517 E1

Statistical optimisation methods in electromagnetic product design

In engineering optimization, statistical methods are popular. But no proper comparison between them has been done because the solution time varies with each trial. Being statistical methods, convergence is based on chance and therefore a method that takes long with one run might converge quickly in the next.

Coding these optimization methods for finite element design processes is very difficult, particularly where gradients need to be numerically computed since multiple finite element solutions with multiple mesh generations are involved. In industry practice therefore, organizations do not invest in multiple method code development. The present approach of corporate entities encoding one method and then not looking at others because of the huge development costs, is unacceptable. This is because much time can be spent in grappling with design problems where the method takes days to converge or does not converge at all. Therefore it is necessary to make an informed choice even when we do decide that we would program only one method.

This paper compares the three well-used statistical methods, simulated annealing, global random search and the genetic algorithm by applying them to electromagnetic product design. A standard bench-mark problem with the required features (multiple solutions, local minima, non-trivial) is developed and then the methods are tested on that problem. Multiple runs of each are used for a statistical analysis. Importantly, the results show that the genetic algorithm gives slightly faster mean convergence time with no statistical significance (7138 s against 7432 s or more for other methods on a problem of 8 design variables and a matrix of approximate size 1350x1350) but the variance is significantly lower (283 s against 907 s for simulated annealing and 2481 s for global random search). We may therefore expect the genetic algorithm not to have large swings in solution time and conclude that it is the best of the statistical methods for the problems treated.