Q.1 a. List three reasons why the production system offers an important "architecture" for computer based problem solving.

Answer: Production system offers an important "architecture" because of its simplicity, modifiability and flexibility in applying problem solving knowledge.

b. Does admissibility imply monotonicity of a heuristic? If not, can you describe when admissibility would imply monotonicity?

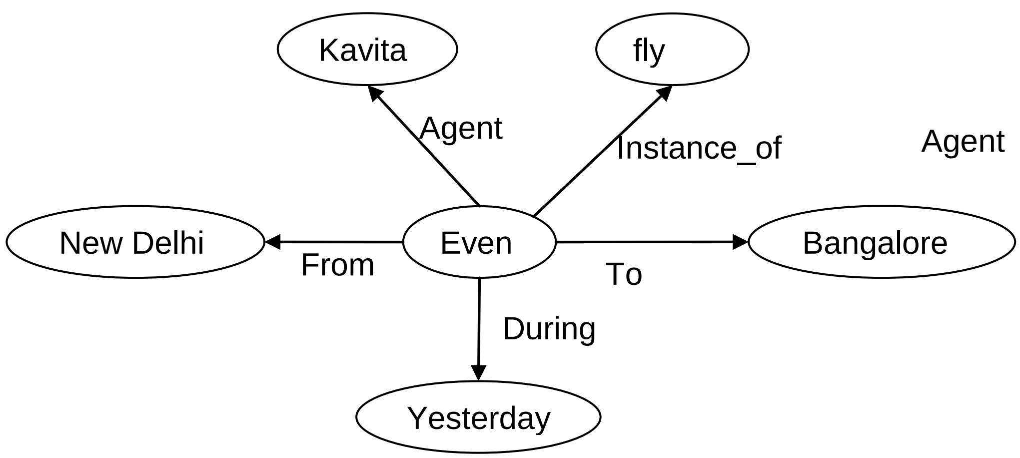
Answer: Admissibility implies monotonicity only when the heuristic value of the goal is zero and any state in the search space may be used as a goal state, without revising the heuristic in the A* algorithm. An example is the heuristic of "tiles out of place" in the 8-puzzle that may be applied equally well to any state in the search space.

c. Why is the most general unifier important?

Answer: Unification specifies conditions under which two (or more) predicate calculus expressions may be said to be equivalent. This allows use of inference rules, such as resolution.

d. Draw semantic network of the following sentence:
Yesterday Kavita flew from New Delhi to Bangalore.

Answer:



e. Consider the evidence e_1 = single, e_2 = high income, e_3 = young, supporting the hypothesis h_1= high-risk investor or h_2 = low-risk investor, which are mutually exclusive and exhaustive. Assume that the domain expert estimates the posterior probabilities as:
$P(h_1) = 0.3$, $P(h_2) = 0.7$, $P(e_1/h_1) = 0.6$, $P(e_1/h_2) = 0.3$, $P(e_2/h_1) = 0.2$, $P(e_2/h_2) = 0.8$, $P(e_3/h_1) = 0.5$, $P(e_3/h_2) = 0.2$
Prove that if e_1 and e_3 are present then the investor is high-risk investor.

Answer: $P(h_1 / e_1 \wedge e_3) = 0.618$ and $P(h_2 / e_1 \wedge e_3) = 0.318$.
Hence investor is high-risk investor

f. Explain the significant aspects of the momentum to the training by gradient decent approach.

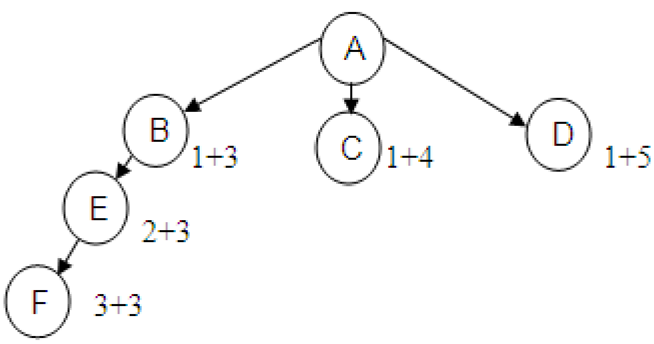
Answer: The significant aspects of momentum are:

a. In training formulations involving momentum, when $\frac{\partial E}{\partial w_{ji}}$ has the same algebraic sign on consecutive iterations, Δw_{ji} grows in magnitude and so w_{ji} is modified by a large amount. Thus, momentum tends to accelerate descent in steady downhill directions

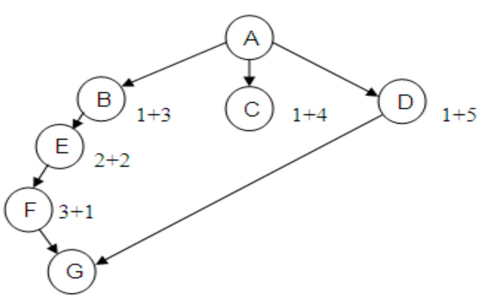
b. In training formulations involving momentum, when $\frac{\partial E}{\partial w_{ji}}$ has alternating algebraic signs on consecutive iterations, Δw_{ji} becomes smaller and so the weight adjustment is small. Thus, momentum has a stabilizing effect on learning.

Q.2 a. Explain the effect of underestimation and overestimation of the heuristic function in the A* algorithm.

Answer: If *h** underestimates *h*, then there may be a wastage of some effort.



First explore B, then E then F and after this it will explore C so exploring B, E and F is wastage of effort due to underestimate of *h*.



If *h** overestimates *h*, then there may be a wastage of some effort.

First explore B, then E then F then we get G. Suppose there is a direct path from D to G then that path would have been cheaper. So there is wastage of efforts due to overestimation of *h*.

b. Consider the following knowledge base:

$\forall x\ \forall y$ cat(x) $\wedge$ fish(y) $\Rightarrow$ likes_to_eat(x, y)
$\forall x$ calico(x) $\Rightarrow$ cat(x)
$\forall x$ tuna(x) $\Rightarrow$ fish(x)
tuna(Charlie)
tuna(Herb)
calico(Puss)

(a) Convert these wff's into Horn clauses.

(b) Convert the Horn clauses into a Prolog program.

(c) **Write a PROLOG query corresponding to the question, "What does Puss like to eat?" and show how it will be answered by your program.**

Answer:

(a) Horn Clauses:

$\neg$cat(x) $\vee$ $\neg$fish(y) $\vee$ likes_to_eat(x, y)
$\neg$calico(x) $\vee$ cat(x)
$\neg$tuna(x) $\vee$ fish(x)
tuna(Charlie)
tuna(Herb)
calico(Puss)

(b) PROLOG program:

```
likes_to_eat(X, Y) :- cat(X), fish(Y).
cat(X) :- calico(X).
fish(X) :- tuna(X).
tuna(Charlie).
tuna(herb).
calico(puss).
```

(c) Query:

```
?- likes_to_eat(puss, X).
```

Answer: Charlie

Q.3 a. Name the various Heuristics used for planning using Constraint Posting.

Answer: Heuristics used for planning using Constraint Posting:

(i) Step Addition – Creating new step to come before another in a final plan.
(ii) Promotion – Constraining one step to come before another in a final plan.
(iii) Declobbering – Placing one (possibly new) step s_2 between two old steps s_1 and s_3, such that s_2 reasserts some precondition of s_3 that was negated (or clobbered) by s_1.

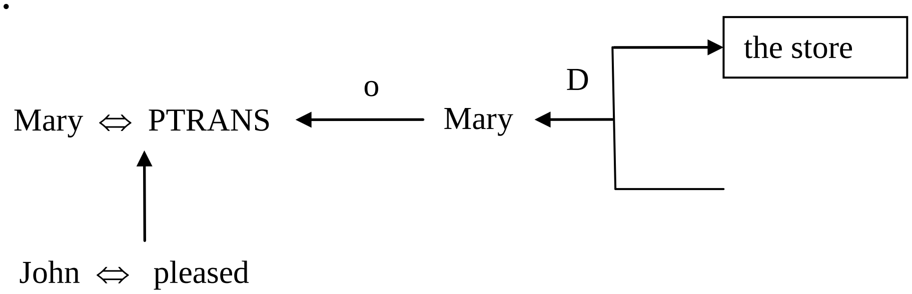
(iv) Simple Establishment – Assigning a value to a variable, in order to ensure the preconditions of some step.
(v) Separation – Preventing the assignment of certain values to a variable.

b. Under what conditions $\alpha-\beta$ pruning will prove to be worse?

Answer: The effectiveness of the $\alpha-\beta$ procedure depends greatly on the order in which paths are examined. If the worst paths are examined first, then no cutoff at all will occur.

c. Show the conceptual dependency representation of the following sentence John wanted Mary to go to the store.

Answer:



Q.4 a. Discuss the architecture of Expert System and explain its components.

Answer: Components of Expert System:
(i) Knowledge Acquisition Module
(ii) Knowledge Base
(iii) Inference Engine
(iv) I/O interface
(v) Explanation Module

b. Consider as frame of discernment the set H = {flu, cold, pneumonia}. Write its Powerset. Given the evidence "fever" an expert assigns these mass probabilities
m_1({flu, pneumonia}) = 0.8, m_1(H) = 0.2
Given as a second symptom, "shivering" the expert may assign the mass probabilities
m_2({pneumonia, cold}) = 0.6, m_2(H) = 0.4
Compute the certainty intervals of all the hypotheses flu, cold and pneumonia.

Answer:

	m_1 {FL, PN} = 0.8	m_1{(H) = 0.2
m_2 {PN, CL} = 0.6	{PN} = 0.48	{PN,CL} = 0.12
m_2 (H) = 0.4	{FL, PN} = 0.32	(H) = 0.08

Normalizing factor N = 1
Bel({FL}) = 0, Bel({PN}) = 0.48, Bel({CL}) = 0
Bel({PN,CL}) = .48+.12 = 0.6, Bel({FL, PN}) = .32+.48 = 0.8, Bel(H) = 1
Pl({FL}) = 1 - 0.6 = 0.4, Pl({PN}) = 1 – 0 = 1, Pl({CL}) = 1 - .8 = 0.2
Intervals for {FL} = [0, 0.4]
{PN} = [0.48, 1]
{CL} = [0, 0.2]

Q.5 a. Given: Premise P: *x* is little; a relation R: *x* and *y* are approximately equal.

$$\mu_{\tilde{p}}(x) = [1/1,\ 2/.4,\ 3/.2,\ 4/0] \text{ and } \mu_R(x, y) = \begin{bmatrix} 1 & .5 & .1 & 0 \\ .4 & 1 & .6 & 0 \\ 0 & .6 & 1 & .4 \\ .1 & .1 & .5 & 1 \end{bmatrix}$$

Prove that y is more or less little.

Answer:

$\mu_{\tilde{p}\circ\tilde{R}}(y)$ = [1/1, 2/.5, 3/.4, 4/.2] i.e. *y* is more or less little.

b. For a 5-unit feedback network the weight matrix is given by

$$w = \begin{bmatrix} 0 & 1 & -1 & -1 & -3 \\ 1 & 0 & 1 & 1 & -1 \\ -1 & 1 & 0 & 3 & 1 \\ -1 & 1 & 0 & 3 & 1 \\ -3 & -1 & 1 & 1 & 0 \end{bmatrix}$$

Assuming that the bias and input of each of the units to be zero, compute the Hopfield energy at the following states.

$s = [\ -1\ \ 1\ \ 1\ \ 1\ \ 1\ ]^T$ and $s = = [\ -1\ \ -1\ \ 1\ \ -1\ \ -1\ ]^T$

Answer:

Given $\theta_i = 0$, & $w_{ii} = 0$, $\forall\ i = 1, 2, \ldots, 5$. Therefore

$V = -(1/2) \sum w_{ij}\, s_i\, s_j = -\,(w_{12}s_1\, s_2 + w_{13}s_1\, s_3 + w_{14}s_1\, s_4 + w_{15}s_1\, s_5 + w_{23}s_2\, s_3 + w_{24}s_2\, s_4 + w_{25}s_2\, s_5 + w_{34}s_3\, s_4 + w_{35}s_3\, s_5 + w_{45}s_4\, s_5\,)$

V(–1 1 1 1 1) = – (–1+1+1+3+1+1–1+3+1+1) = –10

Similarly, V(–1 –1 1 –1 –1) = 6.

Q.6 b. Design a perceptron for AND function of two inputs. Define appropriate weights and bias in the range [-1, 1] and use step activation function where if weighted sum is strictly greater than 0 then output 1 and if it is strictly less than 0 then output 0.

Answer: Let x be an input vector (x_1, x_2, … x_n). The weighted sum function g(x) and the output function o(x) are

$$g(\mathrm{x}) = \sum_{i=0}^{n} w_i x_i$$

$$o(\mathrm{x}) = \begin{cases} 1 & \text{if } g(\mathrm{x}) > 0 \\ 0 & \text{if } g(\mathrm{x}) < 0 \end{cases}$$

In this problem we have 2 inputs i.e. x_1 and x_2.

$$g(\mathrm{x}) = w_0 + w_1 x_1 + w_2 x_2$$

AND truth table

x_1	x_2	output
0	0	0
0	1	0
1	0	0
1	1	1

Therefore

$w_0 < 0$

$w_0 + w_1 < 0$

$w_0 + w_2 < 0$

$w_0 + w_1 + w_2 > 0$

Possible values of w_0 , w_1 , w_2 may be -0.5, 0.4, 0.3.

Text Books

1. **Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw-Hills, Reprint 2003.**

2. **S Russell and Peter Norvig, Artificial Intelligence – A Modern Approach, Pearson Education, Reprint 2003.**

3. **Saroj Kaushik, "Logic and Prolog Programming", New Age International Ltd, Publisher, 2007.**