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Commutation-Angle Iterative Learning Control for Walking Piezo-Stepper Actuators

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1 Background

Iterative learning control (ILC) can compensate repeating disturbances in control applications by modifying a feedforward input signal based on preceding experiments [1]. During the walking motion of a piezo-stepper actuator, engagement and release between the piezo elements and the mover lead to position disturbances that are repeating in the domain in which the actuating waveforms are repeating, known as the commutation-angle or α-domain [2]. For varying velocities, the temporal domain error profile caused by these disturbances is varying. Since typical ILC approaches amplify trial-varying disturbances [3], temporal domain ILC is not suited for a piezo-stepper actuator and an α-domain approach is needed instead.

2 Problem Formulation

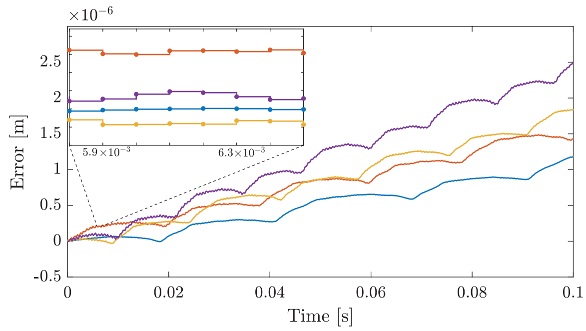
The position disturbances for a piezo-stepper actuator are repeating in the α-domain for varying drive frequencies, but the number of samples within a step and the distance between the samples is varying, as shown in Figure 1. The aim of this research is to develop an ILC framework that is applicable to systems such as a piezo-stepper actuator that involve both position domain disturbances and intermittent sampling.

3 Approach

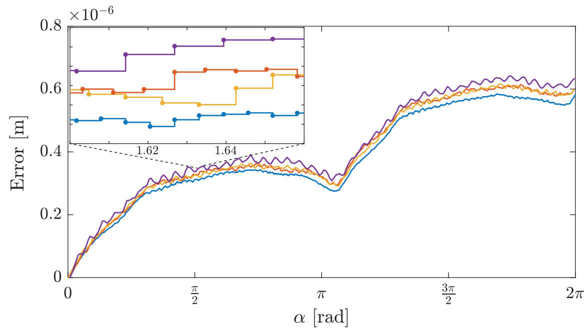
Since the sampling is iteration-varying, ILC cannot be applied directly to the sampled input and error signals. Therefore, the input and error signals are parameterized using radial basis functions [4], ch.14. An optimal ILC update law for continuous signals in the α-domain is developed to determine the input parameters for each iteration. Conditions for monotonic convergence of the sequence of parameter vectors are determined.

4 Experimental Results and Conclusions

The feasibility of the developed ILC framework is validated experimentally using a piezo-stepper actuator walking at varying drive frequencies. The α-domain repeating disturbance is compensated, leading to significant improvements in the positioning accuracy and jogging smoothness of the actuator.



(a) Disturbance as a function of time.



(b) Disturbance as a function of the commutation angle α.

Figure 1: Disturbances for a piezo-stepper for drive frequencies 20 Hz (—), 25 Hz (—), 30 Hz (—) and 40 Hz (—). In the temporal domain (a) the sampling is equidistant but the disturbance is drive-frequency dependent. In the α-domain (b) the sampling is non-equidistant for varying drive frequencies, but the disturbances are similar.

References

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