Master Thesis

Multi-stage GNN-based reinforcement learning solution for real-time operation of distribution grid

Context:
Distribution networks have been witnessing rapid changes in recent years; particularly the high penetration of renewable energy sources, distributed generators, controllable loads, and remotely controllable switches [1–3]. This has resulted in many challenges in the operation of distribution networks due to its attendant consequences such as the uncertainty of RESs and loads which can cause power imbalances in the real-time operation of distribution systems. Addressing such challenges requires efficient automatic reconfiguration processes and automatic determination of set-points of distributed generators in the real-time operation of distribution networks. Further, it has been reported the occurrence of failures at different locations of distribution networks is inevitable and needs to be isolated and addressed as quickly as possible. Several optimization solutions using mixed-integer nonlinear programming, heuristics/metaheuristics, particle swarm optimization, etc. exist in the literature, however, they generally employ a model-based control approach for the reconfiguration process which consequently requires recomputation for every event in the system. This becomes quite expensive to perform especially for large distribution networks. On the other hand, the success of deep reinforcement learning (RL) in several domains such as games has spurred researchers to apply it to power network problems with remarkable success. Unlike existing approaches, we plan to not only use historical operational datasets of distribution networks but also to leverage the rich spatial information (our current work on voltage control and congestion management has proven this to be quite beneficial in terms of requiring less training time and better performance) of the distribution networks to arrive at a GNN-based multi-stage RL solution for real-time operation of distribution networks.

Similar to the approach proposed in [4], the solution proposed in this thesis will include the following stages (i) day-ahead scheduling to determine the optimal solution for minimizing the total operation cost of the entire system under normal operation mode (ii) deep RL-based approach for optimal network reconfiguration considering different scenarios and (iii) deep RL-based solution for determining the set-points of all power sources in the network to minimize total operation cost considering various uncertainties.

Student Tasks:
- Literature review on distribution network reconfiguration approaches and distribution network management
- Contribution to the solution formulation
- Implementation/validation of the proposed solution
- Thesis report writing

Your profile:
- Master student in Computer Engineering, Electrical engineering or other related disciplines
- Programming experience in Python and its ML libraries (e.g., Pytorch, Numpy, pandas)/strong desire to learn them
- Programming experience in MATLAB
- Interest in AI

- Preferred Experience (not compulsory):
  - Previous HiWi or internship or work experience in machine/deep learning
  - Knowledge of reinforcement learning, game theory, or GNN

The thesis will be conducted in English. Your application should include your CV and transcripts. Also, feel free to make initial contact if you need clarifications about the topic or discussion on your fitness to work on the topic.

References


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