# Collocation Methods for Optimization in a Modelica Environment

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Optimization of large-scale dynamic systems is becoming a standard industrial technology. Applications include minimization of material and energy consumption during set-point transitions in power plants and chemical processes, minimizing lap times for vehicle systems or trajectory optimization in robotics.

There are different kinds of dynamic optimization problems and in this paper we consider two categories. The first is optimal control, where the aim is to find control variable trajectories (and possibly parameters) that minimize, for example, the amount of resources spent to perform a specified action. The second category is parameter estimation, where the problem is to find the values of unknown model parameters that allow the model to behave according to given measurement data.

There are many approaches to solving dynamic optimization problems. In this paper, an algorithm based on direct collocation is developed and implemented. Details regarding the theory and implementation are presented. The algorithm is implemented in JModelica.org. Modelica is used to model the system dynamics, and the language extension Optimica is used to encode the optimization formulation.

JModelica.org is an open-source Modelica platform targeting large-scale dynamic optimization. It already has an old and well-tested collocation algorithm. The purpose of the newly developed algorithm is to offer improved flexibility and performance, through the use of the automatic differentiation tool CasADi. The new algorithm is compared to the previous one in two benchmarks. The first benchmark is optimal control of a small-scale but highly non-linear tank reactor. The second benchmark regards optimal start-up of a combined cycle power plant of larger scale. Below are the results from the second benchmark, where we see that the new algorithm is consistent with the old algorithm. In this case, the solution time of the new algorithm is 8 times shorter than that of the old algorithm.

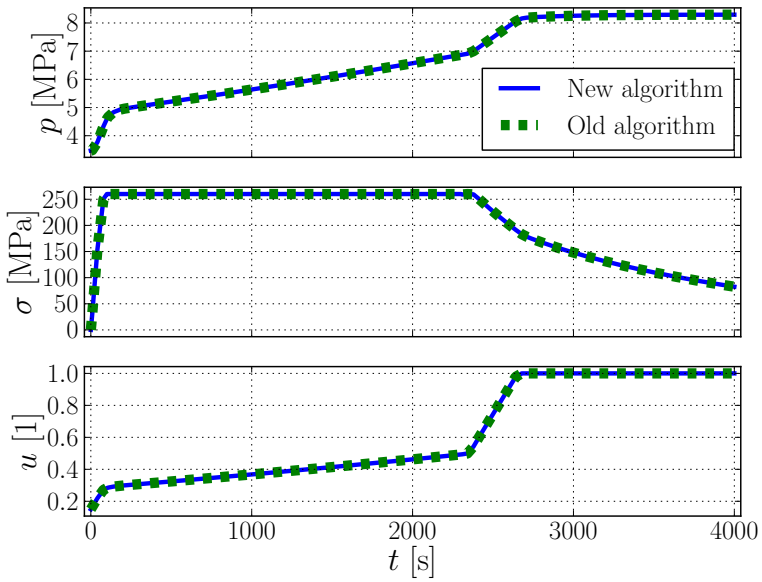


Figure 1: Comparison of the old and new algorithm on optimal start-up of a power plant