OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

INF FAKULTÄT FÜR INFORMATIK

Institut für Intelligente Kooperierende Systeme

Magdeburg, 26th July 2019

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Exam for the course: Computational Intelligence in Games (SS 2019)

Last Name:	First Name:
Matriculation number:	Student Signature:

1. Please prepare to show us your student ID while writing the exam.
2. Please fill in *Last Name*, *First Name* and *Matr.-No.* legibly.
3. The exam consists of **6 Assignments**, and has **11 pages + 1 Extra page**. Please check whether your exam is complete before starting.
4. You are allowed to use an additional sheet brought by you as long as it is A4.
5. Unreadable solutions or solutions written with pencil may be excluded from evaluation. Please use only blue or black pens.
6. The duration of the exam is **120 minutes**.

Assignment:	1	2	3	4	5	6	sum
points							60

Assignment 1 **Expected Payoff** **(2 + 2 + 5 = 9 Points)**

You (X) want to choose an activity for the weekend. Possible options are going to the cinema (C) or going to the zoo (Z). It is even more fun if you go there with your best friend (Y). However, Y does not respond to your messages, so you need to decide on your own.

We assume that the expected payoff matrix is:

$$\begin{array}{cc} & \begin{array}{cc} \mathrm{Y(C)} & \mathrm{Y(Z)} \end{array} \\ \begin{array}{c} \mathrm{X(C)} \\ \mathrm{X(Z)} \end{array} & \begin{bmatrix} 3 & 1 \\ 2 & 5 \end{bmatrix} \end{array}$$

a) You throw a coin to decide where to go this weekend. What is your expected payoff, in case it is known that your friend will always go to the cinema.

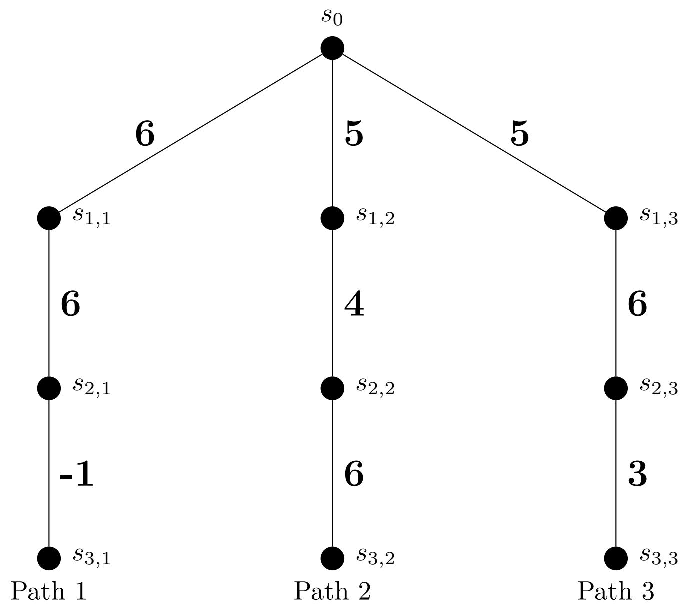
b) We further assume that your friend really likes to go to the cinema, but sometimes he is going to the zoo instead. Based on this you estimate that it is about three times as likely to meet him at the cinema than meeting him at the zoo. What is your expected payoff if you still choose your option by throwing a coin?

c) You and your friend seem to be very unlucky in meeting each other. It seems to be the case that no matter which mixed strategy you choose, your friend always chooses the exact opposite strategy.

   Let us assume you choose to play the mixed strategy $(x, 1-x)$ and your friend plays the mixed strategy $(1-x, x)$. What is the optimal value for x, if you want to maximize your expected payoff?

Assignment 2 Discounted Return $(4 + 6 = 10$ Points)

Consider the following three paths generated by the Rolling Horizon Evolutionary Algorithm (RHEA). The number on each edge denotes the reward from transitioning between the two states it connects (e.g. reward from s_0 to $s_{1,1}$ is 6).



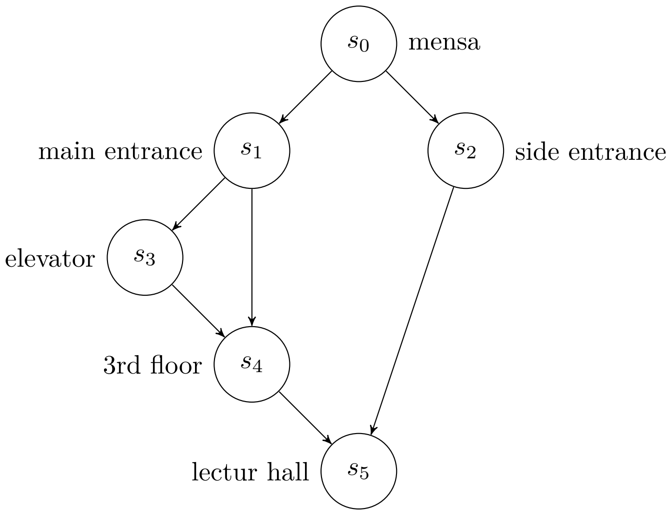
a) Calculate the non-discounted and the discounted return for $\gamma = 0.5$.

Path	Undiscounted Return	Discounted Return
Path 1		
Path 2		
Path 3		

b) Compute the range of γ for which the agent will pick path 3. Note: Path 3 will be picked in case the discounted return of path 3 is larger than the discounted return of path 1 and of path 2.

Assignment 3 Reinforcement Learning (8 + 3 + 3 = 14 Points)

Suppose the following scenario in which you want to find the **fastest** path from the Mensa to G29/307. Multiple paths lead to the lecture hall. You always start at the Mensa s_0. From there you can go through the main entrance s_1 or the side entrance s_2. At the main entrance you can either use the stairs to go to the 3rd floor s_4 or first wait for the elevator s_3 which will also bring you to the 3rd floor s_4. From there it is only a short walk to the lecture hall s_5. For simplicity, we assume that the stairs at the side entrance directly bring you to the lecture hall.



We use the walking time as reward and the remaining time till you arrive at the lecture hall as your return function. Let the base estimate of $V(s_i)$ be:

$$V(s_0) = 10, \quad V(s_1) = 7, \quad V(s_2) = 4, \quad V(s_3) = 3, \quad V(s_4) = 1, \quad V(s_5) = 0$$

a) Use the Monte Carlo Method to update the value estimate for each of the following episodes.

- Starting at the Mensa you decide to take the side entrance. After 3 minutes, you arrived at the side entrance. At the first floor you quickly look at the examination plan, but get distracted in a discussion with other students. After 8 minutes, you arrive at the lecture hall. The total walking time was 11 minutes.
- Today you feel lazy so you want to take the elevator. After 5 minutes, you arrive at the main entrance and you need to wait another 2 minutes for the elevator to arrive. In just 1 minute it brings you upstairs and you need 2 minutes to get from the 3rd floor to the lecture hall. The total walking time was 10 minutes.
- After eating lunch you are a bit late for the exam. At 12:57 you start running from the Mensa to the main entrance. After a minute you arrive and decide to take the stairs. In just 1 minute you get to the 3rd floor, but since you are exhausted it takes 1 minute to arrive at the lecture hall. You arrive in time for the exam. The total walking time was 3 minutes.

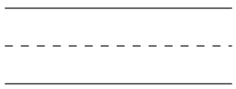
b) Shortly explain the differences between Dynamic Programming, Temporal Difference Learning, and Monte Carlo method in terms of the width and height of their backup-diagrams.

c) Shortly describe the general effect of the parameter α in the constant-α Monte Carlo method. Also describe the two special cases in which we set $\alpha = 0$ or $\alpha = 1$?

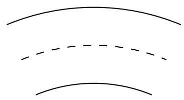
Assignment 4 EA / Procedural Content Generation ($7 + 2 = 9$ Points)

Suppose you want to develop a racetrack generator for a racing game. Your designers presented you six tiles you may use as building blocks.

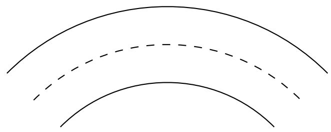
radius 2.5
curvature 0



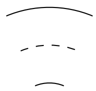
radius 2.5
curvature 45



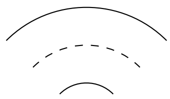
radius 2.5
curvature 90



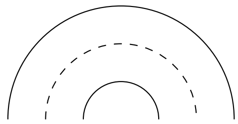
radius 1
curvature 45



radius 1
curvature 90



radius 1
curvature 180



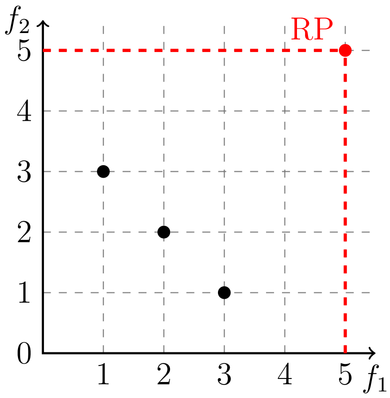
a) Describe all necessary building blocks of an evolutionary algorithm capable of generating racetracks that do not need to loop. Note that the curvature needs to stay in the range of $[0, 180]$ to avoid sharp angles and the radius should stay in the range of $[0.5, 5]$.

b) Explain in a few sentences how we could make use of game-playing agents to measure the difficulty of such a generated racetrack?

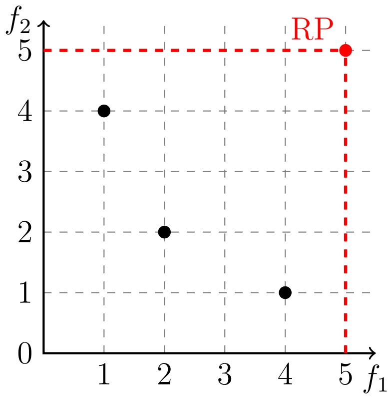
Assignment 5 Multi-Objective Optimization (4 + 3 + 2 = 9 Points)

In this task we compare the result of three different multi-objective optimization algorithms for minimization. Each solution represents the reported Pareto-Front of the algorithm. We further compute the Hypervolume in regard of the Reference Point (RP) at $(5, 5)$.

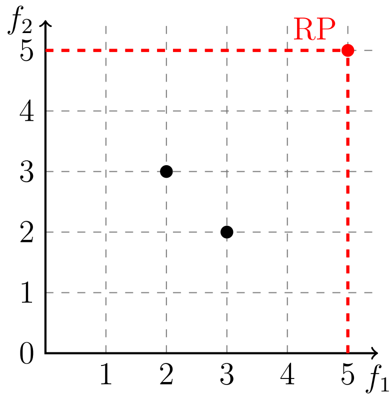
Set of Solutions A



Set of Solutions B



Set of Solutions C



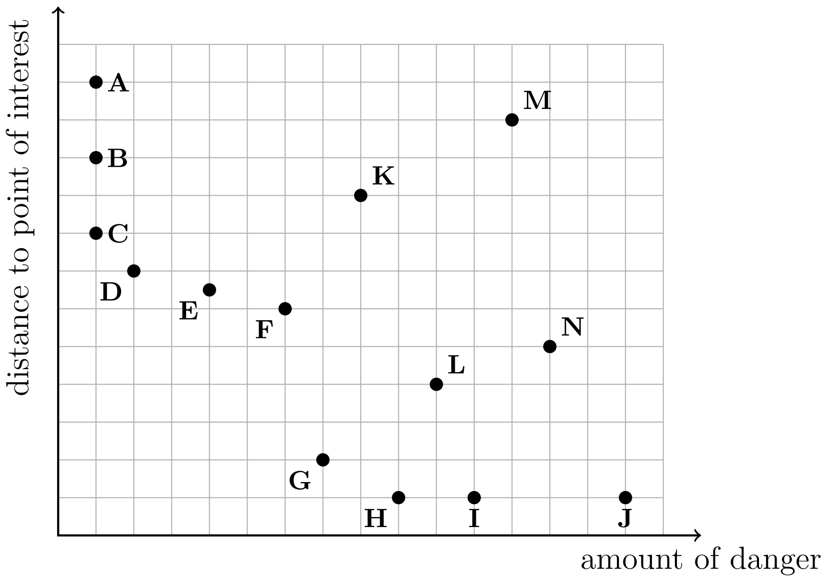
a) Describe the difference between Convergence and Diversity in the output of a multi-objective optimization algorithm. Compare the output of all three presented solutions in terms of convergence and diversity.

b) Indicate the Hypervolume of each solution in their respective plots and compute its value.

c) We previously discussed how the position of the Reference Point (RP) can increase or decrease the Hypervolume of a solution. Can we find a position such that the set of solutions C has a larger Hypervolume than the set of solutions A?
Shortly explain your answer.

Assignment 6 Multi-Objective Learning $(2 + 2 + 2 + 3 = 9$ Points)

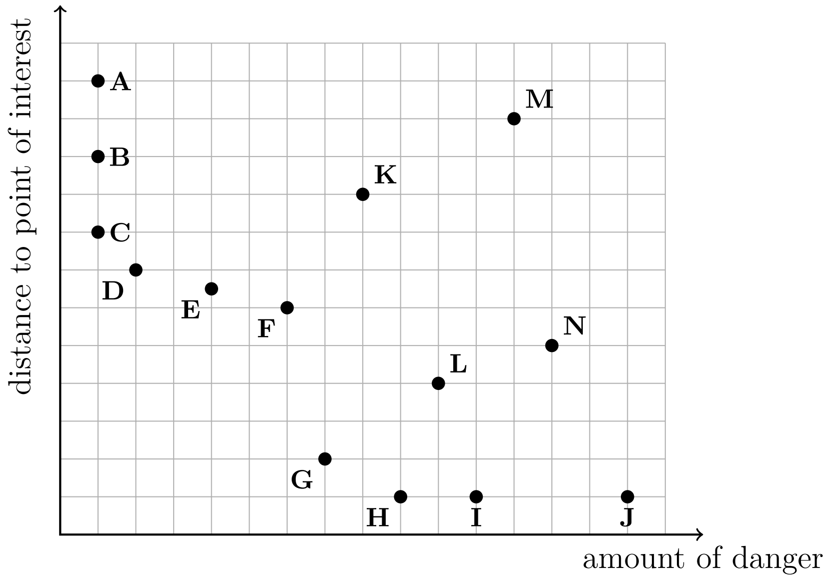
Consider the following "steering" scenario:
The agent has to find the direction with the shortest distance to the point of interest and with minimal amount of danger. The following objective plot shows the actions A to N with different values for "amount of danger" and "distance to the point of interest" both of which have to be **minimized**. Actions H, I, and, J have the same distance to the point of interest. Actions A, B, and, C have the same value for the amount of danger.



a) Indicate the set of non-dominated actions on the objective plot.

b) Suppose that an agent has to select one action using the weighted sum approach with weight vector $(0.5, 0.5)$. Which solution(s) will be selected?

c) Describe a method to detect knee-points. Mark the knee action points on the plot based on your described method.



d) Which solutions of the Pareto-front cannot be detected using the weighted sum approach? Why is this the case and which alternative selection method can be used in case we want to select these points? **Provide an example.**

Extra Page