Grey-box identification of a SCARA robot

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1 Introduction

Modeling mechatronic systems based on physical knowledge can lead to models with inherent nonlinearities. If our model does not fit into a certain class of nonlinear models for which tailored algorithms exist (e.g. PLNSS [1], NLARX [2]), we can easily encounter problems, for example the solver is unable to find a solution within the specified error threshold, or the running time of the solver makes the method practically infeasible. Possible reasons for these can be for example local minimums, or instability of the model for a set of parameter values. As a result, parameter estimation methods that work on a general set of nonlinear models are still a challenge.

In this study the task considered is estimating the parameters of a SCARA robot (in this case limited only to the masses of the links), with the goal to provide an accurate model for control. Having preliminary knowledge about the mechanical structure, the ODEs of the system were derived using the recursive Newton-Euler algorithm.

2 The method

Our approach is based on optimal control problems (OCP) for the simulation of the states of the system. In addition to the single shooting (SS) and multiple shooting (MS) formulations, we are using a hybrid formulation (X_{sim}, see Figure 1) that is in between SS and MS. This is similar to the idea in [1], but there it was limited to the scope of PLNSS models. The recursion depth in the formula can be controlled to find a compromise between memory usage, running time and the robustness of the algorithm.

We use CasADi to formalize the problem in MATLAB and solve it using Ipopt, an off-the-shelf solver for nonlinear programs. For the SS formulation, we also test the Ceres Solver, a solver from Google for nonlinear least-squares problems.

A comparison of running times and the memory usage for different initial parameter values and recursion depths has been carried out on a simulated robot. In addition, using different approximations of the Hessian matrix were also included in the comparison.

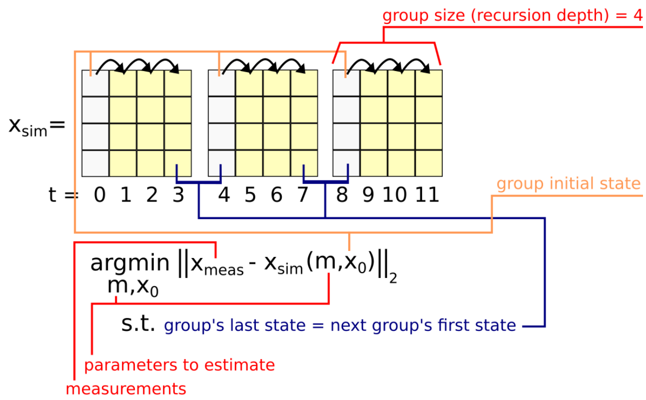

Figure 1: The hybrid formulation of the OCP

3 Results and future work

The simulations show that we can decrease the running time of the algorithm by choosing the appropriate recursion depth. The method will be validated on a model and measurements corresponding to a real system. Furthermore, we are planning a parallelized implementation to speed up the computation of the Hessian matrix.

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References

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