Politecnico di Torino

AEROSPACE ENGINEERING

DIMEAS - Scientific machine learning and digital twins for hydrogen-based propulsion

Funded By	DIMEAS - Progetti ricerca MIUR e altri ministeri
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Context of the research activity	Scientific machine learning; fluid mechanics; propulsion
Objectives	Sustainable aviation: Hydrogen flames are extremely prone to make the gas turbine noisy and operationally unstable. This is due thermoacoustic instabilities, which are caused by a positive energetic feedback between the acoustics and the heat-release rate from hydrogen chemistry. Thermoacoustic instabilities are a major challenge for gas-turbine manufacturers. These instabilities can be a showstopper for the transition to hydrogen-fuelled power plants because hydrogen chemistry properties are more sensitive to external perturbations than natural gas. In this project, we will create versatile models by combining data from sensors and real-time digital twins, which will provide quantitatively accurate predictions on the acoustic pressure and the heat-release rate. In parallel, the digital twin will be trained with an ensemble method with scientific machine learning and data assimilation, to both obtain the state (pressure) and parameters of the hydrogen-driven instability. We will undertake an assessment of the robustness of the real-time digital twin in terms of (i) amount of data necessary to adaptively re-calibrate itself; and (ii) robustness to design parameters and off-design operating conditions (amount of fuel, impedance boundary conditions, flow speed). After validation of the real-time digital twin, we will apply it to the feedback control of an instability. The real-time digital twin will run on the CPU-GPU cluster. We assume that we will find an unstable thermoacoustic oscillations, which is likely to occur if the flame is positioned at a quarter of the tube length (Rayleigh criterion). If the system remains stable, we will increase the hydrogen fuel intake and calibrate the iris to incentivise acoustic reflection at the boundary.
Skills and competencies for the development of the activity	Scientific machine learning; fluid mechanics; computing; programming; optimisation