TUNKU ABDUL RAHMAN UNIVERSITY OF MANAGEMENT AND TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATION TECHNOLOGY

ACADEMIC YEAR 2023/2024

OCTOBER EXAMINATION

COMPUTER SCIENCE BACS2003
ARTIFICIAL INTELLIGENCE

THURSDAY, 26 OCTOBER 2023 TIME: 9.00 AM - 11.00 AM (2 HOURS)

BACHELOR OF SOFTWARE ENGINEERING (HONOURS)

Instructions to Candidates:

Answer **ALL** questions. All questions carry equal marks.

BACS2003 ARTIFICIAL INTELLIGENCE

Question 1

a) Artificial Intelligence (AI) has been applied in wide ranges of industries, including medicine, agriculture, finance and many more. Provide and explain **TWO (2)** applications on how AI technologies can enhance the education field. (2 + 2 marks)

b) Figure 1 shows a map's state space consists of 10 stations. An AI search robot is used to find the travel path between stations A and G by using two search algorithms: Breadth First Search (BFS) and Depth First Search (DFS).

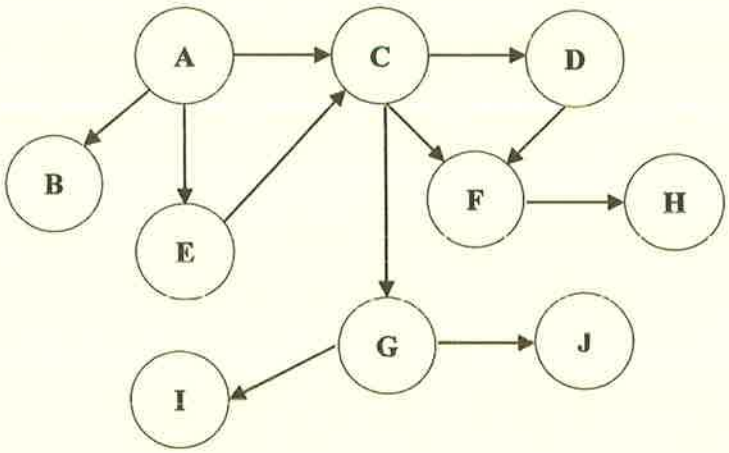


Figure 1: State space

(i) Formulate the *goal, optimal solution, abstraction, initial state, successor function, goal test, step cost and path cost* in the problem above. (8 marks)

(ii) For each search algorithm, illustrate a resulting search tree.
(Note: The search should be conducted in alphabetical order). (5 marks)

(iii) For each search algorithm, identify its search path and the solution path returned. (2 + 2 marks)

(iv) Compare the performance between the BFS and DFS in terms of completeness and optimality. (4 marks)

[Total: 25 marks]

Question 1 a)

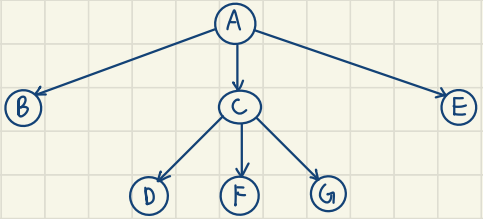
- AI technologies can be applied to analyze students' performance data to personalize the lessons for different types of students.
- Natural Language Processing (NLP) technique can be used to automatically mark students' essays and provide the grade with appropriate feedbacks.

Question 1 b) (i)

- Goal : Reach station G
- Optimal solution : Reach station G using the shortest path
- Abstraction : Time
- Initial state : Station A
- Successor function : Function that stores all possible successor movement from the current state
- Goal test : Test if the current state equals to the goal state (station G)
- Step cost : Cost between two station
- Path cost : Total cost from station A to G

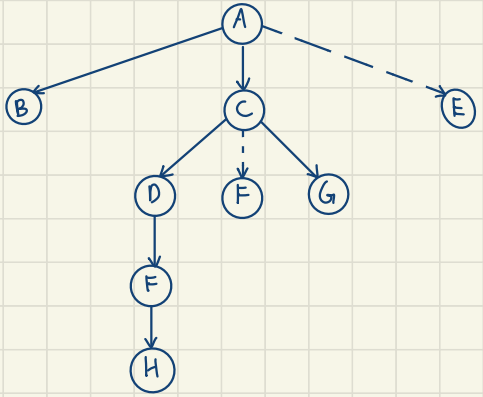
Question 1 b) (ii)

Breadth First Search (BFS)



Open	Closed
~~A~~	
~~B~~, ~~C~~, E	A
	B
E, D, F, G	C

Depth First Search (DFS)



Open	Closed
~~A~~	
~~B~~, ~~C~~, E	A
	B
~~D~~, F, G	C
~~F_D~~, ~~F_C~~, G	D
~~H~~, G	F_D
G	H

Question 1 b) (iii)

Search path

BFS : A - B - C

DFS : A - B - C - D - F - H - G

Solution path

BFS : A - C - G

DFS : A - C - G

Question 1 b) (iv)

	BFS	DFS
Completeness	BFS is complete since it has successfully found out the solution path.	DFS is complete since it has successfully found out the solution path.
Optimality	BFS is more optimal compared to DFS. Since the goal state is at a lower level, it is suitable for BFS to explore the nodes by level to level	DFS is less optimal compared to BFS It is suitable for exploring the nodes in deeper level. However, the goal state is at a shallow level.

BACS2003 ARTIFICIAL INTELLIGENCE

Question 2

a) Below shows the segment of the knowledge.

James logged into multiplayer game. He teamed up with 4 players for a mission. Together, they battled fierce enemies, looted treasures and levelled up skills. James communicated with his teammates using in-game chat and coordinated strategies in the mission. After overcoming the mission, they unlocked new abilities and discovered hidden secrets.

(i) Frames and semantic networks are two commonly used methods for representing knowledge before system coding. Explain why a semantic network is a more suitable choice for representing the aforementioned information. (2 marks)

(ii) Illustrate the information above with a semantic network. (7 marks)

b) Consider a sentence *S* = *The woman shot the man with a camera.*
Explain **TWO (2)** types of ambiguities found in the sentence *S*. (2 + 4 marks)

c) Illustrate **ONE (1)** parse tree for the sentence *S* provided in **Question 2 b)**, with the use of the grammar rules provided in Figure 2. (6 marks)

```
noun_phrase(NP)
verb_phrase(VP)
preposition_phrase(PP)
determiner(D)
noun(N)
verb(V)
S -> NP VP
NP -> N | N PP | D NP | D N | N N
VP -> VP PP | V NP
PP -> P NP
N -> [woman, man, camera]
V -> [shot]
P -> [with]
D -> [the, a]
```

Figure 2: Grammar rules

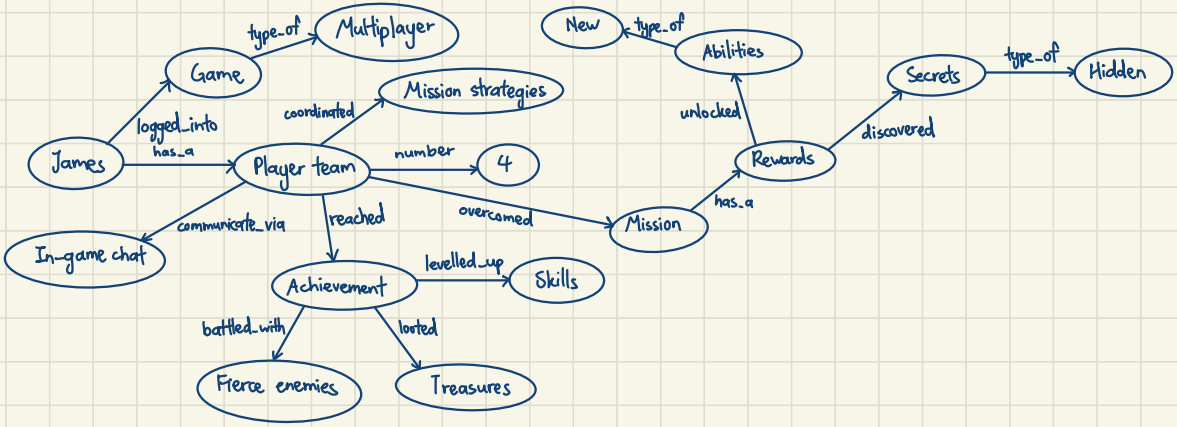
d) Provide and explain **TWO (2)** symbolic analysis in Natural Language Processing. (4 marks)

[Total: 25 marks]

Question 2 a)

(i) Semantic network is more suitable for describing the relationship between object and the overall concept.

(ii)



Question 2 b)

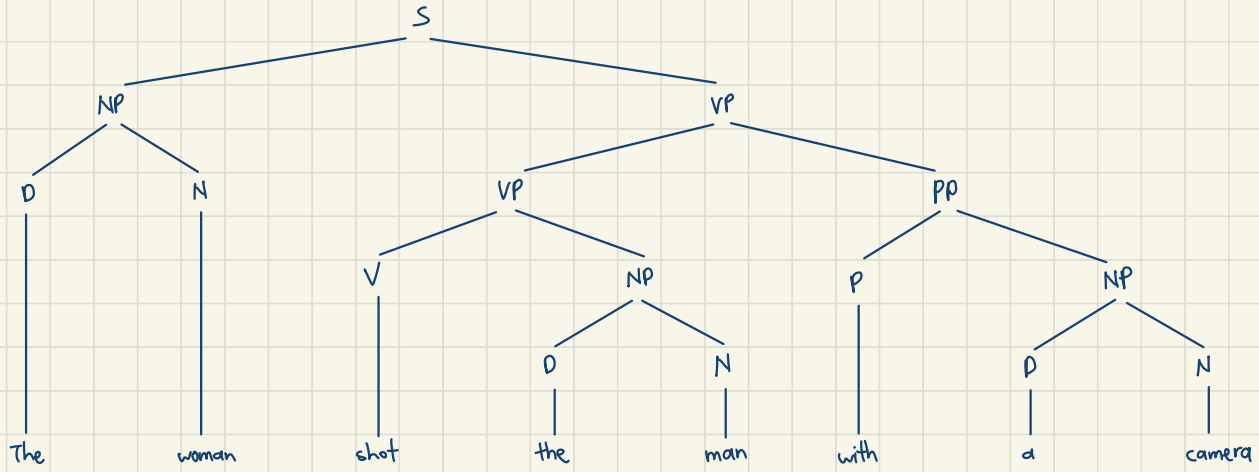
Semantic ambiguity

- The word 'shot' may represents two meanings.
- First meaning is capturing something.
- Second meaning is shooting something to hit someone.

Syntactic ambiguity.

- The sentence may represent two syntactic structures although they have the same sequence.
- First structure is the woman shot the man who is bringing a camera.
- Second structure is the woman using a camera to shot the man.

Question 2 c)



Question 2 d)

Phonology
- Combination of sound to form a language.
- It is related to pronunciation.

Pragmatic
- Study of the ways in which language is used and its effect on listener
- It can be analyzed through experience.

Question 3

a) Table 1 shows the attributes and sample values found in a dataset on hypertension (high blood pressure), which was compiled by a team of researchers from ABC University. The dataset comprises 12 records of hypertension data obtained through direct questionnaires administered to patients at XYZ Hospital. The data collection process was approved by a specialist, and the dataset was compiled with the aim of early-stage hypertension risk identification.

Table 1: Attributes of the hypertension dataset collected from XYZ Hospital

Family History	Obesity	Alcohol Consumption	Smoker	Hypertension
Yes	No	Yes	No	Yes
No	Yes	No	Yes	No
No	No	No	Yes	Yes
Yes	No	Yes	Yes	Yes
No	No	Yes	No	No
Yes	No	No	No	No
No	Yes	No	Yes	Yes
No	Yes	Yes	No	Yes
Yes	No	No	Yes	No
Yes	Yes	Yes	Yes	Yes
No	No	Yes	No	No
No	Yes	No	Yes	Yes

Refer to Table 1, given a new sample, $D = <$ Yes, Yes, Yes, No $>$, predict the class it belongs to, $P(h|D)$, using Naïve Bayes classification. The equation of the Naïve Bayes classification is provided below.

$$P(h|D) = \frac{P(D|h)P(h)}{P(D)}$$

(15 marks)

b) A team of researchers from S University aims to predict risk of hypertension using a multilayer Neural Network (NN). The dataset that the researchers use is shown in Table 1. Design an architecture of multilayer NN based on the attributes as shown in Table 1 and label the structure clearly. (4 marks)

c) Table 2 shows a confusion matrix. Calculate the accuracy, precision and recall in 2 decimal places for "Yes" case. (6 marks)

Table 2: Confusion matrix

	Predicted Yes	Predicted No
Actual Yes	83	5
Actual No	10	64

[Total: 25 marks]

Question 3 a)

$$P(\text{Yes} \mid D) = P(\text{Yes} \mid \text{Yes}) \times P(\text{Yes} \mid \text{Yes}) \times P(\text{Yes} \mid \text{Yes}) \times P(\text{No} \mid \text{Yes}) \times P(\text{Yes})$$

$$= \frac{3}{7} \times \frac{4}{7} \times \frac{4}{7} \times \frac{2}{7} \times \frac{7}{12}$$

$$= 0.0233$$

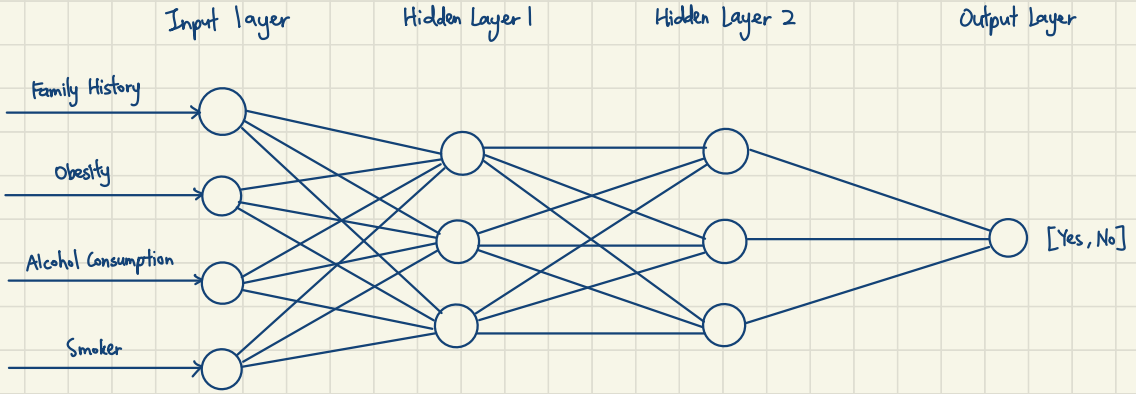
$$P(\text{No} \mid D) = P(\text{Yes} \mid \text{No}) \times P(\text{Yes} \mid \text{No}) \times P(\text{Yes} \mid \text{No}) \times P(\text{No} \mid \text{No}) \times P(\text{No})$$

$$= \frac{2}{5} \times \frac{1}{5} \times \frac{2}{5} \times \frac{3}{5} \times \frac{5}{12}$$

$$= 0.008$$

$\therefore$ Since $P(\text{Yes} \mid D) > P(\text{No} \mid D)$, the patient is most probably belongs to class 'Yes' which is hypertension.

Question 3 b)



Question 3 c)

$$\text{Accuracy} = \frac{83+64}{83+5+10+64}$$

$$= \frac{147}{162}$$

$$= 0.91$$

$$\text{Recall} = \frac{83}{83+5}$$

$$= \frac{83}{88}$$

$$= 0.94$$

$$\text{Precision} = \frac{83}{83+10}$$

$$= \frac{83}{93}$$

$$= 0.89$$

BACS2003 ARTIFICIAL INTELLIGENCE

Question 4

a) The scanned document in Figure 3 shows a missing portion of pixels (with an actual value of 2) resulting from a poor scanning process. Figure 4 represents the pixel value of Figure 3. Utilising the structuring element depicted in Figure 5, apply both dilation and erosion operations to Figure 4. Then, develop a resulting complete pixel for each operation. The origin of the structuring element is denoted by the bold box in Figure 5. Also, conclude which technique is more suitable to restore the missing part of the Figure 3.

(10 + 1 marks)

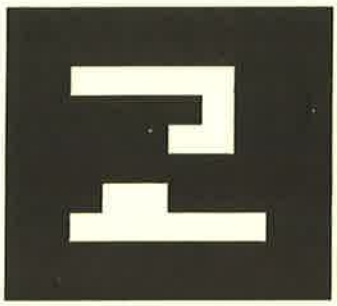


Figure 3: Scanned image

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	1	1	1	1	1	0	0	0
0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	1	1	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	1	1	0	0	0	0	0
0	0	1	1	1	1	1	1	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Figure 4: Pixel value

1	1
1	**1**

Figure 5: Structuring element

b) The following is the rule base for detection of lung cancer.

R1: IF experiences unexplained weight loss,
AND persistent cough lasting more than three weeks,
OR blood in their sputum,
AND has a history of smoking,
THEN there is a high likelihood of lung cancer (0.9)

R2: IF persistent cough lasting more than three weeks,
AND has a history of smoking,
OR exposure to environmental toxins,
THEN there is a high likelihood of lung cancer (0.7)

R3: IF exhibits symptoms of recurring pneumonia or difficulty swallowing,
AND has a history of smoking,
AND exposure to environmental toxins,
THEN there is a high likelihood of lung cancer (0.8)

Figure 6 shows the observed conditions of Patient Z. Based on the expert rules above and the observed conditions, calculate the inference and conclude the likelihood of lung cancer of Patient Z by using certainty factor (CF). If necessary, you are required to use the formulae for combination of 2 rules provided in Figure 7. (10 + 1 marks)

Question 4 a)

Dilation

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	1	1	1	1	1	1	0	0
0	0	1	1	1	1	1	1	0	0
0	0	0	0	0	1	1	1	0	0
0	0	0	0	0	1	1	1	0	0
0	0	0	1	1	1	0	0	0	0
0	0	1	1	1	1	1	1	1	0
0	0	1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0

Erosion

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

- In conclusion, the dilation technique is more suitable to restore the missing part.

Question 4 b)

R1 : CF(Lung Cancer) = min(max(min(0.7, 0.6), −1.0), 0.9) × 0.9
= min(max(0.6, −1.0), 0.9) × 0.9
= min(0.6, 0.9) × 0.9
= 0.6 × 0.9
= 0.54

R2 : CF(Lung Cancer) = max(min(0.6, 0.9), 0.75) × 0.7
= max(0.6, 0.75) × 0.7
= 0.75 × 0.7
= 0.525

R3 : CF(Lung Cancer) = max(max(0.2, 0.9), 0.75) × 0.8
= max(0.9, 0.75) × 0.8
= 0.9 × 0.8
= 0.72

CF(Lung Cancer) = 0.54 + 0.525 − 0.54 × 0.525
= 0.7815

CF(Lung Cancer) = 0.7815 + 0.72 − 0.7815 × 0.72
= 0.93882

∴ There is a high likelihood of lung cancer of Patient Z. (CF 0.93882)

Question 4 b) (Continued)

Experiences unexplained weight loss	= 0.7
Persistent cough lasting more than three weeks	= 0.6
Blood in their sputum	= -1.0
Has a history of smoking	= 0.9
Exposure to environmental toxins	= 0.75
Exhibits symptoms of recurring pneumonia or difficulty swallowing	= 0.2

Figure 6: Observed condition of Patient Z

$CF1+CF2-CF1*CF2$	if CF1 and CF2 are positive,
$CF1+CF2+CF1*CF2$	if CF1 and CF2 are negative,
$\frac{CF1+CF2}{1-\min(\lvert CF1\rvert,\lvert CF2\rvert)}$	otherwise

Figure 7: Formulae for combination of 2 rules

c) Provide and explain **ONE (1)** application of how fuzzy logic techniques can be applied in kitchen appliances. (3 marks)

[Total: 25 marks]

Question 4 c)

- Smart camera can apply fuzzy logic to adjust the focus based on object sharpness.

- R1
  IF the image is very blur
  THEN the camera will have a strong focus adjustment

- R2
  IF the image is slightly blur
  THEN the camera will have a slight focus adjustment