COSC 3P71
Assignment 3

Fall 2017

Instructor:	Beatrice Ombuki-Berman	**Assigned Date:**	TBD
TAs:	Kyle Harrison & Jay Douglas	**Due Date:**	TBD

Goal: Implementation of vanilla Particle Swarm Optimization (PSO).
Languages: Any programming language of your choice, within reason.
Task: Implement the vanilla PSO algorithm and compare the performance of various parameter configurations to random search.

Details

The PSO algorithm is a stochastic search technique that is applicable to real-valued optimization problems. However, it's performance is rather sensitive to the values assigned to its control parameters, namely the inertia weight (ω), the cognitive acceleration coefficient (c_1), and the social acceleration coefficient (c_2). In fact, poor parameter values can lead to performance that is even worse than random search!

Your task is to implement the vanilla PSO and investigate the performance using different parameter configurations, comparing the performance to random search. Random search, in this context, refers to a uniform random sampling of the search space. This can be accomplished by sampling and evaluating random (feasible) points uniformly within the search space. You must ensure that fairness is maintained for the comparison. For example, if your PSO has 30 particles and runs for 1000 iterations, it is evaluating 30,000 positions – a random sampling should then also uniformly sample 30,000 positions within the search space.

Recall that the main components that need to be considered when implementing PSO are:

- **Initialization:** Construct a random initial population of particles, ensuring that each has a valid initial position and velocity. Typically, a swarm will consist of 20–40 particles.
- **Neighbourhood Topology:** You can assume a global-best neighbourhood such that the neighbourhood best refers to the best solution found by any particle throughout the course of the search.
- **Boundary Constraints:** Assume that particles are permitted to exit the feasible region, but you should only allow updating of the personal best when a solution is feasible.
- **Iteration Strategy:** You can assume a synchronous iteration strategy.
- **Termination Criterion:** You are free to determine your own termination criterion. The most straightforward way would be to fix the maximum number of iterations. However, remember that you must ensure a fair comparison between PSO and random search.

Optimization Problem

For the optimization problem, use the Rastrigin function, which is defined as

$$f(\mathbf{x}) = 10n_x + \sum_{i=1}^{n_x}(x_i^2 - 10\cos(2\pi x_i)) \tag{1}$$

with each $x_i \in [-5.12, 5.12]$ and n_x being the dimension of the problem. This goal is to minimize the value of the function – the optimal value is 0 when all values of x_i are 0. Note that the fitness of a particle is simply the value of Equation (1), where $\mathbf{x}$ is the particle position. For the purpose of this assignment, assume the problem is 30 dimensions (i.e., $n_x = 30$). For reference, Figure 1 shows the 2 dimensional version of this function.

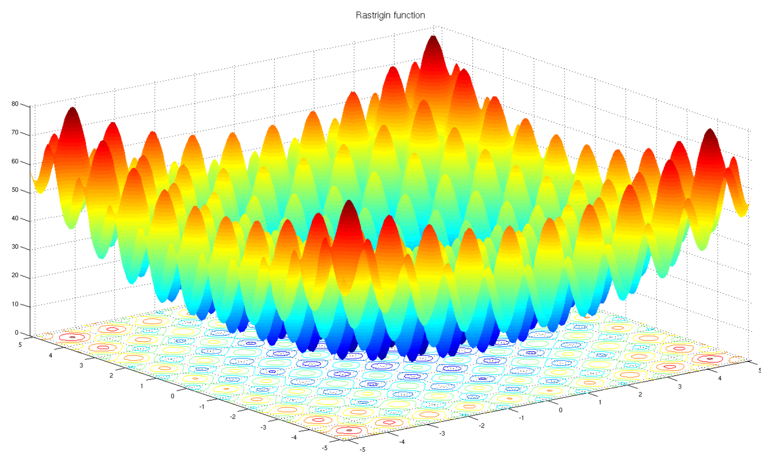

Figure 1: Visualization of the 2 Dimensional Rastrigin function. Source: https://upload.wikimedia.org/wikipedia/commons/8/8b/Rastrigin_function.png.

Parameter Configurations

Compare the following four parameter configurations of PSO:

1. $\omega = 0.729844$, $c_1 = c_2 = 1.496180$
2. $\omega = 0.4$, $c_1 = c_2 = 1.2$
3. $\omega = 1.0$, $c_1 = c_2 = 2.0$
4. $\omega = -1.0$, $c_1 = c_2 = 2.0$

As a point of reference, Table 1 provides a summary of the outputs obtained by running the simulations 100 times using 150,000 evaluations (30 particles, 5000 iterations).

Submission Instructions

- Repeat each experiment at least 5 times (but more is always better!) and provide a short report that highlights your findings. The report does not need to be nearly as extensive as Assignment 2 but should clearly describe the PSO algorithm and what observations you made from the experiments.

Table 1: Summary of fitness values over 100 simulations.

Configuration	Mean	Std. Dev.	Median
Random Search	314.377	13.293	315.607
PSO-1	74.582	16.888	74.124
PSO-2	110.157	21.930	108.002
PSO-3	436.923	29.023	441.585
PSO-4	443.406	27.419	444.806

- You are free to use any language you choose (within reason) so long as your solution can be both opened and executed on the lab computers. Possible languages include Java, C#, C++, and Python. If you are unsure about the suitability of a particular language, ask before proceeding. No matter your choice of language, ensure you have provided sufficient comments such that your program can be understood. At minimum, include a comment describing each function/method and class/module.
- Submissions must be made in both physical and electronic formats. For the physical submission, be sure to include a complete listing of your source code and accompanying report along with a departmental cover page. For the electronic submission, include a complete listing of your source code, experimental data, and report. Use the script SCRIPT for electronic submission.
- All assignments are to be completed individually.

Last edited: November 14, 2017