IJCTA, 10(9), 2017, pp. 901-906 ISSN: 0974-5572

Radial Basis Function Neural Network for estimation of Bandwidth of Antenna

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ABSTRACT

In this article Radial Basis Function Neural Network is presented for the estimation of bandwidth of a microstrip antenna. The different variants of training algorithms of Radial Basis Function Neural Network are used to realize the neural network model. The data for training and testing the neural network are obtained by IE3D software. The results obtained by using RBF Neural Network are compared with IE3D simulation and found quite satisfactory. The results obtained from IE3D and results from RBFNN are in good agreement.

Keywords: Microstrip antenna, UWB, dual Bandwidth, Artificial Neural Network.

1. INTRODUCTION

Neuro models are computationally much more efficient then EM models once they are trained with reliable learning data obtain from a fine model by either EM simulation or measurement. The Neuro models can be used for efficient accurate optimization and designed within the range of training [1-5]. In the present work an Artificial *RBF Artificial Neural Network* (RBF ANN) is developed to analyze the bandwidth of microstrip antenna. The Method of Moments (MOM) based IE3D software has been used to generate training and test data for the ANN. It is a computational EM simulator based on Method of Moments numerical methods. It has analyzed that a 3D and multi layer structure of general shapes feed point must be located at point on the patch where the input impedance of patch matched the feed for the specific resonant frequency. The return loss is recorded and that feed point is selected as the optimum one where the RL is most negative i.e. less than -10dB. It is easy to model and easy to match by controlling the probe feed coordinates [6-12]. The proposed antenna has been designed on glass epoxy substrate to give a wide bandwidth of 88.90%, covering the frequency range from *2.115 GHz to 5.5 GHz* which is best suitable for WLAN application.

2. DESIGN AND DATA GENERATION OF PROPOSED ANTENNA

The configuration of the proposed antenna is shown in fig. 1. The microstrip antenna that has the patch length L and the patch width W has been located on the surface of a ground with glass epoxy substrate having the thickness of h. It is simulated the frequency domain response of the antenna for various patch dimensions using IE3D software for generation of data. For training and testing of the ANN, data sets are generated by using IE3D software. Figure1 shows the layout of a coaxial probe-fed rectangular patch antenna. By varying the feed position of this geometry the training data and test data for RBF-ANN has been generated. The Radial Basis Function Artificial Neural Network model has been developed for rectangular microstrip patch antenna as shown in Figure 2. The RBF Artificial Neural Network has been utilized to calculate the bandwidth of microstrip antenna. These networks can be used as a general function approximation. It can approximate any function with a finite number of discontinuities, arbitrarily well

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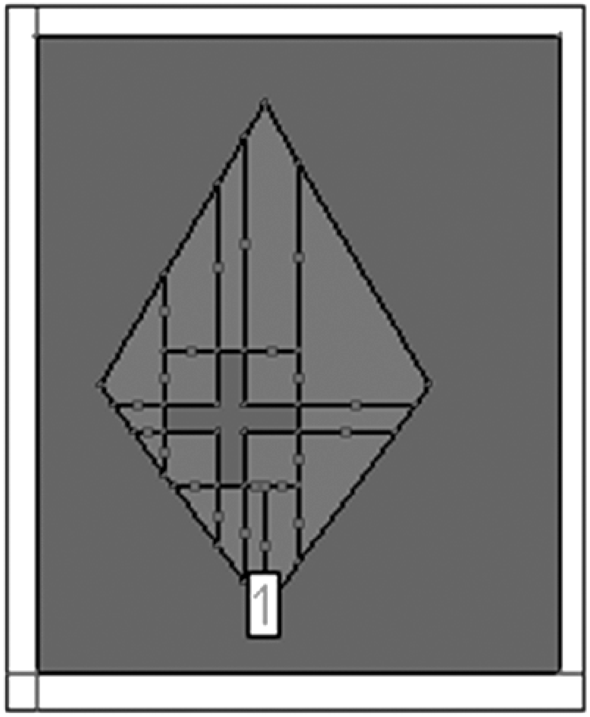

Figure 1: Geometry of proposed Microstrip antenna

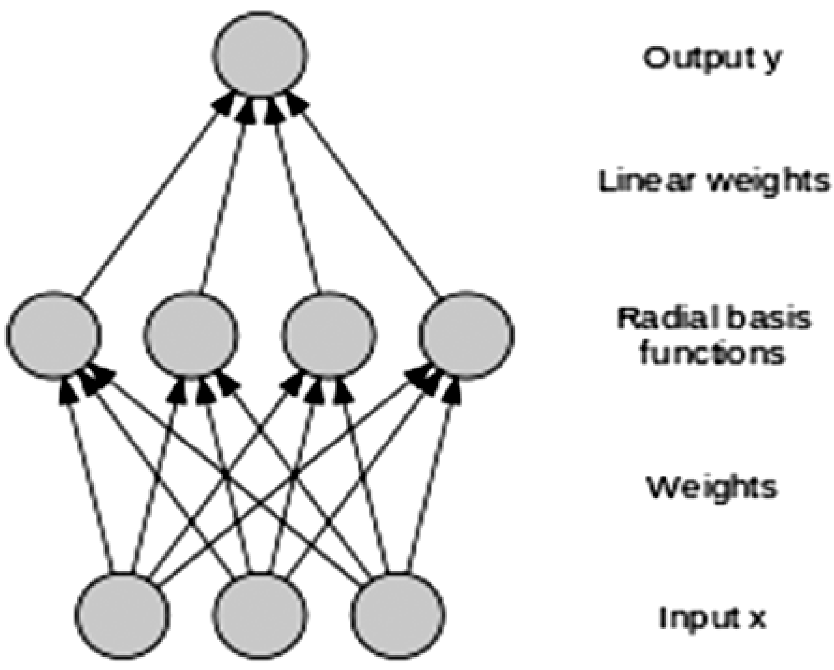

Figure 2: Radial Basis Function Artificial Neural Network Model

given sufficient neurons in the hidden layer. Figure 2 shows the architecture of a radial basis function network. An input vector x {\displaystyle x} is used as input to all radial basis functions, each with different parameters. The output of the network is a linear combination of the outputs from radial basis functions.

3. RADIAL BASIS FUNCTION NETWORK

In this paper, Radial basis function (RBF) neural network is used to analyze microstrip antenna. Radial Basis Function Neural Network is a feed forward neural network with a single hidden layer that used radial basis activation function for hidden neurons. RBF networks are applied for various microwave modeling

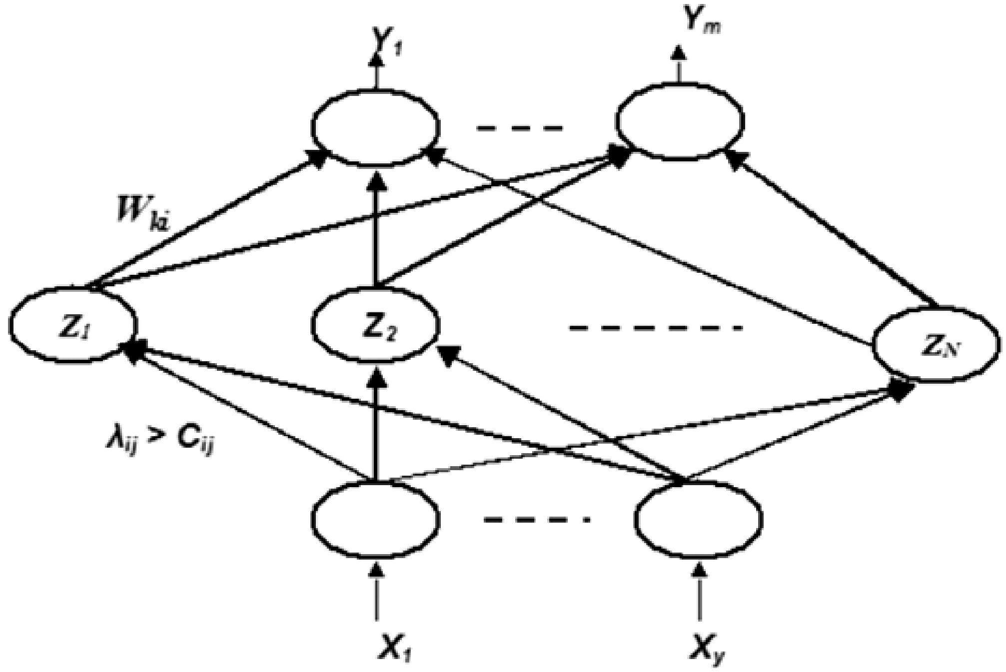

Figure 3: Neural Network approach of Radial Basis Function Network

purposes [13-19]. The RBF neural network has both are supervised and unsupervised components to its learning. It consists of three layers of neurons-input, hidden and output. The hidden layer neuron represents a series of centers in the input data space. Each of these centers has activation functions typically Gaussian. The activation depends on the distance between the presented input vector and the centre. The further the vector is from the centre the lower is the activation and vice versa the generation of centers and their widths is done using an unsupervised k-Means clustering algorithm. The centers and the widths created by these algorithms then form the weight of device of the hidden layer which remains unchanged once the clustering has been done. A typical RBF network is given in figure 3.

The parameters C_{ij} and λ_{ij} a centres and standard deviations of radial basis activation functions. Given the input X, the total inputs to the i_{th} hidden neurons γ_{ij} is given by

$$\gamma_i = \sqrt{\sum_{j=1}^{n}\left(\frac{x_j - c_{ij}}{\lambda_{ij}}\right)^2},\ i = 1,\ 2,\ 3 \ldots\ldots\ldots\ldots\ N \tag{1}$$

Where N is the number of hidden neurons, the output value of the i_{th} hidden neurons is $Z_{ij} = \sigma\, \gamma_i$, γ is a radial base function. Finally the output of the RBF network are computed from hidden neurons as

$$y_k = \sum_{i=0}^{N} W_{ik} Z_{ki} \tag{2}$$

Where W_{ki} is the weight of the link between the i_{th} neurons of the hidden layer and k_{th} neuron of the output layer Training parameters W of the RBF network include w_{k0}, c_{ij}, λ_{ij}, k = 1, 2…, m, i = 1, 2…, N, j = 1, 2… n.

In the RBF network the spread value is chosen as 0.1 which gives the best accuracy. In the structure there is one input and one output was used for the analysis ANN as shown in figure 4. The RBF network automatically adjust the number of processing elements in the hidden layer till the define accuracies reached. The training algorithm is unsupervised k-mean clustering theorem. Figure 5 shows the training performance of the developed neural model using RBF network. It is clear that RBF network is much faster than feed

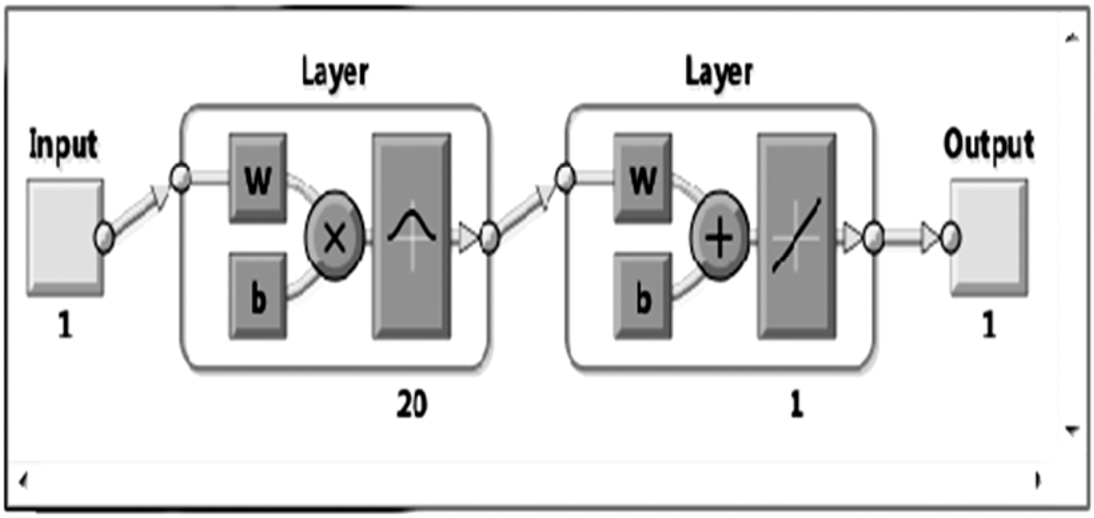

Figure 4: Radial Basis Function Network

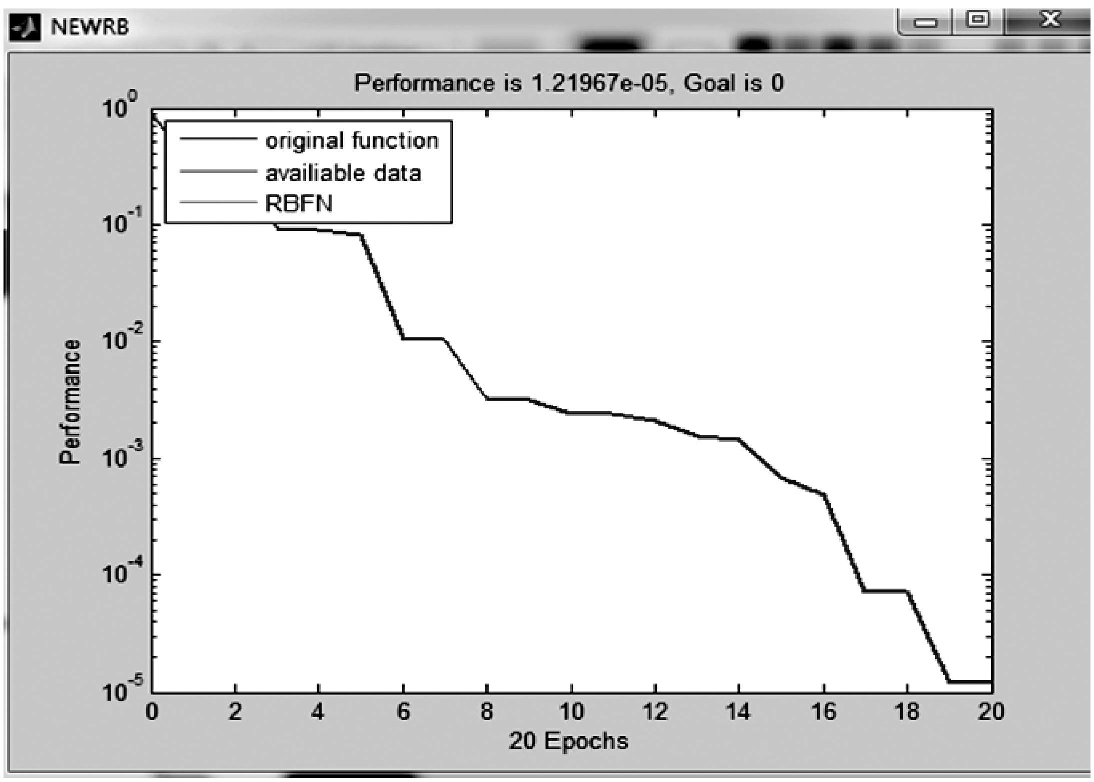

Figure 5: Training performance of developed neural model using RBF network

Table 1
Comparison of results obtained using IE3D and RBF ANN algorithm

Length	*Width*	*Probe(x, y)*	f_1	f_2	*BW IE3D GHz*	*BWRBF GHz*
29.42	38	17.12, 4.9	2.446	5.5	3.054	3.0539
29.42	38	17.12, 5.1	2.115	5.5	3.385	3.384
29.42	38	17.12, 5.4	2.134	5.5	3.366	3.368
29.42	38	17.12, 5.7	2.152	4.819	2.667	2.662
29.42	38	17.12, 5.9	2.189	3.587	1.398	1.398
29.42	38	17.12, 6.1	2.189	3.532	1.343	1.351
29.42	38	17.12, 6.4	2.226	3.624	1.398	1.388
29.42	38	17.12, 6.7	2.263	3.477	1.214	1.216

forward network since RBF network is trained in fewer epochs than feed forward network. In table 2 bandwidth obtained from IE3D software and using RBF network for different test pattern are compared

4. RESULT AND DISCUSSION

Figure 6 shows the return loss (S_{11}) verses frequency plot of proposed microstrip antenna. The results are also depicted in table 1. From the table it is evident that the results obtained from IE3D and ANN tool have good agreement and hence given accurate result after several trainings the length and width of the patch is kept constant and the probe position of the patch is being changed and the network is trained for the same adjustment. It has been observed that 20 epochs are needed to for the simulation with RBF Neural Network. The neuron hidden in the layer contains Gaussian transfer function whose outputs are inversely proportional to the distance from the center of the neuron. The proposed antenna has frequency range from *2.115 GHz to 5.5GHz* giving a wide band width of 88.90%.

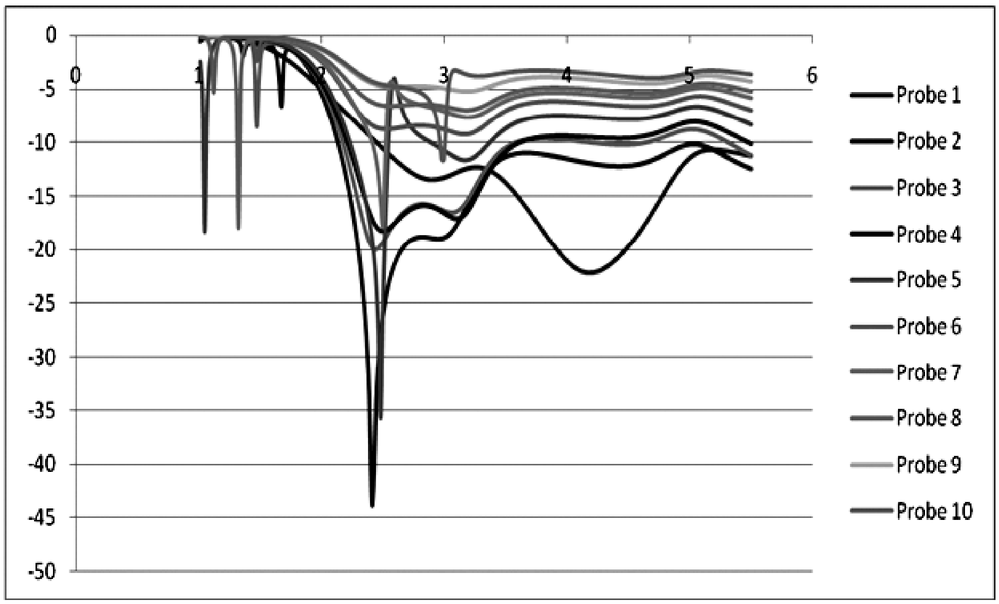

Figure 6: Return loss (S_{11}) Vs Frequency of Proposed Microstrip Patch Antenna

Table 2
Comparison of IE3D Results and RBFANN Results

Parameters	*Simulated Result (IE3D)*	*Simulated Result(RBF ANN)*
Frequency Band	3.385	2.384
Bandwidth	88.90%	88.84%

5. CONCLUSIONS

In this work RBFANN is used as a tool to study the bandwidth of proposed Microstrip Antenna. The results obtained from IE3D and the results obtained from ANN are in good agreement and shows 99.92% accuracy with RBF. The training and test set has been designed with the data obtained from IE3D software.

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