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Prediction of Antenna Parameters Using Machine Learning

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Abstract

Machine learning is playing the key role in the all the fields related to humans. In engineering design, scientific research, medical diagnostics, biotechnology, Economics even in humanities this technique is a using widely to explore the hidden information and decision making. Here in this paper we are using the machine learning in antenna technology to predict and estimate the parameters of antenna. Here we are using neural network technique to complete this task.

Index Terms*— artificial neural network, microstrip patch antenna, gain, bandwidth, regression, mean square error.*

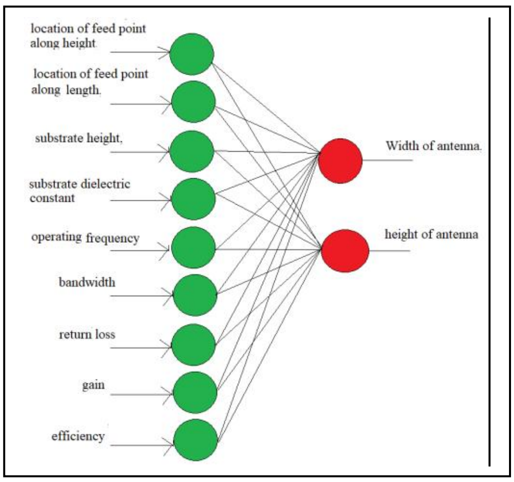
I. INTRODUCTION

Machine learning algorithms are capable in decision making or to optimize the result in nonlinear environment and due to this feature these algorithms can be employed in any application which involves decision making. Machine learning is a feature based learning where inputs of the system are in term of features [6]. Training and testing data are two parts of data.

We are applying Machine learning in antenna application in this work. We have designed a Microstrip patch antenna (MPA). Antenna is feed by coaxial cable. The designing was done on HFSS software. After designing of antenna we calculate the gain, efficiency and return loss of the antenna. We have eleven variables i.e. Width of antenna, height of antenna, location of feed point along height, location of feed point along length, substrate height, substrate dielectric constant, operating frequency, bandwidth, return loss, gain and efficiency. Operating frequency of the antenna is 2.4 GHz. Here we have to use the nine features as the input of the neural networks and predict the two output features. Height and width of the antenna are output variables and rests of the features are input of the proposed neural network as in Fig.1.

Fig. 1. Proposed Neural network for the model.

By Fig.1 all the input variables are used as the input of



the neural network and in training phase we will train the network by supervised learning. All the training data is labeled data, for a given set of input features there is a corresponding output.

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II. Related Work

In 2019 M.A.C. Niamien [2] worked on the estimating of input impedance of patch antenna. The antenna has CPW feed. For impedance matching they used spectral domain method. Wenwen et-al, 2018 [3] designed a fast multi object antenna by back propagation neural network algorithm. The main aim of the work was to reduce the computational cost of the network. Mengtao Xue et-al 2019 [1] also developed regression model for antenna designing. They use the gain, directivity and efficiency as output parameters.
The computational cost of all above model is very high so we develop a simple model to perform this task with very low complexity.

III. Methodology

The whole work is divided into two parts. First part is MPA antenna design and second part is ANN model training and testing [4,5]. The antenna designing part has done on HFSS V15 software and the ANN model is created by python programming on Jupiter note book.

A. *Antenna Design Model*

For experimental purpose we designed a simple micro strip patch antenna with coaxial feed. Dimension of the antenna is as follows: Width of antenna = 37.35mm Height of antenna = 28.8mm Location of feed point

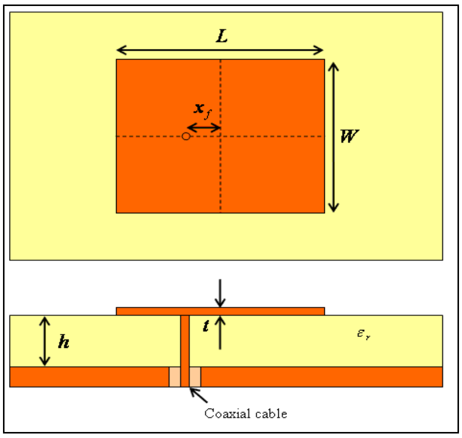

Fig. 2. Diagram of microstrip patch antenna.

along height 18.8mm Location of feed point along length = 9.6mm Substrate height = 1.6mm Substrate dielectric constant= 4.4 (FR4) Operating frequency = 2.4 GHz. Antenna Schematic diagram is shown in Fig.2. Solution frequency was 2.4 GHz and number of passes are 15 with 0.02 maximum delta value. In sweep tab, sweep type was interpolating and the frequency setup was linear setup. We have make all the above features variable and generate the 100 samples. After generating the samples we calculate the bandwidth return loss (S11 parameter) Gain and efficiency of the antenna. For the basic design of antenna the above output s are as follows:
Bandwidth =5 MHz
Return loss = -30.9dB
Gain = 1.86dB
Efficiency = 33%

S11 parameter of MPA is showing in Fig. 3

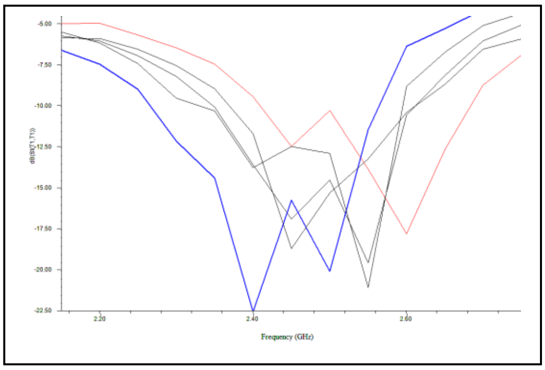

Fig. 3 S11 parameter of MPA

IV. Artificial Neural Network Model

Here we have used multilayered feed forward neural network architecture. We have use to nine features as the input of the neural networks and predict the two output features. Height and width of the antenna are output variables and rest of the features are inputs of the neural network. There are two hidden layers and each hidden layer consist 10 neurons. Experimentally we generate the 100 samples which are very less for training purpose so we use the slicing [7] method and by which we generate 1000 samples. It's a sufficient data set for training the ANN model. Some samples of data set is showing in Table 1. 80% of the data samples are used for training and 20 % of the dataset are used for testing. The performance measure of the network is MMSE.

V. Result and Discussion

Here in this paper we are using the machine learning in antenna technology to predict and estimate the parameters of antenna. Here we are using neural network technique to complete this task.
Location of feed point along height, location of feed point along length, substrate height, substrate dielectric constant, operating frequency, bandwidth, return loss, gain and efficiency are the input features of the model and antenna dimension i.e. height and width of the antenna are the output parameters of the model.

Regression diagram of the model without testing and with testing is shown in Fig.4 and Fig.5 respectively.

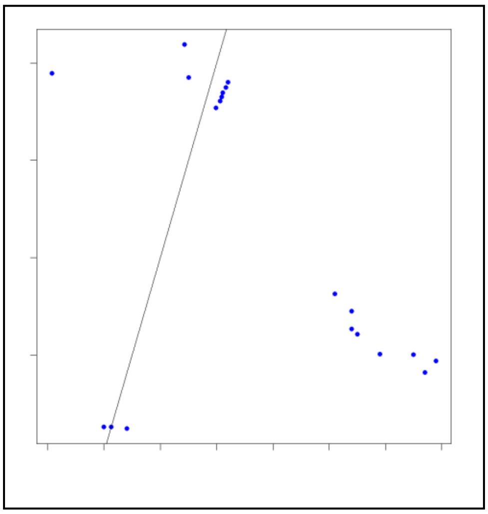

Fig.4 Regression curve without training

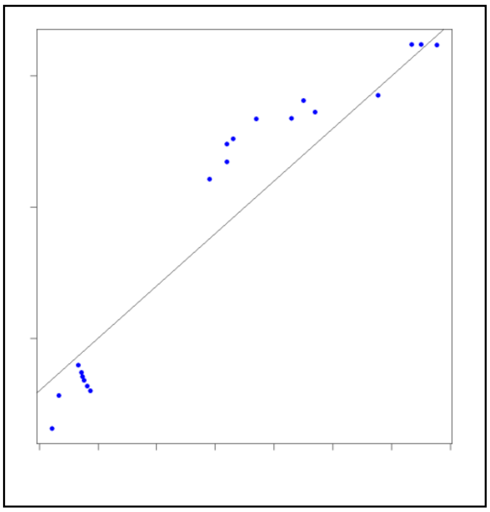

Fig.5 Regression curve with training

We have seen by Fig 4 and Fig.5 the difference that the curve is best fitted by the ANN model, the result of the actual and predicted length is shown in table 2. and similarly the result of the actual and predicted width is shown in table 3.

Performance measure is minimum mean square error as follows:

MMSE for width of antenna: 5.7

MMSE for length of antenna: 1.7

Run time of the system is 62 msec.

VI. Conclusion

Here in this paper we are using the machine learning in antenna technology to predict and estimate the parameters of antenna. Here we are using neural network technique to complete this task.

VII. Tables

TABLE I: The Arrangement of Channels

f	ε	sh	w	l	oof	bw	fpl	fpw	s11	Gain	Efficiency
2.4	4.6	1.6	37.351	28.807	2363	5	9.60	18.6	30.691	6.086	0.478
2.4	4.6	1	37.551	29.007	2380	0	9.66	18.7	37.378	6.098	0.66
2.4	4.6	1.1	37.451	28.907	2383	0	9.63	18.7	59.204	6.114	0.936
2.4	4.6	1.2	37.651	29.107	2362	2	9.70	18.8	40.621	6.122	0.899
2.4	4.6	1.3	37.251	28.607	2395	2	9.53	18.6	35.741	6.136	1.035
2.4	4.6	1.4	37.051	28.507	2398	1	9.50	18.5	32.637	6.152	1.249
2.4	4.6	1.5	37	28.67	2380	4	9.55	18.5	30.335	6.164	1.362
2.4	4.6	1.6	37.1	28.7	2372	4	9.56	18.5	29.972	6.177	1.491
2.4	4.6	1.7	37.151	28.757	2362	6	9.58	18.5	29.69	6.191	1.579
2.4	4.6	1.8	36.957	28.685	2362	6	9.56	18.4	29.06	6.163	1.385

TABLE2: Estimated and Actual Width

Sample No.	Actual	Predicted
7	28.67	27.8212
12	28.432	26.5665
28	29.324	28.98738
32	29.439	28.70971
34	29.479	28.55205
36	29.524	28.39776
39	29.636	28.19037
42	29.734	28.00831
43	41.54691	41.18399
44	40.6913	41.2105
47	41.002	41.20298
48	39.537	39.27682

TABLE3: Estimated and Actual Length

Sample No.	Actual	Predicted
7	37	37.85314
12	36.857	38.19215
28	37.974	37.5378
32	38.125	37.61261
34	38.179	37.6551
36	38.224	37.69668
39	38.325	37.75256
42	38.412	37.80162
43	34.24979	34.2603
44	34.805	34.24501
47	34.001	34.26212
48	32.15	37.89563

Our results are very close to the actual values the MMSE is also quit low and the execution time of the overall model is only 62msec.

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