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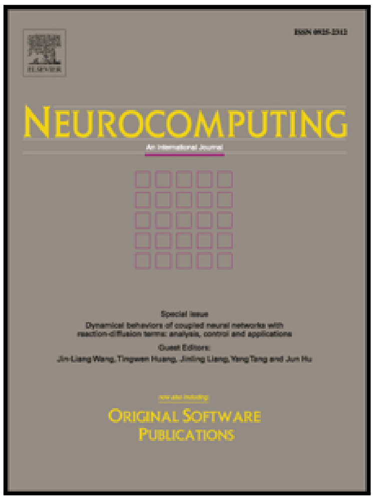

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Variable universe fuzzy control for vehicle semi-active suspension system with MR damper combining fuzzy neural network and particle swarm optimization

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Abstract: This study proposes a novel variable universe fuzzy control design for vehicle semi-active suspension system with magnetorheological (MR) damper through the combination of fuzzy neural network (FNN) and particle swarm optimization (PSO). By constructing a quarter-vehicle test rig equipped with MR damper and then collecting the measured data, a non-parametric model of MR damper based on adaptive neuro-fuzzy inference system is first presented. And then a Takagi-Sugeno (T-S) fuzzy controller is designed to achieve the effective control of the input current in MR damper by using the contraction-expansion factors. Furthermore, an appropriate FNN controller is proposed to obtain the contraction-expansion factors, in which particle swarm optimization and back propagation are introduced as the learning and training algorithm for the FNN controller. Lastly, a simulation investigation is provided to validate the proposed control scheme. The results of this study can provide the technical foundation for the development of vehicle semi-active suspension system.

Key words: vehicle semi-active suspension, variable universe, T-S fuzzy control, FNN, PSO.

1 Introduction

The main functions of vehicle suspension system, no matter what kind of suspension system such as passive, active and semi-active suspensions, are to absorb the shock vibrations caused by uneven road surfaces and simultaneously keep the firm uninterrupted contact of vehicle wheels to rough road in improving ride comfort and handling stability [1-2]. As compared to an active suspension control, semi-active suspension (SAS) can offer both of the stability of passive suspension and the control effect of active suspension without requiring too much external energy. Moreover, SAS can adjust its damping force in real time according to the controller requirements, which are usually based on vehicle suspension dynamics. Therefore, over the past decades, vehicle SAS system has received considerable attentions in the fields of vehicle applications [3-7]. More importantly, a MR damper is often utilized as the promising semi-active device in SAS because it can change its viscosity continuously and produce the controllable damping force using MR fluid.

For the controller design and optimization of vehicle SAS system, many researchers and scholars have proposed a number of control approaches such as H_∞ control [8-9], sliding-mode control [10-11], adaptive backstepping control [12-13] and T-S fuzzy control [14-15]. Among these control schemes, T-S fuzzy control of vehicle semi-active suspension system with MR damper has been widely and extensively investigated in the current studies due to its being independent of the controlled model. For example, the development and