Polynomial tools for discrete-time nonlinear control systems

Ülle Kotta
Institute of Cybernetics at Tallinn University of Technology
Tallinn, Estonia

Control systems research has a long history of mathematical rigor, with application to diverse branches of science and engineering. There is no question that nonlinear thinking can be of major benefit in practical problems, but the main concern of practitioners is that nonlinear methods, as a rule, require specialist knowledge to be understood and properly applied. It has been our purpose for some time by now to focus on development of theory, methods and algorithms that (i) mimic (in certain sense) their linear counterparts to be better accessible for potential users and (ii) are constructive and therefore suitable for implementation in symbolic software.

The algebraic approach, developed by us, uses differential forms (Kähler differentials) to describe the global (generic) linearization of nonlinear control systems. This description may be further rewritten by means of matrices over skew polynomial rings. When polynomial indeterminate is interpreted as a shift (or difference) operator, polynomial matrices act on differential one-forms, including the differentials of inputs and outputs, as operators and allow to represent the algorithms in a compact /transparent way, and sometimes even replace them by explicit formulas. Many important system properties (accessibility, irreducibility / reduction, realizability / realization) and control problem solutions (model matching, dynamic feedback linearization) have been made constructive in this setting.

The talk gives a short overview of polynomial methods, applicable for analytic nonlinear control systems. Though the focus of the talk is on discrete-time case, the approach works equally well in case of continuous-time systems. The additional benefit of the polynomial approach is that it allows to unify the study of continuous- and discrete-time systems, if combined with pseudo-linear algebra or time scale calculus.