Experimental Results

November 5, 2018

1 Effect of simulation fixed step size on the accuracy, architecture on neural network replacement of PID in dc motor speed control

1.1 Performance with 10 hidden neurons

Training Parameter: Tansig hidden layer, maximum epoch 150, stopping criteria epoch, minimum gradient, only the maximum epoch is changed everything else stays default. Such as input Delays = 1:2; feedback Delays = 1:2; hidden Layer Size = 10; With smaller step size, we have more data, and less error. Worst performance is shown in bold

Table 1: Effect of Fixed step size on Accuracy Testing Accuracy - Hidden Neurons 10

Fixed Step Size	Training Error	Test Error
0.001	2.4116e-06	1.9052e-06
0.01	2.3287e-06	1.8463e-06
0.1	7.4570e-05	6.1457e-05
0.2	**2.8739e-04**	**3.4440e-04**

1.2 Performance with 3 hidden neurons

Table 2: Effect of Fixed step size on Testing Accuracy - Hidden Neurons 3

Fixed Step Size	Training Error	Test Error
0.001	2.5779e-06	2.0565e-06
0.01	2.5016e-06	1.9960e-06
0.1	9.5324e-05	7.7856e-05
0.2	**3.6994e-04**	**4.0580e-04**

From the experiment we can conclude that a fixed step size of 0.01 will give better performance and the minimum allowed number of neurons in the hidden layer is 3.

2 Effect of Delay on the accuracy of neural network replacement of PID in DC motor speed control

Using the fixed step size obtained in 1, and the minimum hidden layer of 3 neurons, the following are the results for varying the delay. All other parameters are kept constant.

Table 3: Effect of Delay on Testing Accuracy

Delay	Training Error	Test Error
2	2.5016e-06	1.9960e-06
3	2.5152e-06	2.0026e-06
6	2.4874e-06	1.9868e-06
9	2.4872e-06	1.9871e-06
12	2.4856e-06	1.9859e-06

Observation: as the delay increases, the test accuracy gets better even though the difference is really small. However, the higher the value of the network delay, the more "complex" the architecture.

3 Effect of Hidden Neurons on the Performance of Activation Functions

- With each AF, does the number of hidden neurons have effect on their performance?
- How low can we go before the error is unacceptable?
- Which AF gives the minimum epoch,error with hidden neuron settings.

4 Write Up

The use of PID as a controller in control system applications is ubiquitous. Although the theory behind PID is really simple but the design and implementation of PID controllers are known to be time consuming and difficult. Moreover, PID are linear systems and can only learn a particular plant based on their predefined settings. NN on the other hand are characterised with learning opportunities and adaptability in nature. This means that a NN based controller is robust to several input types and even maybe different plant architectures as will be proved in this work.

Table 4: Effect of Delay on Testing Accuracy

Number of Neurons	3		4		10	
Function	Epoch	Test Error	Epoch	Test Error	Epoch	Test Error
ElliotSig	800	2.0010e-04	800	2.0004e-04		
SQNL	761.69	1.9967e-04	776.47	1.9951e-04		
TanSig	799.8	1.9968e-04	800	1.9921e-04		
ReLu	124.35	4.5861e-04	132.23	3.7159e-04		
SQLU	674.57	2.0031e-04	771.14	2.0023e-04		
ELU	681.81	2.0030e-04	776.21	2.0021e-04		
Leaky ReLu	132.06	3.2981e-04	128.06	3.7556e-04		

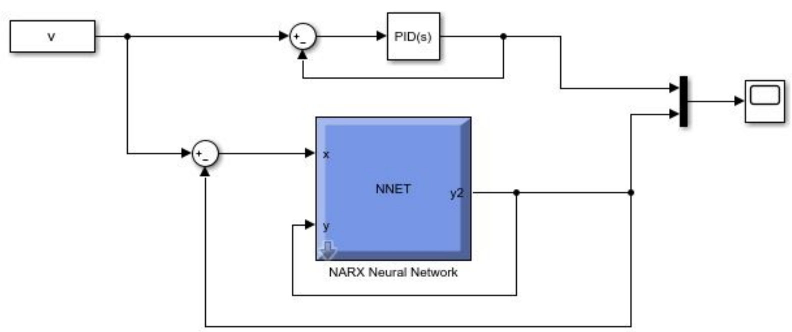

Figure 1: The Experimental setup of the NN replacement of PID controller

5 Neural Network Replacement of PID

We further demonstrated the ability of the proposed SQNL on control application. The use of PID for controlling control systems is a wide area of study however, in recent years, the disadvantages of PID controller have being solved by Neural Network Controllers. We therefore replaced the PID controller with 3 hidden neuron Neural Network architecture using the illustration in