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# Piecewise Interpolation Lyapunov Functional Approach to Stability of Uncertain Neutral Systems with Time-delays

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**Abstract:** This paper investigates the robust stability of uncertain linear neutral systems with time-varying discrete delay. A delay-dependent stability criterion is obtained and formulated in the form of a linear matrix inequality. Two numerical examples are given to indicate signi l cant improvements over some existing results.

**KeyWords:** Stability, Time Delay, Neutral Type, Uncertainty, Linear Matrix Inequality (LMI)

## I. INTRODUCTION

As it is well know that, the occurrence of time delays may cause poor performance or instability, which encountered in various engineering systems. Therefore, the stability analysis for time-delay systems has important great significant both in theory and in practice.

During the past several years, delay-dependent stability of linear neutral systems has attracted considerable attention. Current efforts on this topic can be classified into two categories, i.e., delay-depend and delay-independent. In general, delay-dependent stability criteria, which include information on the size of delays, are less conservative than delay-independent ones.

Various different techniques and approaches have been proposed to derive the delay-dependent stability criteria for a number of different neutral systems, such as the frequency method, the algebraic method and the Lyapunov-Krasovskii method. But the Lyapunov method is frequently used and the resulting criteria are often expressed in form of linear matrix inequalities (LMIs). In order to reduce the conservatism, a descriptor form approach had been proposed by Ref [1]. Park and Kwon [2] investigated delay-dependent stability criteria for the systems of neutral-type by utilizing the parameterized model transformation. In [3] solved the stability and stabilization problem for uncertain neutral systems by using a genetic algorithm. Recently, methods introducing free weighting matrices were used to give large delay bounds. Han[4] applied the idea of the discretized Lyapunov approach. In [5], an augmented Lyapunov function was proposed to treat the cross terms of variables. Parlakci [6] developed a new class of augmented Lyapunov functional and model transformation and bounding of the cross terms are avoided.

In this paper, the piecewise interpolation Lyapunov functional approach is developed to study the constant time-delay neutral system with time-varying constructed uncertainties. Based on the idea of the discretized Lyapunov approach proposed by Han [4], by constructing a suitable piecewise linear interpolation Lyapunov functional, taking the relationship between the terms in the Leibniz-Newton formula into account, utilizing free-weighting matrices in zero equations, a delay-dependent criterion is derived in terms of LMIs. Two numerical examples are included to show the effectiveness of the proposed method.

Notation. Below $R^n$ denotes the $n$-dimensional real space; $R^{n\times n}$ denotes the $n\times n$- dimensional real matrices; $A^T$ denotes the transpose of the matrix $A$; $\|A\|$ denotes the Euclidean norm of the matrix $A$; $P>0$ is a positive-definite symmetric matrix; $I$ denotes the identity matrix with appropriate dimensions; $*$ denotes the symmetric part n matrix.

## II. PROBLEM STATEMENT

Consider the following uncertain neutral system

$$\Theta:\begin{cases}\dot{x}(t)-C\dot{x}(t-h)=(A+\Delta A(t))x(t)+(B+\Delta B(t))x(t-h), t>0\\ x(t)=\varphi(t), t\in[-h,0]\end{cases} \quad (1)$$

Where $x(t)\in R^n$ is the state vector, $A,B,C\in R^{n\times n}$ are constant matrices, $h>0$ is a constant neutral delay, the initial condition $\phi(t)$ is a continuous differentiable function on $[-h,0]$. The time-varying structured uncertainties $\Delta A(t)$ and $\Delta B(t)$ are of the form:

$$[\Delta A(t),\Delta B(t)]=DF(t)[E_1,E_2], \quad (2)$$

Where $D, E_1$ and $E_2$ are appropriate dimensional constant matrices, $F(t)$ is an unknown time-varying real matrix with Lebesgue measurable elements satisfying:

$$F(t)^T F(t)\le I, \forall t\ge 0. \quad (3)$$

In this paper, we will attempt to formulate some practically computable criteria for robust stability of the uncertain

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