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PREFACE

The objectives of the International Conference on Information System Computer Science and Engineering (ICONISCSE) are to gain and expand knowledge of the latest issues, opinions, brilliant ideas about constructive comprehensive technological developments from students, researchers, and academics to bring new innovations in technology to a better future especially in the field of software engineering, computer engineering, computer science and information system.

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Implementation of Backpropagation Neural Network and Extreme Learning Machine of pH Neutralization Prototype

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Implementation of Backpropagation Neural Network and Extreme Learning Machine of pH Neutralization Prototype

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Abstract. This paper presents a comparison between Backpropagation Neural Network and Extreme Learning Machine for pH neutralization process. The system has one input variable and two output variables. The input is pH value in neutralization container and the outputs are time on solenoid valve of acid solution and time on solenoid valve of base solution. There is a sequence system in pH neutralization process to regulate the flow of liquids under certain conditions, so that the liquid does not exceed the maximum capacity if the pH has not reached the setpoint. The performance analysis is done for Backpropagation Neural Network and Extreme Learning Machine implementation in neural region by keeping setpoint 7. From the implementation result, it is found that Backpropagation Neural Network gives better result when compared with Extreme Learning Machine for pH neutralization prototype.

1. Introduction

Wastewater contains acidic or alkaline materials which need to be neutralized before being discharged into water bodies or before entering further process. pH Neutralization requires additional chemicals. In this paper, the weak acid (CH_3COOH) is reacted with a strong base ($Ca(OH)_2$) to reach a neutral pH. The pH sensor used to measure pH in real time and pH controlling. There is a refill system if acid-base solution (for pH neutralization) runs out. pH has not reached to the set point, but full neutralization container is possible. So, a container is required to hold a temporary liquid if neutralization tub is full. All pH neutralization process can be monitored via computer with Visual Studio. Some studies have been done in the pH neutralization controlling, but there is no facility to store acid base solution. Solenoid valve is used to keep pressure in vessel[1]. Two control valves (Equal Percentage type) with 2-way which are used for acid and base flow respectively [2]. Though the use of pumps can be moved to the tank storage system, to save energy, for unit cost per kilowatt-hour (kwh) varies on the time of day [3]. On/off solenoid valves implement to change expensive servo valves[4]. Artificial Intelligent currently has a big power to overcome all kinds problem in real life with the complexity [5]. Artificial neural networks are widely used to solve to complex problems and the backpropagation algorithm has great advantage of simple implementation. It looks for the minimum of the error function [6]. Unlike traditional learning theories, Extreme Learning Machine can randomly generated [7].

2. Methodology

2.1 Design System

The system works automatically to control pH by applying the Backpropagation Neural Network or Extreme Learning Machine. Before the pH of the liquid is neutralized, the liquid from the liquid sample

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container is driven by a DC water pump to the neutralization container. In neutralization container, a method is used to control pH. Data from pH sensor is an input that is processed by the controller. *Time on solenoid valve acid* and *time on solenoid valve base* are the outputs. Backpropagation Neural Network or Extreme Learning Machine are used for controlling time on of solenoid valves. In order for the liquid overload of the neutralization container when the pH has not reached the set point, a temporary storage container is used to temporarily accommodate the liquid. The liquid is returned from temporary storage container to neutralization container if the liquid less than the maximum capacity. If the pH has reached the set point so the liquid is taken out from the neutralization container to the next stage.

2.2 Hardware Design

Figure 1 show the design of a pH control system consists of 5 containers and two tanks. The container is a pH-controlled liquid sample container, neutralization container, temporary storage container, acid solution supply container and base solution supply container. While the two tanks contain acid and base solutions to control pH to fit the set point. The capacity of the three containers is different. The capacity of liquid sample tank is 15 liters, neutralization container is 12 liters, temporary storage container is 6 liter container, 6 liters of base solution and 6 liters of acid solution.

To measure the pH value, the pH E-201C probe is used which is connected to the pH V1.1 DFRobot module. To measure the pH value, the pH E-201C probe is used which is connected to the pH V1.1 DFRobot module. Solenoid valve 1/2 inch is used to regulate acid and base solution. Submersible water pump 12 V DC with a discharge of 240 liters / hour, it is used for the distribution of liquids from liquid sample tanks to neutralization tanks, neutralization tanks into temporary storage and temporary storage tanks to neutralization tanks. 12 V DC motor 50 RPM is used as a stirrer.

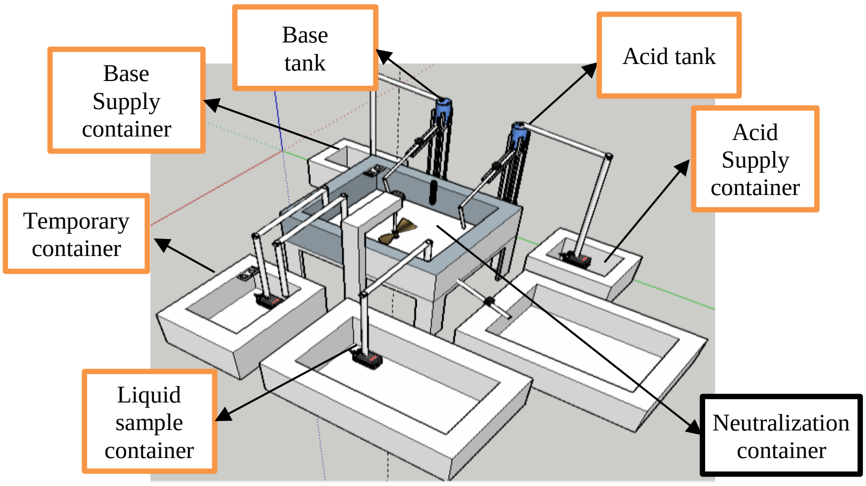

Figure 1 Design of pH neutralization process

2.3 Software Design

Software designs are the implementation of Backpropagation Neural Network and Extreme Learning Machine on microcontrollers for pH neutralization processes and monitoring system with Visual Studio. Input and output parameters are trained with matlab to find weight, bias weights for Backpropagation Neural Network and beta values for Extreme Learning Machines.

2.4 Application of Backpropagation Neural Network

pH value is the input, time on of base solenoid valve and time on of the acid solenoid valve is the output of the Backpropagation Neural Network. The probe is placed in a neutralization container to detect liquid pH in real time. The output variables are time on of acid solenoid valve and time on of base solenoid valve which regulate the amount of acid or base solution released. To apply Backpropagation Neural Network on the pH neutralization system, data input and output parameters are needed. Input and output parameters are learned with MATLAB. From learning input and output parameters, we get the weight and bias value. Then, the weight is applied to the microcontroller, so that it can control the pH according to the set point. In the neuron architecture there is one input of pH value and two outputs of time on acid and base solenoid valves.

Table 1. Parameter Data

Id	S1 (pH)	F1 (time on of base solenoid valve)	F2 (time on of acid solenoid valve)
1	0	1000	0
2	3.8	1000	0
3	4	850	0
4	4.4	850	0
5	4.6	800	0
6	4.8	700	0
7	5	700	0
8	5.4	600	0
9	5.8	600	0
10	6.2	200	0
11	6.6	200	0
12	7	0	0
13	7.4	0	200
14	7.8	0	300
15	8	0	400
16	8.8	0	500
17	9.4	0	500
18	9.8	0	600
19	10	0	700
20	10.4	0	700
21	10.6	0	800
22	10.8	0	800
23	11	0	850
24	11.2	0	900
25	11.4	0	1000
26	14	0	1000

The training process is done with Matlab to get the best model. Figure 2 shows the results of the MSE stop at the 608 iteration. The training results show MSE 4.2069×10^{-8} which is better than the maximum predetermined error (10^{-7}). After training with MATLAB, the next process is to apply weight and bias to microcontroller.

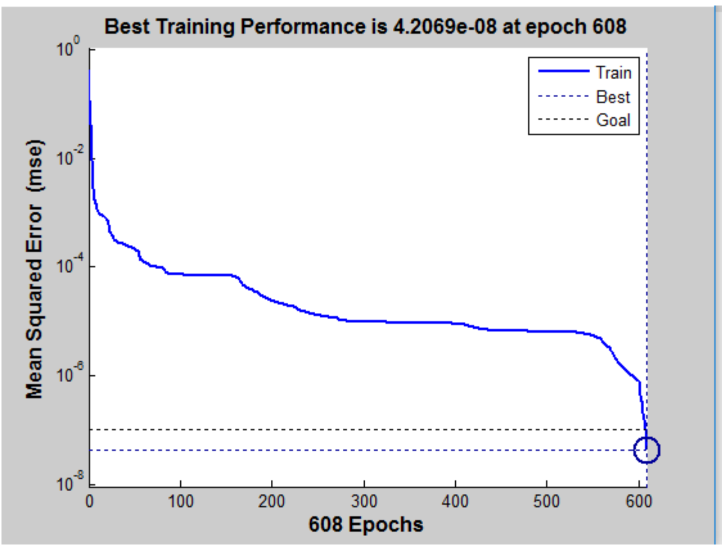

Figure 2 Mean Square Error

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2.5 Application of Extreme Learning Machine

Basically, the Extreme Learning Machine input and output parameters are the same as the input and output parameters of the Backpropagation Neural Network. Unlike traditional learning theories, hidden neurons do not require to be tuned, they can be randomly generated [7]. Implementation steps of Extreme Learning Machine method is described as follows:

1. Determine the input parameter (pH) and output (time on of solenoid valve)
2. Determine *weight* and *bias*
3. Calculate the hidden layer output value
4. Calculate *pseudo-invers* of output *hidden layer*
5. *Beta* are calculated by multiplying the hidden pseudo-inverse layer with the output parameters
6. Apply *weight, bias* and *beta* to microcontroller.

The Extreme Learning Machine neuron architecture has one input of pH value and two outputs of time on of acid and base solenoid valves. There is 1 hidden layer with 5 neurons. Pseudo-inverse of hidden layer value calculated by Matlab. This value is used to calculate beta. Beta is obtained by multiplying the hidden pseudo-inverse layer matrix with the output parameter. After getting the beta value, the next step is to implement beta, weight and bias to microcontroller.

3. Result

The implementation of the Backpropagation Neural Network and Extreme Learning Machine methods is applied to the prototype of the pH neutralization system. Performance analysis of the application of Backpropagation NN and ELM methods with initial pH value 4 to set point 7.

3.1 Result Backpropagation Neural Network

From the results of implementation on the microcontroller with set point 7, the results of pH control with the NN Backpropagation method are shown below :

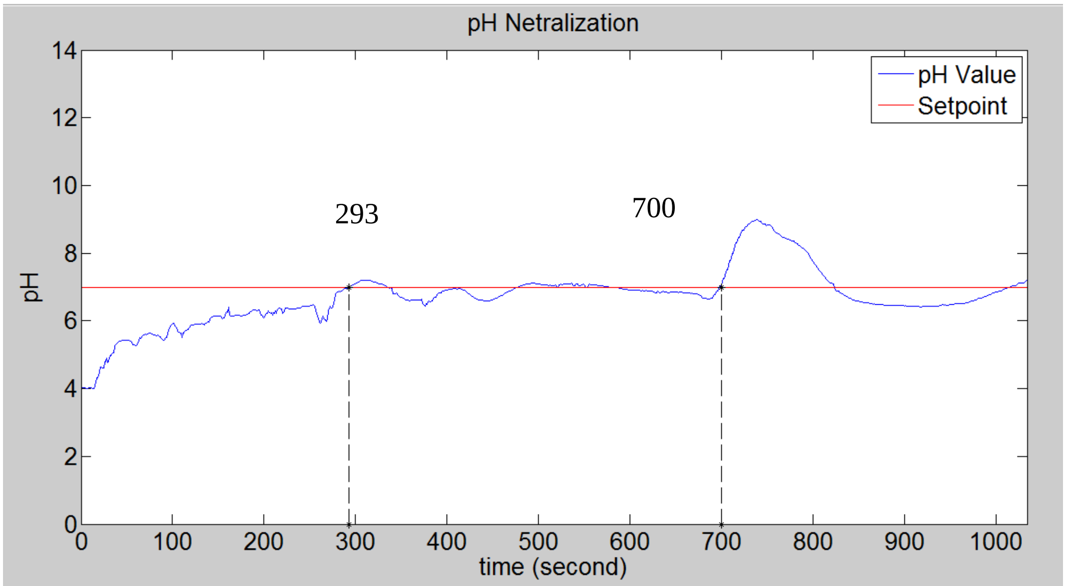

Figure 3 System response of Backpropagation Neural Network

Figure 3 shows system response of Backpropagation Neural Network implementation for pH neutralization. As shown in figure 3, pH reach to setpoint with 293 seconds. The response oscillates for three times around setpoint to reach steady state.

3.2 Result Extreme Learning Machine

From the results of implementation on the microcontroller with set point 7, the results of pH control with the Extreme Learning Machine method are shown below:

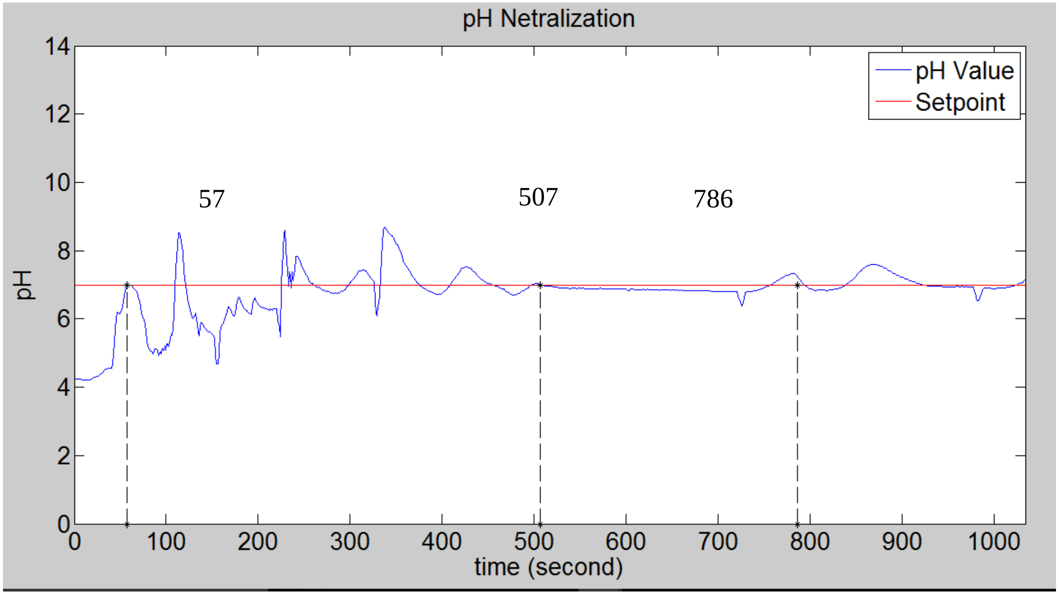

Figure 4 System response of Extreme Learning Machine

Figure 4 shows system response of Extreme Learning Machine implementation for pH neutralization. As shown in figure 4, pH reach to setpoint with 57 seconds. The response oscillates for several times to reach steady state at 507 seconds.

4. Conclusion

Result of pH neutralization to reach the set point, Backpropagation Neural Network implementation reach the setpoint with 293 seconds and average error 4.31 %. Extreme Learning Machine implementation reach the setpoint with 57 seconds and average error 3.25 %. Backpropagation Neural Network more superior with low oscillations around the setpoint to reach steady state than Extreme Learning Machine with oscillations for several times and reach steady state at 507 seconds.

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