DEEP LEARNING FOR CONTROL OF PDES

Many engineering and scientific systems—ranging from traffic flow and fluid dynamics to wave propagation—are naturally modeled by partial differential equations (PDEs). Beyond solving these PDEs, a central challenge is designing effective control strategies to regulate system behavior. For example, in traffic flow, the objective is often to mitigate instabilities such as stop-and-go waves and prevent the onset of congestion. Classical PDE control theory, while powerful, has largely been limited to simplified cases such as linear systems or low-dimensional approximations due to the inherent complexity of the problem. This creates a gap between theory and the demands of modern large-scale applications. Recent advances in deep learning and deep reinforcement learning (DRL) provide new opportunities to address this challenge. By leveraging data-driven approaches, it becomes possible to design control schemes that scale to high-dimensional PDE systems while adapting to complex, nonlinear dynamics. This project will focus on two key directions:

(i) **Accurate and scalable control schemes**: Developing deep learning–based controllers that can regulate PDE systems efficiently, even in high-dimensional or nonlinear regimes where traditional methods fail. Interns will explore modern ML and DRL tools to design and implement such controllers.

(ii) **Theoretical guarantees**: Establishing stability and convergence results for the proposed control frameworks, thereby ensuring that the learned controllers are not only effective but also reliable and mathematically sound.

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, a world leader in PDE control, learning, and large-scale mobility systems. Exceptional contributions could also serve as a pathway to PhD opportunities with the Berkeley team, providing a unique bridge between applied research, theory, and long-term academic development.

Who is eligible. We encourage students interested in either of objectives (i) or (ii) with background in mathematics, control, computer science or related fields apply for this call. An ideal student would have a background in computer science and/or mathematics familiar with the theory of deep learning and deep RL and implementation.

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.