CRII: CPS: High-Performance Adaptive Hybrid Feedback Algorithms for Real-Time Optimization and Learning in Networked Transportation Systems

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The main goal of this project is to develop a framework for the design of fast, robust, and adaptive model-free algorithms for the control and real-time optimization of networked transportation systems (NTS). The project leverages tools from adaptive control, hybrid dynamical systems, and optimization. Applications of interest include traffic light control and dynamic tolling systems.

- NTS are complex dynamical systems for which accurate mathematical models are usually not available for the purpose of control design.
- Common algorithms exhibit slow rates of convergence and have prohibitively aggressive exploration requirements.
- Dynamics of NTS are usually hybrid, which complicates the design of robust and stable control algorithms.
- The theoretical framework developed in the project will be applicable to the design of general adaptive optimization algorithms with acceleration and minimal exploration requirements.
- The algorithms will be tested in different systems, including traffic light control, dynamic tolling, and the optimization of electric transportation systems.

Fast rates of convergence are achieved by combining ideas from control theory and accelerated optimization. To guarantee that such techniques induce suitable robustness margins, we further use use tools from hybrid dynamical systems inspired by reset control. Exploration is minimized by making use of information-rich data sets that are nowadays available in most engineering applications. The result is a family of hybrid data-driven adaptive optimization algorithms with acceleration and robustness properties. The algorithms have been successfully validated via simulations in smart traffic light systems and electric systems.

Successful completion of this project will facilitate transformative changes in infrastructure systems towards more efficient algorithms that could potentially benefit the quality of life of millions of users by minimizing congestion and maximizing safety.

The material developed in this project has been integrated in some of the graduate-level classes at CU Boulder. The project also supports graduate students from URM groups, which are being actively mentored and trained in CPS science at CU Boulder.

The project will incorporate pragmatic implementation, dissemination, and K-12 outreach. The project is also aligned with the long term vision of the state of Colorado, where several technologies are currently being deployed by the Colorado Department of Transportation.