Exam Artificial Intelligence for Module 6 (201700269)
Bachelor TCS and BIT.
January 12 2018, 13:45-16:45

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. Can a model-based reflex agent be perfectly rational for a certain performance measure and task environment?

   (a) This is dependent on **both** the task environment and the performance measure.

   (b) This is dependent **only** on the performance measure.

   (c) This is dependent **only** on the task environment.

   (d) A model-based reflex agent is **never** perfectly rational.

2. As you may know, a rational agent interacts with its environment and the more complex the environment is, the harder it is to act rationally. Which of the following environments is the most complex one?

   (a) Fully observable, stochastic, episodic, dynamic, discrete and single agent.

   (b) Partially observable, stochastic, sequential, dynamic, continuous and multi-agent.

   (c) Partially observable, deterministic, sequential, dynamic, continuous and single agent.

   (d) Fully observable, deterministic, episodic, dynamic, continuous and multi-agent.

3. 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

4. Consider the general A * search algorithm as described in the course book:

   (i) A* search cannot be implemented on a Simple Reflex Agent.

   (ii) A* search cannot be implemented on a Model-based Reflex Agent.

   (iii) A* search can be implemented on a Goal Based Agent

   Which of the following claims is true?

   (a) All statements (i), (ii) and (iii) are false.

   (b) Only statement (iii) is true

   (c) Only statement (i) and (iii) are true

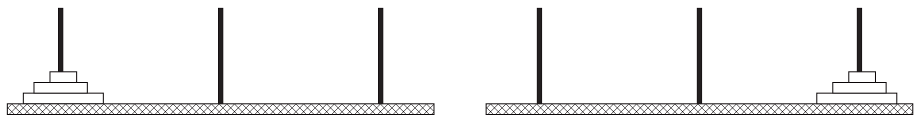
   (d) All statements (i), (ii) and (iii) are true.

Questions about search and problem solving

5. Which of the following search strategies belongs to the class of uninformed search?

   (a) A^* Search
   (b) Greedy Search
   (c) Breadth-First Search
   (d) None of the above

6. Consider the following Tower of Hanoi problem.



Left: Initial state Right: Goal state

The problem is the move one disk at a time from one peg to another peg. But is is not allowed to put a disk on top of a smaller disk. The goal is to reach the goal state with minimal cost. The cost of moving the small disk is 1, moving the middle sized disk is 2, and moving the large disk is 3. Hence the average cost is 2. Define the heuristic function h as follows: $2 \times$ *number of disks not on the rightmost peg.* What is the h value of the initial state?

   (a) 3
   (b) 4
   (c) 5
   (d) 6

7. Assume that we apply A* search to the above Tower of Hanoi problem. Which node will be the **second** one that will be expanded after the initial node (node corresponding to the start state) of the search tree?

   (a) The node corresponding to the state which arises from the initial state by moving the small disk to the rightmost peg and then afterwards moving the middle sized disk to the empty peg.

   (b) The node corresponding to the state which arises from the initial state by moving the small disk to the middle peg and then afterwards moving the middle sized disk to the rightmost peg.

   (c) The node corresponding to the state initial state, i.e. moving the small disk to an empty peg and back.

   (d) The node corresponding to the state which arises from the initial state by moving the small disk first to the rightmost peg and afterwards moving the small disk to the middle peg.

8. Once again consider the above "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?

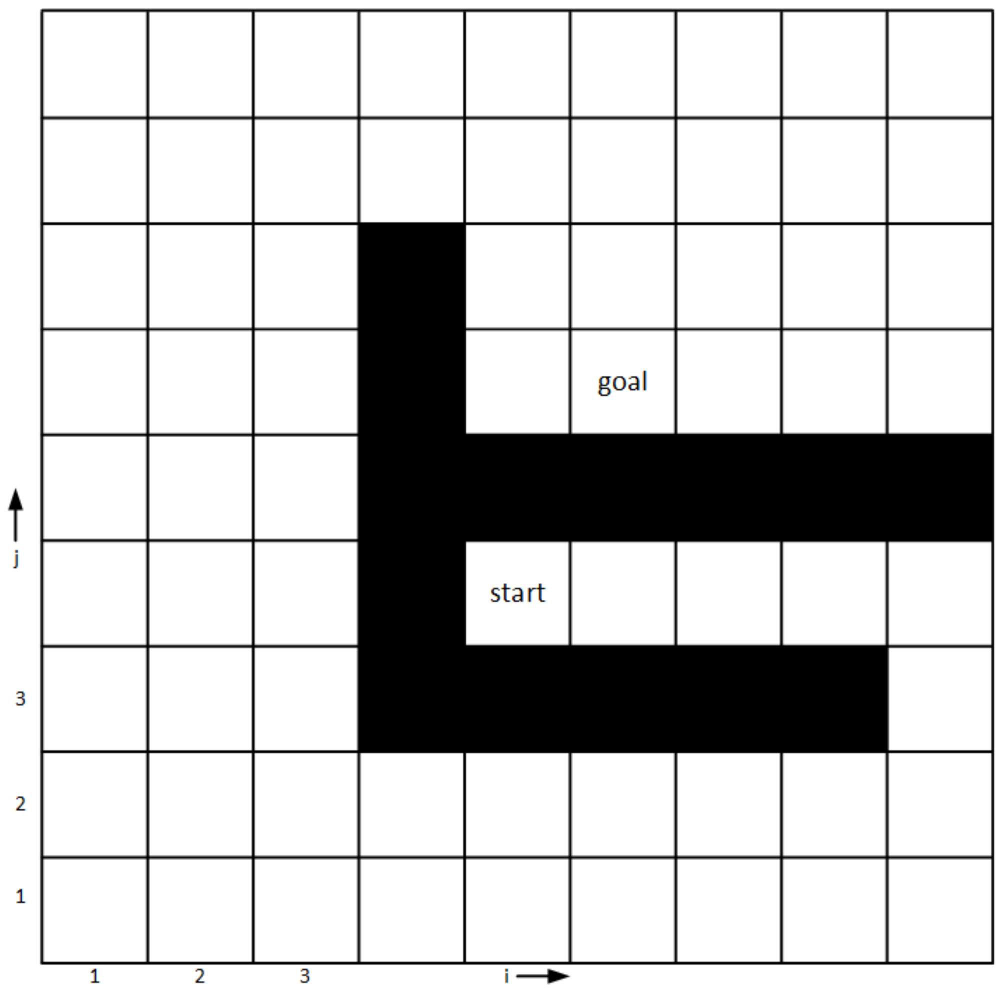
   (a) Only statement (i) is true.

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

   (c) Only statement (ii) is true.

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

9. 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 **A* 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*, but **never** be expanded (removed from this list)?

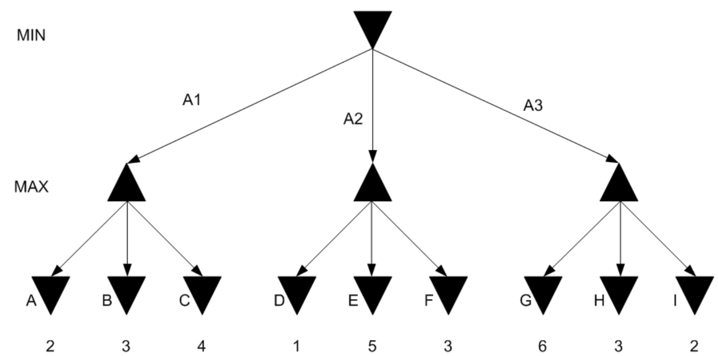
(a) node corresponding to cell (state) $(2, 6)$.

(b) node corresponding to cell (state) $(1, 7)$.

(c) node corresponding to cell (state) $(8, 4)$.

(d) None of the above

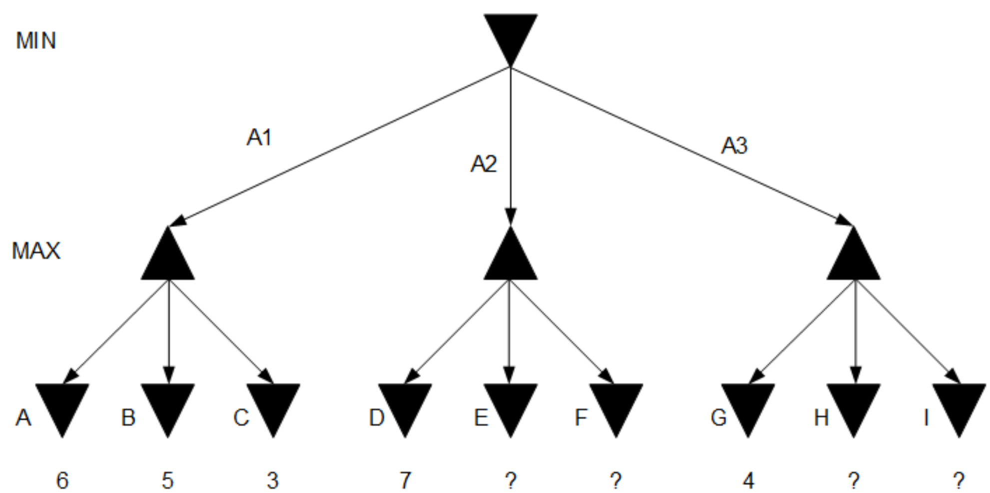
10. Consider the following part of a two-player game tree.



What will be the value of the top MIN node?

(a) 1
(b) 4
(c) 3
(d) 6

11. Consider the following two-player game tree. A ? below a node means that the node is not explored yet, so value is unknown.



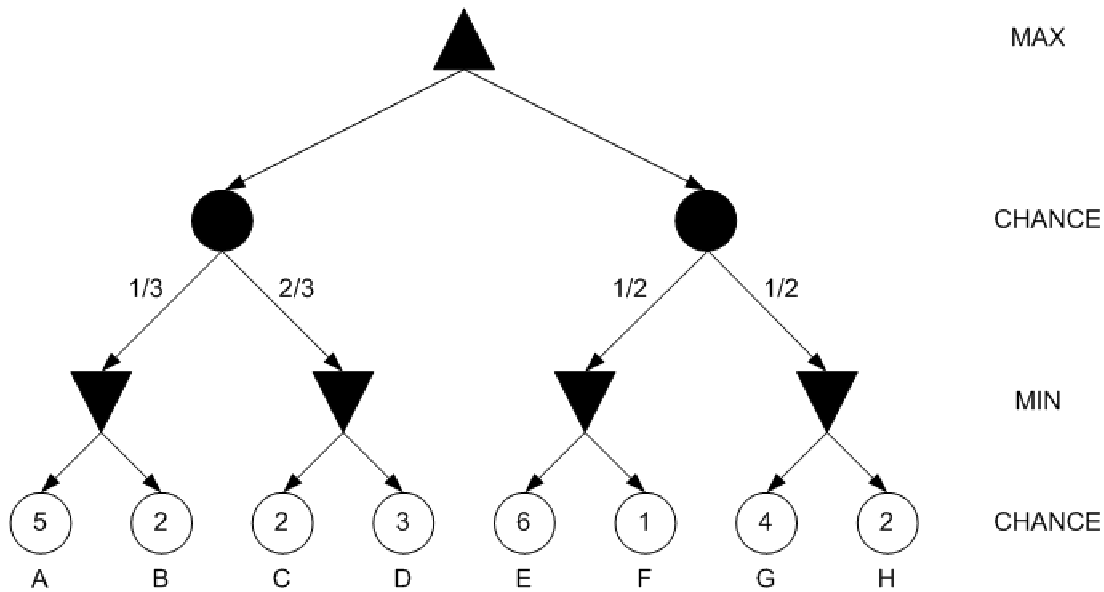
Assume one applies alpha-beta pruning and consider the following statements:

(I) Alpha-beta pruning will expand node F.
(II) Alpha-beta pruning will expand node H.

Which of the above statements are true?

(a) Only (II) is true.
(b) Both (I) and (II) are true.
(c) Only (I) is true.
(d) Both (I) and (II) are false.

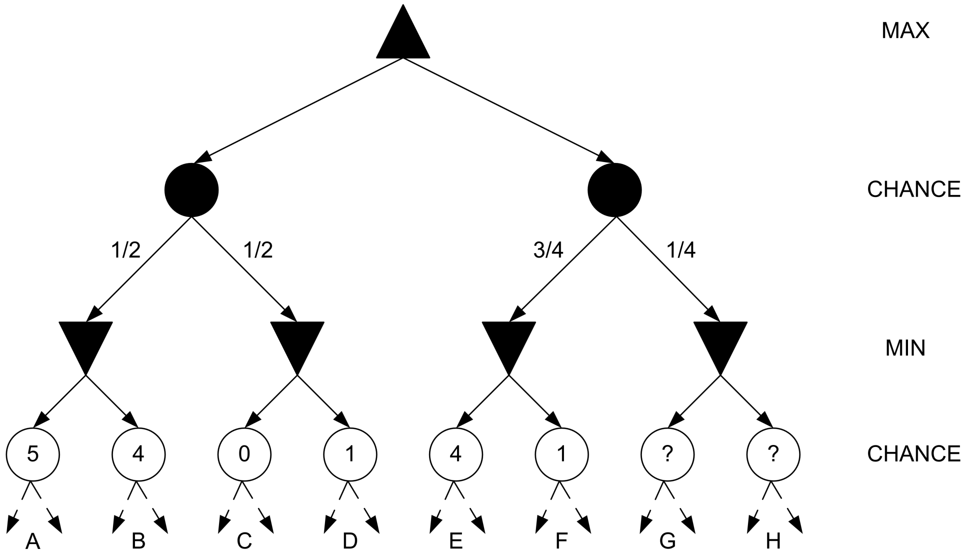
12. Consider the following two-player game tree in which the game has an element of chance, which is shown by the so-called probability nodes in the game tree.



What is the value of the top MAX node if one applies the expectiminimax algorithm?

(a) 6
(b) 4
(c) 3
(d) 2

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 $\alpha - \beta$ (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) If the value of node G is greater than 5 then $\alpha - \beta$ pruning will never expand node H.

(c) If the value of node G is less or equal than 5 then $\alpha - \beta$ pruning will always expand node H.

(d) If the value of node G is greater than 5 then $\alpha - \beta$ pruning will always expand node H.

Questions about Propositional Logic

14. How many models does the propositional formula

$$\neg(A \Rightarrow B) \vee B$$

have?

(a) 2
(b) 3
(c) 4
(d) None of the above.

15. Which of the two following statements is true?

(I) $(A \Rightarrow B) \Rightarrow A$ follows from $(A \Rightarrow B) \Rightarrow B$.
(II) $(A \Rightarrow B) \vee B$ follows from $\neg A \vee B$.

(a) Both are true
(b) (I) is true, (II) is false
(c) Both are false
(d) (I) is false, (II) is true

16. When we transform the formula

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

into conjunctive normal form, we obtain the following formula:

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

17. A knowledge base KB contains the following statement (i.e. considered to be true).

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

   The question is whether we can prove Q from this KB. Which of the following answers is correct?

   (a) Yes, we can prove Q.

   (b) No, we cannot derive Q, but if we add the premiss W to KB the statement Q can be derived.

   (c) No, we cannot derive Q, but if we add the premiss $\neg W$ to KB the statement Q can be derived.

   (d) None of the above.

Questions about Predicate Logic

18. In the context of the Valentine puzzle the predicate $Send(x, c, y)$ means "person x sends card c to person y". What is implied by the following formula in First Order Predicate Logic?

$$\forall x_1, x_2, y_1, y_2, c \;\; Send(x_1, c, y_1) \wedge Send(x_2, c, y_2) \Rightarrow x_1 = x_2$$

   (a) Every card is sent by at most one person
   (b) Every person gets a card from at most one person
   (c) Every person sends a card to at most one person
   (d) Every person sends at most one card

19. In set theory a set x is a *subset of* set y if and only if all elements of x are also elements of y. Let *Subset* and *Equal* are two predicates in FOPL with the following meanings. $Subset(x, y)$ means that set x is subset of set y. $Equal(x, y)$ means that sets x and y are equal. Consider the following sentences:

$$(I): \;\; \exists x \; \forall y \; Subset(x, y)$$

and

$$(II): \;\; \forall x \; \forall y \; Subset(x, y) \wedge Subset(y, x) \Rightarrow Equal(x, y)$$

Which of these statements is true in set theory?

   (a) (I) only
   (b) (II) only
   (c) Both (I) and (II)
   (d) Neither (I) nor (II)

20. Given are the following two predicates:

    - $Man(x)$: x is a man.
    - $Woman(x)$: x is a woman.
    - $Father(x, y)$: x is father of y
    - $Son(x, y)$: x is son of y
    - $Daughter(x, y)$: x is daughter of y

    Now consider the following two sentences in first-order logic:

    (I) $\forall x\ \forall y\ Man(y) \wedge Father(x, y) \Rightarrow Son(y, x)$
    (II) $\exists x\ \exists y\ Daughter(x, y) \Rightarrow Woman(y)$

    Which is these two formula is true (in the normal model of family relations)?

    (a) (I) and (II) are both true
    (b) (I) and (II) are both false
    (c) (I) is true and (II) is false
    (d) (I) is false and (II) is true

21. We apply unification with occurs-check on pairs of literals. Of the following four pairs, only one pair can be unified. Which one?

    (a) $Rules(PresidentOf(x), USA)$ and $Rules(PresidentOf(USA), x)$
    (b) $Rules(PresidentOf(x), x)$ and $Rules(y, y)$
    (c) $Rules(PresidentOf(x), x)$ and $Rules(Obama, USA)$
    (d) $Rules(PresidentOf(x), x)$ and $Rules(y, PresidentOf(y))$

22. We want to Skolemise the following sentence:

    $$\forall x\ \exists y\ \forall z\ A(y, z) \Rightarrow [B(y) \wedge (C(x, y) \vee D(z))]$$

    Only one of the following substitutions produces a correct Skolemisation. Which one?

    (a) $\{y/S(x, z)\}$
    (b) $\{y/S(x)\}$
    (c) $\{y/S(z)\}$
    (d) $\{y/S\}$

Questions about Reasoning under Uncertainty

23. 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 $P(catch| \sim toothache)$?

(a) 0.730
(b) 0.270
(c) 0.800
(d) 0.216

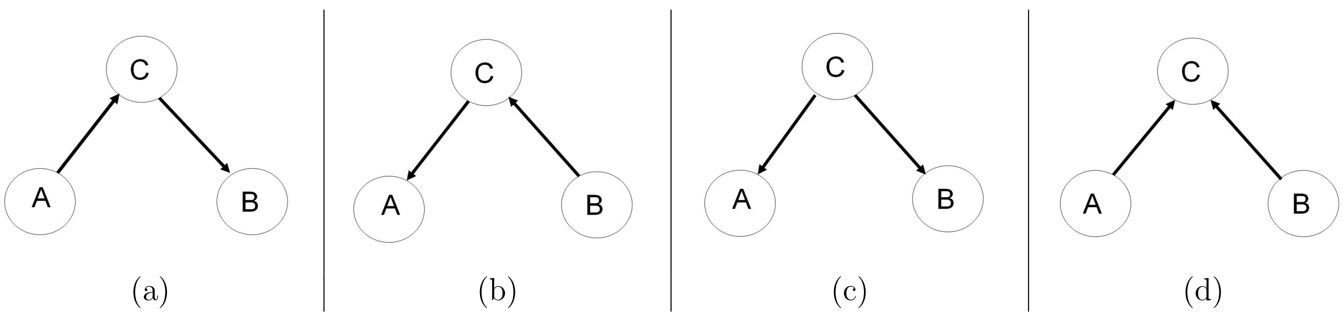


Figure 1: Four Bayesian network structures.

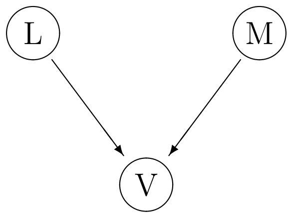
24. Figure 1 shows four Bayesian network structures on three nodes. The difference between the networks is in the direction of the arcs. Based on the shown dependency structures for exactly one of these networks we **cannot** conclude that the conditional independency expressed by the equation

$$P(A, B|C) = P(A|C)P(B|C)$$

(i.e., given C, A and B are independent) holds. Which one?

(a) Network a
(b) Network b
(c) Network c
(d) Network d

25. In the Bayesian Network below with three boolean variables the probabilities for P and M are: $P(M = true) = 0,1$ and $P(L = true) = 0.7$ and the conditional probabilities for variable V are as shown in the table.



L	M	$P(V = true \mid L, M)$
true	true	0,9
true	false	0,5
false	true	0,3
false	false	0,05

What is the value of $P(V = false \mid L = false)$?

(a) 0.075

(b) 0.540

(c) 0.460

(d) 0.925

Questions about Machine Learning

26. Given the following dataset with attributes *U, H, I, T* and *S* and class label *A*:

Ex.	U	H	I	T	S	A
1	Y	M	N	P	M	N
2	N	S	N	P	L	N
3	Y	M	N	A	M	N
4	N	M	N	P	S	N
5	N	M	Y	P	M	Y
6	Y	N	N	A	S	N
7	N	N	N	A	S	Y
8	N	S	N	A	M	Y
9	N	L	Y	P	L	Y
10	N	M	N	P	S	N

What is the information gain for feature U with respect to class label A? Select the alternative which is closest to your answer
You can find a table of $-p\log_2(p)$ values at the last page of this exam.

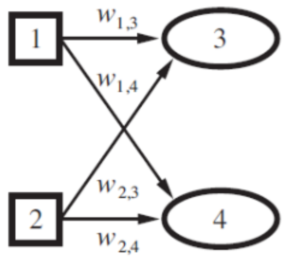
(a) 0.70

(b) 0.27

(c) 0.63

(d) 0.37

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



We assume the following weights: $w_{0,3} = 2$, $w_{1,3} = 1$, $w_{2,3} = -2$, $w_{0,4} = 1$, $w_{1,4} = 2$, $w_{2,4} = -1$. 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) $(0.73, 0.50)$

(d) $(0.27, 0.12)$

28. Once again consider the above NN and weights. Assume that for a given input x the output is $(0.3, 0.5)$ (first component is output of neuron 3) and the target output is $(0, 1)$. 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) 0.063

(b) -0.063

(c) -0.300

(d) 0.300

29. Once again consider the above NN and weights. Assume that for a given input $x = (2, 1)$ the value for $\Delta[3] = 0.5$. What will be the new value for the weight $w_{1,3}$ (old value was 1) if one uses a learning rate $\alpha = 0.6$?

(a) 0.4

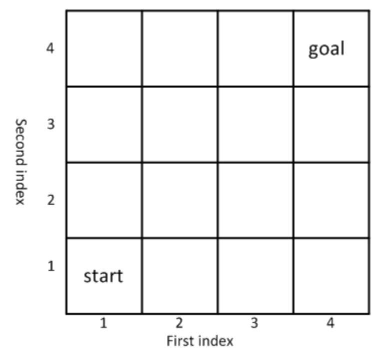
(b) 1.6

(c) 0.7

(d) 1.3

Questions about RL

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



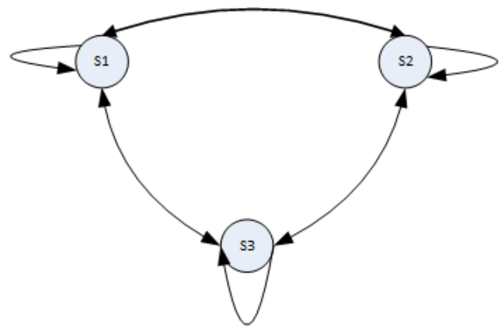
Assume that the agent can move in four directions *up, down, left, right* and these actions are deterministic. If it bounces to a wall it will stay in the same cell. Moreover the agent cannot leave the goal state, it is a terminal state. This means no action can be taken in the goal state. The *max* over an empty set is 0 by definition. Assume that every state has reward of 0 except for the goal state, which as reward 5.00. Assume that the agent applies the following value iteration algorithm, where $\delta(s, a)$ is the deterministic transition function.

1 Initialize U_{old} to 1.
2 Repeat
3   For all $s \in S$
4         $U_{new}(s) = R(s) + max_a[\gamma U_{old}(\delta(s, a))]$
5   End (for all)
6     $U_{old} = U_{new}$
7 Until $U_{new}(s)$ does not change

Assume that the value for discount factor γ is 0.6. What will after 4 iterations of the "Repeat" loop (statements [2] – [7]) be the value of $U_{new}(s)$ for $s = (3, 3)$? Select the alternative which is closest to your answer.

(a) 5.00
(b) 1.80
(c) 1.08
(d) 0.65

31. Consider the following 3 state MDP, with states s_1, s_2 and s_3.



The rewards are given by $R(s_1) = -0.4$, $R(s_2) = -0.8$ and $R(s_3) = -0.6$. In this simple state space the agent can only do two actions *leave* and *stay* with the following transition probabilities:

	s_1	s_2	s_3
$P(s\|s_1, stay)$	0.8	0.1	0.1
$P(s\|s_1, leave)$	0.1	0.8	0.1
$P(s\|s_2, stay)$	0.1	0.8	0.1
$P(s\|s_2, leave)$	0.2	0.6	0.2
$P(s\|s_3, stay)$	0.1	0.1	0.8
$P(s\|s_3, leave)$	0.1	0.8	0.1

Assume that the agent computed the following utilities for these states: $U(s_1) = 3$, $U(s_2) = 4$ and $U(s_3) = 2$. What is the policy π for the states s_1 and s_2 corresponding to the these utilities U?

(a) $\pi(s_1) = leave$ and $\pi(s_2) = leave$

(b) $\pi(s_1) = leave$ and $\pi(s_2) = stay$

(c) $\pi(s_1) = stay$ and $\pi(s_2) = leave$

(d) $\pi(s_1) = stay$ and $\pi(s_2) = stay$

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	40.0
b	50.0
c	30.0
d	40.0

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

action x	$Q(s',x)$
d	70
e	40

Assume that the agent applies Temporal Difference Learning with learning parameter $\alpha = 0.7$ and discount factor $\gamma = 0.9$. What will be the new Q-values for state s?

(a) $Q(s,a) = 63.1$, $Q(s,b) = 66.1$, $Q(s,c) = 60.1$ and $Q(s,d) = 63.1$.

(b) $Q(s,a) = 40.0$, $Q(s,b) = 50.0$, $Q(s,c) = 60.1$ and $Q(s,d) = 40.0$.

(c) $Q(s,a) = 60.0$, $Q(s,b) = 65.0$, $Q(s,c) = 75.0$ and $Q(s,d) = 60.0$.

(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