CSE 461 : INTRODUCTION TO ROBOTICS

FINAL

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SECTION: 09

Pg # 1

(1)(a)

$$\begin{bmatrix} 3 & 5 & 2 & 8 & 1 \\ 9 & 7 & 5 & 4 & 3 \\ 2 & 0 & 6 & 1 & 6 \\ 6 & 3 & 7 & 9 & 2 \\ 1 & 4 & 9 & 5 & 1 \end{bmatrix} * \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 25 & 18 & 17 \\ 18 & 22 & 14 \\ 20 & 15 & 23 \end{bmatrix}$$

image (5×5)

filter (3×3)

~~image~~ feature (3×3) → (X)

$(3*1) + (5*0) + (2*0) + (9*1) + (7*1) + (5*0)$
$+ (2*0) + (0*0) + (6*1) = 25$

(b)

$$\begin{bmatrix} 25 & 18 & 17 \\ 18 & 22 & 14 \\ 20 & 25 & 23 \end{bmatrix} \xrightarrow{\text{average pooling}} \begin{bmatrix} 20.75 & 17.75 \\ 21.25 & 21 \end{bmatrix}$$

feature → (X) (3×3)

final feature → (X') (2×2)

$$\text{average}(1) = \frac{25+18+18+22}{4} = 20.75$$

$$\text{average}(2) = \frac{18+17+22+14}{4} = 17.75$$

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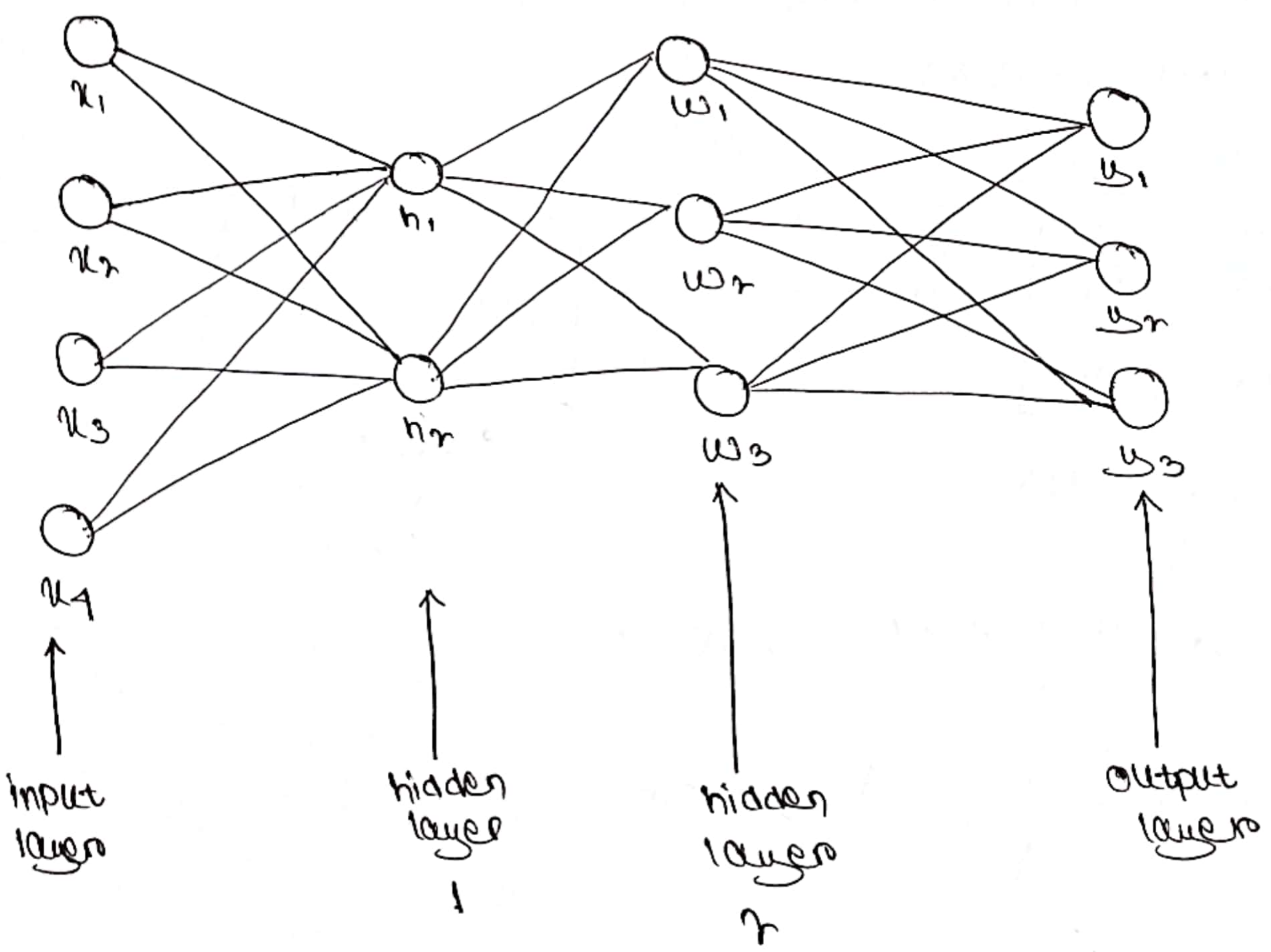
(c) $\underset{(2\times2)}{X'} \xrightarrow{\text{flattened}} \underset{(4\times1)}{X''}$

input layer = 4 $[x_1, x_2, x_3, x_4]$

hidden layer = 2 [2 neurons → 1, 3 neurons → 2]

output layer = 3 [y_1 → cat, y_2 → dog, y_3 → elephant]



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(2) (a) ① Overshoot $= \frac{1.4 - 1}{1} * 100\% = 40\%$

rise time $= t_2 - t_1$

$= 0.6 - 0.2$

$= 0.4$ msec

at 10% of 1 $= 0.01$, $t_1 = 0.2$

at 90% of 1 $= 0.9$, $t_2 = 0.6$

settling time = 4 msec

$1 \pm (5\% \text{ of } 1)$

$\Rightarrow 1 \pm 0.05$

$\Rightarrow [0.95, 1.05]$

~~(b)~~

(b) $Y(s) = G(s) * (X(s) - Y(s)H(s))$

$$\frac{Y(s)}{\cancel{X(s)}} = \frac{G(s)}{1 + G(s)H(s)} X(s)$$

$G(s) = 10$ units

$H(s) = 4$ units

$X(s) = 15$ units

$$Y(s) = \frac{10}{1 + (10)(4)} (15)$$

$Y(s)$ = output of the system

$Y(s) = 3.66$ units

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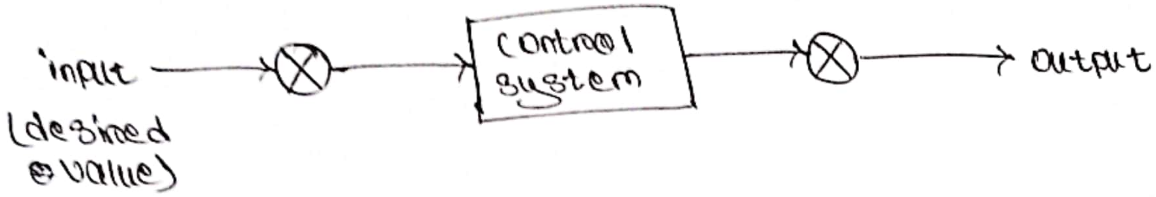
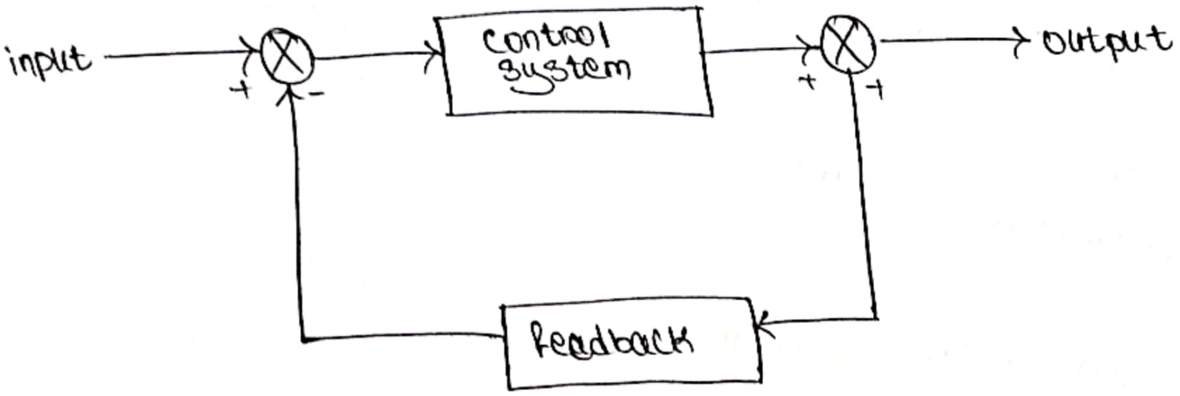
~~(c) Open loop control system~~

(c) The output does not fed back with the input for correction in open loop sy control system, whereas the output fed back with the input for correction in closed loop control system.

~~Example for open loop control system:-~~
~~In a washing machine, the control system is predetermined with all the features and the rules are fixed. So, when we can adjust the speed of the machine,~~



Open loop
control system



Closed loop control system

In closed loop control system, there is a feedback system which allows the action to be adjusted based on the difference between actual and desired ou values.

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(3) (a) A scenario such as a robot has a map ~~and~~ of a room and it needs to turn off the television. ~~which is marked as X~~ It also has GPS location system embedded in it.

~~Since~~ The robot needs to find out its current location which it can ~~f~~ determine using landmark based localization. The GPS helps the robot to find out a landmark by using the intersection of many distances between GPS and sattelites. The robot senses the landmark using sensor and determine its position using the location of landmark. Localization is done.

The robot moves towards the TV using global path planning algorithm such as A*, Dkijstra and BFS. The path planning is also completed.

If there is any unknown ~~on~~ obstacles or objects in the room, the robot can use frontier for exploration. The robot moves ~~f~~ towards frontier cells (unknown cells adjacent to the empty cells) and marks them as "empty" and "occupied" cells on the provided ~~map~~ grid cells represented map. Here, exploration is completed.

The robot reaches the TV and turns it off when all the navigation procedure are conducted properly.

Since, map is provided here, no mapping algorithm is used.

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(b) The grid cell represents the environment which the robot needs to explore to get to the rover ~~, marked by red circle~~. The robot uses sensor to find out the cells which are empty and occupied. As shown in diagram, the robot identifies an obstacle and has marked that position with black. The robot has changed its motion in another direction by following path planning algorithm, such as ~~Dij~~ Dijkstra or A*. The point where an obstacle is found, the entire cells and adjacent cells below are marked black and following that path the robot would be damaged. The moment, the robot senses free space, it marks the empty cell as "blank" cells and follows that route to the rover. The procedure continues until the robot reaches the rover. The robot marks the rover with the red circle.

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(c) Using Visual Homing, the robot can move straight towards its goal, which is the 'X' mark. The robot ~~would~~ would have moved randomly if the goal is not found, but due to the presence of Bug based algorithm, the robot searches for obstacle if the goal is not found. Using the Bug based algorithm, the robot moves straight if there is no obstacle found. If there is any obstacle, then the robot chooses the ~~obstacle~~ boundary of the obstacle which will provide it the quickest path to reach to the 'X' mark with fewer steps.

Since, there is a GPS included, landmark based localization can be used. The GPS sends signal to the satellite nearby and receives the distance of ~~landmark~~ satellite and ~~sate~~ GPS. many distances are found out and the intersection point of all the distances is the probable landmark. The robot can then use its sensor to recognize the landmark and determine its position using the location of the landmark.