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ENHANCED ADAPTIVE SELF-ORGANIZING FUZZY SLIDING-MODE CONTROLLER FOR ROBOTIC MOTION CONTROL

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Abstract. *This study developed an enhanced adaptive self-organizing fuzzy sliding-mode controller (EASFSC) for robotic systems. Rather than using the output error and the error change of the system, the EASFSC uses a sliding surface and its differential as the input variables of a fuzzy logic controller (FLC) in a self-organizing fuzzy controller (SOFC) to generate a control input through fuzzy operation. It also applies an adaptive law to modify the fuzzy consequent parameter of the FLC in the SOFC to improve the stability of the system. The stability of the EASFSC was proven by using the Lyapunov stability theorem. The EASFSC eliminates the problem faced by the implementation of an SOFC where the determination of the stability of the system is difficult. It also overcomes the difficulty of finding appropriate membership functions and fuzzy rules for the design of an FLC. Experimental results showed that the EASFSC has better control performance than the SOFC for robotic motion control.*

Keywords: Robotic systems, Self-organizing fuzzy controller, Sliding-mode, Sliding surface

1. **Introduction.** Most robotic systems are complicated, nonlinear, and multiple-input/multiple-output systems. It is difficult to estimate a robotic mathematical model accurately, so the design of model-based controllers for controlling robotic systems may be impractical. Fuzzy logic control uses human reasoning capabilities to capture a complex and nonlinear system that cannot be described by a precise mathematical model. Specifically, the development of the controller does not require a system model; therefore, fuzzy control methods have been applied extensively to controlling robotic manipulators with complicated dynamics [1-3]. Fuzzy logic controller (FLC) for practical applications, however, has difficulty in determining suitable membership functions and fuzzy control rules, especially when it is applied to controlling complicated and nonlinear systems. Robotic manipulators exhibit nonlinear characteristics such as backlash, friction, gravitational force, clearance of the transmission mechanism and saturation of the actuator. These factors substantially increase the difficulty in designing an FLC for robotic systems.

Procyk and Mamdani [4] first proposed a self-organizing fuzzy controller (SOFC) to solve the problem of an FLC implementation. Instead of using human thinking, this strategy established fuzzy control rules by learning a system's dynamics behavior, which simplified the procedure for the design of an FLC. Shao [5] and Zhang and Edmunds [6] modified learning methods to further improve the design of the SOFC. The construction