Discontinuities handled with events in Assimulo, a practical approach

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Often integrating ordinary differential equations or differential algebraic equations (DAE) do not constitute the problem alone. A common complement is finding the root of an algebraic function (an event function) that depends on the states of the problem. This formulation of a model enables the possibility of including discontinuities, an important part of the Functional Mock-up Interface (FMI) standard which allows hybrid models of differential algebraic equations. The problem of root-finding during integration is however difficult, both in a theoretical aspect and as a software problem.

The Illinois algorithm was chosen as a basis for the event algorithm. An important improvement is to apply the domain formulation, meaning that instead of defining an event as a change in sign (zero-crossing formulation) for the event function, g, it is defined as a change in domain from $g > 0$ to $g \leq 0$ or vice versa, this is consistent with the FMI standard. An advantage is that the zero is no longer a special case and also, more importantly, events caused by event functions becoming exactly zero for a finite time is found correctly.

An implementation of software for the event algorithm is done in Assimulo, a Python/Cython wrapper for integrators. This enabels event location for numerous integrators and therefore also support for simulating FMUs by using PyFMI.

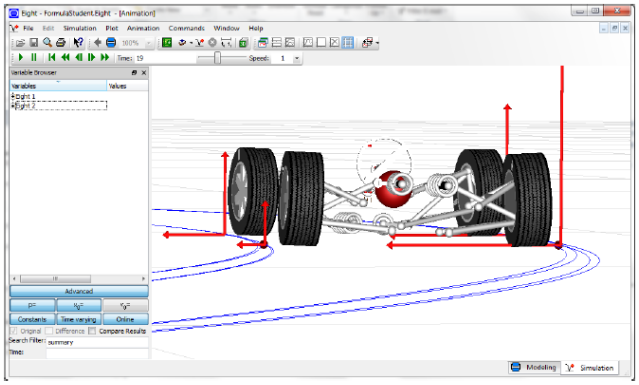

Figure 1: A picture of the car in Dymola, used for the benchmark.

These integrators are benchmarked with industrial relevant models to verify that they work well together with the event algorithm and that they find events accurately, especially for the case where the event functions becomes zero for a finite time. It is also important that the performance does not deteriorate with the modifications to the event algorithm. The models used in the benchmark are a clutch with inputs, a Furuta pendulum and a racing car.

Comparing Sundials using its zero-crossing event algorithm and Sundials using the articles event algorithm no significant loss in performance was seen. Additionally, the events of the clutch model with inputs was found significantly better with the articles event algorithm. The other integrators benchmarked also performed well.