An Efficient Multiobjective Optimizer Based on Genetic Algorithm and Approximation Technique for Electromagnetic Designs

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Abstract—In order to use the information gathered from all non-dominated solutions of an optimizer and to guide the search toward more and better Pareto solutions, this paper proposes an efficient and robust vector optimal algorithm that integrates approximation techniques into an improved genetic algorithm. Numerical results are reported to validate the proposed work.

I. An Efficient Multiobjective Optimizer

To keep up with the ever increasing demands in design studies of electromagnetic (EM) devices, a lot of efforts have been dedicated to the development of multiobjective optimizers. Consequently, a wealth of vector algorithms, such as genetic algorithm (GA), simulated annealing algorithm (SA) and tabu search algorithm, to name but a few, are proposed and used successfully to solve typical EM design problems. However, most of these efforts are focusing on the finding of some non-dominated points, rather than an approximation to the efficient set, which could provide a wealth of useful information to guide the search towards the finding of more and better Pareto solutions with enhanced convergence performance. To address such issue, an approximation technique is proposed and then integrated into an improved vector GA in order to design an efficient vector optimizer.

An Improved Vector Genetic Algorithm: It combines both well-established and newly proposed techniques to distribute uniformly the searched solutions along the Pareto-optimal front. More specifically, it divides the entire search process into a global and a local search phase, stores the most recently found non-dominated solutions externally, uses the concept of the Pareto dominance to assign fitness values and manipulates the fitness value using a simple sharing function to guarantee the diversity of populations.

Approximation and Utilization of The Nondominated Set: To fully use the information gathered from the so far searched discrete non-dominated solutions, a continuous approximation of these discrete points at the end of each population is constructed using a MLS based response surface model [1]. As better non-dominated points may be found in the gradient direction of this approximated presentation from a geometrical perspective, an intensifying searching phase is activated by perturbing a specific point selected from this approximation on its gradient direction in order to obtain such solutions. Essentially, the proposed intensifying searching phase is:

(1) Select a point from the approximated presentation according to the point densities of the searched discrete non-dominated solutions;

(2) Perturb the specific point on its gradient direction, and determine the objective function values of the newly perturbed point;

(3) Calculate the parameter values of the new perturbation point according to their objective function values. Since i) the number of the objective functions is generally smaller than that of the decision parameters, and ii) one image in the objective space may be related to multiple points in the decision parameter space, the values of the decision parameters of the new perturbation point is determined from

$$\min \quad \sum_{i=1}^{k}(f_i^{perturb} - f_i^{compute})^2 \tag{1}$$

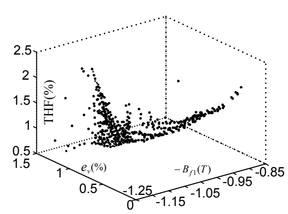
where, $f_i^{perturb}$ and $f_i^{compute}$ are the values of the i^{th} objective function obtained, respectively, in step (2) and from a response surface of the corresponding objective function as proposed in this paper.

(4) Check if the newly calculated decision parameters are in the feasible space. If the answer is "Yes", go to next step; Otherwise, reduce the perturbation value and return to step 2;

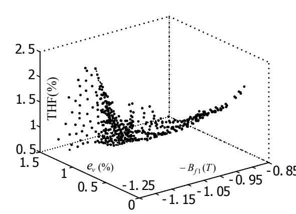
(5) Determine if the stop criterion is satisfied. If the answer is "Yes", stop this search phase; Otherwise, go to step 1.

II. Numerical Example

To critically examine the performances of the proposed algorithm with other vector optimal techniques, the geometrical design of the multi-sectional pole arcs of a large hydro-generator [2] is used as the case study. In the numerical study, both the proposed algorithm and SA based method as reported in [2] are employed. The iteration numbers for a typical run of the proposed and the SA algorithms are, respectively, 1575 and 1678; and the corresponding Pareto solutions searched by the two algorithms for a 300 MW hydro-generator are shown in Fig. 1. When compared with the SA based method, it can be seen that the proposed algorithm is superior both in terms of solution quality and in convergence speed in this case study.



(a)



(b)

Fig. 1. The searched Pareto solutions by the SA based method (a) and by the proposed algorithm (b).

III. References

[1] S. L. Ho, Shiyou Yang, Peihong Ni, and H. C. Wong, "Development of an efficient global optimal design technique-a combined approach of MLS and SA algorithm," *COMPEL*, vol. 21, pp. 604-614, 2002.

[2] S. L. Ho, Shiyou Yang, H. C. Wong, and Guangzheng Ni, *IEEE Trans. Magn.*, vol. 39, pp. 1285-1288, 2003.