Canelon, Jose I., “A New Approach for Neural Control of Dynamic Systems”

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This dissertation focuses on the development of a new approach for the neural network-based control of both discrete-time and continuous-time nonlinear dynamic systems. This approach includes the identification of a neural network discrete-time model of the system, using discrete inputoutput data obtained at a fast sampling rate. Then, at every operating point of the system, an optimal local linear model is obtained from the neural network model. A local fast-rate linear digital controller is designed based on this optimal local linear model, by means of linear control design techniques. Therefore, the proposed approach does not rely on a physical principle model of the dynamic system, since the design of the controller is based on the neural network model identified from data. In addition, regardless of the nature of the nonlinear system to be controlled, a neural network model will always have the same structure. Hence, the optimal linear model is calculated with very small computational effort.

For discrete-time systems, the fast-rate controller is directly applied to the system at that particular operating point. For continuous-time systems, the design procedure includes two additional stages. First, the parameters of a linear continuous-time controller are determined from the fast-rate digital controller, by means of the newly proposed reverse-digital redesign method, which indirectly estimates an analog control law from a fast-rate digital control law without directly utilizing the analog models. Then, the analog controller is digitally implemented by means of a slow-rate digital controller, calculated based on digital redesign techniques. As a result, this digital implementation yields lower controller gains and allows more computation time to complete the whole design process.

The proposed approach showed good performance in the control of linear and nonlinear discrete-time systems and continuous-time chaotic systems. Additionally, a state-space digital PID design approach was successfully proposed for the control of nonlinear continuous-time multivariable systems. The proposed control approach was also successfully tested in the control of helicopter vibration, using a Black Hawk helicopter model identified from the data obtained in a wind tunnel test. In all the examples, the systems to be controlled were assumed unknown.