Artificial Intelligence
Tutorial 4 on Reinforcement Learning
TCS & BIT only

Introduction

The following multiple choice questions are examples of typical questions one can expect on the AI exam. The questions on the AI exam are also multiple choice, but for this tutorial one has to explain the answers given. Moreover there are also some open questions.
After the tutorial the answers to the MC will be available on BB.

Questions on Reinforcement Learning.

1. Consider the following 4x3 environment with reward function as described in the caption.

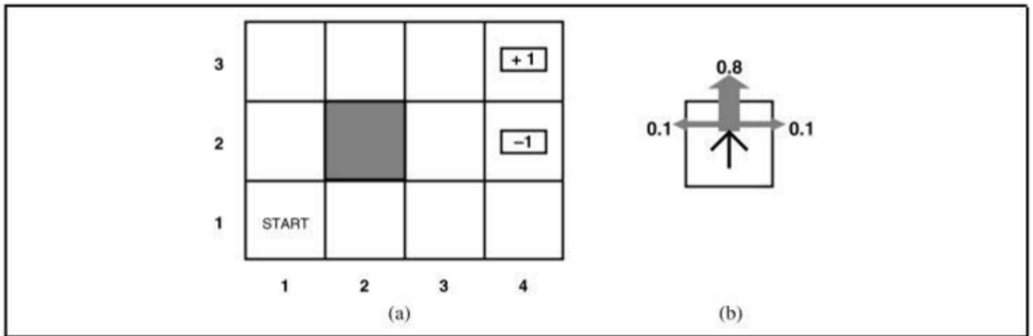


Figure 1 (a) A simple 4×3 environment that presents the agent with a sequential decision problem. (b) Illustration of the transition model of the environment: the "intended" outcome occurs with probability 0.8, but with probability 0.2 the agent moves at right angles to the intended direction. A collision with a wall results in no movement. The two terminal states have reward +1 and –1, respectively, and all other states have a reward of –0.04.

Assume that the agent applies the Bellman update

$$U_{i+1}(s) \ \leftarrow \ R(s) + \gamma \mathbf{max}_a \sum_{s'} \ P(s' \mid s, a) U_i(s')$$

with $\gamma = 1$ and initial values for U equal to 0 except for (4,2) and (4,3), for which the values are as given: -1 and +1 respectively. What will be the values for U after:

(a) One complete update over all states?

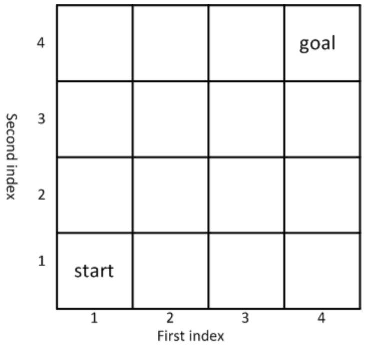
(b) Two complete updates over all states?
(c) Three complete updates over all states?

2. Consider the RL situation with a state space consisting of s states and each state the agent can do a actions. How many policies π are there for this RL problem?
   (a) a^s
   (b) s^a
   (c) $s \times a$
   (d) $s + a$

3. Consider the following statements:
   (i) In order to apply the value iteration algorithm (Bellman update) the agent must know the reward function R and the successor state (transition) function δ.
   (ii) In order to apply Q-learning the agent must know the successor state function δ but does not need to know the reward function R.

   Which of the following claims is true?
   (a) Only statement (ii) is true
   (b) Only statement (i) is true
   (c) Both statements (i) and (ii) are false.
   (d) Both statements (i) and (ii) are true.

4. Consider a grid of 4×4 with start state in the corner left down and goal state right up.



Assume that the agent can move in four directions *up, down, left, right.* If it bounces to a wall it will stay in the same cell. Moreover the agent cannot leave the goal state, i.e. no action can be executed in the goal state or only a null action (do nothing) with reward 0 can be executed. Assume that every state has a reward of 0 except except for the goal state, which as a reward of 10.

Assume that the agent applies the following value iteration algorithm.

```
1 Initialize $U_{old}$ to 0.
2 Repeat
3         For all $s \in S$
4                 $U_{new}(s) = max_a[R(s) + \gamma U_{old}(\delta(s, a))]$
5         End (for all)
6         $U_{old} = U_{new}$
7 Until change in $U_{new}$ is below threshold
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Assume that the value for discount factor γ is 0.8. What will after two iterations of the "Repeat" loop (statements [2] – [7]) be the value of $U_{new}(s)$ for $s = (3, 3)$?

(a) 0

(b) 8

(c) 10

(d) None of the above

5. Consider the following grid world and the given learned values for utility function. The optimal policy (given this utility function) for the top row middle square is moving right (see arrow). This action has a probability of 0.80 of success, and a probability of 0.15 moving down and 0.05 probability of moving left.

0.73	$\rightarrow$	0.89
	0.83	

   What is the utility value of the top middle square given that a move costs 0.1? Discount factor is 1.

6. Consider an agent which lives in a deterministic environment and uses it's learned state value function U for it's policy to select the next action. Assume that an agent is in state s_0 with value $U(s_0) = 3.0$. The possible actions, next states, corresponding reward and value function are given by:

action a	state $\delta(s, a)$	reward $R(s)$	$U(\delta(s, a))$
a_1	s_1	-1	5.0
a_2	s_2	-1	4.0
a_3	s_3	-1	2.0

   Assume that the discount factor is 0.8, what will be the action executed by the agent and what will be the new value $U(s_0)$ if the agent applies Temporal Difference Learning with learning rate 0.5?

   (a) action a_1 and new $U(s_0) = 4.0$
   (b) action a_2 and new $U(s_0) = 2.6$
   (c) action a_3 and new $U(s_0) = 3.3$
   (d) action a_1 and new $U(s_0) = 3.0$