

Master in Biomedical Engineering First Year First Semester Examination, 2025

ARTIFICIAL INTELLIGENCE

Full Marks: 100

Time: 3 Hours

Answer any FOUR questions.

- 1) a) Use Wang's algorithm to prove or disapprove the following theorem:
 $p, p \rightarrow q, q \rightarrow r \Rightarrow r.$
 b) Show that $\neg q \rightarrow \neg p$ follows logically from $p \rightarrow q$. What is this property called?
 c) Using forward and backward chaining, prove or disapprove the following theorem:
 $p, q, p \wedge q \rightarrow r \vee s \Rightarrow r \vee s.$
 d) State resolution theorem in propositional logic and hence prove that q follows from the following assertions:

$$\begin{array}{l} p \rightarrow q, r \\ \neg r \\ p \end{array}$$

 e) Double resolution is dangerous. Explain this with respect to propositional resolution theorem. [5+5+5+6+4]
- 2) a) Unify $P(x, f(x), g(f(y)), c)$ and $P(a, b, w, c)$ and obtain the most general unifier (mgu).
 b) Resolve $P(x, y) \vee \neg Q(y, x)$ and $Q(c, b) \vee W(x)$. Write down the resolvent and the mgu.
 c) Given the predicate logic statements, prove that Hates (bill, elizabeth) using resolution by refutation
 - 1) Wine (volnay)
 - 2) Bill hates women who take wine
 - 3) Women (elizabeth)
 - 4) Takes (elizabeth, volnay)
 Combine 3 and 4 and then express all the predicate logic statements including the combined (3), (4) into English. Also frame the problem in English.
 d) Prove by predicate logic that $\text{Ext} \angle A$ of a triangle $ABC = \angle B + \angle C$.
 e) Why predicate logic is called semi-decisive? [5+6+5+5+4]
- 3) a) For 2 events A and B given that, $P(\neg A \cap \neg B) = 0.1$, $P(\neg A \cap B) = 0.2$, $P(A \cap \neg B) = 0.3$, evaluate $P(B / A)$ and $P(A / B)$.
 b) Given that $A \rightarrow B$, find $P(B)$, when $P(B / A) = 0.2$, $P(A) = 0.4$, $P(B / \neg A) = 0.2$.
 c) Under what condition: $P(B/A) = P(B \leftarrow A)$?

[Turn over

- d) A car does not start if ignition switch, power-on relay and battery system does not work.

The ignition switch is activated by the battery system.

What is the probability that the car will start?

Represent each event by A, B, C etc. and hence determine the above probability.

- e) What is hidden evidence? Compute $P(Y/X \cap E)$ where E is a hidden evidence of X.

[5+5+4+5+6]

- 4) Given a 3L and 5L jug. Separate out 4L water using the jugs and a constant water-flow.

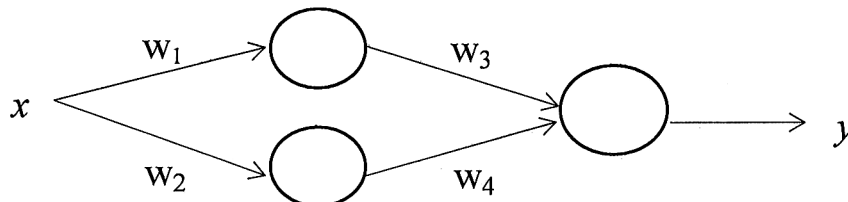
- Write down the rules to solve the problem.
- Design a heuristic function to solve the problem by A* algorithm.
- Expand the OR tree using A* algorithm.
- Design a second heuristic function and explain which one is better and why?
- What is an admissible heuristic? What is its advantage? [5+5+5+5+5]

- 5) a) What is gradient descent learning?

- b) Show that for a one-dimensional function $f(x)$, if $x = x_{opt}$ is a minimum, then the gradient descent learning initialized at $x = x_{opt} + \delta_1$, $\delta_1 > 0$ and at $x = x_{opt} - \delta_2$, $\delta_2 > 0$ always converge towards $x = x_{opt}$.

- c) Derive the weight adaption algorithm in the last and last-but-one-layer of a 3-layered feed-forward Neural Network using gradient learning algorithm.

- d) Use the above results to show one-step of weight adaption in the following network.



Given $x = 3$, $y = 1.5$, $W_1(0) = 1$, $W_2(0) = 1$, $W_3(0) = 2$, $W_4(0) = 2$, Learning rate $\eta = 0.1$.

[5+6+8+6]

- 6) a) Differentiate classification and clustering problem.

- b) Write down the step of k -means clustering algorithm.

- c) Given two sets of one-dimensional data points included in a single set S.

$S = \{1, 2, 3, 4, 5; 20, 21, 22, 23, 24\}$

Use k -means clustering algorithm to segregates the data points into 2 clusters.

- d) In the mouth-region segmentation experiment of a frontal facial image of a woman with green-colour painted lips, a student used RGB intensity parameters, and noted that her green coloured bindi is clustered with the mouth region covering the lips.

i. What is the mistake of the student?

ii. How k -means clustering can be used to solve and eliminate the problem?

[5+6+6+8]

- 7) a) Write down the main steps of Particle Swarm Optimisation Algorithm (PSO).
b) Geometrically, interpret the motion of the particles in a search landscape to optimise a given objective function following PSO.
c) How does swarm-confidence and inertial-velocity influence particle dynamics?
[10+8+7]
- 8) State one interesting problem that can be solved by any standard AI technique, highlighting the following
a) Why AI is needed to solve the problem?
b) Write down the main steps/idea to solve the problem.
c) Can you suggest an alternative AI technique to handle the problem?
d) Which of the 2 techniques seems to be better and why?
[6+7+6+6]