Dimensionality Reduction in Evolutionary Multiobjective Design: Case Study

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ABSTRACT
Real-world applications of Pareto-based optimisation commonly involve many objectives. It causes difficulties because of reduced selection pressure for better solutions. Dimensionality Reduction (DR) is a very appealing approach to overcome this problem. A case study of multiobjective Electric Machine (EM) design based on DR of the model [3] is considered.

Categories and Subject Descriptors
I.2.8 **Artificial Intelligence** Problem Solving–*heuristic methods*

General Terms
Algorithms, Performance, Design.

Keywords
Evolutionary Multiobjective Optimization, Dimensionality Reduction, Electric Machine Design

1. INTRODUCTION
The problem of EM design is one of the most challenging, as it has many objectives, space-distributed nonlinearities and various constraints. These facts justify the application of EMO algorithms. This study is a continuation of the author's research [3].

2. PROBLEM FORMULATION
In this presentation two methodologies, Principal Component Analysis (PCA) and partial δ-Dominance Structure Preservation (DSP), are applied to EM design. The first approach makes use of the PCA-NSGA II algorithm [2] and has been discussed along with the modelling issues in the preceding paper [3].

The basic criterion in DSP approach [1] is preservation of the dominance structure. The additive term δ, which modifies values of one objective, enables relaxation of dominance measure. In this study DSP is applied iteratively - after a redundant objective is found (introducing error smaller than δ) the reduced set of objectives is found after aggregation of the old objectives.

In [3] from seven variables vital to EM design, five are considered the objectives. These are: lamination weight, iron power loss, magnets weight, winding weight, and copper power loss. The remaining two, flux density and winding temperature, are treated as constraints. In the design the two arguments: diameter D, and yoke height h, were considered.

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3. DESIGN
All five objectives are presented in Figure 1a in the form of a 3D mesh view of surfaces elevated over the constrained design space. The PCA and DSP approaches are compared and found to be near-identical. The Pareto sets before and after reduction to final two objectives are shown in Figure 1b (here by use of DSP).

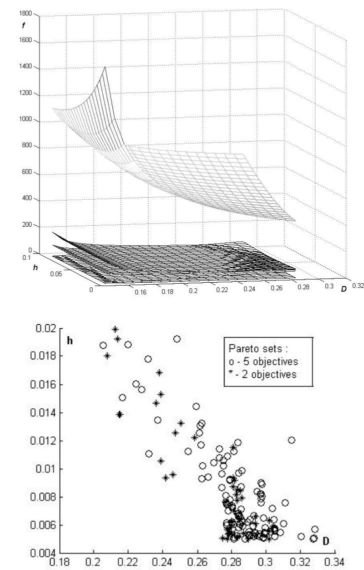

Figure 1a. 3D mesh of 5 objectives. b. sample Pareto sets

4. CONLUSIONS
The PCA and DSP procedures enable dimensionality reduction in EM design. The comparison of Pareto set approximations reveals both methods lead to comparable results. Further research will focus on interactive EMO to allow limiting of Pareto front according to the designer's preference.

5. REFERENCES
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