ISE 5113 Advanced Analytics and Metaheuristics
Homework #5

Instructor: Charles Nicholson

See course website for due date

Requirement details

1. Submit all of your well-documented (e.g. commented) Python code.
2. Homeworks are to be completed in teams of *one*, *two* or *three*. Your choice.
3. No you cannot use available Python packages that do all of the work for you – you must code the logic to receive a grade!

You will develop Python code to implement a Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) algorithm for the Schwefel minimization problem. The Schwefel problem can be formulated in $n > 0$ dimensions. Figure 1 presents the formula and a 2D representation of the solution landscape. The feasible region is an n-dimensional hybercube centered at the origin with possible values ranging from -500 to 500 for each dimension.

$$f(x) = 418.982887272433n - \sum_{i=1}^{n} x_i \sin(\sqrt{|x_i|})$$

Dimensions:	n
Domain:	$-500.0 \leq x_i \leq 500.0$
Global Optimum:	$f(x) \approx 0.0$ at $x = (420.9687, 420.9687, \ldots, 420.9687)$

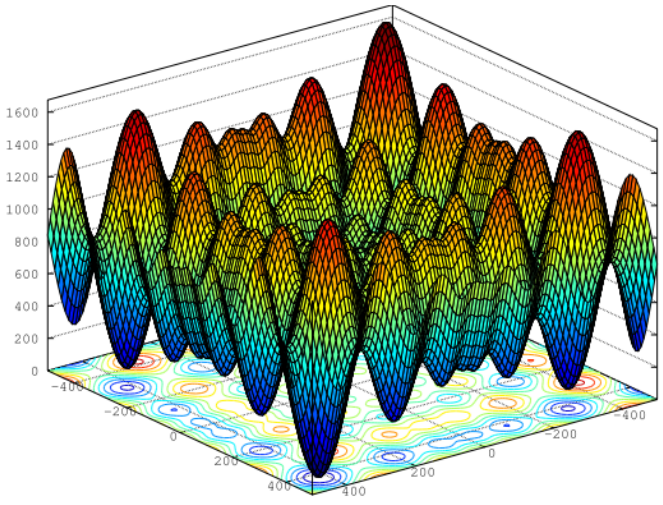

Figure 1: Schwefel function in 2D

Question 1: Genetic Algorithm Implementation (40 points)

Some basic Python code is available to help you begin complete a GA implementation for the Schwefel minimization problem. The code however is incomplete and requires multiple improvements. You may make any changes to the code as you see fit below line 17.

(a) Finalize the code.
   i. Create code to generate chromosomes in the initial population.
   ii. Create code to mutate chromosomes.
   iii. Implement logic for crossover rate and mutation rate.
   iv. Implement some type of elitism in the insertion step.
   v. Complete/modify any other logic as you see fit.

(b) Empirically decide on parameters for population size, stopping criterion, cross over rate, mutation rate, selection, and elitism.

(c) Solve the 2D Schwefel.
   i. Create a small population of 8 chromosomes and depict their locations on a graph for the initial random set and the first generation.
   ii. Solve the problem as best as possible and provide information on the quality of the best solution and the performance of the approach overall.

(d) Solve the 200D Schwefel problem as best as possible. Provide information on the quality of the solution and the performance of the approach overall.

Question 2: Particle Swarm Optimization Implementation (60 points)

Some basic Python code is available to help you begin a PSO implementation for the Schwefel minimization problem.

(a) Complete the *original* PSO implementation based on "particle best" and "global best"; no inertia or constriction is necessary. Make sure to include the following elements:
   - limits on particle position (e.g., particles should primarily remain within the feasible region)
   - limits on particle velocity
   - one or more stopping criteria

(b) Using your code from Part (a), create a swarm of size 5 and solve the 2D Schwefel problem.
   i. Record and list in a table the first 3 positions and velocities of each particle.
   ii. Determine and highlight the particle that represents the "global best" particle position in each of these iterations.
   iii. Plot the first 3 positions of each of the 5 particles (you can use Python, R, Excel, or even draw it by hand)

(c) Implement a PSO algorithm that uses the "local best" in place of the global best. You may also add inertia weighting or constriction if you like. Implement *one* of the following neighborhood topologies, ring, star, von Neumann:

(d) Solve the 2D and 200D Schwefel problem as best as possible. Provide information on the quality of the solution and the performance of the approach overall. Compare the results with the Genetic Algorithm results.

Question 3: Extra-Credit Option: Guided Local Search (25 points)

Solve the 2D and 200D Schwefel using Guided Local Search and compare the results to both the PSO and GA implementations. Make sure to explain your implementation well in your write-up. Since there is no Python code provided for this problem, you must comment well and you should include snippets of code in the write-up itself as you deem appropriate.