Stability and Stabilization Criteria
for a Class of Uncertain Neutral Systems
with Time-Varying Delays

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Communicated by C. T. Leondes

Abstract. In this paper, the robust asymptotic stability and stabilization for a class of uncertain neutral systems with time-varying delays are considered. Based on the Lyapunov-Krasovskii functional theory, some stability and stabilization criteria are derived. Delay-dependent and delay-independent criteria are proposed for the stability and stabilization of the considered systems. State and output feedbacks are considered to stabilize the uncertain neutral systems. A linear matrix inequality approach and a genetic algorithm are used to solve the stability and stabilization problems. Finally, some numerical examples are shown to illustrate the use of the obtained results.

Key Words. Asymptotic stability, stabilization, uncertain time-delay systems, linear matrix inequalities, genetic algorithms.

1. Introduction

Time-delay phenomena appear often in many physical systems (Refs. 1–3). Hence, the stability and stabilization problems for time-delay systems have received considerable attention and have been one of the most interesting topics in control theory (Refs. 1, 4–17). This is due to theoretical interests as well as to powerful tools for practical system analysis and design. Since delay phenomena are encountered often in various mechanics, physics, biology, medicine, economy, and engineering systems, such as

1. The research reported here was supported by the National Science Council of Taiwan under Grant NSC 91-2213-E-214-016.

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AIDS epidemics, aircraft stabilization, chemical engineering systems, control of epidemics, distributed networks, inferred grinding model, manual control, microwave oscillators, models of lasers, neural networks, nuclear reactors, population dynamic models, rolling mills, ship stabilization, and systems with lossless transmission lines. Moreover, frequently a time delay is a source of instability and a cause of generation of oscillation in many systems (Ref. 3).

In practical systems, the analysis of a mathematical model is usually an important step for a control engineer as to the control a system. However, the mathematical model contains always some uncertain elements; these uncertainties may be due to additive unknown internal or external noise, environmental influence, nonlinearities such as hysteresis or friction, poor plant knowledge, reduced-order models, uncertain or slowly-varying parameters. Therefore, under such imperfect knowledge of the mathematical model, seeking to design a robust control such that the system responses can meet some desired properties is an important topic in system theory. Hence, robust stability analysis and stabilization for uncertain time-delay systems have been the focus of much research in recent years (Refs. 6–9, 12, 15–16).

Depending on whether the stability or stabilization criterion itself contains the size of the delays, stability and stabilization criteria of time-delay systems can be classified into two categories, namely delay-independent criteria (Refs. 4, 7, 9, 11–12, 16) and delay-dependent criteria (Refs. 4–6, 10–14, 15, 17–18). Generally speaking, the latter ones are less conservative than the former ones, but the former ones are also useful when the effect of time delay is small. The Lyapunov-based stability theories for systems with time-varying delays are classified into two approaches; the Razumikhin functional theory is used without the assumption \( \dot{h} < 1 \), but the results obtained will be conservative in many cases (Ref. 5). The second approach is based on the Lyapunov-Krasovskii functional theory and many relevant transformations are developed and considered (Refs. 5, 12). To the best of the author's knowledge, there are few results which consider uncertain neutral systems with time-varying delays. Over the past research on time-delay systems, many useful approaches are applied to guarantee the stability or stabilization of systems. The sliding mode control (SMC) is applied in Refs. 15 and 17 to stabilize the time-delay systems. Based on the Razumikhin lemma, a novel nonlinear feedback control is proposed in Ref. 7. The LMI approach is a useful tool to solve many control problems such as the \( H_\infty \) control problem (Refs. 5 and 8), sliding mode control (Ref. 15), stability analysis (Refs. 4, 6, 10, 11, 14, 18), stabilization problem (Refs. 8–10), guaranteed cost problem (Ref. 16), and observer design (Refs. 9 and 19).