# 5. Exercise Sheet

## Exercise 1 Evolutionary Algorithms - Definition and Example

a) Describe and sketch the basic structure of an evolutionary algorithm (EA).

b) How can we solve an instance of the Knapsack Problem (see description below) using an EA. Define suitable representation, fitness function, and genetic operators.

The **knapsack problem** is a problem in combinatorial optimization: Given a set of items, each with a weight and a value, determine the number of each item to include in a collection so that the total weight is less than or equal to a given limit and the total value is as large as possible. It derives its name from the problem faced by someone who is constrained by a fixed-size knapsack and must fill it with the most valuable items. — *Wikipedia, 06.06.2018*

## Exercise 2 Genetic Representation and Genetic Operators

In the lecture we described different encodings for the representation of a solution for the 8-Queens problem, namely

- Binary matrix with up to 64 queens
- Position vector with 8 entries
- Binary matrix with exactly 8 queens
- Integer vector, 1 Queen per row
- Permutation, 1 Queen per row and column

Provide a suitable cross-over and mutation operator for each of them. How does your operator (visually) effect the board state?

**Please note the second and third page of this exercise sheet.**

## Exercise 3 Roulette Wheel Selection

a) Given the fitness distribution in the table below, determine the probability that an individual will be chosen using roulette wheel selection

| Individual | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Fitness | 60 | 250 | 320 | 140 | 80 | 150 | 20 |

b) Determine the probability that an individual with fitness $p$ was chosen $k$ times to be put into the mating pool.

c) How does the probability change if the same individual is included multiple times in the current population.

d) How do we need to adapt the fitness calculation if the fitness of individuals should be minimized.

**Note:** Using Roulette Wheel Selection we assign a probability to each individual and repeatedly sample an individual from the population with replacement.

## Exercise 4 Tournament Selection

a) What is the probability of the best individual to get into the mating pool in case we have a population and mating pool size of 10 and a tournament size of 4.

b) How does the probability change if we change the tournament size to 6. How does it change in general?

c) What is the expected number of copies of the best individual in the mating pool?

d) What is the probability of the worst individual to get into the mating pool?

**Note:** In a single tournament an individual can only participate once, therefore, we choose a sample without replacement of the population to participate in the tournament:

**Please note the third page of this exercise sheet.**

## Exercise 5 Evolutionary Algorithms - Application

After we discussed all the components of an EA in detail want to apply if to solve game related problems. In the video:

`https://www.youtube.com/watch?v=0MFQWEhOTOc`

we can see that an agent was trained to play a fixed level of Super Mario Bros.

a) Describe the necessary components of an evolutionary algorithm such that it should be able to create an agent that is (theoretically) capable of playing Super Mario Bros.

b) Find an appropriate fitness function and representation of the agent.

c) Which genetic operators can we apply. How do they change the behaviour of the agent.

**Hint:** You can define sensors to the game environment. A small if-bot which is reacting to its surroundings of the agent should be able to solve this problem.

**Hint 2:** In case you cannot come up with your own concept prepare a short presentation on the NEAT algorithm, which was already used to solve this problem. A good starting point might be to watch the following video: `https://youtu.be/qv6UVOQ0F44`. However, we would like to compare and discuss different concepts in the exercise. So try to think of a solution on your own.