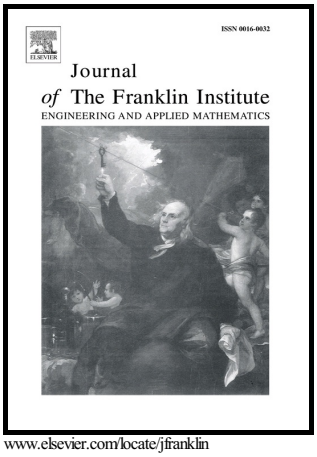

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Multiple-integral Inequalities to Stability Analysis of Linear Time-delay Systems☆

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Abstract

This paper is concerned with the stability analysis of linear systems with constant delay. First, with the help of Schmidt orthogonalization, we define a new set of orthogonal polynomials. By using the orthogonal polynomial set, we propose a novel multiple-integral inequality, which can achieve less conservatism than many existing inequalities, such as the Jensen's single-integral inequality, the Jensen's double-integral inequality, the Wirtinger-based single-integral inequality and the auxiliary function-based double-integral inequality. Then, based on the proposed inequality, we derive a stability criterion for the system under consideration, which is less conservative than the existing ones. Finally, we provide a numerical example to illustrate the effectiveness of the derived criterion.

Keywords: Linear time-delay system; Multiple-integral inequality; Stability; Orthogonal polynomial; Schmidt orthogonalization.

1. Introduction

Time delay arises in a variety of dynamic systems, such as the systems of infectious diseases and epidemics [1], population dynamics [2], neural networks [3, 4], and biological and chemical kinetics [5]. It is generally regarded as a main cause of instability and poor performance [4, 6–8]. Therefore, the stability analysis of time-delay systems is very important and has received considerable attention [9–18]. In the field of stability analysis, Lyapunov functional method is one of the most popular methods [10, 15, 19–24]. Let us consider a linear time-delay system of the form:

$$\dot{x}(t) = Ax(t) + A_h x(t-h),\ t \geq 0, \tag{1.1a}$$

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