

Parameter Optimization Using the Divided Rectangles Global Algorithm with Kriging Interpolation Surrogate Modeling

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Most of the work done so far in optimization for electromagnetic applications has focused on evolutionary optimization schemes like Genetic Algorithms (GA). The primary focus of this paper is to present a comparison of gradient based optimization algorithms like SQP against that of derivative-free, deterministic, global optimization algorithms like DIRECT (Divided Rectangles).

Unlike GAs, DIRECT is a derivative-free global optimization scheme which can be tuned for both local and global properties. It begins at the center of the design space (the starting point) and divides the design space into smaller rectangles. The algorithm iteratively continues this process of selecting and subdividing those rectangles that have the highest likelihood of producing an objective function lower than the current lowest value. This is based primarily on the Lipschitzian optimization theory. It is this process of subdividing the rectangles that the algorithm achieves both global and local properties. Unlike GA which is a global scheme, DIRECT is a deterministic process and needs to be run only once. A disadvantage of this scheme is that it only terminates after a certain number of iterations have been achieved.

The above optimization scheme is then applied to a surrogate model, created by making use of the Kriging non-linear interpolation function to curve fit the data obtained from finite element boundary integral (FE-BI) simulation results. The spatial correlation kriging function $R(w,x) =$

$\prod_{j=1}^n R_j(w_j - x_j)$ and $R(w_j, x_j) = e^{-\theta|w_j - x_j|^2}$ for each j th variable is employed here. As an example,

the above optimization is applied to a unit cell slot array FSS with the dimensions of the slot used as variables. The overall objective/ cost function is written as a weighted summation of the reflection coefficients at several frequency points using the following form: $F =$

$\sum_{i=1}^N w_i |\Gamma_{in,i}|^2 + \sum_{j=1}^M w_j |\Gamma_{in,j} - 1|^2$, i denoting the reflection coefficients in the pass band of the slot

array FSS, j denoting the reflection coefficients outside the pass band.

Mapping the overall cost function with kriging and FE-BI shows a highly wrinkled surface with many local minima causing SQP to converge at the valley of local minima (right). Graphs will be presented comparing DIRECT with kriging surrogate modeling to : (1) using linear exact line search SQP with kriging surrogate modeling and (2) using Armijo inexact line search CFSQP with direct integration to the FE-BI simulator.

