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Iterative Learning Control for a Class of Linear Continuous-time Switched Systems with Fixed Initial Shifts

Xu Guang-zhao, Fu Qin*, Du Li-li,
Wu Jian-rong and Yu Peng-fei
(*School of Mathematics and Physics, Suzhou University of Science and Technology, Suzhou, Jiangsu, 215009*)

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Abstract: This paper deals with the problem of iterative learning control for a class of linear continuous-time switched systems in the presence of a fixed initial shift. Here, the considered switched systems are operated during a finite time interval repetitively. According to the characteristics of the systems, a PD-type learning scheme is proposed for such switched systems with arbitrary switching rules, and the corresponding output limiting trajectories under the action of the PD-type learning scheme are given. Based on the contraction mapping method, it is shown that this scheme can guarantee the outputs of the systems converge uniformly to the output limiting trajectories of the systems over the whole time interval. Furthermore, the initial rectifying strategies are applied to the systems for eliminating the effect of the fixed initial shift. When the learning scheme is applied to the systems, the outputs of the systems can converge to the desired reference trajectories over a pre-specified interval. Finally, simulation examples illustrate the effectiveness of the proposed method.

Key words: iterative learning control, switched system, PD-type learning scheme, fixed initial shift, output limiting trajectory
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* **Corresponding author**.
E-mail address: 2825418339@qq.com (Xu G Z), fuqin925@sina.com (Fu Q).

1 Introduction

Since the complete algorithm of iterative learning control (ILC) was first proposed by Arimoto and Kawamura[1], it has become a hot issues of cybernetics (see [2]–[7]). The basic idea of ILC is to improve the control signal for the present operation cycle by feeding back the control error in the previous cycle. The classical formulation of ILC design problem is to find an update mechanism for the output trajectory of a new cycle based on the information from previous cycles so that the output trajectory converges asymptotically to the desired reference trajectory. Owing to its simplicity and effectiveness, ILC was found to be a good alternative in many areas and applications (e.g., see [8] for detailed results).

In the process of ILC design, an interesting question is how to set the initial value of the iterative system properly at each iteration, such that the output trajectory of the iterative system can converge to the desired reference trajectory. In the previous works, a common assumption about this question is that the initial value at each iteration should be equal to the initial value of the desired reference trajectory (see [1]–[4]), or within its neighborhood (see [5]–[7]). In the case of perturbed initial conditions, boundedness of the tracking error is established and the error bound is shown to be proportional to the bound on initial condition errors (see [5]–[7]). Recently, the initial rectifying strategies are introduced in learning algorithm (see [11]–[13]). For a class of partially irregular multivariable plants, Porter and Mohamed[9] utilized initial impulse rectifying to eliminate the effect of the fixed shift, so that a complete reference trajectory tracking over the whole time interval was achieved. In the case of fixed initial shift, the output limiting trajectory for the first time under the actions of D-type and PD-type learning schemes was obtained in [10], the convergence performance under the action of a PID-type learning scheme was further considered in [11], and the convergence result was extended to nonlinear systems. Sun and Wang[12] addressed the initial shift problem of ILC for affine nonlinear systems with arbitrary relative degrees, and the uniform convergence of the output trajectory to a desired one jointed smoothly with a specified transient trajectory from the starting position was ensured in the presence of a fixed initial shift. Sun *et al.*[13] proposed a feedback-aided PD-type learning algorithm to solve the initial shift problem for linear time-invariant systems in the presence of a fixed initial shift.

Switched systems, each of which consists of a number of subsystems and a switching law, have attracted much attention in the field of control theory (see [14]). Recently, the ILC problem for linear continuous-time switched systems was put forward in [15], under the assumption condition that the initial value at each iteration is equal to the initial value of the desired reference trajectory, the convergence conclusions were obtained based on the D-type learning algorithms. The results obtained in [15] were further extended to nonlinear continuous-time switched systems in [16].

Stimulated by the works of [15], in this paper, we study the problem of iterative learning control algorithms for linear continuous-time switched systems in the presence of a fixed initial shift. A PD-type learning algorithm is put forward and the initial rectifying strategies