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Inferential Iterative Learning Control: Internal Stability and Performance Aspects

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1 Background inferential control

In many physical systems, the variables that define the performance cannot be measured directly. This may for instance stem from constraints on sensor cost, or from physical limitations in sensor placement. The performance has to be inferred from the measured variables with models, and is therefore inherently determined by model accuracy, see [1] for inferential control in the process industry, and [2] for identification and robust inferential control of mechatronics systems.

2 Application in printing systems

An example of a system where the performance cannot be measured directly is the Medium Positioning Drive (MPD) in a wide-format printer [3], see Fig. 1. In this system, the measured variable is the motor position, and performance is defined as the paper position at the carriage. The carriage holds the printheads. The dynamics of the MPD cause differences between the measured and performance variables.

Recently, a sensor has been introduced that can measure the performance directly, but offline in a batch-to-batch fashion, see Fig. 1. This measurement is therefore not suited for traditional real-time feedback control. However, it is well-suited for batch-wise control strategies such as Iterative Learning Control (ILC) [4].

3 From traditional feedback to inferential iterative learning control structures

A conventional control structure where performance variables y are distinguisted from measured variables z is depicted in Fig. 2. The objective of feedback controller is to achieve tracking in the measured variable e^y, where the objective of the ILC is to achieve tracking in the performance variable e^z, by updating the control signal f. The ILC and feedback controller have conflicting objectives in this extended configuration, as is illustrated with the example simulation presented in Fig. 3.

The objective is to analyze this control setting in terms of stability and performance. Furthermore, existing inferential control structures are extended with ILC to provide a solution to the conflicting objectives.

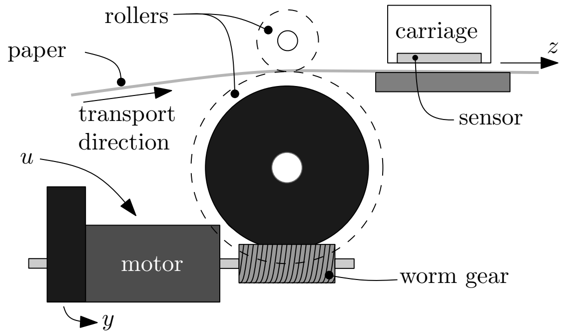

Figure 1: Side-view of the medium positioning drive: the motor is driven with voltage u, the rotor position y is measured using an optical encoder, the paper is transported by the rollers and the paper position z is measured using the sensor inside the carriage.

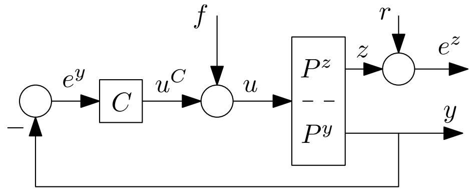

Figure 2: Control structure with feedback controller C, system $[P^z, P^y]^T$, reference r and ILC signal f, measured variables y, and performance variables z.

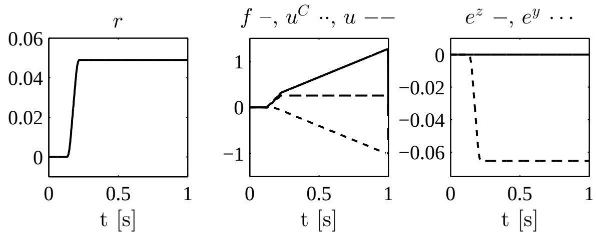

Figure 3: Simulation result: reference r (left), control signals f and u^C (center), and e^z, e^y (right). The ILC achieves $e^z = 0$ by learning the signal f. The center plot reveals the control signals f and u^C are increasing with opposite sign, illustrating the conflicting objectives of C and the ILC.

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