Programming Task - GA
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In the lecture (Programming Exercises), a GA program is given for VRP problems with the following problem specifications:
• Number of destination points : 6
• Number of vehicles : 1
• no capacity limit.

Modify the given program for the following is the development of the problem.

• Added number of destination points → 15 destination points
• Each destination point has a number of requests for goods according to the demand data.
• There are 3 vehicles with a maximum capacity of each vehicle is 100 Kg.

Task Answer :

1. Representation of Solutions

Genetics Algorithm will represent a problem solution as chromosomes. The solution that will be produced in solving this problem will be in the form of a city route that will be traversed by each car along with the amount of demand it carries. The following is a representation of the solution to the VRP problem:

Table 1 Representation of Solutions

Route	11	10	6	13	14	8	1	2	9	15	5	3	4	7	12
Car	1	1	1	1	1	1	2	2	2	1	2	2	2	3	3
Demand	13	14	14	10	14	18	19	19	18	14	12	19	10	14	15

2. Results from the Genetic Algorithm of CVRP and analysis of the results obtained from finding solutions 10 times.

Run	Crossover rate 0.8 Mutation rate 0.1	Crossover rate 0.8 Mutation rate 0.3	Crossover rate 0.6 Mutation rate 0.1	Crossover rate 0.6 Mutation rate 0.3
1	Total distance: 110 Car Route 1: 13-7-12-14-11-15-6 Car Route 2: 1-4-8-9-3-2 Car Route 3: 10-5	Total distance: 85 Car Route 1: 15-14-12-8-7-6 Car Route 2: 5-9-11-13-2-10 Car Route 3: 3-1-4	Total distance: 90 Car Route 1: 2-7-15-14-12-8 Car Route 2: 1-4-6-5-11-10 Car Route 3: 13-9-3	Total distance: 86 Car Route 1: 12-8-6-11-1-15 Car Route 2: 5-1-3-13-9-10-4 Car Route 3: 2-7
2	Total distance: 89 Car Route 1: 15-5-6-3-7-12-13 Car Route 2: 8-1-14-11-9-10 Car Route 3: 4-2	Total distance: 84 Car Route 1: 10-5-9-11-6-7 Car Route 2: 12-8-1-15-3-14-13 Car Route 3: 2-4	Total distance: 78 Car Route 1: 12-3-6-13-7-9-10 Car Route 2: 4-1-8-14-11-5 Car Route 3: 2-15	Total distance: 84 Car Route 1: 7-11-13-15-12-8-10 Car Route 2: 9-4-3-1-14-5 Car Route 3: 2-6
3	Total distance: 92 Car Route 1: 2-8-6-4-14-5 Car Route 2: 3-1-15-9-11-13-7 Car Route 3: 12-10	Total distance: 85 Car Route 1: 5-9-8-4-1-13 Car Route 2: 14-6-3-2-7-11-15 Car Route 3: 12-10	Total distance:93 Car Route 1: 7-10-4-3-9-13-5 Car Route 2: 2-8-1-11-15-6 Car Route 3: 14-12	Total distance: 85 Car Route 1: 10-13-4-1-8-9-3 Car Route 2: 2-6-5-14-11-15 Car Route 3: 12-7
4	Total distance: 89 Car Route 1: 10-4-1-2-3-9	Total distance: 85 Car Route 1: 15-3-6-5-4-1	Total distance: 92 Car Route 1: 12-4-6-8-1-13-3	Total distance: 79 Car Route 1: 15-9-3-5-11-8-13

	Car Route 2: 11-5-6-8-14-15 Car Route 3: 13-7-12	Car Route 2: 13-12-10-9-8-2 Car Route 3: 7-11	Car Route 2: 14-15-5-9-2-7 Car Route 3: 11-10	Car Route 2: 1-2-7-6-14-12 Car Route 3: 10-4
5	Total distance: 93 Car Route 1: 2-1-6-14-12-8 Car Route 2: 15-5-3-9-10-4-13 Car Route 3: 7-11	Total distance: 86 Car Route 1: 2-8-7-9-6-5-11-5-3-1 Car Route 2: 11-14-12-3-1-13 Car Route 3: 10-4	Total distance: 93 Car Route 1: 7-4-9-6-3-2-13 Car Route 2: 10-5-1-8-11-14 Car Route 3: 15-12	Total distance: 82 Car Route 1: 12-8-15-7-11-9 Car Route 2: 6-14-5-3-1-13-4 Car Route 3: 2-10
6	Total distance: 84 Car Route 1: 15-3-1-13-6-4-8 Car Route 2: 10-5-9-11-14-12 Car Route 3: 2-7	Total distance: 79 Car Route 1: 12-6-7-15-13-5-3 Car Route 2: 11-14-1-2-8-9 Car Route 3: 10-4	Total distance: 90 Car Route 1: 2-13-9-11-5-6 Car Route 2: 10-12-8-7-14-15 Car Route 3: 3-1-4	Total distance: 85 Car Route 1: 10-9-2-13-7-11-3 Car Route 2: 4-6-14-15-12-8 Car Route 3: 5-1
7	Total distance: 85 Car Route 1: 10-4-15-14-9-6-3 Car Route 2: 2-8-11-13-7-5 Car Route 3: 5-1	Total distance: 88 Car Route 1: 10-3-13-15-12-8-6 Car Route 2: 5-9-2-7-14-11 Car Route 3: 1-4	Total distance: 96 Car Route 1: 12-9-3-8-5-2 Car Route 2: 1-10-4-7-13-6-11 Car Route 3: 14-15	Total distance: 90 Car Route 1: 2-7-14-15-13-9-3 Car Route 2: 11-10-6-4-1-8 Car Route 3: 5-12
8	Total distance: 81 Car Route 1: 12-6-10-8-9-14 Car Route 2: 3-5-2-13-7-4-15 Car Route 3: 1-11	Total distance: 87 Car Route 1: 5-14-13-7-11-6-4 Car Route 2: 1-8-10-9-2-15 Car Route 3:3-12	Total distance: 87 Car Route 1: 10-8-14-11-12-6-3 Car Route 2: 9-2-7-4-1-13 Car Route 3: 5-15	Total distance: 86 Car Route 1: 15-4-1-14-6-12-3 Car Route 2: 10-9-2-7-11-8 Car Route 3: 13-5
9	Total distance: 86 Car Route 1: 12-14-3-1-13-7-15 Car Route 2: 4-8-10-9-11-5 Car Route 3: 2-6	Total distance:87 Car Route 1: 10-14-3-12-8 Car Route 2: 2-7-9-5-1-13-15 Car Route 3: 4-6-11	Total distance: 83 Car Route 1: 12-5-11-6-14-15-13 Car Route 2: 7-1-4-8-9-3 Car Route 3: 2-10	Total distance: 88 Car Route 1: 15-6-3-9-5-2 Car Route 2: 13-11-14-12-8-7-4 Car Route 3:1-4
10	Total distance: 95 Car Route 1: 7-4-13-11-15 Car Route 2: 9-8-5-6-14-3 Car Route 3: 1-12	Total distance: 89 Car Route 1: 15-14-13-5-3-4-2 Car Route 2: 1-8-7-11-10-9 Car Route 3: 6-12	Total distance: 84 Car Route 1: 13-7-10-15-14-11-5 Car Route 2: 1-2-6-12-8-3 Car Route 3: 9-4	Total distance: 86 Car Route 1: 5-2-9-6-3-13 Car Route 2: 11-15-7-12-8 Car Route 3: 4-1-14
Average total distance	90.5	85.5	88.6	85.1
Standart deviation total distance	8.21	2.76	5.54	3.04
Best value for total distance	81	79	78	79

The solution generated by using the genetic algorithm has the smallest total distance value, which is 78 at a crossover rate of 0.6 and a mutation rate of 0.1. When viewed from the average of each experiment with different mutation or crossover values, the resulting large distance solutions are not much different. The largest average value is in the solution calculation using a crossover value of 0.8 and a mutation value of 0.1.

Comparing the search for solutions using the same crossover values but different mutation values will cause the data distribution to be smaller. In the search for a solution with a crossover rate of 0.8, the standard deviation value gets smaller than the mutation rate. In

this case, the mutation value of 0.3 produces a standard deviation of 2.76 while the mutation value of 0.1 produces a standard deviation of 8.21. By increasing the mutation value, it will reduce the distribution of the data, so that the fitness data from several runs will have a smaller difference in value.