severe conditions for both the system and the generator.

5. "*Decentralized energy trading framework for active distribution networks with multiple-microgrids under uncertainty*" by M. Doostizadeh, M.R. Shakarami, and H. Bastami aims at developing a decentralized framework to optimally coordinate mutual interactions between connected microgrids. It also considers the uncertainty caused by renewable energy sources. In the model, the objective of the utility company as well as microgrid owners is to minimize their associated operation costs.
6. "*Microgrids bidding strategy in a transactive energy market*" by H. Nezamabadi and V. Vahidinasab focuses on developing a model for the optimal participation of a microgrid owner in transactive energy market. In the developed model, there are two levels, namely upper and lower levels. The upper-level problem optimizes decisions made by the microgrid owner. The lower-level problem models the behavior of the rival companies and players in the market. Since bi-level problems are hard to solve, the study uses duality theory and KKT conditions to transform the bi-level model to a single-level problem, which can be simply tackled by the available solvers.
7. "*Reliability enhancement of active distribution grids via emergency V2G programs: An analytical cost/worth evaluation framework*" by H. Farzin and M. Monadi focuses on the role of parking lots in enhancing distribution system reliability. It is assumed that Vehicle to Grid (V2G) capability is activated and discharging the power stored in electric vehicles into the grid can partially supply some interrupted customers during a fault. The paper presents a procedure for calculating costs of enabling V2G capability as well as for estimating system costs mainly including operation and reliability costs. Via the procedure, one can perform cost-worth analysis.
8. "*Incorporating bus-bar switching actions into AC optimal power flow to avoid over-current status*" by M.A. Tavakkoli and N. Amjady integrates flexibility in the optimal power flow problem. Doing so, system operation cost is minimized and over-current conditions are prevented. Since the considered model is AC and switching decisions are made via binary variables, the model is in mixed-integer nonlinear programming fashion. The method is applied to a real-world sub-transmission network in Iran.
9. "*A new computing perturb-and-observe-type algorithm for MPPT in solar photovoltaic systems and evaluation of its performance against other variants by experimental validation*" by V. Bhan, A.A. Hashmani, and M.M. Shaikh evaluates performance of different methods for maximum power point tracking in photovoltaic systems. The focus of the evaluation is on methods developed based on Perturb and Observe algorithm. The evaluation is in terms of stability, accuracy, and tracking speed. Based on the evaluation and comparison made between different approaches, one recently presented approach is found as the best in almost all of the aspects.
10. "*Distribution power system outage diagnosis based on root cause analysis*" by M.S. Bashkari, A. Sami, M. Rastegar, and M.J. Bordbari focuses on data analytics and revolves around data associated with faults in electric power distribution systems. The paper develops a method for evaluating the data to identify the root causes of outages. Furthermore, an ensemble of the decision tree based models is built, which outperforms the other well-known models in almost all cases.
11. "*Enabling demand response potentials for resilient microgrid design*" by M. Chegnizadeh and A. Safdarian focuses on the optimal design of microgrids in a way that they are resilient to unexpected island events. The study also considers demand response as a load shaping tool to decrease the costs as well as to enhance resilience of the system. Since the achieved model is complex and hard to solve, Benders decomposition method is adopted to decompose the problem into a master problem and two subproblem types. The first subproblem type ensures that the designed microgrid has the lowest operation cost while the second type guarantees resilient operation during the island mode.

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