Genetic Algorithms

Question 1

Give an example of combinatorial problem. What is the most difficult in solving these problems?

Question 2

Name and describe the main features of Genetic Algorithms (GA).

Question 3

Consider the problem of finding the shortest route through several cities, such that each city is visited only once and in the end return to the starting city (the Travelling Salesman problem). Suppose that in order to solve this problem we use a genetic algorithm, in which genes represent links between pairs of cities. For example, a link between London and Paris is represented by a single gene '*LP*'. Let also assume that the direction in which we travel is not important, so that *LP* = *PL*.

a) How many genes will be used in a chromosome of each individual if the number of cities is 10?

b) How many genes will be in the alphabet of the algorithm?

$$\frac{n(n-1)}{2}$$

Question 4

Suppose a genetic algorithm uses chromosomes of the form $x = abcdefgh$ with a fixed length of eight genes. Each gene can be any digit between 0 and 9. Let the fitness of individual x be calculated as:

$$f(x) = (a + b) - (c + d) + (e + f) - (g + h)\,,$$

and let the initial population consist of four individuals with the following chromosomes:

$$x_1 = 65413532$$
$$x_2 = 87126601$$

$$x_3 = 23921285$$
$$x_4 = 41852094$$

a) Evaluate the fitness of each individual, showing all your workings, and arrange them in order with the fittest first and the least fit last.

b) Perform the following crossover operations:

i) Cross the fittest two individuals using one–point crossover at the middle point.

ii) Cross the second and third fittest individuals using a two–point crossover (points *b* and *f*).

iii) Cross the first and third fittest individuals (ranked 1st and 3rd) using a uniform crossover.

$$\begin{array}{ll} x_2 = \underline{\mathbf{8}}\,\mathbf{7}\,\mathbf{1}\,\underline{\mathbf{2}}\,\mathbf{6}\,\underline{\mathbf{6}}\,\mathbf{0}\,\mathbf{1} & \\ x_3 = \underline{2}\,3\,9\,\underline{2}\,1\,\underline{2}\,8\,5 & \end{array} \Rightarrow \begin{array}{l} O_5 = 2\,\mathbf{7}\,\mathbf{1}\,2\,\mathbf{6}\,2\,\mathbf{0}\,\mathbf{1} \\ O_6 = \mathbf{8}\,3\,9\,\mathbf{2}\,1\,\mathbf{6}\,8\,5 \end{array}$$

c) Suppose the new population consists of the six offspring individuals received by the crossover operations in the above question. Evaluate the fitness of the new population, showing all your workings. Has the overall fitness improved?

By looking at the fitness function and considering that genes can only be digits between 0 and 9 find the chromosome representing the optimal solution (i.e. with the maximum fitness). Find the value of the maximum fitness.

d) By looking at the initial population of the algorithm can you say whether it will be able to reach the optimal solution without the mutation operator?

Question 5

What two requirements should a problem satisfy in order to be suitable for solving it by a GA?

Question 6

A budget ariline company operates 3 plains and employs 5 cabin crews. Only one crew can operate on any plain on a single day, and each crew cannot work for more than two days in a row. The company uses all planes every day. A Genetic Algorithm is used to work out the best combination of crews on any particular day.

a) Suggest what chromosome could represent an individual in this algorithm?

b) Suggest what could be the alphabet of this algorithm? What is its size?

c) Suggest a fitness function for this problem.

d) How many solutions are in this problem? Is it necessary to use Genetic Algorithms for solving it? What if the company operated more plains and employed more crews?

$$\frac{20!}{10!(20-10)!} = 184,756$$

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