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Generalized dynamical fuzzy model for identification and prediction

Lyes Saad Saoud*, Fayçal Rahmoune, Victor Tourtchine and Kamel Baddari
Faculty of Sciences, Department of Physics, University M'hamed Bougara, Laboratory of Computer Science, Modeling, Optimization and Electronic Systems (L.I.M.O.S.E), Boumerdes, Algeria

Abstract. In this paper, the development of an improved Takagi Sugeno (TS) fuzzy model for identification and chaotic time series prediction of nonlinear dynamical systems is proposed. This model combines the advantages of fuzzy systems and Infinite Impulse Response (IIR) filters, which are autoregressive moving average models, to create internal dynamics with just the control input. The structure of Fuzzy Infinite Impulse Response (FIIR) is presented, and its learning algorithm is described. In the proposed model, the Butterworth analogue prototype filters are estimated using the obtained membership functions. Based on the founding orders of the analogue filters, the IIR filters could be constructed. The IIR filters are introduced to each TS fuzzy rule which produces local dynamics. Gustafson–Kessel (GK) clustering algorithm is used to generate the clusters which will be used to find the number of the IIR parameters for each rule. The hybrid genetic algorithm and simplex method are used to identify the consequence parameters. The stability of the obtained model is studied. To demonstrate the performance of this modeling method, three examples have been chosen. Comparative results between the FIIR model on one hand, and the traditional TS fuzzy model, the neural networks and the neuro-fuzzy network on the other hand. The results show that the proposed method provides promising identification results.

Keywords: TS fuzzy models, IIR filters, identification, prediction, photovoltaic module

1. Introduction

Takagi Sugeno Kang fuzzy modeling is a useful technique for the description of nonlinear systems [1] where nonlinear process behavior is approximated by multiple linear models with fuzzy transitions [2]. This technique has proved its abilities for modeling and prediction of static or dynamic systems, filtering signals [3, 4] and control based model [5–9]. Gao et al. [5] have shown that TS fuzzy dynamic models are universal approximators to general nonlinear systems. The universal fuzzy control problem based on generalized TS fuzzy models has been investigated for deterministic nonaffine nonlinear systems [6] and extended for the stochastic ones in [7]. In [8], Huang has developed fuzzy control with affine delayed models. A dynamic output feedback control problem has been investigated for discrete time TS fuzzy systems with time varying delays in the state [9]. The problem of H_∞ model reduction is studied in [10] for continuous time TS fuzzy stochastic systems by using convex linearization and projection approaches. The problem of H_∞ filtering is investigated for discrete time TS fuzzy time varying delay systems by using the input-output method [11]. In TS fuzzy models the consequence function could be represented mathematically, which helps connectionists to improve the TS fuzzy models. For example, TS fuzzy model could be affine, homogeneous or singleton model [2]. Cao et al. [12], extended TS fuzzy model with local linear model to TS fuzzy model with local dynamic models. In general, TS fuzzy models need several external

*Corresponding author. Lyes Saad Saoud, Faculty of Sciences, Department of Physics, University M'hamed Bougara, Laboratory of Computer Science, Modeling, Optimization and Electronic Systems (L.I.M.O.S.E), Boumerdes 35000, Algeria. E-mail: saadsaoudl@umbb.dz.