RATIONAL APPROXIMATION FOR DATA-DRIVEN MODELING AND COMPLEXITY REDUCTION OF LINEAR AND NONLINEAR DYNAMICAL SYSTEMS (MS - ID 69)

Mixed interpolatory and inference for non-intrusive reduced order nonlinear modelling

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Based on input-output time-domain raw data collected from a complex simulator, the Mixed Interpolatory Inference (**MII**) process approach allows to infer a reduced-order linear or nonlinear (e.g. bilinear or quadratic) time invariant dynamical model of the form

$$\left\{ \begin{array}{rcl} \dot{\hat{\mathbf{x}}} & = & \hat{A}\hat{\mathbf{x}} + \hat{B}\mathbf{u} + \hat{\mathbf{f}}(\hat{\mathbf{x}}, \mathbf{u}) \\ \hat{\mathbf{y}} & = & \hat{C}\hat{\mathbf{x}} + \hat{D}\mathbf{u} + \hat{\mathbf{g}}(\hat{\mathbf{x}}, \mathbf{u}) \end{array} \right. , \tag{1}$$

that accurately reproduces the underlying phenomena dictated by the raw data. In (1), $\hat{\mathbf{x}}(\cdot) \in \mathbb{R}^r$, $\mathbf{u}(\cdot) \in \mathbb{R}^{n_u}$ and $\hat{\mathbf{y}}(\cdot) \in \mathbb{R}^{n_y}$, denote the reduced internal, input and approximated output variables respectively. Moreover, $\hat{\mathbf{f}}$ and $\hat{\mathbf{g}}$ denote either quadratic or bilinear functions.

The approach is essentially based on the sequential combination of **rational interpolation** (e.g. Pencil, Loewner, AAA) with a **linear least square** resolution.

With respect to intrusive methods, no prior knowledge on the operator is needed. In addition, compared to the traditional non-intrusive operator inference approaches, the proposed rationale alleviates the need of measuring and storing the original full-order model internal variables. It is thus applicable to a wider range of applications than the standard intrusive and non-intrusive methods. It is therefore very close to the identification field.

The **MII** is successfully applied on different numerically challenging application related to pollutant dispersion. First *(i)* a large eddy simulation of a pollutants dispersion case over an airport area, and second *(ii)* a flow simulation over a building, both involving multi-scale and multi-physics dynamical phenomena.

Despite the simplicity of the resulting low complexity model, the proposed approach shows satisfactory results to predict the pollutants plume pattern while being significantly faster to simulate.