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Design and Analysis of Neuro Controller Based on Narma – L2 Model

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ABSTRACT - This paper presents the design of Neuro Controller to implement it at Coupled tank System. The liquid level in the coupled tank is controlled as required and also to understand the habit and effectiveness of neuro Controller. Artificial neural network (ANN) is the best method to control an neutralization process and it is better than the conventional method because the mean square error (MSE) is lower and it uses the control strategies in neural network (NARMA-L2) control. The NARMA-L2 controller can be a preferable method for control purposes because it has smaller value of mean square error (MSE). This proposed second order system is implemented using the simulation software environment MATLAB/Simulink 7.13.

KEYWORDS - Neuro Controller, NARMA-L2 Control, Artificial Neural Network, Coupled tank system, Mean Square Error.

I. INTRODUCTION

Coupled two tank liquid level system consists of double tank mounted on a reservoir for liquid storage. At the centre of the double tank, there placed a baffle to divide it into two different small tanks. At the base of each tank, there have a flow valve connected to reservoir. Each of the small tanks has water pump to pump water from reservoir. Capacitance sensor is used to detect the level of the water. To measure the liquid level a scale placed in front of the tank. This equipment widely use in the food processing and chemical industries. Using neuro controller to control the level of the liquid return to the reservoir as wanted. The controller will control the water pump so that liquid in tank 2 is maintained as required. MATLAB has been used as graphic user interface and as simulation respectively

II. COUPLED TANK SYSTEM

The control of liquid level in tanks and flow between tanks is a basic problem in the process industries. In vital industries like Petro-chemical, Paper making and Water treatment industries have the coupled tanks processes of chemical or mixing treatment in the tanks, the level of fluid in the tanks and interacting between tanks must be controlled. It is essential for control system engineers to understand how coupled tank control systems work and how the level control problem is solved. The problem of level control in coupled tank processes are interacting characteristic and system dynamics. The new variable is the flow rate Q_c of fluid out of Tank 2 through valve C.

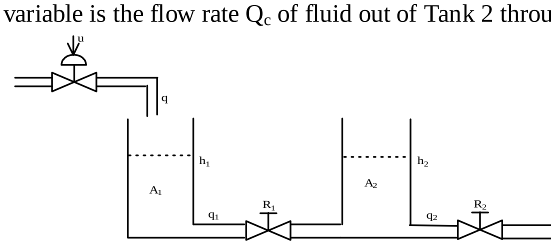

Figure 1. Block Diagram of Coupled tank system

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III. MODELING OF COUPLED TANK SYSTEM

When two tanks are joined together the coupled tank system is formed as shown in Figure 1. In the coupled tank the system states are the level H_1 in tank 1 and the level H2 in tank 2.If the control input is the pump flow rate Q1, then the variable to be controlled would normally be the second state the level H2, with disturbances caused by variations in the rate of flow out of the system by valve B. It is necessary to build a model for each of the tank levels.
For Tank 1 the flow balance equation is

$$Q_i - Q_b = A\frac{dH_1}{dt}$$

where, new variable is the flow rate Q_b of fluid from tank 1 to tank 2 through valve B.
For Tank 2 the flow balance equation is

$$Q_b - Q_c = A\frac{dH_2}{dt}$$

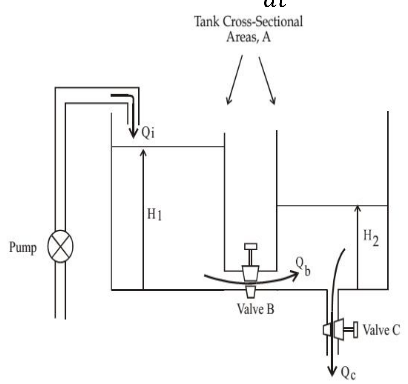

Figure 2. Coupled tank system

The system model shown in Figure 2 comes from the nonlinear equations and the two flow balances through the valves. The system non linearity is again a square root law if the valves are ideal orifices.

$$Q_i - C_{db}a_b\sqrt{2g(H_1 - H_2)} = A\frac{dH_1}{dt}$$

$$C_{db}a_b\sqrt{2g(H_1 - H_2)} - C_{dc}a_c\sqrt{2gH_2} = A\frac{dH_2}{dt}$$

Equations describe the coupled tanks system dynamics in its non-linear form with ideal equations for the valves. The square root law is only an approximation in general applications. To design the control systems for the coupled tanks the equations are linearised by considering small variations qi, h1 and h2. The variations are measured with respect to the normal operating levels.

IV. NEURO CONTROLLER

The ability of humans to be able to recognize and explain their environment is based on the capability of establishing relations between information and information units. The brain's powerful capabilities in thinking, interpreting, remembering and problem-solving have led scientists to simulate the brain's functionality with very simplified computer models. One result of such work is a computing approach different from the commonly known approach of sequential digital computing. It is referred to as (NN) computing or (ANN).

By simulating some of the features of biological networks of neurons, (ANN) are able to analyse data, for patterns, and then make predications on the basis of those patterns. The guiding principle of neural network is to imitate the nervous system considering some relevant aspects of its microstructure, as neurons and synapses. The final aim would be to obtain a human-like behaviour with regard to the solutions of important problems as classification, prediction decision-making, etc.,. Using the NARMA-L2 model, you can obtain the controller which is realizable for (d ≥2). The following figure is a block diagram of the NARMA-L2 controller .

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$$u(k+1) = \frac{y_r(k+d) - f[y(k), \ldots, y(k-n+1), u(k), \ldots, u(k-n+1)]}{g[y(k), \ldots, y(k-n+1), u(k), \ldots, u(k-n+1)]}$$

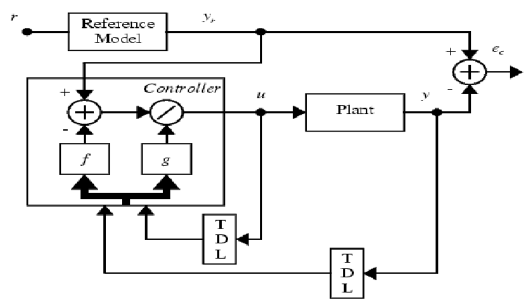

Figure 3. Block diagram of the NARMA-L2 control

This controller can be implemented with the previously identified NARMA-L2 plant model, as shown in Figure 3.

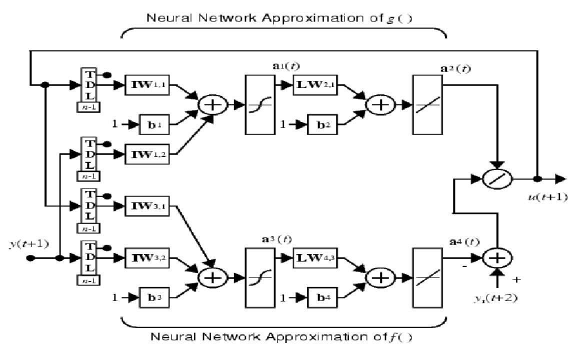

Figure 4. NARMA-L2 control structure

V. SIMULATION RESULT

Simulation studies are performed by using MATLAB-SIMULINK to verify the proposed two tank system level process with NARMA-L2 Neuro controller.

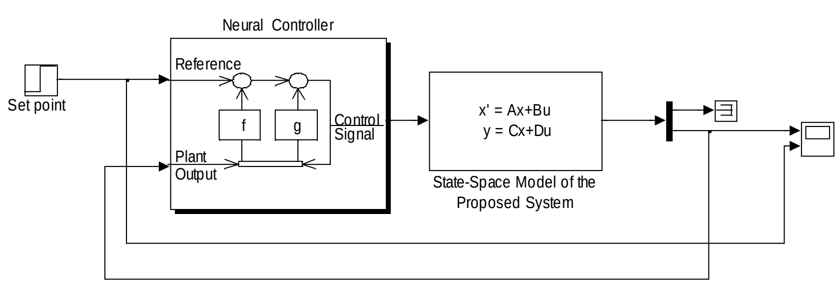

Figure 5. Neural Network Controller Without Disturbance

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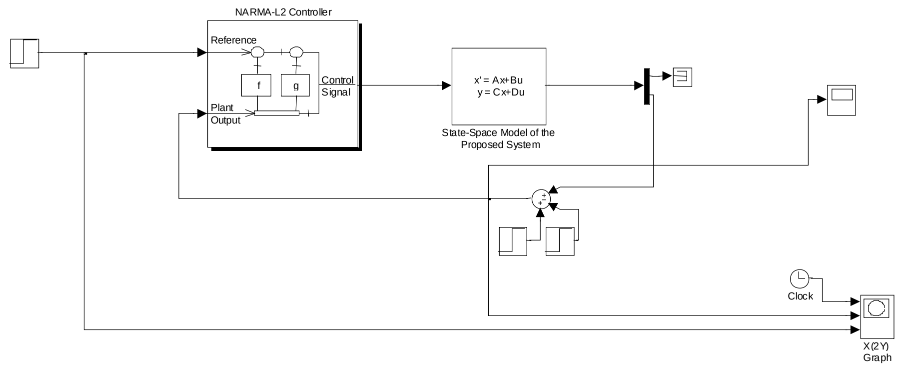

Figure 6. Neural Network Controller With Regulatory Disturbance

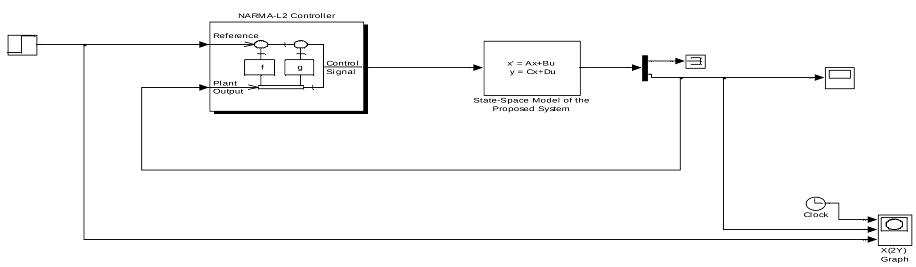

Figure 7. Neural Network Controller With Servo Disturbance

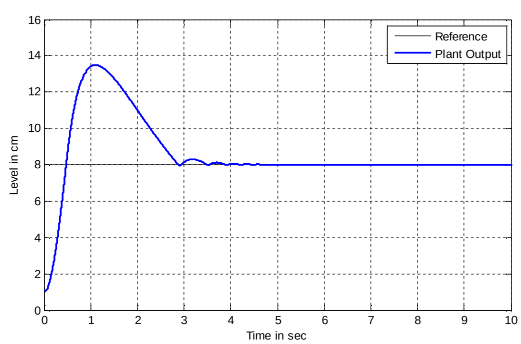

Figure 8. Nominal Response of Neuro Controller

Figure 9 shows the nominal response of neuro controller that was designed based on NARMA algorithm.

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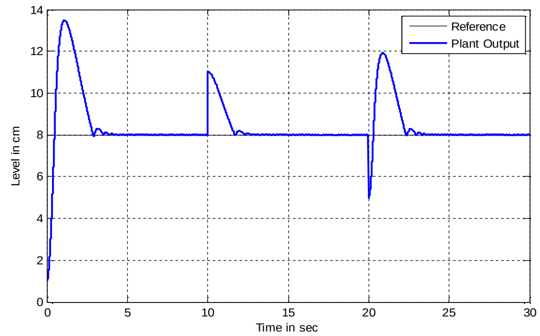

Figure 9.Regulatory Response of Neuro Controller

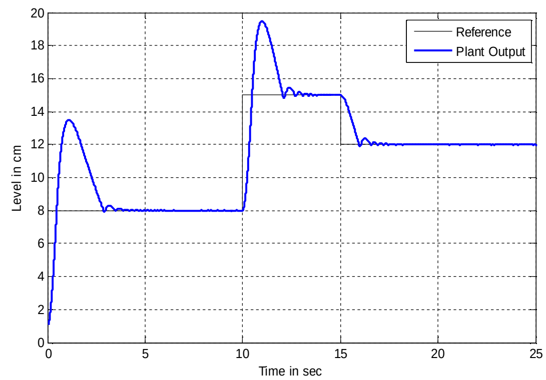

Figure 10. Servo Response of Neuro Controller

The simulation result of regulatory response of neuro controller and servo response of neuro controller that was designed based on NARMA algorithm is shown in figure 9 and figure 10 repectively.

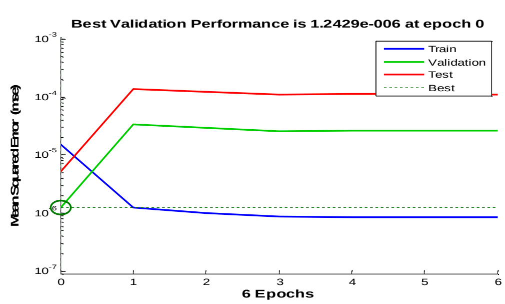

Figure 11. Validation Performance of the System

VI. CONCLUSION

NARMA-L2 algorithm neuro controller is implemented using back-propagation networks in coupled two tank system, the responses of the system and its characteristics which is depends on:

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i. changing the number of neurons in the hidden layer can be represented the degree of complexity of the system

ii. The ability of input layer to store information was used to represent the dynamic behavior of system by using the tapping delay lines for input/output signals.

The important result obtained from this work in the identification stage is how to choose the training to have a good controller. Using Genetic-Algorithms and error back-propagation as hybrid networks for plant model to give better convergence with the on-line training of feed forward model.

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