From reduced physics-based to data-driven empowered computational fluid mechanics.

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In order to speed-up CFD simulations different routes exist, some of them illustrated and analyzed in the present presentation.

From one side, parametric solution making use of model order reduction, and more concretely of PGD (Proper Generalized Decomposition) will be applied in both intrusive and non-intrusive settings. Thus, parametric solutions computed offline, are then particularized online for accomplishing real-time simulation, inverse analysis, optimization, uncertainty propagation and simulation-based real-time control.

When addressing aerodynamics, the first question concerns the number of parameters able to describe the shape of, for example, a car. Manifold learning allows the extraction of those explicative uncorrelated parameters that define the slow-manifold on which the kinematic and mechanical fields are embedded. Now, as soon as a new car, never previously analyzed, comes, it is mapped onto the slow manifold and the associated mechanical fields interpolated from its nearest neighbors. This route enables real-time augmented reality or real-time design space explorations, augmenting designers and engineers.

Finally, when addressing complex fluids, data-driven corrections of a first order constitutive model, ensuring thermodynamically consistency, are defined and efficiently computed for keeping prediction in agreement with experimental measurements, and making reliable long-time predictions.