COMPUTATIONAL INTELLIGENCE TECHNIQUES FOR FAST AN EFFECTIVE ELECTRIC MOTOR DESIGN

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The demand for sustainable electric machines is driving research into eco-friendly motor solutions. Their prototyping involves iterative, time-intensive, and multi-physics simulations. This complexity arises from the non-linear relationship between motor geometry and the performance parameters. Computational Intelligence techniques, such as Evolutionary Optimization and Machine Learning can be successfully employed to improve the process of electric motor design.

Evolutionary Algorithms are stochastic, biologically inspired, iterative, population-based optimization algorithms that are capable of effectively and efficiently solving non-linear, multi-modal, multi-objective optimization problems. Due to their characteristics, they can be applied to electric motor design. Two different approaches can be implemented in this context: parametric design and topology optimization.

In the parametric design the geometry is defined by means of some geometric parameters (lengths, widths, rotations, positions, …) that can be modified by the algorithms to explore the solution space. Figure 1 shows an example of parametrization in Internal Permanent Magnet Synchronous Motors. The main advantages of this approach are manufacturability, since the constraints can be easily introduced in the definition of the parameters, the design control, since it provides control over the magnet shape and position, and the mesh independence. The main disadvantages of parametric design are the limitations of the possible geometries that the algorithm can test; this is highly dependent on the parameters selected for describing the geometries. This parametrization affects also the non-linear relation between the optimization variables and the performances of the motor.

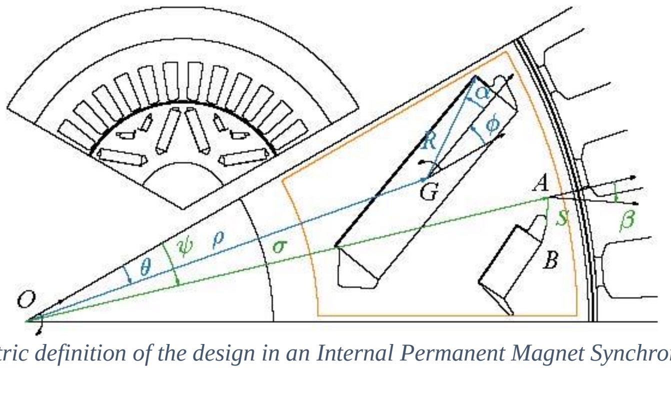

Figure 1: Example of parametric definition of the design in an Internal Permanent Magnet Synchronous Motors

On the other hand, in topology optimization the algorithm can select, for every cell in the mesh, the presence of a material. This allows the algorithm to search among a large number of geometrical configurations; on the other hand, the manufacturability becomes a critical aspect and a multi-physics optimization should be performed combining electromagnetic, mechanical and thermal aspects.

In any case, repeated evaluations for slightly different topologies are required in the due course of optimization. Each evaluation requires in principle a complex numerical analysis. In this respect, it may prove effective to adopt a data-based model linking directly the geometric and material parameters with the required Key Performance Indexes (KPI). In the frame of the project, this approach has been pursued by generating multiple examples of machines, sharing a common topology and materials choice, according to the Latin Hypecube Sampling approach. Data gathered in this way are used to train different Neural Networks (NN), able to provide a prompt, yet possibly not very accurate, estimate for the KPI for machine designs not included in the training dataset. A comparison of adopted NN is underway to select the solution best fit to the problem.

This study was carried out within the MOST — Sustainable Mobility Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1033 17/06/2022, CN00000023). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.