THE EXISTING PROBLEM OR ISSUE

Handling the complexity of electromagnetic design optimisation problems is challenging. These problems often have multiple variables of mixed types, i.e., continuous and discrete. Continuous variables can take any value in a specific range, whereas discrete variables can take only a value from a discrete pre-determined set (e.g., commercially available dielectric slab thicknesses). They also often have geometry constraints, such as the maximum overall length of the device being designed. It is highly desirable to have an optimization technique that can efficiently handle both mixed variables and different types of such geometrical and other constraints, and produce an optimized design that can be implemented directly without additional approximations.

In RF/microwave components and antennas, dielectric materials are frequently used and their thickness and dielectric constant parameters are optimised. Hence, in the optimisation process, available (commercially or otherwise) thickness and dielectric constant values need to be specified as discrete variables. Currently known optimisation methods for electromagnetic problems cannot handle continuous and discrete variables simultaneously. Generally, the quick fix is to use continuous variables during optimization and then find the available values that are closest to the optimal values, but this method does not necessarily produce an optimal design. The few proposed methods that allow the user to incorporate discrete variables are extremely complex, and have therefore not gained popularity. Another common difficulty associated with optimization of RF/microwave components is the maximum overall dimensions of the device provided in specifications. So far, this condition has not been handled well by optimization methods.

OUR SOLUTION

We developed a new optimization method for real-world electromagnetic problems and tested it in conjunction with a commercial simulation software product.

The core of the method is a probability-based optimization technique based on the theory of statistics and information. The algorithm iteratively updates the design parameters of a device under optimization in order to concentrate over the best performing individuals.

Using the invented technique for optimization of electromagnetic devices, we obtained high-performance solutions to the problems with simultaneous mix of discrete and continuous variables and imposed geometric constraints. We showed that the devised optimization method converges faster than the counterparts.

The common practical constraints on available materials (material parameters, thickness, etc.) and specified overall dimensions of electromagnetic devices are no longer a challenging problem for electromagnetic methods.

INVENTORS

Maria Kovaleva, David Bulger, Karu Esselle, Basit Zeb
Two examples of devices with geometry constraints, optimized using the invented method.

Left: A resonant cavity antenna. During optimisation, the overall diameter of the antenna was fixed but the width of each dielectric section was a continuous variable. The dielectric constant of each section was a discrete variable that could take only commercially available values.

Right: A microwave low-pass filter with a predefined overall length of 33.3mm. Length of each section was a continuous variable but their sum was fixed to 33.3mm.