NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2015-2016

CZ3005 – ARTIFICIAL INTELLIGENCE

Nov/Dec 2015 Time Allowed: 2 hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 7 pages.
2. Answer **ALL** questions.
3. This is a closed-book examination.
4. All questions carry equal marks.

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1. (a) State whether each statement is true (T) or false (F).

 (i) The games of chess, checkers, and Go offer a partially observable environment. (Hint: In case you are not familiar with one of the games, the answer is the same for each game.)

 (ii) Uniform-cost search can always find the optimal solution.

 (iii) Given two arbitrary admissible heuristics, h1 and h2, composite heuristic min(h1, h2) is better than the composite heuristic max(h1, h2).

 (iv) Depth-first search always expands at least as many nodes as A* search with an admissible heuristic.

 (v) For a search problem, the path returned by uniform cost search may change if we add a positive constant C to every step cost.

(5 marks)

Note: Question 1 continues on page 2

(b) Consider the following search problem, represented as a graph. The start state is S and the only goal state is G.

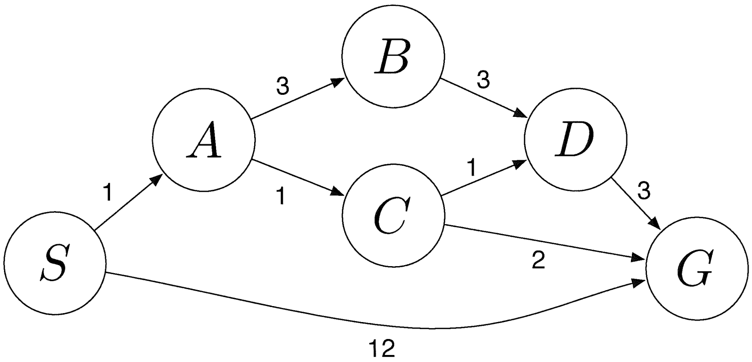


Figure Q1

Answer the following questions about the search problem in Figure Q1. Assume that ties are broken alphabetically. For example, a partial plan S->X->A would be expanded before S->X->B; similarly, S->A->Z would be expanded before S->B->A.

(i) What path would the breadth-first search return for this search problem?

(5 marks)

(ii) What path would the depth-first search return for this search problem?

(5 marks)

(iii) What path would the uniform cost search return for this search problem?

(5 marks)

(c) Explain the concept of Constraint Propagation and briefly discuss how it can make the search process more efficient.

(5 marks)

2. (a) A hurried traveler is seeking an efficient route from Philadelphia to Erie. Figure Q2a shows the map and the numbers on the arcs indicate the cost of traversing that arc.

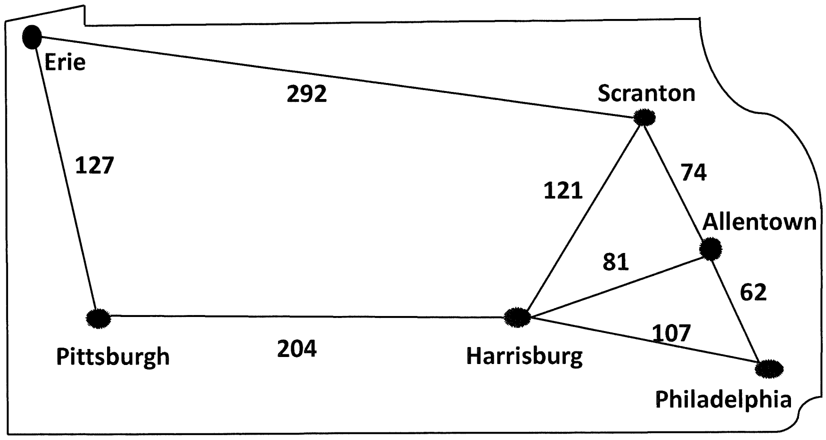


Figure Q2a

We use the heuristic estimating function in Table Q2 below. You need to find the shortest path using different search methods. If you find a path to a node already on the frontier, you update its cost (using the lower value) instead of adding another copy of that node to the frontier. If a node has been expanded, do not add the node to the frontier again. *You can use the first two letters of a city to represent the city.*

Table Q2

n	Pittsburgh	Harrisburg	Scranton	Allentown	Philadelphia
h(n)	100	225	250	290	330

(i) Apply **uniform cost search** to the graph in Figure Q2a: (1) list the nodes and their g(n) values in the order they would be expanded; (2) list the nodes that lie along the final path to the goal state.

(6 marks)

(ii) Apply **greedy search** to the graph in Figure Q2a: (1) list the nodes and their h(n) values in the order they would be expanded; (2) list the nodes that lie along the final path to the goal state.

(6 marks)

(iii) Apply **A* search** to the graph in Figure Q2a: (1) list the n-odes and their f(n) values in the order they would be expanded; (2) list the nodes that lie along the final path to the goal state.

(6 marks)

Note: Question 2 continues on page 4

(b) The tree in Figure Q2b represents all possible outcomes of a zero-sum game. This tree is from the perspective of the MAX player; MAX nodes are represented by squares and MIN nodes by circles. The leaves of the tree represent the value of the game for the MAX player.

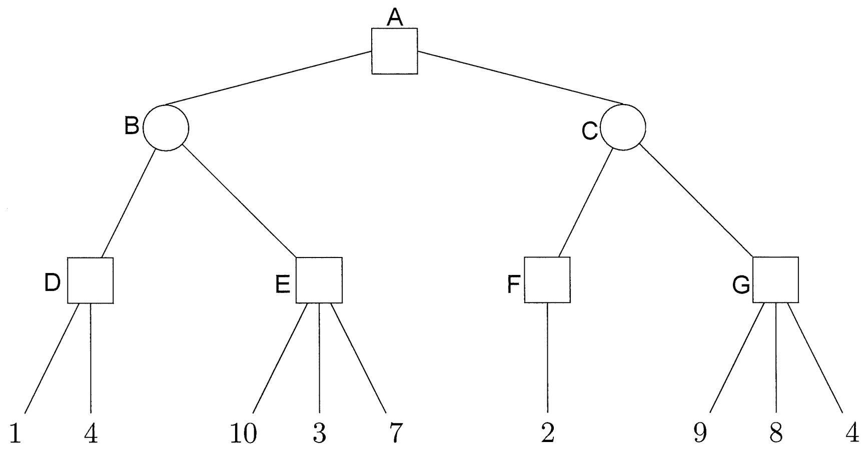


Figure Q2b

(i) Compute the “back-up" values of each node in the tree using the Minimiax strategy.

(6 marks)

(ii) Give the MAX player’s optimal first move.

(1 mark)

3. (a) State whether each statement is true (T) or false (F).

(i) $(\alpha \Rightarrow \beta) \equiv (\neg\alpha \wedge \beta)$ is implication elimination.

(ii) First-order logic assumes that the world consists of objects with certain relations among them that do or do not hold.

(iii) The generalized modus ponens inference rule provides a complete proof system for first-order logic, using knowledge bases in conjunctive normal form.

(iv) The execution of Prolog programs is done through depth-first forward chaining, where the clauses are tried in the order in which they are written in the knowledge base.

(4 marks)

Note: Question 3 continues on page 5

(b) Consider the following knowledge base.

1. $Close(Sumatra, Singapore)$
2. $Sick(Mary, 2014)$
3. $\forall y, HasFever(Susan, y)$
4. $Stay(David, Sumatra, 2013)$
5. $\forall y, ForestFire(Sumatra, y)$
6. $\forall z, Stay(John, Singapore, z)$
7. $\forall a, b, y, ForestFire(a, y) \land Close(a, b) \Rightarrow Haze(b, y)$
8. $\forall a, b, y, Haze(a, y) \land Stay(b, a, y) \Rightarrow Sick(b, y)$
9. $\forall a, y, HasFever(a, y) \Rightarrow Sick(a, y)$

Determine who was/were sick in 2013 using the **Modus Ponens** inference rule repeatedly. Show in detail all successful unifications and inference steps.

(7 marks)

(c) Consider the following passage.

Adrian has insomnia and has a headache. Brian has a blocked nose and does not have any appetite. Calvin has a headache and has a blocked nose. David has no appetite and has a headache. People who have insomnia and do not have appetite are sick. People who have a blocked nose also have insomnia. Sick people are sad.

(i) Convert the English sentences to First-Order Logic (FOL) sentences.

(4 marks)

(ii) Translate the derived FOL sentences in Q3(c)(i) to Conjunctive Normal Forms (CNF).

(4 marks)

(iii) Answer the question "Is anyone sad?" using **resolution with refutation**. Who is/are sad?

(6 marks)

4. (a) The training examples for fourteen match days in Table Q4 show whether a soccer match will be played based on four criteria, namely: haze level, number of reserve players available, humidity, and whether it rains.

Table Q4

Day	Haze Level	Number of Reserve Players	Humidity	Rain	Play Soccer
D1	Unhealthy	1	High	No	No
D2	Unhealthy	1	High	Yes	No
D3	Healthy	1	High	No	Yes
D4	Acceptable	2	High	No	Yes
D5	Acceptable	0	Normal	No	Yes
D6	Acceptable	0	Normal	Yes	No
D7	Healthy	0	Normal	Yes	Yes
D8	Unhealthy	2	High	No	No
D9	Unhealthy	0	Normal	No	Yes
D10	Acceptable	2	Normal	No	Yes
D11	Unhealthy	2	Normal	Yes	Yes
D12	Healthy	2	High	Yes	Yes
D13	Healthy	1	Normal	No	Yes
D14	Acceptable	2	High	Yes	No

Based on the information gain measure, construct a decision tree for classifying whether a soccer match will be canceled from the training examples given above.

(11 marks)

(b) Consider a medical diagnosis problem in which there are two possible outcomes: (1) the patient has liver cancer, and (2) the patient does not have liver cancer. A particular laboratory test provides two possible outcomes: positive and negative. We have the prior knowledge that only 0.6% of the entire population have liver cancer. The test returns a correct positive result on only 97% of the cases in which liver cancer is actually present. The test returns a correct negative result on only 98% of the cases in which liver cancer is actually not present.

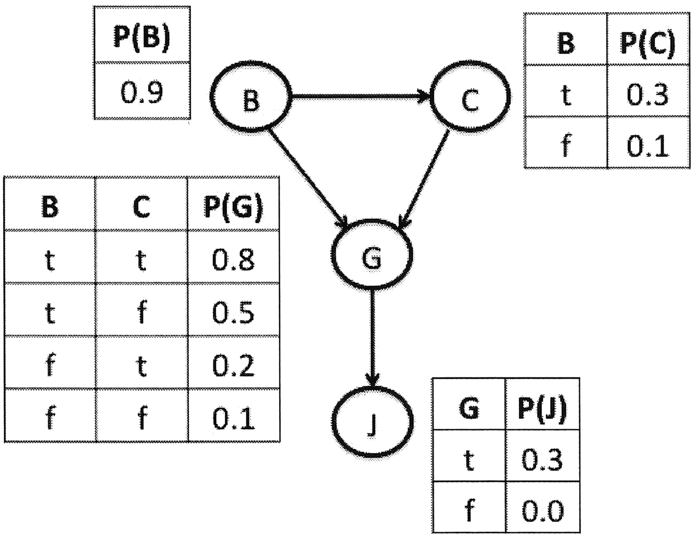
A new patient receives a positive lab test. Justify whether we should diagnose the patient as having liver cancer or not.

(6 marks)

(c) A Bayesian network is shown in Figure Q4. The variables B, C, G, and J are defined as follows. B defines a person who has broken a traffic

Note: Question 4 continues on page 7

law; *C* defines a person taken to court; *G* defines a person found guilty; *J* defines a person jailed.



P(B)
0.9

B	P(C)
t	0.3
f	0.1

B	C	P(G)
t	t	0.8
t	f	0.5
f	t	0.2
f	f	0.1

G	P(J)
t	0.3
f	0.0

Figure Q4

(i) Calculate the value of $P(B, C, \neg G, J)$.

(4 marks)

(ii) Calculate the probability that someone goes to jail given that he broke a traffic law and was taken to court.

(4 marks)

END OF PAPER

CZ3005 ARTIFICIAL INTELLIGENCE

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.