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Original article

A quantitative metric for robustness of nonlinear algebraic equation solvers

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Abstract

Practitioners in the area of dynamic simulation of technical systems report difficulties at times with steady-state initialization of models developed using general declarative modeling languages. These difficulties are analyzed in detail in this work and a rigorous approach to quantify robustness in the context of nonlinear algebraic equation systems is presented. This tool is then utilized in a study of six state of the art gradient-based iterative solvers on a set of industrial test problems. Finally, conclusions are drawn on the observed solver robustness in general, and it is argued whether the reported difficulties with steady-state initialization can be supported using the proposed quantitative metric.

MSC: 65H10; 37M05

Keywords: Robustness; Steady state initialization; Dynamical system; Declarative modeling; Modelica

1. Introduction

Over the last two decades, object-oriented modeling languages emerged in the area of dynamic simulation of technical systems (e.g. Modelica [34], VHDL-AMS [18], gPROMS [29]). Using these languages, a *declarative* high-level description is written by the modeler, which is processed by symbolical manipulation algorithms and transformed into a form that can be solved by standard numerical integration methods. Such languages are particularly useful for multi-domain modeling of large, complex, and heterogeneous technical system with, e.g., mechanical, electrical, thermal, hydraulic, thermo-fluid, and control subsystems. Due to the principles of object-orientation, utilizing these languages is much like building a real system. Standard components with proper specifications such as pipes or pumps are taken from a catalog. Only if a particular subsystem meeting the user's requirements does not exist, she will construct a new model based on standardized interfaces.

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