Robust Electrical Segmentation for Zone Coherency Delimitation Base on Multiplex Graph Community Detection

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Abstract : The electrical grid is a highly intricate system designed to transfer electricity from production areas to consumption areas. The Transmission System Operator (TSO) is responsible for ensuring the efficient distribution of electricity and maintaining the grid's safety and quality. However, due to the increasing integration of intermittent renewable energy sources, there is a growing level of uncertainty, which requires a faster responsive approach. A potential solution involves the use of electrical segmentation, which involves creating coherence zones where electrical disturbances mainly remain within the zone. Indeed, by means of coherent electrical zones, it becomes possible to focus solely on the sub-zone, reducing the range of possibilities and aiding in managing uncertainty. It allows faster execution of operational processes and easier learning for supervised machine learning algorithms. Electrical segmentation can be applied to various applications, such as electrical control, minimizing electrical loss, and ensuring voltage stability. Since the electrical grid can be modeled as a graph, where the vertices represent electrical buses and the edges represent electrical lines, identifying coherent electrical zones can be seen as a clustering task on graphs, generally called community detection. Nevertheless, a critical criterion for the zones is their ability to remain resilient to the electrical evolution of the grid over time. This evolution is due to the constant changes in electricity generation and consumption, which are reflected in graph structure variations as well as line flow changes. One approach to creating a resilient segmentation is to design robust zones under various circumstances. This issue can be represented through a multiplex graph, where each layer represents a specific situation that may arise on the grid. Consequently, resilient segmentation can be achieved by conducting community detection on this multiplex graph. The multiplex graph is composed of multiple graphs, and all the layers share the same set of vertices. Our proposal involves a model that utilizes a unified representation to compute a flattening of all layers. This unified situation can be penalized to obtain (K) connected components representing the robust electrical segmentation clusters. We compare our robust segmentation to the segmentation based on a single reference situation. The robust segmentation proves its relevance by producing clusters with high intra-electrical perturbation and low variance of electrical perturbation. We saw through the experiences when robust electrical segmentation has a benefit and in which context.

Keywords : community detection, electrical segmentation, multiplex graph, power grid
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