Genetic Algorithm Based Multi-Objective Optimization of Electromagnetic Components using COMSOL® and MATLAB® Software

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Introduction: Modern power magnetic devices such as motors, inductors, relays, etc. are designed for reduced loss, mass, volume, power capability, etc. A state-of-the-art global multi-objective optimization technique, namely a genetic algorithm (GA) [1], is herein coupled with a computationally efficient finite element model to design an electromagnet. The magnet is subject to certain constraints (e.g. current density) and it's volume is required to be minimized. The design inputs include geometry, material, and winding parameters.

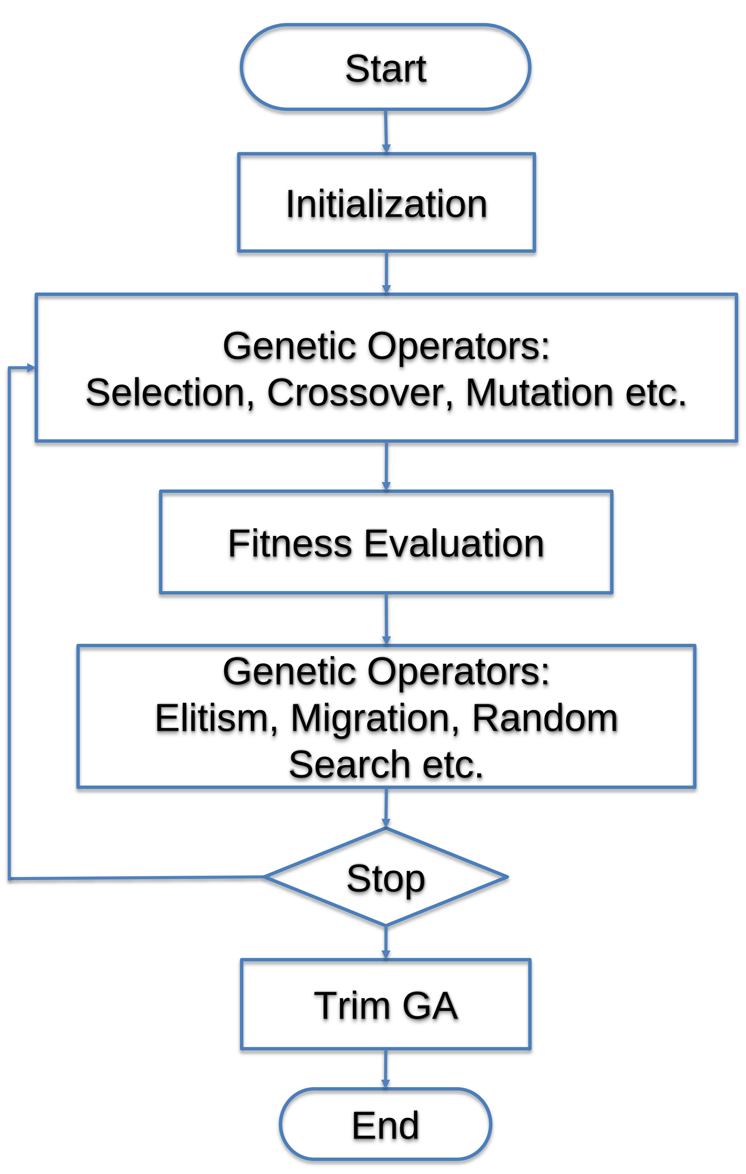


Figure 1. GA structure.

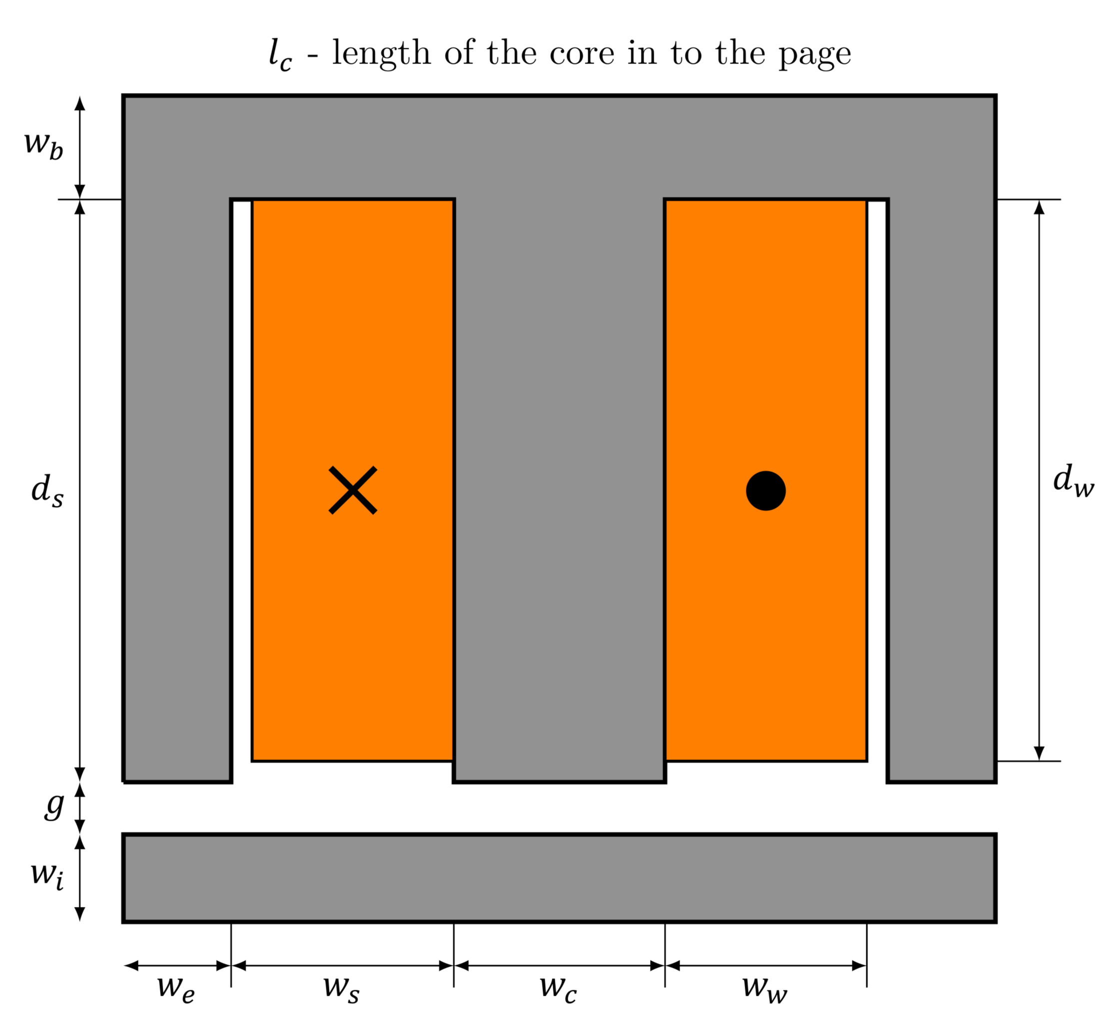
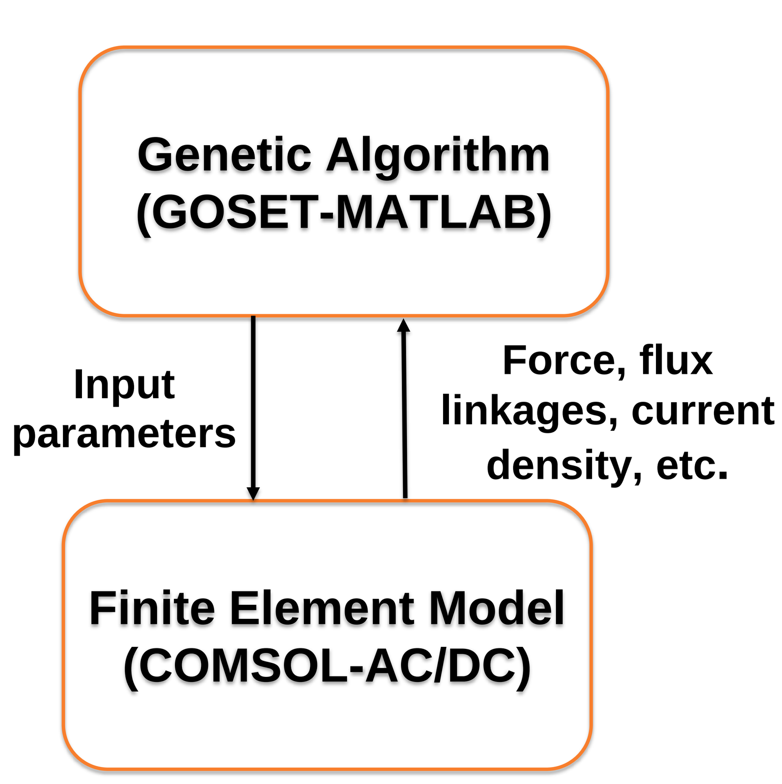


Figure 2. EI-Core Electromagnet[2].

Computational Method:



Genetic Algorithm

- **Input:** design space, constraints, and objectives (i.e. to maximize).
- **Output:** Pareto-optimal front (i.e. optimal designs).

FE Model

- **Input:** geometry, winding, and material parameters
- **Output:** electromagnetic force, flux linkages, current density, etc.

Results: An electromagnetic actuator capable of delivering 2500 N force is designed with loss and volume as objectives. The GA is initialized with 200 population members and run for 200 generations. The results for Design 50, one of 70 optimum designs, is presented here.

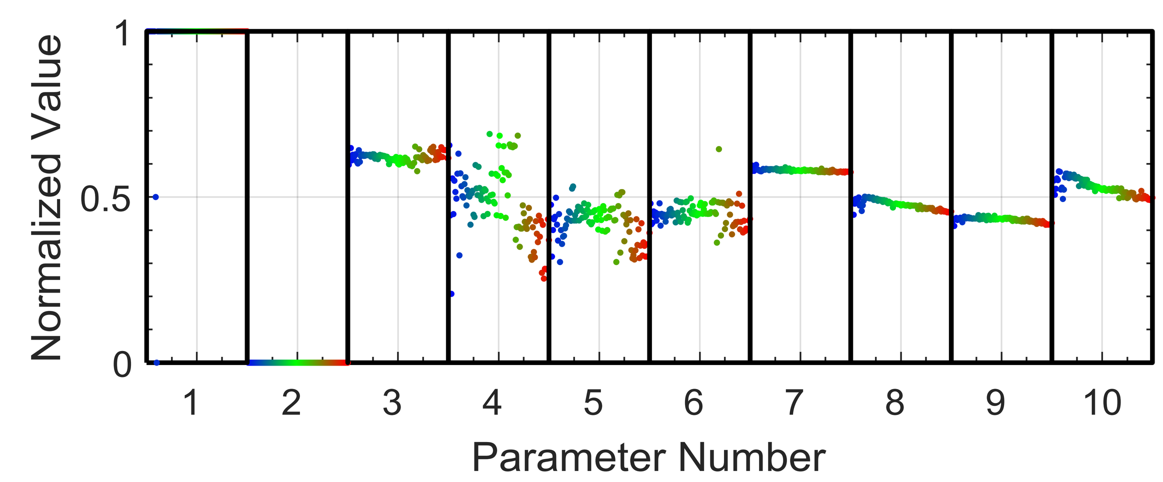


Figure 3. Gene distribution (refer to Table 1) for the study.

Parameter	Symbol	Description	Design 50
1	T_{cr}	Steel core material	Hiperco50
2	T_{cd}	Conductor material	Copper
3	w_c	Width of the core center	2.26 cm
4	$\frac{2w_e}{w_c}$	Twice end-leg width to w_c ratio	1.002
5	$\frac{2w_i}{w_c}$	Twice I-core width to w_c ratio	0.826
6	$\frac{2w_b}{w_c}$	Twice E-core base width to w_c ratio	0.784
7	a_c	Desired cross-sectional conductor area	8.156e-07 m^2
8	N	Desired no. of turns	804.079
9	N_w	Desired slot width in conductors	20.222
10	N_d	Desired slot depth in conductors	41.189

Table 1. Parameter values for Design 50.

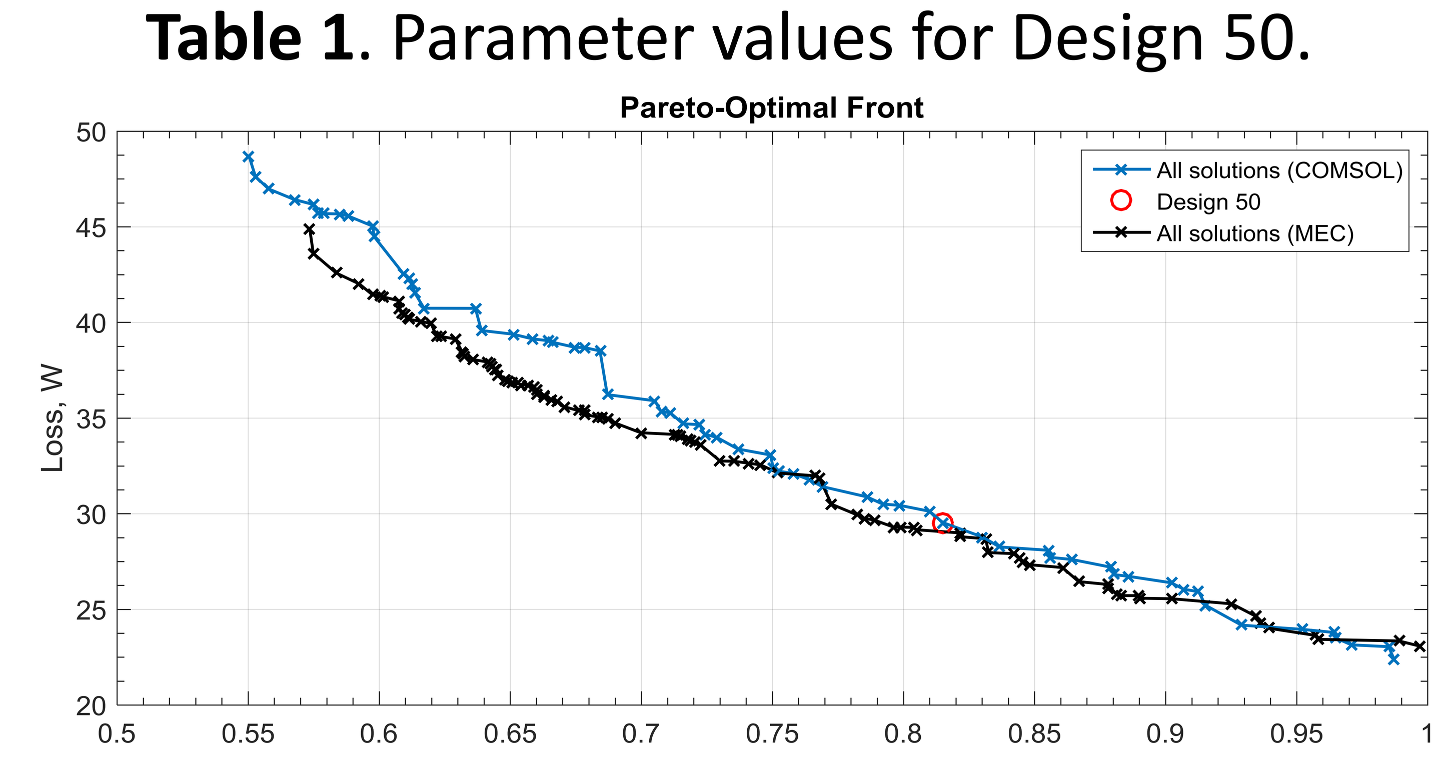


Figure 5. Pareto-Optimal front Obtained using COMSOL and MEC models.

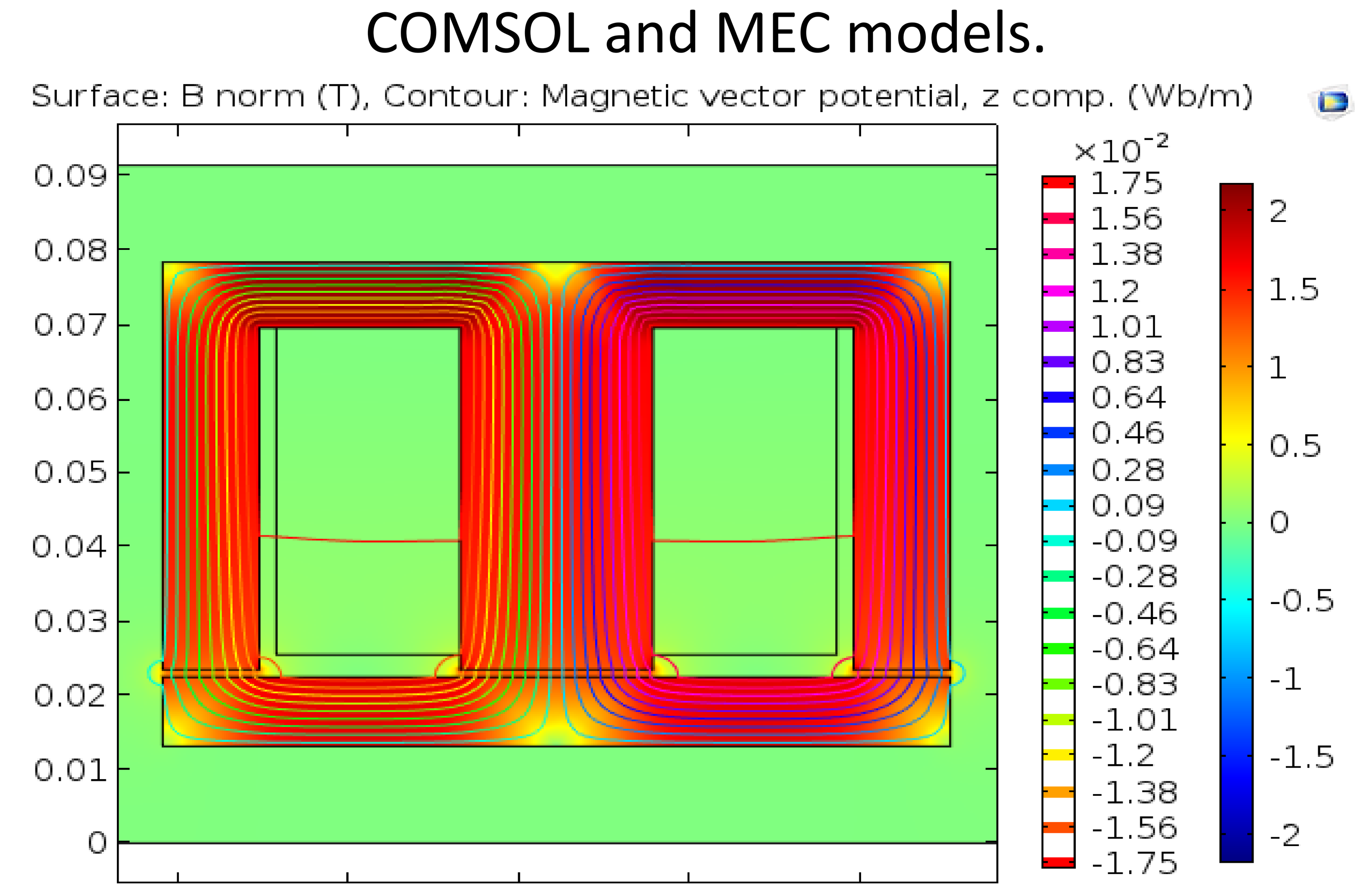


Figure 6. The B-field plot for Design 50.

References:

1. S. D. Sudhoff, GOSET: For Use with MATLAB, Manual Version 2.3.
2. S. D. Sudhoff, Power Magnetic Devices: A Multi-Objective Design Approach, 1st edition, John Wiley & Sons, 2014.