ARTIFICIAL INTELLIGENCE EXAM

Course Code: 1DL340

Ref. This is a student generated exam.

This exam has 18 questions for a total of 49 marks. Grade boundaries are:

3 - 24.5
4 - 32.5
5 - 40.5

In exceptional circumstances these boundaries may be adjusted at the discretion of the examiner. This would be done on an exam-wide basis, NOT for individual students.

You are permitted to make use of a calculator and language dictionary in this exam.

1 A-Star

Table 1 gives the edge values for a shortest path problem. Using these and the A* algorithm, find the shortest path from the start node to the goal node. Provide a valid heuristic and show all working. (4 marks)

Table 1: Edges

	Start	A	B	C	D	E	Goal
Start	0	7	0	0	0	0	0
A	0	0	4	0	4	0	0
B	0	0	0	3	0	4	0
C	0	0	0	0	5	6	2
D	0	0	0	0	0	6	0
E	0	0	0	0	0	0	5
Goal	0	0	0	0	0	0	0

2 MCMC and Directed Graphical Models

Tables 2 to 6 provide the conditional probability distributions for a directed graphical model.

A. Use this information to draw the graph of the associated directed graphical model. (1 mark)

B. Table 7 provides observed values for some of the nodes. Given these, the initial values provided in Table 8 and the random numbers provided below, use the Metropolis within Gibbs MCMC sampling algorithm to generate two complete samples of the variables. Assume that the candidate function gives the opposite of the current value. At each step, explain what value you are considering, what the current and candidate values are, and why you updated it or did not update it. (4 marks)

Random numbers: 0.267,0.386,0.013,0.382,0.87,0.34

Table 2: P(A)

-	A=F	A=T
	0.25	0.75

Table 3: P(B|A)

A	B=F	B=T
A=F	0.35	0.65
A=T	0.6	0.4

Table 4: P(C|A)

A	C=F	C=T
A=F	0.9	0.1
A=T	0.2	0.8

Table 5: P(D|B,C)

B	C	D=F	D=T
B=F	C=F	0.9	0.1
B=F	C=T	0.95	0.05
B=T	C=F	0.65	0.35
B=T	C=T	0.65	0.35

Table 6: P(E|C)

C	E=F	E=T
C=F	0.1	0.9
C=T	0.2	0.8

Table 7: Observed Values

Node	Value
E	FALSE
A	TRUE

Table 8: Initial Values

Node	Value
B	TRUE
C	FALSE
D	TRUE

3 Hidden Markov Models: Forward-Backward Algorithm

Tables 9 to 12 provide the transition matrix, emission matrix, initial state and a sequence of observations for a hidden Markov model. Use the forward-backward algorithm to calculate the probability distributions for the state of the system at times 0, 1 and 2 given the observations. Show all working. (4 marks)

Table 9: Transition Matrix

S_{t-1}	S_t=0	S_t=1
0	0.3	0.7
1	0.4	0.6

Table 10: Emission Matrix

S	$E = 0$	$E = 1$
0	0.6	0.4
1	0.9	0.1

Table 11: Initial State

$S = 0$	$S = 1$
0.5	0.5

Table 12: Observations

Time=1	Time=2
FALSE	TRUE

4 Hidden Markov Models: Viterbi Algorithm

Tables 13 to 16 provide the transition matrix, emission matrix, initial state and a sequence of observations for a hidden Markov model. Use the Viterbi algorithm to calculate the most probable path and its probability. Show all working. (3 marks)

Table 13: Transition Matrix

S_{t-1}	S_t=0	S_t=1
0	0.3	0.7
1	0.4	0.6

Table 14: Emission Matrix

S	$E = 0$	$E = 1$
0	0.6	0.4
1	0.9	0.1

Table 15: Initial State

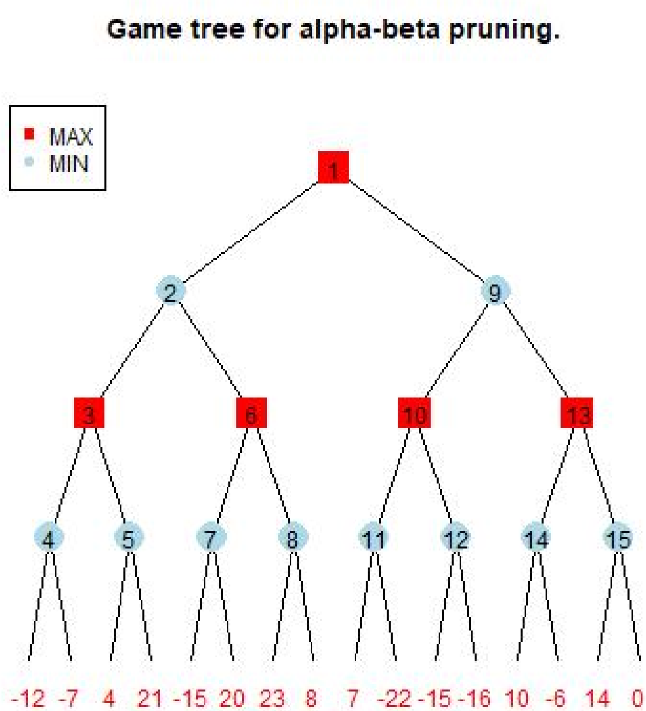
$S = 0$	$S = 1$
0.5	0.5

Table 16: Observations

Time=1	Time=2
FALSE	TRUE

5 Alpha-Beta Pruning

Examine the game tree included in this exam. Note that the values in the nodes are node indices, not mini-max values. Perform alpha-beta pruning on this game tree. You should show all working, where this means all alpha-beta values. You can write these values on the diagram, or alternatively on a separate sheet of paper. In both cases, provide a way of identifying the sequence of updates to alpha-beta values associated with nodes (we suggest you just cross out old values and write new values sequentially downwards). If you write on a separate sheet of paper, use the node indices in the diagram as a way of identifying which node particular alpha-beta values are associated with. Show where pruning occurs, by indicating which branches will not be evaluated. Finally, provide the result (value at end state) of the game assuming optimal play. (3 marks)



6 Scheduling

Provide a complete resource constrained schedule for the actions found in Table 17. (4 marks)

Table 17: Actions

Index	Action	Duration	Uses	Consumes	After
1	Start	0		0 nails	NA
2	Action 1	50		0 nails	1
3	Action 2	45	Saw	-1 nail	1
4	Action 3	35		-1 nail	1
5	Action 4	20	Saw,Hammer	0 nails	3,4,2
6	Action 5	5	Hammer	1 nail	3,4
7	Action 6	45	Saw,Hammer	0 nails	4,2
8	Action 7	30	Saw,Hammer	1 nail	5,7,4,3
9	Finish	0		0 nails	6,8

7 Multi-Armed Bandit Optimization

Image we are testing click through rates on three different web layouts. At the current point, the Dirichlet (beta) distributions associated with each layout have the parameters in Table 18.

Table 18: Dirichlet (Beta) Parameters for Layout

Layout	Parameter 1	Parameter 2
A	8	4
B	9	6
C	8	6

The first value is associated with not clicking through, the second clicking through.

A new person views the site. We generate samples from the distributions to determine which layout is used. These samples are given in Table 19.

Table 19: Samples from Layout Dirichlet (Beta) Distributions

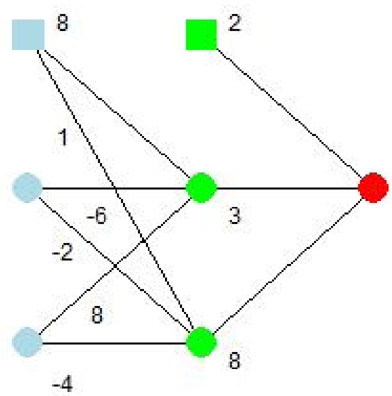
Layout	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
A	0.39	0.22	0.41	0.46	0.29
B	0.64	0.46	0.31	0.12	0.58
C	0.42	0.43	0.58	0.56	0.52

When shown the website with the chosen layout, the person makes a purchase ('clicks through'). Give the new parameters of the three distributions after this event. (2 Marks)

8 Basic Feed-Forward ANNs

Examine the neural network given in the diagram labelled 'Basic Regression Feed-Forward Neural Network'. In this diagram, square nodes represent biases, blue nodes the input layer, green nodes a hidden layer, and red nodes the output layer. The first round blue input node is associated with feature X1, and the second with feature X2 (counting downwards). Assuming that all activation functions are rectifiers (i.e. the hidden nodes are ReLU units), and the output is a basic linear regression function, calculate the output of this network if it was given an input of X1 = -9 and X2 = -6. Show all working. (2 Marks)

Basic Regression Feed-Forward Neural Network



9 Convolution layers in CNNs

Tables 20 to 22 provide an input matrix and two filter matrices for a convolutional layer in a CNN. Assuming no padding, that stride is [1,1], and that all activation functions are rectifiers, calculate the output of this layer. (2 marks)

Table 20: Input Matrix

1	-4	3
-5	2	0
-3	-1	2

Table 21: Filter 1

-2	1
-1	4

Table 22: Filter 1

-3	4
4	1

10 Depth-First Search

Under what conditions could a depth-first search FAIL to find a solution (in a finite search space with at most a single edge between any two nodes)? (1 mark)

11 LSTMs

Explain the steps involving the memory vector in a pass through a LSTM layer at time t. Mention what is done to the memory vector (non-mathematically) and/or what the memory vector is used for in each of these steps. Make reference to the input at time t, and the outputs of time t-1 and t. (2 marks)

12 Local Search

Greedy Hill Climb suffers from the problem of local optima. Name and provide a brief explanation of three alternative local search strategies covered in this course that attempt to overcome or minimize this problem. (3 marks)

13 Bias-Variance

Give a basic explanation (as per what was discussed in the course) of the bias and variance components of expected error and their relationship to model complexity. (3 marks)

14 PDDL

What is PDDL? Explain all components of a PDDL problem. Be as precise and concise as possible. (4 marks)

15 Iterated Deepening

Explain iterated deepening. (2 marks)

16 GANs

Assume you have a GAN where the discriminator network is a simple binary (Genuine/Fake) classifier. Briefly explain how the generator network is trained. (2 marks)

17 Reinforcement Learning

What is the purpose of including randomness in the action-deciding process of a reinforcement learning system? (1 mark)

18 Planning Graphs

Explain the two ways a planning graph can be used to provide a heuristic for A*. (2 marks)