Diagnosis of Array Antennas with Defective Elements Using Artificial Neural Network

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1. Introduction

Array antennas have been widely used for various applications. One of the major problems of array antennas is element failure. The existence of the failures in array antennas may degrade its performance. Diagnosis of the array antennas using source reconstruction technique is one of the effective approaches to find the element failure. On the other hand, it has been reported that so-called Neural Networks (NNs) is effective to solve a large number of EM problems such as antenna design [1-3]. Objective of present study is to design NNs for finding defective elements in array antennas.

2. Neural Network

The structure of the MLP(multilayer perceptrons)-NN in this work is shown in Fig.1. The input layer has N neurons, and the input is **E** which is the magnitude of near-field over a specific measurement plane. The output layer has M neurons, and the output is **I** which corresponds to the magnitude of current of an antenna under test. In this model, the output can be described as follows,

$$\mathbf{I} = \sigma_2 \mathbf{W}^1[\sigma_1 \mathbf{W}^0(\mathbf{E})] \tag{1}$$

where $\boldsymbol{W_l}$ is the weight and σ_l is activation function. l =0 indicates input layer, l=1 indicates hidden layer and l=2 indicates output layer. Here, an activation function is RELU and sigmoid function for the input layer and hidden layer, respectively .

And we define the loss function

$$\text{loss} = \sum_{i=1}^{N}\sum_{j=1}^{M}\left[\left(I^{e}_{ij} - I^{o}_{ij}\right)/0.05\right]^2 \tag{2}$$

where I^{e}_{ij} is the exact current distribution obtained by full-wave simulation and I^{o}_{ij} is estimated current distribution by the NNs. The weight is updated using a gradient descent technique called Adam and backpropagation during training of the NN.

3. Simulation and Results

A planar dipole array antenna with 10 × 10 elements including a couple of defective elements is an antenna under test. The training dataset: near-field **E** on a rectangular scanning surface as input data and current distribution **I** as output data were obtained by Method of Moments (MoM). Training dataset was regularized in advance of training. Length of the dipole is 0.5 λ , radius of the dipole is 0.015 λ and array spacing is 0.6 λ . Every dipole antenna is excited by a voltage source and its work frequency is 1.5 GHz. In this report, the maximum number of defective elements is restricted to three and the defective elements are distributed randomly. And then, we obtain the training dataset.

Results of numerical simulation are shown in Fig. 2. According to Fig. 2, it is found that the designed NNs works well for finding defective elements.

4.Conclusion

In this report, NNs has been designed to find defective elements in an array antenna. It has been demonstrated that the designed NNs enable to find defective elements in the array antenna,

5.Reference

[1] J. Zhang, K. C. Gupta, and V. K. Devabhaktuni, “Artificial neural networks for RF and microwave design: From theory to practice,” IEEE Trans. Microw. Theory Techn., vol. 51, no. 4, pp. 1339–1350, Apr. 2003.

[2] Q. J. Zhang and K. C. Gupta, Neural Networks for RF and Microwave Design. Norwood, MA, USA: Artech House, 2000, pp. 151, 312–315, and 336.

[3] A. Gehani and D. A. Pujara, “Predicting the return loss performance of a hexa-band PIFA using ANFIS,” Microw. Opt. Tech. Lett., vol. 57, no. 9, pp. 2072–2075, Sep. 2015.

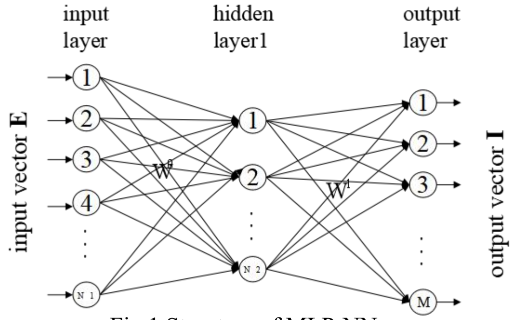
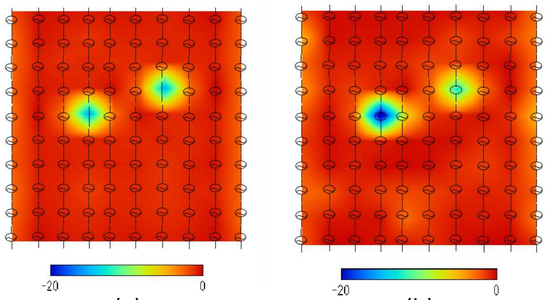


Fig.1 Structure of MLP-NN



(a)　(b)

Fig.2 (a) the current distribution by MoM, (b) the current distribution estimated by model

