PES2UG20CS270
5E

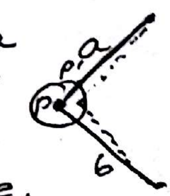
UE20CS302

MACHINE INTELLIGENCE

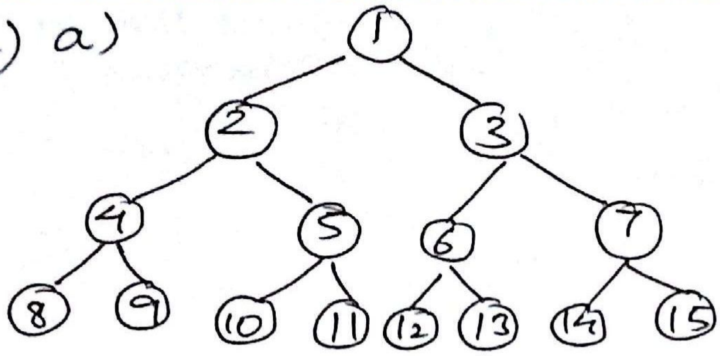
Assignment-1

1) a) Consider the real plane R^2, obstacles O, we need to find shortest distance from (x_s, y_s) to (x_g, y_g) so that is goes through the free space, $F = R^2 - O$. Given, the state space, positions $(x, y) \in R^2$ are all in F (as long as number of obstacles is finite. Consider a small part of F, the number of positions (x, y) present in it is infinite. Therefore, there have to be infinite paths to reach the goal [There will only be one optimal path].

b) The shortest path from the vertex of one polygon to another is a path where each vertex on it is a vertex of one of the polygon obstacles [euclidean shortest distance]. If even one of the vertices in this path wasn't a vertex of the obstacles, then it is observed that the considered path is not the shortest. For example, consider two edges a and b from the same point P, that don't lie on the tangent of an obstacle or that of a vertex. From p's neighborhood, you can pick a point p' such that the lengths of edges a and b are reduced. Hence, we can obtain a shorter path. The state space, $\forall\ (x, y) \longrightarrow (x, y)$ is a vertex of the obstacles as we can ignore all the other (x, y) in free space. The size of the state space is equal to the number of vertices of all the obstacles in the plane.



2) a)



b) Order of nodes for

BFS: 1 → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9
→ 10 → 11

DFS: 1 → 2 → 4 → 8 → 9 → 5 → 10 → 11

IDS: 1,1 → 2 → 3,1 → 2 → 4 → 5 → 3 → 6 → 7,1
→ 2 → 4 → 8 → 9 → 5 → 10 → 11

c) f(x) = { if x=1 then () ~~els~~
elseif (even(x)) then f(floor(x/2)).Left
else f(floor(x/2)).Right }

Yes you can find an algorithm that outputs the solution without any search. Since the left node = 2k and right node = 2k+1, the goal state can be ~~a~~ binary number in the algorithm, use 0 for ~~the~~ left ~~or right~~ and 1 for ~~the~~ right.

3) False. Tree 2 is an elaboration of Tree 1. Tree 1 is extended by extending the -ve branch. Tree 2 is more general than tree 1 ⇒ all examples classified by tree 1 are also classified positive by tree 2 but not the other way around.

4) Assume h() is admissible.
G_2 → sub-optimal goal state is generated and put on frontier. n → unexpanded state which is on optimal path to goal G.
$f(G_2) = g(G_2)$ as $h(G_2) = 0$.
and $g(G_2) > g(G)$

$f(a) = g(a)$

$f(a_2) > f(a) \longrightarrow$ subt.

~~Therefore~~ Since h is admissible,

$h(n) \leq h^*(n)$

$g(n) + h(n) \leq g(n) + h^*(n)$

From the definition of $f(n)$,

$f(n) = g(n) + h(n)$

~~Assume~~ $f(a) = g(n) + h^*(n)$

thus, $f(n) \leq f(a)$.

Hence $f(a_2) > f(n)$. $\Rightarrow A^*$ won't select a_2 for expansion.

$\therefore$ Optimal

5) a)

Age	Income	Type	Family Income	credit rating	Buys computer
≤ 30	H	E	20-37K	L	No
≤ 30	H	E	20-37K	L	No
31-40	H	E	$<$20K	H	No
>40	M	E	20-37K	H	Yes
>40	L	S	20-37K	H	Yes
>40	L	S	$>$37K	H	No
31-40 ~~≤ 30~~	L	S	20-37K	H	Yes
≤ 30	M	E	$<$20K	L	No
<30	L	S	20-37K	L	No
>40	M	S	20-37K	H	Yes
≤ 30	M	S	$<$20K	L	No
31-40	M	E	$<$20K	H	No
31-40	M	S	20-37K	H	Yes
>40	M	E	$>$37K	H	No

$$E(S) = -\frac{9}{14}\log_2\frac{9}{14} - \frac{5}{14}\log_2\frac{5}{14} = 0.94$$

$G(S, Age)$: $E(Age \le 30) = 0$

$E(Age\ 31-40) = 1$

$E(Age > 40) = -\frac{3}{5}\log_2\frac{3}{5} - \frac{2}{5}\log_2\frac{2}{5}$

$= 0.97.$

$$I(Age) = \frac{5}{14}(0) + \frac{4}{14}(1) + \frac{5}{14}(0.97) = 0.63$$

$\therefore G(S, Age) = 0.94 - 0.63 = 0.31$

$G(S. Income)$: $E(Income - H) = -\frac{1}{4}\log_2\frac{1}{4} - \frac{3}{4}\log_2\frac{3}{4}$

$= 0.31$

$E(Income - M) = -\frac{2}{6}\log_2\frac{2}{6} - \frac{4}{6}\log_2\frac{4}{6}$

$= 0.91$

$E(Income - 1) = 1$

$I(Income) = \frac{4}{14}(0.81) + \frac{6}{14}(0.91) + \frac{4}{14}(1)$

$= 0.91$

$\therefore G(S, Income) = 0.94 - 0.91 = 0.03$

$G(S, Type)$: $E(Type - E) = \left[-\frac{1}{7}\log_2\frac{1}{7} - \frac{6}{7}\log_2\frac{6}{7}\right]$

$= 0.59$

$E(Type - S) = \left[-\frac{4}{7}\log_2\frac{4}{7} - \frac{3}{7}\log_2\frac{3}{7}\right] = 0.98$

$I(Type) = \frac{7}{14}(0.59) + \frac{7}{14}(0.98) = 0.785$

$\therefore G(S, Type) = 0.94 - 0.785 = 0.155$

$G(S, Family\ Income)$: $E(Famin < 20k) = 0$

$E(Famin\ 20k - 37k) = 0.95$

$E(Famin > 37K) = 0$

$I(Famin) = \frac{4}{14}(0) + \frac{8}{14}(0.95) + \frac{2}{14}(0) = 0.54$

$G(S, \text{fam in}) = 0.94 - 0.54 = 0.4$

$G(S, \text{credit rating}): E(\text{cr} - \text{low}) = 0$

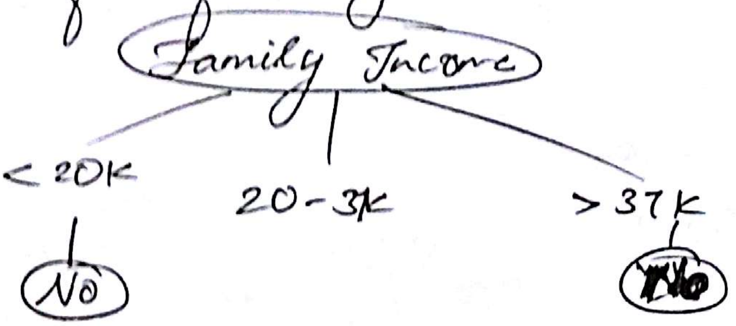
$E(\text{cr} - \text{high}) = -\frac{5}{9}\log_2\frac{5}{9} - \frac{4}{9}\log_2\frac{4}{9}$

$= 0.99$

$I(\text{cr}) = \frac{5}{14}(0) + \frac{9}{14}(0.99) = 0.64$

$\therefore G(S, \text{cr}) = 0.94 - 0.64 = 0.30$

Highest gain for family income $\rightarrow$ root node



$E(S') = 0.95$ (F in 20-37K)

$G(S', \text{Age}): E(\text{Age} \le 30) = 0$

$E(\text{Age } 31-40) = 0$

$E(\text{Age} > 40) = 0$

$I(\text{Age}) = 0$

$G(S', \text{Age}) = 0.95 - 0 = 0.95$

$G(S', \text{in.}): E(\text{in} - \text{high}) = -\frac{1}{3}\log_2\frac{1}{3} - \frac{2}{3}\log_2\frac{2}{3}$

$= 0.92$

$E(\text{in} - \text{medium}) = 0$

$E(\text{in} - \text{low}) = -\frac{2}{3}\log_2\frac{2}{3} - \frac{1}{3}\log_2\frac{1}{3}$

$= 0.92$

$I(\text{in}) = \frac{3}{8}(0.92) + \frac{2}{8}(0) + \frac{3}{8}(0.92) = 0.69$

$G(S', \text{In}) = 0.95 - 0.69 = 0.26$

$G(S', \text{type}): E(\text{type} - E) = -\frac{1}{3}\log_2\frac{1}{3} - \frac{2}{3}\log_2\frac{2}{3} = 0.91$

$E(\text{type} - S) = -\frac{4}{5}\log_2\frac{4}{5} - \frac{1}{5}\log_2\frac{1}{5}$

$= 0.72$

Scanned by CamScanner

$I(\text{type}) = \frac{3}{8}(0.91) + \frac{5}{8}(0.72) = 0.79$

$\therefore G(S', \text{type}) = 0.95 - 0.79 = 0.16$

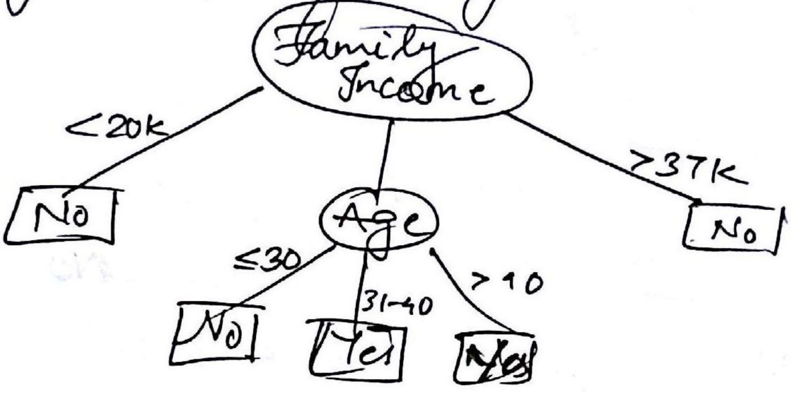
$G(S', cr)$: $E(cr - high) = 0$

$E(cr - low) = 0$

$I(cr) = 0$

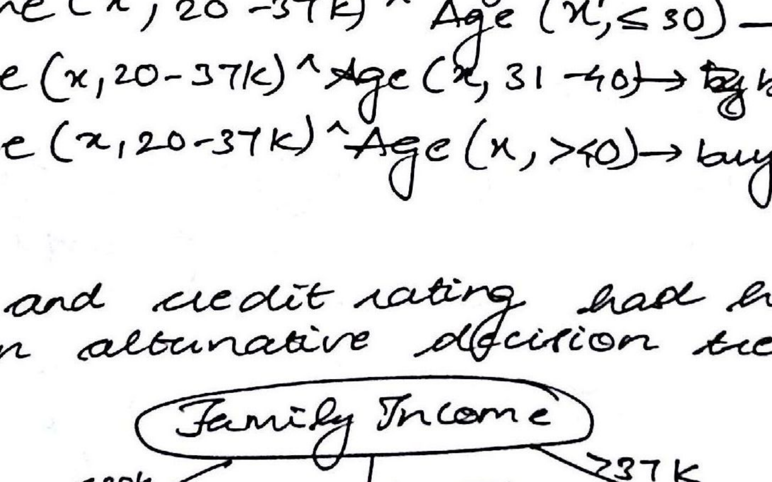
$\therefore G(S', cr) = 0.95$

Highest gain ~~of~~ is for age and credit rating.



b) Family Income$(x, <20K) \rightarrow$ buys Computer(x, No)
Family Income$(x, >37K) \rightarrow$ buys computer(x, No)
Family Income$(x, 20-37K) \wedge$ Age$(x, \leq 30) \rightarrow$ buys Computer(x, No)
Family Income$(x, 20-37K) \wedge$ Age$(x, 31-40) \rightarrow$ buys computer(x, Yes)
Family Income$(x, 20-37K) \wedge$ Age$(x, >40) \rightarrow$ buys Computer(x, Yes)

c) As age and credit rating had highest gains, an alternative decision tree:



6) a) Instance space size $= 3 \times 3 \times 2 \times 3 \times 2 = 108$

b) No. of semantically diff. hypothesis $=$

$$4 \times 4 \times 3 \times 4 \times 3 + 1 = 577$$

c) No. of syntactically diff. hypothesis

$$= 5 \times 5 \times 4 \times 5 \times 4 = 2000$$

d) concept space size $= 2^{108}$

Assignment 2

4.1) Output: $o = sgn(w_0 + w_1 x_1 + w_2 x_2)$

Decision surface, $w_0 + w_1 x_1 + w_2 x_2 = 0.$

points: $(-1, 0)$, $(0, 2)$

$$\Rightarrow \frac{x_1 - (-1)}{0 - (-1)} = \frac{x_2 - 0}{2 - 0}$$

$$x_1 + 1 = \frac{x_2}{2}$$

$$2x_1 - x_2 + 2 = 0.$$

$w_0 = 2,\ w_1 = 2,\ w_2 = -1$

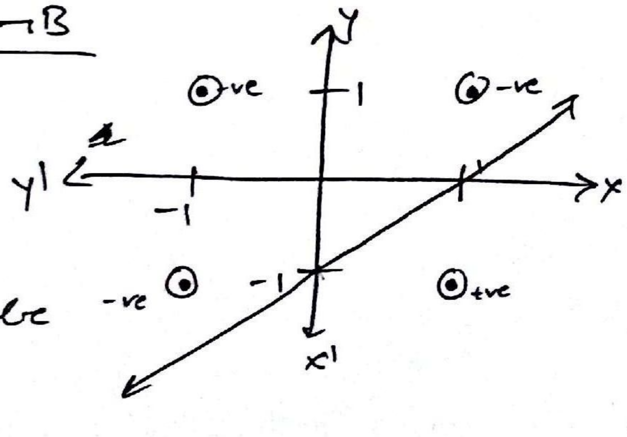
consider $O(0,0)$, output is +ve instead of -ve

$\rightarrow$ negate weights.

$\therefore\ w_0 = -2,\ w_1 = -2,\ w_2 = 1$

4.2)

A	B	$\neg B$	$O = A \wedge \neg B$
-1	-1	1	-1
-1	1	-1	-1
1	-1	1	1
1	1	-1	-1



Decision boundary can be drawn, passes through $(1,0)$, $(0,-1)$

Its equation, $\frac{x-0}{1-0} = \frac{y-(-1)}{0-(-1)}$

$-x+y+1=0$.

$w_0 = 1,\ w_1 = -1,\ w_2 = 1$

output of perceptron for $(1,-1) \rightarrow -ve$.

$\Rightarrow$ negate weights

$\therefore$ $w_0 = -1,\ w_1 = 1$ and $w_2 = -1$

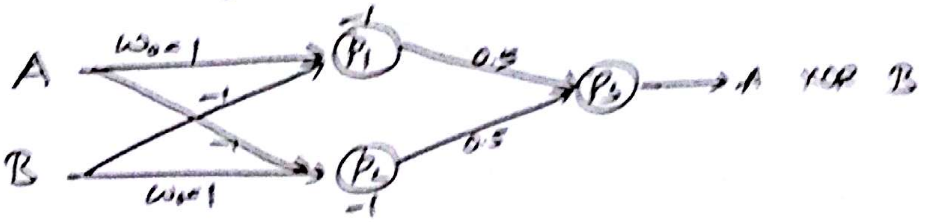
A XOR B = $(A \wedge \neg B) \vee (\neg A \wedge B)$

$\hookrightarrow P_1$ $\hookrightarrow P_2$

Let $P_3 = O(P_1) \vee O(P_2)$

For $P_1 \rightarrow w_0 = -1,\ w_1 = 1,\ w_2 = -1$ as done.

similarly for P_2.



4.3) $B(x_1, x_2) = 1$

$2x_1 + x_2 > 0$

$1 + 2x_1 + x_2 > 0$

$\Rightarrow A(x_1, x_2) = 1$

$\therefore$ A is more-general-than B only if $B(x_1, x_2) = 1$ for all $\langle x_1, x_2 \rangle$