

**Final Exam**  
January 2022

**Remarks and advice:**

- 1) You can answer question in English or French.
- 2) Please read each question closely.
- 3) Precise the number of the question before answering it.
- 4) The marking scheme is purely indicative and may change.
- 5) A double-sided paper in format A4 as a memory aid is accepted.
- 6) A calculator is accepted.

**Exercise 1: Course questions (6 points)**

1. You want to find the sequence of moves to play in the game Tic-Tac-Toe. Can this problem be solved by a machine learning algorithm? Which one for example? **(2 points)**
2. Explain as clearly as possible the differences between Supervised Learning, Unsupervised Learning and Reinforcement Learning. **(2 points)**
3. Explain as clearly as possible what are the motivations and the principles behind the principal component analysis. **(2 points)**

**Exercise 2: Decision Tree and Perceptron (7 points)**

A) The entropy of a set of  $K$  events is given by:  $Entropy(P) = -\sum_{i=1}^K P(e_i) \log_2 P(e_i)$  , where  $P(e_i)$  is the probability that events  $i$  occurs.

Suppose that the probability of three events are :

1.  $P(e_1)=0,5$  and  $P(e_2)=P(e_3)=0,25$
2.  $P(e_1)=P(e_2)=P(e_3)=1/3$

Compute the entropy for both cases. What does it measure? What can you conclude from it by comparing the two cases?

B) Make a Decision Tree and a Perceptron Network that compute the logical XOR function.

**Exercise 3: Reinforcement Learning (7 points)**

*We have two water jugs. They are initially empty. One can contain 3 liters of water, the other can contain 4 liters of water. We want to obtain 6 liters of water, distributed among the two jugs: 3 liters in one jug and 3 in the other, or 2 liters in one and 4 in the other.*

*We can empty or fill entirely a jug, or we can transfer the amount of water from one jug to the other. For the latter case, one jug can be empty after the move, or it can fill entirely the other jug. For example, if the little jug have already 1 liter and the big jug have 4 liters and we transfer the big jug into the little jug, after the move the little jug will have 3 liters and the big jug 2 liters. Then we have transferred in this case 2 liters from the big jug into the little jug.*

1. Formalize this problem as an MDP as precisely as possible.
2. Explain which algorithm should be preferred for this problem, and how you could apply it.
3. What could be the optimal policy for this problem?