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FILTERED REPETITIVE CONTROL OF ROBOT MANIPULATORS

Quan Quan and Kai-Yuan Cai

National Key Laboratory of Science and Technology on Integrated Control
Department of Automatic Control
Beijing University of Aeronautics and Astronautics
No. 37, Xueyuan Road, Haidian District, Beijing 100191, P. R. China
qq_buaa@asee.buaa.edu.cn; kycai@buaa.edu.cn

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Abstract. *In this paper, a filtered repetitive controller (FRC) is proposed for robot manipulator tracking. Error dynamics are obtained first, leaving an unknown periodic signal to be compensated. A new model to describe the periodic signal is proposed then. By this model, an FRC is designed to compensate for the unknown periodic signal. The resulting closed-loop error dynamics are analyzed with the help of a Lyapunov-Krasovskii functional. In order to compare stability of the closed-loop error dynamics with the FRC and corresponding repetitive controller, the convergence rate is proposed to measure their stability. It is shown that the resulting closed-loop error dynamics with the FRC is more stable. In comparison with existing repetitive controllers, the proposed controller provides the flexibility to choose parameters to achieve a tradeoff between tracking performance and stability. Numerical simulations demonstrate the effectiveness of the proposed controller.*
Keywords: Repetitive control (RC), Robot manipulator, Disturbance

1. **Introduction.** Repetitive control (RC) is an internal-model-based control approach in which the infinite-dimensional internal model $\frac{1}{1-e^{-sT}}$ gives rise to an infinite number of poles on the imaginary axis. It was proved in [1] that, for a class of general linear plants, exponential stability of RC systems could be achieved only when the plant is proper but not strictly proper. Moreover, the internal model $\frac{1}{1-e^{-sT}}$ may destabilize the system. To enhance stability, a suitable filter is introduced as shown in Figure 1, forming a *filtered repetitive controller*[1] (FRC or *filtered repetitive control*, also designated FRC) in which the loop gain is reduced at high frequencies. Stability results only at some sacrifice of high frequency performance. With appropriate design, however, an FRC can often achieve an acceptable tradeoff between tracking performance and stability, a tradeoff which broadens the application of RC in practice [1-7].

Over the years, RC of robot manipulators has received considerable attention [8-12]. The works of these literatures require the disturbances to be periodic. It is well known that, besides a periodic disturbance, robot manipulator tracking is often subject to a persistent nonperiodic disturbance as well. However, to the best knowledge of the authors, few works have investigated such a case. Theoretically speaking, a persistent nonperiodic disturbance may lead to RC systems instability, because non-exponential stability of RC systems implies that input-to-state stability may not be satisfied. Inspired by the fact that an FRC system is more stable than the corresponding RC system, we attempt to apply an FRC to robot manipulator tracking in the presence of both types of disturbance.

[1]In this paper, we have replaced the term "modified" in [1] with the more descriptive term "filtered".