QUALIDAES - A Software Package for the Numerical Integration of Quasi-Linear DAEs

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Abstract: The complete virtual design of dynamical systems, e.g., mechanical systems, electrical circuits, flow problems, or whole production processes, plays a key role in our technological progress. Therefore, the interconnection of automatic modeling tools with efficient and robust simulation tools is of growing interest. Automatic modeling using coupling of modularized subcomponents is widely used in industry. Here the coupling of subcomponents often is described by algebraic constraints which leads to differential-algebraic equations (DAEs) in quasi-linear form

$$E(x,t)\dot{x} = f(x,t) \tag{10}$$

as model equations with the vector of unknowns x and the time t. Further constraints can be path following constraints or artificial and constructive restrictions. Unfortunately, in general the direct numerical integration of DAEs is not feasible due to so-called hidden constraints

$$0 = h(x,t). \tag{11}$$

They are contained in the DAE but not explicitly stated as equations. The occurrence of hidden constraints leads to difficulties like instabilities or order reduction in the numerical integration. Hence, before a robust numerical integration is possible it is necessary to regularize or remodel the model equations.
A further important aspect in the simulation of dynamical systems are conservation laws

$$0 = e(x,t) \tag{12}$$

(e.g. conservation of mass or momentum, mass or population balances, etc.) which are included in the model equations and should be preserved during the numerical integration.

In this talk we will present the software package `QUALIDAES` for the numerical integration of quasi-linear DAEs of the form (10) which covers the model equations of many dynamical processes. A key point for the robust and efficient numerical integration in `QUALIDAES` is the precise consideration of hidden constraints. Therefore, the approach implemented in `QUALIDAES` based upon on the interaction of a regularization of the DAE (10) with an efficient numerical treatment of the regularization in form of an overdetermined fomulation consisting (10), (11), (12). Furthermore, we will demonstrate the performance and the applicability of `QUALIDAES` for several examples of different degrees of complexity.

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