TUNKU ABDUL RAHMAN UNIVERSITY OF MANAGEMENT AND TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATION TECHNOLOGY

ACADEMIC YEAR 2024/2025

OCTOBER EXAMINATION

BACS2003 ARTIFICIAL INTELLIGENCE

TUESDAY, 15 OCTOBER 2024 TIME: 2.00 PM – 4.00 PM (2 HOURS)

BACHELOR OF INFORMATION SYSTEMS (HONOURS) IN ENTERPRISE INFORMATION SYSTEMS

BACHELOR OF INFORMATION TECHNOLOGY (HONOURS) IN SOFTWARE SYSTEMS DEVELOPMENT

BACHELOR OF SOFTWARE ENGINEERING (HONOURS)

Instructions to Candidates:

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

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Question 1

a) The *Turing Test*, introduced by Alan Turing in his 1950 paper "Computing Machinery and Intelligence", aims to determine a machine's ability to exhibit intelligent behaviour indistinguishable from that of a human. Explain how *Turing Test* works. (3 marks)

b) **Figure 1** shows map's state space with 8 stations. An Artificial Intelligence (AI) search robot uses *Breadth First Search (BFS)* and *A* Search* algorithms to find the shortest travel distance from station *A* to station *H*. The values inside the state space show the distance from one station to another in *km*. **Table 1** lists the heuristic cost of each station relative to Station *H*.

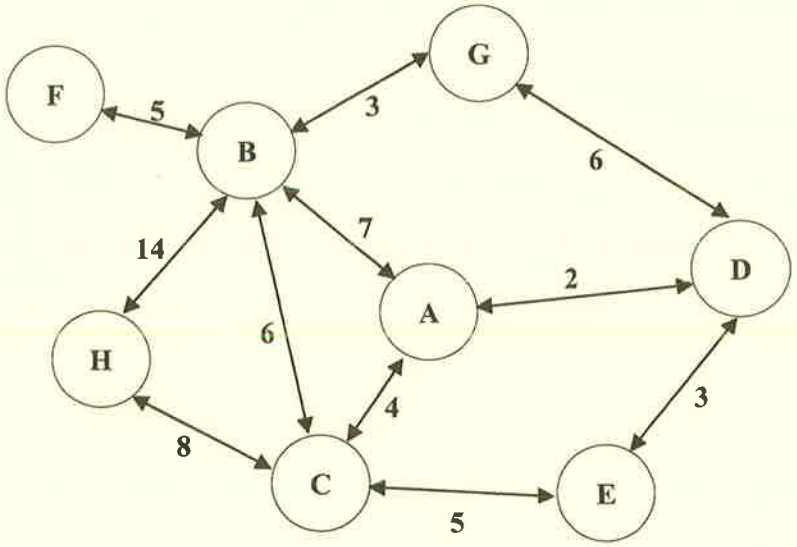


Figure 1: State space

Table 1: Heuristic cost

Station	A	B	C	D	E	F	G	H
Heuristic cost *(km)*	7	12	10	8	3	6	7	0

(i) Formulate the *goal, optimal solution, abstraction, initial state, successor function, step cost* and *goal test* in the problem above. (7 marks)

(ii) For each search algorithm, illustrate the *resulting search tree*.
(**Note:** The search should be conducted in alphabetical order). (11 marks)

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

[Total: 25 marks]

Question 1 a)

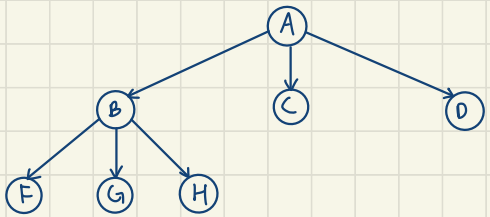
- The human judge (interrogator), machine and human are involved in Turing test.
- Interrogator asks a question to both machine and human via text-based interface such as computer keyboard and screen.
- Machine will take role of producing a response which is indistinguishable from human participants and exhibit intelligent behavior.
- Human will provide a baseline for comparison with machine response.
- If the interrogator cannot consistently tell which is machine, it means that the machine has passed the turing test.

Question 1 b) (i)

- Goal : Reach Station H
- Optimal solution : Reach Station H using the shortest distance
- Abstraction : Time
- Initial state : Station A
- Successor function : Function that stores all the successors from the current state
- Step cost : Cost between two stations
- Goal test : Test if the current state is equal to the goal state (Station H)

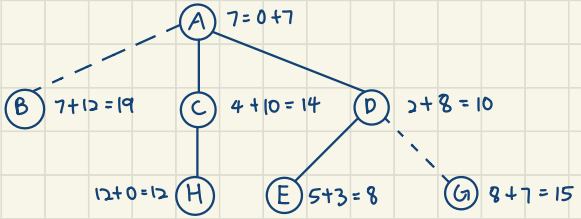
Question 1 b) (ii)

Breadth-First Search



Opening	Closed
A	
~~B~~, C, D	A
~~C~~, D, F, G, H	B

A* Search



(iii) Breadth-first search

- Search path : A - B
- Solution path : A - B - H

A* search

- Search path : A - D - E - C
- Solution path : A - C - H

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Question 2

a) **Figure 2** depicts the *semantic network* of a knowledge representation system.

(i) "The *semantic network* is not suitable to represent the knowledge. Instead, it is more suitable to be represented by *frames*."
Discuss the assertion above. (2 marks)

(ii) Reconstruct the knowledge in **Figure 2** into *frames*. (11 marks)

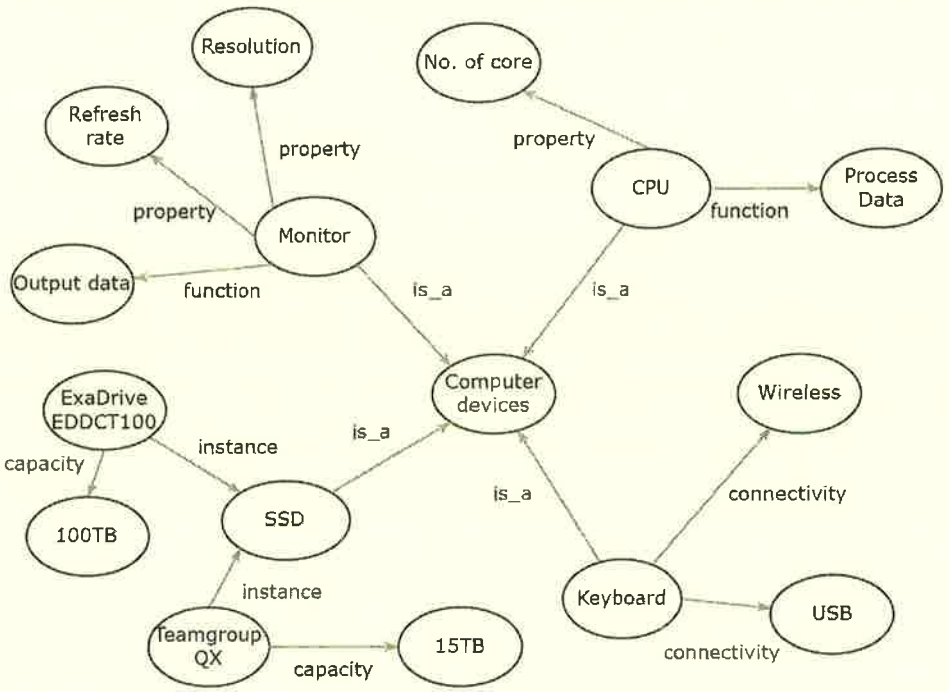


Figure 2: *Semantic network*

b) Consider a sentence *S* = *The large dog bit the man with a red hat.*
Name and explain **ONE (1)** ambiguity found in the sentence *S*. (3 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 3**. (9 marks)

noun_phrase(NP) verb_phrase(VP) preposition_phrase(PP) determiner(DET) noun(N) verb(V) preposition(P) adjective (ADJ)	Sentence -> NP VP NP -> DET N | N PP | DET NP | ADJ N VP -> V | V PP | V ADJ | VP PP | VP NP PP -> P NP | P VP N -> [dog, man, hat] V -> [bit] P -> [with] DET -> [the] ADJ -> [large, red]

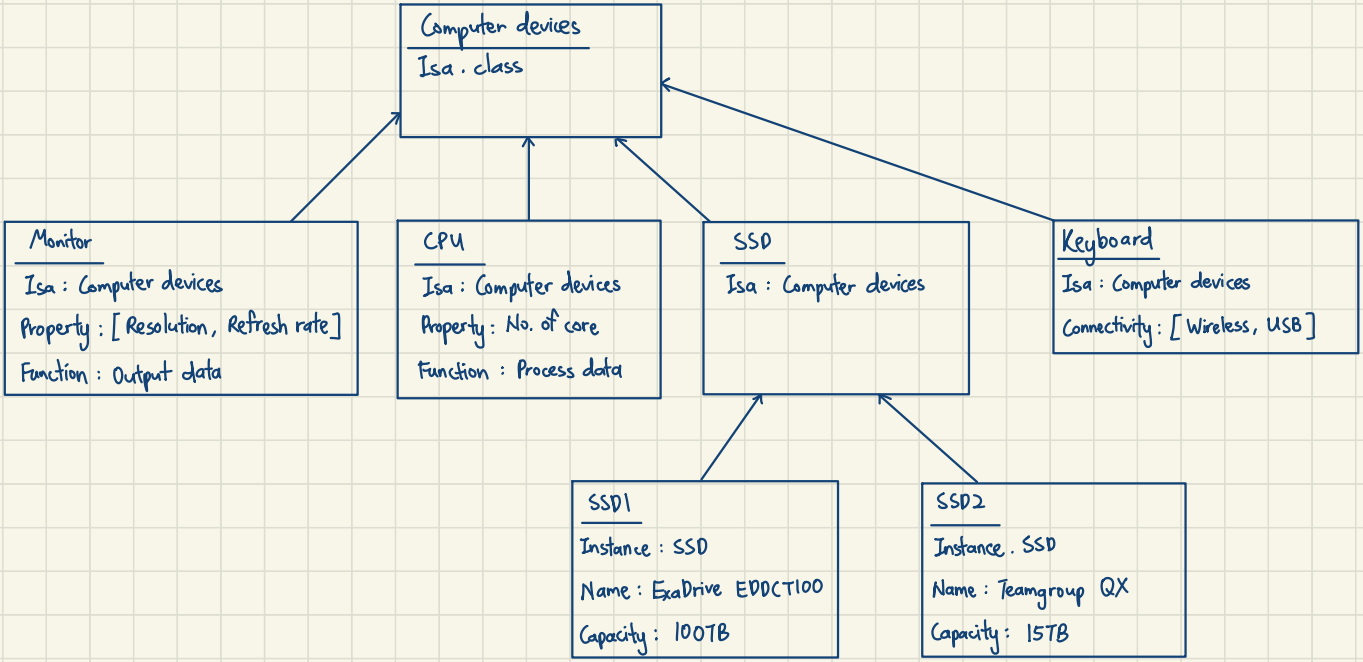
Figure 3: Grammar rules

[Total: 25 marks]

Question 2 a) (i)

- Frame is suitable to show the details of object and their relationship.
- The first syntactic structure is the large dog bits the man who is wearing a red hat.
- The second syntactic structure is the large dog uses a red hat to bit the man.

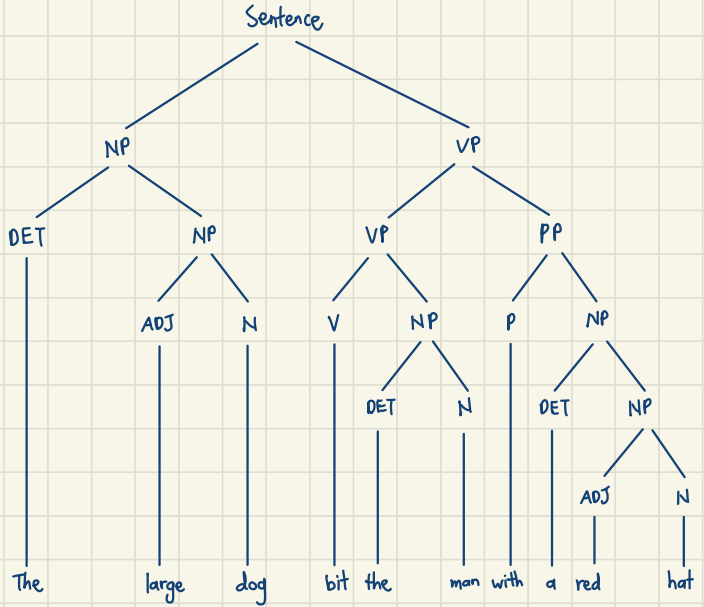
Question 2 a) (ii)



Question 2 b)

- Syntactic ambiguity.
- The sentence can represent two syntactic structure although it remains the same sequence.
-

Question 2 c)



Question 3

a) In machine learning, *k-means* clustering is a method employed to categorise similar data points into groups. Specifically, in **Table 2**, the data is clustered into two groups, denoted by k=2. Initially, the centre points for these groups are chosen randomly: *C1* at (14.0, 35.0) and *C2* at (30.0, 40.0).

Table 2: Sample of data

Data point	Feature 1	Feature 2
1	12.8	43.6
2	24.3	37.1
3	18.7	35.5
4	33.9	47.9
5	31.6	48.8
6	24.5	26.7
7	16.9	20.8
8	10.5	19.6

(i) Identify the clusters to which each data point will be assigned in the first iteration. (**Note**: You need to show the step-by-step process of assigning each data point to its respective cluster.) (12 marks)

(ii) Calculate the new centre points for the first iteration. (4 marks)

b) Based on a sample of 1200 collected data points, it was observed that 7% of the patients have been diagnosed with eczema. Using *k-nearest neighbours (KNN)*, the test results classify 72 eczema cases and 1100 non-eczema cases correctly. Meanwhile, *Support Vector Machine (SVM)* correctly identifies 69 eczema cases and 1097 non-eczema cases. Construct the confusion matrix for each algorithm. (2 + 2 marks)

c) Calculate the accuracy and precision of predicting eczema cases using *KNN* and *SVM* from **Question 3 b)**, using the equation shown in **Figure 4**. Determine which algorithm performs better. Justify your answer. (5 marks)

Accuracy = (TP + TN)/ (TN+FP+FN+TP)
Precision = TP / (TP +FP)

Figure 4: Equation of accuracy and precision

[Total: 25 marks]

Question 3 a) (i)

Data point	Center 1	Center 2
1	8.6833	17.5727
2	10.5119	6.3953
3	4.7265	12.1631
4	23.7154	8.8102
5	22.3652	8.9443
6	13.3843	14.3924
7	14.4931	23.2433
8	15.7927	28.2207

We obtain two clusters containing: $\{1, 3, 6, 7, 8\}$ and $\{2, 4, 5\}$

Question 3 a) (ii)

New cluster centers.

$C1\_new = \left(\frac{1}{5} \times (12.8 + 18.7 + 24.5 + 16.9 + 10.5), \frac{1}{5}(43.6 + 35.5 + 26.7 + 20.8 + 19.6)\right)$

$= (16.68, 29.24)$

$C2\_new = \left(\frac{1}{3} \times (24.3 + 33.9 + 31.6), \frac{1}{3}(37.1 + 47.9 + 48.8)\right)$

$= (29.94, 44.6)$

Question 3 b)

Actual yes = 1200 × 0.07
= 84

Actual no = 1200 - 84
= 1116

KNN

TP = 72

TN = 1100

FP = 1116 - 1100
= 16

FN = 84 - 72
= 12

SVM

TP = 69

TN = 1097

FP = 1116 - 1097
= 19

FN = 84 - 69
= 15

Confusion matrix of KNN

	Predicted Yes	Predicted No
Actual Yes	72	12
Actual No	16	1100

Confusion matrix of SVM

	Predicted Yes	Predicted No
Actual Yes	69	15
Actual No	19	1097

Question 3 c)

KNN

$$\text{Accuracy} = \frac{72 + 1100}{1200} = 0.9767$$

$$\text{Precision} = \frac{72}{72 + 16} = 0.8181$$

SVM

$$\text{Accuracy} = \frac{69 + 1097}{1200} = 0.9717$$

$$\text{Precision} = \frac{69}{69 + 19} = 0.7841$$

∴ KNN performs better than SVM because the accuracy and precision percentage of KNN is higher than SVM

Question 4

a) **Figure 5** displays the pixel values of a 9 x 9 image. Utilising a 3 x 3 structuring element with its origin at the centre, as depicted in **Figure 6**, show the modified pixel values after applying both *erosion* and *dilation* effects to the 9 x 9 image shown in the **Figure 5**. (9 marks)

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

Figure 5: 9 x 9 binary image

0	1	0
1	**1**	1
0	1	0

Figure 6: 3 x 3 structuring element

b) The following is the rule based for influenza detection used in an expert system.

R1: IF Fever (temperature > 37.8°C)
AND Cough
OR Sore throat
THEN There is a likelihood of influenza. (0.70)

R2: IF Sudden onset of fever
OR Sudden onset of body aches
THEN There is a likelihood of influenza. (0.80)

R3: IF Fever (temperature > 37.8°C)
AND Body aches (few days or weeks)
OR Fatigue
THEN There is a likelihood of influenza. (0.90)

Figure 7 shows the observed conditions of a new patient. Based on the expert rules above and the observed conditions, calculate the inference and conclude the likelihood of influenza for the new patient by using *certainty factor (CF)*. The formulae for combination of two rules are provided in **Figure 8**. (10 + 1 marks)

Question 4 a)

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

Dilation

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

Question 4 b)

R1 : CF(Influenza) = max(min (0.65, -1.00), 0.60) X 0.70 = max(-1.00, 0.60) X 0.70 = 0.60 X 0.70 = 0.42

R2 : CF (Influenza) = max (0.00, 0.85) X 0.80 = 0.85 X 0.80 = 0.68

R3 : CF (Influenza) = max (min (0.65, -1.00), 0.70) X 0.90 = max (-1.00, 0.70) X 0.90 = 0.70 X 0.90 = 0.63

CF (Influenza) = CF1 + CF2 - CF1 X CF2

= 0.42 + 0.68 - 0.42 X 0.68

= 0.8144

CF (Influenza) = 0.8144 + 0.63 - 0.8144 X 0.63

= 0.931328

≈ 0.9313

Conclusion : The new patient may get influenza. (CF 0.9313)

Question 4 b) (Continued)

Fever (temperature > 37.8°C)	= 0.65
Cough	= -1.00
Sore throat	= 0.60
Sudden onset of fever	= 0.00
Sudden onset of body aches	= 0.85
Body aches (few days or weeks)	= -1.00
Fatigue	= 0.70

Figure 7: Observed condition of a new patient

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 8: Formulae for combination of two rules

c) Name **ONE (1)** application of fuzzy logic in home appliance. In addition, design **TWO (2)** fuzzy rules with *different actions* for the mentioned application. (1 + 4 marks)

[Total: 25 marks]

Question 4 c)

- Smart washing machine can adjust the washing time and water level based on different load size.

- R1
  IF the load size is light
  THEN washing time is short

- R2
  IF the load size is heavy
  THEN washing time is long