Efficient Impedance Interpolation and Pattern Approximation for Linear Microstrip Phased Arrays Using Neural Networks

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Antenna array optimization techniques such as genetic algorithms require efficient evaluation of essential design parameters including driving point impedances and radiation patterns. Rigorous full-wave electromagnetic simulation techniques provide accurate impedance calculations. However, these simulations are often computationally intensive, thereby greatly increasing the time required to perform antenna array optimizations. This study attempts to lay the foundation for extending the technique developed in (M. G. Bray et al., Proceedings of *The 2001 IEEE AP-S Symposium*, Vol. 3, pp. 688-691, July 2001). This design synthesis technique was originally developed for dipole arrays and will be extended here to include linear microstrip antenna arrays. An efficient impedance representation is sought through neural network interpolation. The corresponding radiation pattern calculations are made using a cavity model. These efficient simulation techniques are then applied to the analysis of a linear microstrip antenna array as shown in Figure 1.

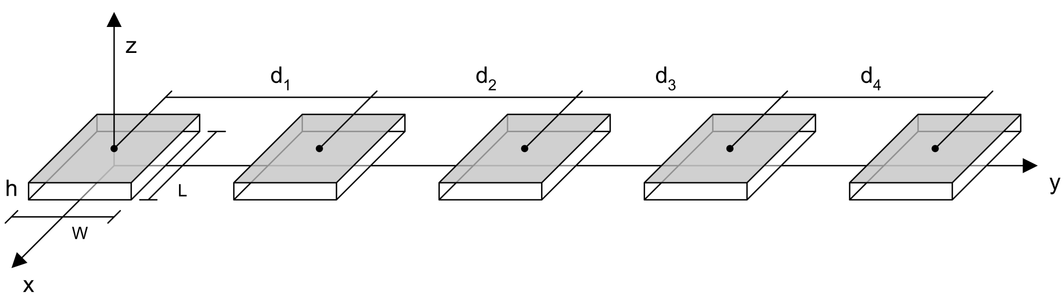

Figure 1. Example of Linear Microstrip Antenna Array Geometry.

Initially, a single microstrip antenna design with a given value of L, w, and h is chosen for use in the array. This single isolated antenna is simulated using a numerically rigorous full-wave method at multiple feed positions to find the corresponding self-impedance curves. Two patch antennas are then simulated at varying separation distances and feed positions to create a database of mutual impedances. Separate neural networks can then be trained to represent the self-impedance of a patch and the mutual impedance between two patches given specified feed positions and element locations. Using N-port network theory, the driving point impedances can be calculated from source excitations, self-impedances, and mutual impedances for each patch in an N-element array. Once the driving point impedances are known, the antenna array pattern is calculated using the cavity model for a single patch and applying pattern multiplication to find the radiation pattern for the entire array. The methods developed in this study are applied to the design of several five-element linear microstrip antenna arrays with comparisons made to full-wave electromagnetic simulations.