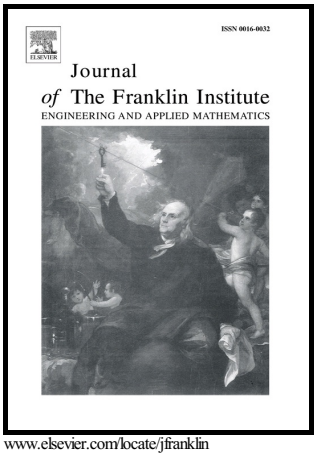

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Exponential Stability Analysis of Integral Delay Systems with Multiple Exponential Kernels*

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Abstract

This paper studies stability analysis of a class of integral delay systems (IDSs) with multiple exponential kernels. Some coupled linear matrix inequalities based sufficient stability conditions are firstly obtained with the help of the Lyapunov-Krasovskii functional approach. The obtained results include several existing ones as special cases if the corresponding IDSs are simplified. Characteristic equations based necessary and sufficient conditions are then established for a special class of IDSs. Three numerical examples show the effectiveness of the proposed approaches.

keywords: Integral delay systems; Stability analysis; Characteristic equation; Multiple exponential kernels

1 Introduction

Analysis and design of time-delay systems have been hot research topics for several decades since this class of systems have very wide applications in engineering practice such as networked systems and chemical process control (see, for example, [2, 3, 13, 21, 29]). The difficulty in the study of time-delay systems is due to the fact that time-delay systems are inherently infinite dimensional systems. For this reason, it is in general very hard to derive necessary and sufficient conditions in the analysis and design. Hence, in most cases, only sufficient conditions can be established based on some indirect methodologies such as the Lyapunov stability theory. For example, by the Lyapunov stability theory with appropriate Lyapunov-Krasovskii functionals, sufficient conditions are derived in [24] for guaranteeing stochastic synchronization of Markovian jump neural networks with time-varying delays and in [25] for guaranteeing the passivity of discrete-time stochastic Markovian jump neural networks with mixed time-delays. In recent years, some advanced techniques have been built to derive less conservative results in terms of linear matrix inequalities to the analysis and design of time-delay systems. See [4, 8, 9, 14, 15, 23, 26] and the references therein for further progress on the topic.

For the control of time-delay systems with input and output delays, a very particular approach referred to as predictor feedback has been recognized to be very effective (see [1, 10, 11, 19, 27, 28] and the references therein). The idea of this approach is to use the future state, which can be predicted from the current state and the past control signals, to compensate the input delay completely. The cost is that the resulting controllers involve integrals of the past control signals over the delay range and may suffice some implementation problems [22]. To avoid this problem, a truncated predictor feedback (TPF) has been established in [28] for linear systems with a large input delay.

In this paper, we are going to study a class of integral delay systems (IDSs) that are related to the predictor feedback control of linear systems with multiple input delays. To make the problem clear, let us consider a

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