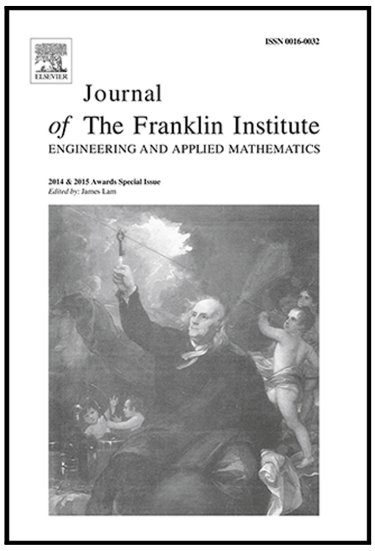

A generalized double integral inequalities approach to stability analysis for time-delay systems

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A generalized double integral inequalities approach to stability analysis for time-delay systems

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Abstract- In this paper, the stability analysis for time-delay systems is investigated. Firstly, further improved double integral inequalities in the forms of infinite series are developed for estimation of the derivatives of triple integral terms. Comparing with the recently introduced Wirtinger-based, refined Jensen and auxiliary function -based double integral inequalities, the estimation gaps of the proposed ones are ever-shrinking with increase of the intermediate terms without requiring any free-weighting matrix. Then, by constructing a triple integral type of Lyapunov-Krasovskii functional (LKF), some stability conditions for time-delay systems are established. By virtue of the new inequalities, the derived criteria are less conservative and more computationally attractive than some existing works. Finally, the improvement and effectiveness of the proposed approaches are demonstrated via the numerical examples.

Keywords: Time-delay systems, Stability, Improved double integral inequalities.

1. Introduction

The phenomena of time delays are inevitably encountered in a great diversity of practical systems [1-4], and often yield the performance degradation or instability of systems [5, 6]. Due to the importance and widespread occurrence of time delays, the stability analysis for time-delay systems has emerged as one of topics of significant interest in both theory and practice [7-12].

With regard to stability for time-delay systems, the Lyapunov-Krasovskii functional (LKF) is one of the most popular and effective tools due to its easy extension and convenient tractability. However, since only sufficient results can be obtained, the derived criteria inevitably induce a certain degree of conservatism, which is usually measured by maximum allowable delay bound (MADB). Therefore, one of the major concerns is to enhance the feasible delay region preserving the asymptotical stability of the systems [11, 12]. Based on the Lyapunov theory, the achievement of the desirable stability region has been usually pursued along two main directions: constructing suitable LKF and estimating its derivative more accurately [13]. As reported in [14], compared with the construction of LKF, the technique used to bound the integral terms arising from the derivative of LKF is recognized as a more effective and direct way to improve the criteria. In this trend, the Jensen inequality has been used widely thanks to its convenient tractability and small amount of calculation. However, it is likely to entail some inherent conservatism [15]. The last few years have seen a tremendous development in the reduction of estimation gap of the Jensen one.

In [16], a more general integral inequality is proposed to deal with the problem of robust H_∞ filtering for uncertain systems with time delay, which avoids both model transformation and bounding technique for cross terms. Recently, the Wirtinger-based inequality is developed in [15] to achieve potential gain with respect to the Jensen inequality. New approach for bounding quadratic term weighted by a time-varying function in the form of