Multilinear Modeling and Linear Analysis of Nonlinear Systems (Tensor Algebra, Realization, System Identification)

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Dissertation Abstract

Multilinear tensor algebra affords a convenient way of treating state space descriptions of nonlinear systems with tensor expansion coefficients. Linear algebra, in some cases, provides tools which may be applied in analysis of input-output descriptions of nonlinear systems. This thesis investigates issues which arise in both of these topic areas. The main body of this study treats internal (state space) descriptions of nonlinear systems comprised of differential equations. Based on a series expansion format, the method employs algebraic tensors to parameterize the nonlinear differential system, leading readily to methods of linear least squares identification in the model building process. Input selection is critical in such modeling studies; thus, ideas from optimal input design are couched in the tensor framework for improved parameter selection. The final step in the overall procedure is model verification and simulation; various error criteria are used with numerous simulation studies enabling clear definition of feasibility regions for the models. Reliable software packages have been developed for these studies. An introduction to studies treating external (input-output) descriptions of nonlinear systems is given which involves manipulations on the basic structure of various spaces making up a closed-loop feedback configuration for nonlinear plants and compensators. Through such manipulations, and under certain assumptions, novel descriptions arise which are analogous to the classical return difference in linear system theory. Possible extensions of these ideas include robustness studies such as sensitivity and disturbance rejection.