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Resonant Frequency of Microstrip Antenna using Artificial Neural Network

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Abstract :- **There are some key parameters in RFID reader antenna which are related closely with the antenna structure, such as resonant frequency, return loss and bandwidth in the antenna design process. Structure and properties of the antenna is a complex nonlinear system with complex state which is difficult to make mode by the mathematic method. In this case, neural network is used to express the nonlinear system in this article. Giving a large number of simulation data for the samples, adaptive artificial neural network is used to train network by simulation experiment which is used to verify the fitting degree of neural networks and simulation results. The experiment result shows that artificial neural network can improve the level of computer-aided design of micro strip antenna and achieve the antenna design quickly.**

Keywords: Microstrip Antenna, Artificial Neural Network(ANN), Resonant Frequency

I. INTRODUCTION

In 1990, Hansen and Salamon creatively put forward the NNE method. They proved that generalization ability of the neural computing system can be improved obviously by the way of training several NNs and then ensembling the results according to the rule of relative plurality voting or absolute plurality voting. Presently, the NNE studies mainly focus on two aspects: one is how to build/select every individual network, and the other is how to ensemble the outputs of every individual network. Taking the regression problem as an example, matrix inversion has to be carried out for getting combination weights of some conventional methods, and it is affected easily by multi-dimensional co linearity and noise in the data, which may decrease the generalization ability of the NNE. To solve the problem of multi-dimensional co linearity, we can adopt some methods, such as avoiding matrix inversion and restricting combination weights, selective ensemble method, extracting principal components, etc. To decrease the influence of noise, we can also adopt some methods, such as restricting combination weights, adjusting objective function, etc.

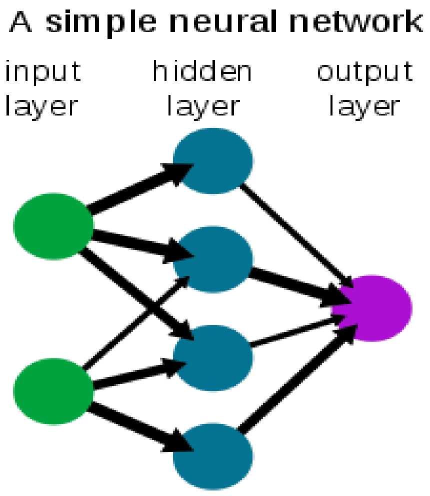

Fig.1 Simple neural network

II. METHODOLOGY

The resonance frequency of microstrip antennas is a phenomenon driven by laws whose behavior can be determined from previously known input/output samples. Empirical models like ANN permit to estimate the resonance frequency for similar cases by interpolation, within the range where the samples were obtained. Feed forward Perceptions Multilayer (PML) and Radial Base Functions (RBF) models were developed, using experimental data presented in references, and compared with the deterministic results presented in through and the empirical results presented in (1) and (2).

In general, PML networks are valid alternatives, but their training is done using the backpropagation algorithm, which can present typical difficulties of the optimization algorithms based on gradient descendent methods. The major difficulties are velocity of convergence and susceptibility to local minima, increasing the computational effort and decreasing the interpretability/ transparency of the results. Good alternatives to the PML networks are the RBF ones. Many different algorithms can be used with the feed forward architecture. A classical algorithm used for the training of PML neural networks is the gradient conjugate, a heuristic method. The Newton analytical method is an alternative to the gradient conjugate method, for a rapid convergence. The basic equation for the Newton method is:

$$\varkappa_{k+1} = \varkappa_k - H_k^{-1} g_k \qquad (1)$$

Where H is a Hessian matrix (second partial derivatives) of the performance index at the current values of the weights and biases. Newton's method often converges faster than conjugate gradient methods. Unfortunately, it is complicated and expensive to compute the Hessian matrix for feed forward neural networks. There is a class of algorithms that is based on Newton's method, but it doesn't require calculation of second derivatives. These are called quasi-Newton (or secant) methods. They update an approximate Hessian matrix at each iteration of the algorithm. The update is computed as a function of the gradient. The quasi-Newton method that has been most successful in published studies is the Broyden, Fletcher, Goldfarb, and Shanno (BFGS) update, whose basic equation is:

$$?\varkappa = [J^T(\varkappa).J(\varkappa)]^{-1} J^T(\varkappa).e(\varkappa) \qquad (2)$$

Where J(x) is Jacobean matrix and e(x) represents the errors. BFGS algorithm was used for rectangular antennas. For triangular antennas, the algorithm that presented best results was the Rprop - Resilient Propagation, described in reference. In the Rprop algorithm the weights and learning rates are modified only once in each training epoch. Each weight wji has its own variation rate (∆ji), which depends of the time t, in the following way:

$$\Delta_{ji}(t) = \begin{cases} \eta^{+}\Delta_{ji}(t-1), & se \dfrac{\partial E}{\partial \omega_{ji}}(t-1).\dfrac{\partial E}{\partial \omega_{ji}} > 0 \\ \eta^{-}\Delta_{ji}(t-1), & se \dfrac{\partial E}{\partial \omega_{ji}}(t-1).\dfrac{\partial E}{\partial \omega_{ji}} > 0 \\ \Delta_{ji}(t-1), & otherwise \end{cases} \qquad (3)$$

Where $0 < \eta- < 1 < \eta+$.
Changes on the weights occur only when the sign of the partial derivatives with respect to the weights change, and are independent of their magnitudes. For triangular antennas, PML networks with Rprop algorithm was more efficient than those based on conjugate gradient method or those based on second order gradient, like Levemberg-Marquardt. However, in the applications of this paper, RBF models presented the best results for both, rectangular and triangular antennas. The basic equation for the RBF network is:

$$\hat{y}(n+1) = \sum_{k=0}^{i} w_k(n) * \varphi(\|u(n) - z_k\|) \qquad (4)$$

Where $\varphi(\|u(n) - z_k\|)$ is a scalar function radially symmetric with z_k as its center. The operator $\|.\|$ is the Euclidian norm and gives the modulus of the argument vector. Further details about the training of this kind of network can be found in references.

Here for the analysis design by has been presented by considering the ANN model with inputs as width (W), length (L), height (h) and permittivity constant (εr) and output parameter as resonant frequency (fr).

This model was developed by considering scale without normalization. It gives accuracy up to 99.78% for training and 99.858% for testing. The NN Model has 4 inputs and 1 output as given in fig 5.1.

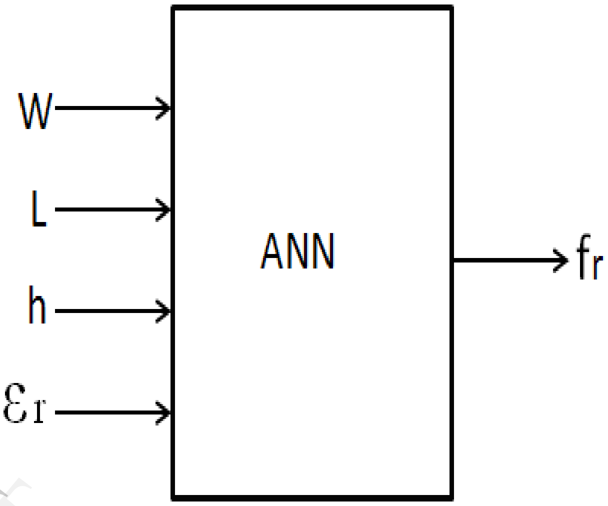

Fig.1.2: Four input & one output ANN Model

Here for the ANN model we are using input width between 0.93 to 1.49 ranges and length between the ranges 0.806 to 1.045, as well as for thickness 1.5 is minimum value and 9.5 is maximum value. Permittivity constant (εr) value is constant between 2.08-2.50

III. FLOW CHART

The flow chart for the analysis of the artificial neural network is given in fig. (1.3). Where in first decision box we decide that if the no. of epoch achieved, it stop otherwise it goes to the next stage. In next stage if desired accuracy have been achieved, it stop otherwise we will check the program. If it is learning over the result, we delete the neurons which are not requiring for the process. On the other hand if learning is under the result than we have to add some more neurons according to the requirement. We will perform the same process still training close to the target. After this whole process we will test the trained model. And after this whole process we achieve required result. It gives the accuracy up to 99%. This is main reason so we are using artificial

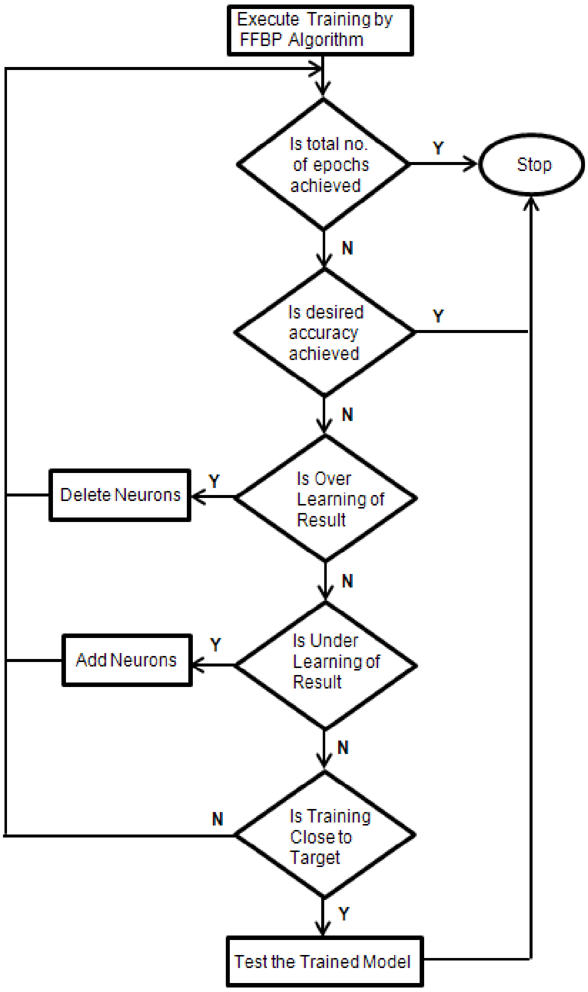

Fig1.3 Flow Chart

RESULTS We calculate the resonant frequency a Microstrip antenna, using its parameters like width (W), length (L), permittivity of the substrate (εr) and height (h) of the substrate. We apply artificial neural network technique for optimization of ΔL. The optimized ΔL is used for calculating the resonant frequency of rectangular Microstrip patch antenna.

we are using input variables width (w), length (L), permittivity of the substrate (εr) and thickness (h) and at output parameter is resonant frequency (fr).

Here, we are using input width (w) between 0.93 to 1.49 ranges, length (L) between the ranges 0.806 to 1.045, as well as for thickness (h) 1.5 is minimum value and 9.5 is maximum value. Permittivity constant (εr) value is constant between 2.08-2.50.

The data sheet for input and output variables is given in table which has 26 input and output data

.

TABLE-1

Input				Output
(W) Mm	**(L) mm**	**(T) (h) mm**	**permittivity (εr)**	**Resonant frequency (fr)**
124.9	91.9	2.2	2.08	1050
92.2	80.6	1.9	2.08	1040
103.0	84.8	4.2	2.50	1060
137.0	94.4	9.2	2.10	890
143.3	91.3	5.1	2.10	930
111.3	103.2	1.7	2.20	860
114.0	81.3	5.6	2.50	960
93.0	81.0	8.8	2.20	1060
98.1	83.0	4.5	2.25	960
113.7	93.7	9.5	2.25	870
127.1	82.4	2.6	2.25	1040
149.2	82.4	2.3	2.25	890
110.1	104.5	1.5	2.25	840
122.2	110.0	8.5	2.50	770
120.4	100.4	6.7	2.50	955
130.4	102.0	8.0	2.50	992
134.0	102.0	6.7	2.50	812
126.0	100.0	7.8	2.50	995
100.0	100.6	1.8	2.50	980
135.6	100.0	2.3	2.50	1010
132.0	103.4	2.4	2.25	1039
124.5	104.5	2.5	2.25	974
137.4	100.7	2.4	2.25	1012
123.4	98.7	3.4	2.25	886
100.0	94.5	4.4	2.25	942
104.5	88.8	5.5	2.25	988
100.2	89.3	3.3	2.25	987
122.4	89.3	5.6	2.25	1096

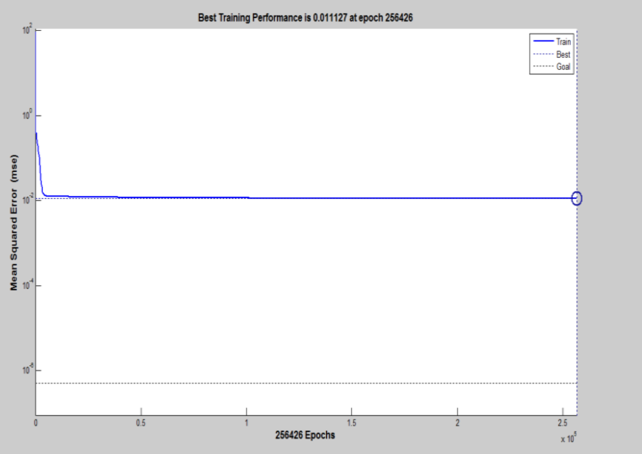

Fig.2The performance plot for the epoch is

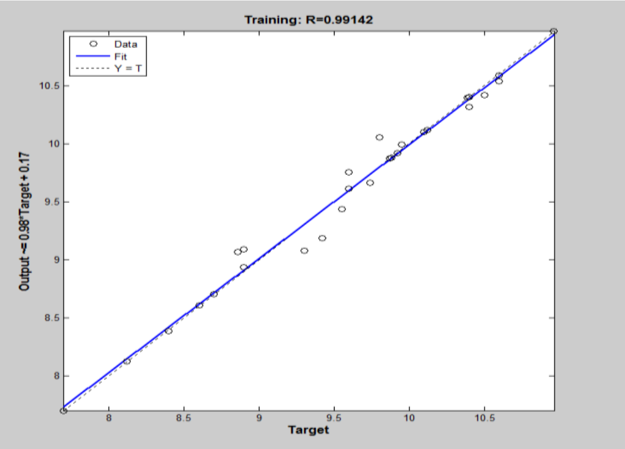

Fig.2.1 The regression plot for the epoch is

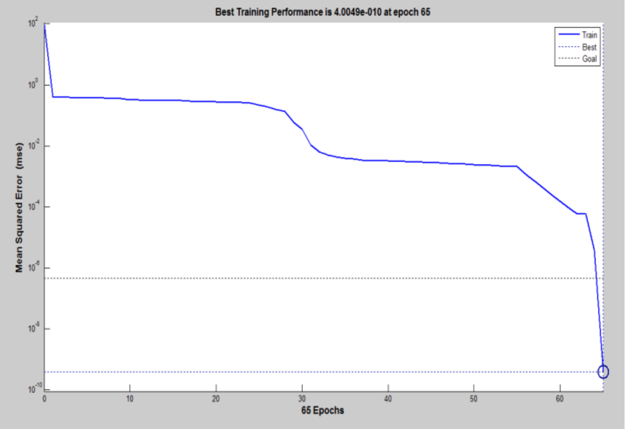

Fig.2.2 The performance plot for training is given in

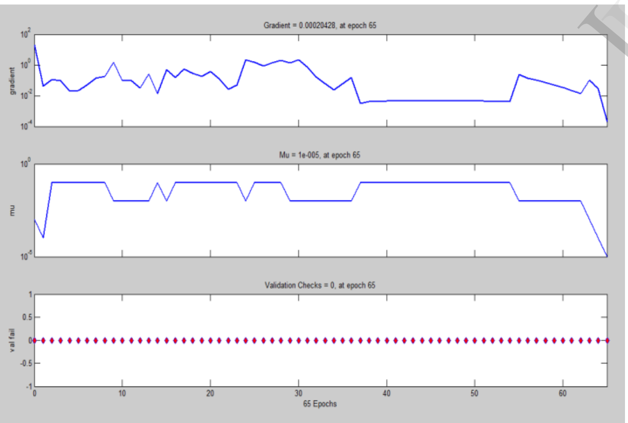

Fig2.4The training state plot for the training

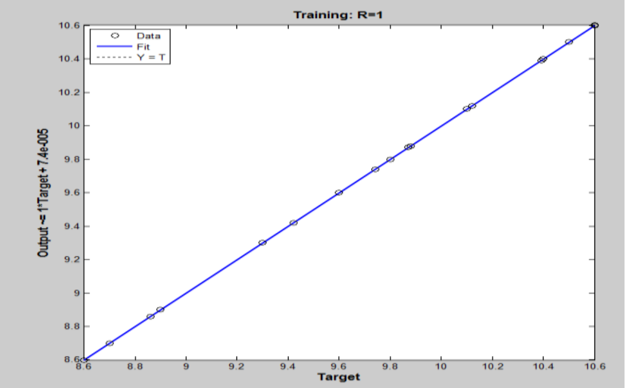

Fig.2.5 The regression plot for the training

(W)	(L)	(h)	(εr)
1.101	1.045	1.5	2.25
1.222	1.100	8.5	2.25
1.204	1.004	6.7	2.50
1.304	1.020	8.0	2.50
1.340	1.020	6.7	2.50
1.260	1.000	7.8	2.50
1.224	0.893	5.6	2.25

Testing output of resonant frequency for Microstrip antenna is:

y1 = 10.6227
y2 = 9.1522
y3 = 10.0329
y4 = 9.6663
y5 = 10.0867
y6 =9.6709
y7 =9.5835

IV. CONCLUSION

From the above experimental results, artificial neural network has the faster convergence rate and the smallest error. This proves the effectiveness of neural network to solve the problem of the design and calculation of micro strip antenna's different parameters. The neural network method can significantly improve the level of computer-aided design of micro strip antenna to achieve the calculation of antenna's parameters quickly.

In future we can use PSO to solve the problem of the design and to calculation the different parameters of micro strip antenna. Because the optimization of the Microstrip Patch is partially realized this concludes that the PSO code is functioning correctly

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