

# ARTIFICIAL INTELLIGENCE EXAM

Course Code: 1DL340

Ref. 0-7569-0-0-0-7569-7569-0-7569-144

This exam has 6 questions for a total of 17 marks. Grade boundaries are:

3 - 8.5

4 - 11.0

5 - 14.0

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 MCMC and Directed Graphical Models

Tables 1 to 5 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 6 provides observed values for some of the nodes. Given these, the initial values provided in Table 7 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: 0.444,0.475,0.487,0.3,0.61,0.229

Table 1:  $P(A)$

-	A=F	A=T
	0.3	0.7

Table 2:  $P(B|A)$

A	B=F	B=T
A=F	0.7	0.3
A=T	0.85	0.15

Table 3:  $P(C|A)$

A	C=F	C=T
A=F	0.95	0.05
A=T	0.75	0.25

Table 4:  $P(D|B,C)$

B	C	D=F	D=T
B=F	C=F	0.45	0.55
B=F	C=T	0.85	0.15
B=T	C=F	0.85	0.15
B=T	C=T	0.6	0.4

Table 5:  $P(E|C)$

C	E=F	E=T
C=F	0.45	0.55
C=T	0.85	0.15

Table 6: Observed Values

Node	Value
A	TRUE
D	TRUE

Table 7: Initial Values

Node	Value
B	FALSE
C	FALSE
E	FALSE

## 2 Scheduling

Provide a complete resource constrained schedule for the actions found in Table 8. (4 marks)

Please note that the values in the 'After' column refer to the *index* of the action. So '1' refers to Start, not Action 1.

Table 8: Actions

Index	Action	Duration	Uses	Consumes	After
1	Start	0		0 nails	NA
2	Action 1	50	Saw	0 nails	1
3	Action 2	45	Saw	-1 nail	1
4	Action 3	25	Saw	-1 nail	1
5	Action 4	5		0 nails	4,3
6	Action 5	25		1 nail	3,5,4
7	Action 6	50	Saw	1 nail	5,6,2,3,4
8	Action 7	10	Saw,Hammer	0 nails	4
9	Finish	0		0 nails	7,8

### 3 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 9.

Table 9: Dirichlet (Beta) Parameters for Layout

Layout	Parameter 1	Parameter 2
A	8	5
B	10	6
C	10	4

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 10.

Table 10: Samples from Layout Dirichlet (Beta) Distributions

Layout	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
A	0.56	0.41	0.25	0.36	0.41
B	0.6	0.34	0.36	0.37	0.41
C	0.38	0.45	0.31	0.43	0.25

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)

## 4 Convolution layers in CNNs

Tables 11 to 13 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 11: Input Matrix

1	5	-1
0	-4	-1
4	-5	1

Table 12: Filter 1

-2	3
2	4

Table 13: Filter 1

2	3
0	3

## 5 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)

## 6 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)