THESE

Estimation and control of noise amplifier flows using data-based approaches

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Closed-loop control may provide technological solutions to efficiently modify flow behaviours that are undesirable in industrial applications. The implementation of efficient and robust controllers however, requires the computation of models of the target system that can be handled in real time. In fluid dynamics applications, the computation of these models is a challenging task due to the high number of degrees of freedom required to discretize the Navier-Stokes equations.

This work aims to provide new modelling strategies for noise amplifier flows using data-based techniques. This kind of flow is particularly difficult to model since the upstream noise environment, triggering the flow via a receptivity process, is not known. We propose a system-identification approach, rather than a classical Galerkin technique, to extract the model from time-synchronous velocity snapshots and wall-shear stress measurements. The technique is illustrated using the case of a transitional flat-plate boundary layer, where the snapshots of the flow are obtained from direct numerical simulations. Particular attention is directed to limiting the processed data to data that would be readily available in experiments, thus making the technique applicable to an experimental setup. The proposed approach combines a reduction of the degrees of freedom of the system by projection of the velocity snapshots onto a POD basis combined with a system-identification technique to obtain a state-space model. This model is then used in a feed-forward control setup to significantly reduce the kinetic energy of the perturbation field and thus successfully delay transition.

In the second part of this work, the extracted model is used to determine coherent structures of the flow that are inherent to the system and not a representation of the external driving noise. The global modes and frequency response of the reduced-order model are qualitatively compared to global modes of the full-order boundary layer reported previously in the literature.

Finally, the influence of the estimation sensor on the performance of the model is studied. The sensor's location is shown to be optimal when it is placed in the most upstream-located edge of the velocity window. The estimator is found to be rather sensitive to white noise corrupting the estimation sensor.

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Salle AY0263 à l'ONERA Meudon

Composition du jury

Rapporteurs	:	Francois Gallaire (EPFL, Professeur) George Papadakis, (Imperial College of London, Professeur)
Examinateurs	:	Shervin Bagheri (KTH Mechanics, Maître de conférence) Jean-Luc Aider (PMMH, Directeur de recherches CNRS) Jean-christophe Robinet (ENSAM, Professeur)
Directeur de Thèse	:	Denis Sipp (ONERA, Maître de recherches)
Co-directeur de Thèse	:	Peter Schmid (Imperial College of London, Professeur)