NEW STABILITY CRITERIA FOR DISCRETE-TIME SYSTEMS WITH INTERVAL TIME-VARYING DELAY AND POLYTOPIC UNCERTAINTY

W. ZHANG†, Q.Y. XIE†, X.S. CAI‡, and Z.Z. HAN†

†*School of electronic information and electrical engineering, Shanghai Jiao Tong University*
200240, Shanghai, China
wizzhang@gmail.com, qyxie@sjtu.org, zzhan@sjtu.edu.cn
‡*College of Mathematics, Physics, and Information Engineering, Zhejiang Normal University*
321004, Jinhua, Zhejiang, China
xiushan@zjnu.cn

***Abstract*— This paper is considered with the robust stability problem for linear discrete-time systems with polytopic uncertainty and an interval time-varying delay in the state. On the basis of a novel Lyapunov-Krasovskii functional, new delay-range-dependent stability criteria are established by employing the free-weighting matrix approach and a Jensen-type sum inequality. It is shown that the newly proposed criteria can provide less conservative results than some existing ones. Numerical examples are given to illustrate the effectiveness of the proposed approach.**

***Keywords*— Delay-range-dependent stability; Lyapunov-Krasovskii functional; Discrete-time systems; Time-varying delay; Linear matrix inequality (LMI)**

I. INTRODUCTION

Time-delays are frequently encountered in many fields of engineering systems such as long transmission lines in pneumatic systems, nuclear reactors, rolling mills, communication networks and manufacturing processes (Gu *et al.*, 2003; Hale and Lunel, 1993; Su and Zhang, 2009). In general, the existence of delays in system models may induce instability or poor performance of the closed-loop schemes. Therefore, the stability problem of time-delay systems has attracted much attention during the past decades. Numbers of stability criteria have been established for various types time-delay systems. These criteria can be classified into two types: delay-dependent and delay-independent stability conditions; the former includes the information on the size of the delay, while the latter does not (Xu and Lam, 2008). Usually, delay-dependent stability conditions are less conservative than the delay-independent ones especially in the case when the delay is small. Therefore, in recent years many researchers have devoted to investigating delay-dependent stability of time-delay systems (see e.g., Gu *et al.*, 2003; Xu and Lam, 2008; and the references therein).

Surveying in the literature, various approaches have been proposed to derive the delay-dependent stability conditions (Xu and Lam, 2008). For instance, the discretized Lyapunov-Krasovskii functional approach (Gu *et al.*, 2003) and the descriptor system approach (Fridman and Shaked, 2002) together with the bounding techniques (Park, 1999 and Moon *et al.*, 2001). Recently, the free-weighting matrix method (He *et al.* 2004a, 2004b) has been extensively used in deriving the delay-dependent criteria, which is very helpful to reduce the conservatism in existing stability criteria (He *et al.*, 2007; Peng and Tian, 2008; Li *et al.*, 2008). In Jiang and Han (2008), new stability criteria for uncertain systems with interval time-varying delay are proposed by introducing new Lyapunov-Krasovskii functional and employing an integral inequality (Han, 2005). However, it is worth mentioning that most of the delay-dependent stability results in the existing literature are concerned with norm-bounded uncertain continuous-time systems, while little attention has been paid to discrete-time case with polytopic uncertainty (Liu *et al.*, 2006).

Recently, the delay-dependent stability problem for discrete-time systems with interval time-varying delay has been studied in Gao *et al.* (2004), Fridman and Shaked (2005), Jiang *et al.* (2005), and Gao and Chen (2007). Some delay-dependent stability criteria are established by employing the free-weighting matrix approach (Gao and Chen, 2007) or the descriptor system approach (Fridman and Shanked, 2005). Very recently, Zhang *et al.* (2008) presented an improved stability criterion by considering the useful terms ignored in the Lyapunov-Krasovskii functional of the previous literature. However, there is still room for further investigation. For example, in Zhang *et al.* (2008), the term A^TPA^T is involved in the stability criterion. Therefore, it is not easy to extend the proposed criterion to polytopic-type systems. Moreover,