Learning control systems for high performance printing

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Introduction

In printing systems, the positioning accuracy of the medium with respect to the print heads directly impacts print quality. In a regular document inkjet printer, the main task of the media positioning drive is to shift the medium after the printhead has finished a pass. Most media have the tendency to deform while it is being printed due to variations in temperature and moisture content. To compensate for these deformations a control strategy where the repetitive nature of tasks is exploited and variations in references can be allowed is necessary.

Iterative Learning Controller design

Iterative Learning Control (ILC) with basis functions [1] is suited for the requirements. Consider the block diagram of the ILC in figure 1. The selected basis functions Ψ are depicted in figure 2. The parameters θ are updated every repetition of the reference using Newton optimization. The required gradients are calculated using a combination of model and measurement data.

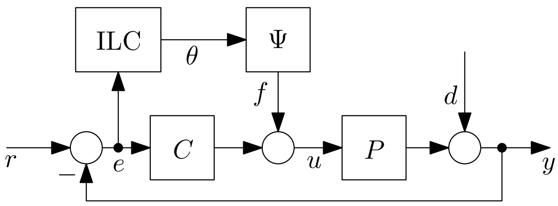

Figure 1: Closed-loop system. The control loop consists of a standard linear feedback controller C which drives plant P with input u. The ILC updates the parameters θ at the end of each trial. The feedforward f is constructed using the basis functions Ψ. The tracking error is e which is calculated using the positioning reference r and measured output y, which is affected by an unknown disturbance d.

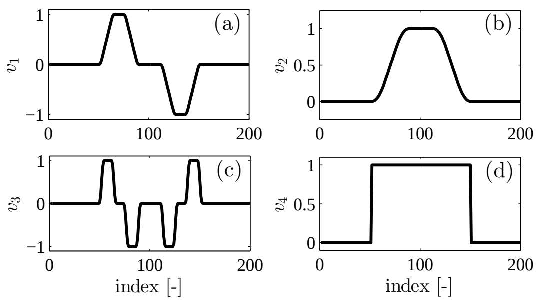

Figure 2: The basis functions Ψ. Acceleration feedforward with basis function v_1 is shown in (a), velocity feedforward v_2 is shown in (b), plot (c) shows the Jerk feedforward and the basis function for Coulomb friction v_4 is shown in (d).

Experimental results

The ILC is applied to a mechanical system which performs a positioning task [2]. The tracking error is shown in figure 3. The evolution of the parameters is shown in figure 4. It shows that the tracking error is reduced substantially and that the parameters converge in approximately 1 trial.

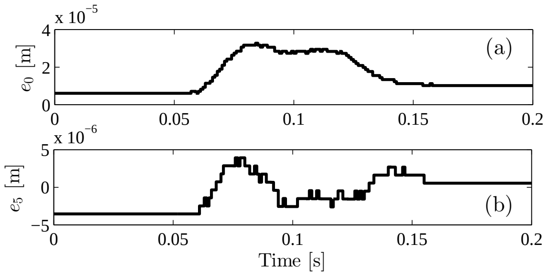

Figure 3: Tracking errors for trials 0 (a) and 5 (b). The peak-peak error reduction is about a factor 8.

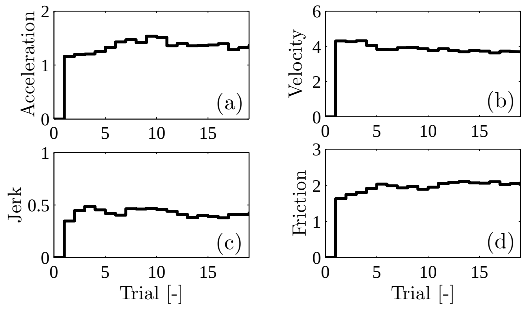

Figure 4: The feedforward parameters as function of the trial number. It shows that the parameters converge to 90% of their final values in 1 trial.

Conclusions and future work

By using ILC with basis functions the tracking accuracy of a motion system is improved substantially. The tracking performance after convergence is strongly depended on the choice of basis functions, hence the determination of optimal basis functions is a subject for future research.

References

[1] J.J.M. van de Wijdeven and O.H. Bosgra, "Using basis functions in iterative learning control: analysis and design theory," International Journal of Control, vol 84, p.p. 661-675, 2010.

[2] J.J. Bolder, B.P. Lemmen, S.H. Koekebakker, T.A.E. Oomen, O.H. Bosgra, M. Steinbuch,"Itertive learning control with basis functions for media positioning in scanning inkjet printers." *accepted for the 2012 Multi-conference on Systems and Control, Dubrovnik, Croatia.*