Broadband Antenna Optimization Using an Artificial Neural Network

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Antenna design is a parameter optimization problem. This class of problems is computationally intensive, especially for broadband antennas, for which the parameter exploration is needed over a wide range of frequencies. To reduce the computational cost we propose the use of a neural network to predict the broadband characteristics of antennas over a broad range of parameter spaces.

For efficient broadband data generation, the Gaussian function is considered for the modeling of the input resistance of an antenna. The rationale is that the resistance as a function of frequency can be matched well by a sum of a few Gaussians, yielding a model with relatively few parameters. The neural network takes the geometric parameters of the antenna as inputs and produces the coefficients of the Gaussian model as its outputs. A multi-layered perceptron (MLP) with one hidden layer is employed for the network structure. This neural net describes the nonlinear relationship between the antenna geometry and the coefficients of the model. After the neural network is trained, it can generate the input resistance without the use of a computational electromagnetics code. The input reactance of the antenna is then obtained from the predicted input resistance using the integral form of the Hilbert transform.

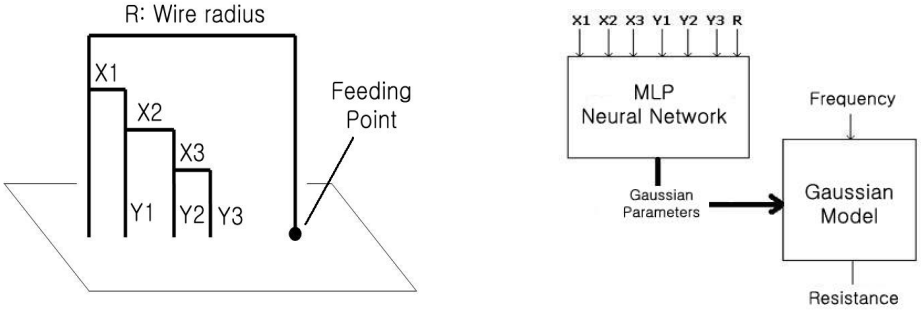

Fig. 1. (a) The antenna to be optimized, (b) The neural net structure.

The proposed method is tested on the design of a loop-based, broadband vehicular antenna that should be well-matched from 170 to 230 and 470 to 650 MHz (Kim et al, *Elec. Lett.*, 40, 1566-1568, 2004). The antenna has seven variable geometric parameters: the lengths and heights of its three rectangular tuning arms, and the radius of the antenna wire. The neural net is first trained by the conjugate gradient descent method using 135 antenna configurations. Next, the antenna is optimized using a genetic algorithm, which uses the neural network for all antenna cost evaluations. Using the proposed method, the optimization time is reduced by a factor of seven as compared to the brute-force evaluation of the cost function during the optimization process.