Chapter 5

Multi Layer Feed-forward Network

4th Class

INTELLIGENT APPLICATIONS

التطبيقات الذكية

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Multi Layer Feed-forward Network

5.1 Introduction
5.2 Example

5.1 Introduction

Multi Layer Feed-forward Network, it consists of multiple layers. The architecture of this class of network, besides having the input and the output layers, also have one or more intermediary layers called *hidden layers*. The computational units of the hidden layer are known as *hidden neurons.*

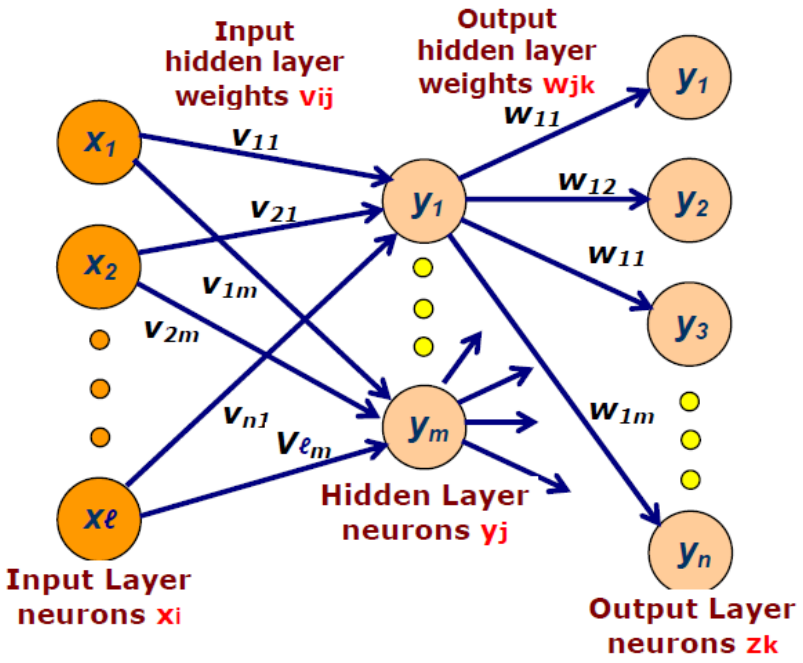
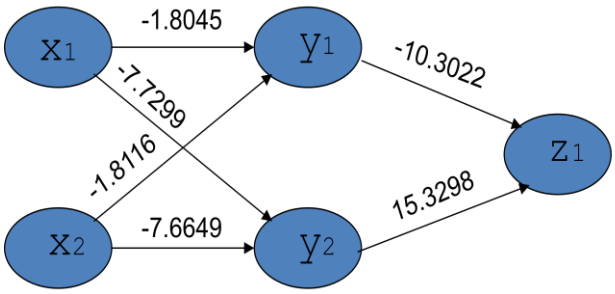


Fig. Multilayer feed-forward network in $(\ell - m - n)$ configuration.

5.2 Example

Consider Network Architecture in below figure, **Find the value of (Z_1, Error) using Sigmoid function when inputs:**

Inputs		Goal outputs (d)	Z_1	Error
X_1	X_2	$O_{desired}$	O_{actual}	E
0	**0**	**1**	?	?
0	**1**	**0**	?	?
1	**0**	**0**	?	?
1	**1**	**1**	?	?



Sol:

INPUT #1:

When (X_1=0, X_2=0)

$u_1 = \sum W_{ij} * X_j$
$= (V_{11}*X_1+V_{21}*X_2)$
$= ((-1.8045 * 0) + (-1.8116 *0))$
$= (0+0)$
$= 0$

$u_2 = \sum W_{ij} * X_j$
$= (V_{12}*X_1+ V_{22}*X_2)$
$= ((-7.7299 * 0) + (-7.6649 *0))$
$= (0+0)$
$= 0$

$F(u) = 1/(1+e^{-X})$ (Sigmoid function)
$F(u_1) = 1/(1+e^{-u1})$
$F(u_1) = y_1 = 1/(1+e^0)$ note: $e^0 = 1$,
$= 1/(1+1)$
$= 0.5$

Inputs		Goal outputs (d)	Z_1	Error
X_1	X_2	$O_{desired}$	O_{actual}	E
0	**0**	**1**	0.925	0.075
0	**1**	**0**	0.1912	0.1912
1	**0**	**0**	0.1891	0.1891
1	**1**	**1**	0.4329	0.5671

NOTE١ :
Goal output=desired output=Target
الهدف وهي المخرجات التي يحددها المصمم
او تسمى النتائج المرغوبة او النتائج المطلوبة

NOTE٢ :
Actual output= وهي المخرجات التي تظهر
اثناء الحسابات على الشبكة او تسمى النتائج
الحقيقية للشبكة

$F(u_2) = 1/(1+e^{-u2})$

$F(u_2) = y_2 = 1/(1+e^{0})$

$= 1/(1+1)$

$= 0.5$

$u_3 = \sum W_{ij} * y_j$

$= (W_{11}*y_1 + W_{21}*y_2)$

$= ((-10.3022 * 0.5) + (15.3298 * 0.5))$

$= (-5.1511 + 7.6649)$

$= 2.5138$

$F(u_3) = 1/(1+e^{-u3})$

$F(u_3) = Z_1 = 1/(1+e^{-2.5138})$ note: $e^{-2.5138} = 0.0809$

$= 0.925$

Error = $\triangle i = \mathbf{E = / O_{desired} - O_{actual} /}$

$E_1 = /1 - 0.925 /$

$= 0.075$

Error signal= $\triangle i = \mathbf{E = / O_{desired} - O_{actual} /}$

$\mathbf{E = / d - z_1 /}$

.....

INPUT #2:

When ($X_1=0, X_2=1$)

$u_1 = \sum W_{ij} * X_j$

$= (V_{11}*X_1 + V_{21}*X_2)$

$= ((-1.8045 * 0) + (-1.8116 * 1))$

$= (0 + (-1.8116))$

$= -1.8116$

$u_2 = \sum W_{ij} * X_j$

$= (V_{12}*X_1 + V_{22}*X_2)$

$= ((-7.7299 * 0) + (-7.6649 * 1))$

$= (0 + (-7.6649))$

$= -7.6649$

$F(u) = 1/(1+e^{-x})$ (Sigmoid function)

$F(u_1) = 1/(1+e^{-u1})$

$F(u_1) = y_1 = 1/\ 1/(1+e^{-(-1.8116)})$

$= 1/\ 1/(1+e^{1.8116})$ note: $e^{1.8116} = 6.1202$

$= 1/(1+6.1202)$

$= 1/7.1202$

$= 0.140$

$F(u_2) = 1/(1+e^{-u2})$

$F(u_2) = y_2 = 1/(1+e^{-(-7.6649)})$

$= 1/(1+e^{7.6649})$ note: $e^{7.6649} = 2132.179$

$= 1/(1+2132.179)$

$= 1/\ 2133.179$

$= 4.687839136^{-04}$

$= 0.00004$

$u_3 = \sum W_{ij} * y_j$

$= (W_{11}*y_1 + W_{21}*y_2)$

$= ((-10.3022 * 0.140) + (15.3298 * 0.00004))$

$= (-1.442308 + 6.13192^{-04})$

$= (-1.442308 + 0.00006)$

$= -1.442248$

$F(u_3) = 1/(1+e^{-u3})$

$F(u_3) = \mathbf{Z}_1 = 1/(1+e^{-(-1.442248)})$ note: $e^{1.442248} = 4.2302$

$= 1/(1+e^{1.442248})$

$= 1/(1+4.2302)$

$= 1/\ 5.2302$

$= 0.1912$

Error = $\triangle i = \mathbf{E} = / \mathbf{O}_{\mathbf{desired}} - \mathbf{O}_{\mathbf{actual}} /$

$E_2 = / 0 - 0.1912 /$

$= /- 0.1912/$

$= 0.1912$

……

INPUT #3:

When (X_1=1, X_2=0)

$u_1 = \sum W_{ij} * X_j$
$= (V_{11}*X_1+V_{21}*X_2)$
$= ((-1.8045 * 1) + (-1.8116 *0))$
$= (-1.8045 + 0)$
$= -1.8045$

$u_2 = \sum W_{ij} * X_j$
$= (V_{12}*X_1+ V_{22}*X_2)$
$= ((-7.7299 * 1) + (-7.6649 *0))$
$= (-7.7299 + 0)$
$= -7.7299$

$F(u) = 1/ (1+e^{-X})$ (Sigmoid function)
$F(u_1) = 1/ (1+e^{- u1})$
$F(u_1) = y_1 = 1/ 1/ (1+e^{- (-1.8045)})$
$= 1/ 1/ (1+e^{1.8045})$ note: $e^{1.8045} = 6.0769$
$= 1/ (1+6.0769)$
$= 1/7.0769$
$= 0.1413$

$F(u_2) = 1/ (1+e^{- u2})$
$F(u_2) = y_2 = 1/ (1+e^{- (-7.7299)})$
$= 1/ (1+e^{7.7299})$ note: $e^{7.7299} = 2,275.375$
$= 1/ (1+2,275.375)$
$= 4.3948^{-04}$
$= 0.00004$

$u_3 = \sum W_{ij} * y_j$
$= (W_{11}*y_1+W_{21}*y_2)$
$= ((-10.3022 *0.1413) + (15.3298 *0.00004))$
$= (-1.4557 +6.13192^{-04})$
$= (-1.442308 +0.00006)$
$= -1.4556$

$F(u_3) = 1/(1+e^{-u3})$

$F(u_3) = \mathbf{Z}_1 = 1/(1+e^{-(-1.4556)})$ note: $e^{1.4556} = 4.2870$

$= 1/(1+e^{1.4556})$

$= 1/(1+4.2870)$

$= 1/5.2870$

$= 0.1891$

$E_3 = /0 - 0.1891/$

$= /- 0.1891/$

$= 0.1891$

……..

INPUT #4:

When ($X_1=1$, $X_2=1$)

$u_1 = \sum W_{ij} * X_j$

$= (V_{11}*X_1+V_{21}*X_2)$

$= ((-1.8045 * 1) + (-1.8116 *1))$

$= -3.6161$

$u_2 = \sum W_{ij} * X_j$

$= (V_{12}*X_1+ V_{22}*X_2)$

$= ((-7.7299 * 1) + (-7.6649 *1))$

$= -15.3948$

$F(u) = 1/(1+e^{-X})$ (Sigmoid function)

$F(u_1) = 1/(1+e^{-u1})$

$F(u_1) = y_1 = 1/1/(1+e^{-(-3.6161)})$

$= 1/1/(1+e^{3.6161})$ note: $e^{3.6161} = 37.1922$

$= 1/(1+37.1922)$

$= 1/38.1922$

$= 0.0262$

$F(u_2) = 1/(1+e^{-u2})$

$F(u_2) = y_2 = 1/(1+e^{-(-15.3948)})$

$= 1/(1+e^{15.3948})$ note: $e^{15.3948} = 48515$

$= 1/(1+4\ 8515)$

$= 1/\ 48516$

$= 2.0611^{-05}$

$= 0.000002$

$u_3 = \sum W_{ij} * y_j$

$= (W_{11}*y_1 + W_{21}*y_2)$

$= ((-10.3022 * 0.0262) + (15.3298 * 0.000002))$

$= (-0.2699 + 3.0659^{-05})$

$= (-0.2699 + 0.000003)$

$= -0.2699$

$F(u_3) = 1/(1+e^{-u3})$

$F(u_3) = \mathbf{Z}_1 = 1/(1+e^{-(-0.2699)})$ note: $e^{0.2699} = 1.3098$

$= 1/(1+e^{0.2699})$

$= 1/(1+1.3098)$

$= 1/\ 2.3098$

$= 0.4329$

Error = $\triangle i = \mathbf{E} = / \mathbf{O}_{\mathbf{desired}} - \mathbf{O}_{\mathbf{actual}} /$

$E_4 = / 1 - 0.4329 /$

$= 0.5671$

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Homework :

Q: Consider Network Architecture in below figure, **Find the value of (Z_1, Error) using Sigmoid function** for hidden units (hidden layer) and **linear function** for output units (output layer) when inputs:

Inputs		Goal outputs (d)	Z_1	Error
X_1	X_2	$O_{desired}$	O_{actual}	E
0	**0**	**1**		
0	**1**	**0**		
1	**0**	**0**		
1	**1**	**1**