Global Exponential Stability of Takagi-Sugeno Fuzzy Cohen-Grossberg Neural Network With Time-Varying Delays

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***Abstract*—In this letter, global exponential stability of Takagi-Sugeno fuzzy Cohen-Grossberg Neural Network (CGNN) with time-varying delay factor has been investigated based on the criteria of non-singular M-matrix and the Lyapunov stability technique. The stability inequality is derived with the help of Lipschitz condition for the nonlinear activation functions and a sufficient condition is shown to verify the criterion of the exponential stability condition for the CGNN with time-varying delay terms, which is described in the presence of delay terms of T-S Fuzzy model. Thus, the global exponential stability for T-S fuzzy CGNN in the presence of time-varying delay terms is derived in an easy way. This letter contains quite a new result for delayed CGNN for the T-S Fuzzy model. Finally, a numerical example is taken to validate the efficiency and unwavering quality, and to exhibit the superiority of the considered method as compared to the existing method for particular cases.**

***Index Terms*—Cohen-Grossberg neural network, Takagi-Sugeno fuzzy model, exponential stability, Lyapunov stability analysis, time-varying delay.**

I. Introduction

THE CONTROL of dynamical system, especially in engineering processes, is dealt with by control theory. The objective is to propose or develop a method or model to drive the system to a desired state by designing the controllers to ensure stability through minimizing delays, overshoots and error states [1]–[5]. In last few decades, there is a lot of progress in the theory and practice of control using neural networks which provides a reason to believe that artificial neural network-based control systems will develop further in near future to support complex control problems [6]. During the last few years, CGNNs have attracted a lot of interest among the researchers, scientists and engineers. Cohen and Grossberg [7] initiated the investigation of a neural network system and this resulted in the name CGNN. From the application point of view, CGNNs play a useful role in neural processing system with application to significant practical problems in engineering, for example, image processing, parallel computing, pattern recognition, optimization and control. If the designed neural network is applied to solve certain kinds of engineering issues in the field of optimization, control systems and image processing, then these types of neural networks require a unique equilibrium point to which the neural network systems asymptotically converges. In various applications, stability and convergence are prerequisites for every neural network system. The study of the dynamical neural networks must be executed because of its physical significance and relevance. Therefore, it is essential to include the time delays in the equations of a neural network system. The stability of the neural networks by including time delay terms must be established. Using time delays, analog electronic circuits in practical applications of CGNNs will be imperative, and this also appear in the signal transmission surrounded by neurons [8]. Due to the promising potential of the engineering applications, CGNNs have received great attention [9]. Stability analysis of the neural network models by including delay terms is the extended form of stability analysis of neural network models with fluctuations.

In the literature, it is seen that many scientists and researchers have found the innovative properties of global asymptotic stability of the equilibrium point of the CGNNs with time delay terms. In the year 2017, Arslan *et al.* [10] have used Markovian jumping parameters for the finite-time stability of the stochastic CGNNs in the presence of distributed time-varying delays. Using Hardy-Poincare inequality, Li *et al.* [11] have discussed passivity analysis for the delayed reaction-diffusion CGNNs. In 2015, Du and Xu [12] have introduced multi-stability and multi-periodicity for a class of CGBAMNNs with time delays by using discontinuous activation functions. Using the effect of Markovian jump impulsive, Zhu and Cao [13] have considered robust exponential stability of the stochastic CGNNs in the presence of mixed time delays. Xie and Zhu [14] have introduced the mean square

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