# CURRENT AND FUTURE TRENDS IN DESIGN OPTIMISATION FOR ELECTROMAGNETICS

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Design may be defined as a plan or specification for the construction of an object or system or for the implementation of an activity or process; in engineering, it normally refers to a series of steps to be undertaken to create functional products or processes. The design may also be perceived as a 'fitness for purpose' exercise which provides assurances that the components and the finished product are fit for their intended purpose.

Optimisation plays a pivotal role in the design process as inevitably we wish to end up with a product which is better, lighter, cheaper and more reliable than what the competition can offer. This necessitates a specification of an objective function – or a set of often conflicting objectives – which we attempt to minimise or maximise simultaneously; we often find, however, that it is impossible to achieve all optima at the same time and we therefore need to compromise, which may not be an easy decision and we therefore need some sound principle to follow rather than making a random choice. Moreover, when manufacturing a product, we are often faced with machining tolerances and variability of material properties – and yet we expect all (or at least the vast majority) of our units to meet the performance specifications, not just some of them.

When predicting the performance of a device or a system, we typically use various models: some may be simple and rapid but not particularly accurate, others very reliable but computationally expensive. Rather interestingly, all such models are relevant as encapsulated in the concept of 'hierarchical design'.

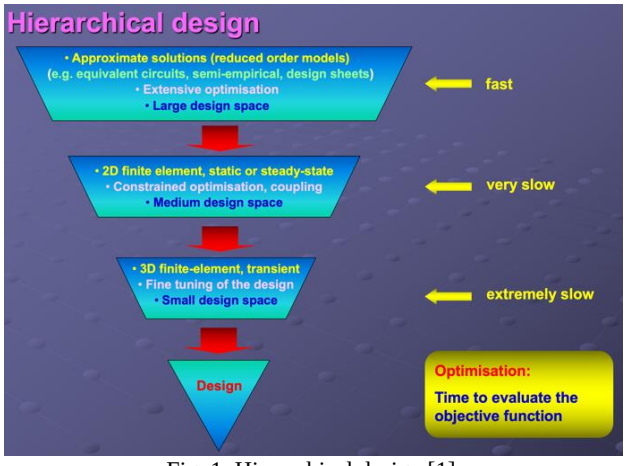


Fig. 1. Hierarchical design [1]

We then need to identify a good (fast and accurate) algorithm to tackle the actual optimisation task – there is no shortage of such algorithms and recent years have produced literally hundreds (or even thousands) of possible candidates, many inspired by nature; if anything we are spoiled for choice. The decision of which approach might be the most appropriate for our problem may not necessarily be straightforward. It may also be argued that there is no optimisation scheme which would perform efficiently always: clearly if there were such an algorithm we would all be using it without the need to search for alternatives. But some approaches have been demonstrated to work well most of the time and are available as toolboxes of popular general software.

This presentation will provide a review and critical assessment of recent advances in design optimisation, emphasising the main features and the most promising approaches, discussing the particular challenges, and finally making some projections regarding possible future developments.

The importance of the 'no free lunch' theorem will be emphasised, the fundamentals of 'surrogate modelling' explained, the concepts of a robust design and pareto-optimisation elaborated upon, several 'nature inspired' algorithms briefly mentioned. It will be argued that methods employing 'kriging techniques' are particularly promising. Several examples will be given. Finally, projections for the possible future trends will be offered and discussed.

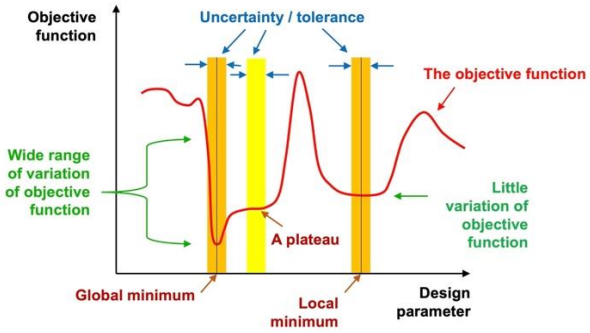


Fig. 2. A robust optimum [1]

The keywords of the presentation are as follows:

- Hierarchical design
- Robust optimization
- Exploitation vs exploration
- Cloud computing
- Model order reduction techniques
- Multi physics
- AI and machine learning

The talk will rely heavily on a chapter written by the author for a recently published book [1], where comprehensive relevant literature may be found.

References

[1] Sykulski, J. Chapter 2: Advances and trends in design optimization, in *Optimal Design Exploiting 3D Printing and Metamaterials*, ISBN-13: 978-1-83953-351-8, IET Publishing, 2021.