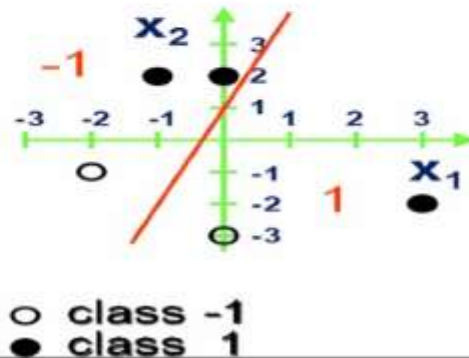


Course : Selected Topics in Computational Intelligence I
Course Code : COMP8038 Lecturer Name : Dr. Ir. Diaz D. Santika, M.Sc.
Class : LTY-1 Lecturer Code : D1159
Student Name : Edward (2201741971)

PROBLEM

Latih (train) sebuah single neuron ANN dengan ADALINE yang mampu dengan tepat mengklasifikasikan 5 data set (X, t) sebagaimana terlihat pada gambar di atas. Gunakan LMS Learning Rules dengan bobot awal $W_{11} = 3.0$, $W_{12} = 1.0$, $b = 1.0$ dan learning rate $\alpha = .05$ untuk menghitung nilai bobot W dan bias b berikutnya. Lakukan perhitungan 3 epoch pertama dan berdasarkan hasil proses training tsb, turunkan persamaan garis boundary decision model ADALINE Sdr dan hitung Loss yang Sdr peroleh. Berikan justifikasi Sdr apakah proses training Adaline tsb akan mampu menghasilkan generalisasi yang optimal



Jawaban:

Proses Training Adaline mampu menghasilkan generalisasi yang optimal dilihat dari Mean Squared Error yang semakin kecil. Untuk Perhitungan Secara *HandWritten* di halaman berikutnya.

Course : Selected Topics in Computational Intelligence I

Course Code : COMP8038

Lecturer Name : Dr. Ir. Diaz D. Santika, M.Sc.

Class : LTY-1

Lecturer Code : D1159

Student Name : Edward (2201741971)

$$\begin{aligned} w_1 &= 3.0 \\ w_2 &= 1.0 \\ b &= 1.0 \\ \alpha &= 0.05 \end{aligned} \quad \left. \begin{array}{l} \\ \\ \\ \end{array} \right\} \text{diketahui}$$

Edward / 2201741971
LTY-1

Ditanya: Loss dari 3 epoch pertama.

Jawab:

x_1	x_2	t
-2	-1	-1
-1	2	1
0	-3	-1
0	2	1
3	-2	1

First Input (Epoch I)

$$x_1 = -2$$

$$x_2 = -1$$

$$t = -1$$

$$y_{in} = b + w_1 x_1 + w_2 x_2$$

$$= 1.0 + (3.0 \cdot -2) + (1.0 \cdot -1)$$

$$= 1.0 + (-6.0) + (-1.0)$$

$$= -6.0$$

$$(t - y_{in}) = -1 - (-6.0)$$

$$= 5.0$$

update weight

$$w_{1(new)} = w_{1(old)} + \alpha(t - y_{in})x_1$$

$$= 3.0 + 0.05(5.0)(-2)$$

$$= 3.0 + (-0.5) = 2.5$$

$$w_{2(new)} = w_{2(old)} + \alpha(t - y_{in})x_2$$

$$= 1.0 + 0.05(5.0)(-1)$$

$$= 1.0 + (-0.25) = 0.75$$

$$b(new) = b(old) + \alpha(t - y_{in})$$

$$= 1.0 + 0.05(5.0)$$

$$= 1.0 + (0.25) = 1.25$$

$$\Delta w_1 = -0.5$$

$$\Delta w_2 = -0.25$$

$$\Delta b = 0.25$$

Compute Error

$$\text{Error} = (t - y_{in})^2 = (5.0)^2 = 25.0$$

Second Input (Epoch I)

$$x_1 = -1$$

$$x_2 = 2$$

$$t = 1$$

$$y_{in} = b + w_1 x_1 + w_2 x_2$$

$$= 1.25 + (2.5 \cdot -1) + (0.75 \cdot 2)$$

$$= 1.25 + (-2.5) + (1.5)$$

$$= 0.25$$

$$(t - y_{in}) = 1 - 0.25 = 0.75$$

update weight

$$w_{1(new)} = w_{1(old)} + \alpha(t - y_{in})x_1$$

$$= 2.5 + 0.05(0.75)(-1)$$

$$= 2.5 + (-0.0375) = 2.4625$$

$$w_{2(new)} = w_{2(old)} + \alpha(t - y_{in})x_2$$

$$= 0.75 + 0.05(0.75)(2)$$

$$= 0.75 + 0.075 = 0.825$$

$$b(new) = b(old) + \alpha(t - y_{in})$$

$$= 1.25 + 0.05(0.75)$$

$$= 1.25 + 0.0375 = 1.2875$$

$$\Delta w_1 = -0.0375$$

$$\Delta w_2 = 0.075$$

$$\Delta b = 0.0375$$

Compute Error

$$\text{Error} = (t - y_{in})^2 = (0.75)^2 = 0.5625$$

Course : Selected Topics in Computational Intelligence I

Course Code : COMP8038

Lecturer Name : Dr. Ir. Diaz D. Santika, M.Sc.

Class : LTY-1

Lecturer Code : D1159

Student Name : Edward (2201741971)

Third Input (Epoch I)

$$x_1 = 0$$

$$x_2 = -3$$

$$t = -1$$

$$y_{in} = b + w_1 \cdot x_1 + w_2 \cdot x_2$$

$$= 1,2875 + (2,4625 \cdot 0) + (0,825 \cdot -3)$$

$$= 1,2875 + 0 + (-2,475)$$

$$= -1,1875$$

$$(t - y_{in}) = -1 - (-1,1875)$$

$$= 0,1875$$

$$\Delta w_1 = 0,009375$$

$$\Delta w_2 = -0,028125$$

$$\Delta b = 0,009375$$

Compute Error

$$\text{Error} = (t - y_{in})^2 = (0,1875)^2 = 0,03515625$$

Update Weight

$$\begin{aligned} w_1(\text{new}) &= w_1(\text{old}) + \alpha (t - y_{in}) x_1 \\ &= 2,4625 + 0,05 (0,1875) \cdot 0 \\ &= 2,4625 \end{aligned}$$

$$\begin{aligned} w_2(\text{new}) &= w_2(\text{old}) + \alpha (t - y_{in}) x_2 \\ &= 0,825 + 0,05 (0,1875) \cdot -3 \\ &= 0,825 + (-0,028125) \\ &= 0,796875 \end{aligned}$$

$$\begin{aligned} b(\text{new}) &= b(\text{old}) + \alpha (t - y_{in}) \\ &= 1,2875 + 0,05 (0,1875) \\ &= 1,2875 + 0,009375 \\ &= 1,296875 \end{aligned}$$

Fourth Input (Epoch I)

$$x_1 = 0$$

$$x_2 = 2$$

$$t = 1$$

$$y_{in} = b + w_1 \cdot x_1 + w_2 \cdot x_2$$

$$= 1,296875 + (2,4625 \cdot 0) + (0,796875 \cdot 2)$$

$$= 1,296875 + 0 + 1,59375$$

$$= 2,890625$$

$$(t - y_{in}) = 1 - 2,890625$$

$$= -1,890625$$

$$\Delta w_1 = -0,09453125$$

$$\Delta w_2 =$$

$$\Delta b = -0,09453125$$

Compute Error

$$\text{Error} = (t - y_{in})^2 = (-1,890625)^2 = 3,574462890625$$

Update Weight

$$\begin{aligned} w_1(\text{new}) &= w_1(\text{old}) + \alpha (t - y_{in}) x_1 \\ &= 2,4625 + 0,05 (-1,890625) \cdot 0 \\ &= 2,4625 \end{aligned}$$

$$\begin{aligned} w_2(\text{new}) &= w_2(\text{old}) + \alpha (t - y_{in}) x_2 \\ &= 0,796875 + 0,05 (-1,890625) \cdot 2 \\ &= 0,796875 + (-0,1890625) \\ &= 0,6078125 \end{aligned}$$

$$\begin{aligned} b(\text{new}) &= b(\text{old}) + \alpha (t - y_{in}) \\ &= 1,296875 + 0,05 (-1,890625) \\ &= 1,296875 + (-0,09453125) \\ &= 1,20234375 \end{aligned}$$

Course : Selected Topics in Computational Intelligence I

Course Code : COMP8038

Lecturer Name : Dr. Ir. Diaz D. Santika, M.Sc.

Class : LTY-1

Lecturer Code : D1159

Student Name : Edward (2201741971)

Fifth Input (Epoch I)

$$x_1 = 3$$

$$x_2 = -2$$

$$t = 1$$

$$y_n = b + w_1 x_1 + w_2 x_2$$

$$= 1,20234375 + (2,4625 \cdot 3) + (0,6078125 \cdot -2)$$

$$= 1,20234375 + (7,3875) + (-1,215625) = 7,37421875$$

$$(t - y_n) = 1 - 7,37421875$$

$$= -6,37421875$$

Update weight

$$w_1(\text{new}) = w_1(\text{old}) + \alpha (t - y_n) x_1$$

$$= 2,4625 + 0,05 (-6,37421875) \cdot 3$$

$$= 2,4625 + (-0,9561328125)$$

$$= 1,5063671875$$

$$w_2(\text{new}) = w_2(\text{old}) + \alpha (t - y_n) x_2$$

$$= 0,6078125 + 0,05 (-6,37421875) \cdot (-2)$$

$$= 0,6078125 + 0,637421875$$

$$= 1,245234375$$

$$b(\text{new}) = b(\text{old}) + \alpha (t - y_n)$$

$$= 1,20234375 + 0,05 (-6,37421875)$$

$$= 1,20234375 + (-0,3187109375)$$

$$= 0,8836328125$$

Compute Error

$$\text{Error} = (t - y_n)^2$$

$$= (-6,37421875)^2$$

$$= 40,63066467285156$$

$$\text{Mean Squared Error (Epoch I)} = 25,0 + 0,5625 + 0,03515625 + 3,574462890625 + 40,63066467285156$$

$$= 69,80278381347656$$

Course : Selected Topics in Computational Intelligence I

Course Code : COMP8038

Lecturer Name : Dr. Ir. Diaz D. Santika, M.Sc.

Class : LTY-1

Lecturer Code : D1159

Student Name : Edward (2201741971)

First Input (Epoch #)

$$x_1 = -2$$

$$x_2 = -1$$

$$t = -1$$

$$y_{in} = b + w_1 x_1 + w_2 x_2$$

$$= 0,8836328125 + (1,5063671075 \cdot -2) + (1,244503125 \cdot -1)$$

$$= 0,8836328125 + (-3,012734375) + (-1,244503125)$$

$$= -3,3736046875$$

$$(t - y_{in}) = -1 - (-3,3736046875)$$

$$= 2,3736046875$$

Update weight

$$w_1(\text{new}) = w_1(\text{old}) + \alpha(t - y_{in})x_1$$

$$= 1,5063671075 + 0,05(2,3736046875) \cdot -2$$

$$= 1,5063671075 + (-0,23736046875)$$

$$= 1,26900663875$$

$$w_2(\text{new}) = w_2(\text{old}) + \alpha(t - y_{in})x_2$$

$$= 1,244503125 + 0,05(2,3736046875) \cdot -1$$

$$= 1,244503125 + (-0,118680234375)$$

$$= 1,125822890625$$

$$b(\text{new}) = b(\text{old}) + \alpha(t - y_{in})$$

$$= 0,8836328125 + 0,05(2,3736046875)$$

$$= 0,8836328125 + 0,118680234375$$

$$= 1,002313046875$$

Compute Error

$$\text{Error} = (t - y_{in})^2 = (2,3736046875)^2$$

$$= 5,633999657572851$$

Course : Selected Topics in Computational Intelligence I

Course Code : COMP8038

Lecturer Name : Dr. Ir. Diaz D. Santika, M.Sc.

Class : LTY-1

Lecturer Code : D1159

Student Name : Edward (2201741971)

Second Input (Epoch II)

$$\begin{aligned} X_1 &= -1 & Y_n &= b + w_1 X_1 + w_2 X_2 \\ X_2 &= 2 & &= 1,002313046875 + (1,26900670975 \cdot -1) + (1,125822890625 \cdot 2) \\ t &= 1 & &= 1,002313046875 - 1,26900670975 + 2,25164578125 \\ & & &= 1,984952118375 \end{aligned}$$

$$\begin{aligned} (t - y_n) &= 1 - 1,984952118375 \\ &= 0,984952118375 \end{aligned}$$

update weight

$$\begin{aligned} w_1(\text{new}) &= w_1(\text{old}) + \alpha(t - y_n) X_1 \\ &= 1,26900670975 + 0,05(0,984952118375) \cdot -1 \\ &= 1,26900670975 + (-0,04924760591875) \\ &= 1,2197591033125 \end{aligned}$$

$$\begin{aligned} w_2(\text{new}) &= w_2(\text{old}) + \alpha(t - y_n) X_2 \\ &= 1,125822890625 + 0,05(0,984952118375) \cdot 2 \\ &= 1,125822890625 + 0,0984952118375 \\ &= 1,2243181024625 \end{aligned}$$

$$\begin{aligned} b(\text{new}) &= b(\text{old}) + \alpha(t - y_n) \\ &= 1,002313046875 + 0,05(0,984952118375) \\ &= 1,002313046875 + 0,04924760591875 \\ &= 1,0515606527875 \end{aligned}$$

Compute Error

$$\begin{aligned} \text{Error} &= (t - y_n)^2 = (0,984952118375)^2 \\ &= 0,97013067549140012640625 \end{aligned}$$

Third Input (Epoch II)

$$\begin{aligned} X_1 &= 0 & Y_n &= b + w_1 X_1 + w_2 X_2 & (t - y_n) &= -1 - (-2,56) \\ X_2 &= -3 & &= 1,1 + (1,21 \cdot 0) + (1,22 \cdot -3) & &= 1,56 \\ t &= -1 & &= 1,1 + 0 + (-3,66) & &= -2,56 \\ & & &= -2,56 \end{aligned}$$

update weight

$$\begin{aligned} w_1(\text{new}) &= w_1(\text{old}) + \alpha(t - y_n) X_1 \\ &= 1,21 + 0,05(1,56) \cdot 0 \\ &= 1,21 \end{aligned}$$

$$\begin{aligned} w_2(\text{new}) &= w_2(\text{old}) + \alpha(t - y_n) X_2 \\ &= 1,22 + 0,05(1,56) \cdot -3 \\ &= 1,22 + (-0,234) \\ &= 0,986 \end{aligned}$$

$$\begin{aligned} b(\text{new}) &= b(\text{old}) + \alpha(t - y_n) \\ &= 1,1 + 0,05(1,56) \\ &= 1,1 + 0,078 = 1,178 \end{aligned}$$

Compute Error

$$\begin{aligned} \text{Error} &= (t - y_n)^2 \\ &= (1,56)^2 = 2,4336 \end{aligned}$$

Course : Selected Topics in Computational Intelligence I

Course Code : COMP8038

Lecturer Name : Dr. Ir. Diaz D. Santika, M.Sc.

Class : LTY-1

Lecturer Code : D1159

Student Name : Edward (2201741971)

Fourth Input (Epoch II)

$$\begin{aligned} X_1 &= 0 \\ X_2 &= 2 \\ t &= 1 \\ y_{in} &= b + w_1 X_1 + w_2 X_2 \\ &= 1.2 + (1.21 \cdot 0) + (1.2) \cdot 2 \\ &= 1.2 + 0 + 2.4 \\ &= 3.6 \end{aligned}$$

$$(t - y_{in}) = 1 - (3.2)$$

$$= -2.2$$

Update weight

$$\begin{aligned} w_1(\text{new}) &= w_1(\text{old}) + \alpha(t - y_{in})X_1 \\ &= 1.21 + 0.05(-2.2) \cdot 0 \\ &= 1.21 \end{aligned}$$

$$\begin{aligned} b(\text{new}) &= b(\text{old}) + \alpha(t - y_{in}) \\ &= 1.2 + 0.05(-2.2) \\ &= 1.2 - 0.11 \\ &= 1.09 \end{aligned}$$

$$\begin{aligned} w_2(\text{new}) &= w_2(\text{old}) + \alpha(t - y_{in})X_2 \\ &= 1 + 0.05(-2.2) \cdot 2 \\ &= 1 - 0.22 \\ &= 0.78 \end{aligned}$$

Compute Error

$$\begin{aligned} \text{Error} &= (t - y_{in})^2 \\ &= (-2.2)^2 = 4.84 \end{aligned}$$

Fifth Input (Epoch II)

$$\begin{aligned} X_1 &= 3 \\ X_2 &= -2 \\ t &= 1 \\ y_{in} &= b + w_1 X_1 + w_2 X_2 \\ &= 1.1 + (1.21 \cdot 3) + (0.78 \cdot -2) \\ &= 1.1 + 3.63 - 1.56 \\ &= 3.17 \end{aligned}$$

$$(t - y_{in}) = 1 - (2.67)$$

$$= -1.67$$

Update weight

$$\begin{aligned} w_1(\text{new}) &= w_1(\text{old}) + \alpha(t - y_{in})X_1 \\ &= 1.21 + 0.05(-1.67) \cdot 3 \\ &= 1.21 + (-0.2505) \\ &= 0.9595 \end{aligned}$$

$$\begin{aligned} b(\text{new}) &= b(\text{old}) + \alpha(t - y_{in}) \\ &= 1.1 + 0.05(-1.67) \\ &= 1.1 + (-0.0835) \\ &= 1.0165 \end{aligned}$$

$$\begin{aligned} w_2(\text{new}) &= w_2(\text{old}) + \alpha(t - y_{in})X_2 \\ &= 0.78 + 0.05(-1.67) \cdot 2 \\ &= 0.78 - 0.167 \\ &= 0.613 \end{aligned}$$

Compute Error

$$\begin{aligned} \text{Error} &= (t - y_{in})^2 \\ &= (-1.67)^2 = 2.7889 \end{aligned}$$

$$\begin{aligned} \text{Mean Squared Error (Epoch II)} &= 5.6 + 1 + 2.4 + 4.8 + 2.8 \\ &= 16.6 \end{aligned}$$

Course : Selected Topics in Computational Intelligence I

Course Code : COMP8038

Lecturer Name : Dr. Ir. Diaz D. Santika, M.Sc.

Class : LTY-1

Lecturer Code : D1159

Student Name : Edward (2201741971)

First Input (Epoch III)

$$X_1 = -2$$

$$X_2 = -1$$

$$t = -1$$

$$\begin{aligned} y_n &= b + w_1 X_1 + w_2 X_2 \\ &= 1.02 + (1 \cdot -2) + (0.63 \cdot -1) \\ &= 1.02 - 2 - 0.63 \\ &= -1.61 \end{aligned}$$

$$\begin{aligned} (t - y_n) &= -1 - (-1.61) \\ &= 0.61 \end{aligned}$$

Update weight

$$\begin{aligned} w_1(\text{new}) &= w_1(\text{old}) + \alpha(t - y_n)X_1 \\ &= 1 + 0.05(0.61) \cdot -2 \\ &= 1 + (-0.061) \\ &= 0.939 \end{aligned}$$

$$\begin{aligned} b(\text{new}) &= b(\text{old}) + \alpha(t - y_n) \\ &= 1.02 + 0.05(0.61) \\ &= 1.02 + 0.0305 \\ &= 1.0505 \end{aligned}$$

$$\begin{aligned} w_2(\text{new}) &= w_2(\text{old}) + \alpha(t - y_n)X_2 \\ &= 0.63 + 0.05(0.61) \cdot -1 \\ &= 0.63 + (-0.0305) \\ &= 0.5995 \end{aligned}$$

Compute Error

$$\begin{aligned} \text{Error} &= (t - y_n)^2 \\ &= (0.61)^2 = 0.3721 \end{aligned}$$

Second Input (Epoch III)

$$X_1 = -1$$

$$X_2 = 2$$

$$t = 1$$

$$\begin{aligned} y_n &= b + w_1 X_1 + w_2 X_2 \\ &= 1.05 + (1 \cdot -1) + (0.6 \cdot 2) \\ &= 1.05 - 1 + 1.2 \\ &= 1.25 \end{aligned}$$

$$\begin{aligned} (t - y_n) &= 1 - (1.25) \\ &= -0.25 \end{aligned}$$

Update weight

$$\begin{aligned} w_1(\text{new}) &= w_1(\text{old}) + \alpha(t - y_n)X_1 \\ &= 1 + 0.05(-0.25) \cdot -1 \\ &= 1 + 0.0125 \\ &= 1.0125 \end{aligned}$$

$$\begin{aligned} b(\text{new}) &= b(\text{old}) + \alpha(t - y_n) \\ &= 1.05 + 0.05(-0.25) \\ &= 1.05 - 0.0125 \\ &= 1.0375 \end{aligned}$$

$$\begin{aligned} w_2(\text{new}) &= w_2(\text{old}) + \alpha(t - y_n)X_2 \\ &= 0.6 + 0.05(-0.25) \cdot 2 \\ &= 0.6 - 0.025 \\ &= 0.575 \end{aligned}$$

Compute Error

$$\begin{aligned} \text{Error} &= (t - y_n)^2 \\ &= (-0.25)^2 = 0.0625 \end{aligned}$$

Course : Selected Topics in Computational Intelligence I

Course Code : COMP8038

Lecturer Name : Dr. Ir. Diaz D. Santika, M.Sc.

Class : LTY-1

Lecturer Code : D1159

Student Name : Edward (2201741971)

Third Input (Epoch III)

$$X_1 = 0 \quad X_2 = -3 \quad t = 1$$
$$y_{in} = b + w_1 X_1 + w_2 X_2 = 1.01 + (1.01 \cdot 0) + (0.6 \cdot -3) = 1.01 + 0 + (-1.8) = -0.76$$
$$(t - y_{in}) = 1 - (-0.76) = 0.24$$
$$w_1(\text{new}) = w_1(\text{old}) + \alpha(t - y_{in})X_1 = 1.01 + 0.05(-0.24) \cdot 0 = 1.01$$
$$w_2(\text{new}) = w_2(\text{old}) + \alpha(t - y_{in})X_2 = 0.6 + 0.05(-0.24) \cdot -3 = 0.636$$
$$b(\text{new}) = b(\text{old}) + \alpha(t - y_{in}) = 1.01 + 0.05(0.24) = 1.022$$

Compute Error

$$\text{Error} = (t - y_{in})^2 = (0.24)^2 = 0.0576$$

Fourth Input (Epoch III)

$$X_1 = 0 \quad X_2 = 2 \quad t = 1$$
$$y_{in} = b + w_1 X_1 + w_2 X_2 = 1 + (1.01 \cdot 0) + (0.6 \cdot 2) = 1 + 0 + 1.2 = 2.2$$
$$(t - y_{in}) = 1 - (2.2) = -1.2$$

update weight

$$w_1(\text{new}) = w_1(\text{old}) + \alpha(t - y_{in})X_1 = 1.01 + 0.05(-1.2) \cdot 0 = 1.01$$
$$w_2(\text{new}) = w_2(\text{old}) + \alpha(t - y_{in})X_2 = 0.6 + 0.05(-1.2) \cdot 2 = 0.4$$
$$b(\text{new}) = b(\text{old}) + \alpha(t - y_{in}) = 1 + 0.05(-1.2) = 0.94$$

Compute Error

$$\text{Error} = (-1.2)^2 = 1.44$$

Fifth Input (Epoch III)

$$X_1 = 3 \quad X_2 = -2 \quad t = 1$$
$$y_{in} = b + w_1 X_1 + w_2 X_2 = 1 + (1.01 \cdot 3) + (0.5 \cdot -2) = 1 + 3.03 - 1 = 3.03$$
$$(t - y_{in}) = 1 - 3.03 = -2.03$$

update weight

$$w_1(\text{new}) = w_1(\text{old}) + \alpha(t - y_{in})X_1 = 1.01 + 0.05(-2.03) \cdot 3 = 0.7055$$
$$w_2(\text{new}) = w_2(\text{old}) + \alpha(t - y_{in})X_2 = 0.5 + 0.05(-2.03) \cdot -2 = 0.705$$
$$b(\text{new}) = b(\text{old}) + \alpha(t - y_{in}) = 1 + 0.05(-2.03) = 0.8985$$

Compute Error

$$\text{Error} = (t - y_{in})^2 = (-2.03)^2 = 4.1209$$

Mean Squared Error
(Epoch III)

$$= 0.4 + 0.06 + 0.06 + 1.44 + 4.12$$
$$= 6.08$$