Modified Multiple Shooting Combined with Collocation Method in JModelica.org with Symbolic Calculations

Evgeny Lazutkin, Abebe Geletu, Siegbert Hopfgarten, Pu Li
Simulation and Optimal Processes Group
Institute for Automation and Systems Engineering,
Technische Universität Ilmenau, P.O.Box 10 05 65, 98684 Ilmenau, Germany.
(evgeny.lazutkin, abebe.geletu, siegbert.hopfgarten, pu.li)@tu-ilmenau.de

This paper presents an efficient and novel implementation of a combined multiple shooting and collocation (CMSC) algorithm for the solution of nonlinear optimal control problems (NOCP). The implemented algorithm is a modification of the approach proposed in [1, 2]. The new implementation is done under the JModelica.org framework along with CasADi and Ipopt. The framework uses a symbolic pre-calculation of functions and derivatives. The paper gives a description of the algorithm and elaborates the components of the framework. Comparative numerical experimentations show that the new implementation is efficient in comparison with the published results of other authors.

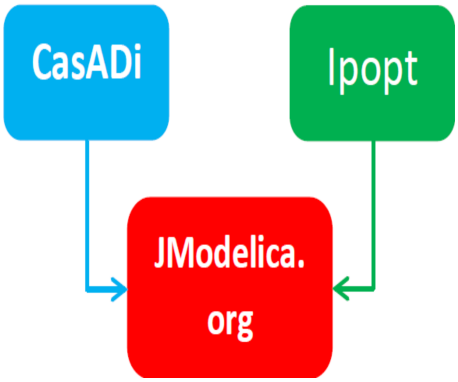

Figure 1: Software framework

The major difference from the original version of the CMSC approach in [1, 2] consists in the use of pre-calculated derivatives and their symbolic representation. That is, in every iteration of the optimization algorithm, sensitivities are automatically available without further calculations. This leads to accurate results with outstanding speedup of the overall computation time. In the framework shown in Fig. 1, the NOCP is modeled under JModelica.org using a Python script. Then the problem is discretized using our CMSC with the help of CasADi to obtain a nonlinear programming problems (NLP). Subsequently, CasADi is again invoked to generate symbolic expressions for the derivatives. Finally, JModelica.org invokes Ipopt to solve the NLP by using the pre-calculations.

References

[1] Tamimi, J.: Development of the Efficient Algorithms for Model Predictive Control of Fast Systems. PhD Thesis, Technische Universität Ilmenau, VDI Verlag, 2011.

[2] Tamimi, J., Li, P.: A Combined approach to nonlinear model predictive control of fast systems. J. Process Control, 20(2010)9, pp. 1092-1102.