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CSC Seminar

SPEAKER / AUTHORS

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TITLE

Extensions of the Loewner framework to quadratic-bilinear systems: some recent results

ABSTRACT

In general, dynamical systems with analytical nonlinearities can be transformed exactly into polynomial systems, by means of applying "lifting" procedures. More precisely, this is done by introducing auxiliary variables, computing the derivatives of these new states, and expressing everything as polynomial terms. This procedure increases the state dimension of the original system of nonlinear ODEs. By applying lifting transformations, the dynamics of the lifted polynomial system are equivalent to that of the original nonlinear system. In this talk, we will concentrate on a special class of polynomial systems, i.e., quadratic-bilinear (QB) systems. These were extensively studied in recent years with applications spanning from model order reduction (MOR) to learning models from data. Moreover, we will discuss recent extensions of the data-driven method known as the Loewner framework, applied to the class of QB systems. The advantage of these methods is that they need only input-output data to compute reduced-order models (ROMs), without requiring state access (snapshots of the state variable or of its derivative for particular control inputs). The presentation is divided into two parts:

Part 1 (IVG): We discuss classes of lifting formulations and their impact on the generalized transfer functions associated with the resulting QB system. The motivation for this is that the lifting transformation is not unique (actually, one can build infinitely many such transformations by introducing free parameters). While the QB systems are equivalent to the original system with polynomial nonlinearity, MOR approaches applied to the different QB systems may generate different ROMs. Moreover, the approximation quality could drastically differ from case to case. Although the main method of our study is the Loewner framework, the choice of lifting transformations could also be important for other approaches.

Part 2 (DSK): We discuss ways of incorporating measurements of nonlinear frequency response functions (NFRFs) corresponding to the underlying system, for identifying reduced models of quadratic-bilinear systems. Such measurements can be inferred from the spectrum of the observed output. Moreover, we discuss how to incorporate the case of non-zero initial conditions into the proposed procedure. More precisely, by computing the asymptotic state equilibrium of the system, we can derive modified NFRFs that incorporate the equilibrium value. Then, the proposed procedure is appropriately modified to take into account the structure of these new functions.

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