# Assignment 3

CS 776: Evolutionary Computing
Fall 2020
Max Score: 100

## Objectives

- Learn and demonstrate knowledge of genetic algorithms and how to use them to solve function optimization problems.

## Problem

I have provided you with the code for the simple genetic algorithms on canvas and on the class web page. Use this genetic algorithm to solve the following function optimization problems where I provide the objective function to be minimized or maximized.

1. Unimodal:

$$\text{Minimize} \quad f_1(x_i) = \sum_{i=1}^{5} x_i^2$$

   where $x_i$ satisfies $-5.12 \leq x_i \leq 5.12$

2. Rosenbrock's function:

$$\text{Minimize} \quad f_2(x_i) = 100(x_1^2 - x_2)^2 + (1 - x_i)^2$$

   where $x_i$ satisfies $-2.048 \leq x \leq 2.048$

3. Step:

$$\text{Minimize} \quad f_3(x_i) = \sum_{i=1}^{5} \text{integer}(x_i)$$

   where $x_i$ satisfies $-5.12 \leq x_i \leq 5.12$

4. Noise:

$$\text{Minimize} \quad f_4(x_i) = \sum_{i=1}^{30} i x_i^4 + Gauss(0, 1)$$

   where $x_i$ satisfies $-1.28 \leq x_i \leq 1.28$

5. Multimodal:

$$\text{Minimize} \quad f_5(x_i) = 0.002 + \sum_{i=1}^{25} \frac{1}{i + (x_1 - a_{1i})^6 = (x_2 - a_{2i})^6}$$

where

$a_{1i} = -32, -16, 0, 16, 32, -32, -16, 0, 16, 32, -32, -16, 0, 16, 32, -32, -16, 0, 16, 32, -32, -16, 0, 16, 32$

and

$a_{2i} = -32, -32, -32, -32, -32, -16, 16, -16, 16, -16, 0, 0, 0, 0, 0, 16, 16, 16, 16, 16, 32, 32, 32, 32, 32$

where $x_1$ and $x_2$ satisfy $-65.536 \leq x_1 \leq 65.536$ and $-65.536 \leq x_2 \leq 65.536$

6. Unimodal again: Maximize the number of ones in a chromosome of length 100.

For each of these functions, run the given genetic algorithm 30 different times with different random seeds. Use the following parameters

- Population size: 50
- Number of generations: 75
- Probability of Crossover: 0.7
- Probability of Mutation: 0.001

## Analysis

Store the runtime data in order to analyse performance, reliability, and speed. Then for each function:

1. Performance Graphs. On one graph, plot both
   - The average of the average (over 30 runs) fitness against the number of generations. In other words, the first point on your plot will be the average population fitness in generation 0 over all 30 runs of your GA with different random seeds. The second point will be the average population fitness in generation 1 over all 30 runs of the GA. And so no.
   - The average maximum (over 30 runs) fitness against the number of generations
2. Reliability: Track the best solution ever found over the 30 runs. Specify the values of the variables and the objective function value for this best solution. Specify reliability, $r$, where
$$r = \frac{n}{30}$$
where $n$ is the number of times you found the best value.

3. Performance: Specify how close (as a percentage) the best solution the GA found was to the optimum. You will need to plot these functions or search the internet to find the optimum.

4. Speed: On average, how many generations did the GA need to find the best solution? What was the minimum number of generations needed to find the best solution? The maximum number of generations?

## Turning in your assignment

Turn in one document (pdf) with the following information through canvas before the due date.

1. Your FULL name and email address

2. Source code listing for all the functions, and for encoding and decoding variable representations.

3. The graphs and answers to the questions above.

4. I may ask for a demo

Ask me if you have questions.