New algorithms for electromagnetic optimisation problems

THE EXISTING PROBLEM OR ISSUE

Handling the complexity of electromagnetic and microwave 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 propose a new algorithmic application of the cross-entropy method (CE) for real-world optimization and tested it in conjunction with a commercial simulation software product.

The CE method is a probability-based optimization technique based on cross-entropy minimization between probability distributions. Candidate designs are selected according to a changing probability distribution, and evaluated for fitness. The algorithm iteratively updates the distributional parameters to concentrate over the best performing individuals.

A distinct feature of the CE method is that its iterative procedure is independent of the probability distribution describing the optimization problem. In the invented technique for optimization of electromagnetic devices, we utilized this feature for simultaneous handling of a mix of discrete and continuous variables and imposing geometric constraints. By using different probability distribution families, we showed that common practical constraints on available materials (material parameters, thickness, etc.) and overall dimensions of electromagnetic optimization problems can be specified.

INVENTORS

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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.

FEATURES | BENEFITS
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Fast and robust electromagnetic optimization method | Allows for accurate design and optimization of RF/microwave components
Capable of solving complex problems with both discrete and continuous variables | Allows for real world considerations to be met, such as available substrates, substrate thickness values, metal thickness values, via sizes etc.
Incorporates diverse geometrical constraints such as maximum overall dimensions | Useful for optimization of various RF/microwave components to fit within a specific space
Simulation-driven electromagnetic optimization | Usable with a wide range of commercial simulation software products

INTELLECTUAL PROPERTY POSITION
Australian Patent Application:
*New algorithms for electromagnetic optimization problems*

APPLICATIONS
- Commercial computer-aided-design or simulation software products
- Mixed-variable and constrained optimizations of electromagnetic problems

WOULD YOU LIKE TO KNOW MORE?
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