KRYLOV SUBSPACE-BASED MODEL ORDER REDUCTION OF RCL CIRCUIT EQUATIONS

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Abstract

A simple approach to generate reduced-order models of high-dimensional linear time-invariant dynamical systems is to project the system's data matrices onto suitably chosen low-dimensional subspaces. Employing Krylov subspaces in such projection procedures results in reduced-order models that are characterized by a Padé or Padé-type approximation property of the dynamical system's transfer function. The underlying theory of Krylov subspace-based model order reduction has been known since the 1980s, but it was not until the early 1990s that actual algorithms were employed to solve relevant problems in practice. One of the first such applications was model order reduction of large RCL networks arising in the simulation and verification of integrated electronic circuits. RCL networks contain only resistors, capacitors, and inductors as circuit elements, and the circuit equations of such networks can be stated as linear time-invariant dynamical systems. Applying Krylov subspace-based projection to such RCL circuit equations results in very efficient reduction algorithms, mainly due to the Padé or Padé-type approximation property of the reduced-order models. Unfortunately, these reduction algorithms suffer from a major flaw: in general, the resulting reduced-order models do not correspond to actual reduced RCL networks. This has motivated the development of so-called structure-preserving variants of Krylov subspace-based reduction that retain key properties of RCL networks in the generated reduced-order models, with the goal of making it possible to synthesize the models as actual RCL networks. Despite a lot of progress in this area, the "perfect" Krylov subspace-based algorithm, which is guaranteed to produce reduced RCL networks in all cases, has still not been discovered.

In this talk, we describe the state-of-the-art of structure-preserving Krylov subspace-based reduction of RCL circuit equations. In particular, we discuss the importance of preserving passivity and reciprocity in the reduced-order models, we present results about the problem of synthesizing models as RCL networks, and we state some open problems.