# Integration of Matlab based search engines into iSIGHT and Model Center

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UTP for design

## Rationale:

Matlab/OptionsMatlab have become the vehicles for new DSO algorithm development in the Southampton UTP.
To be able to deliver these algorithms to BAE Systems & Rolls-Royce easily and quickly for incorporating in iSIGHT & Model Center (MC) we have used the Matlab plug-in facilities available in these tools. Matlab code can also be compiled into C code both for efficiency and obviating the need for a Matlab license on the user system.

## iSIGHT Plug-ins:

Two sets of plug-ins have been developed for iSIGHT:
1.  For single objective optimisation problems:-
•  a GUI driven plug-in that incorporates Options methods directly into the iSIGHT set of optimisers.
•  a Matlab based plug-in that uses OptionsMatlab to run an optimiser schedule input via the Options GUI.
2.  For multi-objective optimisation problems:-
•  a Matlab based plug-in that runs the NSGA2 multi-objective algorithm to build a global Pareto-optimal front solution to the optimisation problem.
•  a Matlab based plug-in that runs the NSGA2_RSM multi-objective algorithm to build a global Pareto-optimal front solution where any combination of objective functions and constraints can be approximated by one of the Options RSM methods.

## Basic Options iSIGHT Plug-In GUI:

Run control parameters:
Maximum iterations:    500
Optimisation mode:    Minimise
Last method selected:        dynamic hill climbing
Optimisation, DOE and RSM methods available for selection (45+ DOE, RSM and optimisation algorithms).

Run schedule selected:
Build Kriging model of Objective Function and main constraint. Minimise Kriging predictor on objective function using GA followed by local search.

## Matlab based NSGA2/RSM Plug-in:

Uses a modified form of the NSGA2 multi-objective algorithm to map out a global optimal Pareto-front of the problem.
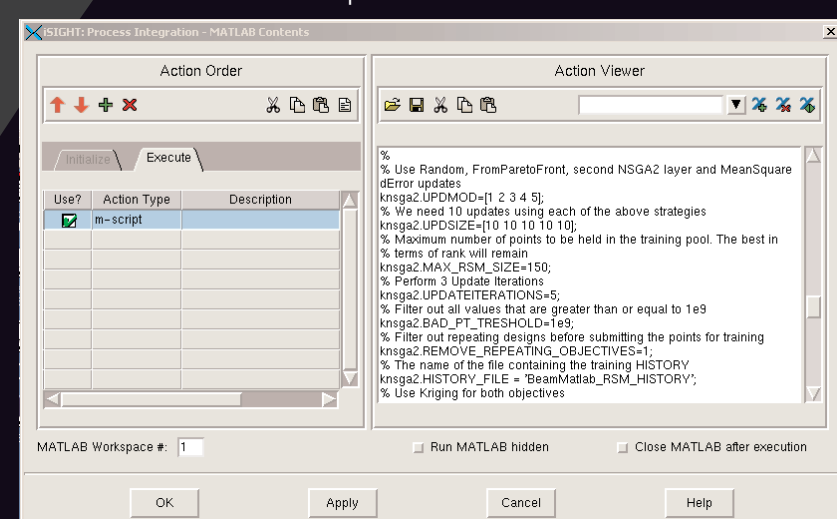
Matlab Plug-in script: showing settings for NSGA2 algorithm parameters.
In the NSGA2_RSM version, any combination of objective function and/or constraints can be approximated (rather than evaluated directly by the analysis code) using Options RSM techniques (including various forms of kriging)
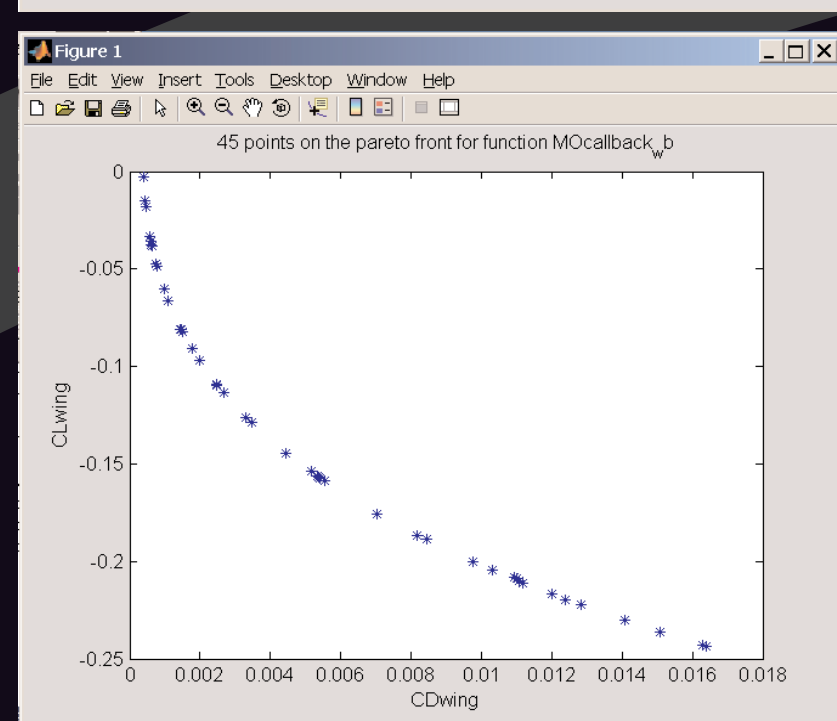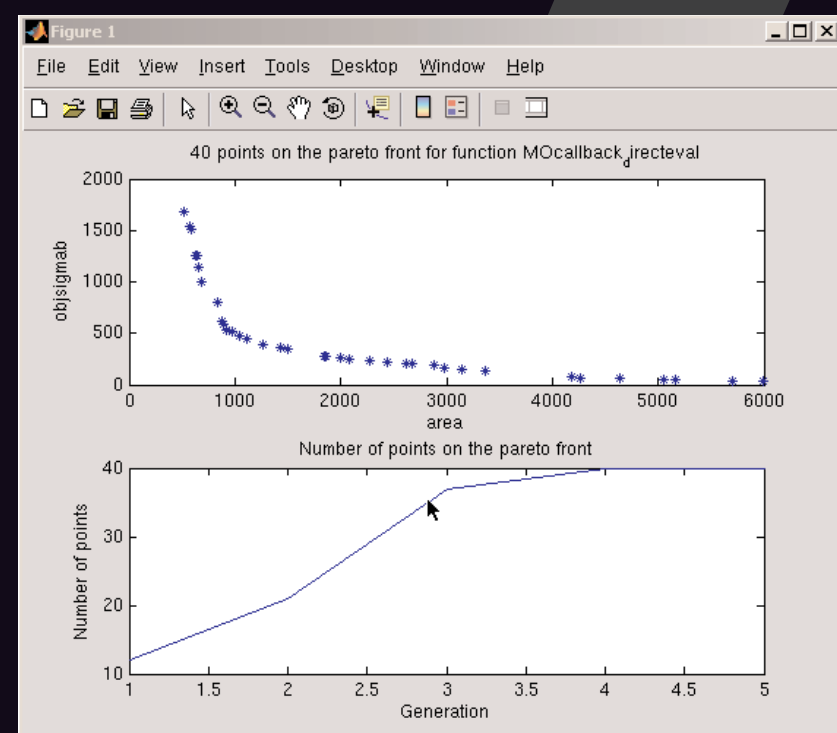
NSGA2 progress monitor showing progress in building up the Pareto-front shown on the right. The Options and OptionsMatlab plug-ins are implemented using the iSIGHT Techgen utility. No proper API is provided for the Matlab plug-in, only a facility for mapping iSIGHT variables to Matlab variables. This has meant developing a way of communicating between the Matlab plug-in and iSIGHT on a client/server basis. This has been achieved for SunOS/Linux versions by using a shared memory scheme and a set of semaphores. The semaphores control both access and passing of data via the shared memory and the order in which the Matlab plug-in (OptionsMatlab client code) and the iSIGHT (server simcode) trigger each other s operations. A Windows version is also being developed.

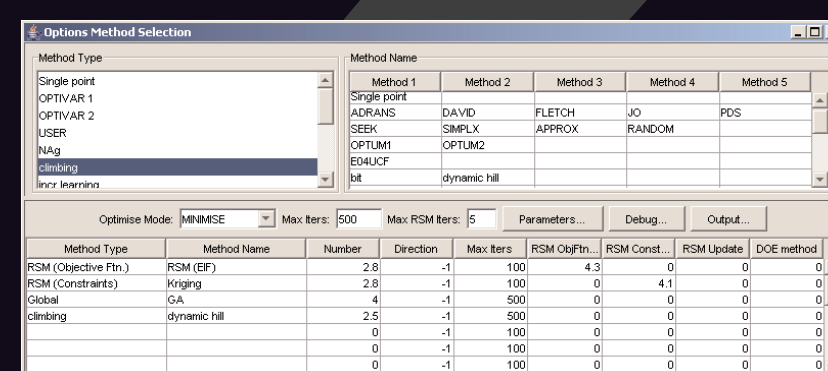## Options Plug-In for ModelCenter:

Two sets of plug-ins have been developed for ModelCenter:

1.  For single objective optimisation problems:-
•  a GUI driven plug-in that incorporates Options methods directly into the Model Center set of optimisers.
•  a Matlab based plug-in that uses OptionsMatlab to run an optimiser schedule input via the Options GUI.

2.  For multi-objective optimisation problems:-
•  a Matlab based plug-in that runs the NSGA2 multi-objective algorithm to build a global Pareto-optimal front solution to the optimisation problem using direct evaluation of the objective functions and constraints
•  a Matlab based plug-in that runs the NSGA2_RSM multi-objective algorithm to build a global Pareto-optimal front solution where any combination of objective functions and constraints can be approximated by one of the Options  RSM methods.

## Options Method Selection (Scheduling) GUI:

## Matlab based Options Plug-in:

The OptionsMatlab Plug-in enables the Options optimisation suite to be called from a Matlab script running in the Model Center (MC) Matlab Plug-in component. The aim being eventually to provide compiled code for all the Matlab scripts so that the OptionsMatlab Plug-in can be run without a Matlab license. Although the OptionsMatlab plug-in references the version of Options contained in the OptionsMatlabMX.dll library in the OptionsMatlab directory, it is also integrated back into the MC Options Plug-in. This means that the model files and setup/optimisation schedule GUI s available in the Options Plug-in can be used to setup a model for the OptionsMatlab plug-in. DOE data, if present, is picked up from the model data object or is generated by calling OptionsMatlab with a particular DOE method and number of DOE points required.
OptionsMatlab supplies a number of utility functions to plot the output of an optimisation. These functions take the output of an optimisation and plot it in a number of ways. In all cases, additional parameters can be used to produce different forms of plots (see HYPERLINK "http://argos.e-science.soton.ac.uk/blogs/OptionsMatlab/" http://argos.e-science.soton.ac.uk/blogs/OptionsMatlab/ for further details).
HYPERLINK "http://www.geodise.org/documentation/Options Matlab/html/optimisationTerrain.htm" optimisationTerrain: This function plots surfaces produced by interpolation between the points at which the objective function was evaluated. The optimisation terrain may be represented as a mesh, surface or contour plot. The points which do not meet the optimisation constraints will be cropped from the surface.
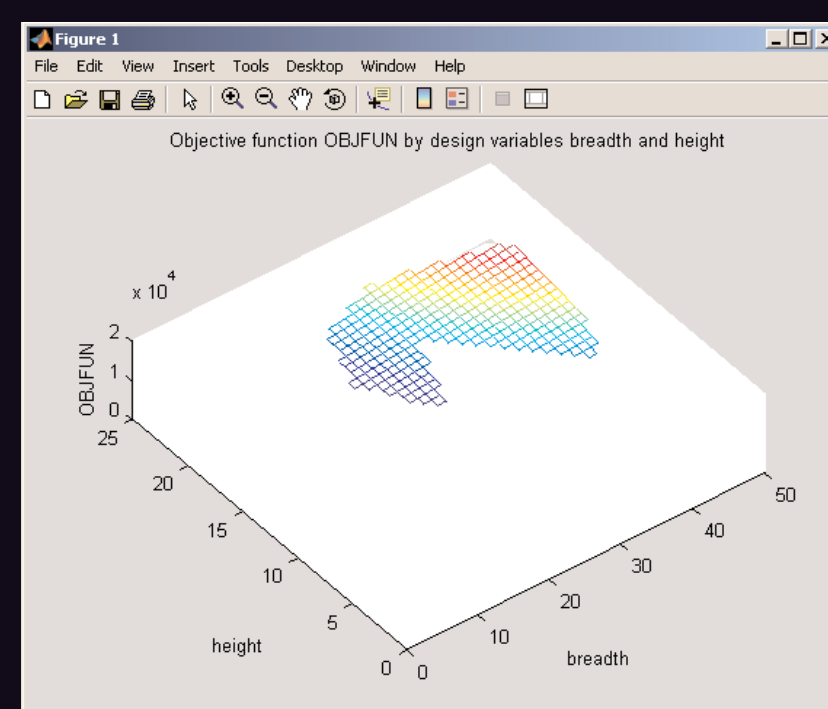
HYPERLINK "http://www.geodise.org/documentation/Options Matlab/html/optimisationTrace.htm" optimisationTrace: This function plots points at which the objective function was evaluated. The objective function points may be plotted in colour or black and white. The points may also be joined to represent the sequence of function evaluations.
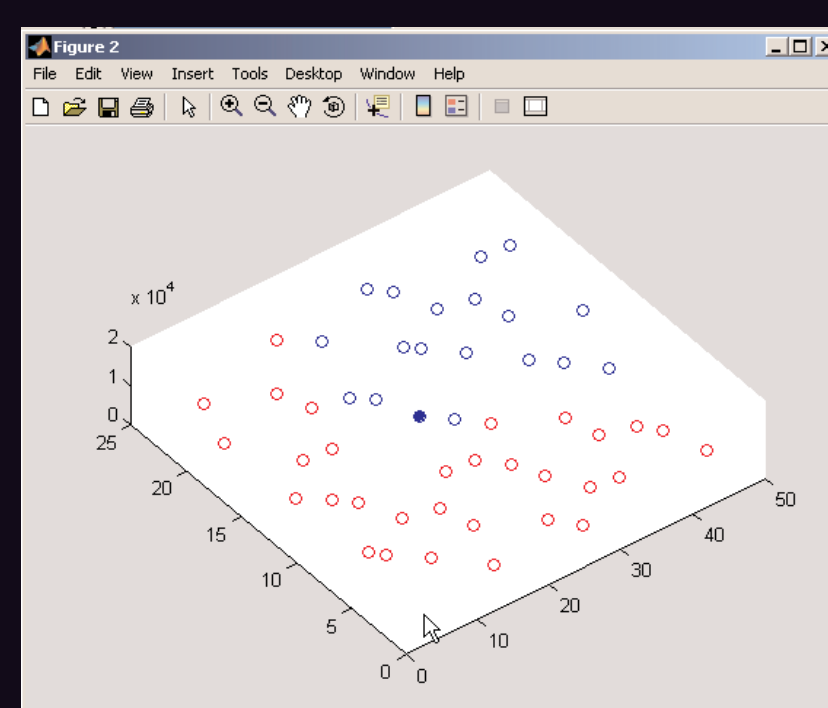
HYPERLINK "http://www.geodise.org/documentation/Options Matlab/html/optimisationHistory.htm" optimisationHistory: optimisationHistory plots a trace of the objective function over the search history. optimisationHistory provides a convenient way to view the search history over a number of searches by combining this information in a single plot.
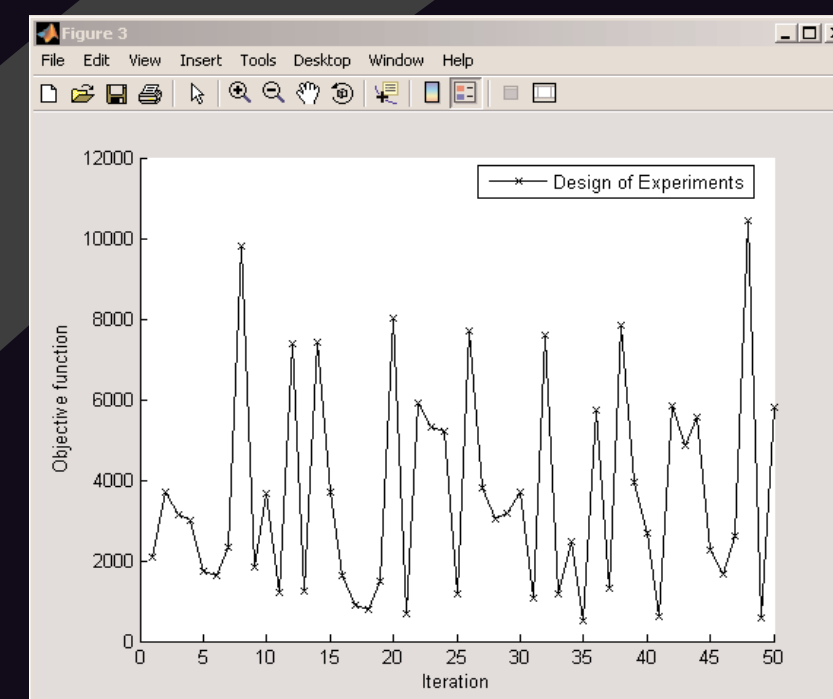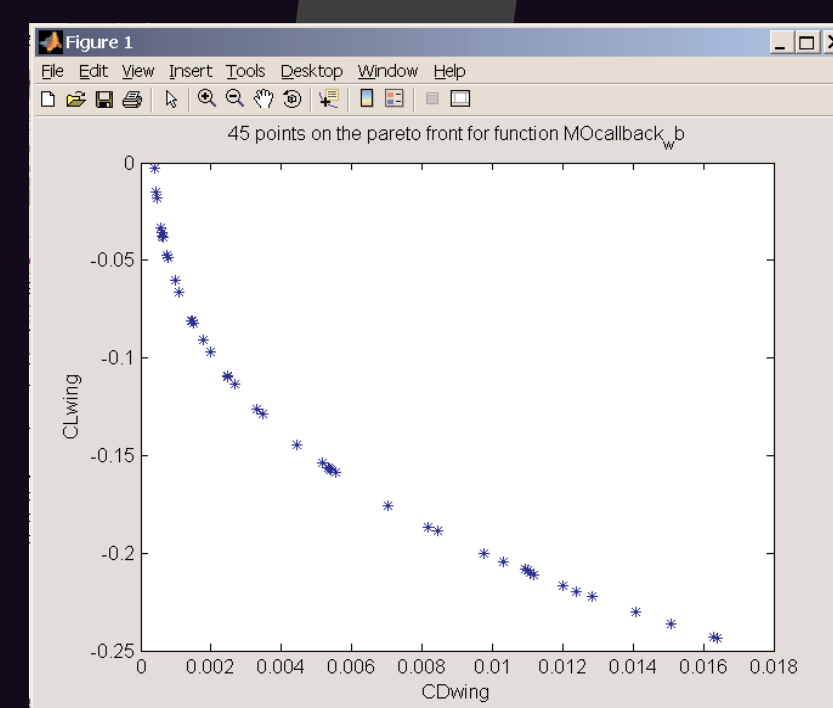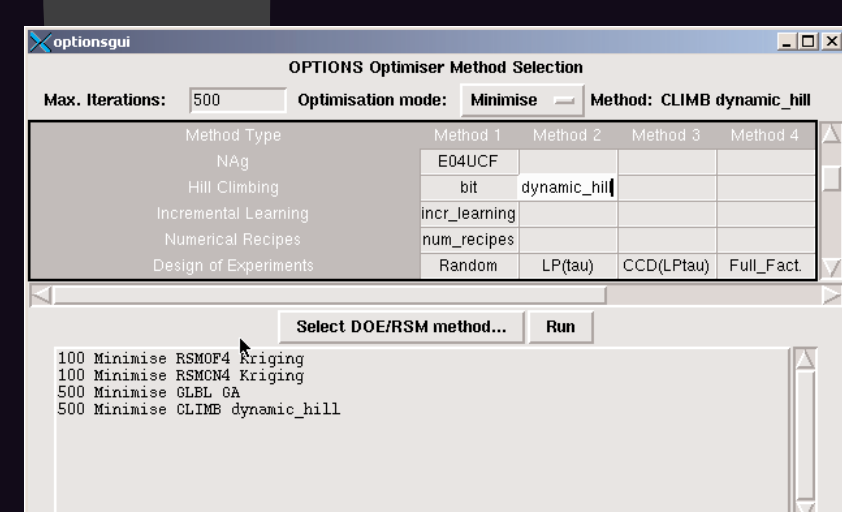
## The OptionsNSGA2 Matlab Plug-in

The presence of multiple objectives in a problem gives rise to a set of optimal solutions. The NSGA2 algorithm seeks to find this Pareto-optimal solution set. The OptionsNSGA2 Plug-in contains the original NSGA2 multi-objective algorithm modified by Ivan Voutchkov and written in Matlab. It is callable through the MC Matlab plug-in.
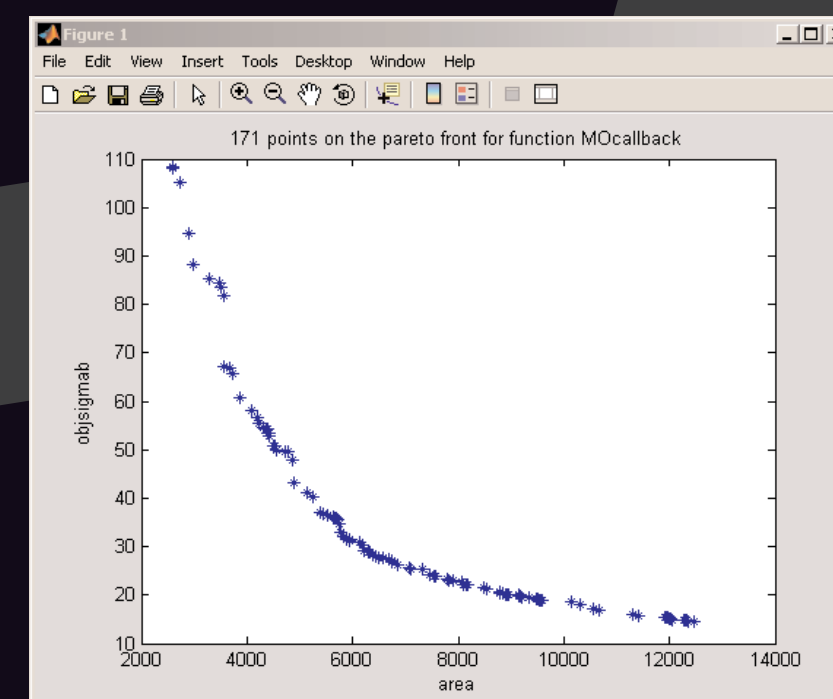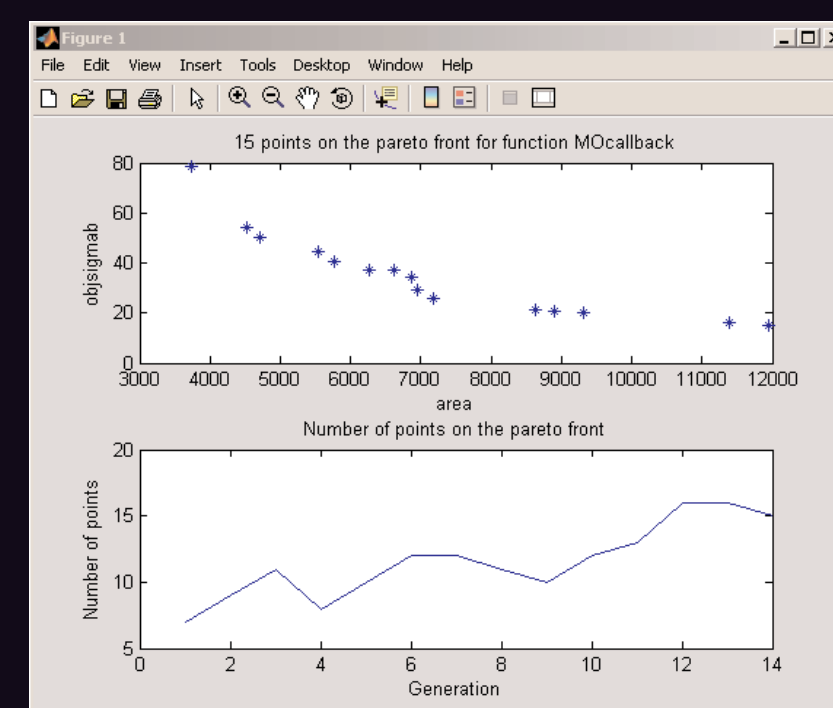
## The OptionsNSGA2_RSM Matlab Plug-in

The OptionsNSGA2_RSM algorithm is a development of the OptionsNSGA2 algorithm and is a combination of the multi-objective search algorithm NSGA2 and a collection of RSM techniques available in Options. Written in Matlab, by setting parameters in this function, a range of objective function and constraint response surface models can be built and then searched multi-objectively by the NSGA2 algorithm.

Resultant Pareto-front for the above OptionsNSGA2_RSM script on the wing-body

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