Stellenbosch University
Department of Industrial Engineering

Optimisation (Eng) 774/874

Post-block Assignment 2 — Due on 5 August 2020 at 23:55
(On multi-objective optimisation metaheuristics)

Instructions

This assignment covers those parts of Chapters 2 and 4 of the textbook by E-G Talbi, titled *Metaheuristics: From design to implementation*, considered during the lectures of the module Optimisation (Eng) 774/874. Kindly complete this assignment and submit it as a single electronic submission in PDF format on SUNLearn by the above date.

Optimisation (Eng) 774 students should attempt Question 1, while both questions should be attempted by Optimisation (Eng) 874 students.

Rubrics are provided after the assignment questions according to which the assignment will be assessed. Please pay careful attention to the requirements laid out in these rubrics.

Late submissions (*i.e.* later than the required submission time mentioned above) will be penalised by 20% per day or part thereof. A final cut-off per assignment will apply after four days, and no assignments will be accepted after this cut-off (*i.e.* a 100% penalty will be applied). Please work independently and ensure that the assignment you submit contains your own work.

Assignment questions

(1) Implement, in a computer language of your choice, the method of *dominance-based multi-objective simulated annealing* (DBMOSA) for finding an approximation of the following continuous multi-objective optimisation problem's Pareto front.

$$\begin{aligned} &\text{Minimise} && f_1(x) = x^2, \\ &\text{minimise} && f_2(x) = (x-2)^2, \\ &\text{subject to} && -10^5 \leq x \leq 10^5. \end{aligned}$$

For the method of simulated annealing determine its appropriate parameter values and operator settings empirically, they are:

- Starting temperature T_0, *e.g.* accept all, acceptance deviation, or acceptance ratio.
- Epoch length, *e.g.* static or dynamic paradigm.
- Cooling and reheating schedule, *e.g.* linear, geometric, logarithmic, or adaptive, to name a few.
- Search termination criterion, *e.g.* reaching a final temperature, reaching a pre-determined number of iterations without improvement, or achieving a small number of move acceptances over a pre-specified successive number of epochs.

Report on the different performance levels achieved between the various parameter and operator settings above. Note: You do not have to evaluate the performance of every single option. Choose, for example, two different approaches in respect of each parameter and operator and compare the performance. Employ the best combination of parameters and operators in your final implementation of DBMOSA.

Provide a graphical illustration of both the approximate Pareto optimal set and the Pareto optimal set in decision space. In addition, provide a graphical illustration of both the approximate Pareto front and (true) Pareto front in objective space. Tabulate the corresponding decision variable and objective function values with respect to the aforementioned.

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(2) Incorporate a diversity-based criterion when updating the archive — *i.e.* use some diversity preservation technique (*e.g.* kernel methods, nearest-neighbour methods, or histogram methods) to measure the diversity of a neighbouring solution before considering its inclusion. Based on the measured diversity devise a strategy that can be used to decide whether or not to include the neighbouring solution in the archive. Compare the performance (*i.e.* spread and convergence) of DBMOSA with and without the diversity preservation technique.

Assessment Rubric for Question 1

Criterion A: Commenting of program to make it readable/interpretable (Mark awarded: A Marks)

1 Mark	2 Marks	3 Marks	4 Marks	5 Marks
No or virtually no commenting; basically impossible for a marker to figure out the functionality of the different program parts	Existing but poor commenting; leaving the marker to figure out the functionality of the various program parts; although possible to do this, it is very difficult	A serious attempt at commenting, but leaving much to be desired; the onus is on the marker to figure out the working of the program	A good attempt made at commenting, but still leaving the marker to figure out the functionality of some program parts	Excellent, clear comments making it easy to read and interpret the entire implementation

Criterion B: Modularity of independent program parts/procedures/functions (Mark awarded: B Marks)

1 Mark	2 Marks	3 Marks	4 Marks	5 Marks
Little or no modularity; programming structure resembling a bowl of spaghetti; almost impossible to verify various metaheuristic component implementations	Existing but poor modularity, making it difficult to verify various metaheuristic component implementations	An attempt at functional modularity, making it possible to verify some metaheuristic component implementations, but leaves much to be desired in terms of sensibility of the scoping of various functions/procedures	Acceptable functional modularity of implementation, but could have been better in terms of facilitating easy verification	Very clear functional modularity of implementation, with sensible scoping of various functions/procedures, making it easy to verify metaheuristic component implementations

Criterion C: Perceived integrity and adherence to specified elements of metaheuristic implementation (Mark awarded: C Marks)

1 Mark	2 Marks	3 Marks	4 Marks	5 Marks
Very serious questions about program integrity and significant non-adherence to metaheuristic component specification	Very serious questions about program integrity or significant non-adherence to metaheuristic component specification (but not both)	No serious questions about implementation integrity, but average coding efficiency of various metaheuristic components, adherence to metaheuristic component specification	No questions about program integrity, acceptable coding efficiency of various metaheuristic components, adherence to metaheuristic component specification	Crisp, high-quality and efficient coding of various metaheuristic components, adherence to metaheuristic component specification, implementation integrity beyond question

Criterion D: Credibility and quality of numerical results output (Mark awarded: D Marks)

1 Mark	2 Marks	3 Marks	4 Marks	5 Marks
Numerical results fundamentally flawed and presented poorly	Serious numerical errors and presentation thereof lacking	Acceptable numerical results with few serious errors and presented decently	Good numerical results, which are virtually error-free and presented well	Excellent, error free numerical results and presented superbly

Criterion E: Quality of approximation front (Mark awarded: E Marks)

1 Mark	2 Marks	3 Marks	4 Marks	5 Marks
Approximate Pareto front far from true Pareto front and no spread	Approximate Pareto front somewhat off the true Pareto front with moderate spread	Approximate Pareto front approaching true Pareto front with acceptable spread	Approximate Pareto front close to true Pareto front with a decent spread	Approximate Pareto front matches true Pareto front with good spread

Final mark awarded for Question 1 (out of 50): $A + 2B + 3C + 3D + E$

Assessment Rubric for Question 2

Criterion A': Scope of diversity preservation techniques considered (Mark awarded: A' Marks)

2 Mark	4 Marks	6 Marks	8 Marks	10 Marks
Only one technique addressed superficially	Two techniques addressed superficially or one technique addressed in detail	Two techniques addressed in detail	Three techniques addressed superficially	Three techniques addressed in detail

Criterion B': Credibility and quality of numerical results output (Mark awarded: B' Marks)

3 Mark	6 Marks	9 Marks	12 Marks	15 Marks
Numerical results fundamentally flawed and presented poorly	Serious numerical errors and presentation thereof lacking	Acceptable numerical results with few serious errors and presented decently	Good numerical results, which are virtually error-free and presented well	Excellent, error free numerical results and presented superbly

Final mark awarded for Question 2 (out of 25): $A' + B'$