AEROSPACE ENGINEERING

DIMEAS - Scientific machine learning and digital twins in Fluid mechanics and wind energy

Funded By	Dipartimento DIMEAS
Supervisor	MAGRI LUCA - luca_magri@polito.it
Contact	Imperial College London
Context of the research activity	Scientific machine learning; fluids mechanics
Objectives	Wind energy and offshore wind energy are crucial sources of renewable energy, which are necessary for the EU sustainable energy strategy for achieving a de-carbonised economy by 2050. Rapid progress has seen the EU, and other countries', agreed strike price per MWh fall in ten years to maintain the attractiveness of offshore wind energy in a competitive market, which requires innovation to improve efficiency. There are two factors to the goal functional of a wind-farm optimisation: maximising the power output from a given land area whilst minimising maintenance costs by reducing fatigue damage to wind-turbine components. The accurate and real-time optimisation of wind farms is still an open problem. First, we will run high-fidelity simulations with a spatial resolution of ~0.5m per mesh nodes of a full-scale multi-km offshore wind farm during operation. These effects will be key to accurately investigating wake-to-wake interactions for maximising the power output of offshore wind farms. Second, experiments will be conducted (or data will be acquired by collaborators) in the wind tunnel for repeatability, scalability, and uncertainty quantification. Third, the digital twin of the wind farm will be trained based on neural networks, in which the physics will be enforced both in the training and the architecture. The conservation laws will enable the machine to learn solutions that do not violate the physics of fluids. Specifically, we will use a Bayesian neural network, which can provide predictions on the quantities of interest (wake dynamics, cost functionals) and their uncertainties. The time series and dynamics will be inferred by the Physics-Informed Echo State Network, which our group has developed for dynamical systems. A multi-fidelity method will be implemented to combine data from the two sources: high-fidelity simulations and experiments.
Skills and competencies	

competencies for the development of the activity	Scientific machine learning; fluid mechanics; computing; programming; optimisation