Options NSGA2 in practice

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About OptionsNSGA2
OptionsNSGA2 is a multi-objective optimization tool that has been developed in the Computational Engineering and Design Group since 2001. It attempts to meet the increasing demand for solving a variety of optimization problems, where more than one goal needs to be searched simultaneously. The tool is based on the NSGA2 approach, pioneered by Prof. Kalyanmoy Deb and the OptionsNSGA suite developed by Prof. Ian Anderson and the e-Science research group at Southampton. By combining these two powerful packages, adding various improvements, substitutions and new functionality, OptionsNSGA2 has become the preferred tool for increasing numbers of researchers and development groups across industry.

Acknowledgements are made to Rolls-Royce, Derby, as our tool has been developed with their sponsorship.

Modes of Operation
Direct OptionsNSGA2 provides an easy-to-use interface for engineers to set up their optimization problems in various environments and platforms. Those who like the flexibility of MATLAB can use the tool directly in MATLAB, while others can run it without any prerequisite directly from the command prompt or embed it in various integration tools such as BRIGHT.

The strength of this package, however, is demonstrated when used with Response Surface Methods (RSM). The OptionsNSGA2, RSM version. Using this version it has become possible to run a complex robust design optimization of a Whole Engine Model, on a single PC within two days. The significance of this achievement is obvious if compared to a direct optimization which would take over 6 months and therefore was never thought feasible. The general idea is presented in Fig. 1. Heavy optimization runs are carried out on a response surface model, which is continuously updated until convergence of the Finite Element code is obtained.

Quick facts about OptionsNSGA2 and OptionsNSGA2_RSM
- Based on OPTIONS, NSGA, OptionMatlab and Matlab.
- Works under Windows, Linux and Unix
- Direct and Response Surface versions
- Selection of five update strategies for the response surface model
- Selection of 15 response surface models
- Options for user tuning and customised settings
- Parallelisation techniques
- Parallel function evaluations
- Can be easily restarted from a specified checkpoint
- Can be used on continuous or discrete variables

Achievements to date
- Optimization with 9 design variables (Andy Keane, Mathew Bohn)
- Optimization with 9 objective functions (Neil Scronce)
- Optimization with 4 discrete variables (Chandran Bhanaraj)
- Compiled as a standalone application and deployed on Rolls-Royce (Ivan Youichkov)

Applications
- Whole engine robust optimization (Ivan Youichkov)
- Turbo SFC and MASS optimization (Ivan Youichkov)
- Earth system modelling (GENESIS - Andrew Price)
- Discrete multi-objective optimization (Chandran Bhanaraj)
- Guideline optimisation (Andy Keane, Ivan Youichkov)
- Fixed wall thickness analyser and contour shape optimisation (IHPAIF - Ivan Youichkov, Tony Scronce - Fig. 3)
- Thermal isolation structures (Alexander Forrest - Fig. 4)
- Structural shape optimisation (Appu Kumar - Fig. 5)
- Manufacturing cost optimisation (Alok Rao - Fig. 8)

Further work
OptionsNSGA2 is being continuously refined. The ability to use more variables with the RSM approach as well as further methods for relative quality improvement are currently being investigated. Work is ongoing to apply and deploy the tool with various teams at Rolls-Royce.

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