Implementation of Neural Network for PID Controller

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ABSTRACT
The conventional PID (proportional-integral derivative) controller is widely applied to industrial automation and process control field because of its simple structure and robustness, but it does not work well for nonlinear system, time-delayed linear system and time varying system. Artificial Neural Network (ANN) can solve great variety of problems in areas of control systems, pattern recognition, image processing and medical diagnostic. A Neural Network is a powerful data-modeling tool that is able to capture and represent complex input/output relationships. This paper represents the advantage of using neural network for PID controller.PID controller for surge tank has been implemented in MATLAB.

Keywords
PID controller, Artificial neural network.

1. INTRODUCTION
Control objects became more popular With the development of industry, making it more complex, especially for the system with unknown parameters or slow changes in large delay, time-varying, nonlinear complex systems, with delay or random interference. Proportional-Integral-Derivative (PID) control is the most used control algorithm in industry and has been universally accepted in industrial control, like for industries such as chemical, petrochemical, robotics etc. PID controllers became popular due to the reasons that they are low cost and easy to maintain , gives robust performance in a wide range of operating conditions and its simplicity in the functionality, this allows to operate the controller in a simple, straight forward manner, but the drawback of conventional PID control is that parameters will have no changes after completion, resulting in the parameter variations of controlled objects, which is difficult in real time, other thing to be considered is meeting increasing requirements of control quality in the production process is difficult.[11].

Various methods have been therefore introduced for improvement of controller like by improvement of structure i.e variable structure control. Other method introduced was of combining the fuzzy theory, artificial neural networks, genetic algorithms and other intelligent control theories with conventional PID control, that could be called as intelligent PID control by using the advantages of these algorithms. Advantages of Intelligent PID is that control does not depend on precise mathematical model, has better robustness for system parameters, so it has good prospects, giving clear picture of the space-time tradeoff.

2. RELATED WORK
For conventional PID controller many strategies have been proposed to improve its performance by determining the optimum setting of PID parameters. Ziegler and Nichols, Cohen and coon are amongst the pioneers in PID tuning method. They proposed tuning methods based on trial and error and process reaction curve. But these methods were found difficult when system became complex such as of higher order, time-delay, non-linear processes. For example Ziegler-Nichols method gives high overshoot, high oscillatory and longer settling time for a higher order system and Cohen Coon method is only valid for system having S-shaped step response.

The conventional control strategy also involves taking in to consideration the integral of area control error as the control signal. An integral controller provides zero steady state deviation but it exhibits poor dynamic performance [3]. To improve the transient response, various control strategies such as linear feedback, optimal control and variable structure control have been proposed [8][9]. However, these methods need some information of the systems states, which are very difficult to know completely. Thus various methods have been used to obtain the optimum PID parameter from conventional methods to heuristic optimization technique such as Genetic algorithm, simulated annealing, particle swarm etc.

Fuzzy controller is other algorithm which is used for implementing PID controller. It is easy to understand because of its natural representation of control knowledge [4]. But most fuzzy controllers use two inputs, takes the error into account, rate of change of error approximately behaves like a PD controller, and there exist steady-state error when industrial process systems are controlled by fuzzy controller. The steady-state error of the control system is eliminated to consider the integration of error in input of the fuzzy controller. Thus, a fuzzy controller can be realized with three inputs, error, error change rate and integration of error. However, in practice it is hard to implement because of the difficulty in constructing control rules base as it is not easy in the practice to observe the integration of error. Also adding one input variable in fuzzy controller will greatly increase the number of control rules [2][4].

The other way is the artificial neural network that has the ability of learning and function approximation. In addition, the artificial neural network learning processes are independent of human intervention and expert experiences. For such situations, ANN is used to approximate PID formula to realize ANN-PID controller.

3. PID CONTROL PRINCIPLE
Since today computer is accessed in control field, digital computer is used to replace simulated computer adjuster to form compose computer control system, thus these digital computer is not only used to achieve PID control algorithm, but also can use the computer's logic function to make PID control more flexible. In the production process digital PID control is the most commonly used control method, widely used in metallurgy, machinery, chemical and other industries. In the simulated control system, the PID controller is controlled according to the proportion of deviation (P), integral (I) and differential (D) is the most widely used automatic controller, the control principle as shown in figure 1 and is given by the equation[1].

$$U(t) = K_p[e(t) + \frac{1}{Ti}\int_0^t e(t)dt + \frac{Tde(t)}{dt}].....[1]$$

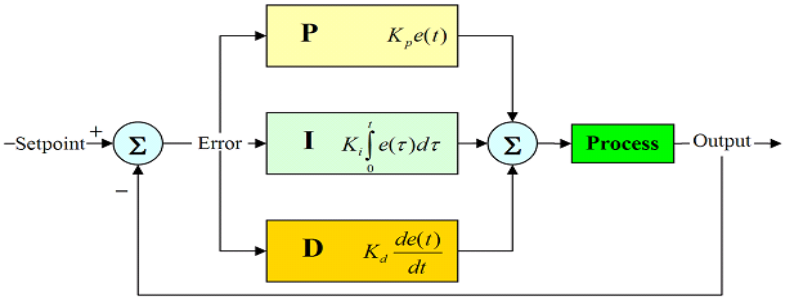

Figure1: PID Controller

Therefore, PID controller has the following characteristics:

Principle is simple, easy to achieve, it is a basic controller that can meet the majority of actual needs, controller can be applied to a variety of different objects, the algorithm has strong structural robustness in many cases, its control quality is not sensitive to the structure and parameter perturbations of controlled object.

The main limitation of PID control is its dependence on the controlled object, generally needs to know in advance the mathematical model of the controlled object to design. In practical industrial control, due to this requirement the controlled object has non-linear, time variability and other characteristics, so it is difficult to establish accurate mathematical model or the characteristic parameters obtaining online, making its application limited.

4. ARTIFICIAL NEURAL NETWORK

Artificial Neural Networks (ANNs) can solve great variety of problems in areas of pattern recognition, image processing and medical diagnostic, robotics etc. The biologically inspired ANNs are parallel and distributed information processing systems.

In order to capture and represent complex input/output relationships, Neural Network is a powerful data-modeling tool. The motivation for the development of neural network technology stemmed from the desire to develop an artificial system that could perform "intelligent" tasks similar to those performed by the human brain. Neural networks resemble the human brain in the following two ways:

1. A neural network acquires knowledge through learning.

2. A neural network's knowledge is stored within inter-neuron connection strengths known as synaptic weights.

The concept of ANNs is emerged from the principles of brain that are adapted to digital computers. The first work of ANNs were the models of neurons in brain using mathematics rule. Each neuron in ANNs takes some information as an input from another neuron or from an external input. This information is propagated as an output that are computed as weighted sum of inputs and applied as non-linear function as shown in figure2.

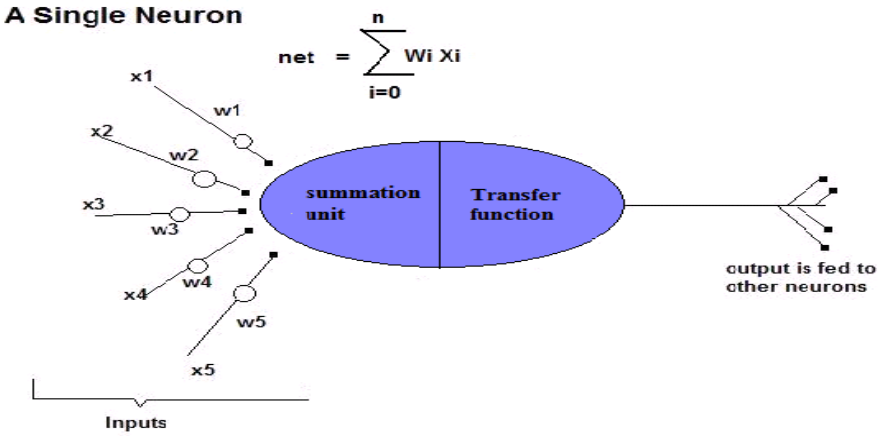

Figure2: Block diagram for single neuron

Neural network are a form of multiprocessor computer system with:

1. Simple processing element,

2. High degree of interconnection,

3. Adaptive interaction between elements.

5. ADVANTAGES OF NEURAL NETWORK FOR PID CONTROLLER

Artificial neural network is a powerful data-driven, self-adaptive and flexible computational tool having the capability of capturing nonlinear and complex underlying characteristics of any physical process (e.g. damage detection) with a high degree of accuracy.

When an element of neural network fails, it can continue without any problem because of there parallel nature.

Adaptive learning: An ability to learn how to do tasks based on the data given for training or initial experience. It is thus helpful where formulating an algorithmic solution is difficult or where examples of the behavior is available.

Self-Organization: An ANN can create its own organization or representation of the information it receives during learning time.

Real Time Operation: ANN computations may be carried out in parallel, and special hardware devices are being designed and manufactured which take advantage of this capability.

Thus, these advantages of neural network overcomes the disadvantages of conventional controller. As an example surge tank has been implemented using neural controller.

6. RESULTS

Following are the results so obtained for controller used in surge tank.Figure 3 shows the feedback linearizing input through controller comparison to reference input. Shows the precision of controller to maintain water level as required for the surge tank.

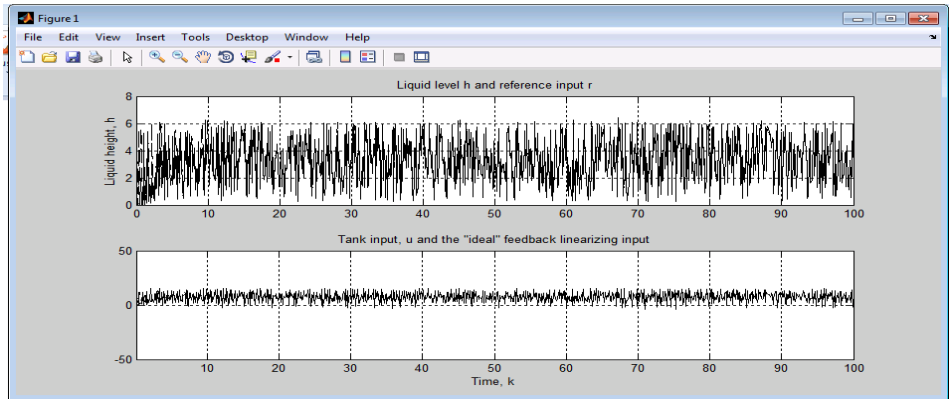

Figure.3 Comparison of tank input and ideal feedback linearizing input

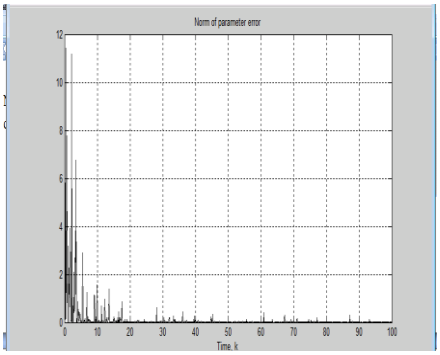

Figure 4. Norm of parameter error for proposed controller

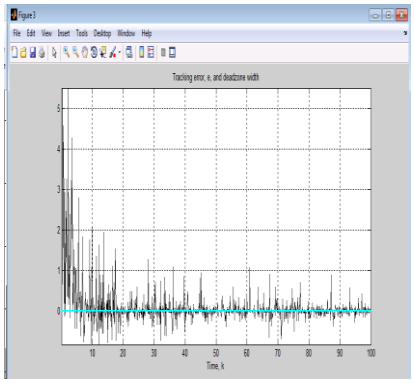

Figure 5. Tracking of the error

7. CONCLUSION

In this paper, we have discussed various ways of implementing PID controller and there disadvantages. The advantages of neural network for implementing PID controller to e which has strong adaptive and self-learning capability, which further improves the performance of PID controllers removing the drawbacks of conventional PID. Neural PID controller for the surge tank has been implemented. Thus, the neural controller could be useful in various areas of application like automation.robotics etc. providing the precision required.

8. ACKNOWLEDGMENT

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