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, **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*, *f*ind 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) *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);

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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 sue 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, 28th March 2023, 3:00 PM

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