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Design of Neuro-Controller

Suyog S. Shah, Ambadas B. Shinde, Kishor K. Pandyaji
Electronics Engineering, PVPIT Budhgaon

***Abstract*— Since the past few years, fuzzy control has emerged as one of the mainly active and fruitful areas for research. The fuzzy logic controller based on wavelet network provides a means of converting a linguistic control strategy based on expert knowledge into an automatic strategy. In the traditional methods lack of disadvantages are there. To overcome that, we are presenting the designing of a controller by various methods like fuzzy, Adaptive PID, Neural-Network, Wavelet etc. In this paper, adaptive PID controller and controller using neural network are discussed in subsequent section. An adaptive neural network structure was proposed. This structure was used to replace the linearization feedback of a second order system (plant, process). It is shown that Adaptive controller be capable of locating high performance areas in complex domains without experiencing the difficulties associated with high dimensionality or false optima as may occur with gradient decent techniques. Research work done so far in this area shows that Adaptive controller gave fast convergence for the nonparametric function under consideration in comparison with PID Controller.**

***Index Terms*—Fuzzy logic, Adaptive PID, Neural Network.**

I. INTRODUCTION

It is known that (proportional integral derivative) PID controller is employed in every facet of industrial automation. The application of PID controller spans from small industry to high technology industry. In this paper, the selected model is a second order system which may concern the control of a robot arm position or dc motor position and so on. Intelligent systems cover a wide range of technologies related to hard sciences, such as modeling and control theory, and soft sciences, such as the artificial intelligence (AI). Intelligent systems, including neural wavelet networks (NWN), fuzzy logic, and wavelet techniques, utilize the concepts of biological systems and human cognitive capabilities. The Artificial Intelligence (AI), Neural Wavelet Network, Fuzzy systems have been recognized as a robust and attractive alternative to the some of the classical modelling and control methods. The major drawbacks of these architectures are the curse of dimensionality, such as the requirement of too many parameters in (Neural Wavelet Network) NWNs, the use of large rule bases in fuzzy logic, the large number of wavelets, and the long training times, etc. These problems can be overcome with network structures, combined two or all these system. Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale.

Manuscript received April 25, 2015. Suyog Shah is with the P V P Institute of Technology, Budhgaon, Sangli, India 416304 (e-mail: ssshah.eln@ pvpitsangli.edu.in).
Ambadas Shinde is with the P V P Institute of Technology, Budhgaon, Sangli, India 416304 (e-mail: abshinde.eln@ pvpitsangli.edu.in).
Kishor Pandyaji is with the P V P Institute of Technology, Budhgaon, Sangli, India 416304 (e-mail: kkpandyaji.eln@ pvpitsangli.edu.in).

The fundamental idea behind wavelets is to analyze the signal at different scales or resolutions, which is called multiresolution. Wavelets are a class of functions used to localize a given signal in both space and scaling domains. A family of wavelets can be constructed from a mother wavelet. Compared to Windowed Fourier analysis, a mother wavelet is stretched or compressed to change the size of the window. In this way, big wavelets give an approximate image of the signal, while smaller and smaller wavelets zoom in on details. Therefore, wavelets automatically adapt to both the high-frequency and the low-frequency components of a signal by different sizes of windows. Fuzzy controller with wavelet network is one of the succeed controller used in the process control in case of model uncertainties. But it may be difficult to fuzzy controller to articulate the accumulated knowledge to encompass all circumstance. Finally in this paper we discuss a controller using neural network and compare that with conventional PID.

II. CONVENTIONAL METHODs

A. PID Controller

It is known that various conventional strategies are available to design controller in the application of industrial automation. The PID controller is one of the conventional method.

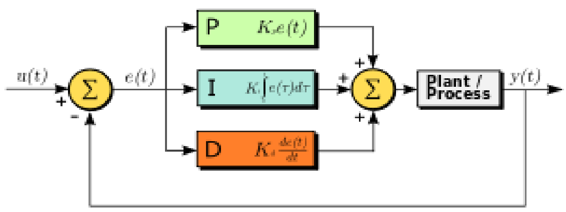

Fig.1: A block diagram of a PID controller

A block diagram of a PID controller is shown in Fig1.A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller) widely used in industrial control systems.PID is the most commonly used feedback controller. A PID controller calculates an "error" value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process control inputs. The PID controller calculation (algorithm) involves three separate constant parameters, and is accordingly sometimes called three-term control: the proportional, the integral and derivative values, denoted P, I, and D. Heuristically, these values can be interpreted in terms of time: P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, or the power supplied to a heating element.

PID controller has been considered to be the best controller. By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set point and the degree of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system or system stability. Some applications may require using only one or two actions to provide the appropriate system control. This is achieved by setting the other parameters to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are fairly common, since derivative action is sensitive to measurement noise, whereas the absence of an integral term may prevent the system from reaching its target value due to the control action.

In the case of PID controller or by tuning the PID controller while plotting step response normally we observed that there is a problem of overshoot as well as undershoots. Overshoot refers to an output exceeding its final, steady-state value. For a step input, the percentage overshoot (PO) is the maximum value minus the step value divided by the step value. In the case of the unit step, the overshoot is just the maximum value of the step response minus one. Similarly undershoots are also occurs which is shown in Fig.2 that figure shows step response of 2nd order system. From the figure it is clear that because of PID controller the system require some time to become a stable. To overcome that we will design a controller using different methods like Fuzzy logic, Neural Network etc. Figure shows snapshot of step response.[2]

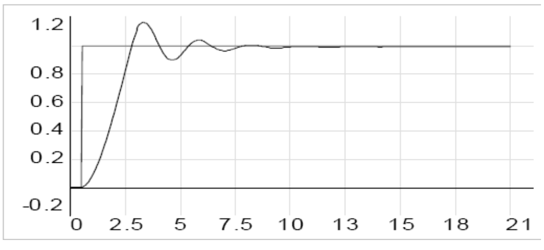

Fig 2: Sustained oscillation of PID

B. Characteristics of PID Controller

A proportional controller (K_p) will have the effect of reducing the rise time and will reduce ,but never eliminate, the steady-state error. An integral control (K_i) will have the effect of eliminating the steady-state error, but it may make the transient response worse.

A derivative control (K_d) will have the effect of increasing the stability of the system, reducing the overshoot, and improving the transient response. Effects of each of controllers K_p, K_d, and K_i on a closed-loop system are summarized in the table shown Below. These correlations may not be exactly accurate, because K_p, K_i, and K_d are dependent of each other. In fact, changing one the other two. For this reason, the table should determine the values for K_i, K_p and K_d.

Closed loop Response	**Rise Time**	**Overshoot**	**Settling Time**	**S-S Error**
K_p	Decrease	Increase	Small Change	Decrease
K_i	Decrease	Increase	Increase	Eliminate
K_d	Small Change	Decrease	Decrease	Small Change

Table 1: Characteristics of PID

C. Features of PID Controller

The PID controller is the most controlling form of feedback. More than 90% of all control loops are PID. Integral, proportional and derivative feedback is based on the past (I), present (P) and future (D) control error signals. The PID controller is used for a comprehensive range of problems: process control, motor drives, magnetic and optic memories, automotive, flight control, instrumentation, etc. The controller comes in various forms, as standard single-loop controller, in programmable logic controllers and in robots and CD players. Automatic tuning, another is the increased use of model predictive control which requires well tuned PID controllers. Most applications on single loop control use PID controllers with Ziegler–Nichols tuning. This is an actual unsatisfactory state because the Ziegler–Nichols rules are known to give very poor results in many cases [1].

III. CONTROLLER BASED ON NEURAL NETWORK

A. Introduction

The Artificial Intelligence (AI), Neural Wavelet Network, Fuzzy systems have been recognized as a strong and smart alternative to the some of the established modelling and control methods. The major disadvantages of these designs are the requirement of too many parameters in (Neural Wavelet Network) NWNs, the use of huge rule bases in fuzzy logic, the large number of wavelets and the long training times etc. These difficulties can be overwhelmed with network structures, combined two or all these systems which is developed by Parker, T. E., and Matsakis [10].

Neural network controller with wavelet network (wave-net) is proposed for application in process control area to model uncertainties. The wave-net algorithms consist of two processes: the self-building of networks and the minimization of faults. In the first process, the network structures applied for representation are found by using wavelet analysis. The network progressively recruits hidden units to effectively and adequately cover the time-frequency section occupied by a given target. Simultaneously, the network factors are updated to preserve the network topology. In the second process, the calculations of immediate faults are minimized. The parameter of the initialized network is modernized using the steepest gradient-descent method.

B. The Perceptron

The perceptron is a single level connection of McCulloch-Pitts neurons sometimes called single-layer feed forward networks. The network is clever for linearly separating the input vectors into a pattern of classes. In such an application, the network allies an output pattern (vector) Vi, and information is kept in the network by virtue of modifications made to the synaptic weights of the network. The perceptron, which is described by:

$$Y = f(\sum_{j=1}^{N} W_{ij}\, x_j - v_i)$$

Where i= 1, 2... M (output nodes), j= 1, 2… (Inputs)

After assembling the initial WN and after computing output signal of the network, the training of WN starts. It is further trained by the gradient descent algorithms to minimize the mean-squared error. During learning, the parameters of the network are adjusted. The wavelet network parameters can be adjusted in the gradient descent algorithm by minimizing a cost function or the energy function, E.

The energy function is defined by:

$$E = \frac{1}{2} \sum_{t=1}^{T} e^2(t)$$

Where, $e(t) = y(t) - y'(t)$

T =Total interval of the function.

This procedure absorbs the advantage of high resolution of wavelets and the advantages of learning and feed-forward of neural network (NN). The NN arrangement and its learning algorithm are used for development of controller to control dynamic plant. Neural control system synthesis is achieved in the closed control system. For learning of NN the error between target characteristic of control system and output of control object is used. The Neural Network we will give the input set as well as target set. After that in the next step we will select the structure of Neural Network. After selecting the structure of Neural Network, we train that for input and target values. Once the training is competed we will simulated that network and see the plot.

IV. SIMULATION RESULTS

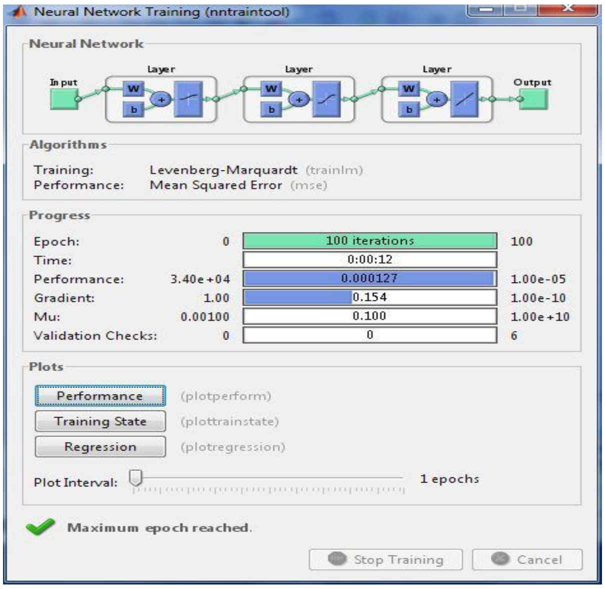

Fig.3: Neural Network Training

Fig.3 Shows Simulation of Neural Network Training. For the training of Neural Network We used Levenberg-Marquardt algorithm. Network consist of input layer, output layer, Hidden layer & Hidden layer has nodes with combination (20,30). Fig 4. Shows Response using Neural Network.

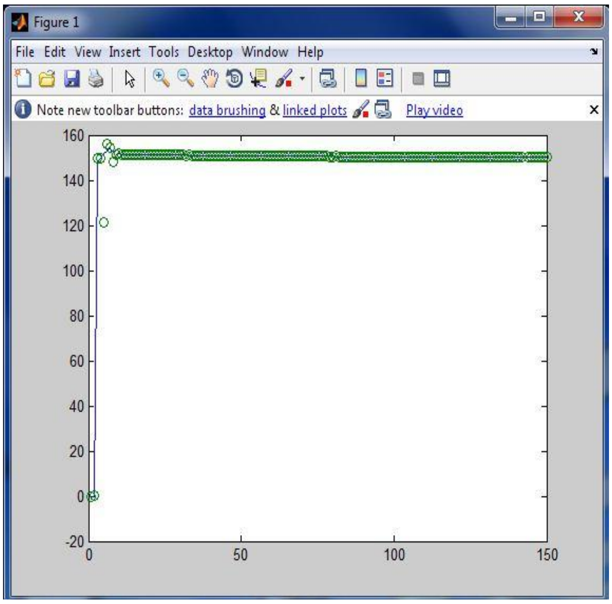

Fig 4: Step response using Neural Network

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Suyog S. Shah is presently working as Assistant Professor in Department of Electronics Engineering, at P V P Institute of Technology, Budhgaon, Sangli, India. He has completed his Masters degree in 2014, in Electronics from DKTE's College of Engineering, Ichalkaranji, Kolhapur, India.

His working areas are Artificial Neural Network & Wavelets.

Suyog S. Shah is Life member of Indian Society of Technical Education.

Ambadas B. Shinde is presently working as Assistant Professor in Department of Electronics Engineering, at P V P Institute of Technology, Budhgaon, Sangli, India. Presently he is pursuing the Ph D form Savitribai Phule Pune University, Pune, India. He has completed his Masters degree in 2011, in Electronics from KIT's College of Engineering, Kolhapur, India.

His working areas are Image Processing & VLSI system design.

Ambadas B. Shinde is Life member of Indian Society of Technical Education.

Kishor K. Pandyaji is presently working as Associate Professor in Department of Electronics Engineering, at P V P Institute of Technology, Budhgaon, Sangli, India. Presently he is pursuing the Ph D from Shivaji University, Kolhapur, India. He has completed his Masters degree in 1999, in Electronics from Walchand College of Engineering, Sangli, India.

His working areas are Wireless & Mobile Communication and Artificial Neural Network.

Kishor K. Pandyaji is Life member of Indian Society of Technical Education.