Intermittent Sampling in Iterative Learning Control: a Monotonically-Convergent Gradient-Descent Approach with Application to Time Stamping

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1 Background: Iterative Learning Control

Iterative learning control (ILC) can significantly improve the performance in control applications by learning from past experiments. A mature framework has been developed in the past decades for disturbances that are iteration-invariant acting on LTI dynamical systems [1].

2 Problem Formulation

The standard assumption that a measurement signal is available at each sample in iterative learning control (ILC) is not always justified, e.g., in systems with data dropouts or when exploiting time-stamped data from incremental encoders [2]. When designing an ILC algorithm for this type of systems, where only intermittent data is available to the ILC algorithm, a few challenges arise:

- monotonic convergence is not defined due to varying lengths of error signals,
- computation time for an explicit ILC update explodes due to exponentially growing number of possible data points.

3 Decentralized Intermittent ILC

To address this, a new notion of monotonic convergence is defined and a decentralized ILC approach is developed where both theoretical and design aspects are fully commenced, in addition to its application on state-of-the-art applications [3]. The developed ILC framework guarantees monotonic convergence of the sequence of control input signals for all possible time-stamp sequences. Moreover, a decentralized design approach is developed that consists of designing a single diagonal matrix that should only suffice a single LMI. This approach is computationally efficient due to its independence of the number of time-stamp sequences. Moreover, this approach delicately connects to existing gradient-descent based ILC algorithms.

4 Results

When applying the decentralized ILC controller to a mass-spring-damper system from which exact time-stamped data is available the results presented in Figure 1 are obtained. It can be observed that each iteration the time instances of the available data are varying. Nonetheless, the ILC algorithm is capable of reducing the error significantly, and monotonic convergence of the input signal is guaranteed.

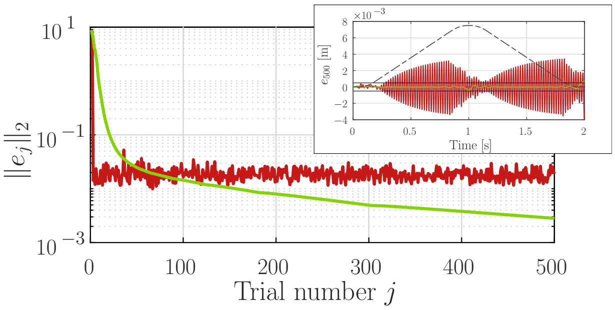

Figure 1: Error norm $\|e_j^h\|_2$ when applying traditional quantized ILC (—) and when applying the decentralized ILC controller (—). Error e_{500} at trial 500 after applying traditional quantized ILC (—) and after applying the decentralized ILC controller (—).

5 Ongoing research

Future research focuses on extending the ILC framework to a wider range of systems and applying the developed framework to experimental setups.

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References

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