**Data Analytic for Real-Time Event Identification Using Real Phasor Measurement Unit Data**

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Abstract

With the rapid development of smart grids, the large-scale deployment of phasor measurement units (PMUs) has enabled an enhanced awareness of power system operation by revealing the inherent physical laws of power systems from a data perspective. However, achieving real-time system event identification has been challenging due to the high granularity and non-stationary nature of PMU time series, imperfect data quality, and the expensive cost of collecting high-quality event labels. To address these issues, this dissertation demonstrates novel data-driven methods that not only improve the classification accuracy and reliability of models with limited and imperfect data but also exploit the interaction relationships between multiple PMUs.

Firstly, we propose a two-stage learning-based framework to identify PMU events. We utilize the Markov transition field (MTF) algorithm to extract latent data features by encoding temporal dependency and transition statistics of PMU data in graphs. Next, we establish a spatial pyramid pooling (SPP)-aided convolutional neural network (CNN) to efficiently and accurately identify operation events. Secondly, we present a novel semi-supervised learning-based method to enhance the performance of event classifiers trained with limited labeled events by utilizing information from numerous unlabeled events. Furthermore, we develop a safe learning mechanism to mitigate the effects of class distribution mismatch and prevent performance degradation.

Moreover, we propose a novel graph neural network-based method to perform event identification by mining interaction graphs among different PMUs. This method follows a completely data-driven approach without requiring knowledge of the physical topology. In contrast to previous works that treat interactive learning and event identification as separate stages, our method learns interactions jointly with the identification task, improving the accuracy of graph learning and ensuring seamless integration between the two stages. Additionally, we investigate a dilated inception-based method to perform feature extraction of PMU data, capturing multi-scale event patterns.