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PARAMETER TUNING OF FUZZY SLIDING MODE CONTROLLER USING PARTICLE SWARM OPTIMIZATION

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Abstract. *In this paper, an auto-tuning fuzzy sliding-mode controller design approach using particle swarm optimization (PSO) is proposed. This approach provides a simple way of designing a fuzzy sliding controller for nonlinear systems. Moreover, for this method the heuristic sliding factors are not needed to be known. Therefore, the proposed method eliminates the trial-and-error process for finding the appropriate sliding factors and fuzzy parameters. The superiority of the proposed auto-tuning technique is that there is no need for the partial derivative with respect to the parameter for parameter tuning. All parameters of fuzzy controller are auto-tuned by PSO in the proposed approach. This paper proposes and describes an effective utilization of PSO to design and tune fuzzy sliding mode controller for highly nonlinear systems. The simulation results for four highly nonlinear chaotic systems are presented to demonstrate the effectiveness and robustness of the proposed method. Simulation results show the high performances of the proposed method for stabilizing the unstable periodic orbits of chaotic systems.*
Keywords: Sliding mode control, Fuzzy controller, Particle swarm, Parameter tuning, Chaotic system control

1. **Introduction.** Most real systems exhibit nonlinear behaviors and uncertainties that are difficult to describe by using mathematical models. Even though control theory is well developed for linear systems, there is still no universal control method/solution for many kinds of nonlinear systems [1]. Chaotic systems are good examples for nonlinear systems. Chaotic behavior is irregular, complex and highly nonlinear. Therefore, the controlling of chaos has received increasing consideration within the related research area. Sliding-mode control systems have been studied widely and owing to their robustness and simplicity, are used in many applications. Designing the control law, which drives the system to desired a trajectory, is the main task for designer.

Sliding-mode control (SMC) [5] provides an effective solution to deal with nonlinearity, and has been successfully applied in the studies of chaos control such as [1,2,6-9,44,45]. In SMC, control signal is fast switched from one value to another, and this is a problem in practical systems. These switchings make up an adverse affect called chattering. In order to deal with this difficulty, fuzzy logic control is applied to determine control law in SMC [17,41].

The fuzzy set theory was initiated by Zadeh. The fuzzy logic control (FLC) schemes have been developed for more than 40 years, and have been successfully applied to many applications some examples of which are [10-14]. Benefiting directly from various conventional nonlinear control schemes, many different controller structures have been developed and successfully used in the design of fuzzy adaptive controllers. The promising one of these controllers is the fuzzy adaptive sliding mode control. The sliding mode control