Exam Artificial Intelligence for Module 6 (201700269)
Bachelor TCS and BIT.
January 30 2018, 8:45-11:45

Name and student number

Name: ____

Student number: ______________________________________

Introduction

This exam is closed book, you may only use a simple calculator (addition, substraction, multiplication, division and exponentiation).
This examination consists multiple-choice questions, for which you have 3 hours. At the end of the exam you must hand in this question paper and the answer form.
Tips:

- Read each question carefully keeping the possible answers covered.
- Try to answer the question yourself, before you look at the answers you are given to choose from. Make a note of your first thoughts and calculations on a scribbling-paper (kladpapier).
- Beware of double negations (negatives) as these can be confusing.
- Do not stay on any one question too long. If you do not know the answer and have spent more than 10 minutes on the question, move on to the next question and come back to this one later.
- If you have any time over at the end, check your answers.
- Fill in your answers on this question form first and transfer them to the answer form at the end.
- At the last page of this exam you can find a table with values for $-p\log_2(p)$ and the `Logistic` or `sigmoid` function.

Good luck!

Multiple-choice questions

Questions about AI in general and Intelligent Agents

1. Which of the following agent architectures does **not** contain an internal world model?

   (a) Model-based reflex agent
   (b) Utility-based agent
   (c) Simple reflex agent *
   (d) Goal-based agent

2. Consider the following statements about search:

   (i) Search is applicable (the found solution is optimal also when executing the action sequence) in a deterministic, static and fully observable environment.

   (ii) Search is applicable (the found solution is optimal also when executing the action sequence) in a non-deterministic, static and fully observable environment.

   Which of the above statements are true?

   (a) Both statements (i) and (ii) are false.
   (b) Only statement (i) is true. *
   (c) Only statement (ii) is true.
   (d) Both statements (i) and (ii) are true.

3. Consider an A* search algorithm for which $g(n) = 0$. To which of the following search algorithms is this kind of A^* search algorithm equivalent (meaning an equal search strategy)?

   (a) Greedy best-first search *
   (b) Depth-First Search
   (c) Breadth-First Search
   (d) None of the above.

4. Underlying each search problem is a *search graph* in which the states are the vertices of the search graph and the edges (connections) are determined by the possible actions; there is an edge from s to s' with label a in the search graph, if and only if there is an action a which leads from state s to state s'. These two conditions together completely define the *search graph*. A cycle in the search graph is a vertex (state) s and a non-empty sequence of actions as such that if we start in s and execute the sequence of actions as then we will end up in s again. Consider the following statements about search problems and graphs:

   (i) If the **Depth First Search Tree Algorithm** does not terminate on a given search problem then the corresponding search graph is infinite or contains cycles.

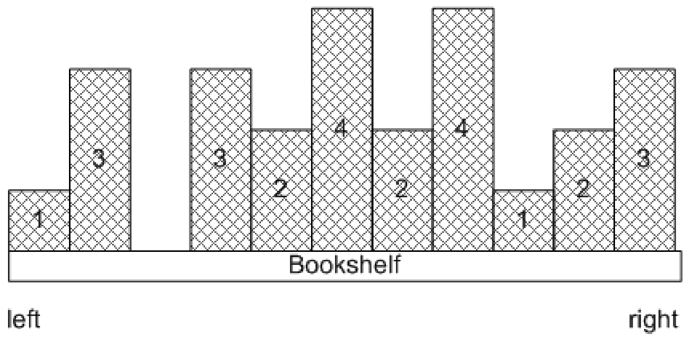
   (ii) If the corresponding search graph is infinite or contains cycles then the **Depth First Search Graph Algorithm** still terminates always on the corresponding search problem.

   Which of the following claims is true?

   (a) Both statements (i) and (ii) are false.
   (b) Only statement (i) is true. *
   (c) Both statements (i) and (ii) are true.
   (d) Only statement (ii) is true.

Questions about search and problem solving

5. Consider the problem of arranging books on a bookshelf using minimal energy in such a way that the books are ordered from left to right in increasing weight. The empty place(s) should at the far right. A possible configuration of such a problem is depicted below. The numbers indicate the weights of the books.



The legal moves are:

- Moving a book to an adjacent free space. Energy cost: the weight of the book
- Moving a book over exactly 1 book to the free space. Energy cost: also the weight of the book.

A corresponding heuristic "cost to go" function $h(n)$ is defined as follows. A book is called "misplaced" of there is a lighter book somewhere to the right (not only directly to the right). Now $h(n)$ is the sum of weights of the misplaced books in the state (configuration) corresponding to node n. What is the h value for the node n corresponding to configuration above?

(a) 18 *

(b) 16

(c) 14

(d) 12

6. Assume that A* search is applied to the above problem. The start state is the node to configuration above. A bookshelf configuration can be coded as a sequence of numbers in which the number codes the weight of the book and the place in the sequence codes the place on the bookshelf. The empty place is coded by the number 0. For instance the configuration above can be coded as $[1, 3, 0, 3, 2, 4, 2, 4, 1, 2, 3]$. After expanding the start node (node corresponding to the initial configuration) there are 4 nodes in the *frontier* queue. Consider the following two statements:

   (I): The node corresponding to the state $[0, 3, 1, 3, 2, 4, 2, 4, 1, 2, 3]$ is the head of the *frontier* (first node to be removed).

   (II): The order in which the nodes corresponding to the states $[1, 0, 3, 3, 2, 4, 2, 4, 1, 2, 3]$ and $[1, 3, 3, 0, 2, 4, 2, 4, 1, 2, 3]$ respectively are removed from the *frontier* queue depends in the implementation of the A* search algorithm.

   (a) Both statements are true. *

   (b) Both statements are false.

   (c) Only (I) is true.

   (d) Only (II) is true.

7. Once again consider the above search problem, the "cost to go" function h and the following statements about h:

   (i) h is admissible.

   (ii) h is consistent.

   Which of the above statements are true?

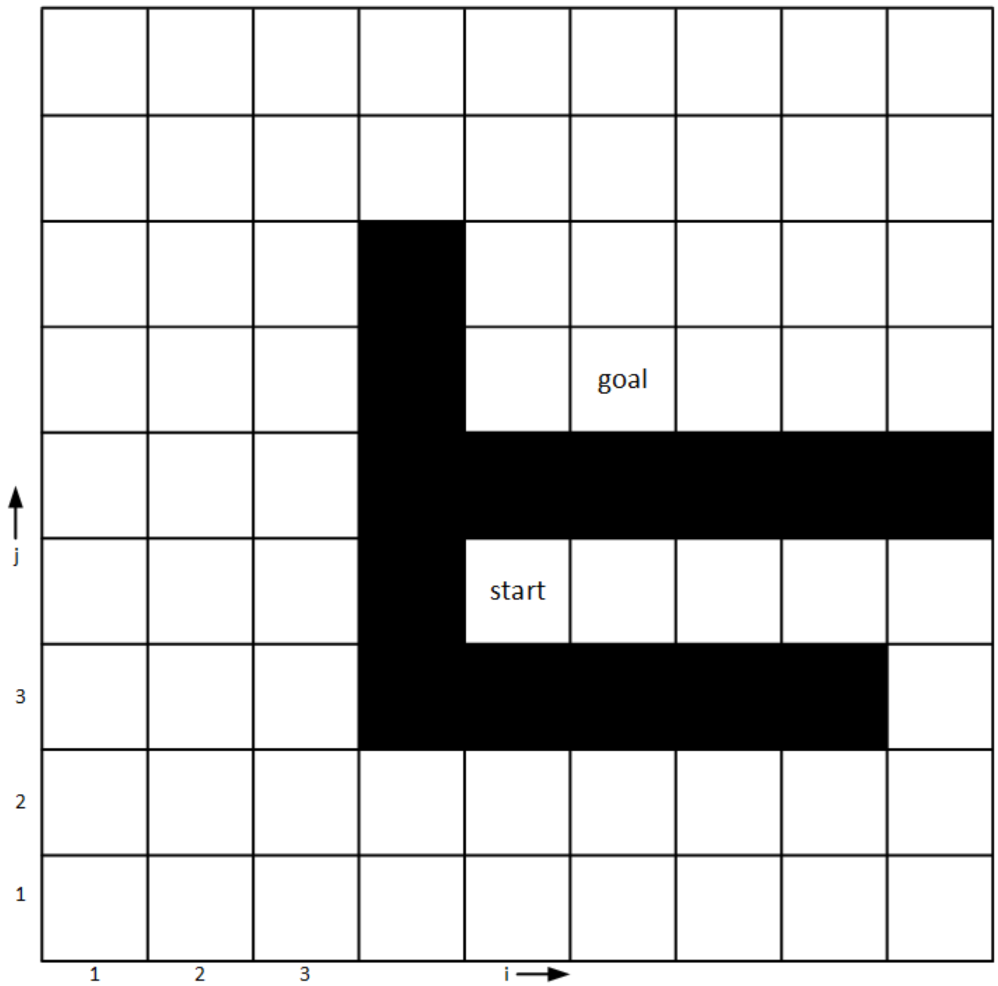
   (a) Only statement (i) is true.

   (b) Both statements (i) and (ii) are true.

   (c) Only statement (ii) is true.

   (d) Both statements (i) and (ii) are false. *

8. Consider the following path finding problem in which an agent wants to go from the start cell $(5, 4)$ to the goal cell $(6, 6)$. The agent can only make the following moves: *one cell up, down, left or right* and each move has a cost of 1. The black cells form a barrier which the agent cannot pass. Assume the agent applies **Greedy Graph Search** with heuristic function h the Manhattan distance.



Which of the following nodes will **eventually** be in the list of open nodes, called *frontier* and will also be expanded (removed from this list)?

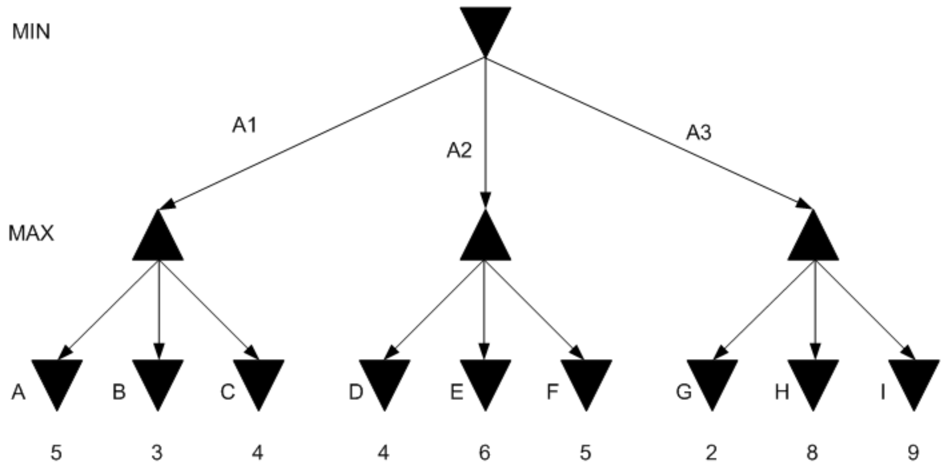
(a) node corresponding to cell (state) $(2, 6)$. *

(b) node corresponding to cell (state) $(2, 2)$.

(c) node corresponding to cell (state) $(4, 9)$.

(d) None of the above.

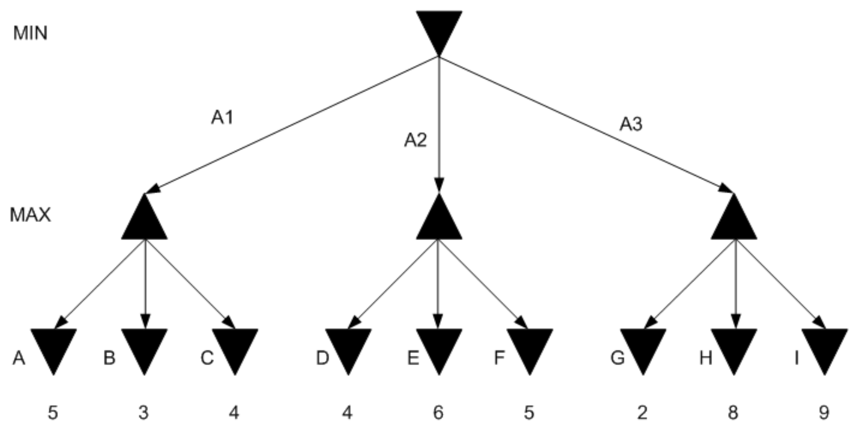
9. Consider the following part of a two-player game tree.



What will be the value of the top MIN node

(a) 2
(b) 3
(c) 4
(d) 5 *

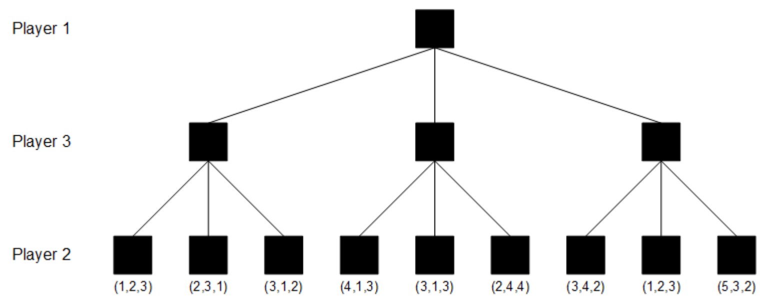
10. Once again consider the above two-player game tree



If one does not apply alpha-beta pruning then the values for lower level nodes are given. Now assume that one applies alpha-beta pruning, for which of the following collection of nodes will **all** nodes being explored?

(a) $\{D, E, F\}$
(b) $\{A, F, G\}$
(c) $\{G, H, I\}$
(d) None of the above.*

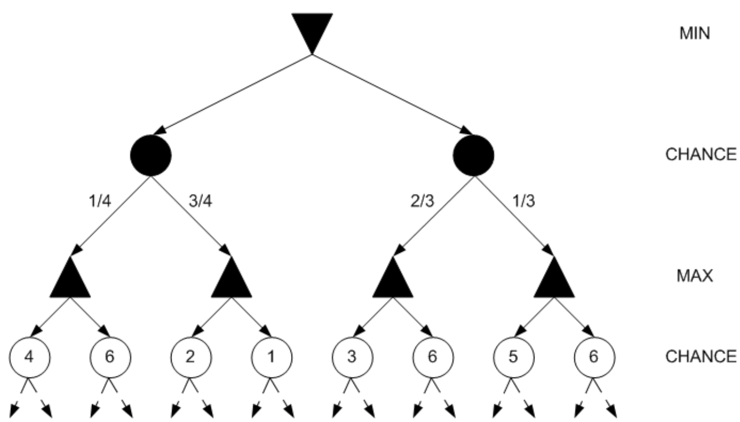
11. Consider the following game tree for three players, player 1, 2 and 3.



At the lowest nodes the evaluation value of the relevant node is given (the value of the evaluation function) for each of the players. In the i position the evaluation value of the node for player i is given, $i = 1, 2, 3$. What is the value of the top node?

(a) $(5, 3, 2)$
(b) $(4, 1, 3)$
(c) $(2, 4, 4)$ *
(d) None of the above.

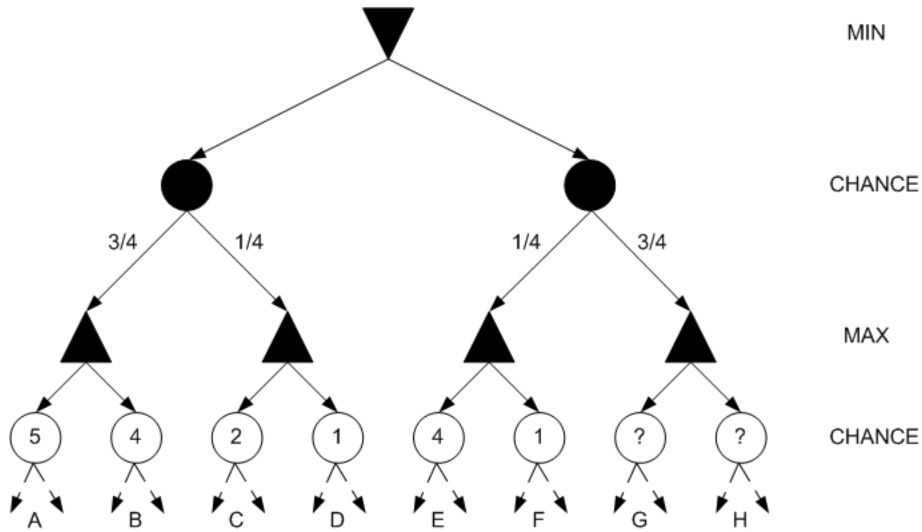
12. Consider the following two-player game tree in which the game has an element of chance, which is shown by the so-called probability nodes in the game tree.



What is the correct value for the top MIN-node if one applies the expectiminimax algorithm?

(a) 1
(b) 2
(c) 3 *
(d) 4

13. Consider the following game tree with an element of chance.



The letters under the bottom row of chance nodes are labels for the nodes just above the letter. One can also apply $\alpha - \beta$ pruning on this game tree. The numbers inside the chance nodes on the bottom row are the computed values of these chance nodes; ? indicates not computed yet. Which of the following statements is true?

(a) $\alpha - \beta$ pruning will **always** expand node H.

(b) $\alpha - \beta$ pruning will **never** expand node H.

(c) For all values of node G which are less than 1 $\alpha - \beta$ pruning will expand node H. *

(d) For all values of node G which are less than 5 $\alpha - \beta$ pruning will expand node H.

Questions about Propositional Logic

14. Given is the following sentence:

    $$[(R \vee S) \wedge \neg T] \Rightarrow (P \Rightarrow R)$$

    How many models does the sentence have?

    (a) 13
    (b) 14
    (c) 15 *
    (d) 16

15. A knowledge base *KB* contains the following statements:

    - $R \Rightarrow (\neg A \wedge T)$
    - $B \vee \neg S$

    The question is whether we can prove $A \Rightarrow B$ from *KB*. Which of the following answers is correct?

    (a) Yes, the conclusion follows.
    (b) No, the conclusion does not follow, but if you add the premiss $T \vee A$ to *KB* the conclusion can be derived.
    (c) No, the conclusion does not follow, but if you add the premiss $A \wedge \neg B$ to *KB* the conclusion can be derived.
    (d) No, the conclusion does not follow, but if you add the premiss $R \vee S$ to *KB* the conclusion can be derived. *

16. Which formula do we obtain when we transform the formula

    $$(W \Rightarrow R) \vee (Q \wedge R)$$

    into conjunctive normal form?

    (a) $(\neg W \vee R \vee Q) \wedge (\neg W \vee R)$ *
    (b) $(\neg W \vee R) \vee (Q \wedge R)$
    (c) $(W \vee R \vee Q) \wedge (W \vee R)$
    (d) None of the above

Questions about Predicate Logic

17. In a Dutch village there is a street that has exactly five houses numbered 1 through 5 that are next to each other. Carol, who lives on number 2, has one bike, a Batavus . When asked about the bikes of the other people in the street, she answers with the following sentence in first-order logic:

$$\forall x, y, z, w, b\ N(x, y) \wedge H(x, z) \wedge H(y, w) \wedge B(z, b) \Rightarrow B(w, b)$$

and she explains the meaning of the predicates as follows:

- $N(x, y)$: x and y are neighbours.
- $H(x, y)$: x has a bike y.
- $B(x, y)$: the brand of x is y.

Of the following four statements, one constitutes a contradiction with what Carol says while the other three do not. Which statement generates the contradiction?

(a) John, who lives on number 5, has a Batavus.

(b) Mary, who lives on number 3, has a Batavus and a Gazelle. *

(c) Alice, who lives on number 1, has no bike.

(d) Bob, who lives on number 4, has two bikes, both Batavus.

18. We want to formalise the sentence "No student who attends the Artificial Intelligence course is stupid" in first-order logic. Given are the following predicates:

- $S(x)$: x is a student.
- $A(x, y)$: x attends course y.
- $D(x)$: x is stupid.

We further introduce a term constant, AI, that stands for the Artificial Intelligence course. We are given two different formalisations:

I. $\forall x\ S(x) \wedge A(x,\ AI) \Rightarrow \neg D(x)$
II. $\exists x\ \neg\,(S(x) \wedge A(x,\ AI) \wedge D(x))$

Which of the following assertions is correct?

(a) Formalisation I is correct while formalisation II is incorrect. *

(b) Formalisation I is incorrect while formalisation II is correct.

(c) The two formalisations are inferentially equivalent and they are both correct.

(d) The two formalisations are inferentially equivalent and they are both incorrect.

19. We want to Skolemise the following sentence in first-order logic:

$$\forall x, y, z\ \exists w\ P(x, y) \wedge Q(w, z) \Rightarrow (R(x, z) \wedge S(z, w, x))$$

Of the following four substitutions, only one produces a correct Skolemisation. Which one?

(a) $\{w/S(x)\}$

(b) $\{w/S(x, y)\}$

(c) $\{w/S(x, z)\}$ *

(d) $\{w/S(x, y, z)\}$

Questions about Reasoning under Uncertainty

20. A full joint distribution for the *Toothache, Cavity, Catch World* is given by the table below, copied from Figure 13.3 in the book of Russel and Norvig.

	toothache		¬ toothache	
	catch	¬catch	catch	¬catch
cavity	0.108	0.012	0.072	0.008
¬cavity	0.016	0.064	0.144	0.576

What is the value of $P(catch|\neg cavity)$?

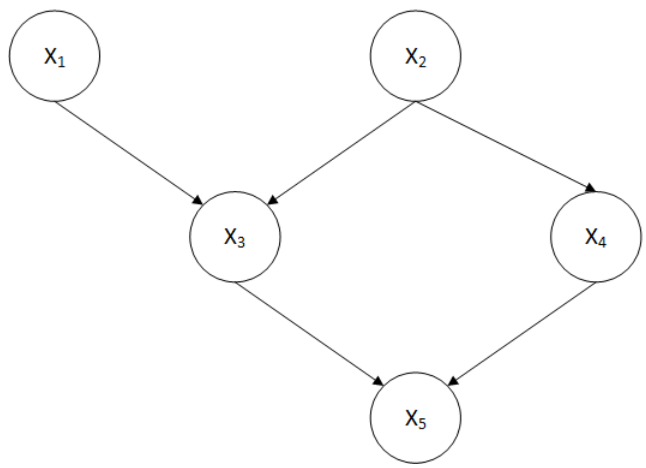
(a) 0.016

(b) 0.160

(c) 0.144

(d) 0.200 *

21. Given the Bayesian network shown below.



Only one of the following statements is true, which one?

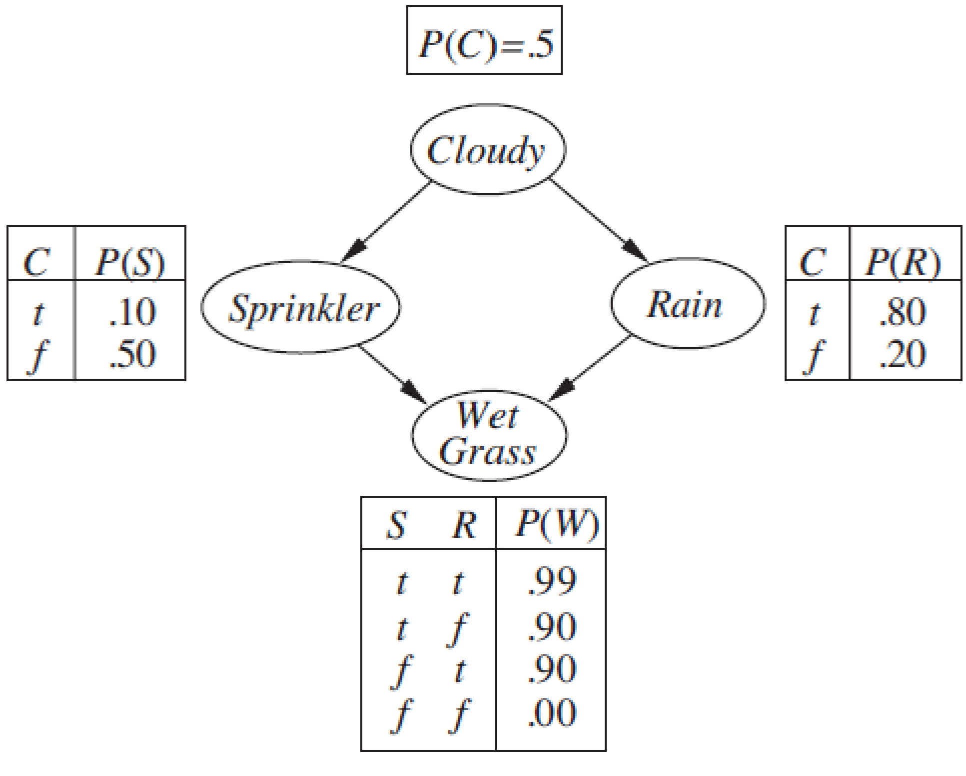
(a) X_3 and X_4 are independent.

(b) X_3 and X_4 are independent given X_2. *

(c) X_3 and X_4 are independent given X_2 and X_5.

(d) X_3 and X_4 are independent given X_1, X_2 and X_5.

22. Given the Sprinkler network shown below.



What is the best approximation of the value of $P(S|W)$ (the probability that the **S**prinkler was on given that the grass is **W**et)?

(a) 0.2781

(b) 0.6471

(c) 0.1945

(d) 0.4298 *

Questions about Machine Learning

23. A data analyst has collected data (see table below) about customer loans. The goals is to predict, based on the customer profile, if a loan for a customer has a high risk or not.

payment history	debt	guarantee	income	risk
average	low	no	15-35 KEuro	low
average	low	no	0-15 KEuro	high
average	low	no	> 35 KEuro	low
average	low	sufficient	> 35 KEuro	low
bad	low	no	0-15 KEuro	high
bad	low	sufficient	> 35 KEuro	low
good	high	sufficient	> 35 KEuro	low
good	high	no	0-15 KEuro	high
good	high	no	15-35 KEuro	low
good	high	no	> 35 KEuro	low
bad	high	no	15-35 KEuro	high

What is the information gain of the attribute *payment history*?

(a) 0.11 *

(b) 0.89

(c) 0.85

(d) 0.15

24. The analyst wants to learn the above classification problem using decision trees. If he uses "information gain" as selection criteria what will be the the attribute at the root of the decision tree (top node)?

(a) payment history

(b) debt

(c) guarantee

(d) income *

25. Consider the following statements about decision trees and logical formula's.

(i) Every decision tree hypothesis can be represented in a logical first order sentence.

(ii) Every classification hypothesis represented in a logical first order sentence can be represented in a decision tree.

Which of the above statements are true?

(a) Both statements (i) and (ii) are false.

(b) Only statement (i) is true. *

(c) Only statement (ii) is true.

(d) Both statements (i) and (ii) are true.

26. Assume that we are training a logistic classifier (linear classifier with logistic regression) using the `Logistic` function (called the `sigmoid` function in the slides) and that the current logistic classifier has the weights $(w_0, w_1, w_2) = (1, 2, -1)$. The next feature point in our training set is given by $x = (-1, -2)$. What is the output of this logistic classifier? You can find a table values for the `Logistic` function at the last page of the exam.

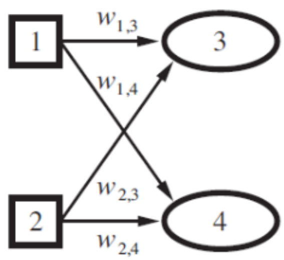
(a) 1.00

(b) 0.50

(c) 0.27

(d) 0.73 *

27. Consider the Neural Network depicted below, the dummy inputs and weights are not shown!



We assume the following weights: $w_{0,3} = 1,\ w_{1,3} = 2,\ w_{2,3} = -1,\ w_{0,4} = 2,\ w_{1,4} = 1,\ w_{2,4} = -2$, The activation function of the neurons 3 and 4 is the `Logistic` function (called the `sigmoid` function in the slides). What is the output of this NN on the input $x = (1, 1)$? First (second) component is output of neuron 3 (4). You can find a table values for the `Logistic` function at the last page of the exam.

(a) $(0.73, 0.88)$

(b) $(0.50, 0.88)$

(c) $(0.88, 0.73)$ *

(d) $(0.27, 0.12)$

28. Once again consider the above NN and weights. Assume that for a given input x the output is $(0.2, 0.6)$ (first component is output of neuron 3) and the target output is $(1, 0)$. Moreover we assume a L_2 loss function $1/2[(y_3 - a_3)^2 + (y_4 - a_4)^2]$ (formula book: $\Delta[j] \leftarrow g'(in_j) \times (y_j - a_j)$). What is the value for the delta of neuron 3: $\Delta[3]$?

(a) 0.80

(b) -0.80

(c) 0.13 *

(d) 0.03

29. Once again consider the above NN and weights. Assume that for a given input $x = (2, 1)$ the value for $\Delta[4] = 0.6$. What will be the new value for the weight $w_{2,4}$ (old value was -2) if one uses a learning rate $\alpha = 0.5$?

(a) -1.7 *

(b) -2.3

(c) -1.4

(d) -2.6

Questions about Reinforcement Learning

30. Consider the following 4x3 environment with reward and transition function as described in the caption and the figure.

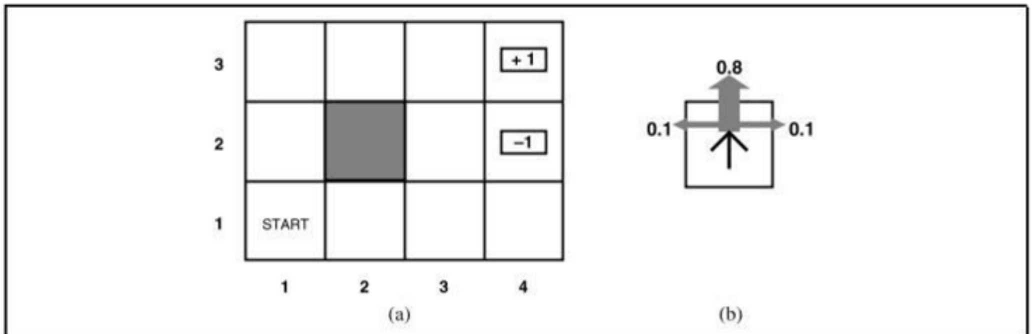


Figure 1 (a) A simple 4×3 environment that presents the agent with a sequential decision problem. (b) Illustration of the transition model of the environment: the "intended" outcome occurs with probability 0.8, but with probability 0.2 the agent moves at right angles to the intended direction. A collision 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 agents 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 $U(3,3)$ after one complete update of U:

(a) 0
(b) -0.04
(c) 0.76 *
(d) 0.96

31. 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) $s \times a$
(b) $s + a$
(c) a^s *
(d) s^a

32. An agent uses Q-learning, to learn an optimal strategy for a probabilistic game. The current (internal) state of the agent is s. In this state s the agent can do four actions; a, b, c and d. The Q-values, computed by the agent, for these state action pairs are given by:

action x	$Q(s,x)$
a	20.0
b	60.0
c	40.0
d	50.0

Moreover assume that the agent decides to do some exploration and does the action d and receives a reward 10.0. Due to this action d the agent ends up in state s'. In this new state s' the agent can do actions e, f with the following Q-values:

action x	$Q(s',x)$
e	20.0
f	30.0

Assume that the agent applies Temporal Difference Learning with learning parameter $\alpha = 0.6$ and discount factor $\gamma = 0.8$. What will be the new Q-values for state s?

(a) $Q(s,a) = 28.4$, $Q(s,b) = 44.4$, $Q(s,c) = 36.4$ and $Q(s,d) = 40.4$.

(b) $Q(s,a) = 20.0$, $Q(s,b) = 60.0$, $Q(s,c) = 50.0$ and $Q(s,d) = 40.4$.

(c) $Q(s,a) = 20.0$, $Q(s,b) = 60.0$, $Q(s,c) = 50.0$ and $Q(s,d) = 34.0$.

(d) None of the above. *

Table for $-p\log(p)$

p	$-p\log_2(p)$	p	$-p\log_2(p)$	p	$-p\log_2(p)$
0	0	1/8	0.38	1/10	0.33
1	0	2/8	0.50	2/10	0.46
1/2	0.50	3/8	0.53	3/10	0.52
1/3	0.53	4/8	0.50	4/10	0.53
2/3	0.39	5/8	0.42	5/10	0.50
1/4	0.50	6/8	0.31	6/10	0.44
2/4	0.50	7/8	0.17	7/10	0.36
3/4	0.31	1/9	0.35	8/10	0.26
1/5	0.46	2/9	0.48	9/10	0.14
2/5	0.53	3/9	0.53	1/11	0.31
3/5	0.44	4/9	0.52	2/11	0.45
4/5	0.26	5/9	0.47	3/11	0.51
1/6	0.43	6/9	0.39	4/11	0.53
2/6	0.53	7/9	0.28	5/11	0.52
3/6	0.50	8/9	0.15	6/11	0.48
4/6	0.39			7/11	0.42
5/6	0.22			8/11	0.33
1/7	0.40			9/11	0.24
2/7	0.51			10/11	0.13
3/7	0.52				
4/7	0.46				
5/7	0.35				
6/7	0.19				

Table for Logistic or sigmoid function $\sigma(x)$

x	$\sigma(x)$
-4	0.02
-3	0.05
-2	0.12
-1	0.27
0	0.50
1	0.73
2	0.88
3	0.95
4	0.98