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Direct Adaptive Control of Unknown Nonlinear Systems Using a New Neuro-Fuzzy Method Together with a Novel Approach of Parameter Hopping

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Abstract: The direct adaptive regulation for affine in the control nonlinear dynamical systems possessing unknown nonlinearities, is considered in this paper. The method is based on a new Neuro-Fuzzy Dynamical System definition, which uses the concept of Fuzzy Dynamical Systems (FDS) operating in conjunction with High Order Neural Network Functions (F-HONNFs). Since the plant is considered unknown, we first propose its approximation by a special form of a fuzzy dynamical system (FDS) and in the sequel the fuzzy rules are approximated by appropriate HONNFs. The fuzzy-recurrent high order neural networks (F-RHONN) are used as models of the unknown plant, practically transforming the original unknown system into a F-RHONN model which is of known structure, but contains a number of unknown constant value parameters. The proposed scheme does not require a-priori experts' information on the number and type of input variable membership functions making it less vulnerable to initial design assumptions, is extremely fast and, hence, can be applied in several difficult and very demanding real-time engineering applications. When the F-RHONN model matches the unknown plant, we provide a comprehensive and rigorous analysis of the stability properties of the closed loop system. Convergence of the state to zero plus boundedness of all other signals in the closed loop is guaranteed without the need of parameter (weights) convergence, which is assured only if a sufficiency-of-excitation condition is satisfied. The existence of the control signal is always assured by introducing a novel method of parameter hopping and incorporating it in weight updating law. Simulations illustrate the approximation superiority of the proposed scheme in comparison to other well established approaches. The applicability of the method is also tested on well known simulated nonlinear plants where it is shown that by following the proposed procedure one can obtain asymptotic regulation. Comparison is also made to simple RHONN controllers, showing that our approach is superior to the case of simple RHONN's.

Keywords: Neuro-Fuzzy systems; direct adaptive control; parameter hopping;

AMS Subject Classification: 68T05; 93C40; 93C42; 93D05;

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