ABSTRACT

This thesis deals with mathematical modeling and analysis of the "simplest" and "general" Takagi-Sugeno fuzzy controllers. The term simplest is coined to illustrate that minimum number of fuzzy sets (two) is employed on each input variable and the term general stands for multiple fuzzy sets employed on each input variable. The membership functions can be trapezoidal or triangular. Using algebraic product/minimum t-norm, bounded sum/maximum t-conorm and proposed rule bases four models of the simplest fuzzy Single-Input Single-Output (SISO) PI or PD controllers, two models of the simplest fuzzy SISO PID controllers, and two models of the simplest Two-Input Two-Output (TITO) fuzzy PI or PD controllers are derived. Similarly for the general case, four models of fuzzy SISO PI or PD controllers, two models of fuzzy SISO PID controllers, and two models of TITO fuzzy PI or PD controllers are derived in this thesis. The models of these controllers are new and qualitatively different from the existing ones. Properties of these controllers are studied in the context of control and some useful results have been established. Computational aspects of fuzzy controllers are studied. Bounded-Input Bounded-Output stability of the closed-loop system with any of these fuzzy SISO PI/PD/PID controllers in the loop has been studied. Considering nonlinear plants simulation results are presented to demonstrate the applicability of the proposed fuzzy controllers. A real-time implementation of the simplest fuzzy PID controller models is also demonstrated.

Keywords: Mathematical modeling, Stability analysis, Computational aspects, Nonlinear control, Fuzzy control, PI/PD/PID control, Takagi-Sugeno controller.