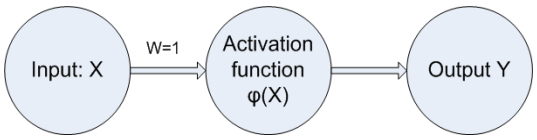
CSC7130 Advanced Artificial Intelligence
Homework Assignment for Artificial Neural Networks
Sample Answer

1.2.

Suppose X=1 or 0 in this question.

1.2.1 (5 marks)

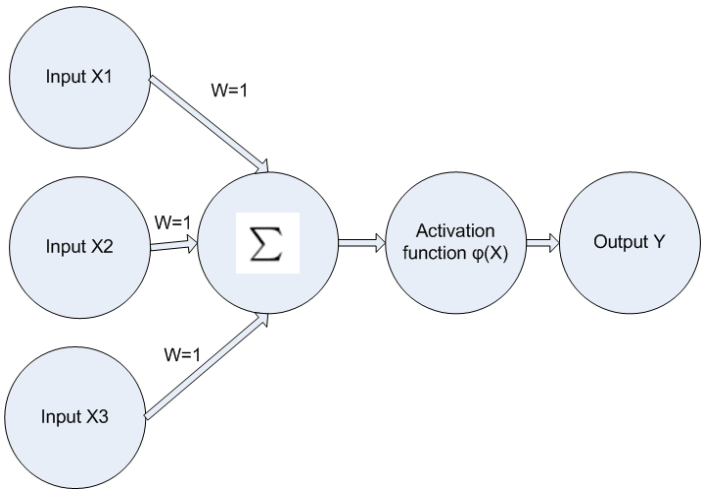


Activation Function:

$$\varphi(X) = 1, if X = 0$$

$$\varphi(X) = 0, if X = 1$$

1.2.2 (5 marks)

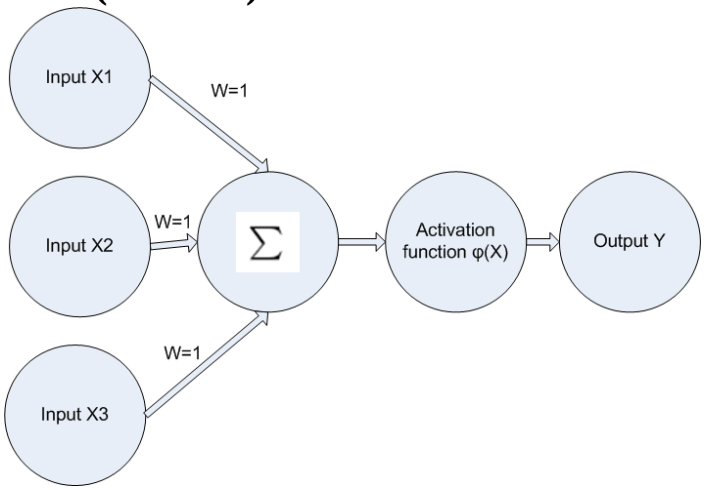


Activation Function:

$$\varphi(X) = 1, if X = 3$$

$$\varphi(X) = 0, otherwise$$

1.2.4 (5 marks)



Activation Function:

$$\varphi(X) = 0, if X \geq 1$$

$$\varphi(X) = 1, otherwise$$

1.3.1 (5marks)

$$\begin{aligned} \varphi'(v) &= \frac{d\varphi(v)}{dv} = \frac{-(1+exp(-av))'}{(1+exp(-av))^2} \\ &= \frac{a \times exp(av)}{(1+exp(-av))^2} = a \cdot \frac{1}{1+exp(-av)} \cdot (1 - \frac{1}{1+exp(-av)}) \\ &= a\varphi(v)(1-\varphi(v)) \end{aligned}$$

1.3.2 (5 marks)

$$\varphi'(v) = a \cdot \frac{1}{1+e^0} \cdot (1 - \frac{1}{1+e^0}) = \frac{1}{4}a$$

1.4.1 (5 marks)

$$5 \times (-0.8) + 10 \times 0.5 + 1.0 \times (-2) + (-0.9) \times (-10) = 8$$

1.4.2 (5 marks)

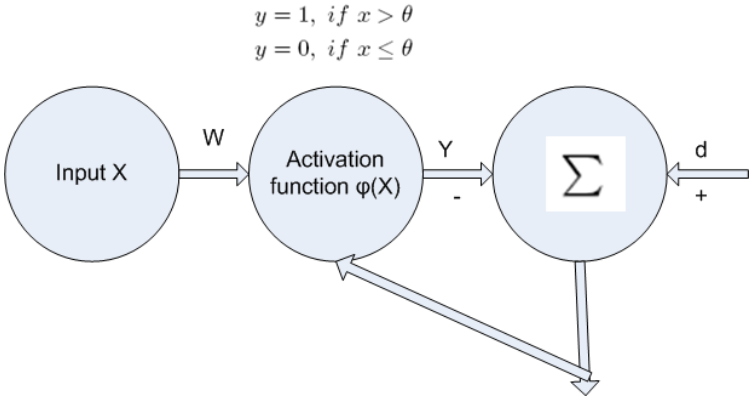
Based on the activation function:

$$v = 8, \varphi(v) = 1$$

1.4.3 (5 marks)

$$\varphi(v) = \frac{1 - exp(-8a)}{1 + exp(-8a)}$$

1.6.1 (20 marks)



$$\eta = 2, w = 1, \theta = 100$$

x	Old w	y	d	e	eta	dw	w
90	1	0	1	1	2	2	3
90	3	1	1	0	2	0	3
40	3	1	0	-1	2	-2	1

…

This procedure does not converge. There is no output.

$$\eta = 1, w = 1, \theta = 100$$

x	Old w	y	d	e	eta	dw	w
90	1	0	1	1	1	1	2
90	2	1	1	0	1	0	2
40	2	0	0	0	1	0	2
30	2	0	0	0	1	0	2
60	2	1	1	0	1	0	2
50	2	0	0	0	1	0	2
45	2	0	0	0	1	0	2
65	2	1	1	0	1	0	2
80	2	1	1	0	1	0	2

Output: w = 2

$$\eta = 0.5, w = 1, \theta = 100$$

x	Old w	y	d	e	eta	dw	w
90	1	0	1	1	0.5	0.5	1.5
90	1.5	1	1	0	0.5	0	1.5
40	1.5	0	0	0	0.5	0	1.5
30	1.5	0	0	0	0.5	0	1.5

60	1.5	0	1	1	0.5	0.5	2
90	2	1	1	0	1	0	2
40	2	0	0	0	1	0	2
30	2	0	0	0	1	0	2
60	2	1	1	0	1	0	2
50	2	0	0	0	1	0	2
45	2	0	0	0	1	0	2
65	2	1	1	0	1	0	2
80	2	1	1	0	1	0	2

Output: w = 2

$$\eta = 0.1, w = 1, \theta = 100$$

x	Old w	y	d	e	eta	dw	w
90	1	0	1	1	0.1	0.1	1.1
90	1.1	0	1	1	0.1	0.1	1.2
90	1.2	1	1	0	0.1	0	1.2
40	1.2	0	0	0	0.1	0	1.2
30	1.2	0	0	0	0.1	0	1.2
60	1.2	0	1	1	0.1	0.1	1.3
90	1.3	1	1	0	0.1	0	1.3
40	1.3	0	0	0	0.1	0	1.3
30	1.3	0	0	0	0.1	0	1.3
60	1.3	0	1	1	0.1	0.1	1.4
90	1.4	1	1	0	0.1	0	1.4
40	1.4	0	0	0	0.1	0	1.4
30	1.4	0	0	0	0.1	0	1.4
60	1.4	0	1	1	0.1	0.1	1.5
90	1.5	1	1	0	0.1	0	1.5
40	1.5	0	0	0	0.1	0	1.5
30	1.5	0	0	0	0.1	0	1.5
60	1.5	0	1	1	0.1	0.1	1.6
90	1.6	1	1	0	0.1	0	1.6
40	1.6	0	0	0	0.1	0	1.6
30	1.6	0	0	0	0.1	0	1.6
60	1.6	0	1	1	0.1	0.1	1.7
90	1.7	1	1	0	0.1	0	1.7
40	1.7	0	0	0	0.1	0	1.7

30	1.7	0	0	0	0.1	0	1.7
60	1.7	1	1	0	0.1	0	1.7
50	1.7	0	0	0	0.1	0	1.7
45	1.7	0	0	0	0.1	0	1.7
65	1.7	1	1	0	0.1	0	1.7
80	1.7	1	1	0	0.1	0	1.7

Output: w=1.7

1.6.2 (5 marks)

One possible way is to choose:

$$w = \frac{\theta}{\text{mean of the input values}}$$

mean = 57.5 in this question.

or choose:

$$w = \frac{\theta}{\text{median of the input values}}$$

median = 55 in this question.

1.6.3 (5 marks)

It depends. Usually, least-mean-square error is used as the cost function:

$$J = E(0.5 \sum_{k} e_k^2(n))$$

A plot of the cost function J versus w is a multidimensional surface referred to as an error surface.

With linear processing units, the error surface is bowl-shaped with a unique minimum point. In other words, the initial starting condition does not matter.

With nonlinear processing units, the error surface has a global minimum as well as local minima. Thus, different initial starting conditions may lead to different local minima.

1.6.4 (5 marks)

It does not affect the output but may affect the speed of convergence.

1.7 (5 marks)

Delta rule: can be used in error-correction learning. It is not biologically motivated, and it is used in supervised learning.

Hebb's rule: Strong physiological evidence for hebbian learning in hippocampus. It is used in unsupervised learning.

1.12 (20 marks)

When $0 <= \alpha < 1$, it means we give more weight to the recent step.

But when $-1 < \alpha <= 0$, different steps will have either positive or negative impact, resulting in instable learning. In addition, it can not reach the idea of giving more weight to the recent step.