Example 5 – Local Search Algorithms:

Problem Statement:

The following problem was provided by the same speed runner from the previous example 4. Now the speed runner for the game Fallout New Vegas wants to find the most optimal route to 100% complete the game of Fallout New Vegas. To complete this speed run he must travel to every single city in the game and make it back to the original city he started at. The problem is equivalent to the travelling salesman problem (TSP) and to solve it a genetic algorithm will be applied to discover the most optimal path for the speed runner's character to visit all the cities around the map and make it back to the starting city. Similarly, to the previous example the following map will be used to base the program off.

Source: (https://fallout.fandom.com/wiki/Fallout:_New_Vegas_merchants)

In this particular case the speed runner will start at Goodsprings and travel throughout New Vegas visiting all the cities until they return to Goodsprings.

Description of the AI technique:

The genetic algorithm is a local search technique that is used in optimization problems. To understand what an optimization involves it requires an agent with simulated intelligence to find the minimum or maximum to a problem. In this example's case the optimization problem requires the agent to discover the minimum distance required to travel to all the different cities in the game Fallout New Vegas. To

understand how the agent undertakes this problem the idea of simulated intelligence must be understood. Essentially the agent understands three things which state it is in, how fit the current state is and what the possible actions are. The state in this case would be a city and the actions are which state the agent can move to. In terms of how fit a state is this is judged by how close a given state is to the maxima or minima of the problem. For instance, taking a position on a curve the fitness of a state would be how close it is to the maximum or minimum. An example of this is seen below.

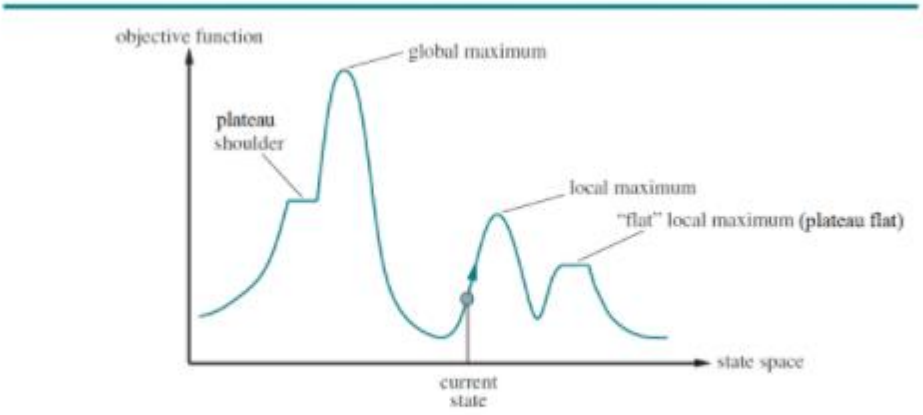

Figure 4.1 A one-dimensional state-space landscape in which elevation corresponds to the objective function. The aim is to find the global maximum.

Russell S, Norvig, P. (2020)

In the traveling salesman case, the state would be fit if the minimum distance between all the states has been found. For this example, the AI technique that will be focused on is the genetic algorithm. This algorithm follows this concept of Darwinism's natural selection which states that a species will evolve over time through reproduction of the strongest or most suited within that species for a given environment. In terms of the programmed AI, the algorithm is given a number of k individuals and the individuals that have the highest fitness, indicated by the highest objective function value, are chosen to produce offspring called the successor states to generate the next generation. This continues until a certain generation passes the fitness threshold or until the number of iterations through the generations is complete. The step by step process of taking the initial generation and producing a new generation is as follows. The initial population is generated and then ranked by its fitness, next the individuals with the highest fitness are selected to reproduce, then the individuals will reproduce called crossover and finally the offspring will randomly be mutated which changes a random location within the state. One this process is complete it is repeated until a generation meets the fitness threshold as discussed previously. The following diagram helps visualise the process of the genetic algorithm:

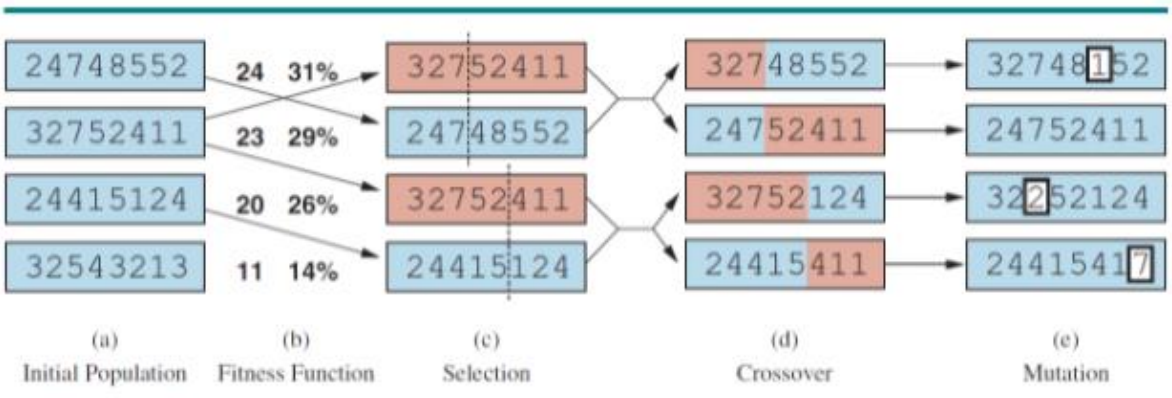

Figure 4.5 A genetic algorithm, illustrated for digit strings representing 8-queens states. The initial population in (a) is ranked by a fitness function in (b) resulting in pairs for mating in (c). They produce offspring in (d), which are subject to mutation in (e).

Russell S, Norvig, P. (2020)

How the AI technique is used to solve the problem:

In order for the genetic algorithm to solve the given problem the distances between all the cities had to be calculated, then the algorithm had to be defined. The first step was defining how many individuals would be in each population, in the example the max population was set to 200. Next the mutation rate was set to 0.5 meaning that each location in a given state had a 0.5 chance of being changed and finally given that there are 19 cities on the map the number of elements in a gene pool was set at 19.

Once the population was generated the next step was to set the variables for the algorithm to reproduce an optimal fitting generation. After looking at the problem statement the speed runner informed that to get the world record the distance had to be less than 675km in game. Therefore, the fitness threshold was set to 675 meaning that once a generation had a fitness below 675 the model will stop. Otherwise, if the algorithm could not find a solution that could beat the world record of 675 the algorithm would stop after 500 generations. Once the population was set and the algorithm was ready to run the generations were set to reproduce in the hopes it would find a bath that would beat the threshold of 675.

Solution Results:

After 318 generations the genetic algorithm discovered a path that had a fitness of 651.7298155841 significantly surpassing the threshold of 675. The final path the algorithm found was ['Goodsprings', 'Mojave_Outpost', 'Novac', 'Hidden_valley', 'Crimson_caravan_co', 'Freeside', 'Gun_Runners', 'Camp_McCarran', 'Grub_n_Gulp', 'Nellis_AFB', 'one_eight_eight_trad', 'Boulder', 'Gibson_sct', 'Camp_Forlorn_Hope', 'Hoover_dam', 'NCR_correct_fa', 'Primm', 'Westside', 'Jacobstown', 'Goodsprings']. This path is what the speed runner should follow in order to get the world record for 100% completing Fallout New Vegas.

If the record was beaten again and the current method had to be improved, increasing the number of generations could result in a better solution if the threshold was lowered once again, the rate of mutations could also be increased or decreased to enhance the final output and the amount of individuals in each generation could also be changed to possibly increase the output. Other methods that could improve the optimization method include hill climbing and simulated annealing. Hill climbing is typically used for linear regression problems where a computer scientist would need to find the maxima or minima of a curve while simulated annealing finds the minimal value of the objective function, so it performs valley descending through changing the temperature much like how a genetic algorithm

changes its fitness. These other two methods could produce a better output for the optimisation problem due to the genetic algorithm being slower and more reliant on probability than the other two methods. Overall, the genetic algorithm managed to solve the optimisation problem well providing a path that the speed runner can use to beat the world record.

References:

Fallout: New Vegas merchants. (2021). Retrieved from https://fallout.fandom.com/wiki/Fallout:_New_Vegas_merchants

Lu, H. 2021, 'Module 5 -- Search algorithms Part I', UTS Online Subject 41040 lecture notes, UTS, Sydney, viewed 21 September 2021, < https://canvas.uts.edu.au/courses/18678/modules>.

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