Design a flattop Window Based Digital Filter by Using Neural Network a Comparison

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Abstract: **In this paper, we have designed the digital filter based on flattop window function using ANN. Firstly we have designed the 10th order digital filter based on flattop window function then calculate the coefficient of designed filter. We have designed filter at frequency ranges 1 to 45 Hz. Then we calculated the coefficients of filter at different frequencies. Some data group of coefficients is used to train the neural network designed using feed forward back prop, radial basis and layer recurrent algorithm and rest are used as test input to neural network. The output corresponding to test input is approximate equal to output calculated using FDA tool. After training the neural network using prefer three network algorithms we got the output. The output gathered from all three methods has been compared on the basis of nearest value of cut-off frequency. The layer recurrent method provides more accurate result as compare to other two methods.**

KEYWORDS: **ANN, RADIAL BASIS, LAYER RECURRENT, NEURAL NETWORK**

I. INTRODUCTION

A FILTER IS ESSENTIALLY A SYSTEM OR NETWORK THAT SELECTIVELY CHANGES THE WAVE SHAPE AMPLITUDE – FREQUENCY AND OR PHASE – FREQUENCY CHARACTERISTICS OF A SIGNAL IN A DESIRED MANNER. COMMON FILTERING OBJECTIVES ARE TO IMPROVE THE QUALITY OF A SIGNAL, TO EXTRACT INFORMATION FROM SIGNALS OR TO SEPARATE TWO OR MORE SIGNALS. A DIGITAL FILTER IS A MATHEMATICAL ALGORITHM IMPLEMENTATION IN HARDWARE AND/OR SOFTWARE THAT OPERATES ON A DIGITAL INPUT SIGNAL TO PRODUCE A DIGITAL OUTPUT SIGNAL FOR THE PURPOSE OF ACHIEVING A FILTERING OBJECTIVE. A SIMPLIFIED BLOCK DIAGRAM OF A REAL-TIME DIGITAL FILTER, WITH ANALOG INPUT AND OUTPUT SIGNAL IS AS SHOWN IN FIGURE.1

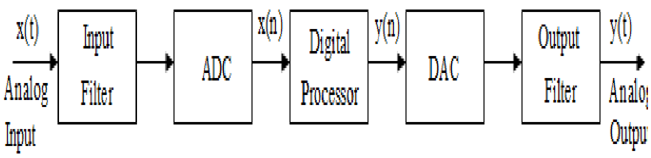


Figure 1: Block diagram of a digital filter

Filter designing is the process of transformation of input sequence to obtain desired output sequence. Filter designing process can be described as an optimization problem where each requirement terms to an error function which should be minimized. Digital filter are of two types, Finite Impulse Response (FIR) filter and Infinite Impulse response (IIR) filter. In this paper the concept of Artificial Neural Network, which is also a wide area of research? The main goal of the design is to find the recursive coefficients that define the filter transfer function. In this research work, DSP a neural networks were combined to produce an excellent algorithm for digital filter design In the previous work, the fir filter was designed by least square method and frequency sampling method. MLP and RBF algorithm were used to train the neural network model. The efficiency of these above method is about 95%, but when layer recurrent algorithm is used the accuracy is about 98%. That is the advantage of this method.

II. DESIGN FIR FILTER USING WINDOW METHOD

The windowing method requires minimum amount of computational effort; so window method is simple to implement. For the given window, the maximum amplitude of ripple in the filter response is fixed. Thus the stop band attenuation is fixed in the given window, but there is some drawback also of this method. The design of fir filter is not flexible. The frequency response of fir filter shows the convolution of spectrum of window function & desired frequency response because of this; the pass band & stop band edge frequency cannot be precisely specified. In this work we use flattop window method.

III. LITERATURE SURVEY

Awadhesh Gupta et. al. Presented a paper on design and analysis of low pass FIR & IIR filter and find optimum result using neural network. Author designed the low pass FIR and IIR filter and tried to reduce the number of side lobes and compact the size of main lobe then compared the result with filter designed using neural network. Filter designed using neural network gives the better result as compare to conventional method of design.

Harpeet Kaur et. al. presented a paper on design of low pass FIR filter using artificial neural network. Author design the low pass FIR filter based on Keiser window function. The stop band attenuation (SBT), transition width (TW),pass band ripple(PBR),sampling frequency and filter length are the varying parameter. This work is carried out using 30such values of all the varying parameter. Trained the same filter using neural network. The filter coefficient can be easily calculate using some known parameter of filter .

Navneet Gupta et. al. presented a paper on design low pass filter using generalize regression neural network. Author design the rectangular window in FDA tool of MATLAB and calculate the coefficient of designed filter corresponding to cut off frequency. Then trained the neural network using data collected from FDA tool. The accuracy of coefficient corresponding to cut off frequency using neural network is better than designed filter in FDA tool.

IV. ARTIFICIAL NEURAL NETWORKS

An Artificial Neural Network (ANN) also known as "Neural Network (NN)" is a computational model based on the structure and function of biological neural network. In other words ANN is computing system which is made up of a number of simple processing elements (the computer equivalent of neurons, Nodes) that are highly interconnected to each other through synaptic weights. The number of nodes, their organization and synaptic weights of these connections determine the output of the network. ANN is an adaptive system that changes its structure/weights based on given set of inputs and target outputs during the training phase an produces final outputs accordingly. ANN is particularly effective for predicting events when the network have a large database of prior examples to draw. The common implementation of ANN has multiple inputs, weight associated with each input, a threshold that determine if the neuron should fire, an activation function that determine the output and mode of operation. The general structure of a neural network has three types of layers that are interconnected: input layer, one or more hidden layers and output layer as shown in Figure 2.

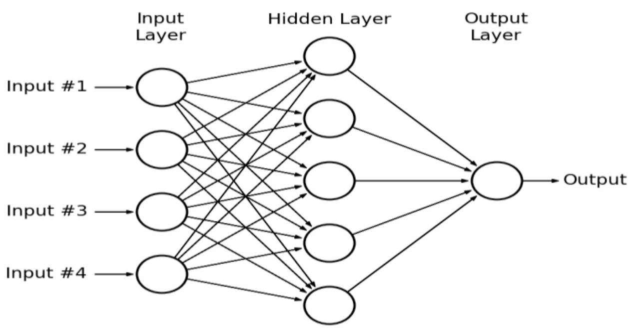
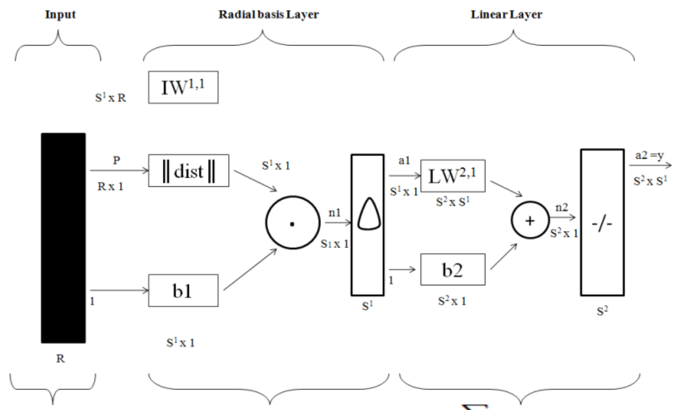


Figure 2: General Structure of Neural Network

There are some algorithms that can be used to train an ANN such as: Back Propagation, Radial-basis Function, and Support Vector learning, etc. The Back Propagation is the simplest but it has one disadvantage that it can take large number of iterations to converge to the desired solution [3]. In Radial Basis Function (RBF) network the hidden neurons compute radial basis functions of the inputs, which are similar to kernel functions in kernel regression. Speech has popularized kernel regressions, which he calls a General Regression Neural Network (GRNN) [3]. General Regression Neural Network (GRNN) is a variation of Radial Basis Function (RBF) network that is based on the Nadaraya – Watson kernel regression. The main features of GRNN are fast training time and it can also model non-linear function. GRNN being firstly proposed by Sprecht in 1991 is a feed forward neural network model base on non linear regression theory. It approximates the function through activating neurons. The network structure of GRNN consists of three layers: input layer, radial basis hidden layer and linear output layer as shown in Figure 3.The transfer function of hidden layer is Radial Basis Function.



$$a_i1 = exp(-\|IW^{1,1} - p\|.b_i1) \quad a2 = \sum LW^{2,1}.a1 + b2$$

Figure 3: Network structure of RBF

IV. FORMULATION OF PROBLEM

The aim of this paper is to estimate the cut off frequency of any given coefficients of FIR filter and increase the accuracy of result from previous work. Accuracy is determined by comparing the result from *fdatool* and *nntool*. For training purpose we use input output dataset derived from *fdatool*, and for testing purpose we use a test input and simulate it using *nntool*.

V. METHODOLOGY

In this methodology we use flattop window technique for filter designing and feed forward back prop, radial basis and layer recurrent neural network algorithms for training purpose.

Step 1

Low pass FIR filter designed by *fdatool*. The order of filter is 10. We use cut of frequency ranges from 1 to 45. Then set the value of fc=1 and design the filter. Repeat the same process for value of fc from 2 to 45. So this gives the 45 dataset of input and output data. Out of these 45 dataset we use 40 for training and 5 for testing. Here input is h(n) and output is fc.

Step 2

In this step we design the neural network model by *nntool*. Training is done by preferred three methods namely feed forward back prop, radial basis and layer recurrent. After training, simulate the network by testing input.

V. RESULTS AND DISCUSSION

In the above experiment, According the Table 2: (Result from *fdatool*) For the test input h(n), the output fc is 26 to 30. This result is deduced from filter designing tool. According to the Table 3: (Simulation result from *nntool*) the output for the same test input h(n) is approximate equal to output got from FDA tool. This result is taken from neural network tool. So the results from *nntool* and *fda-tool* are nearly same, and by this process (layer recurrent) we can easily estimate the cut off frequency of any FIR filter.

VII. CONCLUSION

From this experiment we estimate the cut off frequency and other parameter from filter co-efficient by the help of preferred three methods, but on the basis of comparison the layer current method provides accurate result and it is quite simple method than other method. The above figures show that results come from flattop window method and artificial neural network is almost same. For the filter designing purpose This layer recurrent training algorithm is much better than other training algorithm like MLP, RBF *etc*. In the present work, when feed forward back prop and radial basis are used as a training algorithm, results are about 92% and 94% accurate. By the using of layer recurrent algorithm, the accuracy of result is almost 98%. So there are increment of 6% and 4% in accuracy, which are very effective.

Table1. Result from *fdatool* (for Train Input)

h(n) (Train Input)											**Cut off frequency (Target)**
h(0)	**h(1)**	**h(2)**	**h(3)**	**h(4)**	**h(5)**	**h(6)**	**h(7)**	**h(8)**	**h(9)**	**h(10)**	**Fc**
-0.0002	-0.00723	-0.03141	0.025304	0.281555	0.463957	0.281555	0.025304	-0.03141	-0.00723	-0.0002	1
-0.00019	-0.00722	-0.03139	0.025296	0.281532	0.463956	0.281532	0.025296	-0.03139	-0.00722	-0.00019	2
-0.00019	-0.00721	-0.03135	0.025282	0.281494	0.463953	0.281494	0.025282	-0.03135	-0.00721	-0.00019	3
-0.00019	-0.00719	-0.0313	0.025263	0.28144	0.46395	0.28144	0.025263	-0.0313	-0.00719	-0.00019	4
-0.00019	-0.00716	-0.03123	0.025239	0.28137	0.463946	0.28137	0.025239	-0.03123	-0.00716	-0.00019	5
-0.00019	-0.00713	-0.03115	0.02521	0.281286	0.463941	0.281286	0.02521	-0.03115	-0.00713	-0.00019	6
-0.00019	-0.00709	-0.03105	0.025175	0.281186	0.463935	0.281186	0.025175	-0.03105	-0.00709	-0.00019	7
-0.00019	-0.00704	-0.03094	0.025135	0.281071	0.463929	0.281071	0.025135	-0.03094	-0.00704	-0.00019	8
-0.00019	-0.00699	-0.03081	0.025089	0.280941	0.463922	0.280941	0.025089	-0.03081	-0.00699	-0.00019	9
-0.00018	-0.00693	-0.03067	0.025039	0.280797	0.463915	0.280797	0.025039	-0.03067	-0.00693	-0.00018	10
-0.00018	-0.00687	-0.03052	0.024983	0.280637	0.463908	0.280637	0.024983	-0.03052	-0.00687	-0.00018	11
-0.00018	-0.0068	-0.03035	0.024921	0.280463	0.4639	0.280463	0.024921	-0.03035	-0.0068	-0.00018	12
-0.00017	-0.00673	-0.03017	0.024855	0.280274	0.463894	0.280274	0.024855	-0.03017	-0.00673	-0.00017	13
-0.00017	-0.00665	-0.02997	0.024784	0.28007	0.463887	0.28007	0.024784	-0.02997	-0.00665	-0.00017	14
-0.00017	-0.00657	-0.02976	0.024707	0.279853	0.463881	0.279853	0.024707	-0.02976	-0.00657	-0.00017	15
-0.00016	-0.00648	-0.02954	0.024626	0.279621	0.463877	0.279621	0.024626	-0.02954	-0.00648	-0.00016	16
-0.00016	-0.00639	-0.0293	0.024539	0.279375	0.463873	0.279375	0.024539	-0.0293	-0.00639	-0.00016	17

Table2. Result from *fdatool* (for Test Input)

(Test Input) h(n)											**Cut off frequency (output)**
h(0)	**h(1)**	**h(2)**	**h(3)**	**h(4)**	**h(5)**	**h(6)**	**h(7)**	**h(8)**	**h(9)**	**h(10)**	**Fc**
-0.00012	-0.00535	-0.02662	0.023543	0.276572	0.463943	0.276572	0.023543	-0.02662	-0.00535	-0.00012	26
-0.00011	-0.00521	-0.02627	0.023409	0.276198	0.463969	0.276198	0.023409	-0.02627	-0.00521	-0.00011	27
-0.00011	-0.00507	-0.0259	0.023271	0.275814	0.463999	0.275814	0.023271	-0.0259	-0.00507	-0.00011	28
-0.0001	-0.00493	-0.02553	0.023128	0.275418	0.464034	0.275418	0.023128	-0.02553	-0.00493	-0.0001	29
-9.86E-05	-0.00479	-0.02514	0.022982	0.275011	0.464075	0.275011	0.022982	-0.02514	-0.00479	-9.86E-05	30

Table 3.Simulation Result from *nntool*

S No.	Output from feed forward back prop	Output from radial basis	Output from layer recurrent
1.	26.2288	26.339	26.025
2.	27.3235	27.2141	27.041
3.	28.3704	28.0784	28.0567
4.	29.3672	28.941	29.069
5.	30.3197	29.8121	30.0753

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