A New Systems Analysis Framework

Igor Mezic

University of California, Santa Barbara

Many of the problems that arise in modern engineering encompass an interesting mix of physical (e.g. thermal, fluid, electromagnetic), dynamics and control, and information technologies. From the dynamics and control point of view, such systems require new analysis tools; the dynamics is networked, it contains a mix of deterministic and stochastic elements, and can contain elements that are discrete (on-off) or continuous in time. We present an operator-theoretic framework for analysis of dynamical systems within which such disparate elements can be treated. The framework relies on representation of nonlinear systems as linear, albeit infinite-dimensional operators, and is similar to the one deployed in quantum mechanics. The operators that arise are not necessarily self-adjoint, and new analysis is required in the form of an interplay between formal linear methods, geometric analysis of nonlinear dynamical systems and graph-theoretic formulations. It leads to development of new decompositions such as the recently discovered Koopman Mode Decomposition. Finally, we show applications of this framework to issues of energy efficiency in buildings and new methods for stability analysis of power grids.