Empirical Estimators for Stochastically Forced Nonlinear Systems: Observability, Controllability and the Invariant Measure

Jake Bouvrie, Boumediene Hamzi

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We introduce a data-based approach to estimating key quantities which arise in the study of nonlinear control systems and random nonlinear dynamical systems. Our approach hinges on the observation that much of the existing linear theory may be readily extended to nonlinear systems - with a reasonable expectation of success - once the nonlinear system has been mapped into a high or infinite dimensional feature space. In particular, we develop computable, non-parametric estimators approximating controllability and observability energy functions for nonlinear systems, and study the ellipsoids they induce. In all cases the relevant quantities are estimated from simulated or observed data. It is then shown that the controllability energy estimator provides a key means for approximating the invariant measure of an ergodic, stochastically forced nonlinear system.

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