

Gaussian Process Repetitive Control for Suppressing Spatial Disturbances: With Application to a Substrate Carrier System

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1 Background

Motion systems are often subject to disturbances such as, cogging, commutation errors, gearings and imbalances, which are position-dependent disturbances, i.e., induced by an underlying cause in the spatial domain, see [1]. In the case that a rotary system operates with a constant operating velocity, or a linear system performs a repetitive motion task, these disturbances appear periodic in the time domain. However, if the operating conditions deviate, the disturbances appears a-periodic in the time domain while being periodic in the spatial domain [2].

2 Problem formulation

Classical repetitive control (RC) is not effective for disturbances that appear with varying period or a-periodic in the time domain [3]. This implies that classical RC with a memory loop in the time domain is not applicable to the aforementioned motion systems. The aim of this paper is to develop an RC approach for position-dependent disturbances.

3 Spatial Repetitive Control

The key idea is to construct a memory loop in the spatial domain. This is done by means of a Gaussian Process (GP) [4]. The time-domain signals are transformed to the spatial domain and stored in the GP, see Fig. 1. Furthermore, a suitable periodic kernel is developed to include periodicity and enforce smoothness in the GP. In addition, RC is developed using the traditional design philosophy [3].

4 Simulation case study

A simulation study is performed to show that classical RC fails if the disturbance period varies, whereas, the spatial

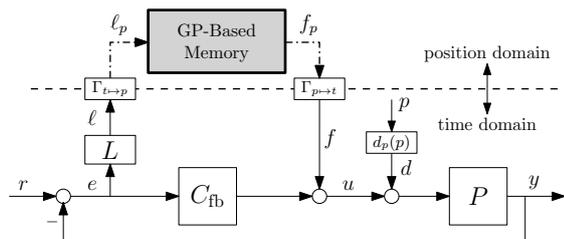


Figure 1: Spatial RC framework, with learning filter L .

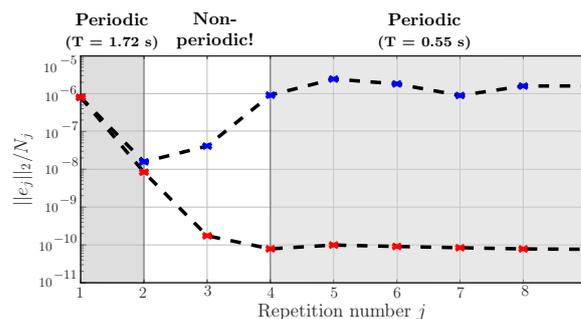


Figure 2: The 2-norm of the error with classical RC (\times) and spatial RC (\times). The disturbance is periodic at first, then non-periodic (after $j = 2$) and becomes periodic again (after $j = 4$) with a different period time.

RC approach is able to deal with these varying disturbances successfully as shown in Fig. 2.

5 Conclusions & Ongoing research

A new spatial RC approach is presented for rejection of disturbances that are periodic in a spatial domain and may appear a-periodic in the time domain. Furthermore, it deals efficiently with the non-equidistant observations through a GP-based memory loop. The potential of this methods is shown and ongoing work aims at the implementation on a substrate carrier system.

6 Acknowledgments

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