School of Computer Science and Engineering

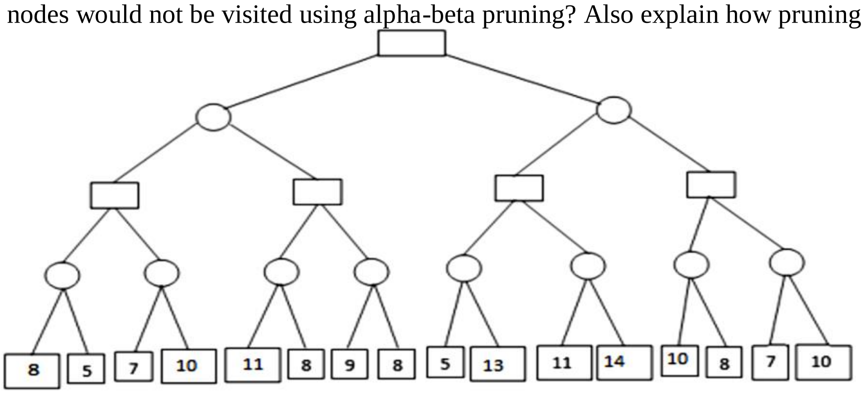
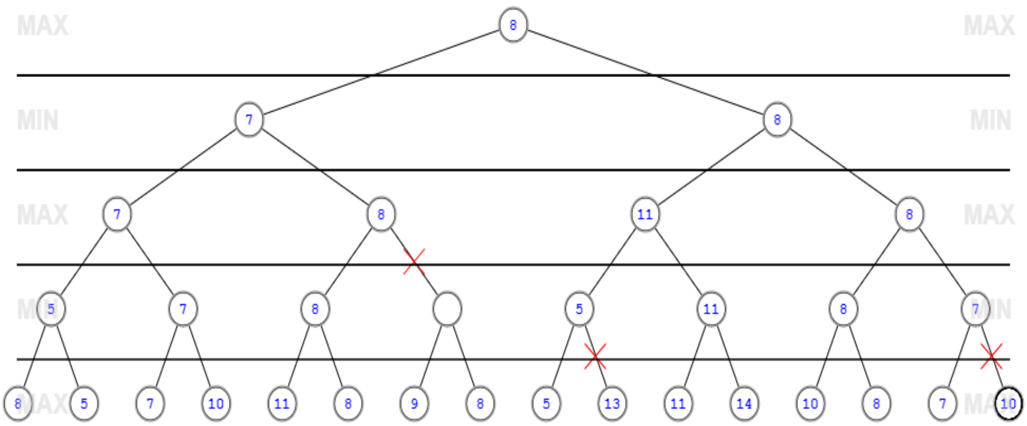
Winter Semester 2023-24

Continuous Assessment Test – II

SLOT: B2+TB2

Programme Name & Branch: B.Tech, (CSE)
Course Name & Code: Artificial Intelligence & BCSE306L
Class Number (s): VL2023240500589, 595, 702, 642, 592, 720, 694, 710, 619, 687, 652, 666, 747, 611, 601, 581, 674, 564, 740
Exam Duration: 90 Min. **Maximum Marks: 50**

General instruction(s): Attempt ALL Questions

Q. No.	Question	Max Marks
1.	Consider the game tree given below in which the first player is the maximizing player. Applying mini-max search, show the backed-up values in the tree. If the nodes are expanded from left to right, what nodes would not be visited using alpha-beta pruning? Also explain how pruning is done.  **Answer**  **Mini Max – 4 marks** **Alpha-beta pruning – 4 marks** **Explanation of pruning process – 2 marks**	10
2.	a) Given a vocabulary including the following symbols: **(4 marks)** Profession(p1, p2): Predicate indicating that person p1 holds profession p2. Client(p1, p2): Predicate signifying that person p1 is a customer of person p2. Boss(p1, p2): Predicate expressing that Person p1 is the boss of person p2 Doctor, Physician, Solicitor, Thespian: Constants representing different occupations. Sarah, Alex: Constants referring to specific individuals Use these symbols to write the following assertions in first order logic.	10

i) Sarah is either a physician or a solicitor.
ii) Alex is a Thespian, yet he also holds another job.
iii) There exists a solicitor all of whose clients are physicians.
iv) Each physician has a solicitor.

Answer

i) Profession (Sarah, Physician) V Profession (Sarah, Solicitor)
ii) Profession (Alex, Thespian) ^ (Profession (Alex, Doctor) V Profession (Alex, Physician) V Profession (Alex, Solicitor))
iii) $\exists p1 \forall p2$ Profession (p1, Solicitor) $\Rightarrow$ Client (p2, p1) ^ Profession (p2, Physician)
iv) $\forall p1 \exists p2$ Profession (p1, Physician) $\Rightarrow$Client(p1, p2) ^ Profession (p2, Solicitor)

b) Complete the following exercises about logical sentences: **(3 marks)**

i) Translate into good, natural English
$\forall x,y,z$: SpeaksLanguage(x,z) ^ SpeaksLanguage(y,z) $\Rightarrow$ Understands(x,y) ^ Understands(y,x)
ii) Explain why this sentence is entailed by the sentence given in (i)
$\forall x,y,z$: SpeaksLanguage(x,z)^SpeaksLanguage(y,z) $\Rightarrow$Understands(x,y)
iii) Convert the following statements to its contrapositive form and write the converted statements in formal language. **(3 marks)**
- If it is not sunny, then I will take an umbrella.
- For every person x, there exists a person y whom x loves.

Answer

i) If two people speak the same language, then they understand each other
ii) If two people speak the same language and one of them understands the other, then it must follow that the other person also understands the first, since they both speak the same language.
iii) Contrapositive sentence
  a. Contrapositive English: "If I do not take an umbrella, then it is sunny."

     Formal representation (Original Sentence): $\neg P \Rightarrow Q$, where

     P represents "It is sunny" and
     Q represents "I will take an umbrella."

     The contrapositive representation in formal language would be: $\neg Q \Rightarrow P$
  b. Contrapositive English: For every person x, if there doesn't exist a person y whom x loves, then x doesn't exist.

     Formal Representation (Original sentence): $\forall x \exists y$Loves(x,y)

     The contrapositive representation in formal language would be:
     $\forall x \neg \exists y$Loves(x,y)$\rightarrow \neg$Exists(x)

3. a) Consider the following set of rules for identifying animals. 10

- Animals that give milk are mammals
- Animals that have feathers, flies, and lays eggs are birds
- Animals that eat meat and are mammals are carnivores..
- Animals that have black stripes and are carnivores are tigers

The working memory contains the following assertions:

- A1: Fluffy has black stripes
- A2: Fluffy eats meat
- A3: Whiskers has feathers
- A4: Fluffy gives milk
- A5: Whiskers flies

i) Use forward chaining to derive ALL assertions that are derivable from this knowledge base (that is, from the set of rules together with the assertions in the working memory).
ii) Use backward chaining to determine Fluffy is a tiger.

Construct all trees showing the steps followed by forward and backward chaining and show when and how the working memory is updated during the process. **(6 Marks)**

Answer:

R1: Animals that give milk are mammals
R2: Animals that have feathers, flies, and lays eggs are birds
R3: Animals that eat meat and are mammals are carnivores..
R4: Animals that have black stripes and are carnivores are tigers

A1: Fluffy has black stripes
A2: Fluffy eats meat
A3: Whiskers has feathers
A4: Fluffy gives milk
A5: Whiskers flies

<u>**FORWARD CHAINING:**</u>

```
Animal = x

R1:  Fluffy gives milk                      ?x gives milk

             succeeds due to A4


     WM := WM + {A6: Fluffy is a mammal}    ?x is a mammal


R2:  Whiskers has feathers                    ?x has feathers
          |
          |  succeeds due to A3
          |
     Whiskers flies                           ?x flies
          |
          |  succeeds due to A5
          |
     Whiskers lays eggs                       ?x lays eggs

             fails


      hence rule R2 is not triggered.


R3:   Fluffy eats meat                      ?x eats meat
          |
          |  succeeds due to A2
          |
      Fluffy is a mammal                    ?x is a mammal

             succeeds due to A6


      WM:= WM + {A7: Fluffy is a carnivore} ?x is a carnivore


R4:   Fluffy has black stripes              ?x has black stripes
          |
          |  succeeds due to A1
          |
      Fluffy is a carnivore                 ?x is a carnivore

             succeeds due to A7
```

```
      WM:= WM + {A8: Fluffy is a tiger}     ?x is a tiger


Applying again R1, R2, R3, R4 does not yield any new assertions
and so the forward chaining process stops.
```

BACKWARD CHAINING:

```
Animal = x


  Fluffy is a tiger                 ?x is a tiger
          |
          |  R4
          |
  Fluffy has black stripes          ?x has black stripes
          |
          |  succeeds due to A1
          |
  Fluffy is a carnivore             ?x is a carnivore
          |
          |  R3
          |
  Fluffy eats meat                  ?x eats meat
          |
          |  succeeds due to A2
          |
  Fluffy is a mammal                ?x is a mammal
          |
          |  R1
          |
  Fluffy gives milk                 ?x gives milk

             succeeds due to A4


hence the working memory is updated with:
   A6: Fluffy is a mammal
   A7: Fluffy is a carnivore
   A8: Fluffy is a tiger
```

b) Consider the following propositional logic statement: $P \rightarrow (Q \land R)$ **(4 Marks)**

i) Prove that the statement $P \rightarrow (Q \land R)$ is logically equivalent to $(\neg P \lor Q) \land (\neg P \lor R)$ using laws of inference.

ii) Determine whether the statement $(\neg P \lor Q) \land (\neg P \lor R)$ is a tautology, satisfiable, or a contradiction.

Answer

a) let's apply the material implication equivalence, which states that $P \rightarrow Q$ is equivalent to $\neg P \lor Q$.

$P \rightarrow (Q \land R)$ is equivalent to $\neg P \lor (Q \land R)$

Then, we can apply the distributive law:

$\neg P \lor (Q \land R)$

$(\neg P \lor Q) \land (\neg P \lor R)$

Therefore, $P \rightarrow (Q \land R)$ is logically equivalent to $(\neg P \lor Q) \land (\neg P \lor R)$.

b) To determine whether the statement $P \to (Q \wedge R)$ is a tautology, satisfiable, or a contradiction, we can construct a truth table.

P	Q	R	Q ∧ R	P → (Q ∧ R)	(¬P ∨ Q) ∧ (¬P ∨ R)
T	T	T	T	T	T
T	T	F	F	F	F
T	F	T	F	F	F
T	F	F	F	F	F
F	T	T	T	T	T
F	T	F	F	T	T
F	F	T	F	T	T
F	F	F	F	T	T

From the truth table, we can see that there are assignments of truth values to P, Q, and R such that $P \to (Q \wedge R)$ is true (e.g., rows 1, 5, 6, 7, 8). Therefore, $P \to (Q \wedge R)$ is satisfiable.

Additionally, we can see that there is no assignment of truth values to P, Q, and R such that $P \to (Q \wedge R)$ is always true (i.e., no row where $P \to (Q \wedge R)$ is true for all assignments). Therefore, $P \to (Q \wedge R)$ is not a tautology.

Furthermore, we can observe that there is no assignment of truth values to P, Q, and R such that $P \to (Q \wedge R)$ is always false (i.e., no row where $P \to (Q \wedge R)$ is false for all assignments). Therefore, $P \to (Q \wedge R)$ is not a contradiction.

Hence, $P \to (Q \wedge R)$ is satisfiable, but not a tautology or a contradiction.

4. Consider the following dataset 10

Age	Gender	Income	Education	Occupation	Credit Score
<40	Male	High	Graduate	Professional	Low
<40	Female	Medium	High School	Managerial	Low
>40	Male	High	Postgraduate	Professional	High
>40	Female	High	Postgraduate	Professional	High
>40	Male	Low	High School	Skilled	Low
<40	Female	Medium	Graduate	Managerial	Medium
<40	Male	Medium	Graduate	Professional	High
>40	Female	High	Postgraduate	Managerial	High
>40	Male	High	High School	Skilled	Low
<40	Female	Medium	Graduate	Professional	Medium
>40	Male	Medium	High School	Skilled	Medium
>40	Female	Low	Graduate	Skilled	High

a) Using the provided dataset, which includes demographic information and credit scores of individuals, apply Naive Bayes classification to predict the credit score of a new individual based on their following demographic features: Age>40, Gender=Male, Income=Medium, Education=Graduate, Occupation=Skilled **(6 Marks)**

Answer

P(High | Age>40, Gender=Male, Income=Medium, Education=Graduate, Occupation=Skilled)
= (4/5) x (2/5) x (1/5) x (2/5) x (1/5) x (5/12) = 0.417

P(Medium | Age>40, Gender=Male, Income=Medium, Education=Graduate, Occupation=Skilled)
= (1/3) x (1/3) x (3/3) x (2/3) x (1/3) x (3/12) = 0.0062

P(Low | Age>40, Gender=Male, Income=Medium, Education=Graduate, Occupation=Skilled)

= (2/4) x (3/4) x (1/4) x (1/4) x (1/4) x (4/12) = 0.0019

So, Credit score of new individual is **High.**

b) Based on the data given in the table answer the followings: **(4 Marks)**

i) What is the probability that an individual has a High credit score given that they are Female and have a Postgraduate education?

ii) Given that an individual has a High income and a Skilled occupation, what is the probability that their credit score is Low?

Answer:

i)

$$P(\text{High}|\text{Female, Postgraduate}) = \frac{P(\text{Female}|\text{High}) \times P(\text{Postgraduate}|\text{High}) \times P(\text{High})}{P(\text{Female}) \times P(\text{Postgraduate})}$$

ii)

$$P(\text{Low}|\text{High Income, Skilled}) = \frac{P(\text{High Income}|\text{Low}) \times P(\text{Skilled}|\text{Low}) \times P(\text{Low})}{P(\text{High Income}) \times P(\text{Skilled})}$$

= ((2/4) x (2/4) x (4/12)) / ((5/12) x (4/12)) = 0.6

5. a) Convert the given knowledge base into Propositional logic statements. Prove "I will score well" by resolution. **(6 marks)** 10

Knowledge Base:

- If the question paper was leaked, then I can score good marks.
- The question paper was not leaked.
- If the question paper was set by Stella ma'am, then I can't score well.
- The question paper was set by Stella ma'am or Pearly ma'am.
- The question paper was not set by Stella ma'am.
- I can score well when Pearly ma'am sets the question paper.

Answer

a) $L \rightarrow S$

$\neg L$

$ST \rightarrow \neg S$

$ST \vee P$

$\neg ST$

$P \rightarrow S$

Prove : S

CNF :

$\neg L \vee S$ — 1

$\neg L$ — 2

$\neg ST \vee \neg S$ — 3

$ST \vee P$ — 4

$\neg ST$ — 5

$\neg P \vee S$ — 6

$\neg S$ — 7

$\neg S$, $\neg P \vee S$

$\neg P$, $ST \vee P$

ST, $\neg ST$

$\{\ \}$

∴ Proved.

b) Suppose you live in London, England, and you notice that during the winter, it rains 50% of the time and that it is cloudy 80% of the time (sometimes it is cloudy without rain). You know, of course, that 100% of the time, if it is raining, then it is also cloudy. Using Bayes' rule, compute the chances of rain, given that it is just cloudy. **(4 Marks)**

Answer

p(R|C) = p(R)p(C|R)/p(C) = 0.5 x 1.0 / 0.8 = 0.625 = 5/8.

So, 5/8 of the time, in London during winter, if it is cloudy, then it is rainy.