Analysis and Performance Evaluation for Low Pass Filter Design Using Artificial Neural Network

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Abstract*: This paper presents design of low pass FIR Filter of order 10 by using different algorithm of artificial neural network. In this paper comparison is done between different algorithm of nn tool and window used for designing filter and find which one is best. Here, we use two tools for designing filter FDA Tool and NN Tool and compare the results. Bartlett and Blackman windows are used to calculate filter coefficients by FDA tool then train the network in NN tool and find the results.*

Keywords- Neural network, FDA Tool.

1. Introduction

In signal processing, a Filter is a device or process which removes noise or unwanted components from a signal. FIR (Finite Impulse Response) filter have finite duration impulse response, as it settles to zero in finite time and no requirement of feedback while IIR (Infinite impulse response) filters have infinite duration impulse response because they have internal feedback system.FIR filter known as non-recursive digital filter as they do not have feedback even recursive algorithm can be used to realize Fir Filter. Simple low pass FIR filter diagram is shown in figure 1 and equation are referred by reference [10].

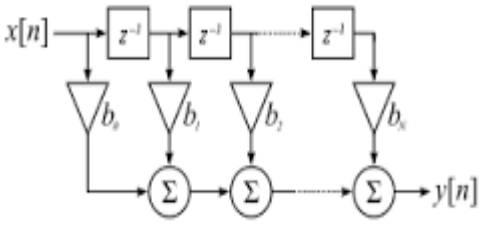

Figure 1. Simple low pass FIR filter

Output sequence $y[n]$ is given by

$Y[n] = b0x(n)+b1x(n-1)+----------+bnx(n-N)$

An FIR filter is designed by finding filter coefficients, filter order or other parameters that meet certain specifications either in time-domain and frequency-domain.

FIR Filters can be designed by many methods like Fourier series method, Frequency sampling method and window method. Commonly window method is used by finding the filter coefficients with different formulas.

Window method is used to converts an “ideal” infinite duration impulse response such as sin function to a finite duration impulse response filter design.

But in this process complex calculations are required to calculate filter coefficients. In window method we need to put some parameters like sampling frequency, cut-off frequency, stop band attenuation, pass band ripple etc to find the filter coefficients h(n). Now days other methods are used like Artificial Neural network (NN). In this paper Artificial neural network is used, it is a highly simplified model of biological neural network and easy to use.

In this paper, I used three algorithm of neural network to design a filter and these are feed forward back propagation, radial basis and feed forward distributed time delay. Bartlett and Blackman window are used to make a data set by FDA tool. Software MATLAB is used where two tool are used- FDA tool and nn tool.

2. Artificial Neural Network

Artificial neural networks (ANNs) are a family of statistical learning models inspired by biological neural networks and are used to estimate or approximate functions that can depend on a large number of inputs are generally unknown. Artificial neural networks mostly presented as systems of interconnected "neurons" which exchange messages between each other. The connections have numeric weights that can be tuned based on experience, making neural network adaptive to inputs and capable of learning.

Artificial neural network is a system which changes its parameters such as structure or weights based on set of input and target outputs during training program to produce final output. It is very efficient to predict samples or events when network has large number of samples in datasheet because of more dataset network trained very well and give better result. Structure of neural network is shown below [7].

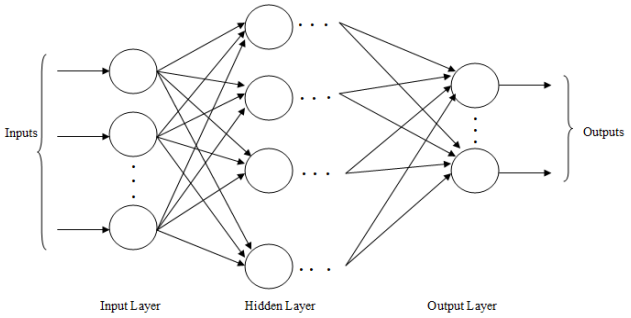

Figure 2. Structure of neural network

Some algorithm are used in artificial neural network which are used to train the network and these are radial basis function, feed forward back propagation, feed forward distributed time delay and many more.

Feed forward back propagation algorithm, in this feed forward implies that network has a link that extends only in one direction that is neurons are connected in forward direction. The back propagation is the easiest algorithm than others. Back propagation defines the neurons are organized in layer that send signal in forward direction and send error in backward direction. Figure 3 shows a feed forward back propagation network [10].

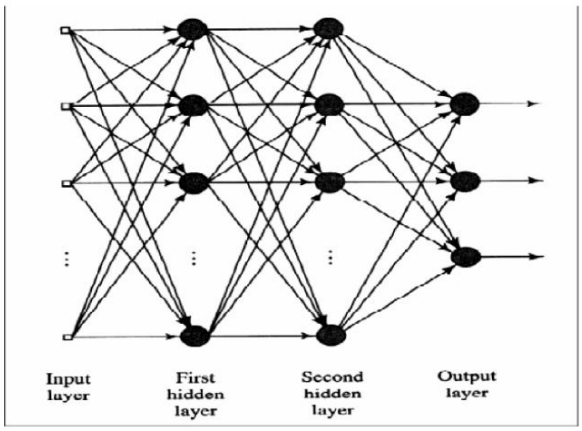

Figure 3. Feed forward back propagation network

Radial basis (exact fit) algorithm is widely used algorithm because it gives better result than other algorithm. Radial basis network may need more number of neurons than feed forward back propagation network. Wasserman gives this concept of radial basis function in 1993 and diagram is given by author [10]. RBFN consist of three layer are input layer, hidden layer and an output layer. Each layer is fully connected to the previous layer.

Feed forward distributed time delay algorithm is an artificial neural network architecture whose basic function is to work on sequential data. Time delay neural network (TDNN) recognize features independent of time-shift and usually form part of a larger pattern recognition system. This network work with many interconnected layers composed of clusters. These clusters are used to represent neurons in a brain; every cluster need only focus on small regions of input. Main features for TDNN are the ability to express relation between inputs and time.

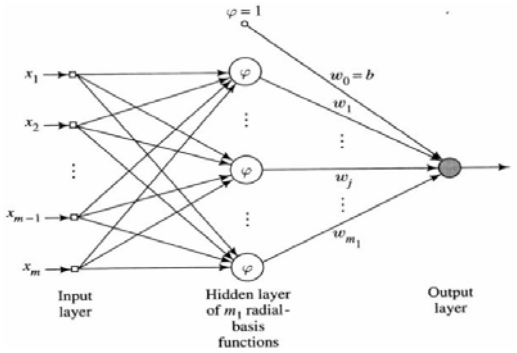

Figure 4. Radial basis network

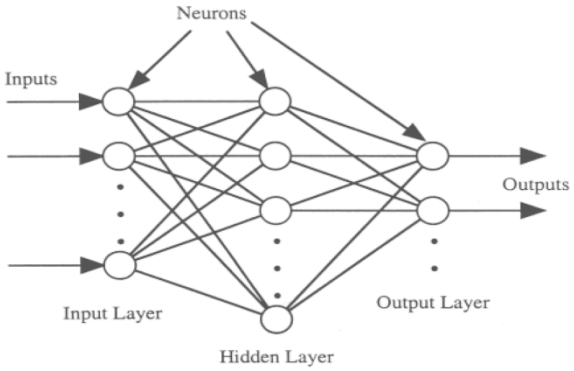

Figure 5. Feed forward distributed time delay network

3. Methodology

In this section, two windows are used to make a dataset of samples in FDA tool and then we compare the results of these two windows and find which gives better result. Datasets are formed by filter coefficients.

Bartlett window results

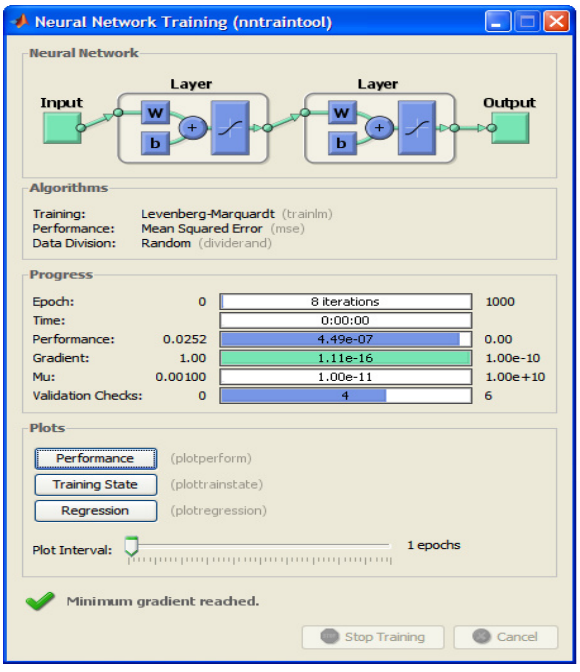

Figure 6. Training process of FFBP

In this normalized cut-off frequency is used i.e. 0-1 Hz and order of filter will be 10. Here three algorithms are used in NN tool by which we get results/outputs namely network 1 by feed forward back propagation, network 2 by radial basis and network 3 by feed forward distributed time delay.

Filter designed by Bartlett Window and Blackman window. Here 34 samples data sheet is formed by Bartlett window out of those approx. one-third values are used for testing and remaining are used to train the network.

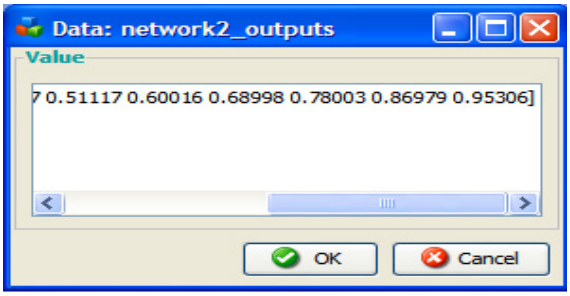

Figure 7. Result of FFBP Network

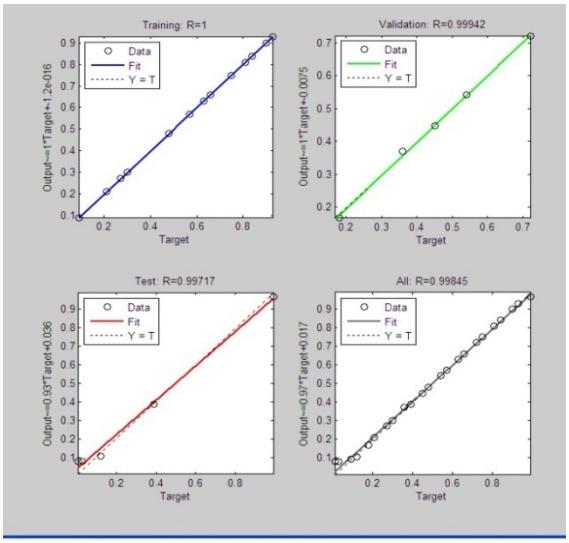

Figure 8. Regression plot of FFBP

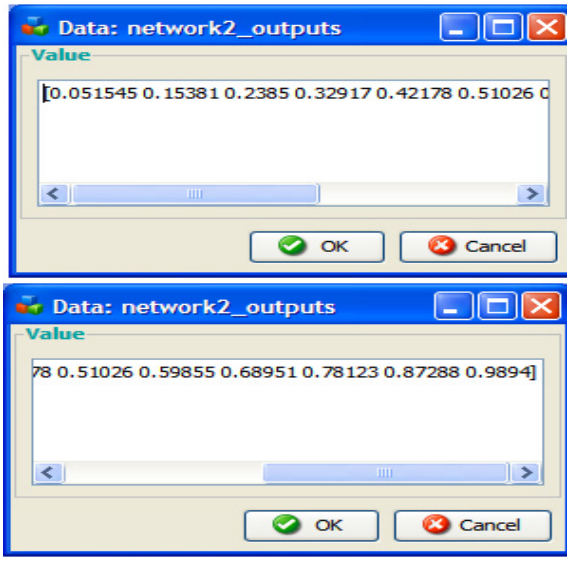

Figure 9. Result of RBF Network

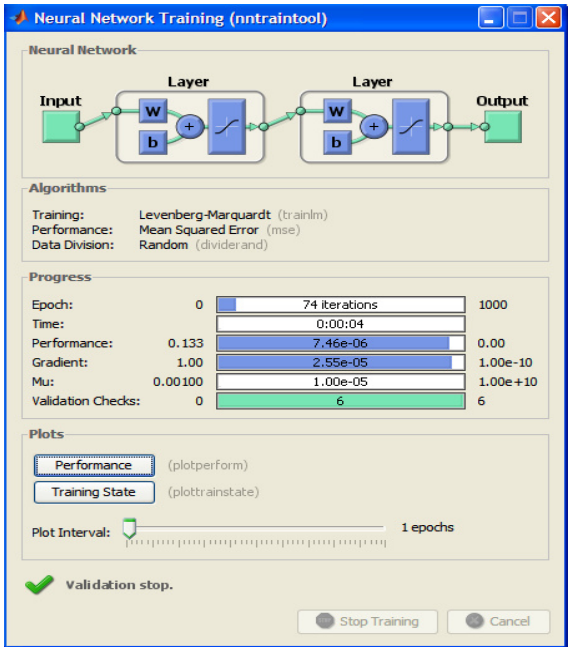

Figure 10. Training process of FFDTD

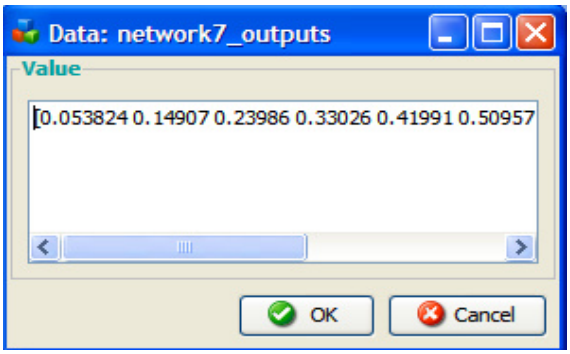

Figure 11. Results of FFDTD Network

Blackman window results

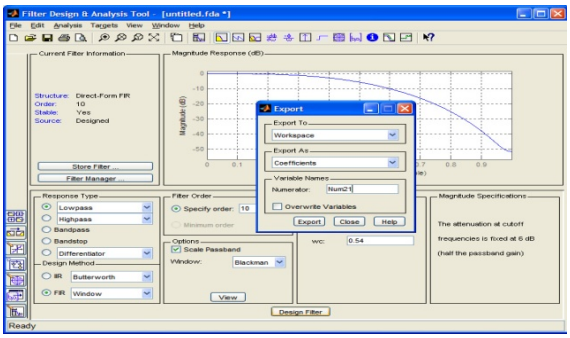

Figure 12. Filter coefficients by FDA tool

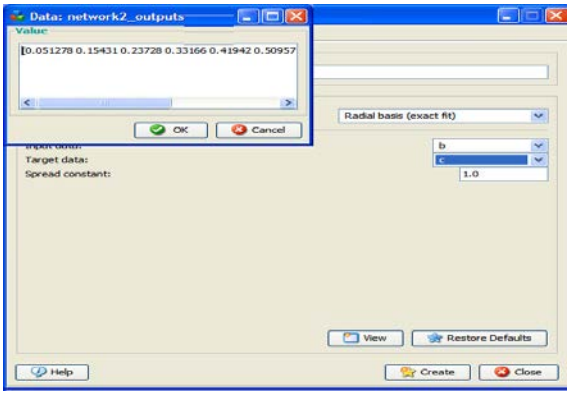

Figure 13. Results of RBF Network

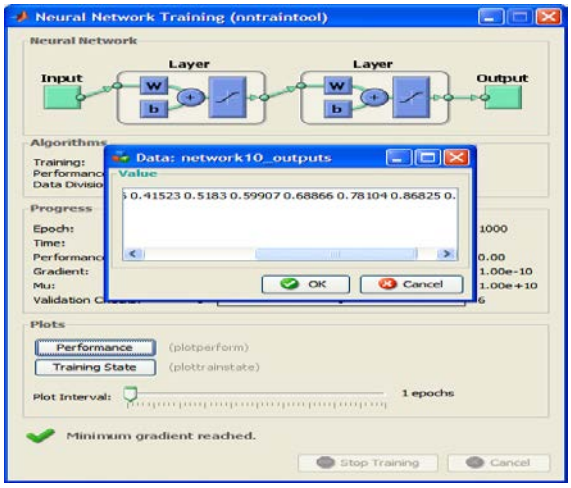

Figure 14. Results of FFDTD Network

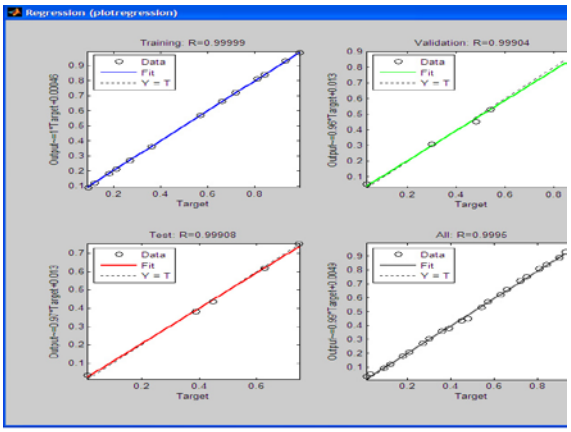

Figure 15. Regression plot of FFBP Network

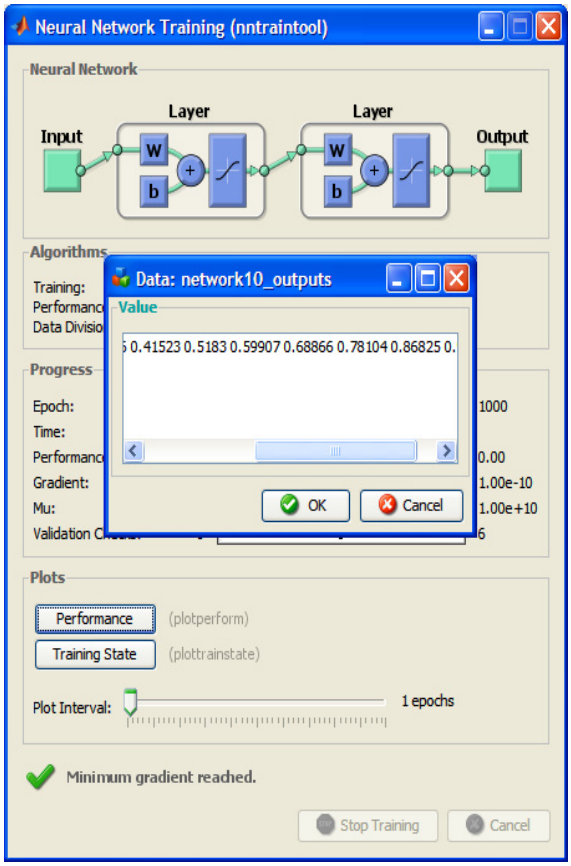

Figure 16. Results of FFBP

Table1. Results of Bartlett and Blackman window using ANN

Frequency samples for testing	Bartlett & Blackman window	Artificial Neural Network					
		Bartlett Window			Blackman Window		
		FFBN	RBF	FFDTD	FFBN	RBF	FFDTD
h(0)	0.06	0.082085	0.051545	0.053824	0.049699	0.051278	0.071122
h(1)	0.15	0.13092	0.15381	0.14907	0.16346	0.15431	0.15663
h(2)	0.24	0.24343	0.2385	0.23986	0.23976	0.23728	0.23588
h(3)	0.33	0.33378	0.32917	0.33026	0.33794	0.33166	0.34256
h(4)	0.42	0.41157	0.42178	0.41991	0.4031	0.41942	0.41523
h(5)	0.51	0.51117	0.51026	0.50957	0.49336	0.50957	0.5183
h(6)	0.60	0.60016	0.59855	0.59526	0.59105	0.60106	0.59907
h(7)	0.69	0.68998	0.68951	0.69535	0.67971	0.68869	0.68869
h(8)	0.78	0.78003	0.78123	0.76772	0.78385	0.78049	0.78104
h(9)	0.87	0.86979	0.87288	0.86498	0.86942	0.97419	0.86825
h(10)	0.96	0.95306	0.9894	0.9527	0.95885	0.9521	0.9537

4. RESULT

From table1, we can get the cut-off frequency easily by using artificial neural network. Here, 11 samples are used for testing rest 23 are used for training. From figure 8 and figure 13, we can see the error graph; it gives approximately same value what we want. So filter designed by using ANN is a very efficient method, it gives result in less time, get nearer value and easy to use.

5. CONCLUSION

For finding which window gives better result we need to find mean square error (MSE). After finding mean square error, results of both windows are almost same but Bartlett window gives more efficient result than Blackman. And out of three algorithms used in neural network, radial basis is best and gives better result.

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