Detection of Defective Elements in Array Antennas Using Artificial Neural Networks and Eigenmode Currents

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***Abstract*—A method for finding defective elements in array antennas is introduced. The method is named as ANN-EC because the method is based on an artificial neural network (ANN) and eigenmode currents (EC). Current distribution of the array antennas is reconstructed from magnitude of their near-field using the ANN-EC. The ANN-EC is applied to dipole array antennas including defective elements. It is demonstrated that defective elements in the array antennas can be found successfully using the ANN-EC.**

***Keywords*—Artificial Neural Network, Eigenmode Current, Source Reconstruction**

I. Introduction

According to recent advancement of array antennas, a lot of relevant technologies have been developed. For example, efficient numerical analysis techniques for large-scale array antennas have been proposed so far [1] -[4]. Quasi-periodic array antennas such as reflectarrays or transmitarrays have been widely used and their design methods have been developed [5]-[11]. Although extensive efforts have been dedicated to array antenna technologies, challenging problems are still remaining.

One of the remaining problems to be challenged is diagnosis of the array antennas, i.e. finding defective elements in the array antennas [12], [13]. In order to find defective elements in the array antennas, so-called inverse problem is solved using source reconstruction techniques. Usually, equivalent sources of the array antennas are reconstructed from near-field data using the source reconstruction methods. According to the reconstructed equivalent sources, the defective elements are found. In recent years, artificial neural networks (ANN) have been introduced to source reconstruction techniques for non-linear inverse problems [14]-[16]. In previous works, our group has developed a source reconstruction technique using both of the ANN and eigenmode currents (EC) of the array antennas named as ANN-EC [17]-[20]. According to the ANN-EC, complex equivalent current of the array antennas can be reconstructed successfully from magnitude of the near-field data.

In this paper, the ANN-EC is applied to source reconstruction of the array antennas. Eqivalent current distribution of the array antennas is reconstructed using the ANN-EC from the near-field data. The ANN-EC is applied to near-field data measured on specific planes whose spacing d_z from the array antennas is different. Numerical simulation is performed and robustness of the ANN-EC to d_z is demonstrated.

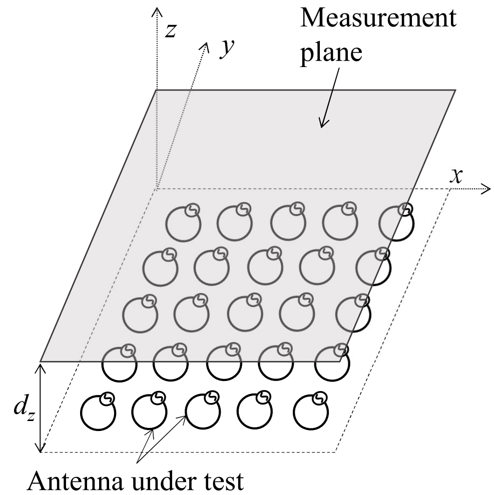

Fig. 1. Loop array antenna.

II. Numerical Simulation

A loop array antenna shown in Fig. 1 is an antenna under test (AUT). Here, the number of loop antennas is 25 ($= 5 \times 5$) and circumference of the loop antenna is 1λ. The loop array antennas include a couple of defective elements. All of the loop antennas are excited uniformly except for the defective elements. Excitation of the defective elements includes random phase shift. Magnitude of near-field of the array antenna is measured over a measurement plane. Spacing between the measurement plane and the loop array antenna is d_z. Complex current distribution of the loop array antenna is reconstructed using the ANN-EC. In the ANN-EC, eigenmode currents of the AUT are obtained numerically and their unknown weight coefficients are obtained using the ANN. Complex current distribution of

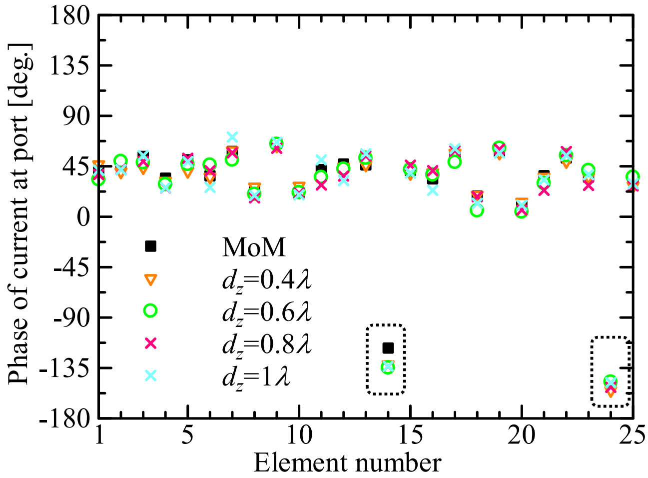

Fig. 2. Phase of current at port of loop array antennas (Dashed line indicates defective elements).

the AUT is reconstruted as a weighted sum of the eigenmode currents. According to limited number of pages, precise geometry of the loop array antenna and details of the ANN-EC are omitted here. The precise geometry of the loop array antenna and details of the ANN-EC are described in the publicated journal and thesis [19], [20].

Phase of current at port of loop antennas is shown in Fig. 2. As shown in this Figure, the equivalent current distributions were reconstructed from the magnitude of near-field measured at different measurement planes of $d_z = 0.4, 0.6, 0.8, 1\lambda$. Phase of real current distribution of the loop antennas obtained using the method of moments (MoM) is also shown in Fig. 2. It is found that phase of the reconstrcted currents using the ANN-EC is coincident with that of the MoM. Moreover, it is demonstrated that defective elements are clearly found using the ANN-EC. According to the results of numerical simulations, robustness of the ANN-EC to d_z is demonstrated.

III. Conclusions

In this paper, the ANN-EC has been applied to source reconstruction of the array antennas. The eqivalent current distribution of the array antennas was reconstructed using the ANN-EC from the near-field data. Near-field data on the measurement planes whose spacing d_z from the array antennas is different. Numerical simulation was performed and robustness of the ANN-EC to d_z has been demonstrated.

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