OPTIMIZATION OF CONTROLLER PARAMETERS USING NEURAL NETWORK BASED LEARNING

Tamara Nestorović, Amit Kumar Pal

Institute of Computational Engineering, Ruhr-Universität Bochum, Universitätsstr. Mechanics of Adaptive Systems, 150, 44801 Bochum, Germany
e-mail: tamara.nestorovic@rub.de, amit.pal@rub.de

Abstract:

Proper selection of controller parameters plays a crucial role in reaching desired control performance and efficiency. Many control techniques rely on constant controller parameters, resulting in satisfactory controller performance in a steady state regime or in the neighborhood of a certain operating point, whereas changing operating conditions could deteriorate the control performance or even lead the failure of the controller. To avoid such problems, controllers with optimized or varying parameters can provide a reasonable solution. Optimization of controller parameters usually requires both an a priori knowledge of working conditions and extensive experience in parameter fine tuning. Using artificial intelligence in parameter optimization can significantly influence the controller design procedure in terms of the control performance improvement through an appropriate selection of parameters in the case of controller design with constant parameters or provide an adaptive approach to parameter learning by adapting to changes in operation conditions. This work presents a design of a control system based on neural networks with radial basis functions to learn the parameters for the optimization of the controller along with the estimation of the plant equivalent gain, which provides the plant model update during parameter optimization. The procedure has resulted in an improved controller with excellent tacking performance. The implementation of the procedure is demonstrated on several examples.

Keywords: neural network, parameter learning, radial basis function

1. Neural network-based controller design

In the proposed scheme of the controller design using neural network (NN) based artificial intelligence (AI) the underlying idea is based on using radial basis function (RBF) as an activation for the NN, which learns the controller parameters on one hand and adapts the plant model required for the controller design on the other hand. Learning the controller parameters requires definition of the appropriate inputs and outputs for the layers of the NN, where the outputs of this primary NN should represent the controller parameters being learned. In a similar way, the secondary NN predicts the model of the plant at every time-step, which in turn results in more precise learning of the controller parameters. The update of the controller parameters is based on the minimization of the squared error e between the desired r and the real system output y using stochastic gradient descent (SGD) learning algorithm. Specifically for the design of the PID controller, the error, its integral and derivative are required as inputs to the NN for the controller parameters learning (Fig. 1).

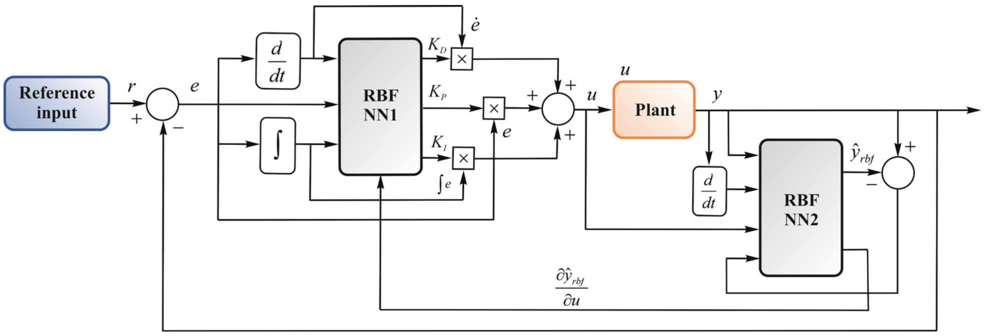

Fig. 1. Block diagram of the control system with RBFNN

2. Implementation results

The proposed controller based on RBFNN is implemented to test the tracking performance of a simple flexible manipulator, designed in the form of a cantilever beam with observed vibration at the tip of the manipulator. A single-input and single-output plant model was obtained through a subspace-based identification relying on experimental data obtained from the experiment with a laser vibrometer for the velocity measurement at the tip of the manipulator as in [3]. The tracking performance for the reference sinusoidal input with a frequency of 0.5 Hz and amplitude of 1 is presented in Fig. 2.

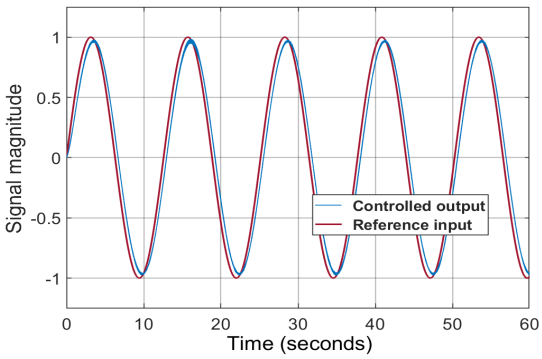

Fig. 2. Tracking performance of the control system designed using NN with radial basis function

This approach can be implemented on different systems in which their outputs should be driven to desired values. Owing to the controller parameter update and the incorporated SGD algorithm, the control input is improved in real time as the RBFNN makes a better prediction of parameters with every time step due to its property that a simplistic architecture of the NN is required with only three layers (input, hidden and output layer) and owing to. Furthermore, the controllers based on this strategy have the ability to adjust their parameters in the presence of disturbances.

Acknowledgement: The support of the German Research Foundation (DFG: 448696650; 77309832) is greatly acknowledged.

References

[1] Pal AK, Nestorović T, Artificial Intelligence Neural Network Approach to Self Tuning of a Discrete-Time PID Control System, 9th International Conference on Systems and Control (ICECCME), 146-151, 2021

[2] Pal AK, Nestorović T, Online Self Tuning of Parameters of a PID Controller that Uses a Radial Basis Neural Network, International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME), 1-6, 2021.

[3] Oveisi A, Nestorović T, Robust nonfragile observer-based H_2/H_∞ controller, Journal of Vibration and Control, 24 (4), 722-738, 2018.