PAV-IA

BEYOND INFORMAL AI TALKS

PAV-IA Inaugural Lecture SIAM Student Chapter UniPV

Francesco Regazzoni (MOX)

Integrating physics-based models with machine learning for fast and accurate simulations

Mathematical models based on differential equations, such as Partial Differential Equations (PDEs) and Stochastic Differential Equations (SDEs), can yield quantitative predictions of physical processes. However, model development requires a deep understanding of the physical processes, that is not always available. Furthermore, the computational cost that accompanies the (possibly many-query) numerical approximation of such mathematical models may be prohibitive and hinder their use in relevant applications. In this talk, we present scientific machine learning methods that integrate physical knowledge with data-driven techniques to accelerate the evaluation of differential models and address many-query problems - such as sensitivity analysis, robust parameter estimation, and uncertainty quantification. To speed up input-output evaluations, we present Universal Solution Manifold Networks, namely emulators of differential models capable of predicting spatial outputs and accounting for the variability of the computational domain. Our method is based on a mesh-less architecture, thus overcoming the limitations associated with image segmentation and mesh generation required by traditional discretization methods, and encodes geometrical variability through an automatic shape encoding technique. Furthermore, we present Latent Dynamics Network, a space-time operator-learning method, which shows, tested in challenging problems, superior accuracy (normalized error 5 times smaller) with significantly fewer trainable parameters (more than 10 times fewer) than state-of-the-art methods. Numerical results demonstrate that these scientific machine learning methods enhance efficiency and accuracy in approximating quantities of interest, as well as in solving parameter estimation and uncertainty quantification problems.

14/01/2025

14:30-16:00

Registration is free but mandatory!

UNIVERSITÀ DI PAVIA
Department of Mathematics "Felice Casorati"

siam
Society for Industrial and Applied Mathematics

imati
Istituto di Matematica Applicata e Tecnologie Informatiche "Enrico Magenes"