Artificial Neural Network Use for Design Low Pass FIR Filter a Comparison

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***Abstract*—The present paper investigates an approach for comparison of different types of artificial neural network used in design and analysis of low pass FIR filter. The simulated values for training and testing the neural network are obtained by designing low pass FIR filter with hamming window method using FDA toolbox in MATLAB. As hamming window is an optimized window method which can minimize the maximum (nearest) side lobe of a signal hence hamming window method is preferred in this work. In this paper three different algorithm of artificial neural network namely generalized regression method, feed forward back propagation and radial basis function are used. The result obtained using artificial neural network are compared and radial basis function founds to give quite satisfactory result then generalized regression method and feed forward back propagation method.**

***Index Terms*—FIR filter, ANN, GRNN, BPNN, RBF**

I. Introduction

A filter is a network that selectively changes phase-frequency and/or amplitude-frequency of a signal in desired manner. The objective of filtering is to improve quality of a signal to extract information from signals or to separate two or more signals. A digital filter is algorithm implemented in both hardware and software that operates on digital input signal to produce digital output signal.

Digital filter are of two types depending upon response Finite Impulse Response (FIR) filter and Infinite Impulse Response (IIR) filter. IIR filters are digital counterpart to analog filter such a filter has internal feedback and may continue to respond indefinitely. FIR filter known as non-recursive digital filter as they do not have feedback even recursive algorithm can be used to realize FIR filter.

Fig. 1 shows a simple low pass FIR filter

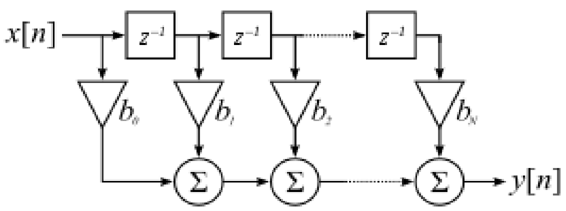

Figure 1. Simple low pass FIR filter

Manuscript received March 3, 2014; revised June 15, 2014.

Output sequence $y[n]$ is given by

$$y[n]=b_0x(n)+b_1x(n\text{-}1)+\text{----------}+b_nx(n\text{-}N) \tag{1}$$

The design of digital filter has received great interest over the past decades FIR traditional method designs a digital FIR filter are: -Fourier series method, Frequency sampling method, window method. According to Ref. [1] Window method is one of the most efficient methods in designing of FIR filter before artificial neural network (ANN), as it gives optimal design better than other methods. Window method is a method use to converts as "ideal" infinite duration impulse response such as sin function to a finite duration impulse response filter design.

Now a days there are various other design method to design filter such as Neural network (NN), Genetic algorithm Ref. [2], particle swarm optimization Ref. [3], radial basis function Ref. [4], Ref. [5] etc. In present paper generalized regression neural network, feed forward back propagation and radial basis function are used. Hamming window method is used to calculate the filter coefficient to prepare data set. The advantage of hamming window is that the window is optimized to minimized the maximum (nearest) side lobe, giving it a height of about one fifth that of other window. Its window function is expressed below

$$w(n) = \alpha - \beta \cos(\frac{2\pi n}{N-1}) \tag{2}$$

$$\alpha = 0.54, \qquad \beta = 1 - \alpha = 0.45 \tag{3}$$

II. Artificial Neural Network (ANN)

An artificial neural network (ANN) is computational models of neurons based on the highly dense inter connected parallel structure of human brain. The number of nodes, their organization and synaptic weights of these connections of any neural network determine the output of ANN.

Artificial neural network is an adaptive system that changes its structure or weights based on given set of input and target outputs during the training phase on produces final output. It is particularly effective for predicting events when the network have a large database of prior examples. Common implementation of ANN has multiples input, weights of each input, a threshold that determine if neurons should fire or not, an activation function that determine output and mode of operation [6]-[8].

doi: 10.12720/ijeee.3.3.216-219

Fig. 2 show general structure of neural network as describe above.

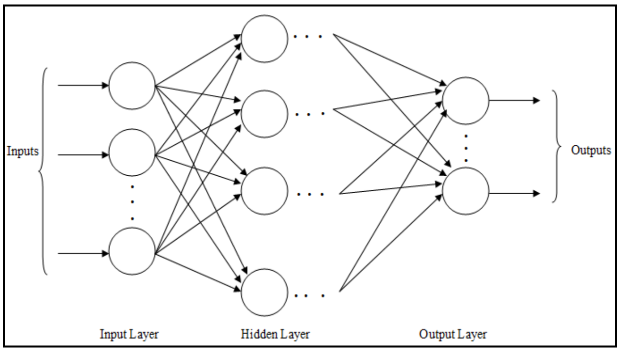

Figure 2. General structure of neural network

There are some algorithms that can be used to train artificial neural network such as feed forward back propagation, radial basis function and general regression neural network etc.

The back propagation is the simplest of all other algorithm. Back propagation means that the neurons are organized in layer send signals in “forward” direction and have errors propagating in backward direction as shown in Fig. 3.

The main aim of back propagation algorithm is to reduce error, until ANN learns the training data. Training started with random weights and aimed to adjust weights so the minimal error is obtained.

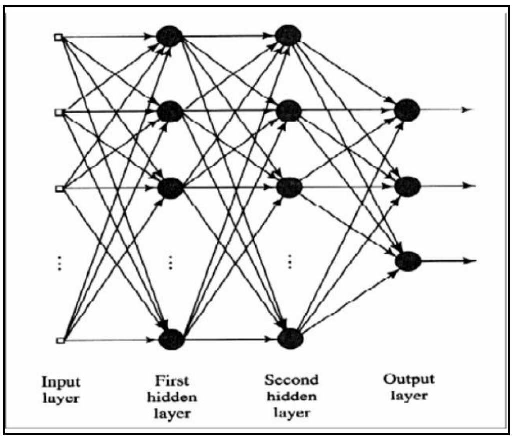

Figure 3. Feed forward back propagation neural network

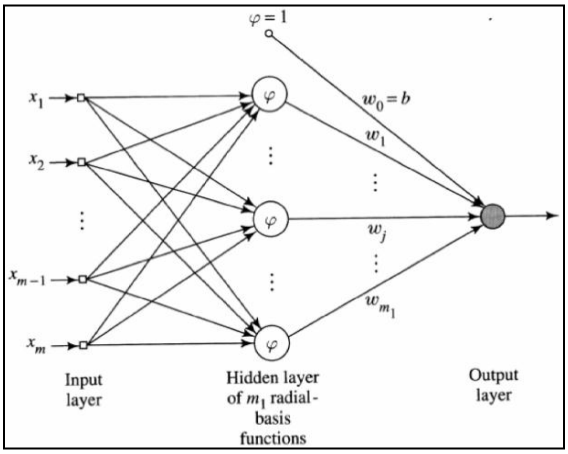

Figure 4. Radial basis function

According to Ref. [9] in radial basis function (RBF) network hidden neurons compute radial basis function of inputs, which are similar to that of kernel functions in kernel regression. Wasserman in 1993 gives the concept of radial basis function on network as show in Fig. 4.

General regression neural network (GRNN) is a variation of radial basis function (RBF) based on the Nadaraya-Watson on kernel regression. By Ref. [10] the main features of GRNN are fat training time and can also model non-linear function.

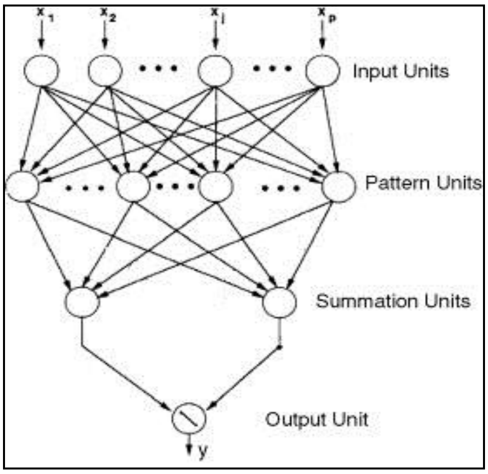

Figure 5. Generalized regression neural network

GRNN (Fig. 5) being firstly proposed by Sprecht in 1991 is a feed forward neural network model base on non liner regression theory; it approximates the function through activating neurons Ref. [11]. In GRNN transfer function of hidden layer is radial basis function.

$$y'i = \frac{\sum_{i=1}^{n} yi * exp - D(x - xi)}{\sum_{i=1}^{n} exp - D(x - xi)} \tag{4}$$

$$D(x - xi) = \sum_{k=1}^{m} \left(\frac{xi - xik}{\sigma}\right)^2 \tag{5}$$

III. Proposed Neural Network Model

In proposed neural network model of low pass FIR filter inputs are normalized cut off frequency that varies between 0 to 1Hz and scale value a constant value equal to 10. By help of these input output in form of filter transfer function coefficients is obtain.

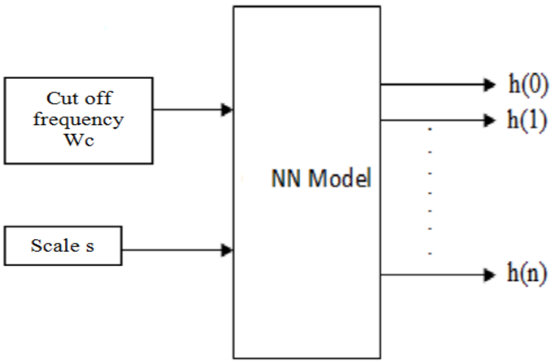

Figure 6. Neural model of low pass FIR filter with Wc and S as constant

Proposed model using above mention filter specification as input and filter coefficient as output is showing in Fig. 6.

In above model all of three artificial neural networks are used to find out results/output of network namely network 1 by GRNN, network 2 by feed forward back propagation and network 3 by RBF.

IV. Result

The trained network has been tested using ten value filter coefficient out of 40 values of filter coefficient obtain by FDA tool of MATLAB using Hamming window. Fig. 7 shows training of neural network done by nntool of MATLAB.

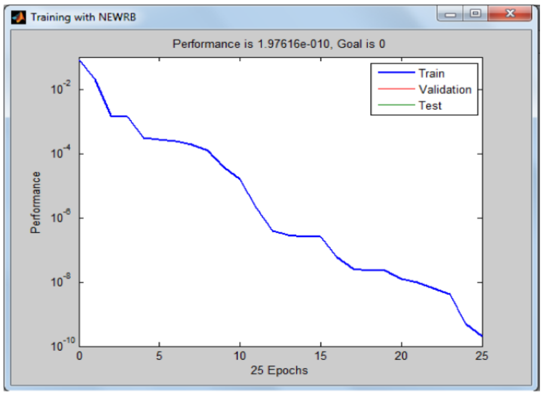

Figure 7. Training of neural network

TABLE I. Hamming Window Versus ANN

h(n)filter	**Hamming**	**Artificial**	**Neural**	**Network**	**Mean**	**Square**	**Error**
Coefficient	**window**	GRNN	BPNN	RBF	GRNN	BPNN	RBF
h(0)	0.30	0.30037	0.28782	0.30	0.0000001369	0.0001483524	0.0
h(1)	0.35	0.36601	0.35726	0.35	0.00025632	0.000052706	0.0
h(2)	0.50	0.49415	0.51111	0.50	0.00003422	0.00012343	0.0
h(3)	0.55	0.54972	0.55465	0.55	0.0000000784	0.0000216225	0.0
h(4)	0.70	0.68314	0.72895	0.70	0.00028459	0.00083810	0.0
h(5)	0.75	0.73413	0.75768	0.75	0.0000759	0.0000589824	0.0
h(6)	0.80	0.78963	0.78742	0.80	0.0001075369	0.0001582564	0.0
h(7)	0.85	0.84538	0.81069	0.85001	0.0000213444	0.0015452761	0.0000000001
h(8)	0.95	0.93703	0.95282	0.94986	0.0001682209	0.000079524	0.0000000196
h(9)	0.99	0.95606	0.94117	0.99001	0.00086436	0.0023843689	0.000000001

Error in calculating the filter coefficients of these input set using GRNN, feed forward back propagation and RBF are shown by respectively in Table I.

By help of the Table I various error graph between ANN output and Hamming window output are drawn.

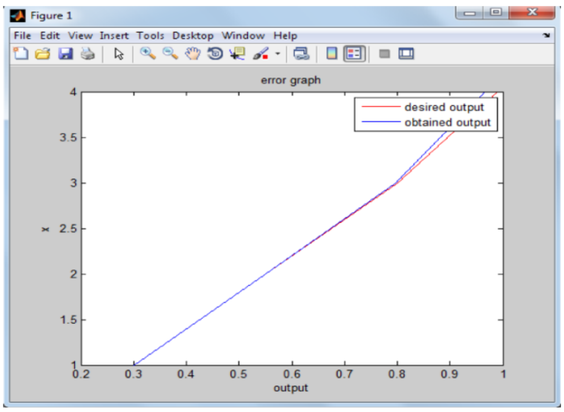

Figure 8. Error graph between hamming window output and GRNN output

Fig. 8 shows error graph between hamming window output and generalized regression neural network output.

Fig. 9 shows error graph between hamming window output and Feed forward back propagation algorithm output.

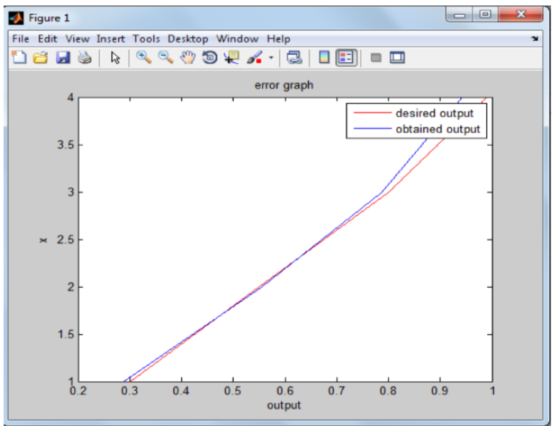

Figure 9. Error graph between hamming window o/p and FFBP o/p

Fig. 10 shows error graph between hamming window output and Radial basis function output.

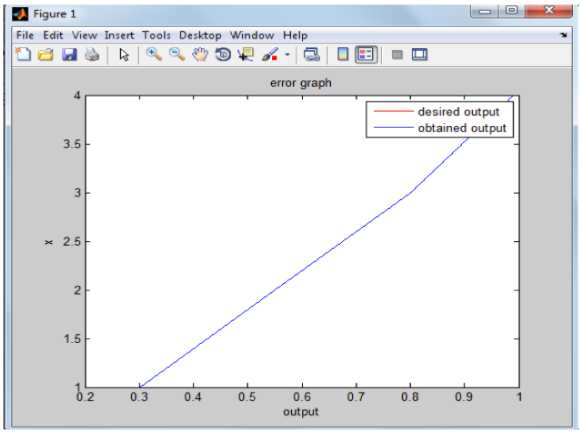

Figure 10. Error graph between hamming window output and radial basis function output

By above figures (Fig. 8, Fig. 9, Fig. 10.) and table no 1 it is clear that RBF gives results 99.9% and back propagation results almost 98.37% and GRNN gives 99.45% result accuracy. So on comparison of these three types of artificial neural network RBF, back propagation, GRNN results shows that designing of low pass FIR filter using radial basis function network gives most accurate, efficient, less complex and easy implemented design.

Fig. 11 shows the result window of RBF method.

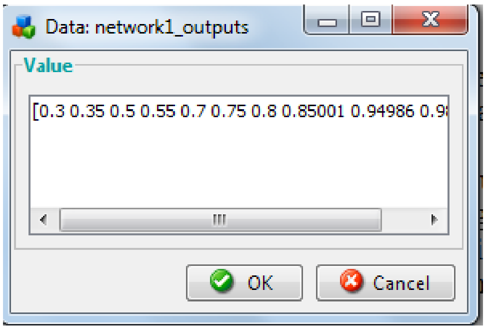

Figure 11. Result window of RBF network

V. Conclusion

The present paper has proposed the comparison of three types of artificial neural network namely RBF, Back propagation and GRNN used in design of low pass FIR filter. RBF is found to be easy, fast and most accurate method to design a low pass FIR filter one trained properly. The filter response error graphs are almost similar for both hamming window and RBF neural network which validate the proposed model and comparisons.

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