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Soln:- 1:- let us consider, σ to be sigmoid fn.

(a) output of hidden unit $= \sigma(w_1 \times \text{input val} + \text{bias})$

$$= \sigma(-2 \times 1 + 2)$$

$$= \sigma(0)$$

$$= \frac{1}{1+e^0} = 0.5$$

$\therefore$ final output $= (w_2 \times \text{output of hidden layer}) + \text{bias}$

$$= 4 \times 0.5 + 0$$

$$= 2$$

(b) error obtained in this training case

$$= \frac{(t-y)^2}{2}$$ given $y = 2$ for golden output $t = 1$

$$= \frac{(1-2)^2}{2} = \frac{1}{2}$$

$$= 0.5$$

(c) $\because$ derivative of loss with respect to w2 for training case

$$\Rightarrow \frac{\partial E}{\partial w} = \frac{\partial\left(\frac{w_2 \times y' - y}{2}\right)^2}{\partial w}$$

$$= 2 \times \frac{1}{2} (w_2 y' - y)(y')\Big|_{y'=0.3,\ y=1}$$

$$= (4 \times 0.5 - 1)(0.5)$$
$$= (2-1) \times 0.5$$
$$= 0.5$$

(d) derivative of loss wrt w_1 for this training case

$$\therefore \frac{\partial E}{\partial \omega_1} = (y - t) \frac{\partial y}{\partial \omega_1}$$

$$= (y-t) \frac{\partial(\omega_2 \times x_{hidden} + b_s)}{\partial \omega_1}$$

$$= (y-t)\, \omega_2 \frac{\partial x_{hidden}}{\partial \omega_1}$$

$\therefore x_{hidden} = \frac{1}{1+e^{-v}}$ where $v = \omega_1 x_{input} + b_x$

$$\therefore \frac{\partial x_{hidden}}{\partial \omega_1} = \frac{e^{-v}}{1+e^{-v}} \frac{dv}{\partial \omega_1} = \frac{e^{-v}}{1+e^{-v}} x_{input}$$

$$\frac{\partial E}{\partial \omega_1} = (y-t)\, \omega_2 \cdot \frac{e^{-v}}{(1+e^{-v})^2} x_{input}$$

now, substituting values we get,

$$\frac{\partial E}{\partial \omega_1} = (2-1) \times 4 \times \frac{e^{-0}}{(1+e^{-0})^2} \cdot 1 = \frac{1 \times 4 \times 1}{(1+1)^2}$$

$$= 4 \times \frac{1}{4}$$

$$= 1$$

Sol^n :- 3:- (a)

consider for covid-19,

$$I(p,n) = I(3,3) = -\frac{3}{6}\log_2\frac{3}{6} - \frac{3}{6}\log_2\frac{3}{6}$$

$$= -\frac{3}{6}\left(2\log_2\frac{1}{2}\right)$$

$$= -\frac{1}{2}\times 2 \times \log_2 2^{-1}$$

$$= \frac{1}{2}\times 2\times 1$$

$$= 1$$

Now, split on 'fever' :-

for (fever = T) : $I(p,n) = I(2,2) = 1$

for (fever = F) : $I(p,n) = I(1,1) = 1$

$\therefore$ remainder (fever) $= \frac{4}{6}\times 1 + \frac{2}{6}\times 1$

$$= \frac{1}{6}(4+2)$$

$$= 6/6 = 1$$

$\therefore$ Information gain (IG) $= 1 - 1 = 0$

now, split on 'cough' :-

for (cough = T) : $I(p,n) = I(3,1)$

$$= -\frac{3}{4}\log_2 3/4 - \frac{1}{4}\log_2 1/4$$

$= -\frac{1}{4}\left(3\log_2 3/4 + \log_2 1/4\right)$

$= \frac{-1}{4}\left(3\log_2 3 - 3\log_2 2^2 + \log_2 2^{-2}\right)$

$= -\frac{1}{4}\left(3\log_2 3 - 6 - 2\right)$

$= -\frac{1}{4}\left(-3.26\right)$

$= 0.815$

for (cough = F) : $I(P, n) = I(0, 2) = 0$

$\therefore$ remainder (cough) $= \frac{4}{6} \times 0.815 + \frac{2}{6} \times 0$

$= 0.543$

$\therefore$ Information gain (IG) $= 1 - 0.543$

$= 0.457$

now, split on 'breathing' :-

for (breathing = T) $= I(P, n)$

$= I(2,1) = -\frac{2}{3}\log_2 \frac{2}{3} - \frac{1}{3}\log_2 \frac{1}{3}$

$= -\frac{1}{3}\left(2\log_2 2 - 2\log_2 3 - \log_2 3\right)$

$= 0.918$

for (breathing = F) : $I(P, n)$

$= I(1, 2)$

$= -\frac{2}{3}\log_2 \frac{1}{3} - \frac{2}{3}\log_2 \frac{2}{3}$

$= 0.918$

$\therefore$ remainder (breathing) $= \frac{3}{6} \times 0.918 + \frac{3}{6} \times 0.918$

$= 0.918$

$\therefore$ Information gain (IG) (breathing) $= 1 - 0.918$
$= 0.08$

Now, split on 'Human contact' :-
for (Human contact = T) : $I(p, n)$
$= I(1, 1) = 1$

for (Human contact = F) : $I(p, n) = I(2, 2)$
$= 1$

$\therefore$ remainder (Human contact) $= \frac{2}{6} \times 1 + \frac{4}{6} \times 1$

$= 1$

$\therefore$ Information gain (IG) (Human Contact) $= 1 - 1 = 0$

Now, split on 'cov contact' :-
for (covcontact = T) : $I(p, n) = I(2, 2) = 1$
for (cov contact = F) : $I(p, n) = I(1, 1) = 1$
remainder (cov contact) $= \frac{4}{6} \times 1 + \frac{2}{6} \times 1$

$= 1$

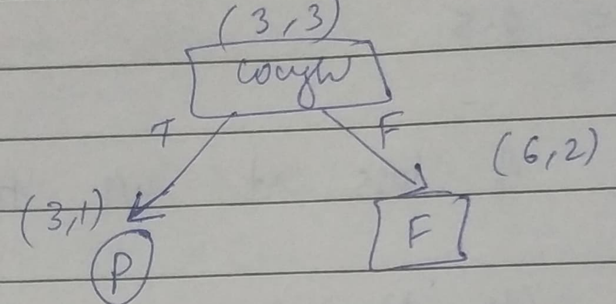
$\therefore$ Information gain (IG) (cov contact) $= 1 - 1 = 0$

(b) ~~Now, to choose the to use for the root of the tre~~

attribute that would be for ID3 algo for the root would be "Cough" because it has the ~~ma~~ highest information gain.

(c) as (b) result will be 'cough'

so, consider this



∴ we need to find position P,

for cought = T

fever	Breathing	Human Contact	Car Contact	Covid 19
T	F	F	F	F
T	T	T	F	T
F	T	F	T	T
T	F	F	T	T

∴ $IG(\text{Breathing}) = I(3,1) - \left[\frac{2}{4} I(1,1) + \frac{2}{4} I(2,0)\right]$

$= 0.811 - \frac{1}{2} \times 1$

$= 0.311$

$IG(\text{Human Contact}) = I(3,1) - \left(\frac{1}{4} I(1,0) + \frac{3}{4} \times (2,1)\right]$

$= 0.123$

$IG(\text{Fever}) = I(3,1) - \left(\frac{3}{4} I(2,1) + \frac{1}{4} I(1,0)\right]$

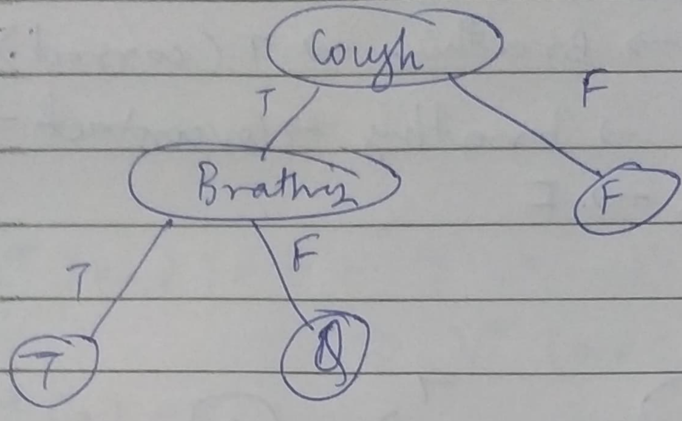
$= 0.123$

$IG(\text{Car Contact}) = I(3,1) - \left(\frac{2}{4} I(1,1) + \frac{2}{4} \times I(2,0)\right)$

$= 0.311$

So for pos. P we consider either breathing on cov contact.

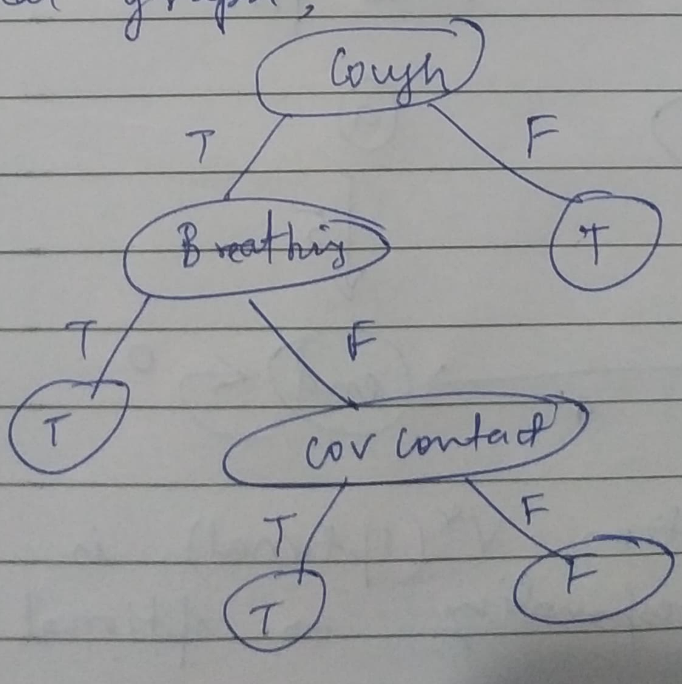
∴



∴ for Q, we choose the attribute data when cough = T & brathing = F

fever	Human contact	Cov contact	Covid 19
T	F	F	F
T	F	T	T

∴ final graph,



now verify,

P_1 → cough → breathing → Cov contact → F (correct)

P_2 → cough → Breathing → T (correct)

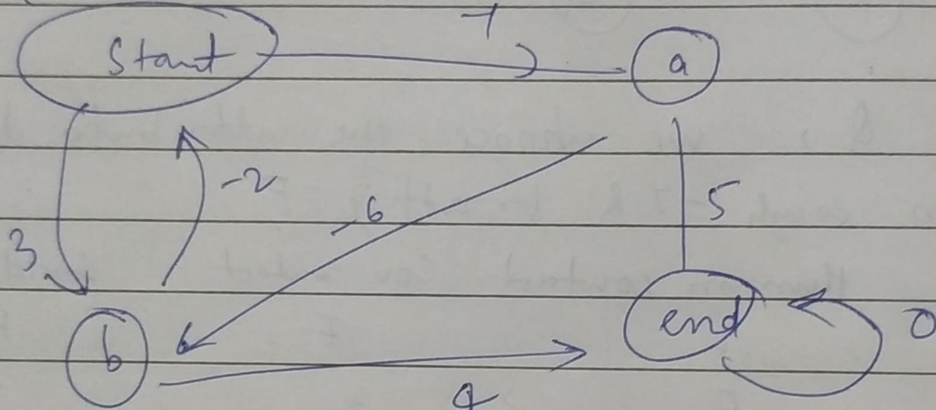
P_3 → cough → F (correct)

P_4 → Cough → Breathing → T (correct)

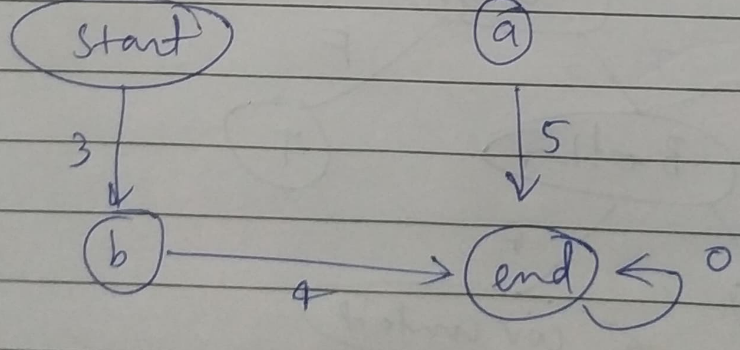
P_5 → cough → breathing → Cov contact → T

P_6 → Cough → F

Sol^n:- 2:-(a)



for optimal condition, we are taken greedily with respect to value fn.



(b) ∵ value function V^* (optimal) is value of State corresponding to optimal condition

$\therefore V^*(\text{start}) = 3 + \gamma V^*(b)$

$V^*(a) = 5 + \gamma V^*(\text{end})$

$V^*(b) = 4 + \gamma V^*(\text{end})$

$\therefore V^*(\text{end}) = 0 + \gamma V^*(\text{end})$

$\Rightarrow V^*(\text{end}) = 0$

$\therefore V^*(a) = 5$

$V^*(b) = 4$

& $V^*(\text{start}) = 3 + 0.9 \times 4$

$= \cancel{6}\ 3 + 3.6$

$= 6.6$