Nature-based Antenna Design: Interpolating the Input Impedance of Fractal Dipole Antennas via a Genetic Algorithm Trained Neural Network

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Over the years engineers have often looked to nature for inspiration when seeking new and innovative ways to solve complex design problems. For instance, the development of fractal geometry was originally inspired by studying the shapes of natural objects such as trees, leaves, ferns, terrain, coastlines, snowflakes, and cloud boundaries. Neural Networks (NN) have been developed to mimic the human decision-making process. Similarly, Genetic Algorithms (GA) are based on the Darwinian notion of survival of the fittest and evolution. In fact the origin of several commonly used analysis techniques of modern day electromagnetics may be traced to processes found in the natural world. This paper will focus on developing a powerful nature-based antenna engineering design tool that combines together for the first time aspects of fractal geometry, neural networks and genetic algorithms. More specifically, an efficient method will be introduced for interpolating the driving point impedance of fractal dipole antennas using a genetic algorithm trained neural network.

A versatile as well as efficient approach based on Iterated Function Systems (IFS) is used to generate the candidate fractal dipole antenna geometries (D. H. Werner et al., *IEE Electronics Letters*, **37**, pp. 1150-1151, Sept. 2001). The GA trains the NN over a set of data which contains the IFS parameters and the corresponding input impedances. Once the NN is trained, it is used to interpolate the input impedances for IFS parameters that are not contained in the training data. The IFS parameter space is discretized such that the training set is extremely small when compared to the actual data set of IFS parameters. This training set of various fractal geometries with their respective driving point impedances is calculated from a numerically rigorous Method of Moments (MoM) simulation. Once the neural network has been trained, the IFS parameters for any fractal dipole antenna geometry belonging to a particular class may be specified and passed on to the neural network. The NN will then interpolate the driving point impedance corresponding to any specific IFS parameters that lie within the parameter space. One of the main advantages of this IFS-GA-NN approach is that it is more computationally efficient than a direct MoM technique.

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