Design of Stable Controllers for Takagi-Sugeno Systems with Concentric Characteristic Regions

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Abstract: The design of a fuzzy Takagi-Sugeno system with concentric regions and the use of discontinuous piecewise Lyapunov functions allows to relax stability conditions which can be expressed very easily as a set of Linear Matrix Inequalities. An adaptive algorithm allows to determine gradually the embedded sets and the corresponding local models.

Keywords: Fuzzy control; linear matrix inequalities; Lyapunov functions; spherical coordinates.

Mathematics Subject Classification (2000): 93D05, 93D15.

1 Introduction

The Takagi-Sugeno (TS) fuzzy model allows to represent a wide class of non-linear systems by a set of fuzzy rules for which the consequent parts are linear state models [10]. Using aggregation of rules, which induce a polyhedral partition of the state-space, a weighted sum of the linear state models is able to describe accurately the non-linear system. The so-called parallel distributed compensation (PDC) technique is an intuitive algorithm which consists of designing a fuzzy control rule according to each model rule of a TS fuzzy system. The premise part of the model rule and its corresponding control rule are identical. A sufficient condition to ensure the stability of a TS fuzzy plant model controlled with the corresponding PDC is to find a common quadratic Lyapunov function for all subsystems [11, 12]. The search of the Lyapunov function can be viewed as a convex optimization problem in terms of linear matrix inequalities (LMI) for which efficient solvers exist [1, 4]. The main drawback of this method is the conservativeness of the results which grows with the number of subsystems which must be taken into account.

The use of multiple (and in particular piecewise quadratic) Lyapunov functions is an alternative method to prove the stability of TS fuzzy controllers [6–9]. The quadratic