Kernel-based learning control for iteration-varying tasks applied to a printer with friction[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, 2], iterative learning control with polynomial basis functions (ILCBF) is introduced to enable extrapolation of the motion tasks. However, polynomial parameterizations are limited in describing flexible system dynamics, hence do not meet the performance requirements. In [3], identification of inverse non-causal LTI systems using kernels [4] is addressed. However, extensions to nonlinear elements and closed-loop systems are not straightforward.

2 Problem formulation

Although developments have been made in iterative learning control for general tasks, at present the use of kernel-based approaches has not been exploited yet. The aim of this research is to develop a kernel-based approach to ILC, and present a specific approach for non-causal and nonlinear basis functions arising in motion feedforward control.

3 Approach

The developed kernel-based ILC (KILC) approach exploits the use of non-causal kernels to regularize the non-causal impulse response parameters and learns these simultaneously with prescribed nonlinear basis functions in closed-loop. Prior knowledge about the system is added through a developed kernel design approach, which enforces model complexity and non-causality to deal with NMP systems.

4 Results

Initial results for positioning of a consumer printer subject to nonlinear friction demonstrate the superior performance of KILC with 201 non-causal impulse response parameters and a non-causal OBF kernel compared to ILCBF with only acceleration as basis. Both methods also have a nonlinear Coulomb friction component. In Fig. 1, the time-domain error and feedforward signals are presented. The results show that KILC automatically identifies impulse response parameters to compensate higher-order dynamics, e.g., the snap parameter.

[1]This work is supported by ASM Pacific Technology. The authors thank Dragan Kostić and Robin van Es for their contributions to this research.

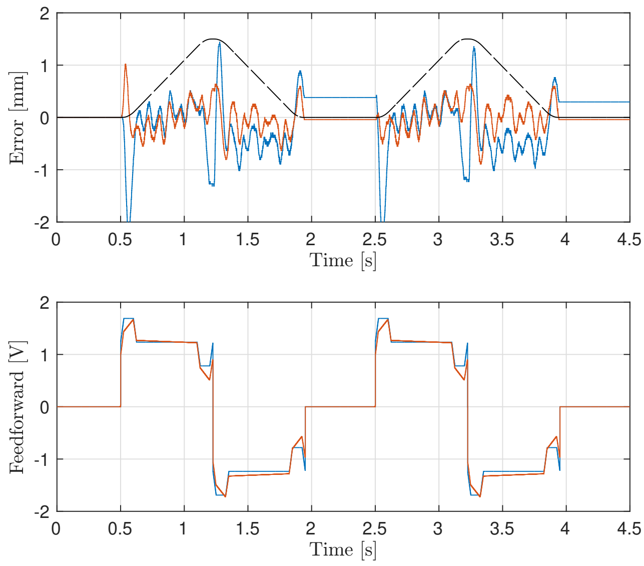

Figure 1: Time-domain error and feedforward signals for the scaled reference (- -) of both ILCBF (—) and KILC using an OBF kernel (—).

5 Conclusion and outlook

The presented KILC framework enables accurate control for a class of non-causal and nonlinear systems. Performance improvements are most prominent for systems with NMP and higher order dynamics. Ongoing research focuses on application to MIMO systems, selecting nonlinear basis functions derived from rigid-body modeling, and modeling position-dependency of the feedforward parameters.

References

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