Project title

Purdue ME 597, Distributed Energy Resources

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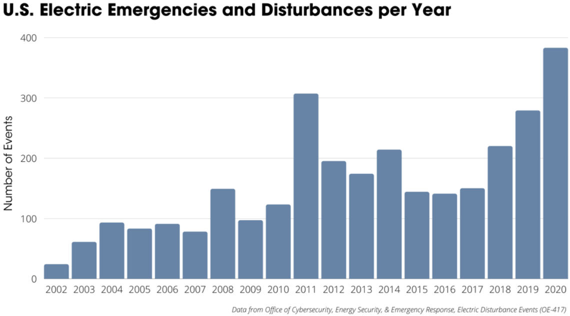
Emergency Microgrid Resilience

- Microgid: interconnected loads and distributed energy resourdces with connect or disconnect from the grid, can provide resilience to emergency situations.
- Increasing the importance of emergence microgrid resilience to comabt increasing emergency situations (e.g., power outrages, natural disasters, individual problems).



Problem statement

Distriubtion System Resilience Enhancement

- has focused on maximizing the total prioritized load to be picked up, using mathematical programming and iterative algorithms.
- has also considered the uncertainty capture in the distribution system operating framework.
- However, their model cannot be fully utilized into the comprehensive situations, with mitigating the load unbalance and capturing the uncertainty situation in the microgrid operation model, simultaneously.

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- However, their model cannot be fully utilized into the comprehensive situations, with mitigating the load unbalance and capturing the uncertainty situation in the microgrid operation model, simultaneously.

$\rightarrow$ Need to applicable algorithm for coping with the comprehensive situation, while optimizing/mitigating the load disturbance in energy trading with microgrid system.

Project obejctive

This project aims to detect the emergency situation and mitigate the risk of load disturbance in energy trading using the deep reinforcemen learning

$\rightarrow$ It can take optimal actions of detecting the emergency situation and mitigating the risk of load disturbance, simultaneously.

$\rightarrow$ It can be applicable in the any emergency situation, even if learning model encounters with it first time.

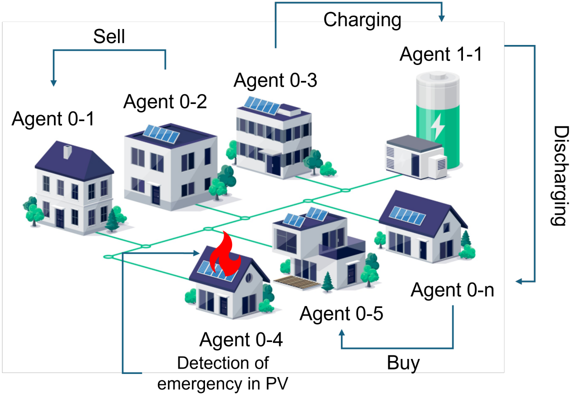
Methodology: Data generation

- Team cannot find the relevant datasets, including the information of DERs and loads.
- Team utilized class materials (linear dynamical systems) to generate the data (e.g., PV power output, charging/discharging)
- Emergency situation is created by referencing the national renewable energy laboratory (NREL) research that cumulative probability of power outrage is less than 1%.

Hamidieh and Ghassemi [2]NREL

Methodology: DRL algorithm

- This project developed existing research, P2P energy trading, through integrating with the detection/mitigation of the emergency risks in the microgrid.
- The multi agents (e.g., consumer, prosumer, producer) interact with an environment (e.g., energy load, PV power output and charging/discharging) to minimize the energy cost (CO_2 cost), with mitigating the risk of emergency risks.
- Each agent takes three actions (e.g., battery state, detection of PV emergency, detection of load emergency) in six states.
- The reward function get the highest expectations when the model find the minimization point of energy costs.



State: (battery capacity, generation, consumption, Next battery, PV emergency, consumption emergency)

Action: (**battery**, PV emergency detection, consumption emergency detection)

battery = (bypassing the battery, charging the battery using surplus energy, discharging, sell, buy)

Reward: Charging the battery + charging the battery with selling + discharging + selling with price + buying with price + emergency response in PV + emergency response in consumption

Results: Learning Patterns via Reward

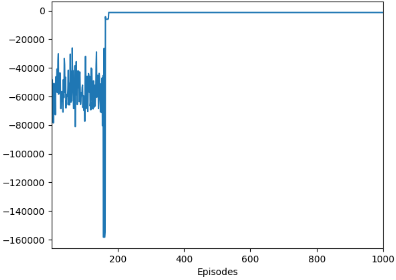


Figure: Reward graph of agent 0

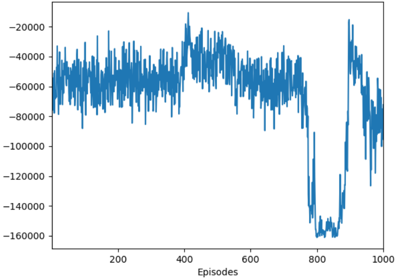


Figure: Reward graph of agent 1

- The agent 0 can be converged after 200 episodes, but agent 1 does not converged well.
- The agent 1 falled into a local minima (catastrophe) around episode 800

Results: Dectection of emergency situations

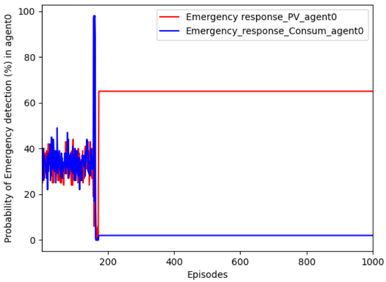


Figure: The evaluation of dection success for PV and Load in agent 0

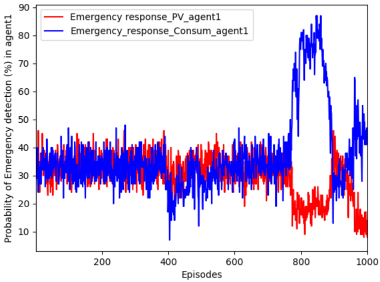
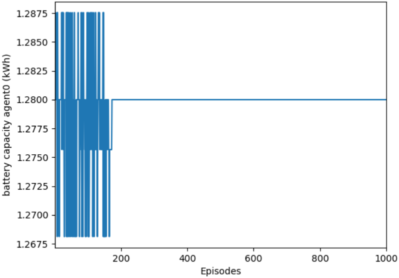


Figure: The evaluation of dection success for PV and Load in agent 1

- Both of agent have same perfomance of the evaluation of dections success, around 40%, but after 200 in agent 0 and 800 in agent 1 has opposite evaluation performance.

Results: Mitigation of load disturances



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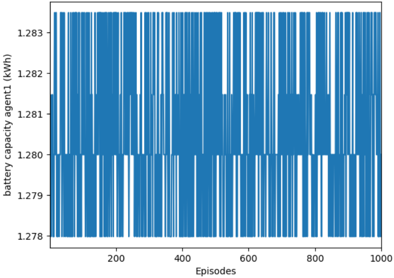

Figure: The evaluation of dection success for PV and Load in agent 1

- Both of results showed that the mitigation of energy trading occures in the load disturbance.

Discussion & Conclusion

- This project developed the microgrid energy trading model with mitigating emergency disturbance using deep reinforcement learning
- Proposed method tried to detect the emergency events while estimating the energy traiding with minizing the co_2 emission.
- However, proposed method does learn the energy trading rule well, but fails to detect the emergency situation accurately: 1) low quality of datasets, 2) deficiency of extracting features in the environment.
- In the future, I will update the learning model with building it on meta-learning and graph neural network.

References I

[1] Chen Feng and Andrew L Liu. “Networked Multiagent Reinforcement Learning for Peer-to-Peer Energy Trading”. In: *arXiv preprint arXiv:2401.13947* (2024).

[2] Mohammad Hamidieh and Mona Ghassemi. “Microgrids and resilience: A review”. In: *IEEE Access* 10 (2022), pp. 106059–106080.

[3] Jeffrey Marqusee, William Becker, and Sean Ericson. “Resilience and economics of microgrids with PV, battery storage, and networked diesel generators”. In: *Advances in Applied Energy* 3 (2021), p. 100049.

Thank You for Listening!