Talk: Scalable GNN Solutions for CFD Simulations

Speaker: Michele Alessandro Bucci (Safran)

Abstract:

Computational Fluid Dynamics (CFD) simulations, essential for modeling various physical phenomena, face significant challenges in solving incompressible Navier-Stokes equations, particularly due to the computationally expensive Pressure Poisson problem. Recent advancements in Deep Learning, especially Graph Neural Networks (GNNs), offer promising solutions for enhancing numerical simulations on unstructured data like meshes. This presentation will introduce an initial approach towards constructing GNN models to solve the Poisson Pressure problem while respecting physical constraints (physics-informed, boundary conditions, mesh size adaptability, etc.). However, these GNN-based models struggle with generalization, accuracy, and scalability when applied to large-scale industrial problems. The central part of this presentation proposes a novel hybrid approach to address these limitations. By combining GNN models with Domain Decomposition techniques, the research aims to improve the accuracy and scalability of GNN-based Poisson solvers. The hybrid method partitions large meshes into smaller sub-problems solvable by GNN models, leveraging batch parallel computing on GPU for efficiency. The last part investigates this hybrid solver when used as a preconditioner for Krylov methods, ensuring convergence to any desired precision, and compares its performance to state-of-the-art industrial solvers.