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Editorial

Machine Learning in Power System Dynamic Security Assessment

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1. Introduction

Recent growing energy crisis in Europe, coupled with the rising energy prices worldwide, is a clear indication of the many difficulties awaiting the transition of modern societies away from fossil fuels. Renewable energy sources (RES), although increasingly penetrating modern power systems, might not be enough to displace the fossil fuels by themselves. On top of that, the increased share of RES in electrical power systems creates new problems that will exacerbate the already difficult energy situation. Namely, the shift of balance between RES and conventional power plants exposes one of the major downside of the RES today, which is a reduced power system inertia. This reduction of the available rotating mass in the electrical power systems will have important (negative) implications on the future stability and security of their operation. The dynamic performance, and associated stability issues, are drawing the attention of various power system stakeholders, due to the fact that operational disruptions arising from them can lead to major outages, which are often accompanied by severe economic losses. Hence, power system dynamic security assessment is taking center stage in these difficult and uncertain times. It is hoped that the use of artificial intelligence techniques will be able to successfully tackle these multi-faceted problems.

This Special Issue is dedicated to exploring novel approaches to the electrical power system dynamic security assessment, and related power disturbance issues, which are based on the applications of artificial intelligence (AI) techniques (i.e., by employing the machine learning, deep learning, and reinforcement learning). It also deals with related problems of advanced data acquisition (wide-area measurement systems) and datasets preparation (statistical processing, features engineering, encoding, embedding). The articles submitted, as well as the ones finally selected to be published, covered from different angles wide range of these issues. A brief review of the published papers is provided in the following section.

2. A Short Review of the Contributions in This Issue

Pacevicius et al. in [1] provide a very detailed and comprehensive view of the difficulties associated with the efficient management of heterogeneous datasets for large-scale infrastructures, with the focus on the electrical power grids. In the process, the authors propose a novel method for selecting, in traceable and reproducible manner, the best datasets according to their informative potential. The application of the proposed method demonstrated that a dataset originating from an initially less valued data source may be preferred to a dataset originating from a higher-ranked data source in certain scenarios.

Kacejko et al. in [2] tackle the problem of optimizing a standing phase angle when closing circuit breakers in high voltage electrical power systems. This problem is closely related to the power system transient stability assessment and associated transitional generator shaft torque vibrations. The authors have developed a novel heuristic optimization method for that purpose based on the algorithm of the innovative gunner (inspired by the selection of parameters of the artillery shelling so that the next shot precisely reaches its

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goal). The proposed algorithm was then successfully tested on a number of cases using the modified CIGRE test power system.

Sarajcev et al. in [3] deal with a power system transient stability assessment (TSA) problem by means of proposing a novel machine learning-based approach that incorporates a stacked autoencoder and a voting ensemble. Autoencoder, as a special device from the deep learning field, is trained in an unsupervised manner on large a corpus of unlabeled data. It served a twofold purpose: (1) to effectively reduce the features space with a minimal loss of information, and (2) to enable transfer learning from the pre-trained autoencoder to the deep neural network classifier. This paper also introduced a soft voting ensemble classifier, built in a traditional manner from a support vector machine and a random forest. Results from the classifier application on the IEEE New England test case power system were reported and discussed. The machine learning application to the power system TSA problem is found to be promising.

A review paper [4] discusses broader aspects of the artificial intelligence applications to the power system transient stability assessment. The review covers data generation processes (from wide-area measurements as well as from simulations), data processing pipelines (features engineering, splitting strategies, dimensionality reduction, embedding, encoding), model building and training (including ensembles and hyperparameters optimization techniques), deployment, and management (with monitoring for detecting bias and data drift). The review focuses, in particular, on different deep learning models that show promising results on standard power system benchmark test cases. It also points out advantages and disadvantages of different possible approaches, presents current challenges with existing models, and offers a view of the possible future research opportunities.

3. Conclusions

Artificial intelligence techniques, including machine learning, deep learning, and reinforcement learning, are increasingly being used for tackling the difficult problem of power system dynamic security assessment. This novel approach changes the angle of attack, so to speak, on this old problem, by viewing it from the data-centrist viewpoint. Extensive data mining of the information emanating from the wide-area measurement systems, coupled with sophisticate deep learning neural networks, offers new insights and opportunities for supporting real-time operational decisions pertaining to power system disturbances. However, the importance of the electrical power systems to modern society mandates that further convincing results be provided in order to corroborate the robustness of AI based approaches. Furthermore, additional and extensive models stress-testing, with different levels of data corruption, is warranted. This creates space for new research outputs that can fill this gap and increase the overall confidence of the entire community in this nascent technology for its safe future deployment across modern power systems.

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