DEEP LEARNING TO APPROXIMATE THE SOLUTION OF HYPERBOLIC PDES

Partial differential equations (PDEs), and in particular hyperbolic PDEs, are central to modeling real-world dynamical systems such as traffic flow, fluid dynamics, and wave propagation. Traditionally, their solutions are computed through numerical schemes—finite difference, finite volume, or finite element methods. However, these approaches face two major challenges. First, improving accuracy typically requires high-resolution schemes, which are increasingly difficult to implement and analyze. Second, as the dimension of the PDE grows (for instance, in kinetic equations or multi-agent systems), the computational cost of classical solvers becomes prohibitive, a manifestation of the curse of dimensionality. These limitations call for innovative alternatives, and deep learning offers a promising direction. By learning solution operators in both supervised and unsupervised settings, neural network–based methods can achieve high accuracy and efficiency while handling complex, high-dimensional problems with greater flexibility. This project will investigate deep learning techniques for approximating solutions of hyperbolic PDEs, with two complementary objectives:

(i) **Computational efficiency and scalability**: Developing methods that remain tractable beyond the limits of traditional numerical schemes. Interns will gain hands-on experience applying modern machine learning tools—such as physics-informed neural networks and operator learning frameworks—to challenging PDE problems.

(ii) **Theoretical guarantees**: Establishing stability, convergence, and efficiency properties for deep learning–based approaches, which are essential to ensuring their reliability and adoption in scientific computing.

Who is eligible. We encourage students interested in either of objectives (i) or (ii) 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 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.