Shanghai Jiao Tong University
CS241
Fall 2019

**Assignment 9**

Ziqi Zhao November 13, 2019

9.3. **Implementation of Question 2.**

(a) **Encoding and decoding.**
We map interval $A[-1, 15]$ uniformly to interval $B[0, 2^{16} - 1]$, using the formula:

$$g(x) = \frac{(x - l)}{(u - l)} * (2^S - 1)$$

where $u = 15, l = -1, S = 16$.
Convert the answer $g(x)$ into binary and place it in a `vector<bool>` or `bitset<16>`, then we obtain a 16-bit binary code as the chromosome.
In a similar way, we can decode a chromosome simply by converting it into decimal then apply $g^{-1}(x)$.

(b) **Initial population.**
Generate random numbers in $[-1, 15]$ for $T = 3000$ times, and encode them using the above method to constitute the initial population.

(c) **Crossover operator.**
First, we randomly decide the couples in the whole population to crossover according to the pre-defined probability $P_c = 0.8$, then randomly extract two crossover points in interval $[0, 15]$ and swap the selected bits.

(d) **Mutation operator.**
For all $16T$ bits in the population, we select some randomly and invert them, using a pre-defined probability $P_m$.

(e) **Selection methods.**
It's obivious that the minimum of $x \cdot \sin x (x \in [-1, 15])$ is not less than 15, so we define the fitness function:

$$f_{itness}(x) = -x \cdot \sin x + 15$$

then $f(x)$ keeps positive in $[-1, 15]$.
Apply the Roulette-Wheel selection, we get the probability of $k$ to be chosen:

$$P_k = \frac{f(k)}{\sum_i f(i)}$$

In order to keep the size of population, we pick individuals by above probabilities for $T$ times independently and then obtain the new population.

(f) **End criterion.**
The algorithm will terminate when the number of iterations is larger than a given number (for instance 5000), or the difference between the average fitness score and the best fitness score is less than 0.01%.