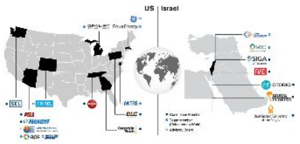
Power Grids: Large and Diverse Action Space



Discrete actions:

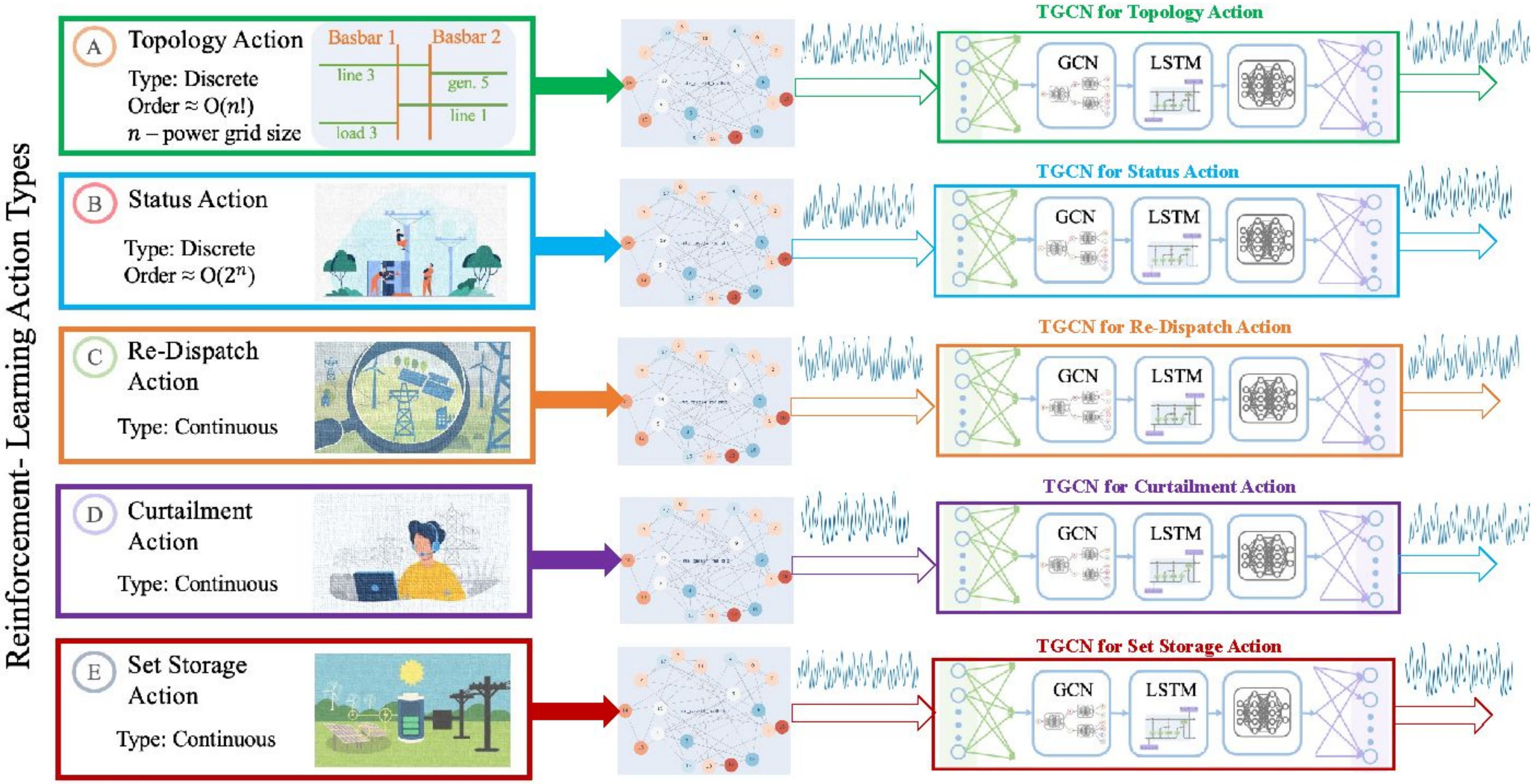
- *Topology actions*: changing the topology of certain substations (TG)
- *Status actions*: transmission or power line switching (PLS)

Continuous actions:

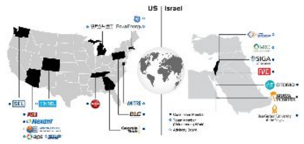
- *Redispatch actions*: changing the operating schedule of power plants
- *Curtailment actions*: limiting the production of renewable generators
- *Set-storage actions*: changing the role of some storage units from loads to generators or vice versa

Example: IEEE 118-Bus system: about 12 million possible actions

Heterogeneous TGCN Framework

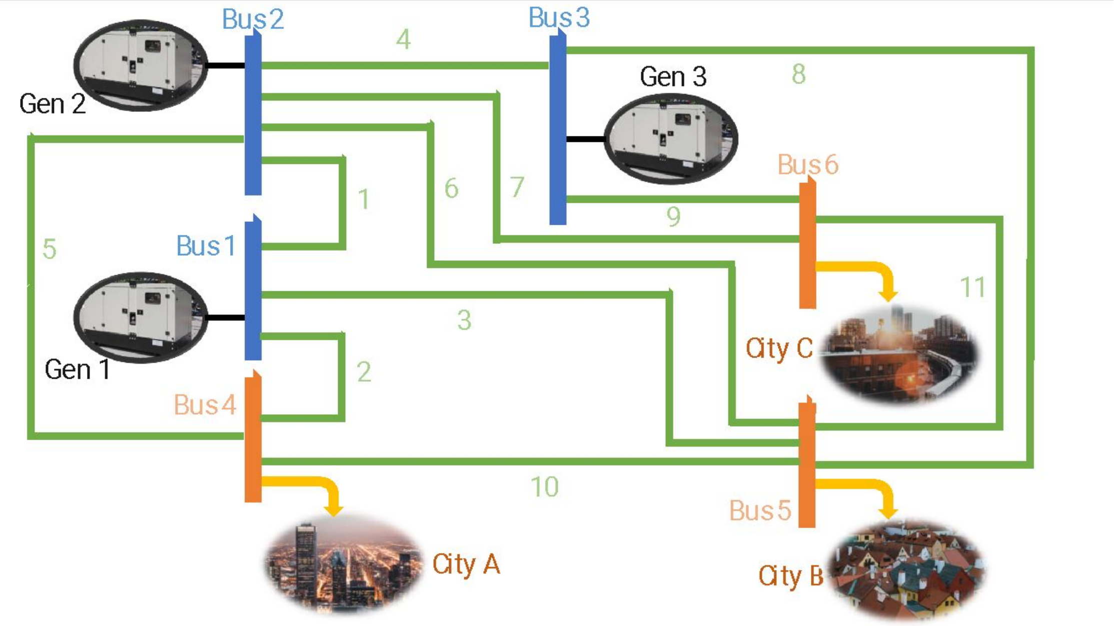


Future Research (1)



- Continue to work closely with our industrial collaborators to test the heterogeneous RL/TGCN framework on real power grids using empirical data to bring the innovative cyberdefense framework closer to commercialization.

- Address the issue of limited available cyberdefense resources by incorporating preferences into heterogeneous RL/TGCN for protecting large smart power grids. This requires theoretical formulation, numerical test, and exploration for commercialization.



Preferential cyber defense for power grids

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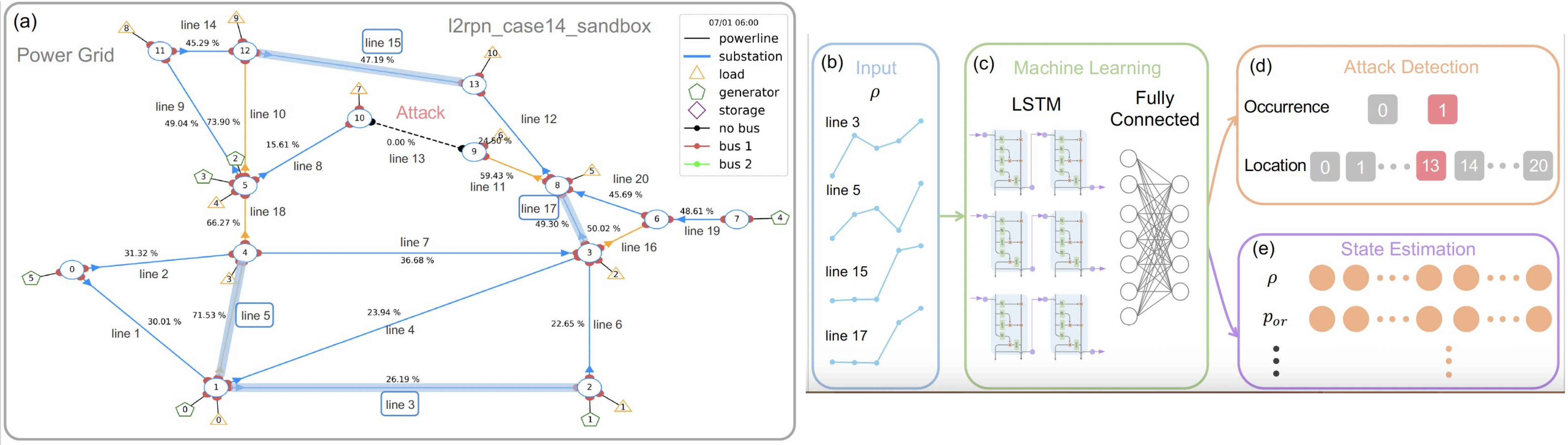
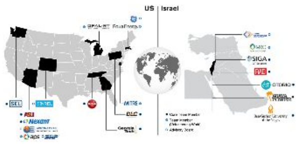
PRX Energy, in press

Future Research (2)

- Investigate the practical issue of partial state observation by developing an LSTM (long short-term memory) based framework for attack detection and full state estimation. Commercialization will be explored.



Future Research (3)



- ❖ Develop a comprehensive framework for probing the "uncharted" to solve the fundamental problem of exploration in machine learning, in particular RL.
- ❖ The problem is motivated by the fact that exploration plays a critical role in RL by enabling agents to discover optimal policies in unknown environments, but how this can be efficiently done remains to be a challenging problem.
- ❖ We propose an efficient approach to exploring the uncharted by leveraging automata theory and mixed integer programming, which enables the agent's behavior to be captured and the temporal or dynamic aspects of exploration to be modeled accurately for effective decision making and discovery of novel states.
- ❖ If successful, this will open a new area of research in AI and Machine Learning as applied to cyberphysical systems, with immediate applications to power grids.