Issues in Applying Iterative Learning Control in Nonlinear Systems

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Abstract: Iterative learning control (ILC) is a relatively new type of control that performs iterations on the real world hardware aiming to optimize an objective function, doing this in a manner similar to what one would think of doing in numerical optimization with a computer model. The advantage is that when successful the objective is optimized based on how the real world behaves instead of optimized based on how a mathematical model of the world behaves. The disadvantage is that hardware iterations must respect hardware limitations, and preferably make well behaved changes from iteration to iteration. And in hardware one will not want to make a very large number of such iteration, while a computer may be happy to perform a large number. A substantial (ILC) literature develops algorithms for such iterations for linear systems. These methods have addressed several unexpected pitfalls, such as a basic internal instability in the control action needed for zero tracking error in most digital control systems. And they attempt to address the underlying modeling conflict, that one needs a mathematical model to guide the iterations, but one wants zero error in the world, not zero error in your model of the world. Several publications by the authors have investigated the use of linear ILC to address nonlinear systems. Methods were developed to obtain the linear time varying control updates appropriate for learning in the neighborhood of the desired output trajectory. And methods were presented to handle realistic actuator constraints in a feedback control loop. It is the purpose of this paper to further investigate the behavior of these ILC methods in a set of important possible situations. One such situation occurs when one aims to apply time optimal control in hardware, and ILC is used to make a feedback controller perform the computed trajectory. Such trajectories often ride the actuator limit boundary. Deviations between the model and the real world behavior can make the stated desired trajectory nonfeasible. This paper develops an understanding of the behavior in such situations and develop methods of dealing with such model error issues.

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