# COMPARISON STUDY OF PATTERN-SYNTHESIS TECHNIQUES USING NEURAL NETWORKS

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**ABSTRACT:** *In this paper, a comparison study among three neural-network algorithms for the synthesis of array patterns is presented. The neural networks are used to estimate the array elements' excitations for an arbitrary pattern. The architecture of the neural networks is discussed and simulation results are presented. Two new neural networks, based on radial basis functions (RBFs) and wavelet neural networks (WNNs), are introduced. The proposed networks offer a more efficient synthesis procedure, as compared to other available techniques.* © 2004 Wiley Periodicals, Inc. Microwave Opt Technol Lett 42: 175–179, 2004; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20244

## 1. INTRODUCTION

The array-pattern-synthesis problem can be defined as that of finding the array excitations to produce the required antenna-radiation pattern. Pattern synthesis is required in different applications of wireless communication, cellular communication, and radar and military systems. There are numerous synthesis methods, such as the Woodward–Lawson method [1], the Orchard–Elliott method [2], the modified Orchard–Elliott method [3], and others. Most of these methods have a high degree of complexity and sometimes they are not suitable for real-time applications. Neural networks offer a fast and easy-to-implement solution due to their unique parallel structure. The neural network is trained with input/output sets of examples with characteristics similar to those of the desired pattern. The input consists of spatial samples of the desired pattern and the output generates the array elements' excitations. After the training phase, a new pattern is introduced to the network and the array excitation is computed. In this work, the different neural networks were trained with examples generated by the Orchard–Elliott method for a flat-top pattern with constant side-lobe level (SLL).

In this paper, two neural-network algorithms for the synthesis of array patterns are introduced. The two algorithms use different activation functions, the radial basis function (RBF), and wavelets function, respectively. A comparison study was conducted among different methods: Orchard–Elliott, the multiplayer perceptrons network (MLP), the RBF network, and the wavelets neural network (WNN) network. In all three neural networks, only one hidden neuron layer was considered. The parameters for comparison are the mean square error (MSE) between the desired and computed patterns and the computation time.

## 2. THEORY

The basic structure of an artificial neural network is an array of processing elements (also called neurons) ordered in layers with a network of interconnection weights $w_i$ ($j = 1, \ldots, L$) between the neurons (also called synaptic weights) [4] in different layers. The input data $x_j$ is processed through an activation function $f(x)$. The basic model of a single neuron is shown in Figure 1. The output $y$ of the neuron in this model is given by

$$y = f\left(\sum_{j=1}^{L} w_j \cdot x_j + b\right), \tag{1}$$

where $b$ is the bias parameter of the activation function $f(x)$. By adding a new fixed input $x_0 = 1$ and defining the synaptic weight of this input as the bias $w_0 = b$, the bias can be evaluated in the