EC HW01 - 313551047 陳以瑄

1. **The eight queens problem.**
   Definition of the 8-Queens Problem:
   Placing eight queens on an 8x8 chessboard so that no two queens threaten each other.

   Observation:
   Since no two queens threaten each other, meaning that no two queens share the same row, column, or diagonal, the feasible solution must follow two constraints:
   i. There is exactly one queen in each row
   ii. There is exactly one queen in each column

   (a) **How big is the phenotype space for the eight queens problem?**
   The phenotype space under the constraint is 8!

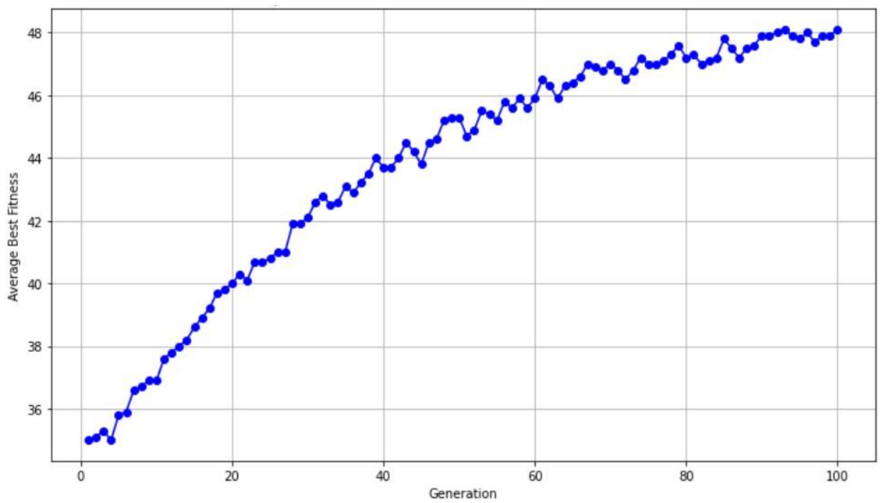
   (b) **Give a genotype to encode the 8x8 chessboard configuration.**
   A suitable genotype is a permutation of the integers 1 to 8. Each integer represents the row position of a queen in a specific column. For example, the genotype [3,7,4,2,8,6,5,1] indicates that the queen in the first column is in the 3rd row, the queen in the second column is in the 7th row, and so on.

   (c) **How big is the genotype space you give in (b)?**
   The genotype space is 8!

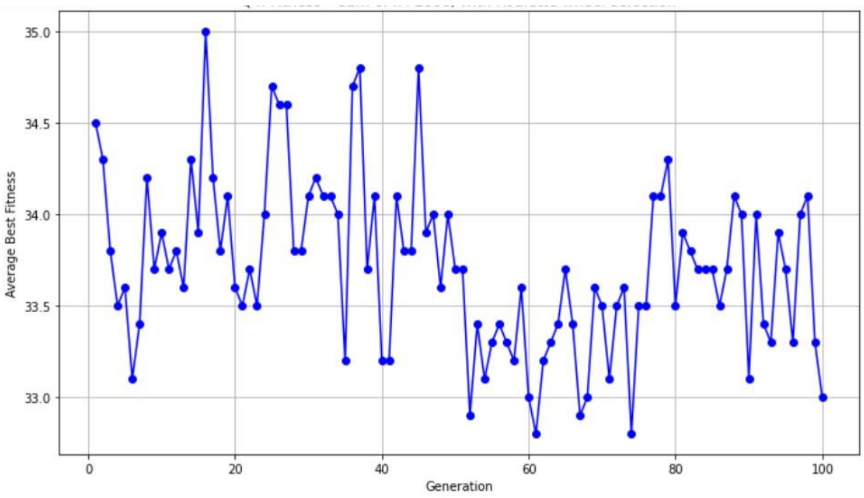
   (d) **Briefly describe why the proposed genotype is able to cover the phenotype space.**
   Since each permutation guarantees that there is exactly one queen in each column and no two queens share the same row, the proposed genotype can cover the phenotype space

2. **Given a function f(x) : [0, 1] → R. We want to find an optimal x value with a required precision of 0.001 of the solution. That is, we want to be sure that the distance between the found optimum and the real optimum is at most 0.001. How many bits are needed at least to achieve this precision for a bit-string genetic algorithm?**
   Since we want to ensure the precision is 0.001, we can divide the interval [0,1] into N subintervals that each of them have length 0.001.
   The number N = 1/0.001 = 1000
   Therefore, we need $\lceil \log_2 1000 \rceil = \lceil 9.97 \rceil = 10$ bits.

3. **The plot of the results where the fitness function is the sum of x, and selection is done using the roulette wheel method.**

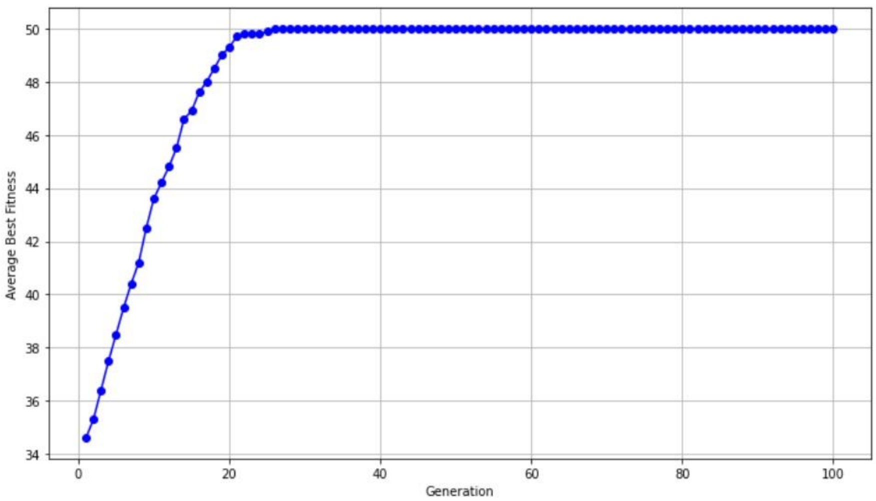


4. **The plot of the results where the fitness function is the sum of x plus 1000, and selection is done using the roulette wheel method.**

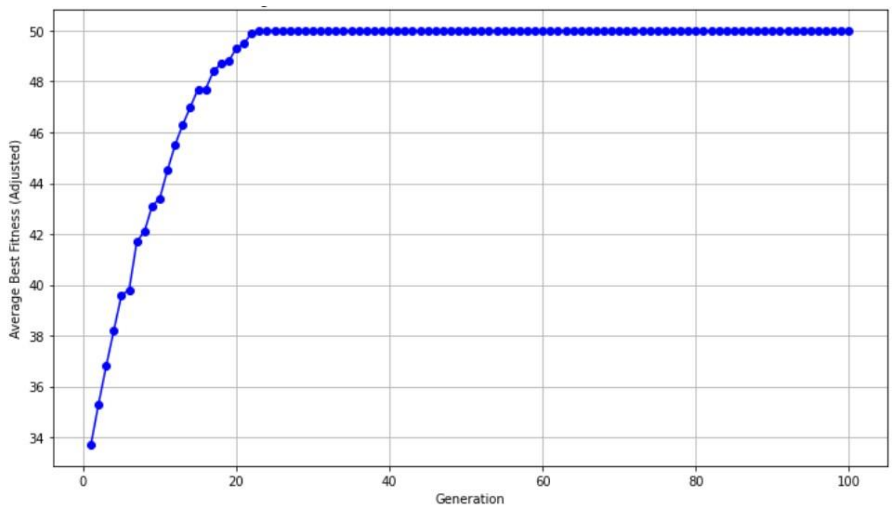


5. **Compare the results of problems 3 and 4.**
   We notice that the best fitness in Problem 3 steadily increases, ultimately reaching 48 at the 100th generation, while the results for Problem 4 hover around 34. This is because our selection method is roulette wheel selection, which operates on the principle that individuals with higher fitness have a greater chance of being selected. Therefore, in Problem 3, we can see continuous improvement. However, in Problem 4, we add a large number, 1000, to the original fitness. Since the original fitness does not exceed 50, this large number makes the fitness of each individual nearly the same, resulting in a selection probability close to uniform. As a result, the overall performance fluctuates.

6. **The plot of the results where the fitness function is the sum of x, and selection is done using the tournament method.**



7. **The plot of the results where the fitness function is the sum of x plus 1000, and selection is done using the tournament method.**



8. **Compare the results of problems 6 and 7.**
The performance of the two results is quite similar because we used tournament selection in these two experiments. In this method, we select the winner as the parent, so individuals with higher original fitness remain relatively higher even after adding 1000. As a result, the winners selected are the same, leading to similar performance.

9. **Compare the results of problems 3, 4, 6and 7.**
We see that adding 1000 to the fitness only affects the outcome of roulette wheel selection and has no impact on tournament selection. This is because roulette wheel selection is fitness-based method and may encounter the issue of function transposition.
We also notice that tournament selection reaches the best solution around the 20th generation, which is faster than roulette wheel selection. This happens because in tournament selection, the fittest individual has a much higher chance of being chosen, while in roulette wheel selection, individuals with high fitness don’t always dominate the selection process.