Nonlinear balanced truncation: Scalable computation and manifold reduction

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Nonlinear balanced truncation is a model order reduction technique that reduces the dimension of nonlinear systems in a manner that accounts for either open- or closed-loop observability and controllability aspects of the nonlinear system. Two computational challenges have so far prevented its deployment on large-scale systems: (a) the computation of Hamilton-Jacobi-(Bellman) equations that are needed for characterization of controllability and observability aspects, and (b) efficient model reduction and reduced-order model (ROM) simulation on the resulting nonlinear balanced manifolds. In this talk I will review several existing methods for nonlinear balanced truncation and present a novel unifying and scalable approach to balanced truncation for large-scale systems. We consider a Taylor-series based approach to solve a class of parametrized Hamilton-Jacobi-Bellman equations that are at the core of the balancing approach. Moreover, I will present a nonlinear balance-and-reduce approach that finds a reduced nonlinear state transformation that balances the system properties. The talk will illustrate the strength and scalability of the algorithm on two semi-discretized partial differential equations, namely Burgers' equation and the Kuramoto-Sivashinsky equation.