PID Instrumented Control Elements Estimation Based on Probabilistic Methods

Estimación de elementos de control PID instrumentado basado en métodos probabilísticos

GARCIA-HERRERA, Mariel Fernanda†* & PEREZ-CARETA, Eduardo

Universidad de Guanajuato / División de Ingenierias del Campus Irapuato Salamanca

ID 1st Author: *Mariel Fernanda, Garcia-Herrera* /

ID 1st Co-author: *Eduardo, Perez-Careta* /

DOI: 10.35429/EJDRC.2022.14.8.31.34 Received March 10, 2022; Accepted June 30, 2022

Abstract

The applications of a controller, such as a control valve, require robust control schemes for all the variables that exist. Have a functional prototype of the automatic systems that operate in the Ingeniero Antonio M. Amor Refinery, to facilitate the movement of the final elements and obtain greater control of the events that occur in the process plants. The behavior analysis for a control valve was performed using probabilistic methods, using the MATLAB Toolbox. In this document it can be seen that a neural network can be trained to provide the coefficients of a PID controller, where the response is close to that of an analog PID controller with a known set point.

Neural Networks, PID Control, Automatic Systems

Resumen

Las aplicaciones de un controlador, tal como lo es en una válvula de control, requieren de esquemas de control robustos para considerar todas las variables posibles que existan. Este articulo, propone tener un prototipo funcional de los sistemas automáticos que operan en la Refinería Ingeniero Antonio M. Amor, para facilitar el movimiento de los elementos finales y obtener un mayor control de los eventos que suceden en las plantas de proceso. El análisis de comportamiento para una válvula de control se realizará mediante métodos probabilísticos, utilizando las Toolbox de MATLAB. En este documento se demostrará que una red neuronal puede ser entrenada para proporcionar los coeficientes de un controlador PID, en donde la respuesta se aproxime a la de un controlador PID analógico con set point conocido.

Redes Neuronales, Control PID, Sistemas Automáticos

Citation: GARCIA-HERRERA, Mariel Fernanda & PEREZ-CARETA, Eduardo. PID Instrumented Control Elements Estimation Based on Probabilistic Methods. ECORFAN Journal-Democratic Republic of Congo. 2022, 8-14: 31-34

* Correspondence to Author (e-mail: mfgarcia@ugto.mx)
† Researcher contributing first author.

Introduction

This project presents background research work and partial results on PID controllers using BP neural networks. Industrial control systems are becoming a trend in describing the networks, hierarchical control layers and communication capabilities of a system through software tools, intelligent sensors and methods designed for fault tolerance and handling of safety critical problems. The structure is established by proportional, integral and derivative (PID) controllers. Due to the practicality of PID controllers, they have become industry standard tools and have well-established rules for tuning controller parameters in real-time applications.

The purpose of control objects is to have high inertia, nonlinear characteristics and an uncertain disturbance factor. Optimization of PID parameters is required to improve the performance of the controllers. There are several studies involved in parameter optimization, some of them: in [1] an adaptive learning algorithm based on genetic algorithms is shown to obtain automatic tuning in PID controllers, aiming to achieve optimal performance. In [2], based on genetic algorithms, fuzzy control rules and membership function have been optimized. In [3], a neural network controller and a fuzzy logic controller are combined.

Neural network technology has been applied in the field of control systems, energy management, fault prediction and diagnosis, identification and optimization. The algorithm uses feedforward neural networks, which was frequency optimized in [4]. In [5] they develop a neural PID control algorithm module, which shows that the neural PID controller strategy is more robust than the conventional PID controller.

The objective of the project is to realize a control system of a control valve for the Engineer Antonio M. Amor Refinery, through a behavioral analysis by means of probabilistic methods using neural networks. In the simulation and optimization of the algorithms it is sought that the PID controller using a neural network has the capacity of self-adaptation.

Methodology

Measurements

In order to know the current operation of the control valve and the conditions in which it is found, a visit was made to the Ingeniero Antonio M. Amor Refinery in the city of Salamanca.

For data collection, three different control valves were chosen, from each one approximately 21,600 data were extracted, in an interval of eight hours, taking data in an interval of 1 second. The data readings came from various pressure indicating controllers (PICs). In the visit to the refinery, it was possible to know the operation of the valves, and we realized that the adjustment of the valves is still manual, which meets the objectives of the project, which is to make a control system in which a control valve is self-adjusting, this would save time and costs for the refinery.

Configuration of a PID control system using neural networks

The PID controller using neural network is the combination of a neural network and a conventional PID control, which combines the excellence of both PID controller and neural networks. The structure of the neural network control system consists of the PID controller using a neural network and a nonlinear prediction model (NNM) as shown in Figure 2.

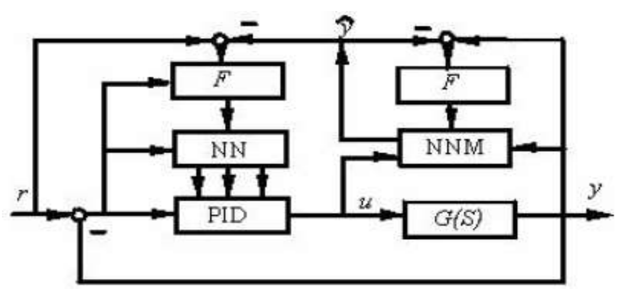

Figure 2 PID control system using a neural network

Where r is the input configuration, G(s) is the controller object, y is the actual output, u is the variable controller, yˆ is the prediction of y, NNM represents the neural network linear prediction model of yˆ, NN represents the neural network and F represents the learning algorithm.

ISSN 2414-4924
ECORFAN® All rights reserved

Algorithm process

Para este proyecto se usará una red neuronal de retroceso con tres capas como se muestra en la

Figure 3, which has M input neurons, Q hidden neurons and three output neurons.

The output of the feedforward neural network are the setting of the three PID controller parameters (k_P, k_I y k_D), which cannot be negative, the activation function is a Sigmoid function.

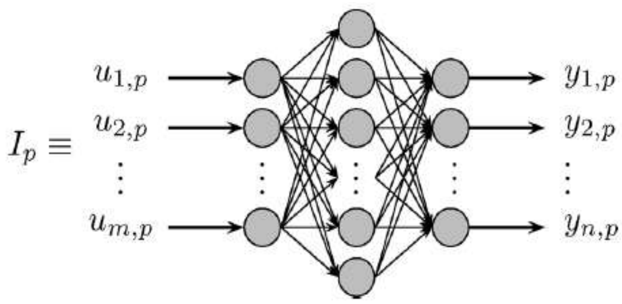

Figure 3 Configuration of the backtracking neural network

Results

The first thing that was done was to observe the behavior of the data obtained from the control valves, the graphs show a similar behavior of each data collection, being a linear behavior until a stabilization point as shown in Figure 4.

Figures 5 to 7 show the results of the neural network training simulation. The performance results of a trained neuron with 1 input layer, 10 hidden layers and one output layer are shown for each of the data sets obtained from the control valves. The graphs show the performance of the network based on epochs, which are periods of time where the performance of the network is analyzed.

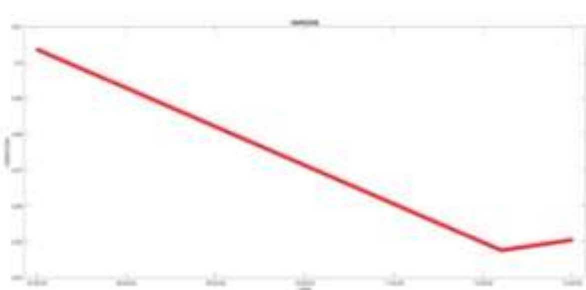

Figure 4 Behavior of data collected from control valves

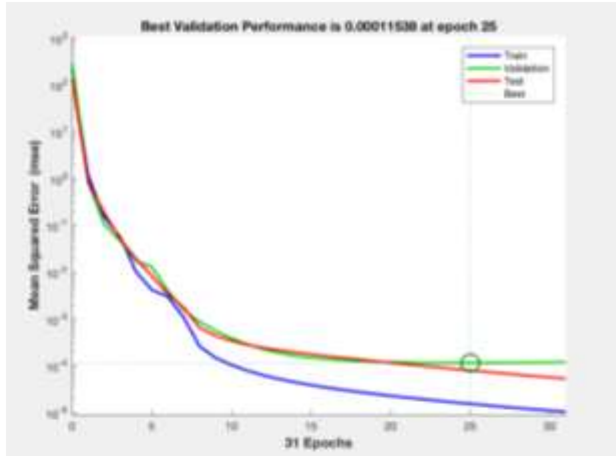

Figure 5 Results of the first data set. It is observed that the neural network simulation reaches its best performance at 25 epochs.

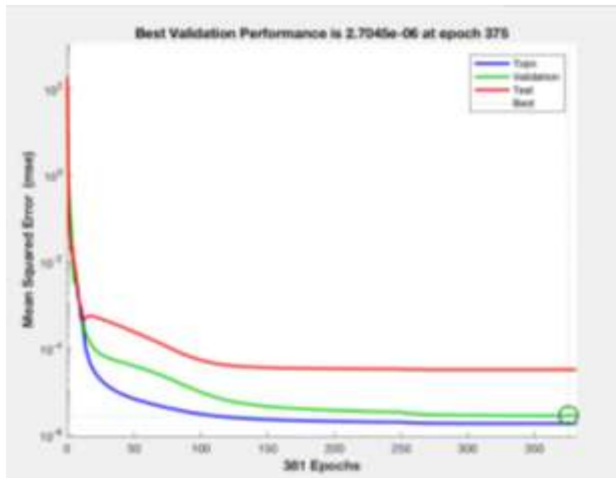

Figure 6 Results of the second data set. It is observed that the neural network simulation reaches its best performance at 375 epochs

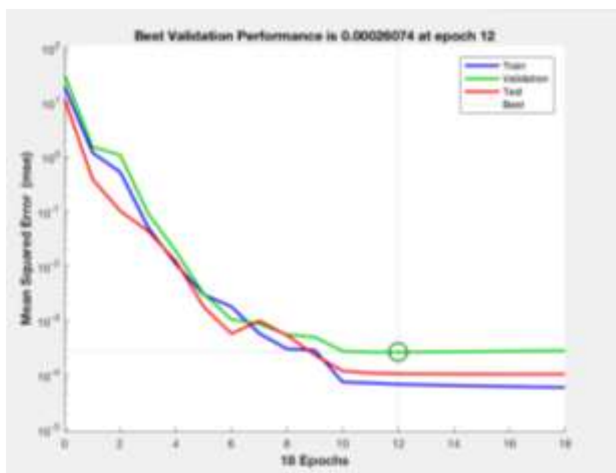

Figure 7 Results of the third data set. It is observed that the neural network simulation reaches its best performance in 12 epochs

ECORFAN® All rights reserved

June 2022 Vol.8 No.14 31-34

Conclusions

The project has shown the various applications of neural network control systems that help in the optimization of different systems. The various parameters that compose the control system have to be taken into account to obtain better performance and accuracy that are adjusted during the training stage of the neural network, however, the robustness levels have to be taken into account when the parameters of the PID controller change.

The advantages offered by a neural network PID controller are the self-study and self-adaptation capabilities, which facilitates faster responses and better performances.

Contribution

The usefulness of the results of the study is to develop and test a new methodology based on probabilistic methods for a controller, such as a control valve, that allows the robust control of the different existing variables that occur in process plants.

References

Huang, W., & Lam, H. (1997). Using genetic algorithms to optimize controller parameters for HVAC systems. Energy and Buildings, 26(3), 277–282. https://doi.org/10.1016/s0378-7788(97)00008-x

Jun-tao, L. (2005). Research on the Simulation System of Fuzzy Intelligence Inverter Air-Conditioner Based on Genetic Algorithm.

(2004). Fuzzy cmac control of inverter air conditioner. Refrigeration Technology.

Wang, Jiangjiang & Zhang, Chunfa & Jing, Youyin & An, Dawei. (2007). Study of Neural Network PID Control in Variable-frequency Air-conditioning System. 317 - 322. 10.1109/ICCA.2007.4376371.

J. Wang, C. Zhang, Y. Jing and D. An, "Study of Neural Network PID Control in Variable-frequency Air-conditioning System," 2007 IEEE International Conference on Control and Automation, 2007, pp. 317-322, doi: 10.1109/ICCA.2007.4376371.

ECORFAN® All rights reserved