Co-simulation with communication step size control in an FMI compatible master algorithm

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Complex multi-disciplinary models in system dynamics are typically composed of subsystems. This modular structure of the model reflects the modular structure of complex engineering systems. In industrial applications, the individual subsystems are often modeled separately in different mono-disciplinary simulation tools. The Functional Mock-Up Interface (FMI) provides an interface standard for coupling physical models from different domains and addresses problems like export and import of model components in industrial simulation tools (FMI for Model Exchange) and the standardization of co-simulation interfaces in nonlinear system dynamics (FMI for Co-Simulation), see [2]. In November 2011, the third β-version of FMI for Model Exchange and Co-Simulation v2.0 was released [3] that supports advanced numerical techniques in co-simulation like higher order extrapolation and interpolation of subsystem inputs, step size control including step rejection and Jacobian based linearly implicit stabilization techniques. Well known industrial simulation tools for applied dynamics support Version 1.0 of this standard and plan to support the forthcoming Version 2.0 in the near future, see the "Tools" tab of website [2] for up-to-date information. The renewed interest in algorithmic and numerical aspects of co-simulation inspired some new investigations on error estimation and stabilization techniques in FMI for Model Exchange and Co-Simulation v2.0 compatible co-simulation environments. The present paper extends recent results from [1] on reliable error estimation and communication step size control in the framework of FMI for Model Exchange and Co-Simulation v2.0. Based on a strict mathematical analysis, we study the asymptotic behaviour of the local error and two error estimates that may be used to adapt the communication step size automatically to the changing solution behaviour during time integration. These theoretical results are illustrated by numerical tests for a (linear) quarter car model and provide a basis for future investigations with more complex coupled engineering systems.

References

[1] M. Arnold, C. Clauß, and T. Schierz. Numerical aspects of FMI for Model Exchange and Co-Simulation v2.0. In P. Eberhard and P. Ziegler, editors, *Proc. of The 2nd Joint International Conference on Multibody System Dynamics, Stuttgart, Germany, May 29 - June 1, 2012*, ISBN 978-3-927618-32-9, 2012.

[2] FMI. The functional mockup interface. `http://www.functional-mockup-interface.org/`.

[3] Modelisar. Functional Mock-up Interface for Model Exchange and Co-Simulation v2.0 Beta 3. `http://www.functional-mockup-interface.org/specifications/FMI_for_ModelExchange_and_CoSimulation_v2.0_Beta3.pdf`, November 2011.