Data-Driven Tuning of Rational Feedforward Controllers for Noncommutative MIMO Systems[1]

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1 Background

Feedforward control is essential in mechatronic systems that perform varying motion tasks with extreme accuracy requirements. In [1], iterative learning control (ILC) with rational basis functions (RBFs) is introduced to enable high tracking accuracy with extrapolation of the motion tasks for rational SISO systems. The rational parameterizations result in a non-convex optimization problem and is solved by using SK-iterations, i.e., solving a sequence of weighted least-squares problems. These algorithms are experimentally efficient due to the fact that the system is commutative and since almost all iterative aspects involve computational steps and not experimental steps.

2 Problem formulation

The aim of this research is to develop a solution method for RBF ILC for MIMO systems that do not commute.

3 Approach

The developed MIMO RBF approach exploits the idea from input shaping [2] to avoid exploitation of the commutation property. By rewriting the optimization problem into an input shaping solution with a compensatory input, a single weighted least-squares problems is obtained that can be solved after each experiment. Instead of solving a sequence of weighted least-squares problems offline, only a single weighted least-squares problem is solved each experiment. This avoids the exploitation of the commutation property at the cost of only slightly slower convergence.

4 Results

Preliminary results, shown in Fig. 1, for positioning of a wire bonder in one-direction only, i.e., SISO, shows indeed that the convergence rate of the cost of the developed MIMO RBF method is slower than the RBF-SK method while attaining the same final cost. As expected, the convergence rate equals that of one-step-only RBF-SK method, i.e., performing only one SK optimization per experiment.

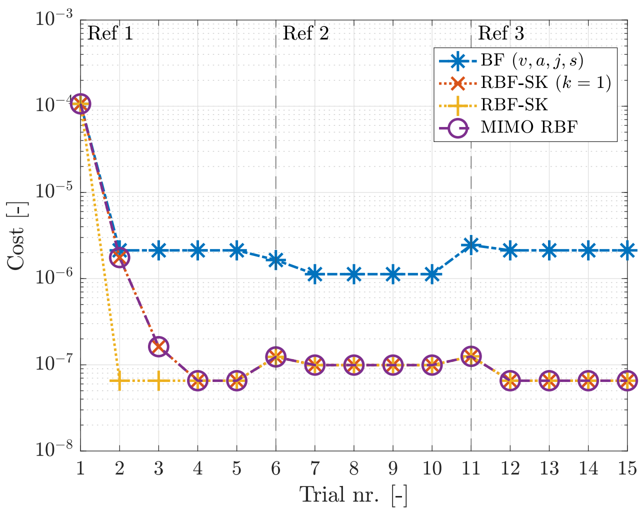

Figure 1: Comparison of cost per trial, i.e., experiment, in SISO ILC simulation of traditional polynomial BF (—), the one-step-only ($k = 1$) RBF-SK (—), standard RBF-SK (—), and the proposed MIMO RBF method (—).

5 Conclusion and outlook

The MIMO RBF framework will enable accurate rational feedforward control for noncommutative MIMO systems. Initial result show that the commutation property can be avoided at the cost of only slightly slower convergence. Ongoing research focuses on the analysis of the convergence properties and experimental validation.

References

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