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The full potential of Continuous System Simulation modelling

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Abstract

Continuous System Simulation (CSS) is a powerful way to study the behaviour of differential-algebraic equation models. Differential-algebraic equation modelling goes back to Newton and works well for models of e.g. physical systems where stochasticity plays almost no role, and where only a single attribute of an object is studied over time. However, when results from a deterministic CSS model are compared with results from a Discrete Event Simulation (DES) model, they are often inconsistent. The reasons behind this CSS-DES inconsistency are nowadays well understood.

In this paper, we demonstrate that a CSS model can contain both continuous state variables (compartments) that change continuously over time and discrete state variables (also compartments) that model discrete entities and change by integer amounts. In both cases, the time-slicing method is used to advance time. Furthermore, stochasticity can and should play the same role in CSS as it does in DES.

This paper first explains how a well-defined conceptual model can be stepwise transformed in a consistent way into a CSS model. These transformation steps provide insights into how to construct a consistent CSS model. In short, this is about preserving uncertainties, attributes and dynamic properties.

An additional benefit of this approach is that continuous and discrete sub-models can interact within the same model, without having to combine different types of simulation languages, types of time handling and incongruent concepts. To facilitate the use and understanding of stochastic CSS, an open source tool for collecting and analysing the outputs from a stochastic CSS model and analysing and presenting the results in statistical form is also developed and approachable to the readers.

Keywords: continuous modelling, CSS, discrete modelling, DES, combined simulation, compartment-based model, stochastic modelling