Energy Matching in Reduced Passive and Port-Hamiltonian Systems

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Conventional structure preserving *model order reduction* (MOR) for *port-Hamiltonian* (pH) systems focus on approximating the input-output dynamics by (approximately) minimizing classical system norms, such as the Hardy $\mathcal{H}_2$ norm. Nevertheless, the definition of a pH system consists of two objects: the input-output dynamics and an energy function, typically called the Hamiltonian. If we thus measure the approximation quality only with respect to the input-output dynamics, then the approximation of the Hamiltonian is not reflected at all. This is particularly relevant since recent results [1] demonstrate that modifying the Hamiltonian of the *full order model* (FOM) may yield better *reduced order models* (ROMs), at least if only the input-output dynamics are analyzed. In this talk, we take a first step towards the dual-objective optimization problem for optimal approximating both objectives: the input-output dynamics and the Hamiltonian, by noticing that in the pH ROM, we can modify the Hamiltonian without changing the input-output dynamics. Thus, for a given pH ROM, we can search for the reduced Hamiltonian that best approximates the FOM Hamiltonian. We prove that the resulting optimization problem is strictly convex and uniquely solvable. Moreover, we propose a numerical algorithm to solve the optimization problem and demonstrate its applicability with two academic toy examples. This talk describes joint work with Paul Schwerdtner (TU Berlin) and Benjamin Unger (U Stuttgart).

References

[1] T. Breiten and B. Unger. Passivity preserving model reduction via spectral factorization. *Automatica J. IFAC*, 142:110368, 2022.