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A new double integral inequality and application to stability test for time-delay systems*

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Abstract: This paper is concerned with stability analysis for linear systems with time delays. Firstly, a new double integral inequality is proposed. Then, it is used to derive a new delay-dependent stability criterion in terms of linear matrix inequalities (LMIs). Two numerical examples are given to demonstrate the effectiveness and merits of the present result.

Keywords: time-delay system, integral inequality, stability analysis, Lyapunov-Krasovskii functional

1 Introduction

Consider the following system with state and distributed delays:

$$\begin{aligned}\dot{x}(t) &= Ax(t) + A_d x(t-h) + A_D \int_{t-h}^t x(s) ds, \\ x(t) &= \phi(t), \quad t \in [-h, 0]\end{aligned}\tag{1}$$

where $x(t) \in \mathbb{R}^n$ is the state vector, $A, A_d, A_D \in \mathbb{R}^{n \times n}$ are constant matrices, h is a constant time delay satisfying $h > 0$, and $\phi(t)$ is a continuous vector-valued initial function.

The stability of system (1) keeps attracting researchers for many years. In order to reduce conservatism of stability criteria, a number of techniques are presented, including for instance, the free-weighting matrix method [1–4], reciprocally convex approach [5, 6] and various integral inequality methods [7–15]. The well-known Jensen's inequality is commonly adopted as it could lead to a stability test with fewer matrix variables. Recently, a so-called Wirtinger-based integral inequality developed in [8] is shown more powerful than Jensen's inequality. Later, some other types of integral inequalities have been reported in [3, 4, 10–14] to further reduce the conservatism of the stability test.

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