CRII: CPS: A Self-Learning Intelligent Control Framework for Networked Cyber-Physical Systems

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The ***goal*** of this project is to addresses challenges in machine learning for intelligent physical systems that interact with one another. The approach is to explore Reinforcement Learning (RL) strategies, where systems are rewarded when behaving correctly, for interacting physical systems when the systems with which they interact may react in inconsistent ways.

Challenge

- Scale reinforcement learning techniques to networked CPS environment to build intelligent systems.
- New generation of intelligent networked CPS is required the abilities of self-learning.

Scientific Impact: This project can advance the RL and association of intelligent control in computational intelligence and control societies. Furthermore, through the developed new RL approaches, this project bridges the connection with other disciplines, all of which will provide new understandings of machine intelligence from different perspectives.

Solution

<u>Intelligent and secure reinforcement learning algorithms design</u>

- Design a detector to monitor the system and identify the attacks;
- Design a secure switching mechanism to automatically switch the control.

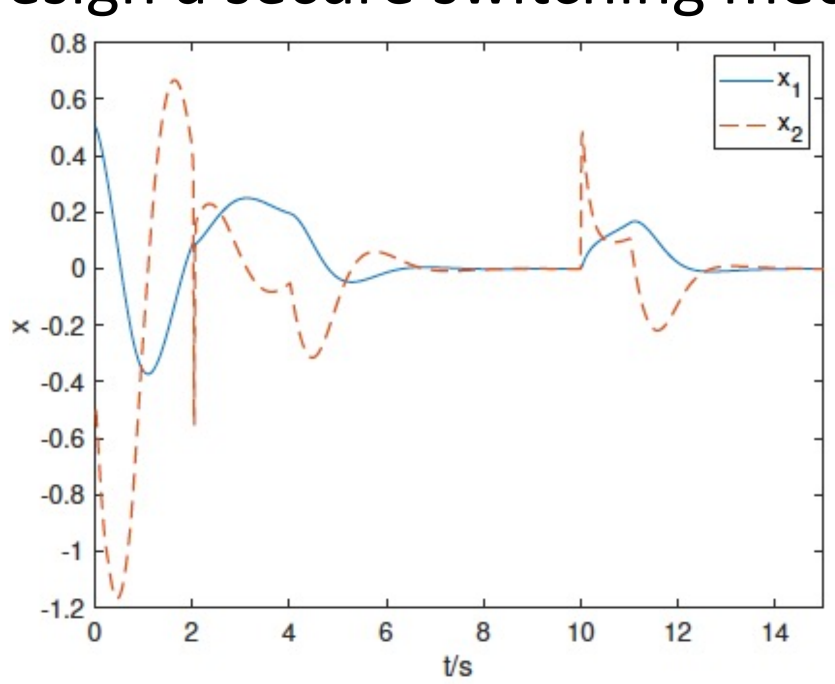

Fig. 1 The trajectories of system states under the proposed method

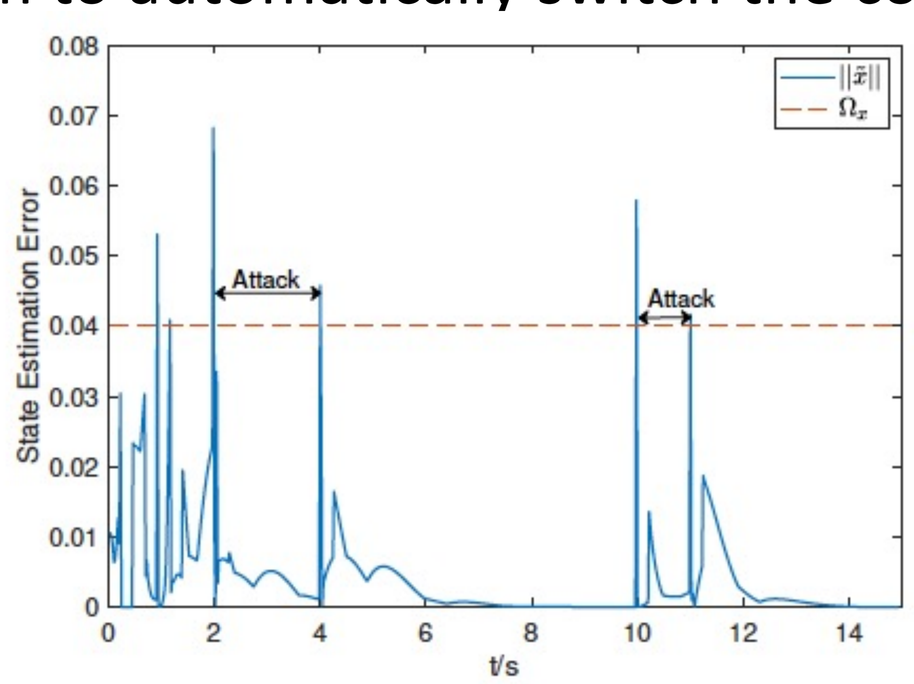

Fig. 2 The comparison of state estimation error and threshold for detector

<u>Multi-agent RL design for a grid-connected microgrid application</u>

- Efficiently schedule the microgrid distributed energy resources, consider the probabilistic emergency operation, and minimize the operational cost.

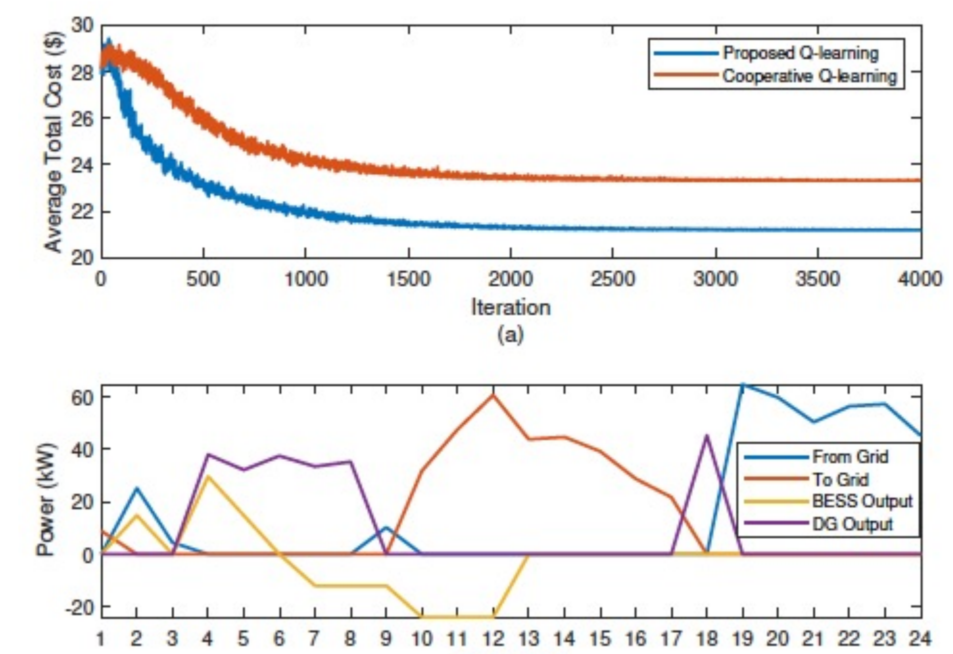

Fig. 3 Microgrid average total cost curve convergence study and the power outputs of the microgrid resources

<u>A robotics testbed development</u>

- The robots were programmed with ROS and were installed with various sensors.

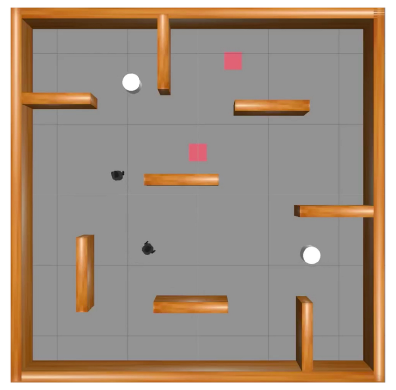

Fig. 4 Multi-agent Cooperation

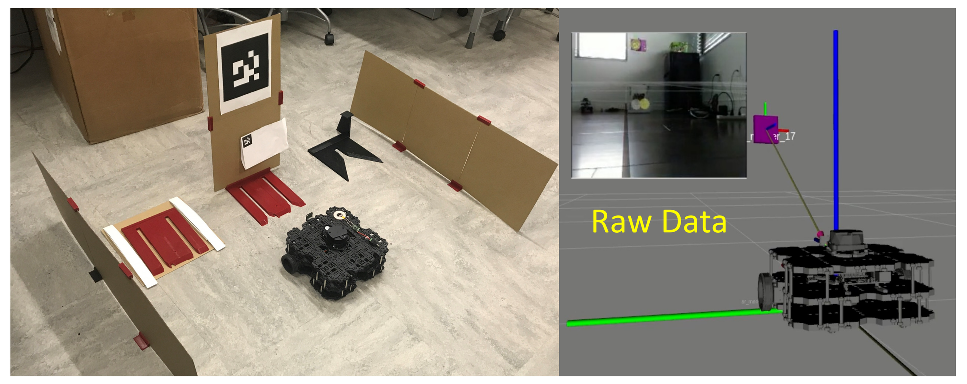

Fig. 5 Autonomous driving and wireless charging

Broader impact

- Advance reinforcement learning for networked CPS which can have emergent behaviors when they interact.
- Provide research opportunities for undergraduate students (e.g., senior designs and direct independent studies) on fundamental design with the established robot testbed.
- Cultivate the scientific curiosity of K-12 students, and students from underrepresented groups, and motivate their interests in Science, Technology, Engineering, and Math (STEM) programs.
- Establish learning models into the current curriculum and also integrate the project's cutting-edge research into new courses.

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