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Master of Science (thesis)
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Title of thesis:

Data-driven System modeling and Optimal Control for nonlinear dynamical systems

Abstract:

Modern era of technology relies on data. For nonlinear dynamical systems, its very hard to obtain a useful model of the system dynamics, whereas there are plenty of methods to obtain input output time-series data. This motivates to investigate how to use data for learning behaviours of systems and design controllers when it comes to stabilization. Transfer operators i.e. Perron-Frobenius and Koopman operators play an undeniable role in advanced research of nonlinear dynamical system stabilization. These operators are fundamentally changing how we approach dynamical systems, providing linear representations for even strongly nonlinear dynamics. There is tremendous benefit of acquiring a linear model of a system using these models but, there remains a challenge of infinite dimension for such models. To deal with it, we approximate a low dimensional matrix of these operators using Extended Dynamic Mode Decomposition (EDMD) or Naturally Structured Dynamic Mode Decomposition (NSDMD). Once we have a linear approximation of PF operator, deriving a control and thereby stabilize the system becomes much simpler. Lyapunov measure can be used along with linear programming based computational framework for stability analysis and almost everywhere stabilizing controller design. In this work, we have introduced a approach to stabilize a system that does not have an explicit model and only requires black box input output time-series data. In addition, we show its possible to stabilize a system (known model dynamics) with stochastic parameters using similar Perron-Frobenius operator approach.