Introduction to Artificial Intelligence

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Exercises, v1

12 Biologically inspired optimization algorithms

1 (T) Constraint satisfaction problems (CSPs) are a subset of state space search problems. **What is characteristic of this type of problems?**

- A They can be solved by the A*-algorithm, but only with an optimistic heuristic and a set of visited states
- B We are guaranteed that the problem's solution exists (but finding it is still a problem)
- C We only really care about the final state
- D The goal predicate works by comparing the solution against a given template (as in the puzzle problem)

2 (T) We are using the genetic algorithm with proportional (roulette wheel) selection. **Which of the following must be fulfilled?**

- A There should be no individuals with negative fitness values
- B Fitness values should be bound to the $[0, 1]$ interval
- C The fitness values across all individuals should add up to 1
- D Binary coding has to be used for chromosome representation

3 (P) We use the genetic algorithm to find the maximum of the function $f(x, y, z)$, using a binary representation of the solution. The value of each of the variables is searched in the interval $[-10, 15]$, and it is necessary to ensure that this search is performed with at least an accuracy of 0.01. **How many bits should the chromosome consists of *minimally*?**

A 34 B 11 C 36 D 33

4 (C) Using genetic algorithm with three-tournament selection, we're searching for the minimum of the function

$$f(x, y, z) = (x - 5)^2 + (y + 2)^2 + (z + 3)^2 + xy$$

We encode every variable with 2 bits. The search region are the integer numbers in the $[0, 3]$ interval for variable x and $[-1, 2]$ interval for variables y and z. The chromosome encodes the bits of x, y, and z, in that order. In one step of the algorithm, the following three chromosomes get selected:

$$K1 = \texttt{000101}, K2 = \texttt{001011}, K3 = \texttt{100001}$$

The fitness function is the negated f function, i.e., the fitness of (x, y, z) equals $-f(x, y, z)$. A one-point crossover at the half-split point is used. **Determine the fitness of the child chromosome to be returned to the population.** Assume that mutation always alters the last choromosome bit (the right-most one). If crossover produces more than a single child, the one with the best fitness will be returned to the population.

A -30 B -25 C -17 D -19

5 (C) We use the ant colony algorithm to find a cycle in a graf. The following is given: $\tau_{1,2} = \frac{1}{\sqrt{3}}$, $\tau_{1,4} = 2$, $\tau_{1,6} = 0.5$, $\tau_{2,4} = \frac{1}{2}$, $\tau_{2,5} = \frac{1}{3}$, $\tau_{2,7} = 2$, $\tau_{3,5} = 1$, $\tau_{3,6} = 3$, $\tau_{3,7} = 10$, $\tau_{4,6} = 0.5$, $\tau_{5,7} = \sqrt{3}$, $\tau_{6,7} = 10\sqrt{2}$, $\eta_{1,2} = 3$, $\eta_{1,4} = \frac{1}{\sqrt{2}}$, $\eta_{1,6} = 2$, $\eta_{2,4} = 2\sqrt{2}$, $\eta_{2,5} = 3\sqrt{3}$, $\eta_{2,7} = 0.5$, $\eta_{3,5} = \sqrt{2}$, $\eta_{3,6} = 3\sqrt{3}$, $\eta_{3,7} = \frac{1}{2\sqrt{5}}$, $\eta_{4,6} = 0.5, \eta_{5,7} = 1$, $\eta_{6,7} = 0.1$. Also, all values are symmetric, i.e., $\tau_{i,j} = \tau_{j,i}$ and $\eta_{i,j} = \eta_{j,i}$. Additionally, $\alpha = 2$ and $\beta = 2$. The first ant starts out from node 1. When an ant needs to make a probabilistic decision, assume that the outcome of the random selection will match the most likely outcome. If the ant cannot go further from a node, the construction of the cycle is terminated. With these assumptions, determine the cycle that this ant will construct. **Which three-node sequence is part of this cycle?**

A 6, 4, 1 B The ant won't be able to constuct a cycle C 2, 7, 5 D 5, 3, 6

6 (P) Consider the Ant System algorithm. If we set τ_0 to a value that is much smaller than the quantity of the pheromone trails deposited by a single ant, **what is going to happen?**

A The algorithm will explore random paths for quite some time, before the ants focus on some of the paths

B The algorithm will quickly converge to a global optimum

C The algorithm will lose its ability to explore good solutions

D Pheromone evaporation will be too large

7 (P) We are solving the ant colony algorithm to solve the traveling salesperson problem over a set of Croatian cities. The following parameters are known for the algorithm: $\tau_0 = 100$, $\alpha = 2$, $\beta = 3$, $\rho = 0.1$, the colony consists of 100 ants and the updating in each epoch is performed only by the ant that found the best solution in that epoch. Consider the edge that connects the cities of Zagreb and Dubrovnik. Suppose that in no epoch these two cities are successors in the path found by the algorithm. **After how many epochs of the algorithm will the amount of the pheromone traces on that edge drop below 1?**

A 44 B 21 C 2 D 53