The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Determination of distinct dynamical process in the flow using machine learning

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Keywords: *flow dynamics, system identification, clustering*

With advances in computing power, larger flow simulations are being performed, producing ever-increasing amounts of data and calling for data-driven techniques, such as system identification and machine learning, to analyse the flow fields. These techniques can in turn be extended to guide model reduction and model design efforts for complex configurations. Taking projection-based model reduction techniques, for example, system identification can be utilised to infer nonlinear coupling between the predetermined modes. The resulting models are particularly suited for control applications, since, by design, the captured dynamics are part of the observed input-output behaviour of the system. However, due to missing information on the nonlinear dynamics of the flow, this reduction procedure faces limitations when applied to complex flow configurations. Alternatively, the identification process can be redirected to discover the dominant dynamics in the flow using machine learning techniques directly on the data rather than extract a basis in which to express it. This work introduces one such algorithm where the active terms in the equation governing the flow (the Navier-Stokes equation) are identified using linear regression techniques, and the recovered coefficients characterize the different dynamics present in the flow. Clustering algorithms are then applied on these coefficients to define different regions of the computational domain with an associated, and distinct dynamics. This method has been applied and validated on various flow configurations using an incompressible Navier-Stokes solver.