The Modelica BehaviorTrees Library

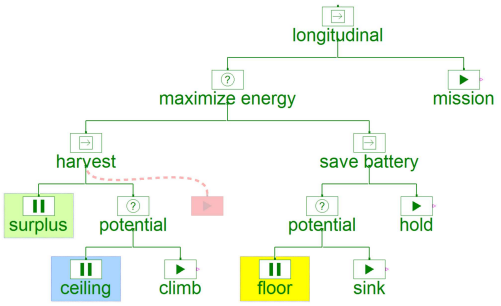
Mission Planning in Continuous-Time for Unmanned Aircraft

Andreas Klöckner
German Aerospace Center (DLR), Institute of System Dynamics and Control
82234 Weßling, Germany, Andreas.Kloeckner@dlr.de

Growing complexity of missions, environmental conditions, and UAV capabilities call for a flexible, scalable and intuitive scheme for UAS control systems and mission plans. Behavior trees have recently been proposed for this purpose. They are distinguished by their standardized structure providing a mission design scheme, which has been argued to combine important advantages of different schemes such as state machines and task planners.

However, conventional behavior tree implementations rely on *discrete-time* processing unsuitable for continuous-time simulation of long-term missions. In order to combine efficient long-term simulations with the capabilities of behavior tree mission plans, a *continuous-time* `BehaviorTrees` library was thus developed and implemented:

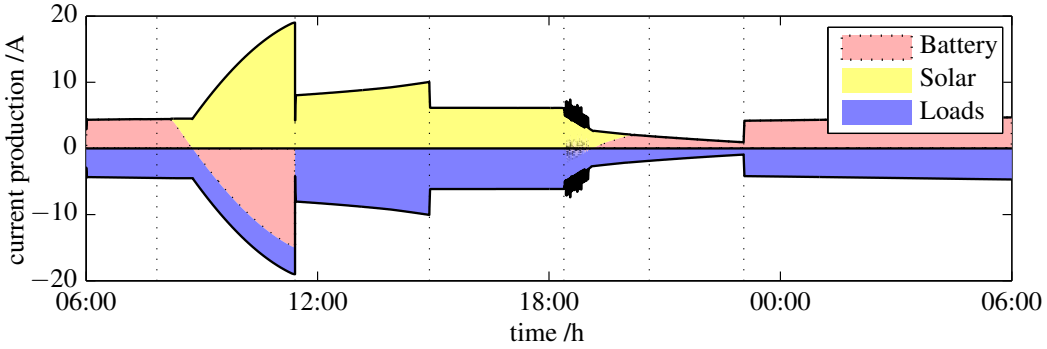
- It allows a simulator to chose large integration step-sizes as desired for long-term mission simulation. The formulation can be generalized to other languages supporting event notifications.
- A library of base tasks with clear internal and external interfaces allows the user to graphically design mission plans and also easily implement new task types.
- The 24 h-simulation with an integrated solar UAV model shown below underlines the modularity of the approach and its good performance.



(a) The example `BehaviorTrees` mission plan.

Configuration	CPU time	time- / state events	
Discrete	368 s	1442	249
Continuous	72 s	0	247
State graph	76 s	60	242
Direct inputs	66 s	25	183

(b) The continuous-time simulation is much faster than the discrete-time implementation. It is as fast as a reference state graph implementation and a direct simulation. Additionally, it does not require any time events.



(c) The simulation is run for 24h of flight with a 72 state continuous-time solar UAV model.