THE UNIVERSITY OF HONG KONG

FACULTY OF ENGINEERING
DEPARTMENT OF COMPUTER SCIENCE

Final Examination

COMP7404A Computational intelligence and machine learning

7 Dec 2019, 2:30 pm - 4:30 pm

This is an open book examination. All answers must be your own.

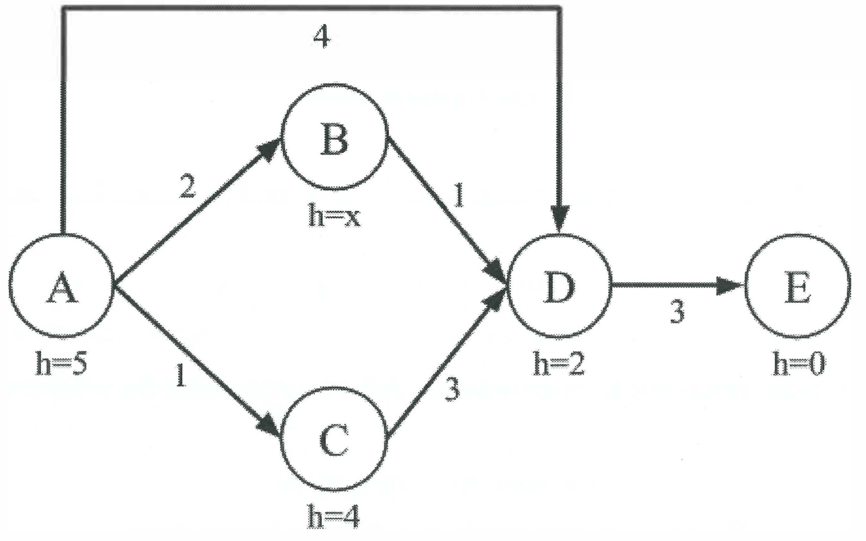
Answer ALL questions.
Write your university number on every page.

Write your answer into a single Microsoft Word file.
You may, if necessary, insert scanned handwritten answers into your Word file.
Submit your Word file to OLEX before the deadline.

Question	Max. Mark
1	18
2	10
3	16
4	15
5	10
6	21
7	10
Total	100

Question 1 [18 marks total]:

Consider the search problem below.



Let A be the start state, E be the goal state and x be an integer variable s.t. 1 <= x <= 10. Consider TSA only.

1.1 [6 marks]: Write down the order of explored states for (a) BFS, (b) DFS.
1.2 [6 marks]: Write down all values for x, s.t. the heuristic h(n) is (a) admissible, (b) consistent for all nodes n.
1.3 [6 marks]: Write down all values for x, s.t. the number of explored states of A^* is less than that of BFS. If there is a tie in A^* use LIFO to resolve it.

Question 2 [10 marks total]:

Peter (P), Mary (M), Otto (O) and Dirk (D) would like to rent an apartment in a particular Yuen Long village house. The village house has three floors: G/F, 1/F, 2/F. Every floor has only one apartment. P, M, O and D must be assigned to exactly one floor. Note that more than one person can live in the same apartment. Consider the following constraints.

- P and M cannot live in the same apartment.
- D must live on a higher floor than O.
- D must live alone.
- If P and O live together, they must be on 1/F.
- If P and O live separate, one of them must live on the 2/F.

We are going to model this as a constraint satisfaction problem as follows.

- Four variables P, M, O and D represent the different people above.
- Three values 0, 1, and 2 representing the floors G/F, 1/F and 2/F, respectively.

2.1 [5 marks]: Consider the following partial assignment: O = 1. Other variables have full domain. Apply forward checking.

2.2 [5 marks]: Let all variables have full domains. Enforce arc-consistency.

Question 3 [16 marks total]:

Let there be an MDP with an agent that has 5 possible actions. Up, Down, Left, Right and Exit. We are going to use the same transition model that we have seen many times in class:

- Up, Down, Left and Right transitions are successful 80% of the time and 20% of the time one of the two perpendicular directions is chosen with equal chance.
- Exit action are successful 100% of the time.
- If the agent bumps into a wall it stays put.

The agent operates in the following grid world. Black squares represent a wall.

The states A1, A2, A3, and A4 only have Up, Down, Left and Right actions available and the states B3 and A5 only have the exit action available. All transitional rewards are 0 except for

- R(A5, exit, TerminalState) = +1, and
- R(B3, exit, TerminalState) = -100.

3.1 [4 marks]: Determine $\pi^*(A1)$, $\pi^*(A2)$, $\pi^*(A3)$ and $\pi^*(A4)$ assuming a discount of $\gamma = 1$.
3.2 [4 marks]: Determine $V^*(A1)$, $V^*(A2)$, $V^*(A3)$ and $V^*(A4)$ assuming a discount of $\gamma = 1$.
3.3 [4 marks]: Determine $V^*(A4)$ assuming a discount of γ, where $0 < \gamma < 1$. Give your answer in terms of γ.
3.4 [4 marks]: We are adding a new available action: Woom (W). This action doesn't do anything (i.e., agent stays put) except it guarantees the next time the agent takes an action it will be successful 100% of the time. The special ability of W is only for one timestep. However, action W can be taken an unlimited number of times. Determine $V^*(A4)$ assuming a discount of γ, where $0 < \gamma < 1$. Give your answer in terms of γ. Assume that the previous action was W.

Question 4 [15 marks total]:

In this question we are going to build an MDP and use approximate reinforcement learning to pick an attraction in Disneyland. There is a chance that some attractions make you feel sick. Initially you feel well and enjoy the attractions. You are getting rewards. When you are sick and you continue visiting the attraction there is a chance that you feel well again. When you feel sick and you continue visiting an attraction you will get a lower reward.
This is your first time in Disneyland. You don't know how much reward you may obtain while sick or well. You also don't know what the chances are of getting sick/well again for each attraction.
The available actions and some more information about them is available in the following table.

action	type	wait	speed
Big Grizzly	rollercoaster	short	slow
Iron Man	rollercoaster	long	fast
Dumbo	carousel	short	fast
Toy Soldier	drop tower	short	slow
Leave Disney	leave	short	slow

In our MDP, let there be two states: Well and Sick. Every attraction is an action. The leave Disney action will end the current run through the MDP. Taking an attraction action will lead back to the same state with some probability or take you to the other state. We are going to use the following features

- f_0(state, action) = 1, if and only if type = rollercoaster,
- f_1(state, action) = 1,
- f_2(state, action) = 1, if and only if wait = short,
- f_3(state, action) = 1, if and only if type = rollercoaster,

and the weights: $w_0 = 2$, $w_1 = 1$, $w_2 = 1$, $w_3 = 1/2$. Assume a discount of $\gamma = 1/2$ and a learning rate of $\alpha = 1/2$.

4.1 [3 marks]: Determine Q(Well, Big Grizzly)
4.2 [8 marks]: Apply an approximate Q-Learning update based on the sample
(Well, Big Grizzly, Sick, -9.5).
Write down all weights after the update is complete.
4.3 [4 marks]: Is Q(Well, Big Grizzly) = Q(Sick, action) for all actions after the update of 4.2? Use at most two sentences to explain why / why not.

Question 5 [10 marks]:

In this question you are going to apply the Perceptron algorithm on four 2D training samples. Let the training samples be given as follows.

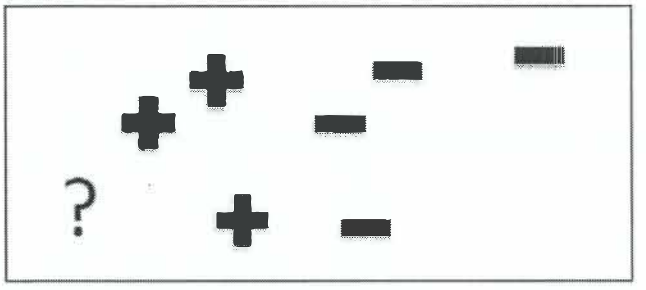
x_1	x_2	y
1	1	-1
1	-1	1
-1	1	-1
-1	-1	-1

In the table above, x_1 and x_2 are the features and y is the class label. Let all initial weights be $w_1 = w_2 = 0.2$ and let the bias be $w_0 = -0.2$.

5.1 [4 marks]: Calculate the estimate $\hat{y}$ for all samples.
5.2 [6 marks]: Perform one epoch of training using a learning rate of 0.5.

Question 6 [21 marks]:

6.1 [4 marks]: Use KNN with euclidean distance to classify the point ?. Show all classification results for the following values of k = 1, 2, 3, …, 7.



6.2 [7 marks]: We will use the dataset below to learn a decision tree which predicts if students pass COMP7404A (Yes or No), based on their cumulative GPA (High, Medium, or Low) and if they studied (True, False).

CGPA	Studied	Passed
L	F	N
L	T	Y
M	F	N
M	T	Y
H	F	N
H	T	Y

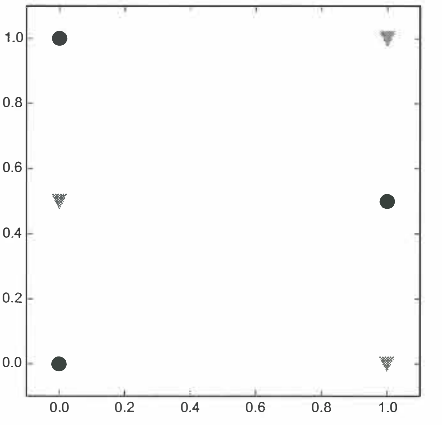
Draw the full decision tree that would be learned for this dataset using the entropy (use $\log_2$). Show all calculations and write down the entropy values for all nodes in the tree.

6.3 [3 marks for correct answer, -3 marks for incorrect answer]: (True/False) Support vector machines, like logistic regression models, give a probability distribution over the possible labels given an input example. Use at most one sentence to explain.

6.4 [3 marks for correct answer, -3 marks for incorrect answer]: (True/False) The maximum margin decision boundaries that support vector machines construct have the lowest generalization error among all linear classifiers. Use at most one sentence to explain.

6.5 [4 mark for correct answer, -2 mark for incorrect answer]: Select all binary classifiers that are able to correctly separate the training data (circles vs. triangles) given in the figure below. Use at most two sentences to explain.

A. Logistic regression
B. SVM with linear kernel
C. SVM with RBF kernel
D. Decision tree
E. 3-nearest-neighbor classifier (with Euclidean distance)

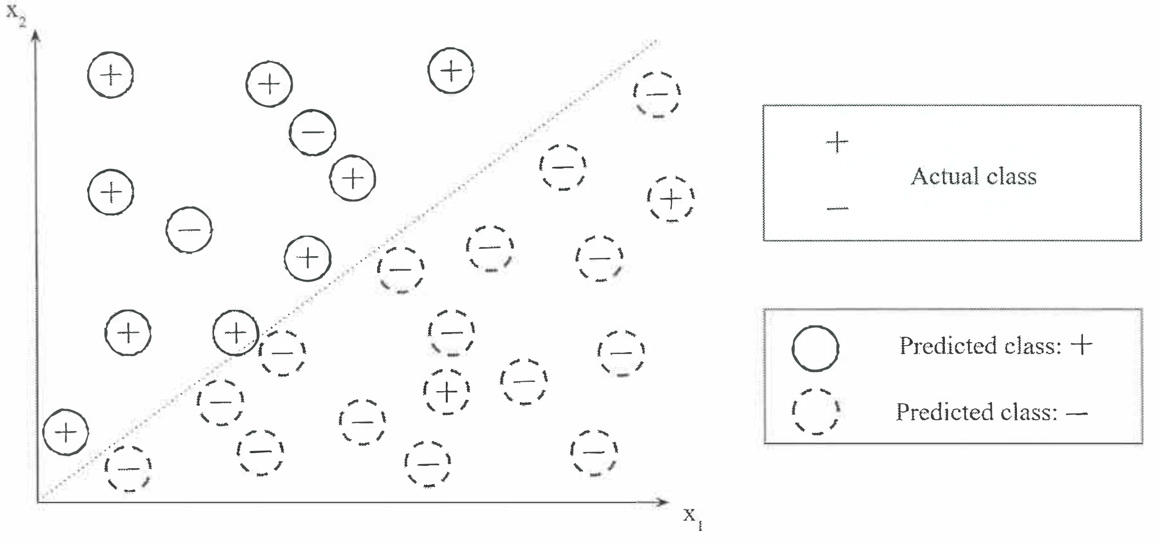


Question 7 [total 10 marks]

7.1 [4 mark for correct answer, -2 mark for incorrect answer]: In a medical application domain, suppose we build a classifier for patient screening (True means patient has cancer). Which of the following situations would you like your classifier to have? Only select one answer, select the one that you think is most important. Use at most two sentences to explain. The double greater-than sign denotes much greater-than.
(FP: false positive, FN: false negative, TP: true positive, TN: true negative)

A. FP >> FN
B. FN >> FP
C. FN = FP × TP
D. TN >> FP
E. FN × TP >> FP × TN
F. All of the above

7.2 [6 marks]: Consider a 2D binary classification problem with two classes: + and -. The result of some classifier is shown in the following figure.



Calculate the precision, recall and F1-score of the classifier. Notations in this example are identical to the one we used chapter 6 of the lecture notes.

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