BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

CSF 407 (ARTIFICIAL INTELLIGENCE), First Semester 2022 - 2023

Mid Semester Exam [CLOSED BOOK]

November 01, 2022 **MM: 27 [90 Mins]**

Answer all parts of a question together. There are five questions in all.

Q1 [2+3=5M]. Give a trace of DPLL to find the satisfiability/un-satisfiability of the following two formulas:

a) $(p \lor q \lor \neg r) \land (\neg p \lor s) \land (\neg r \lor (\neg q \land \neg s))$

b) $(p1 \lor \neg p3 \lor \neg p5) \land (\neg p1 \lor p2) \land (\neg p1 \lor \neg p3 \lor p4) \land (\neg p1 \lor \neg p2 \lor p3) \land (\neg p4 \lor \neg p2)$

Q2 [2+3 = 5M]. A propositional *2-CNF* expression is a conjunction of clauses, each containing exactly 2 literals.

$$(A \lor B) \land (\neg A \lor C) \land (\neg B \lor D) \land (\neg C \lor G) \land (\neg D \lor G)$$

a. Prove using resolution that the above sentence entails G.

b. Let S be a set of clauses and RC(S) be the resolution closure of S. RC (S) is the set of all clauses derivable by repeated application of all the resolution rule to clauses in S or their derivatives. With respect to this, (i) Is RC (S) always finite? Justify. (ii) If RC(S) contains an empty clause, then S is satisfiable. True/False with justification.

Q3 [4M]. True/False with justification:

a) In logical systems, the set of entailed sentences can only increase as information is added to the KB. For any sentences alpha and beta, if KB entails alpha then KB and beta entails alpha.

b) DFS always expands atleast as many nodes as A* search with an admissible heuristic.

c) h(n) = 0 is an admissible heuristic for the 8-puzzle.

d) Uniform cost search is a special case of A* search.

Q4 [1+3+4 = 8M]. With respect to CSP, answer the following:

a) What is node consistency and how does it help solving CSP problems?

b) Suppose the following class scheduling problem is to be formulated using CSP:

<u>Problem</u>: There is a fixed number of professors and classrooms, a list of classes to be offered, and a list of possible time slots for classes. Each professor has a set of classes that he or she can teach.

The four variables in this problem are: Teachers, Subjects, Classrooms and Time slots. We can use two constraint matrices, T_{ij} and S_{ij} . T_{ij} represents a teacher in classroom i at time j. S_{ij} represents a subject being taught in classroom i at time j. The domain of each T_{ij} variable is the set of teachers. The domain of each S_{ij} variable is the set of subjects. Let's denote by D(t) the set of subjects that teacher named t can teach.

Specify the constraints in the above problem.

c) Consider the following binary-constraint network: There are 4 variables: X1, X2, X3, X4, with the domains: D1 = {1, 2, 3, 4}, D2 = {3, 4, 5, 8, 9}, D3 = {2, 3, 5, 6, 7, 9}, D4 = {3, 5, 7, 8, 9}. The constraints are: X1 ≥ X2, X3 − X2 = 2, X3 ≠ X4. Draw the constraint graph which is arc consistent.

Q5. [3+2=5M] Answer the following:

a) Consider the given BFS algorithm. There are few mistakes in it. Correct it.

b) Is BFS algorithm complete? Is it optimal? Justify your answer.

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function BREADTH-FIRST-SEARCH(problem) returns a solution, or failure
  node ← a node with STATE = problem.INITIAL-STATE, PATH-COST = 0
  frontier ← a FIFO queue with node as the only element
  explored ← an empty set
  loop do
      if EMPTY?(frontier) then return failure
      node ← POP(frontier)  /* chooses the shallowest node in frontier */
      add node.STATE to explored
      for each action in problem.ACTIONS(node.STATE) do
          child ← CHILD-NODE(problem, node, action)
          if child.STATE is not in explored then
              frontier ← INSERT(child, frontier)
              if problem.GOAL-TEST(child.STATE) then return SOLUTION(child)
```