Nonlinear Modelica Models in Control Applications

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In this overview presentation, a short introduction to the Modelica modelling language and advanced Modelica applications is given. Modelica is suited and used to describe complex cyber-physical systems based on differential-algebraic and difference equations. It is especially utilized in research and in industry whenever nonlinear dynamic models from several physical domains have to be treated.
The central part of the presentation gives an overview about actual and future developments in the Modelica community with respect to advanced control applications:

- Constructing automatically inverse dynamic models and utilizing them in sampled data systems. The goal is to use model knowledge of the controlled system directly (and semi-automatically) in a nonlinear controller over the complete operating range of the system. From a mathematical point of view this means to change the causality of a differential-algebraic equation (DAE) system, perform automatic index reduction and transform the resulting DAE into a sampled data system.
- Formulate multi-rate integration techniques in Modelica to solve the inverse dynamic systems with different integration methods and (fixed) step sizes as it is appropriate for the different controller parts.
- Add meta-information to a Modelica model (via custom annotations) especially to define optimization setups. The goal is to tune the free parameters of a control system by performing many simulations in a multi-criteria design optimization loop. Custom annotations also provide the possibilities for other types of analysis, for example by adding uncertainty information of model parameters.
- Define formal requirements on the operation of the control system and check the fullfillment of these requirements automatically, whenever a simulation of the controlled system is performed. The goal is to verify and assess the operation of a designed control system in a semi-automatic way.