LMS Seminar

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Fusion of Finite Element Methods and Deep Learning algorithms: some recent developments

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ABSTRACT

In this talk, I will provide an overview of our recent attempts to blend machine learning algorithms and traditional simulation methods to improve the predictive capabilities of numerical models in solid mechanics. The first part of the talk will be devoted to the prediction of stress fields in porous media. I will discuss the performance of a novel class of multi-fidelity models whereby a coarse scale solution is given to a convolutional neural network, the task of which consists in performing inexpensive microscale corrections. The spatial convolutions in three dimensional settings are advantageously performed using Graph Neural Networks, the geometrical information begin completely encoded in a triangulation of the surface of the pores. Although interesting performances may be achieved through offline training using moderate amount of microscale simulations, I will discuss ways to improve extrapolation capabilities of the network using adaptive learning and physics-based constraining at inference time. In a second part of the talk, I will address the topic of regularisation in inverse problems through Gaussian Processes and Neural Networks. I will show how modern probabilistic machine learning methodologies may be deployed to provide tuning-free inverse problem frameworks, thereby circumventing the need to use cumbersome L-curve methodologies. The coupling between finite element codes and AI platforms through back propagation and adjoint methodologies will also be discussed.

BIOGRAPHY

Pierre Kerfriden is a Professor at Centre des Matériaux, Mines Paris - PSL. His research focusses on the development of hybrid methods combining artificial intelligence and advanced simulation algorithms in Computational Solid Mechanics. Applications of these concepts range from the acceleration of high-fidelity simulations in additive manufacturing to the development of digital twinning strategies for the non-destructive testing of composite materials.