ENHANCED PID CONTROLLER USING NEURAL NETWORKS IN MATLAB SIMULATION

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ABSTRACT:

"ENHANCED PID CONTROLLER BASED ON BACK PROPAGATION NEURAL NETWORK"

Is used to tune the PID controller to update its gain automatically to its desired value. The conventional PID controller has a constant gain value where it is difficult to choose its gain if the system is a non linear system. In order to overcome this problem we are going for Adaptive PID controller based on back propagation neural network. According to the requirements of system output performance, the BP neural network can automatically adjust its weights to vary kp, ki and kd, in order to match the system. Here the system we are using is the position control system where the servo valve is used to control the position of the piston. It is called the "Electro Hydraulic Servo Valve position control system." The simulation results of an electro- hydraulic servo valve position control system using adaptive PID controller based on BP neural network shows that it can get better control characteristics adaptability and strong robustness in the nonlinear time varying system compared to correctional PID controller. At the same time, simulate results provides a theoretical basis for the design and application of electro-hydraulic position servo control system. The system here we are using is aSISO.

Keywords: Adaptive, Electro hydraulic system, SISO- Single input and single output system, BP-back propagation.

1.INTRODUCTION

The proportional-integral-derivative (PID) controller is one of the most commonly used controllers in the industrial closed loop control system for its simple algorithm, good robustness and stability(fig 1). But PID controller has its disadvantage that it is not suitable for the control of long time-delay and nonlinear system, in which the P, I and D parameters are difficult to choose and can hardly adapt to time varying of characteristics in wide range. With the development of modern computer technology and control theories such as fuzzy, neural networks and gray theory these difficulties can be overcome. Back propagation (BP) is one of the neural network algorithm and is a powerful computational tool that have been used extensively in the areas of pattern recognition, systems and identification. The adaptive PID controller based on back propagation neural network which is designed combining traditional PID strategy with neural network has created a new concept and a new tool for control. The self-learning ability of BP neural network can tune automatically and modify the robust PID parameters online.Below fig shows

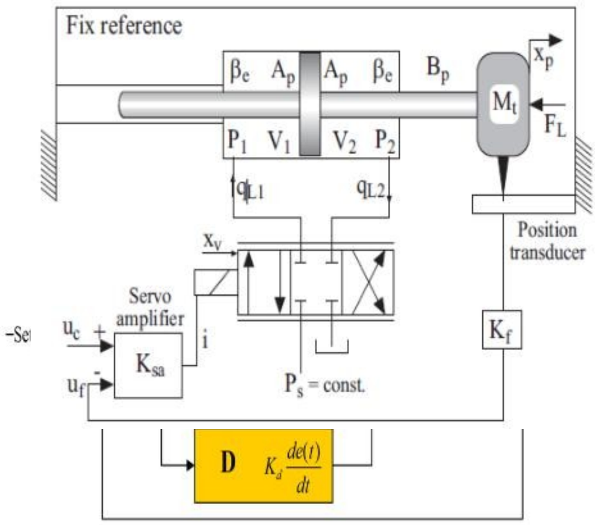


FIGURE 1: PID Controller

Where as in the case of BP neural network based PID controller. The BP identifies kp, ki and kdvalue for each instances. According to the magnitude of the error signal. Here kp, ki and kdvalues keeps on changing to improve the system performance.

Figure 2 shows the complete block diagram of the enhanced PID controller based on BP neural network. The block shows that there is an input to the system which isr.

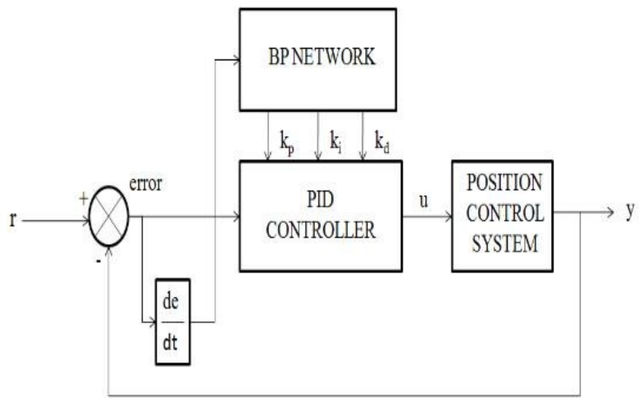


FIGURE 2: Structure of enhanced PID controller based on BP neural network.

r= desired input (step), $\frac{K_v}{\omega_h} = \delta_h = 0.2$ tput of the

$K_{vmax} = 10^{-\frac{A_m}{20}} 2\delta_{hmin}\omega_{hmin}$

system, error=desired-current output of the system,

kp, ki, kd =PID controller gain values,U=controlleroutput, = the delay given to the errorsignal.

The input is compared with the current controller output and the error is feed as input to the PID controller and also the BP neural network. The BP neural network is used to train the kp, ki, kd values. These values will be given as the PID controller gain values for that instant. Then the controller will generate the controller output for that instant and give it as the input for the position control system..

2. ELECTRO HYDRAULIC POSITION CONTROLSYSTEM

Here we are going to use Electro Hydraulic Position control system. Here the position of the piston is to be controlled finally to the desired input value. The delay given to the error signal is because the previous state error signals are needed for the manipulation of the current controller output and the controller gain values. Hence there is a necessary for the delay in the error value. The most basic closed-loop control system is a position servo.

FIGURE 3: General Position servo system

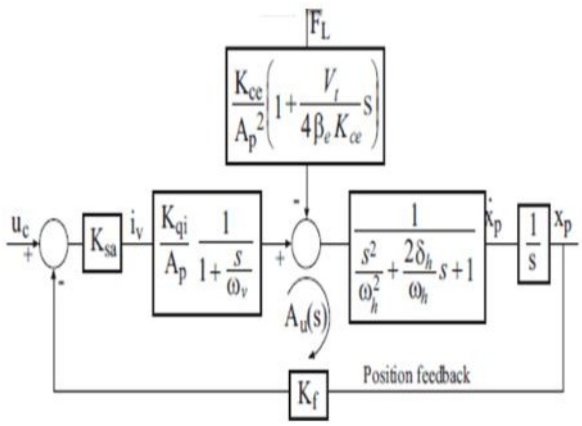
A schematic diagram of a complete position servo the actuator or load position is shown in figure 3 and the position is measured by a position transducer, which gives an electric signal (uf) in voltage as an output. The servo amplifier compares the command signal (uc) in voltage with the feedback signal (uf). Then, the resulting error signals are gained with the factorKsa.

Mathematical Model of the system

Ksa=servo amplifier gain, Kqi=flow gain, Kf=position feedback gain, Ap=piston area, ωh=hydraulic resonance frequency, δh=hydraulic damping.

FIGURE 4. Mathematical model

$K_v < 2\delta_{hmin}\omega_{hmin}$



3. CONTROLLERDESIGN

The adaptive PID controller based on back propagation neural network is designed combining traditional PID strategy with neural network has created a new concept and a new tool for control. The self-learning ability of BP neural network can tune automatically and modify the robust PID parametersonline.

Structure of BPNN

BPNN is composed of input layer, hidden layer and output layer. In figure 5 the structure of BP neural network, whose numbers are determined by complexity of controlled plant is shown. The first layer is input layer, Neurons at the middle layer are in hidden layer, The third layer is output layer including PID parameters kp, kiandkd.

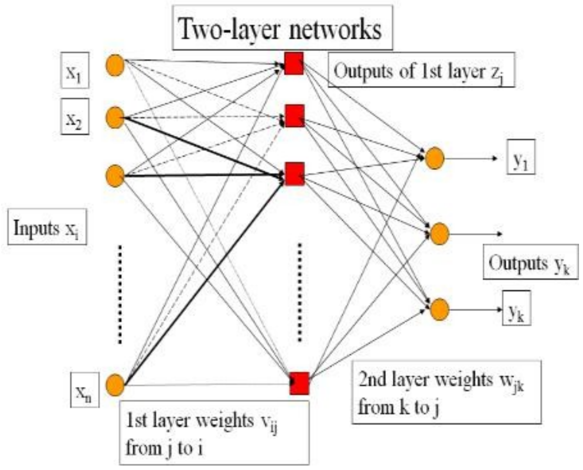


FIGURE 5., Structure of BP neural network

A. *Algorithm of BP Neural Network*

The proportional-integral-derivative (PID) controller is the common controller in the industrial closed loop control system.

u(k)= u(k-1)+Kp(e(k)-e(k-1))+Kie(k)

$$net_o(k) = \sum_{j=0}^{M} w_{ij} O_h$$

+Kd(e(k)-2e(k-1)+e(k-2)) (1)

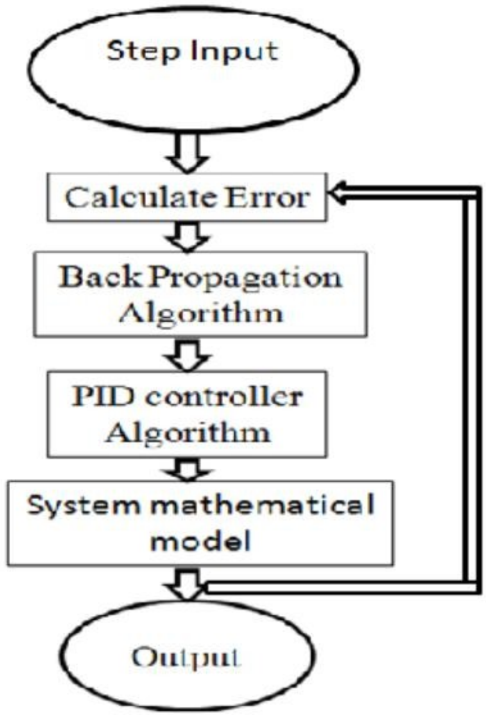
Learning algorithm of BP neural network is described as follow:

The network input is Xj(j=1,2,3….n), the input and output of hidden layer is shown in formulas (2) and (3).

II. $$net_h(k) = \sum_{j=0}^{M} w_{ij} x_j \quad (2)$$

Oh(k) =f(neth(k)) h=1,2,3…n (3)

Where wij is the weight value of hidden layer. The activation function of hidden layer adopts symmetrical sigmoid function.



III. $$f(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}} \quad (4)$$

Inputs and outputs of output layer is formulated as follow

$$net_o(k) = \sum_{j=0}^{M} w_{ij} O_h$$

FIGURE 6: General flow chart

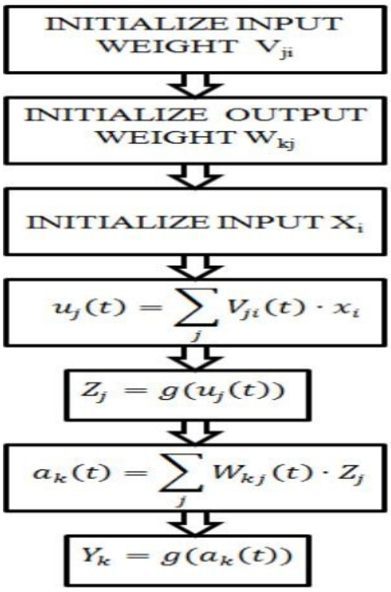


FIGURE 7: Feed forward path BP
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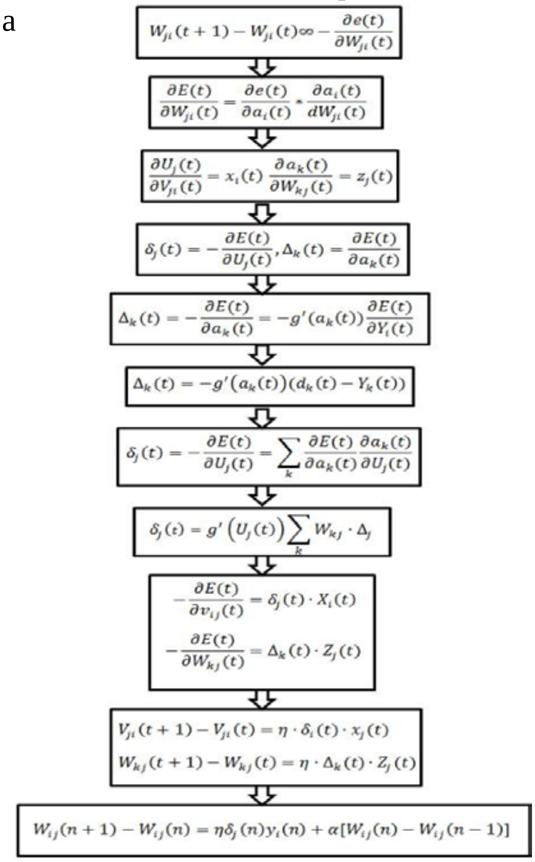
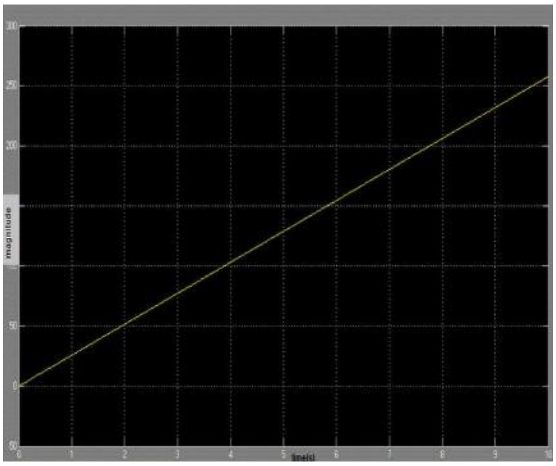


FIGURE 7: Feed forward path BP algorithm

5. SIMULATIONRESULTS

OPEN LOOP RESPONSE:

The system function is given with a step input of 1 directly. The response is taken from the scope.



A. FIGURE 9 :Open loop

response CLOSE LOOP

RESPONSE:

The close loop response of the system with the conventional PID controller for the given unit step input shown in the figure 10. The output taken from the scope shows long settlingtime.

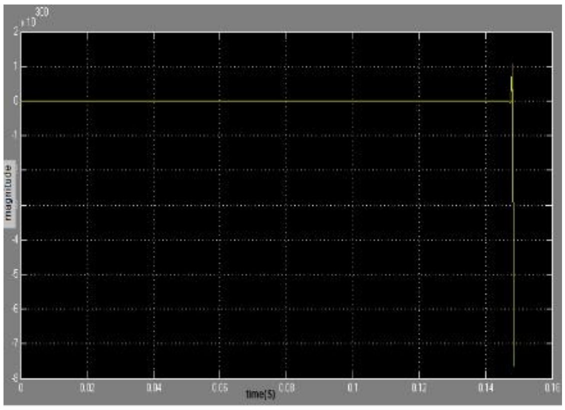


FIGURE 10: Closed loop response

PID WITH BP SIMULATION RESULT

FIGURE 11 : There are 2 plots here. The first is between the input “rin” vs time. It is marked in red. The second is between output “yout” vs time. It is marked in blue. Here it is observed that the settling time is reduced and for the change in

the step the system output follows the desired the desired input.

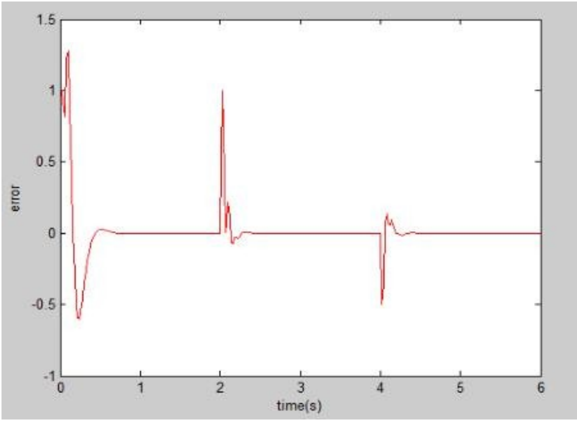


FIGURE 12 : The graph shows the variation of the error signal that is given to the controller with respect to time.

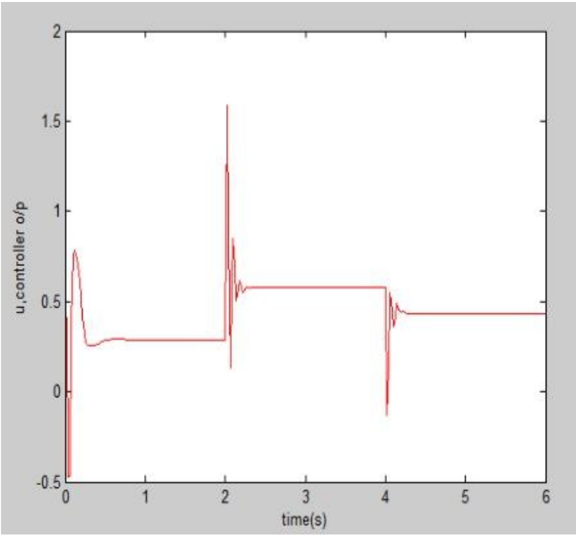
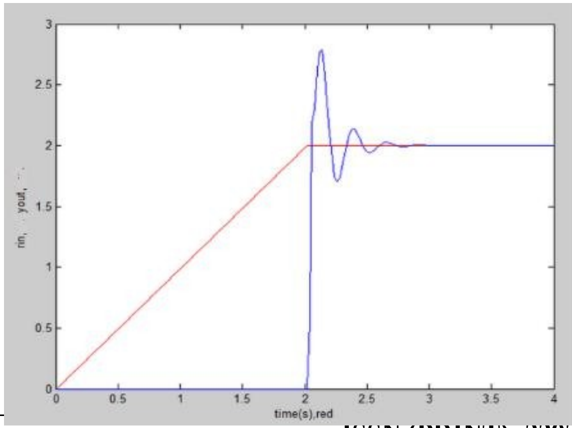


FIGURE 13: The graph shows the variation in the controller output with respect to time.



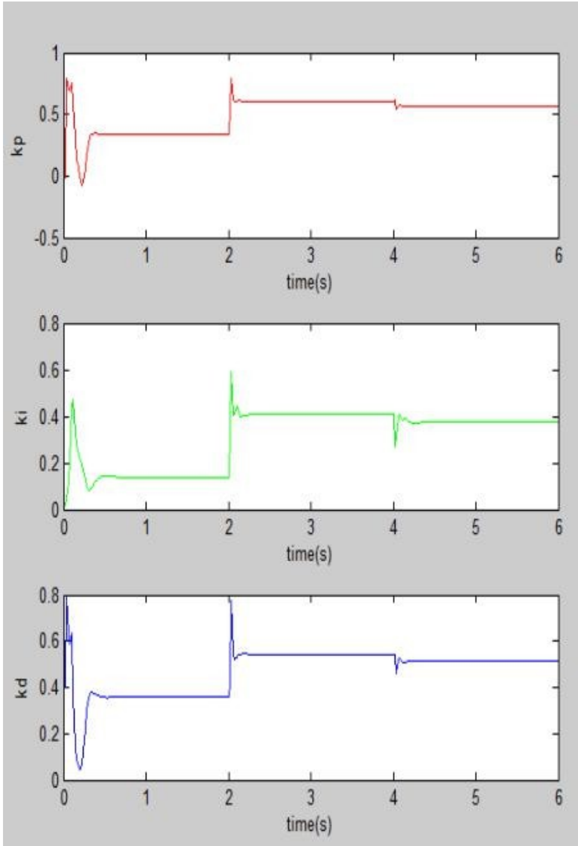


FIGURE 14: The graph shows the Kp, Ki, Kd values.

6. VALIDATION

Validation is process to cross check the controller if it is working properly. Here the system is made to run for only a given period of time in the whole cycle and the results are cross checked with the original. If the controller is working properly then there should not be much variation in the outputs but if it differs greatly then there is a problem in the controller .For validation 3 graphs are necessary to check.

i) The input and output graph
ii) The controller output graph
iii) The error graph

- The input output graph is to check if the output settles properly with the desiredinput,
- The controller output graph is used to compare with the pervious graph to see if the controller output variations are there.
- The error graph is to check if the error in the system has settled,If the graphs match then the

controller is workingproperly.

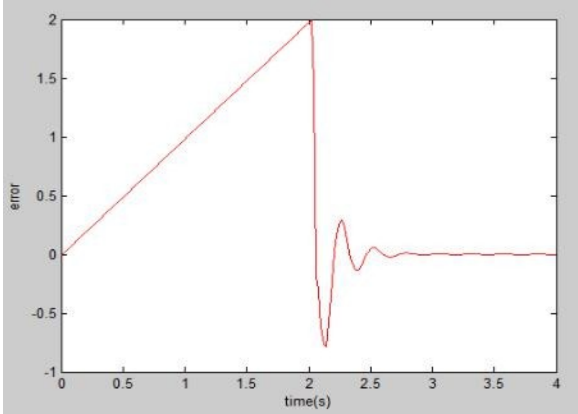


FIGURE 15: Input and output graph

CONCLUSION

Adaptive PID controller based on BP neural network is proposed in this paper. The proposed controller has advantages of both self-learning capability of neural network and simplicity of PID controller. The simulation results of an electro-hydraulic position serve control system using adaptive PID controller based on BP neural network shows that it can get better control robustness such as advantages of fine control precision, good self-adaptive, excellent robustness, convenient parameter setting and simple control algorithm.

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