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INTELLIGENT CONTROLLER FOR MULTIPLE-INPUT MULTIPLE-OUTPUT SYSTEMS – PART I

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Abstract. *A self-organizing fuzzy controller (SOFC) has been developed for control engineering applications. However, in practical applications, it is difficult to choose the values of the SOFC's learning rate and weighting distribution appropriately to achieve reasonable control performance. In addition, the SOFC is mainly used to control single-input single-output systems. When the SOFC is applied to manipulating multiple-input multiple-output (MIMO) systems, it is hard to eliminate the dynamic coupling effects between the degrees of freedom (DOFs) of the MIMO system. To address the problems, this study developed a hybrid self-organizing fuzzy and radial basis-function neural-network controller (HSFRBNC), which applies a radial basis function neural-network (RBFN) to regulate the learning rate and weighting distribution of the SOFC to optimal values in real time, to solve the problems faced when the SOFC was applied to controlling MIMO systems. The HSFRBNC can compensate for the dynamic coupling effects between the DOFs of the MIMO system control because its learning rate and weighting distribution are adjusted by the RBFN which has a coupling weighting regulation ability of the neural-network. Stability and robustness of the HSFRBNC have been demonstrated using a state-space approach. From the simulation results of the 2-link robotic manipulator application and the experimental results of the 6-DOF robot tests, the HSFRBNC demonstrated better control performance than the SOFC.*
Keywords: Self-organizing fuzzy controller, Radial basis-function neural-network, Stability and robustness, State-space approach

1. **Introduction.** Multiple-input multiple-output (MIMO) systems typically have dynamic coupling characteristics with complexities and nonlinearities. It has been difficult to identify a dynamic model of an MIMO system accurately and to decouple it for controller design. The model-based control strategy requires extensive computation that renders it nearly impossible to adapt correctly to the complexities of MIMO systems. Therefore, a model-free, intelligent control strategy for MIMO systems is slowly attracting interest.

Fuzzy control theory has been successfully applied to many control engineering fields [1-3], however, fuzzy control strategies are designed primarily for single-input single-output (SISO) systems. Although fuzzy control strategies for manipulating MIMO systems have been developed, these strategies have not focused on overcoming the dynamic coupling effects between the degrees of freedom (DOFs) of MIMO systems. Moreover, the number of control rules and the computational burden of a fuzzy logic controller (FLC) grow exponentially with the number of variables considered.