An example of beneficial use of variable-structure modeling to
enhance an existing rocket model

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This paper introduces a rocket model and discusses the advantages of refining it using a variable-structure approach to remodel computationally intensive parts.

The aim of our simulation is to predict the trajectory of a rocket, beginning with the ignition on earth's surface up until it reaches the moon as destination. The rocket is multi-staged, and as such consists of three booster modules and a payload module without means of propulsion. The model takes into account the chemical reactions in the boosters combustion chambers, which generate the thrust, the gravity of both earth and moon as well as atmospheric influences. First, we introduce a classical implementation of the model which is a rather stiff system of equations and does take quite a long time to simulate.

We are then introducing a variable-structure approach [1] which allows us to divide the rocket model into different modes. This is possible since the chemical reactions in the boosters only need to be regarded while starting a new stage. After a short time a steady state is reached and the chemical reactions, which also lead to the stiff system of equations, is not necessary anymore and they ca be taken out of the simulation. This leads to a faster simulation and less saved data volume without reducing the accuracy of the model.

Both versions of the model are implemented in Modelica and were simulated using Dymola as simulation environment. The DySMo framework [2], which supports the simulation of variable-structure models in common simulation environments, was used to facilitate the redesign.

The general benefits of the variable-structure approach are presented, and with the example of the rocket model we present that simulation time and the data volume of the simulation can be reduced while maintaining the accuracy of the simulation results.

References

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