ANFIS Controller And Its Application

Akhil V. Gite, Raksha M. Bodade, Bhagyashri M. Raut
Department of Electronics & Telecommunication
Jawaharlal Darda Institute of Engineering and Technology Yavatmal
Maharashtra State, INDIA

Abstract

The concept of fuzzy logic and artificial neural network for control problem has been grown into a popular research topic in recent years. The reason is that the classical control theory usually requires a mathematical model for designing the controller. The inaccuracy of mathematical modeling of the plants usually degrades the performance of the controller, especially for nonlinear and complex control problems. The advent of the fuzzy logic controllers (FLC) and the neural controllers based on multilayered neural networks has inspired new resources for the possible realization of better and more efficient control. In recent years, the integration between fuzzy logic and neural network namely fuzzy neural network (FNN) has been proposed and developed; generally the combination of fuzzy logic and neural network is called as ANFIS (Adaptive Neuro Fuzzy Inference System). Neural system has many input and also has multiple outputs but the fuzzy logic has multiple inputs and single output, so the combination of this two is know as ANFIS which is used for nonlinear applications.[1]

Keywords:- ANFIS, Artificial neural network, Temperature control, PID.

I. INTRODUCTION

Process control systems are often nonlinear and difficult to control accurately. Their dynamic models are more difficult to derive than those used in aerospace or robotic control, and they tend to change in an unpredictable way. The conventional PID controllers, in various combinations have been widely used for industrial processes due to their simplicity and effectiveness for linear systems, especially for first and second order systems. It has been well known that Proportional Integral Derivative (PID) controllers can be effectively used for linear systems, but usually cannot be used for higher order and nonlinear systems [3]. This paper addresses an application that involves the temperature control system also it address to the application of water bath temperature controller. Other controller such as PID was not accurate for non-linear system but this ANFIS controller is accurate as compared to other controllers also it is useful for nonlinear system. This is the biggest advantage of this controller. So by training the neural and combining with will gate the ANFIS Controller which used for temperature water bath control, intelligent temperature water bath control

II. LITERATURE SURVEY

Fuzzy systems have the ability to represent comprehensive linguistic knowledge: given for example by a human expert and perform reasoning by means of rules. However, fuzzy systems do not provide a mechanism to automatically acquire[2] or tune those rules. On the other hand neural-networks are adaptive systems that can be trained and tuned from a set of samples. Once they are trained, neural-networks can deal with new input data by generalizing the acquired knowledge. Nevertheless, it is very difficult to extract and understand that knowledge. In other words, fuzzy systems and neural-networks are complementary paradigms [4]. The fuzzy logic controllers and the neural networks (both static and dynamic) are two modern system analyses which had been applied successfully in many practical applications .These two techniques are very useful when the system under study is partially unknown and previously assumed to be nonlinear. The combination between the two methods (Neuro-fuzzy control systems) is a powerful identification and control technique [5]. In recent years, Fuzzy Inference Systems (FISs) and Artificial Neural Networks (ANNs) have attracted considerable attention as candidates for novel computational systems because of the variety of the advantages that they offer over conventional computational systems. Unlike other classical control methods, Fuzzy Logic Control (FLC) and ANNs are more model free controllers, i.e. they do not require exact mathematical model of the system [6]. For non-linear modeling, neural networks and neuro-fuzzy modeling approaches have received a great deal of attention. The drawbacks are the complexity and the darkness of their structures, especially, in modeling complex nonlinear systems. It has been shown that many types of nonlinearities in industry processes are effectively modeled with

hybrid models, like heating and cooling processes, fermentation, solid drying processes, continuous stirred tank reactor (CSTR) [7]. The temperature system has non linearity, long delay time, and large time constant and undetermined system. At present Industries uses the PID technique for temperature control. PID control is a crisp control, the self tuning of the P, I, D parameters are quite difficult and the resultant control is with overshoot and with large time constants [4]. Fuzzy logic used to express uncertainty in an expert system. The problem of Fuzzy controller is reduced to acquisition of a correct set of IF-THEN rules that can be obtained by human expert. ANFIS controller is the combination of fuzzy logic and ANN and capable to generate expert systems by itself. [8].The fixed gain feedback controllers (PID) are insufficient to compensate for parameter variations in the plant as well **as** to adopt to changes in the process environment. The Advent of Fuzzy Logic Control (FLC) has inspired new resources for more efficient control. It does not require a ***priori*** model of the process for implementation. In the traditional FLC the optimal membership values are found by trial and error which is laborious. Also the conventional method of transferring the range of input variables into corresponding universe of discourse is time consuming. The transfer of the range of input variables into corresponding universe of discourse can be carried out using Artificial Neural Networks [9]. The applications of neural networks to control systems have become increasingly important. The backpropagation neural network based on the generalized delta learning rule, a gradient descent search technique, has been widely used. The backpropagation algorithm has several disadvantages, among which is lack of guaranteed convergence, but it's simple yet powerful mathematical algorithm has made it the mainstay of neuro-computing. Before the neural network can be used as a controller, it first must learn the model of the plant. There are several learning architectures proposed whereby the neural network may be trained [10].

III. SYSTEM OVERVIEW

Takagi and Sugeno proposed the T-S fuzzy model in1985. Students called it as Sugeno fuzzy model after. The Sugeno fuzzy model is a nonlinear model. It can aptly express the dynamic characteristic of complex systems. Furthermore, it is the fuzzy inference model that is in the most common use. A typical fuzzy rule in a Sugeno fuzzy model has the format:

If x is A and y is B, Then Z=f(x,y)

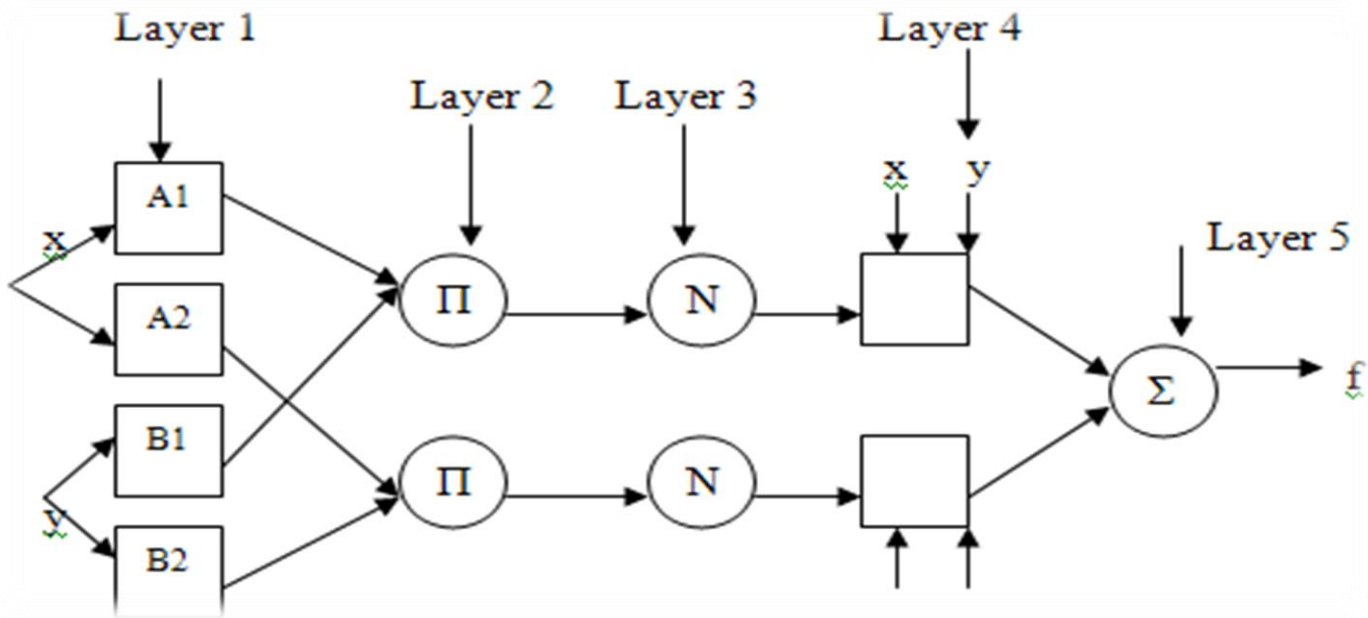
Where A & B are fuzzy set antecedent, Z=f(x,y) is a crisp function in the Consequent.

Let us assume the fuzzy inference system with two inputs x and y and one output. Suppose that the rule base contains two fuzzy if-then rules of Takagi and Sugeno's type as given below:

$$\text{Rule 1: If x is } A_1 \text{ and y is } B_1 \text{ Then } f_1 = p_1x + q_1y + r_1$$

$$\text{Rule 2: If x is } A_2 \text{ and y is } B_2 \text{ Then } f_2 = p_2x + q_2y + r_2$$

IV. ANFIS structure for 2 –input variables for TSK Model



Layer 1: Every node i in this layer is a square node with a node function

$$O_{1,i} = \mu_{A_i}(x) = exp\left[-\left(\frac{x - m_i}{\sigma_i}\right)^2\right] for$$

$$O_{1,i} = \mu_{B_{i-2}}(x) = exp\left[-\left(\frac{x - m_i}{\sigma_i}\right)^2\right] fo$$

where x is the input to node 0, and A is the linguistic label associated with this node function.
In other words, μ is the membership function of A, and it specifies the degree to which the given x satisfies the quantifier Ai. Gaussian Membership function is chosen with maximum equal to 1 and minimum equal to 0. Parameters in this layer are referred to as the premise parameters. Membership functions are used for each of the input in this layer. [1]

Layer 2: Every node in this layer is a circle node labeled H, which multiplies the incoming signals and sends the product out. For instance,

$$O_{2,i} = w_i = \mu_{A_i} * \mu_{B_i} for\ i = 1,2$$

Each node output represents the firing strength of a rule.[1]

Layer 3: Every node in this layer is a circle node labeled N. The i-th node calculates the ratio of the i-th rule's firing strength to the sum of all rules' firing strengths:

$$O_{3,i} = \bar{w}_i = \frac{w_i}{w_1 + w_2} for\ i = 1,2$$

For convenience, outputs of this layer will be called normalized firing strengths. [1]

Layer 4: Every node 1 in this layer is a square node with a node function

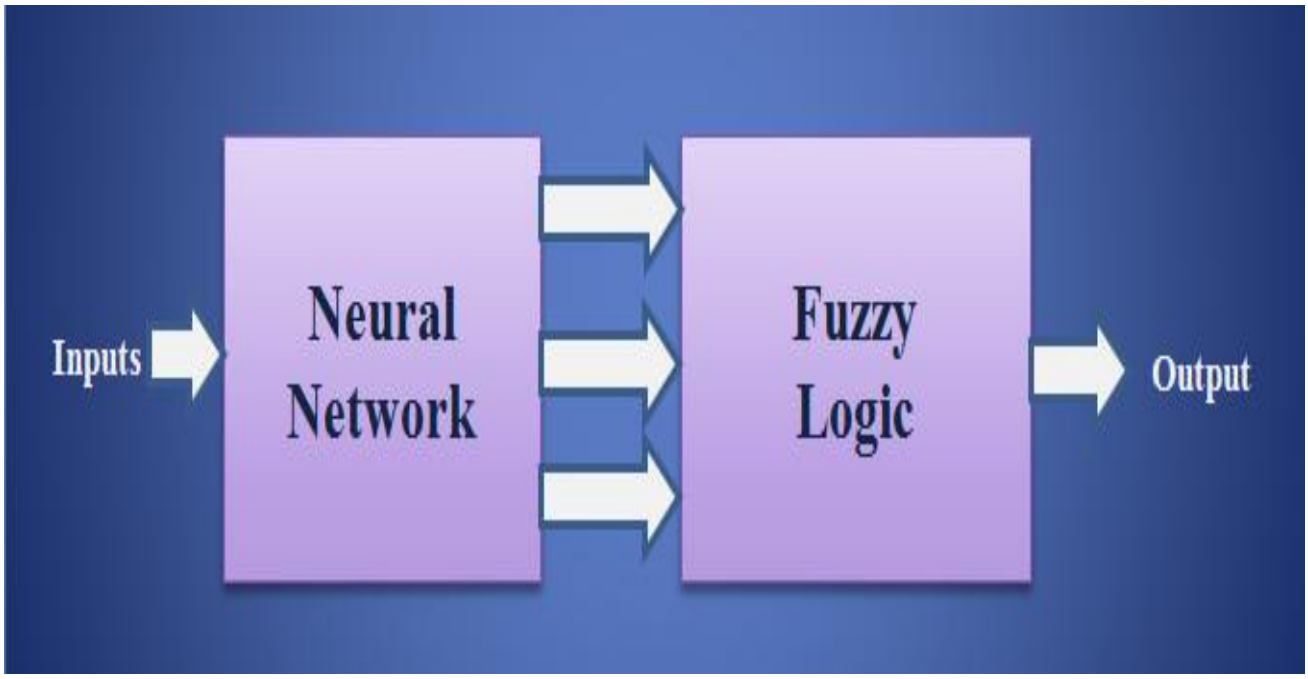
$$O_{4,i} = \bar{w}_i f_i = \bar{w}_i(p_i x + q_i y + r_i)$$

Where $\bar{w}_i$, is the output of layer 3 and {pi, qi, ri} is the parameter set. Parameters in this layer will be referred to as consequent parameters.[1]

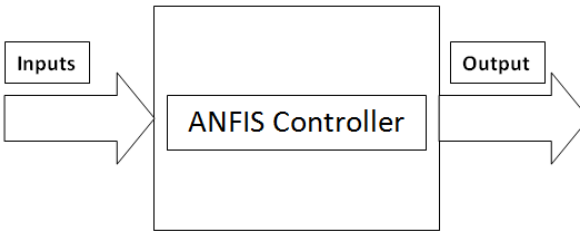
Layer 5: The single node in this layer is a circle node labeled E that computes the overall output as the summation of all incoming, signals, i.e.

$$O_5 = f = \sum_i \bar{w}_i f_i$$

V. ANFIS Model



This is the block diagram of ANFIS Controller, ANFIS controller is the combination of neural network and Fuzzy Logic. Many inputs are applied to the neural network depending upon the inputs the neural network has some standard output, so depending upon the input and the output the neural network is trained, after training the neural network the output is applied to the fuzzy logic which generates the IF THEN rules and membership functions, This is done in MATLAB Below is the block diagram of ANFIS controller



VI. APPLICATION

This ANFIS controller is widely used for controlling the non-linear system. As this is the best controller as compared to conventional PID controller, and other controller. This controller is used in Temperature water bath controller. Also
this controller is used in planes to controller them now a days research is going on for Intelligent Planes which learn by themselves and do take take off and landing so these are the applications

VII. CONCLUSION

In this paper a ANFIS controller for temperature control of a water bath system is proposed. ANFIS based NFC is suitable for adaptive temperature control of a water bath system. As ANFIS is the combination of Neural Network and Fuzzy Logic, and it gives accuracy to non-linear systems Hence ANFIS is the good controller as compared to other controller, and it is widely being used.

ACKNOWLEDGEMENT

The authors would like to thank firstly, our GOD, and all friends who gave us any help related to this work. Finally, the most thank is to our families and to our country INDIA which born us.

REFRENCES

[1] Jafar Tavoosi, Majid Alaei, BehrouzJahani, Mohammad Amin Daneshwar, "A Novel Intelligent Control System Design for Water BathTemperature Control" ISSN 1991-8178

[2] **T.P.Mote, Dr.S.D.Lokhande, "**Temperature Control System Using ANFIS" ISSN: 2231-2307, Volume-2, Issue-1, March 2012

[3]Ajay B Patil "Adaptive Neuro Fuzzy Controller for Process Control System", 978-1-4244-2806-9/08/2008, IEEE.

[4]Kaijun Xu, Xiaoping Qiu ,Xiaobing ,Li Yang Xu "A dynamic neuro-fuzzy controller for gas-Fired water heater", 3304-9/08 /2008 IEEE.

[5]Valdez D., Ortiz V., Cabrera A. and Chairez I "Extended Kalman FilterWeights Adjustment For Neonatal Incubator Neurofuzzy Identification", 0-7803-9489-5/06/$20.00/©2006 IEEE.

[6]Otman M. Ahtiwash and Mohd Zaki Abdulmuin, V.N. Alexandrov "An Adaptive Neuro-Fuzzy Approach for Modeling and Control of Nonlinear Systems", ICCS 2001, LNCS 2074, 198–207, 2001. Springer-Verlag Berlin Heidelberg.

[7]J. A. Vieira, F. Morgado Dias and A. M. Mota "Hybrid Neuro-Fuzzy Network-Priori Knowledge Model in Temperature Control of a Gas Water Heater System", 0-7695-2457-5/0 /2005, IEEE.

[8]S.Ravi P .A.Balakrishnan, "Modeling And Control of an ANFIS Temperature Controller For Plastic Extrusion Process", 978-1-4244-7770- 8/10/2010 IEEE.

[9]Advanced Control Schemes for Temperature Regulation of Air Heat Plant 0-7803-5406-0/99/1999**,** IEEE.

[10]Marzuki Khalid and Sigeru Omatu "A Neural Network Controller for Temperature Control System", 0272- 1708/92/1992IEEE.