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ANTENNA ANALYSIS USING NEURAL NETWORKS

by

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ABSTRACT

Conventional computing schemes have long been used to analyze problems in electromagnetics (EM). The vast majority of EM applications require computationally intensive algorithms involving numerical integration and solutions to large systems of equations. In this study, the feasibility of using neural network computing algorithms for antenna analysis is investigated. The ultimate goal is to use a trained neural network algorithm to reduce the computational demands of existing reflector surface error compensation techniques.

Neural networks are computational algorithms based on neurobiological systems. Neural nets consist of massively parallel interconnected nonlinear computational elements (see Fig. 1). They are often employed in pattern recognition and image processing problems. Recently, neural network analysis has been applied in the electromagnetics area for the design of frequency selective surfaces and beam forming networks.

In this study, the backpropagation training algorithm was employed to simulate classical antenna array synthesis techniques. The Woodward-Lawson (W-L) and Dolph-Chebyshev (D-C) array pattern synthesis techniques were used to train the neural network. The inputs to the network were samples of the desired synthesis pattern. The outputs are the array element excitations required to synthesize the desired pattern. Once trained, the network is used to simulate the W-L or D-C techniques.

Various sector patterns and cosecant-type patterns (27 total) generated using W-L synthesis were used to train the network. Desired pattern samples were then fed to the neural network. The outputs of the network were the simulated W-L excitations. For this part of the study, a 20 element linear array was used. There were 41 input pattern samples with 40 output excitations (20 real parts, 20 imaginary). A comparison between the simulated and actual W-L techniques is shown in Fig. 2 for a triangular-shaped pattern.

Dolph-Chebyshev is a different class of synthesis technique in that D-C is used for side lobe control as opposed to pattern shaping. The interesting thing about D-C synthesis is that the side lobes have the same amplitude. Five-element arrays were used. Again, 41 pattern samples were used for the input. Nine actual D-C patterns ranging from -10 dB to -30dB side lobe levels were used to train the network. Figure 3 shows a comparison between simulated and actual D-C techniques for a pattern with -22 dB side lobe level.

The goal for this research was to evaluate the performance of neural network computing with antennas. Future applications will employ the backpropagation training algorithm to drastically reduce the computational complexity involved in performing EM compensation for surface errors in large space reflector antennas.

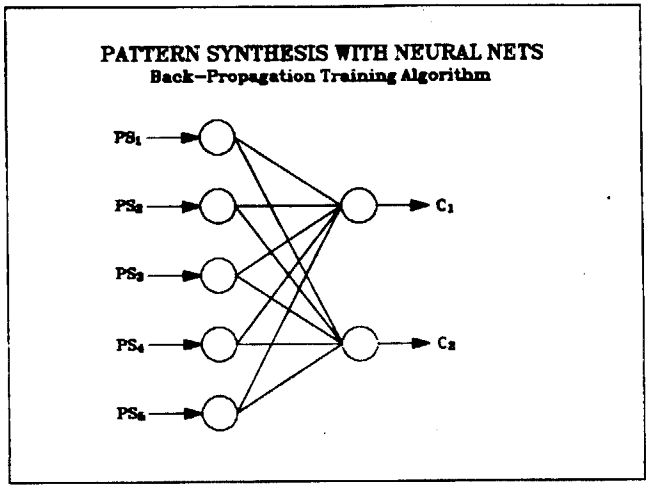

Figure 1. Neural network diagram.

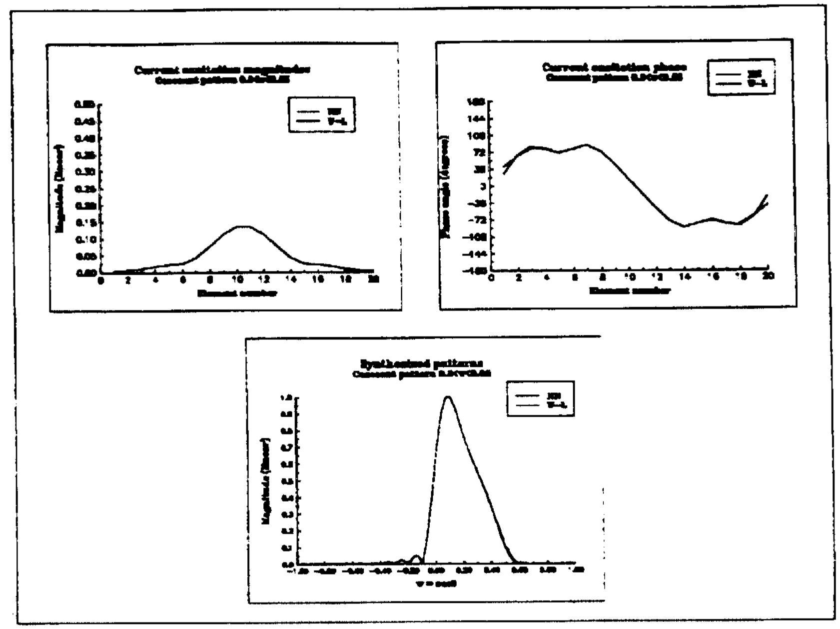

Figure 2. W–L synthesis for a triangular pattern.

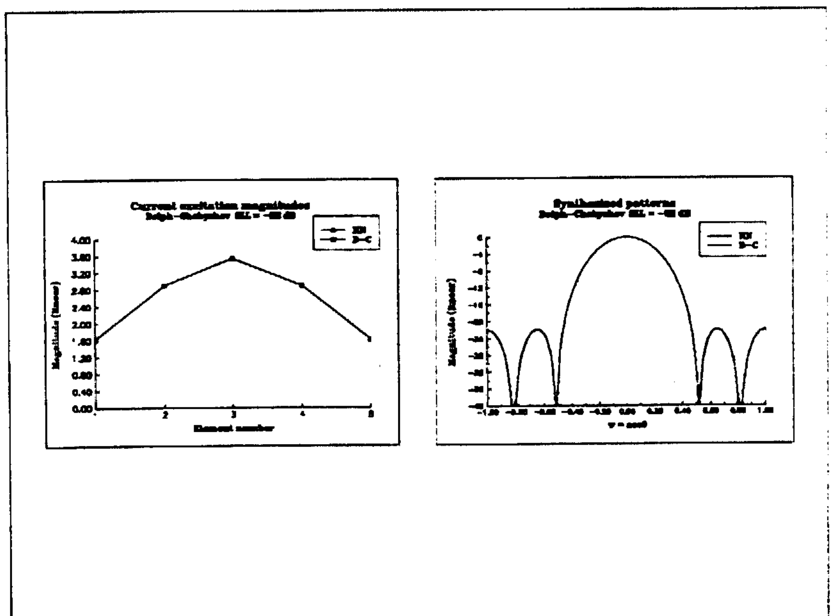

Figure 3. D–C synthesis for a pattern with –22 dB side lobes.