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

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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. **Simulation.** As noted in Part I of this paper [1], an HSFRBNC was developed for MIMO systems. To evaluate the control performance and the stability behavior of the proposed HSFRBNC, this study presented a 2-DOF robot with a complex dynamics model. Figure 1 shows a two-link robotic manipulator, where $\overline{m}_1$ and $\overline{m}_2$ are the masses of links 1 and 2, respectively, and $\bar{l}_1$ and $\bar{l}_2$ are the lengths of links 1 and 2, respectively. The dynamic equation of the robotic manipulator is

$$\mathbf{M}(q)\ddot{q} + \mathbf{C}(q,\dot{q})\dot{q} + \mathbf{G}(q) = \tau \tag{1}$$

where $q = [\ q_1 \quad q_2\ ]^{\mathrm{T}}$ is a 2×1 vector of joint position; $\dot{q} = [\ \dot{q}_1 \quad \dot{q}_2\ ]^{\mathrm{T}}$ is a 2×1 vector of joint velocity; $\ddot{q} = [\ \ddot{q}_1 \quad \ddot{q}_2\ ]^{\mathrm{T}}$ is a 2×1 vector of joint acceleration; τ is a 2×1 vector of the control input torque; $\mathbf{M}(q)$ is a 2×2 inertial matrix; $\mathbf{C}(q,\dot{q})$ is a 2×2 matrix