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Application of ANFIS for Water Flow Rate Control in a Rawmill of Cement Manufacturing Process

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Abstract— ANFIS (Adaptive Neuro Fuzzy Inference System) model of flow rate control system is developed for water flow rate control in a rawmill of cement industry using ANFIS Editor GUI (Graphical User Interface). Rawmill is a mill which is used to grind the raw materials used in manufacturing of cement. It is essential to control water flow rate efficiently to produce high quality cement. ANFIS combines the learning capabilities of neural networks and control capabilities of fuzzy logic control. Water flow rate control system is two input and one output system. This concept is taken from ambuja cement plant. In this paper, ANFIS model is presented and the experimental results of the developed model are also shown.

Index Terms— ANFIS, flow rate control, process value, rawmill, setpoint.

I. Introduction

The cement production is one of the most fundamental industries. The cement can be found almost everywhere in the everyday life and the industrial society cannot be imagined without it. Due to increasing population, various constructional activities are increasing day by day. As a result the market demand of cement is also increasing continuously. The Indian cement industry is the second largest producer of cement in the world, just behind China but ahead of the United States and Japan [1]. Cement is typically made from limestone and clay or shale [2]. The cement manufacturing process consists broadly of mining, grinding in a rawmill, heating in a kiln, clinker cooling, finish milling, packing and loading [1]. The quality of the produced cement depends on the raw materials and also on the processing operations. The control system of the cement production controls these operations to produce the maximum quantity of the cement with prescribed quality and minimum cost. Our interest is to control water flow rate in raw grinding systems.
The rest of the paper is organized as follows: Section 2 gives overview of ANFIS, section 3 shows the development of ANFIS controller with results in section 4, and section 5 reports the conclusion of the paper.

II. Anfis

The acronym ANFIS derives its name from adaptive neuro fuzzy inference system. ANFIS is a hybrid neuro fuzzy technique that brings learning capabilities of neural networks to fuzzy inference systems. Jang was one of the first to introduce ANFIS. He reported that the ANFIS architecture can be employed to model nonlinear functions [3]. This technique provides a method for fuzzy modeling procedure to learn information about a data set, in order to compute membership function parameters that best allow the associated FIS to track the given input/output data. Using a given input/output data set ANFIS constructs a FIS whose membership function parameters are tuned. The modeling approach used by ANFIS is: first to hypothesize a parameterized model structure. Next, collect input/output data in a form that will be usable by ANFIS for training [4]. In ANFIS two optimization methods are available one is back propagation and other is hybrid in which back propagation is combined with least squares method.
ANFIS Architecture: In ANFIS, Takagi-Sugeno type fuzzy inference system is used. The output of each rule can be a linear combination of input variables plus a constant term or can be only a constant term. The final output is the weighted average of each rule's output. Basic architecture with two inputs x and y and one output z is shown in fig. 1.
Suppose that the rule base contains two fuzzy if-then rules of Takagi and Sugeno's type.
Rule 1: If x is A_1 and y is B_1, then $f_1 = p_1x + q_1y + r_1$,
Rule 2: If x is A_2 and y is B_2, then $f_2 = p_2x + q_2y + r_2$.

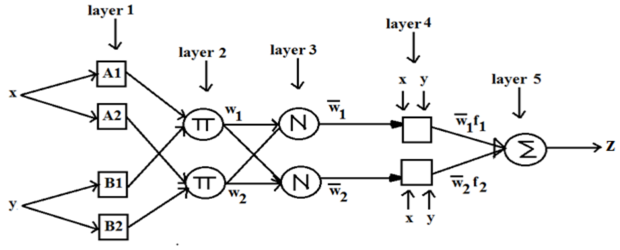

Fig. 1 Architecture of ANFIS [3]

Layer 1: Every node *i* in this layer is an adaptive node with a node function

$$O_i^1 = \mu_{A_i}(x) \qquad (1)$$

Where x is the input to node *i*, and A_i is the linguistic label (small, large, etc.) associated with this node function. In other words, O_i^1 is the membership function of A_i and it specifies the degree to which the given x satisfies the quantifier A_i. Usually we choose μ_{A_i}(x) to be bell shaped with maximum equal to 1 and minimum equal to 0, such as

$$\mu_{A_i}(x) = \frac{1}{1+[(\frac{x-c_i}{a_i})^2]b_i} \qquad (2)$$

or

$$\mu_{A_i}(x) = e^{\{-(\frac{x-c_i}{a_i})^2\}} \qquad (3)$$

Where $\{a_i,\ b_i,\ c_i\}$ is the parameter set. As the values of these parameters change, the bell shaped functions vary accordingly, thus exhibiting various forms of membership functions on linguistic label A_i. In fact, any continuous and piecewise differential functions, such as trapezoidal or triangular shaped membership functions, can also be used for node functions in this layer. Parameters in this layer are referred to as premise parameters.

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

$$w_i = \mu_{A_i}(x) * \mu_{B_i}(y),\ i = 1{,}2. \qquad (4)$$

Each node output represents the firing strength of a rule.

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

$$\overline{w}_i = \frac{w_i}{w_1+w_2},\ i = 1{,}2. \qquad (5)$$

For convenience, outputs of this layer will be called as normalized firing strengths.

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

$$.O_1^4 = \overline{w}_i f_i = \overline{w}_i(p_i x + q_i y + r_i) \qquad (6)$$

Where $\overline{w}_i$ is the output of layer 3, and $\{p_i,\ q_i,\ r_i\}$ is the parameter set. Parameters in this layer will be referred to as consequent parameters.

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

$$O_1^5 = overall\ output(z) = \sum_i \overline{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i} \qquad (7)$$

III. Development of ANFIS Controller

This controller for flow rate control system is developed using ANFIS Edit GUI with two inputs and one output. The two inputs correspond to change in setpoint and difference between process value and set point take the name 'input1' and 'input2' respectively. The output corresponds to the flow rate of water and takes the name 'output'. The two inputs each have four triangular membership functions and output has sixteen membership functions of constant nature. This generated FIS is then trained for a inputoutput data set gathered from technical expertise. The membership functions of input1 and input2 take a scale of -4˚C - 6˚C and 0˚C - 1˚C respectively as shown in Fig. 2 and Fig. 3. ANFIS architecture for flow rate control system is shown in Fig. 4. The rule base of the neuro-fuzzy controller is given in Table 1.

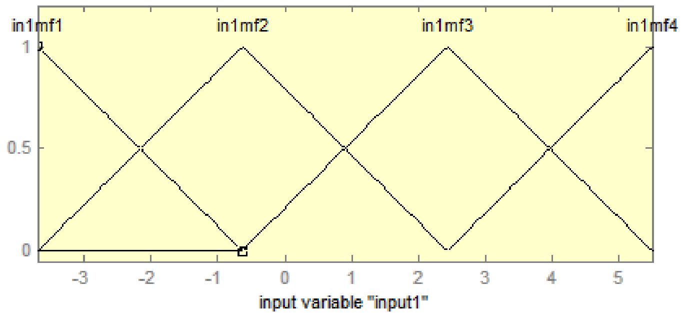

Fig. 2 Input1 membership functions

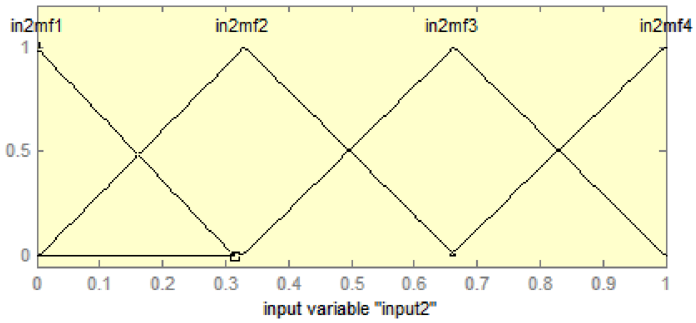

Fig. 3 Input2 membership functions

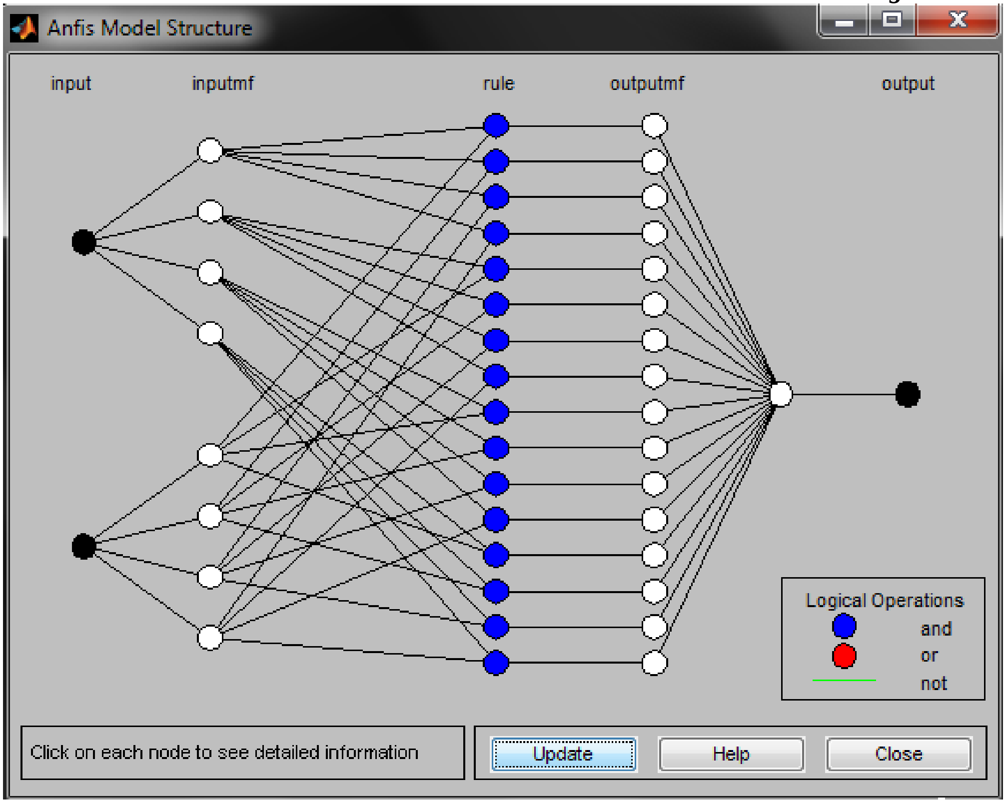

Fig. 4 Architecture of neuro-fuzzy system

Table 1 Rule Base

S. No.	Input1	Input2	Output
1.	In1mf1	In2mf1	Out1mf1
2.	In1mf1	In2mf2	Out1mf
3.	In1mf1	In2mf3	Out1mf
4.	In1mf1	In2mf4	Out1mf
5.	In1mf2	In2mf1	Out1mf
6.	In1mf2	In2mf2	Out1mf
7.	In1mf2	In2mf3	Out1mf
8.	In1mf2	In2mf4	Out1mf
9.	In1mf3	In2mf1	Out1mf
10.	In1mf3	In2mf2	Out1mf
11.	In1mf3	In2mf3	Out1mf
12.	In1mf3	In2mf4	Out1mf
13.	In1mf4	In2mf1	Out1mf
14.	In1mf4	In2mf2	Out1mf
15.	In1mf4	In2mf3	Out1mf
16.	In1mf4	In2mf4	Out1mf

IV. Experimental Results

Surface viewer is shown in fig. 5. Surface viewer is used to examine the dependency of output on both inputs. Fig. 6 & 7 show the dependency of output on input1 and input2 individually.

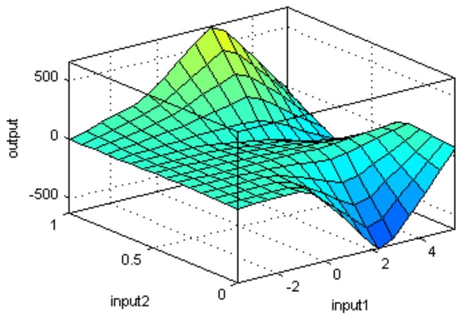

Fig. 5 Surface Viewer of Controller

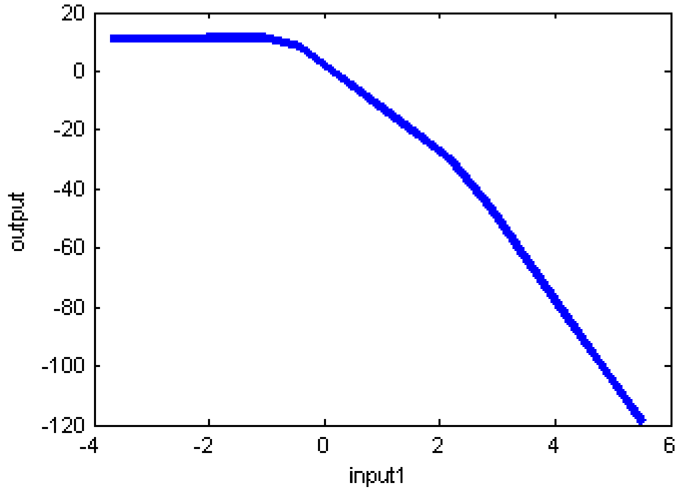

Fig. 6 Graph between input1 and output

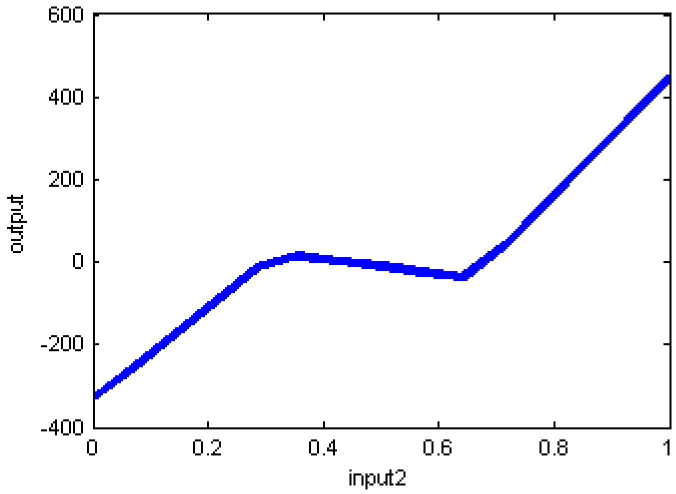

Fig. 7 Graph between input2 and output

From these experimental results it can be deduced that ANFIS controller for water flow rate control provides smoother control. From the curve in Fig. 6 it is evident that flow rate of water decreases with increase in difference between present and previous setpoint temperature. Because as the setpoint increases then flow rate decreases. From curve in Fig. 7 it is evident that flow rate of water increases with increase in difference between actual temperature and required temperature i.e. if actual temperature is greater than the required temperature then flow rate should also be increased to maintain required temperature. Hence, the system can be easily and efficiently controlled with the usage of ANFIS.

V. **Conclusion**

It can be concluded from this paper that ANFIS model provides an efficient control for flow rate control system in a rawmill. Neuro-fuzzy algorithm is definitely superior to fuzzy logic algorithm as it inherits adaptability and learning.

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References

[1] Akash Samanta, Ankush Chowdhury, and Arindam Dutta, “Process Automation of Cement Plant” International Journal of Information Technology, Control and Automation (IJITCA) Vol.2, No.2, April 2012.

[2] Can Ozsoy and Cuneyt Yilmaz, “Constrained Self-Tuning Control of Raw Material Blending Process in Cement Industry” IEEE International Symposium on industrial Electronics, Vol. 1, pp. 135-142, 1997.

[3] Jyh Shing and Roger Jang, “ANFIS: Adaptive-Network-Based Fuzzy Inference System”, *IEEE Transactions on Systems, Man, and Cybernetics*, vol. 23, Issue 3, pp 665-685, May/June 1993.

[4] MATLAB(R2008b)/Help.

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