DEEP REINFORCEMENT LEARNING FOR THE OPTIMAL CONTROL PROBLEM WITH APPLICATION IN TRAFFIC FLOW DYNAMICS

Context and Motivation. Optimal control problems play a central role in many areas of engineering, physics, and applied sciences. The goal is to determine control strategies that optimize a desired objective such as minimizing fuel consumption, improving efficiency, or stabilizing system behavior.

For instance, in **traffic flow dynamics**, one aims to regulate vehicle behavior to improve average speed, reduce congestion, or minimize environmental impact. Classical optimal control methods often rely on analytical or numerical approximations, which become impractical for complex, nonlinear, and high-dimensional systems.

With the recent progress in **deep reinforcement learning (RL)**, new opportunities have emerged to learn control strategies directly from data and system interactions. This project explores such methods for developing **interpretable and explainable RL-based control solutions** applicable to **autonomous vehicles and traffic flow systems**.

Objectives

- Formulate optimal control problems in traffic and autonomous systems within the RL framework.
- Design and train interpretable deep RL controllers.
- Analyze and visualize learned strategies for interpretability and robustness.

Expected Outcomes

- Implementation of RL-based controllers for benchmark dynamical systems.
- Evaluation of performance, robustness, and interpretability.
- Preparation of a conference/journal publication

Intern Profile. Student in Applied Mathematics, Control Theory, Computer Science, or related fields, familiar with reinforcement learning and its applications to physical systems and preferably with background in control systems and optimization are encouraged to apply.

How to Apply

Interested candidates should send the following document to Dr. Hossein Matin department of computer science (ORAILIX team) at Ecole Polytechnique:

hossein.matin@polytechnique.edu

- A short CV
- Transcript of records
- A brief motivation statement

Bonus Opportunity. Depending on progress and performance, selected interns may have the opportunity to continue their work through a follow-up internship with Professor Alex Bayen's research group at UC Berkeley, one of the leading teams at the intersection of PDEs, control, and machine learning. Outstanding contributions may also serve as a pathway for consideration into PhD opportunities with the Berkeley team, offering interns a unique academic and professional growth trajectory.