Coursework 2 - Implementing and Comparing Genetic Algorithm and Particle Swarm Optimisation

F21BC: Biologically Inspired Computation

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# Introduction

The task was to implement Genetic Algorithm (GA) and Particle Swarm Optimisation (PSO) optimization algorithms from scratch and to carry out some experiments to see how they compare when evaluated on the CEC 2005 test functions (Suganthan et al., 2005). These test functions are used to assess optimization functions on an artificial landscape. The goal of the optimization algorithms was the find the global minimum (optimum value) in these test functions.

# Implementation

The implementations were based on the pseudocode from Luke (2016). The logic for the algorithms can be found in GA.py and PSO.py.

The following test functions were picked to test the algorithms with the following properties in mind:

* F2: Shifted Schwefel’s Problem 1.2
* F4: Shifted Schwefel’s Problem 1.2 with Noise in Fitness
* F8: Shifted Rotated Ackley’s Function with Global Optimum on Bounds
* F13: Shifted Expanded Griewank’s plus Rosenbrock’s Function (F8F2)
* F17: Rotated Version of Hybrid Composition Function with Noise in Fitness
* F24: Rotated Hybrid Composition Function

The aim was to cover a lot of different types of function properties. F2 and F4 are both unimodal, without and with noise. All the rest are multi-modal. F8 is a single function, F13 is an expanded function and F17 and F24 are composite. F17 has a Gaussian noise in its fitness and for this reason this is in-deterministic. All the other functions are deterministic. F17 and F24 are composite and due to this nature of the function it has a lot of spikes in their artificial landscape which results in a high number of local optima. F8 has its local optima on its bounds.

## Genetic Algorithm

The genetic algorithm was implemented with elitism (Luke, 2016, pp. 46-47.). The code follows the same structure as the pseudocode, however, it had to be tweaked to allow multiple elites. The pseudocode’s line 10-11 is responsible for saving the best results after assessing the fitness. This was implemented differentially by using Python’s inbuilt sorting functions.

The algorithm has the option to use decreasing mutation rate. The program slowly decreases the mutation rate per generation if this is used. I.e. if the mutation rate is 80% then for the first generation the rate is unchanged, at half-point it's halved for 40% and the last generation is near 0%. The advantage of using decreasing mutation rate is to have a high mutation rate at the beginning which helps the algorithm to explore the artificial landscape and also to avoid local optimums but narrows down the randomness as it progresses forward which helps to focus on attired solutions towards the last generations without scrambling it with high mutation.

Tournament selection is used with adjustable tournament size, 2 on default as per Luke (2016, pp. 45.).

Crossover percentage can be defined as well, this parameter gives the probability of crossover happening between parents. By default, it is 95%.

## Particle Swarm Optimisation

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# Results

The execution and analysis of the optimization functions can be found in….

# Discussion and Conclusions

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# References

Luke, S. (2016). *Essentials of Metaheuristics.* 2.3 ed. [online] Lulu, pp.31–58. Available at: https://cs.gmu.edu/~sean/book/metaheuristics/ [Accessed 27 Nov. 2022].

Suganthan, P., Hansen, N., Liang, J., Deb, K., Chen, Y., Auger, A. and Tiwari, S. (2005). Problem Definitions and Evaluation Criteria for the CEC 2005 Special Session on RealParameter Optimization. *Natural Computing*, 341-357.