Stellenbosch University
Department of Industrial Engineering
Optimisation (Eng) 774/874
Post-block Assignment 3 — Due on 14 August 2020 at 23:55
(On hybrid metaheuristics)

Instructions

This assignment covers those parts of Chapters 2, 4, and 5 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.

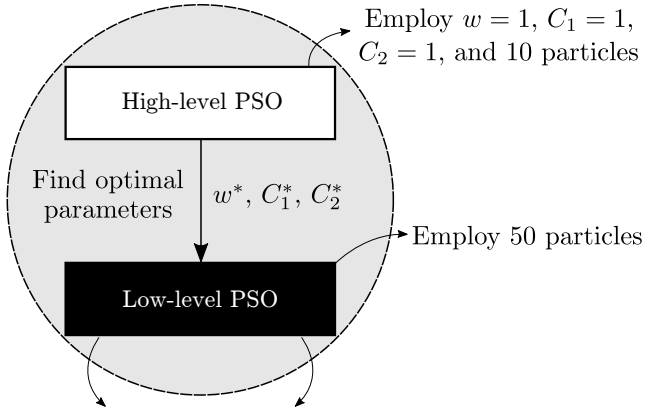
Late submissions (*i.e.* later than the required submission time mentioned above) will be penalised by 20% per day or part thereof. A final cut-off per assignment will apply after four days, and no assignments will be accepted after this cut-off (*i.e.* a 100% penalty will be applied). Please work independently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

Assignment questions

(1) Construct and implement, in a computer language of your choice, a meta-optimisation algorithm (*i.e.* specialist hybrid metaheuristic) that employs a high-level particle swarm optimisation (PSO) algorithm to find optimal (or near optimal) hyper-parameter values — *i.e.* inertia weight w^* and cognitive factors C_1^* and C_2^* — for another PSO algorithm which is applied to the following optimisation problem

$$\text{Minimise} \quad f(x,y) = -(y+47)\sin\left(\sqrt{\left|y+\frac{x}{2}+47\right|}\right) - x\sin\left(\sqrt{|x-(y+47)|}\right),$$

where $-512 \leq x, y \leq 512$. The global optimum corresponds to $f(512, 404.2319) = -959.6407$. For the high-level PSO algorithm employ $w = 1$, $C_1 = 1$, $C_2 = 1$ and use 10 particles. For the low-level PSO algorithm use 50 particles. Adopt a dynamic stopping criterion according to which the algorithm terminates after no improvement in the global best particle (solution) is found after a certain number of iterations. A graphical depiction of the meta-optimisation problem is presented in the figure below.



$$\text{Minimise} \quad f(x,y) = -(y+47)\sin\left(\sqrt{\left|y+\frac{x}{2}+47\right|}\right) - x\sin\left(\sqrt{|x-(y+47)|}\right)$$

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Report on the hyper-parameter values found for the high-level PSO algorithm. Furthermore, for the low-level PSO algorithm illustrate the objective function values of the entire final swarm graphically, *i.e.* plot x and y against f. Include a carefully commented print-out of your program source code in your final submission.

(2) Adopt a *high-level relay* hybridisation approach and use multi-start local search to improve upon five different non-optimal particles (*i.e.* solutions) found by the low-level PSO algorithm in Question 1. Include a carefully commented print-out of your program source code in your final submission.

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 final results front (Mark awarded: E Marks)

1 Mark	2 Marks	3 Marks	4 Marks	5 Marks
Final swarm does not exhibit convergence to global or local optima	Only a few particles in final swarm exhibit convergence to local optima	Almost half of final swarm exhibit convergence to local optima	Few particles in final swarm converged to global optima however many at local optima	Vast majority of particles in final swarm converged to global optima

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

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Assessment Rubric for Question 2

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′: Perceived integrity and adherence to specified elements of metaheuristic implementation (Mark awarded: B' 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 C′: Credibility and quality of numerical results output (Mark awarded: C' 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

Final mark awarded for Question 2 (out of 20): $A' + 2B' + C'$