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Modeling and Performance Analysis of a Process Based on Conductivity Measurement using Neural Networks.

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ABSTRACT

Conductivity as a measured parameter has been used to evaluate the model of a non linear process (spherical tank) at three different temperatures. The model was generated using neural network (NN) available in MATLAB. The experimental and the model value were subjected to error analysis and the mean square error (MSE) was found to vary from 0.0008 to 0.00327 as temperature varies from 60^0C to 80^0C.
Keywords: Neural, Conductivity, Temperature, MSE, Spherical, Model

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INTRODUCTION

Development of model based on neural network using Conductivity as measured variable especially for process such as power plant, chemical, biochemical and semiconductor industries will help in design of industrial plants. Sundaram et al [1-3] have developed a conductivity measurement setup for designing control system. Neelemagam [4] et al have developed a conductivity measurement circuit using micro controller for ionic solution. Munoz et al [5] have used electrical conductivity measurement for Kcl solution. Lu [6] et al have discussed uncertainty in chemical sensor. Tse et al [7] have developed a model using neural network algorithm for air handling unit. Karacan [8] has used neural networks to extend the capacity of linear MPC to control non linear systems. Radhakrishnan et al [9] have designed a modified recurrent Elman networks using back propagation through time algorithm (BPTT) for non linear plants. Silva et al [10] have designed a new NMPC algorithm for SISO and MIMO systems. Henriques et al [11] have modified the Elman network for higher order systems. Margrave et al [12] have detected the flaw in the engineering materials using neural networks. In this work model parameters are established from open loop analysis of a non linear process and model generated using neural network. The model was compared with experimental data using error analysis.

EXPERIMENTAL

Figure 1 Real time Experimental setup for conductivity measurement

Figure 1 shows the experimental setup wherein water and tracer sodium chloride was metered and fed to the spherical tank at flow rates indicated in Table 1.The water and tracer solution was well mixed in the spherical tank. The exit solution conductivity was measured on line with a Honeywell conductivity sensor. The sensor was interfaced with Pentium IV PC using M/s AD Instrumentation 16 channel data acquisition card. The card can be connected directly to the USB port of the computer. It has in built anti aliasing filter. The card supports 16 ADC and DAC channels in the range of ±15 volt. Figure 2 shows the response curve for a step change in tracer for three different temperature (60^0C ,70^0C 80^0C). The ultimate value of conductivity increases with increasing temperature. The time delay also increases with temperature due to decreasing viscosity.

Table 1 Experimental Parameters

Variables	Meaning	Initial Settings
V	Volume of the tank	40 liters
Fw	Flow rate of water	2L/min
Ft	Flow rate of tracer	0.250L/min
Cw	Conductivity of water	150 millimho
Ct	Conductivity of tracer	1000 millimho

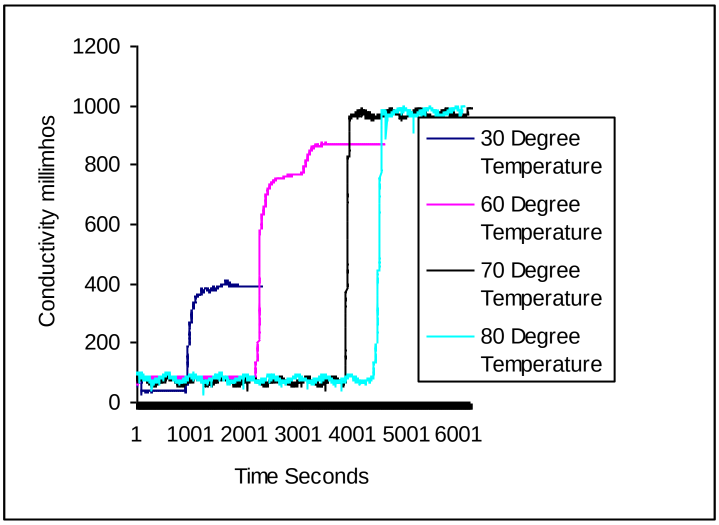
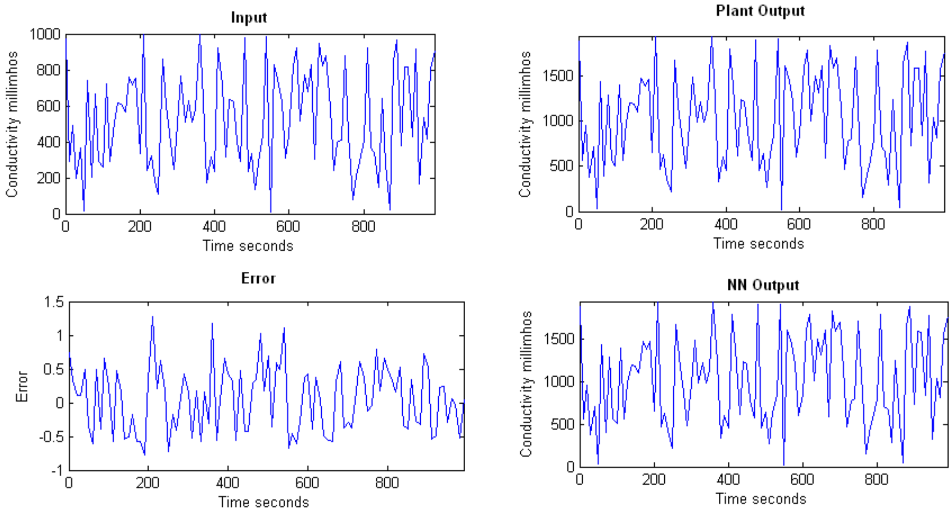


Figure 2 Response of conductivity with time for different temperature(30^{0}C, 60^{0}C ,70^{0}C 80^{0}C)

MEASUREMENT DETAILS AND MODELING

Figure 3 Training of neural network



Identification of the process data was performed using neural network algoritham.The neural model network process consists of three operational steps: prediction, correction and control move determination. In this work water and tracer flow rate was input variable and conductivity was the output variable. A sampling time of 10 seconds was used for the simulation. For training the neural model step response data of the process was taken. A total of 1000 data were taken continuously and it was saved in file. By training the input output data the NN model of the non linear process was obtained. The neural net work used for training consists of 2 neurons in the input layer,1 neuron in the out put layer and 21 neurons in the hidden layer. The back propagation through time (BPTT) algorithm was used for training the recurrent network.

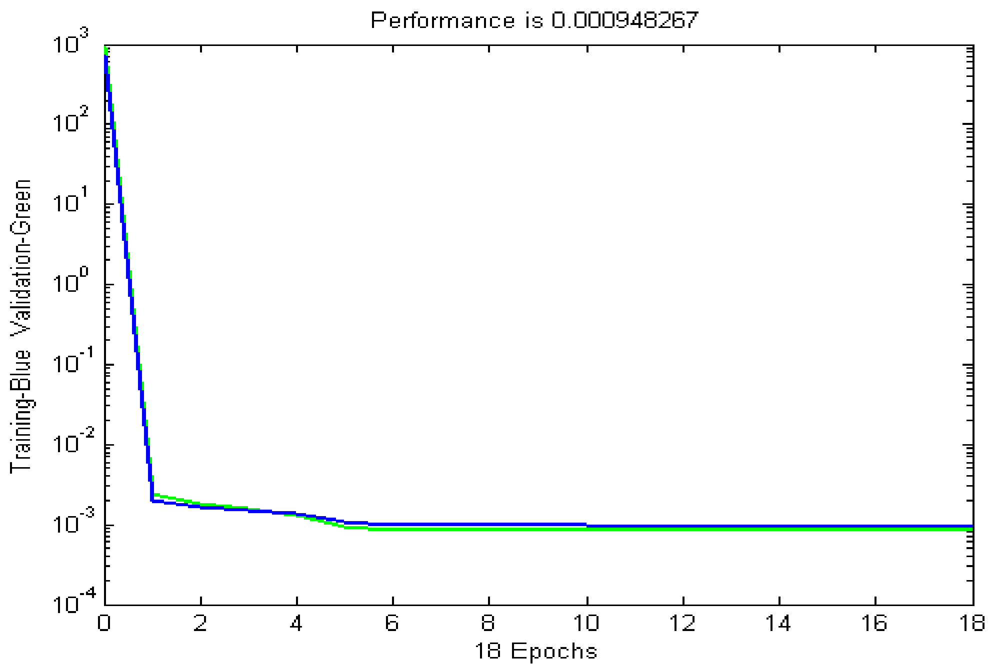


Figure 4 Validation of the NN model with process

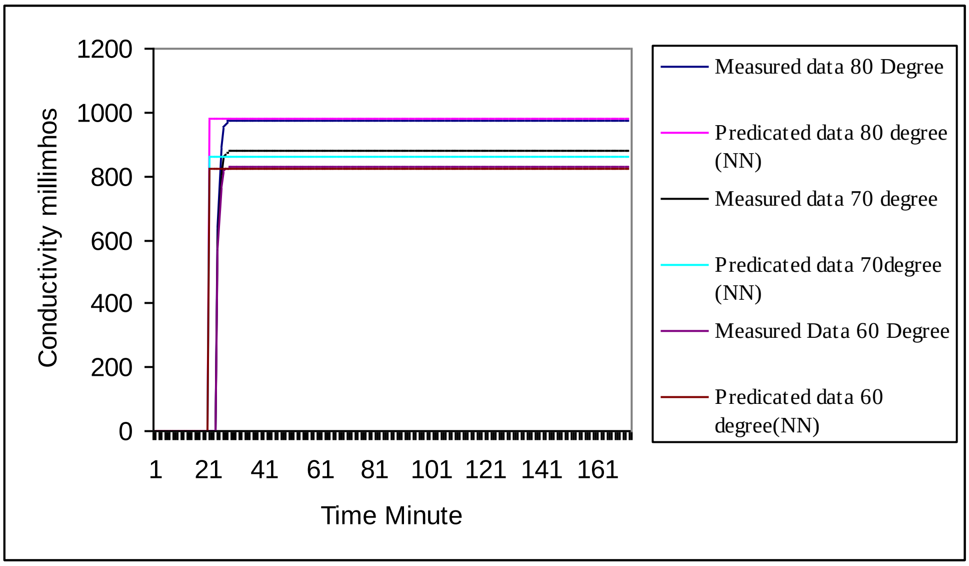


Figure5 Measured and predicated response of the process at 60^{0}C, 70^{0}C, 80 ^{0} C

RESULTS

Neural model was designed for the prediction horizon 5 and control horizon 2 using trained input-output data. Figure 4 shows the training performance of the NN. For the network training and validation, the Levenberg-Marquardt back propagation algorithm was used. The convergence criterion was selected as 10^{-3}, and this was achieved in28 epochs. Figure 5 shows the validation response .The mean square error for validation are calculated and shown in Table 2.

Table 2 Selection of optimum alpha value

SNo	Alpha	Measured Data	Predicated Data		
		Mean Square Error(MSE) 30^0C	Mean Square Error(MSE) 60^0 C	Mean Square Error(MSE) 70^0C	Mean Square Error(MSE) 80^0C
1	0.4	0.039	0.0113163	0.001663	0.000826
2	0.5	0.007	0.000987267	0.001137	0.000799
3	0.6	0.009	0.000504093	0.00101	0.000837
4	0.7	0.002	0.000320783	0.000865	0.000803

CONCLUSION

In this work neural network with back propagation through time (BPTT) algorithm was used for prediction of measured data. Performance graph and error values from Table 2 show that neural model effectively reduces the disturbance present in the system and reaches the set point quickly. The performance comparisons result shows that neural model design is well best suited for this process.

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