CAREER: Towards an Intermittent Learning Framework for Smart and Efficient Cyber-Physical Autonomy

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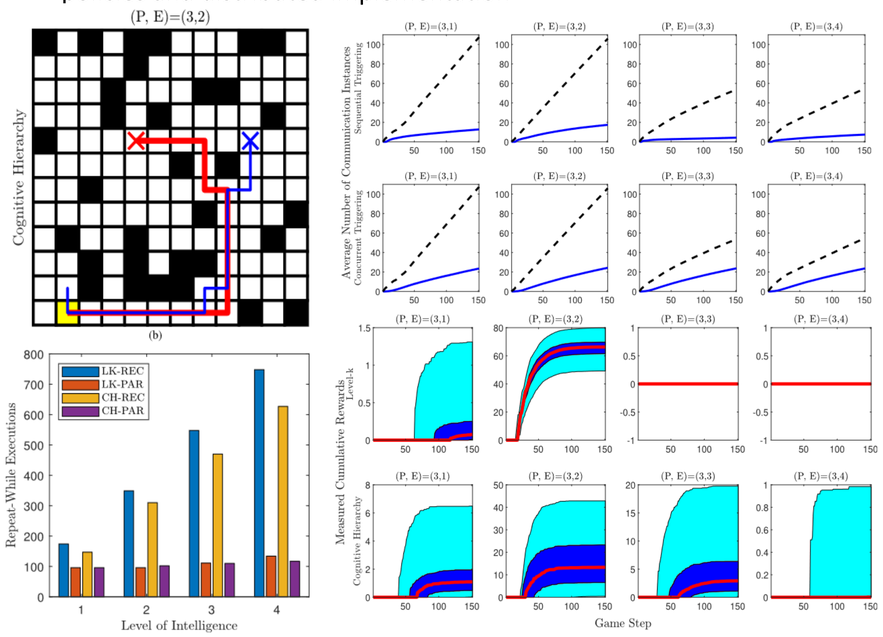
Recursive Reasoning With Intermittency for Nonequilibrium Learning in Stochastic Games

Modeling bounded rationality in stochastic games

- Ideas from behavioral psychology to model multi-agent behavior
- Alleviation of communication and computation burdens via intermittent policies and distributed implementation



Data-Driven Actuator Selection for CPS

- Selecting the most controllable and resilient actuators for CPS, without knowledge of its dynamics
- Using techniques from the literature of reinforcement learning and approximate dynamic programming
- The data used for learning-based actuator selection can be recycled for the purpose of data-driven actuation attack detection

Scholar work and outcomes for year 2023 (only):
4 book chapters
11 journal publications
15 peer reviewed conference papers
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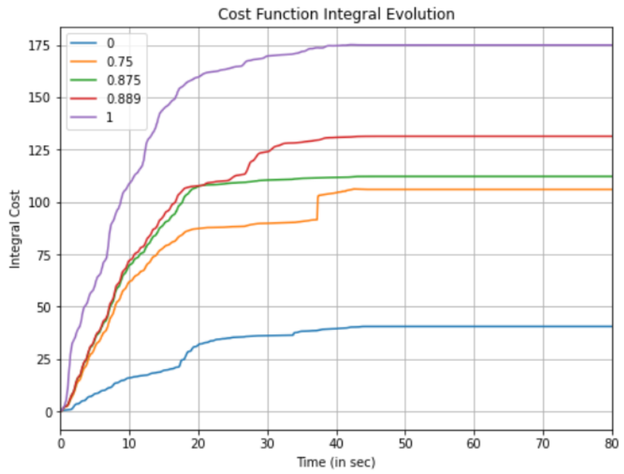
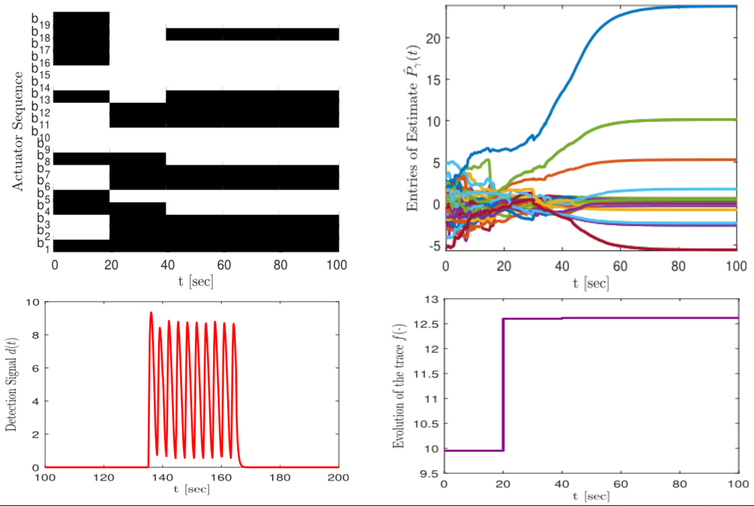
Self-Model-Free Learning versus Learning with External Rewards in Information Constrained Environments:

- Reinforcement learning framework for learning agents that experience loss of the reinforcement signals
- Trade-off scheme: reconstructs the reward using a goal network when the reinforcement signals are lost, utilizes true reinforcement signals when they are available.
- Stability of the equilibrium point is guaranteed despite fractional information loss in the reinforcement signals





Challenge:

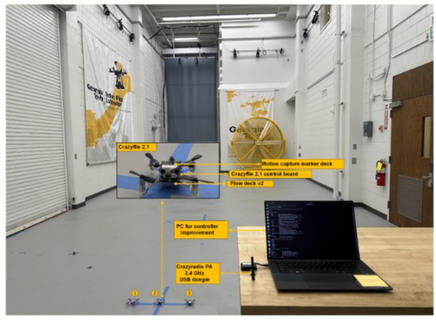
- Theoretical framework that will allow the efficient use of resources while adapting optimally to changing and adversarial environments
- Issues of smart autonomy under limited bandwidth usage, resilience and attack mitigation are investigated

Scientific Impact:

- How can human predictive models be used to model multi-agent behavior in stochastic games, where policies incorporate intermittency?
- How can we select the most controllable and resilient actuators for a system with uncertain dynamics?
- How can we develop reinforcement learning algorithms that provably converge in the presence of partial information loss due to packet drops or DoS attacks?
- How robust are reinforcement learning algorithms to uncertainty in the data due to clock offsets, quantization, and intermittency?

Broader Impact:

- Deepen ties between the learning, control, game theory, and CPS communities and offer an engineering perspective to behavioral psychology
- Lead of a tutorial paper on game theory in the American Control Conference at San Diego, CA, 2023
- Experimental verification of the reinforcement learning rules that incorporate intermittency on nano quadrotors, at the flight facilities of Georgia Tech



Solution:

- Intermittent learning through novel sampling structures, based on behaviorism
- Non-equilibrium game theory to model bounded rationality decision making in the context of intermittency

2024 Cyber-Physical Systems PI Meeting
Wednesday, March 20, 2024 and Thursday, March 21, 2024

Award ID#: 1851588