CPS: Medium: Collaborative Research: Developing Data-driven Robustness and Safety from Single Agent Settings to Stochastic Dynamic Teams: Theory and Applications

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Key Challenges: Taking traffic signal control systems within smart transportation systems as our motivating CPS application, this project develops new foundational methodologies that will enable robust and safe RL for complex CPSs by answering the following questions:

- ❑ How to engender Robust RL solutions?
- ❑ How to develop efficient, safe and constrained RL algorithms?
- ❑ How to develop RL algorithms for constrained partially observed settings with provable guarantees?

Key innovations:

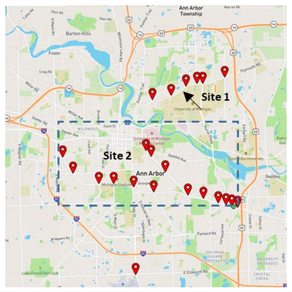
- ❑ Generalize certainty equivalent optimal control and information gain to study adaptive control schemes using Lyapunov function-based or RL-based value function estimates.
- ❑ Two-step approach: Use statistical concentration inequalities such as Azuma-Hoeffding inequality or Berstein inequality to identify the set of safe policies (with a high probability), and then use off-policy RL, restricted to the set of safe policies, to learn the best safe policy.
- ❑ Use data-driven, low-dimensional information state representations for RL based on model-class knowledge-based approaches and predictions, and Lagrangian duality-based methods for constrained partially observed systems.

Scientific Impact:

- ❑ New robust RL algorithms via a multi-pronged approach including the use of model class knowledge, future predictions plus uncertainty and robustness characterizations.
- ❑ Fundamental limits and model-free algorithms for safe RL applications and methods for partially-observed systems.
- ❑ RL algorithms with provable guarantees and good properties via data-driven approaches and simpler representations for constrained partially observed systems

Evaluation

- ❑ Evaluation using data from two sites from the City of Ann Arbor, one being a corridor and the other a grid network.



Societal Impact:

- ❑ New traffic signal control algorithms for smart transportation systems.
- ❑ New algorithms for resource allocation and pricing in constrained networked systems.

Education and outreach:

- ❑ Development of graduate and undergraduate courses on RL theories and applications.
- ❑ Recruitment of under-represented groups and promotion of undergraduate research
- ❑ Annual K-12 outreach activities such as STATpros

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