Experiment Design for System Identification using Learning/Repetitive Control that is Deliberately Near Instability

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Abstract: There is a field of optimal experiment design that aims to create a sequence of experiments that deliver maximum information for system identification based on the Fisher information matrix. This paper takes a totally different approach, using iterative learning control (ILC) or repetitive control (RC). These fields were motivated by robotics and by systems subject to periodic disturbances.

RC lacks robustness to model error, requiring phase error of the model to be less than ± 90 degrees. As a general rule, there are always extra dynamics at high frequencies from unmodeled parasitic poles or unmodeled modes, which produce such phase errors, and hence instability in application. In this paper the objective is to create data from experiments that enhances ones ability to do system identification. The sensitivity of the iterations to model error becomes an advantage, something to exploit for improving the identified model. The particularly important property is that the part of the output error history that is related to correctly modeled dynamics decays to zero with the experimental iterations, while the part of the dynamics that has substantial phase error in the model is amplified, growing toward infinity as the iterations progress. The iterations then become a filtering process that first isolates the poorly modeled part of the system dynamic behavior, and then amplifies the signal as much as needed for good identification.

A previous work made an initial investigation of the potential of ILC and RC for improved system identification. It is the purpose of this paper to exploit methods of tuning the RC or ILC design so that it lies close to the stability boundary for the current system model. This maximizes the ability of a model error to destabilize the process and produce experimental data that targets the poorly modeled part of the system dynamics. The aim is to not only be able to pick up residual modes or parasitic poles, but also to make the iterations sensitive to parameter errors. To do this, some developments are necessary in appending end points to the problem.

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