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Optimization Material Distribution in Electromagnetic Actuators

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Abstract: In this paper, a new approach for Optimization Material Distribution is proposed. The principle behind this approach is to use a surface genetic algorithm in order to determine material distribution in a fixed Finite Element Computation mesh. The method proved to be very adaptive to various kinds of electromagnetic actuator optimizations. In the final paper, several optimal actuators will be presented.

1 Introduction

Optimization Material Distribution (OMD, or TOFEM) constitutes one of the most promising optimization techniques for electromagnetic applications [1]. The principle calls for considering a mesh fixed in space. The optimization algorithm is then required to select the material property of each element. The main advantage to this technique lies in the originality of the final solution, which does not depend on knowledge held by the designer. In contrast, the main drawback is the computation time involved in conducting such an optimization sequence.

Two kinds of algorithms have already been proposed for this application:

- design sensitivity analysis (DSA), based on computing the sensitivity of each mesh element [2,3];
- the classical genetic algorithm (GA), which does not require any such computation [4].

In this paper, we will present several improvements made to the classical binary genetic algorithm for OMD-type problems, thereby giving rise to the "surface genetic algorithm".

2 Principles for applying the surface genetic algorithm

Genetic algorithm efficiency is heavily tied to data representations. In electromagnetic problems, The electromagnetic coupling between zones related to Maxwell equations is determining. In order to respect this detail, operations of mutation and crossover are done on elementary surfaces that correspond to neighboring matrixes bites as shown in the following figure:

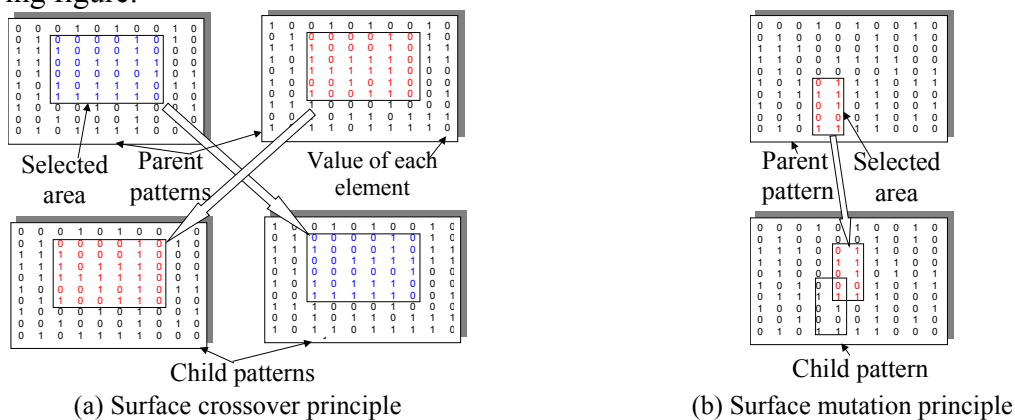


Figure 1

One problem encountered in this set-up is the algorithm's difficulty to change the nature of the solution. We have remarked that the optimization is more efficient if several preliminary optimizations have been used to define the initial population.

3 Sample results

To illustrate, we present a simple example corresponding to an elementary linear actuator to variable reluctance. Iron and air compose the mobile part. The fixed part is made of iron and copper with a fixed current density. The objective function is to maximize the flux ratio between the conjunction and opposition positions.



Figure 2: Example of linear actuator

As pointed out in Section 2, several preliminary optimizations have been performed in order to define the initial population of the final optimization. Preliminary optimization results along with the final result are presented in the following figure:

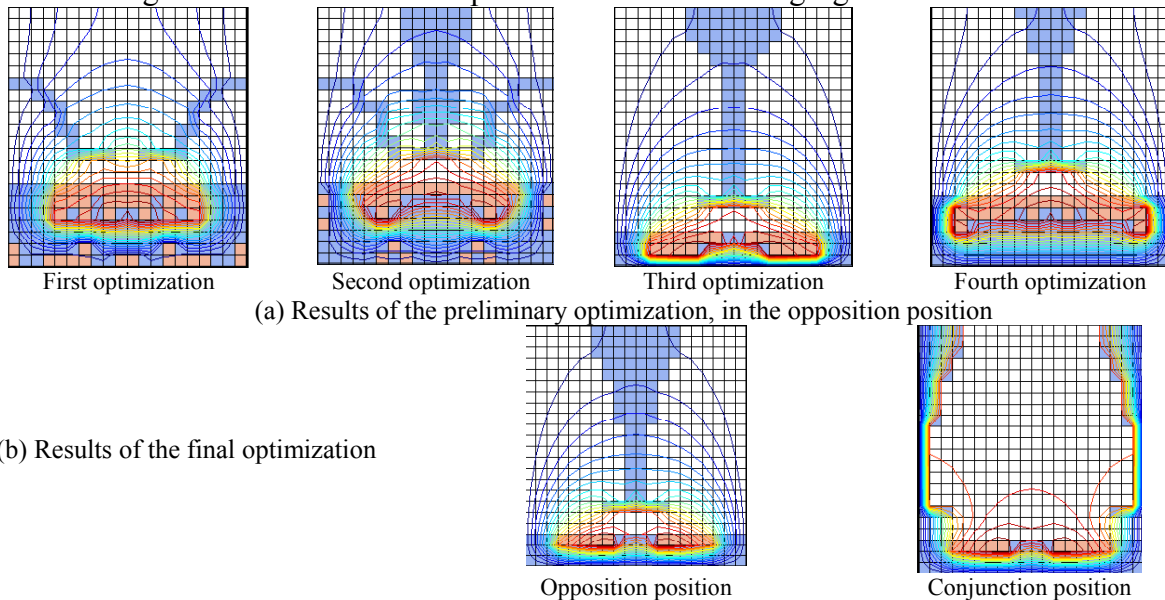


Figure 3: Results of the optimisation

This final geometry enhances the benefit of splitting the copper coil to increase flux variation.

4 Conclusion

This paper has presented an improvement to the genetic algorithm used for OMD; this improvement is based on respecting the magnetic pattern geometry. The final paper will set forth a comparison between several OMD optimization algorithms. An application example, which has led to an original result, is also discussed. The final paper will provide more examples of optimal electromagnetic actuators.

5 References

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