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Presentation of the textbook "Modeling and Simulation in Engineering using Modelica"

Abstract. The textbook "Modeling and Simulation in Engineering using Modelica" is one of the deliverables created in the InMotion project of the Erasmus EU Programme for Capacity Building in Higher Education - Project No. 573751-EPP-1-2016-1-DE-EPPKA2-CBHE-JP (2016-2565/001-001).

This textbook has been elaborated from a selection of educational materials employed by the authors in their Master's level courses on modeling and simulation at UNED, the National Distance Education University of Spain. The structure and content of the textbook is summarized in Table 1.

The instructional objective is twofold. Firstly, to provide an introduction to the object-oriented design, and the development in Modelica, of model libraries with application in Engineering. Secondly, to discuss the analyses and manipulations that the Modelica modeling environments automatically perform on the model for translating its description in Modelica into efficient simulation code. The level of detail in this discussion should be enough for understanding the diagnosis messages generated by the Modelica modeling environments during the model translation and simulation.

The textbook will be written in English language and translated into Russian language. The former version will be published during the third quarter of 2017 by Editorial UNED (Madrid), and will be freely available in electronic format.

Table 1. Textbook content.

PART 1. Continuous-time modeling

1. Object-oriented modeling methodology and tools
   The physical modeling paradigm. Principles of modular, hierarchical and object-oriented modeling. Capabilities of Modelica modeling environments. Getting started with Dymola and OpenModelica.
2. Continuous-time atomic models
   Types. Variables. Equations and algorithms. Functions. Development of atomic models in the electrical, mechanical, thermal and hydraulic domains with Modelica.
3. Model libraries
   Inheritance and composition. Library design for model reuse. Packages. Development of Modelica libraries in the electrical, mechanical, thermal and hydraulic domains.

PART 2. Simulation of continuous-time models

4. Computational causality of DAE systems
   Structurally singular systems of differential and algebraic equations (DAE). Partition algorithm. Overdetermined and underdetermined DAE systems.
5. Index and initialization of DAE systems
   Index of DAE. Hidden constraints and index reduction.
6. Systems of simultaneous equations
   Symbolic manipulation of algebraic loops. Solution during simulation initialization. Tearing of nonlinear algebraic loops.
7. Selection of the state variables
   Symbolic manipulation of the DAE system. Dynamic selection by the modeling environment. Selection by the model developer.
8. Numerical solution of ODE and DAE systems
   Numerical methods for ODE. DASSL. Inline and mixed-model integration.

PART 3. Hybrid system modeling and simulation

9. Hybrid system specification
   The OHM formalism. Relationship between formal specification, simulation algorithm and Modelica description.
10. Detection and handling of events
    Crossing function. Restart problem. Simultaneous events. Chattering.
11. Hybrid system modeling in Modelica
    Multi-mode system modeling. State and time events. Models with a variable structure. Event modeling.
12. Model initialization
    Initialization of continuous-time and discrete-time variables in Modelica.
13. Experimenting with Modelica models
    Scripting language for experimenting with Modelica models. Model calibration. Model validation.

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