8.7 Derive new facts from the rules given in Problem 8.6.

8.8 What are knowledge sources? Describe a blackboard system and use it to solve crypt-arithmetic problem.

8.9 Give two examples of non-monotonic system. Consider some monotonic and non-monotonic applications and show how you can solve them using truth maintenance system.

8.10 Implement expert systems for the following applications:

i. For identifying faults in printer
ii. For advising on financial matters
iii. For planning a vacation trip

... implementation of Common LISP.[10] ... and is fairly

Exercises

8.1 What are the different phases in building an expert system?

8.2 How is an expert system different from a traditional program? How is a production system different from an expert system? Describe the knowledge acquisition component of ES.

8.3 What is an inference engine? Describe backward and forward chaining mechanism used by an inference engine.

8.4 Write MYCIN style rules that will help you in performing the following activities:

i. Planning your daily schedule
ii. Buying electronic gadget for your house
iii. Buying a car
iv. Executing a research project
v. Car repair
vi. Weather prediction

8.5 Consider the knowledge base given below. Perform forward and backward chaining to satisfy the goal

R1: if A then B
R2: if C then E
R3: if A and C then F
R4: if B and E then D
Facts: A, C
Goal: D

8.6 Suppose hotels are classified by rating system as follows:

One-star:	poor quality
Two-star:	modest quality
Three-star:	good quality
Four-star:	very good quality
Five-star:	excellent quality

Imagine characteristics for the rating of quality and design rules for the four classes of hotels given above.

[10] *Source*: www.cs.utexas.edu

Predicate *search* will basically retrieve the list of slots–facet pair and will try to match Y for slot. If a match is found then its facet value is retrieved, otherwise the process is continued till we reach the root frame.

Exercises

7.1 Draw a semantic network representing the following knowledge:

i. Every vehicle is a physical object. Every car is a vehicle. Every car has four wheels. Electrical system is a part of car. Battery is a part of electrical system. Pollution system is a part of every vehicle. Vehicle is used in transportation. Suzuki is a car.

ii. Every living thing needs oxygen to live. Every human is a living thing. John is human. Answer the query John is a living thing and John needs oxygen to live using inheritance.

7.2 Write an inheritance rules in Prolog to answer queries related to the statements given in part (i) of Problem 7.1, such as Suzuki has battery, electrical system, pollution system, etc.

7.3 Draw an extended semantic network for representing the following English text and infer the conclusion for each of the following:

i. Teachers who work hard are liked by students. Mary is a hardworking teacher. John is a student. Conclude that John likes Mary.

ii. Everyone who sees a movie in a theatre has to buy a ticket. A person who does not have money cannot buy a ticket. John sees a movie. Conclude that John had money.

iii. All senior citizens and politicians get air concession. Mary is a senior citizen. John does not get air concession. Conclude that Mary gets air concession and John is neither senior citizen nor politician.

iv. Every member of an association named ROA is either retired or an officer of central government. John is a member of ROA. Conclude John is retired or an officer.

7.4 Develop a complete Frame-Based System (FBS) for University and Hospital applications in Prolog.

7.5 Create a network of frames (NOF) with ako, a_part_of, and inst links with the following characteristics:

i. Insert a frame in NOF with all slot values filled up.

ii. Delete a frame from NOF.

iii. Update the value of the slot of a given frame.

iv. Query module to ask questions using FBS.

Exercises

6.1 A 'monkey and bananas' problem is defined as follows:

A monkey is in a room with some bananas hanging from the ceiling. The bananas are out of its reach. A box is available to the monkey. The monkey is short in height but if it climbs onto the box, then it gains the height required to reach the bananas.

Initially, the monkey is at an arbitrary position, say A, the bananas at B, and the box at C. Actions available to the monkey are GO (from one place to another); PUSH (push an object); CLIMBUP (climb onto a box); CLIMBDN(climb down from the box); GRASP; and UNGRASP an object. Grasping results in holding the object if the monkey and object are in the same place at the same height.

i. Write down the start state description.
ii. Write down STRIPS Style definitions of the six actions.
iii. Give the plan using goal stack method

6.4 Write a set of STRIPS-style operators used for the following problems. Write start and goal state descriptions in each case. Generate plans using goal stack, goal set, and constraint posting methods.

i. Consider the problem of washing clothes using a washing machine.
ii. Devise a plan for cleaning a room.
iii. Devise a plan to go to room A and bring a bag to room B.
iv. Generate a plan to shift from a house.
v. Generate a plan to prepare tea for a guest.

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Exercises

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iii. Update the value of the slot of a given frame.

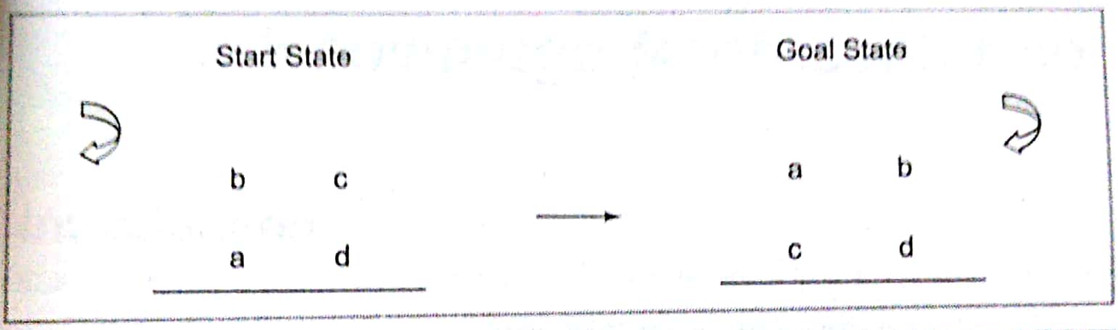
iv. Query module to ask questions using FBS.

6.2 Consider the block world problems given below and solve them using the following methods.

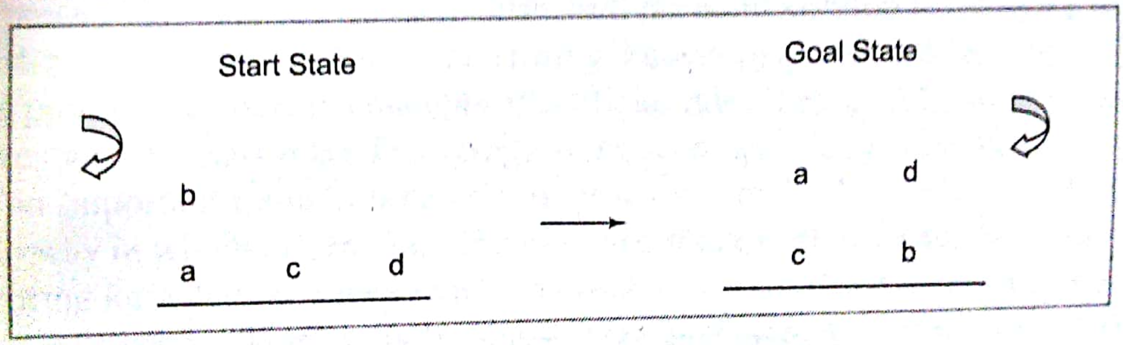
- STRIPS
- Goal Set
- Constraint Posting

i.

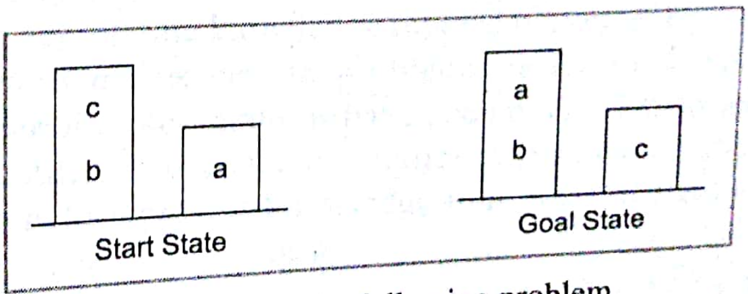
ii.



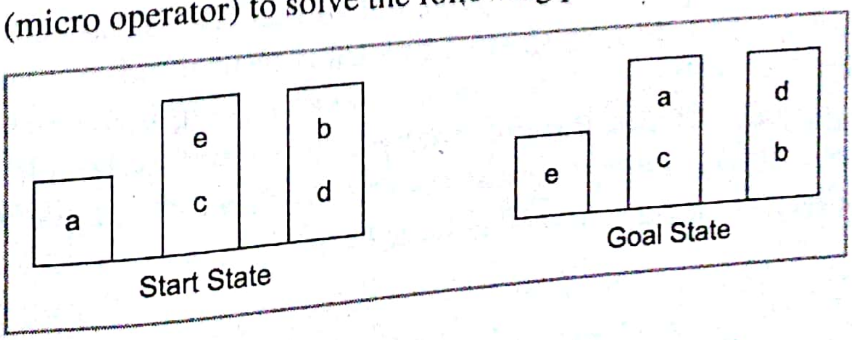
iii.



6.3 While solving the following block world problem, the system learns the plan and stores it as a micro operator.



Apply this plan (micro operator) to solve the following problem.



Exercises

5.1 Define predicates even(X) and odd(X) for determining whether a natural number X is even or odd.

5.2 Write a Prolog program to find gcd of two integers.

5.3 Write recursive and iterative Prolog programs for finding n^{th} Fibonacci term. Draw search or proof trees for the following queries:

?- fib(5, 5). ?- fib(7, F). ?- fib(10, F).

5.4 Write Prolog rules to define the following relations:

i. Sibling
ii. Uncle
iii. Cousin

5.5 A stack of blocks can be defined as a collection of blocks stacked on each other. The fact on(X, Y) means that X is placed on top of Y. Define a predicate 'above(X, Y)' that succeeds if X is above block Y in a stack.

5.6 Write iterative and recursive programs in Prolog to perform the following tasks:

i. Add the elements of a given list of integers
ii. Reverse a list
iii. Check if a list L is a prefix or suffix of M, such as, [2, 3] is prefix and [3, 5, 6] is suffix of [2, 3, 5, 6]

5.7 Write a Prolog program to generate all permutations of a given list.

5.8 Write a Prolog program to sort a list of numbers using quick sort method.

5.9 Merge two sorted lists using merge sort.

5.10 Linked list and binary tree data structures are defined in this chapter. Write a Prolog program to carry out the following tasks:

i. Concatenate two linked lists
ii. Reverse a given linked list
iii. Create a mirror image of the binary tree
iv. Create a binary search tree (values on left sub tree of a node are less and on right sub tree are greater than the value in the node)
v. Insert a value in binary search tree
vi. Delete a given value from binary search tree

4.7 Determine whether the following formulae are consistent or inconsistent using tableau method.

i. $(A \wedge \sim B) \wedge (\sim A \wedge B)$
ii. $(A \vee B) \wedge (\sim A \wedge \sim B)$
iii. $(\sim A \vee B) \rightarrow (A \rightarrow B)$
iv. $(A \rightarrow B) \leftrightarrow (\sim B \rightarrow \sim A)$
v. $(A \rightarrow B) \leftrightarrow (\sim C \rightarrow B) \wedge (C \vee B)$

4.8 Show that the following formulae are valid by giving tableau proof of each of these.

i. $A \rightarrow (B \rightarrow A)$
ii. $\sim(A \vee B) \leftrightarrow (\sim A \wedge \sim B)$
iii. $(\sim A \vee B) \leftrightarrow (A \rightarrow B)$
iv. $(A \wedge (B \vee C) \leftrightarrow [(A \wedge B) \vee (A \wedge C)]$
v. $((A \rightarrow (B \rightarrow C)) \rightarrow [(A \wedge B) \rightarrow C]$

4.9 You are given a set of propositional formulae. Show that the following are logical consequence (LC) of the given set using resolution refutation method.

i. $(B \vee C)$ LC $\{A \wedge B, \sim A \vee C\}$
ii. $(A \vee C)$ LC $\{A, B \rightarrow C, B\}$
iii. $(C \rightarrow A)$ LC $\{B \wedge C) \rightarrow A, B\}$
iv. $(A \vee \sim B)$ LC $\{A \vee C, \sim B \vee \sim C\}$
v. $(\sim U \wedge S)$ LC $\{A \vee C, \sim C \rightarrow B, \sim B, A \rightarrow S, \sim U\}$

4.10 Evaluate the truth values of the following formulae. Define your own interpretation.

i. $(\exists X)\ (p[f(X)] \wedge q[X, f(c)]\ )$
ii. $(\exists X)\ [p(X) \wedge q(X, c)]$
iii. $(\exists X)\ [p(X) \rightarrow q(X, c)]$
iv. $(\forall X)\ [p(X) \wedge (\exists Y)\ q(X, Y)]$
v. $(\forall X)\ (p(X) \rightarrow (\exists Y)\ q[f(c), Y])$

4.11 Transform the following formulae into PNF and then into Skolem Standard Form.

i. $(\forall X)\ (p(X) \rightarrow (\exists Y)\ q[f(c), Y])$
ii. $(\forall X)\ (\exists Y)\ [q(X, Y) \rightarrow p(X)]$
iii. $(\forall X)\ \{(\exists Y)\ p(X, Y) \rightarrow \sim[(\exists z)\ q(z) \wedge c(X)]\}$
iv. $(\forall X)\ (\exists Y)\ p(X, Y) \rightarrow ((\exists Y)\ p(X, Y)$
v. $(\forall X)\ [(\exists Y)\ p(X, Y) \wedge \{(\exists z)\ q(z) \wedge c(X)\}]$

4.12 Consider the following English sentence:

"Anything anyone eats is called food. Mita likes all kinds of food. Burger is a food. Mango is a food. John eats pizza. John eats everything Mita eats."

Translate these sentences into formulae in predicate logic and then to program clauses. Use resolution algorithm to answer the following goals

i. What food does John eat?
ii. Does Mita like pizza?
iii. Which food does John like?
iv. Who likes what foods?
v. Prove the statement "Mita likes pizza and burger" using resolution.

esolution is particularly efficient for proof by contradiction, where we assume negation of a ement (goal) to be proved from a set of clauses and see if we can derive a contradiction from it. type of resolution is called backward chaining. Backward chaining method is used in logic amming and subsequently in PROLOG, which is a language based on logic programming. language is covered in the next chapter.

Exercises

4.1 Consider A, B, C, and D to be propositional symbols. Which of these formulae are tautologies? Show by using truth tables.

i. $\sim(A \vee \sim B \wedge C)$

ii. $A \wedge (B \rightarrow C)$

iii. $(A \vee B) \rightarrow C$

iv. $A \rightarrow (A \vee B)$

v. $(\sim A \rightarrow B) \rightarrow (C \vee D)$

vi. $A \rightarrow (B \vee C) \rightarrow D$

vii. $A \leftrightarrow (B \wedge C)$

viii. $(A \leftrightarrow B) \wedge (C \rightarrow D)$

ix. $(A \rightarrow B) \rightarrow (A \rightarrow \sim B)$

x. $(A \leftrightarrow B) \leftrightarrow (A \rightarrow B) \wedge (B \rightarrow A)$

4.2 Which of the following pair of expressions are logical equivalent? Show by using truth table.

i. $[A \wedge B \vee C, A \wedge (B \vee C)]$

ii. $[A \rightarrow (B \vee C), \sim A \vee B \vee C]$

iii. $[(A \wedge \sim B) \rightarrow C, \sim(A \wedge \sim B \wedge \sim C)]$

iv. $[(A \rightarrow B) \rightarrow C, A \rightarrow (B \rightarrow C)]$

v. $[A \vee \sim B \rightarrow C, A \vee (\sim B \rightarrow C)]$

4.3 Prove the following theorems using deductive inference rules.

i. from $A \rightarrow B \wedge C, A$ infer C

ii. from $A \wedge B, A \rightarrow C$ infer C

iii. from $A \wedge B, A \rightarrow C$ infer C

iv. from $Q \rightarrow P, Q \rightarrow R$ infer $Q \rightarrow (P \wedge R)$

v. from $A \leftrightarrow B, B$ infer A

4.4 Prove the following theorems in natural deduction system.

i. infer $(A \rightarrow B) \rightarrow (\sim A \rightarrow \sim A)$

ii. infer $\sim A \rightarrow (A \rightarrow B)$

iii. infer $A \rightarrow (\sim B \rightarrow \sim A)$

iv. infer $(A \rightarrow B) \rightarrow [(\sim A \rightarrow B) \rightarrow B]$

v. infer $A \wedge B \leftrightarrow B \wedge A$

4.5 Prove the following in axiomatic system

i. $\{A \rightarrow (\sim B \rightarrow C), \sim B\} \vdash A \rightarrow C$

ii. $\{A \rightarrow B, A\} \vdash (C \rightarrow B)$

iii. $\{A \rightarrow \sim B, B \rightarrow \sim A\} \vdash (A \rightarrow \sim B)$

iv. $\{A, (A \rightarrow B)\} \vdash (B \rightarrow C) \rightarrow C$

v. $\{A, (B \rightarrow (A \rightarrow C))\} \vdash B \rightarrow C$

4.6 Prove the following theorems in axiomatic system

i. $\vdash \sim A \rightarrow (A \rightarrow B)$

ii. $\vdash (\sim A \rightarrow A) \rightarrow A$

iii. $\vdash (A \rightarrow B) \rightarrow (\sim B \rightarrow \sim A)$

iv. $\vdash (A \rightarrow \sim B) \rightarrow (B \rightarrow \sim A)$

v. $\vdash (\sim A \rightarrow B) \rightarrow (\sim B \rightarrow A)$