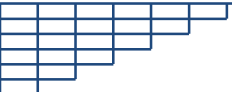


# **ME527 – Introduction to Engineering Optimisation**

## **2023-24 – Coursework**

### **Bi-Objective Optimisation of Expensive Functions**

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# The problem

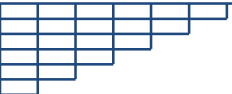
As attachment you have two functions:

- the **problem** function in the routine *ExpModel.p* (*expensive*), and
- the **auxiliary** function in the routine *AuxModel.p* (*not expensive*)
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Both functions take as input a design vector bounded as

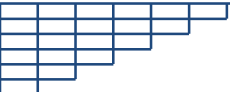
- Lower bounds  $LB = [-10, -50, -200, -1000, -5000, -50000]$
  - Upper bounds  $UB = [10, 50, 200, 1000, 5000, 50000]$
- and gives as output a vector,  $\mathbf{F}$ , of two elements:  $[F(1), F(2)]$

The final aim of the work is minimising both  $F(1)$  and  $F(2)$  given by the expensive routine *ExpModel.p*



# The steps to perform are:

- a) Using the auxiliary function in the file *AuxModel.p*, find the global minimum of  $F(1)$  with a precision of 4 decimal digits, and the global minimum of  $F(2)$  with a precision of 1 decimal digit.
- b) Implement a strategy (NO surrogate based) to find a good approximation of the ENTIRE Pareto front with at most **30000** function evaluations using the auxiliary function in the file *AuxModel.p*; the strategy should be reliable and should be tested on **10 independent runs** (only if a stochastic method is used).
- c) Implement a SURROGATE based strategy to find a good approximation of the ENTIRE Pareto front with at most 300 function evaluations of the true auxiliary function in *AuxModel.p*; the strategy should be reliable and should be tested on **10 independent runs** (only if a stochastic method is used)
- d) Use the SURROGATE based strategy developed at point c) to find the best approximation of the true Pareto front for the problem function implemented in *ExpModel.p* (the expensive routine) with at most **300 function evaluations** of the expensive function.



# REPORT

You are required to write a very short report not exceeding **1500 words** (excluding appendix).

Your report should include the following sections:

- 1) *Description of the NON-surrogate based global search strategy* (just the name of the algorithm is not enough - you should mention and describe the main steps of the algorithm – an algorithmic form would be appreciated);
- 2) *Description of the SURROGATE based global search strategy* (just the name of the algorithm is not enough - you should mention and describe the main steps of the algorithm – an algorithmic form would be appreciated);

...



# REPORT

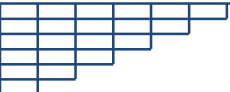
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### 3) *Results* of all the optimisation processes, reporting:

- for point a) the achieved approximations of the global minima, as well as a short description of the used method/approach and the computational cost (number of function calls, and wall-time) of the optimisation processes. (.mat file containing the results)
- for point b) the achieved 10 approximations of the Pareto front (clear figure), and the computational cost of the optimisation. (.mat file containing the results)
- for point c) the achieved 10 approximations of the Pareto front (clear figure), and the computational cost of the optimisation. (.mat file containing the results)
- for point d) the achieved approximation of the Pareto front (clear figure and table of results), and the computational cost of the optimisation. Make sure that you report/show the Pareto front of the true function and not that of the surrogate (**i.e., verify the final results of the surrogate, with the true function, this will not be counted as part of the 300 budget**) (.mat file containing the results)

### 4) *Discussion and Conclusions* on the obtained results, including the analysis of the performance of both strategies (NON-surrogate based and SURROGATE based), and the use of the surrogate based approach to solve the expensive problem;

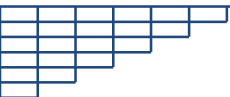
**SUBMISSION: 1) one Word/PDF file containing the report, and 2) one compressed file containing all the routines and the .mat files with the results.**



# Marking criteria

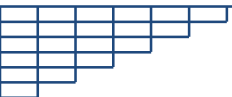
Assessment criteria (total marks: 100)

- **Description** of the global search strategies (clarity, **effort**, and logic; for both cases there should be the explicit description of the global exploratory and local exploitative parts) – Sections i) & ii) – **50 Marks (15 clarity, 20 effort, 15 logic)**
- **Results** (completeness, correctness/goodness, and presentation) – Section iii) – **35 Marks (15 completeness, 15 correctness, 5 presentation)**
- **Final discussion** (comment the obtained results and explain why the algorithms worked well, if – you think - you obtained good results, or why the algorithms did not work well, if – you think - you did not obtain good results) – You will be marked on correctness and clarity – Section iv) – **15 Marks**
- **Appendix** – instructions to run the scripts.
- **NOTE:** all the routines and instructions to use them should be "run ready", i.e., the lecturer should be able to run the main script(s) and replicate your results; if that cannot be done, **marks will be penalised**.



Due date

**Thu, 28<sup>th</sup> March 2023, 3:00 PM**





# University of **Strathclyde** **Glasgow**