Integral Concurrent Learning-Based Accelerated Gradient Adaptive Control of Uncertain Euler-Lagrange Systems

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Abstract: Recent results in the adaptive control literature have made connections to methods in optimization and have led to new adaptive update laws based on accelerated gradient methods. Accelerated gradient methods such as Nesterov's accelerated gradient in numerical optimization have been shown to yield faster convergence than standard gradient methods. However, these results either assume available measurements of the regression error or do not guarantee convergence of the parameter estimation error unless the restrictive persistence of excitation condition is satisfied. In this paper, a new integral concurrent learning (ICL)-based accelerated gradient adaptive update law is developed to achieve trajectory tracking and real-time parameter identification for general uncertain Euler-Lagrange systems. The accelerated gradient adaptation is a higher-order scheme composed of two coupled adaptation laws. A Lyapunov-based method is used to guarantee the closed-loop error system yields global exponential stability under a less restrictive finite excitation condition. A comparative simulation study is performed on a two-link robot manipulator to demonstrate the efficacy of the developed method. Results show the higher-order scheme outperforms standard and ICL-based adaption by 19.6% and 11.1%, respectively, in terms of the root mean squared parameter estimation errors.