Registration No _____

National University of Computer and Emerging Sciences, Lahore Campus

Course:	Artificial Intelligence	Course Code:	CS401
Program:	BS(Computer Science)	Semester:	Spring 2017
Duration:	3 hour	Total Marks:	45
Paper Date:	18-05-17	Weight	45%
Section:	A, B, C, D and E	Page(s):	
Exam:	Final	Reg. No(Sec)	----------

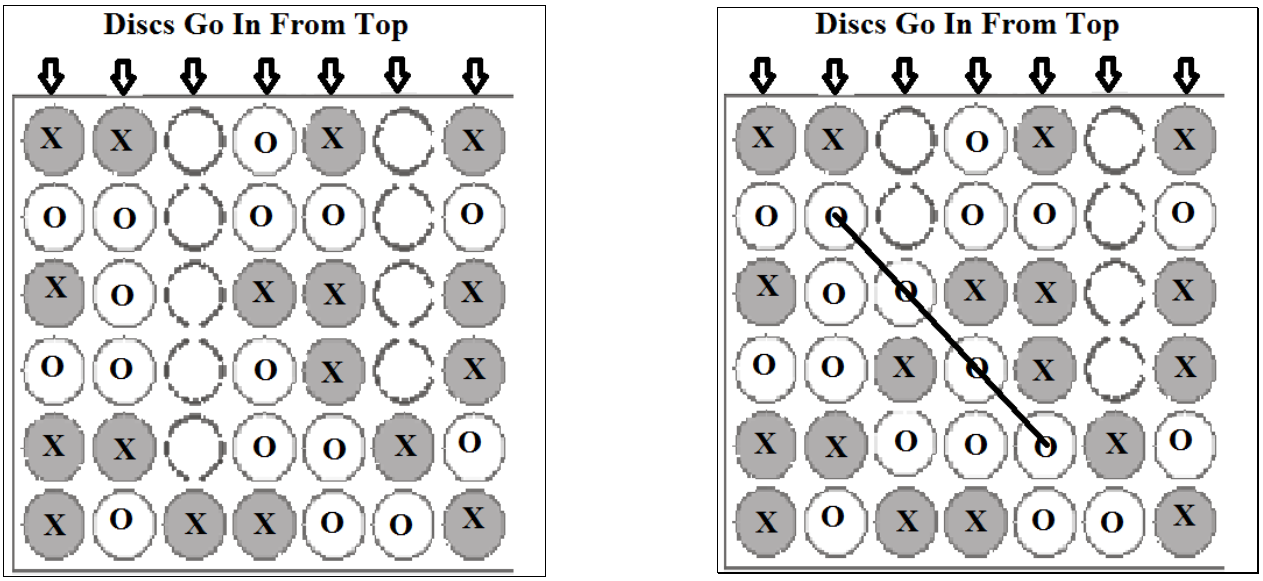
Instruction/Notes:

- *One hand written A4 cheat sheet is allowed.*
- *You are allowed to use rough sheets but please write your final answers on the provided space and do not forget to attach all rough sheets at the end of this paper*

Question 1: **[1 + 4] Points**

Game Playing: Four In A Row **Estimated Time: 25 Minutes**

Four in a Row is a two-player connection game in which the players first choose a color and then take turns dropping colored discs from the top into a seven-column, six-row vertically suspended grid. (As shown in figure 1a) The objective of the game is to be the first to form a horizontal, vertical, or diagonal line of four of one's own discs before your opponent.



a b

Figure 1

Figure 1: a Four in a Row Game grid. Discs can only be added from top. For sake of paper we represent two different colors by X and O
Figure 1: b Grey Win state for, as four grey discs are on diagonal

The rules for Four in a Row are simple.

- The field (board) has seven columns and six rows.
- Two players play by alternately dropping a chip down one of the columns (from top).
- The chip drops to the lowest unoccupied spot in that column.
- The first player to get four of his own chips in a row, either vertical, horizontal, or diagonal, wins.
- The game ends in a draw if it fills before someone wins.

An AI student has decided to build an automatic player of FOUR IN A ROW using MINIMAX algorithm. Initially he decide to calculate a move at any given point in the game by building a complete game tree.

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a) How many nodes will the game tree have when making the first move? (Give an approximate Answer)
Note that at each level a player has about seven possible moves

The student figured out that the number of nodes in the game tree is large enough to prohibit building a complete game tree therefore he decided to choose a move by looking only **D** level deep in the tree. For this purpose he comes up with a heuristic/evaluation function E.

```
int[][] evaluationTable = {{3, 4, 5,  7,  5,  4, 3},
                           {4, 6, 8,  10, 8,  6, 4},
                           {5, 8, 11, 13, 11, 8, 5},
                           {5, 8, 11, 13, 11, 8, 5},
                           {4, 6, 8,  10, 8,  6, 4},
                           {3, 4, 5,  7,  5,  4, 3}};
//This evaluation table is used as follows

int evaluateContent() {
        int utility = 128;
        int sum = 0;
        for (int i = 0; i < rows; i++)
            for (int j = 0; j <columns; j++)
                if (board[i][j] == 'O')
                    sum -= evaluationTable[i][j];
                else if (board[i][j] == 'X')
                    sum += evaluationTable[i][j];
        return utility + sum;
    }
```

The main idea behind this evaluation function is that the numbers in the table indicate the number of four connected positions which include that space. This gives a measurement of how useful each square is for winning the game and hence it helps decide the strategy.
The student implemented the MINIMAX (with alpha-beta pruning) algorithm using his heuristic/evaluation function. For the state of game given in figure 2**.**

b) It is X's turn to make a move show which move will be selected by the MINIMAX if D = 1

			X			
			O	O		

Figure 2 Representing one player with **X** *and one with* **O,** *instead of colored discs*

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Hint (Now the tree will only be looked D levels deep from current state, and the move with best value will be chosen.**)**

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Question 2 **10 Points**

Search Algorithms: BFS, Heuristics, A* Estimated Time: **25 Minutes**

Answer the following questions about the search space shown in the figure 3, S is source and G is destination. The arrows indicate the moves and the numbers by the arrows give the step-cost associated with a move. Assume that any ties are settled alphabetically.

For the questions that ask for a path, please give your answers in the form 'S – A – D – G.' for path.

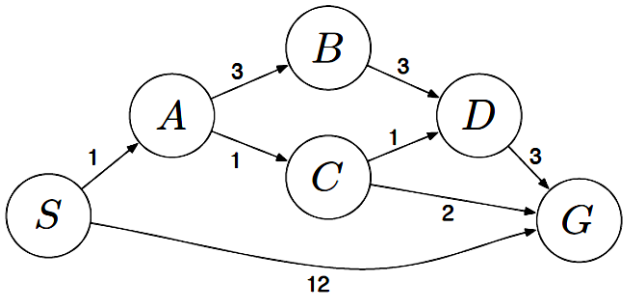

Figure 2

Note: Nodes in the fringe (i.e. Open List) are mentioned in the order they are pushed in the fringe.

a) **What path would breadth-first graph search return for this search problem and also mention the nodes in the fringe/frontier (i.e. Open List) after the goal is found?** **[2 + 2 Points]**

i)	Consider the heuristics for this problem shown in the table below **Is h_1 admissible? Also give reason for your answer**	**[1 + 1 Points]**
ii)	**Is h_2 admissible? Also give reason for your answer.**	

State	h_1	h_2
S	5	4
A	3	2
B	6	6
C	2	15
D	3	3
G	0	0

a) What path would A* graph search return if h_2 is used as the heuristic. Also mention the nodes in the fringe after the path found? [2 Points]

b) What path would A* graph search return if h_1 is used as the heuristic. Also mention the nodes in the fringe after the path found? [2 Points]

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Question 3 **[10 Points]**

Probabilities and Naive Bayes' Estimated Time: **25Minutes**

In a high level meeting at GOOGLE it has been decided to use the Naive Baye's along with unigram features to classify each email as **SPAM** or **HAM**. An email with K words $\mathbf{w_1, w_2, \ldots, w_K}$ is assigned a label by computing

$$\text{class} = \arg\max_{c \in \mathbb{C}} P(c|d) = \arg\max_{c \in \mathbb{C}} P(c) \prod_{i=1}^{K} p(w_i|c).$$

Where **arg max** means that the class with maximum probability will be the predicted class.

The probabilities $\mathbf{P(w_i|c)}$ have already been estimated and given in following table.

W	P(w|c=spam)	P(w|c=Ham)
note	1/6	1/8
to	1/8	1/3
self	1/4	1/4
become	1/4	1/12
perfect	1/8	1/12

NOTE: $\Sigma_{c \in C} P(c) = 1$, *where P(c) is prior probability*

a). Compute the label of the following email consisting of only two words perfect and note **[4 Points]**

perfect note

i) if P(Y = SPAM) is 0.3

ii) if P(Y = HAM) is 0.4

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b). Given the following five emails as a training set: **[2 + 2 + 2 Points]**

Training Set

(SPAM) dear sir, I write to you in hope of recovering my gold watch. sir please return my watch.

(SPAM) dear customer, please retry.

(HAM) hey, lunch at 12?

(HAM) fine, watch it tomorrow night

(HAM) dear baig, I am planning to join FAST-LAHORE.

Compute the estimates of following probabilities using Laplace smoothing. Ignoring all words of length less than 3, and ignoring all non-alphabetical characters.

i) P(W = sir | Y = HAM)
ii) P(W = dear | Y = SPAM)
iii) P(Y = HAM)

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Question 4 **[8 points]**

Genetic Algorithm and Hill Climbing Estimated Time: **25 Minutes**

a). Training neural network with Genetic Algorithms: **[6 points]**

Training a neural network is a task of finding the optimal weights such that the error is minimized. Algorithms we read in class such as delta rule used gradient decent to find optimal solution.

Genetic algorithms are also commonly used to generate high-quality solutions for optimization problems by relying on bio-inspired operators such as mutation, crossover and selection.

Can we use genetic algorithm to train neural network? (Assume that the network architecture is given)

I. **How will you design a chromosome?**
II. **What will be your fitness function?**
III. **How will cross over and mutation work?**

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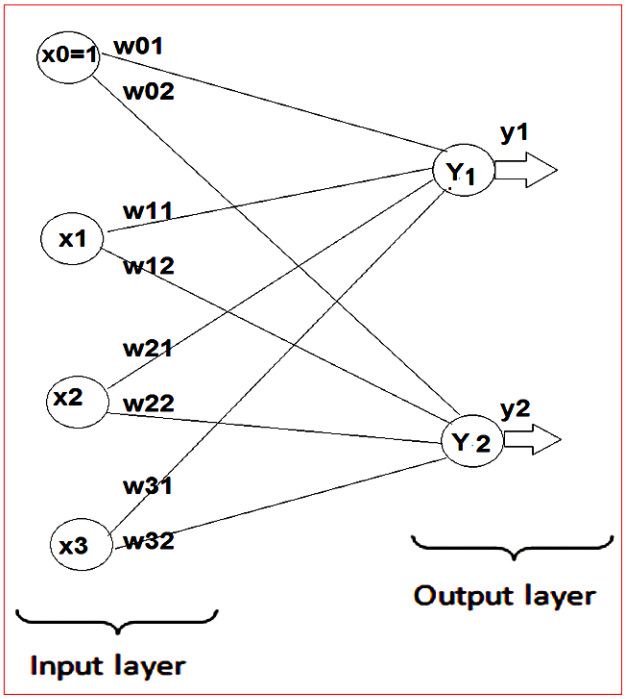
b). Getting stuck in local minima is a problem of Hill climbing algorithm. Suggest one solution to avoid this problem. State your answer in 2 to 3 lines. **[2 points]**

Question 5 **[12 Points]**

Classification Estimated Time:**35 Minutes**

a). Neural Network. **[8 Points]**

The university is considering to standardize the grading system that will be based on their overall performance throughout the semester. Percentage obtained in Quiz Mid and Final will all be used as features and one Letter Grade will be assigned from A B C or F. This makes it a multiclass classification problem, where scores are input and Grades are classes. We have decided to use the following architecture of Neural Network to solve the problem.



$y_1 = \begin{cases} 1 \text{ if } x_0*w_{01}+x_1*w_{11}+x_2*w_{21}+x_3*w_{31} >= 0 \\ 0 \text{ otherwise} \end{cases}$

$y_2 = \begin{cases} 1 \text{ if } x_0*w_{02}+x_1*w_{12}+x_2*w_{22}+x_3*w_{32} >= 0 \\ 0 \text{ otherwise} \end{cases}$

x0 is bias
x1 percentage obtained in Quizzes
x2 percentage obtained in Mid
x3 percentage obtained in Finals

Note that this network has only two output neurons and each output neuron is a simple threshold unit

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The mapping of output y_1 and y_2 to class **A, B, C or F** is given in following table

y1	y2	class
1	1	A
1	0	B
0	1	C
0	0	F

Use perceptron learning rule to update the network weights using only one training instance given below Consider all the weights to be **1** initially. After training, **test** your network for the given single test instance.

Training Instance			
Quiz% (x1)	**Mid% (x2)**	**Final% (x3)**	**Grade(class)**
0.83	**0.23**	**0.94**	**B**
Test Instance			
Quiz% (x1)	**Mid% (x2)**	**Final% (x3)**	**Grade(class)**
0.79	**0.47**	**0.97**	**A**

Training

Test

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b). What is the difference between regression and classification? State your answer in 2 to 3 lines with an example. [2 point]

c). What is the difference between supervised and unsupervised learning? State your answer in 2 to 3 lines. [2 point]

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Question [BONUS/OPTIONAL PART]

We need to create an intelligent shopping Robot which will operate in large single-story shopping mall to facilitate the customers.

The shopping mall is divided into a number of regions and each region contains a range of products. Some of the regions are adjacent to each other and the Robot can directly go to any of the neighboring/adjacent region of a given region.
The whole map of the shopping mall can be represented as a graph with the nodes as regions and there is an undirected edge between neighboring regions.

As programmer of the shopping robot we can use a simple command MOVE_To(R_ID) move to region R_ID that is adjacent to the present region and the Command PICK_UP(ITEM_ID) to pick the item using the ITEM_ID.

The user of our Robot will provide it the ITEM_ID of a single item to be purchased and the main job of our shopping Robot will be to identify the target region that contains the item by using a database and then go to the appropriate part of the store and bring the requested item by using minimum number of steps. You can assume that we can query the database by using the interface function R_ID = QUERY(ITEM_ID); It has been decided to formulate the problem of finding the shortest path from the Robots initial position to the destination region and hence your first job is to formulate this problem as a search problem.

Part a) **[2 Points]**

Completely specifying a minimal set of items needed to keep the state of the problem.

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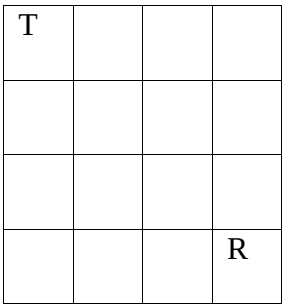
Part b) **[1 + 2 Points]**

Now assume that each floor of the mall is divided into **n x n** square regions. The robot is in the right-bottom corner and the target region is in the upper-Left corner where the Robot can only move either horizontally or vertically. Such a floor is shown in the figure below.



- How many regions would be expanded, in the best and worst case, by **DFS** algorithms? give a brief JUSTIFICATION of your answer (Assume Graph Search Versions of DFS is implemented).

- How many regions would be expanded by the A* search algorithms if the City-block-Distance is used as a heuristic function? give a brief JUSTIFICATION of your answer (Assume Graph Search Versions of DFS is implemented).
  The City-Block-Distance is defined as the sum of horizontal and vertical distances.