Structure preserving Bayesian identification of a reduced order model for the control of the circular cylinder wake

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ABSTRACT

Reduced Order Models (ROM) derived from Proper Orthogonal Decomposition (POD), generated from snapshots of solutions from a High Fidelity numerical Model (HFM), are extensively analyzed for flow control purposes. In contrast to purely formal models based only on the input and output data, ROMs have the advantage of preserving the underlying physics of the problem. Unfortunately, the truncation of the modes is often chosen in an ad-hoc way trying to capture a certain percentage of the energy of the system. The truncation may result in loosing stability properties of the original HFM. Furthermore, the derived models are usually highly tuned to one specific control configuration, while used under varying control circumstances.

In this contribution we focus on deriving ROMs which are on the one hand small enough to be able the be used for closed loop flow control, and on the other hand are robust and capable of representing the HFM in acceptable accuracy. The analysis is carried out by coupling the flow problem with a probabilistic approach and it is herein shown on the circular cylinder wake problem.

As a first step variance based sensitivities of the ROM and of the eigenfunctions to the variation of the control inputs are analyzed. Secondly it is shown how to tune further a chosen ROM with the help of Bayesian inversion. This inversion is carried out by preserving as much of the underlying physics of the High Fidelity Model and its model structure as possible. This is done by keeping apart the terms originating from the inhomogeneous boundary conditions, enabling the preservation of the original symmetric and skew-symmetric nature of the linear and nonlinear terms of the other part.

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