Práctica #4 Red ADALINE (con y sin bias)

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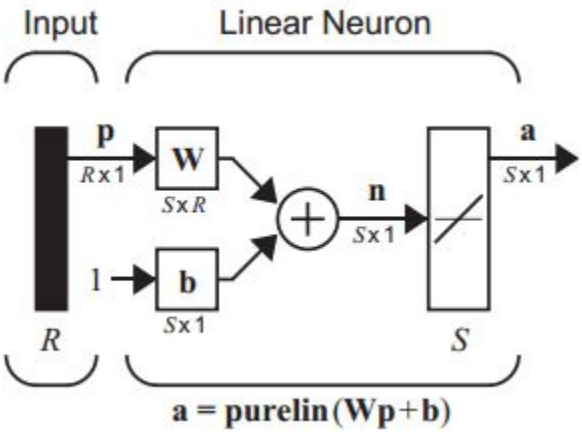
Índice

1. Introducción

La red ADALINE(ADAptive LInear NEuron) fue inventada por Bernard Widrow y Marcian Hoff, esta usa un algoritmo de aprendizaje llamado LMS(Least Mean Square). En comparación con el perceptrón, esta usa una función de activacion lineal, solo puede resolver problemas linealmente separables pero esta no es sensible al ruido.

1.1. Modelo

Figura 1: Modelo



2. Diagrama de Flujo

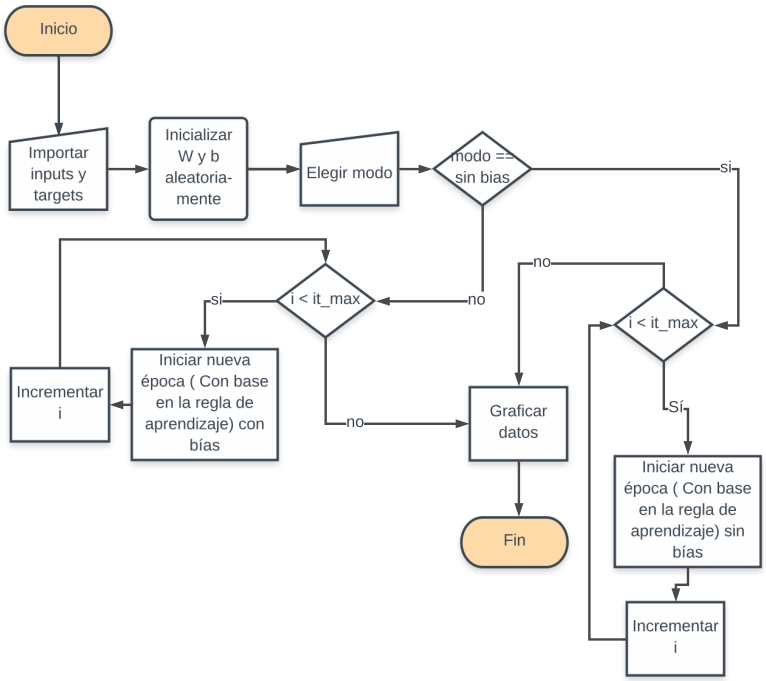


Figura 2: Diagrama de Flujo

3. Resultados

3.1. Ejemplo 1

3.1.1. Datos

$$p_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, t = \begin{bmatrix} -1 \\ -1 \end{bmatrix}$$

$$p_2 = \begin{bmatrix} 1 \\ 2 \end{bmatrix}, t = \begin{bmatrix} -1 \\ -1 \end{bmatrix}$$

$$p_3 = \begin{bmatrix} 2 \\ -1 \end{bmatrix}, t = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

$$p_4 = \begin{bmatrix} 2 \\ 0 \end{bmatrix}, t = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

$$p_5 = \begin{bmatrix} -1 \\ 2 \end{bmatrix}, t = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

$$p_6 = \begin{bmatrix} -2 \\ 1 \end{bmatrix}, t = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

$$p_7 = \begin{bmatrix} -1 \\ -1 \end{bmatrix}, t = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$p_8 = \begin{bmatrix} -2 \\ -2 \end{bmatrix}, t = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$W_0 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$b_0 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

3.2. Resultado

3.3. Consola

```
Elija un modo: 1–>Sin bias, 2–>Con bias
>>>2
Ingrese epochmax: >>>10
Ingrese E epoch: >>>.01
Ingrese el factor de aprendizaje: >>>.04

W =

1      0
0      1
```

b =

1
1

La red convergió

W =

−0.5389 0.0055
0.2313 −0.6378

b =

0.0303
0.2362

3.4. Parametros Finales

Pesos
−0.53893 0.0055407
0.2313 −0.63776

Bias
0.030263
0.23615

3.5. Imágenes

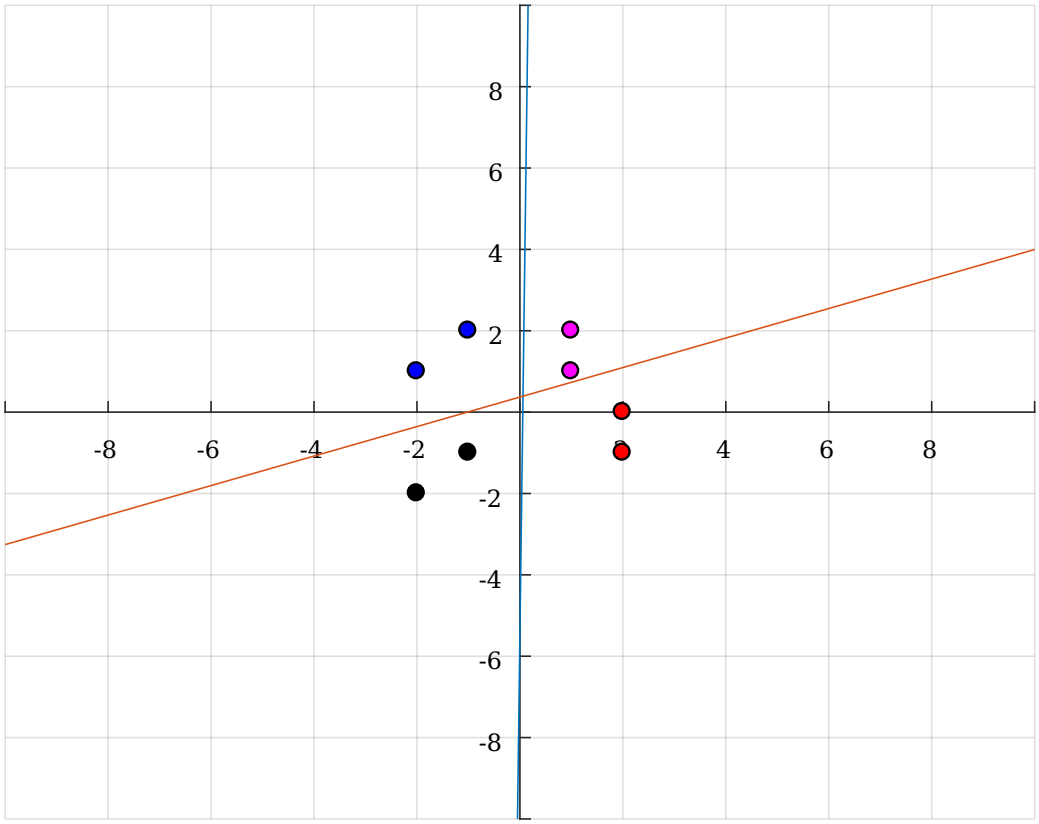


Figura 3: Gráfica 1.1

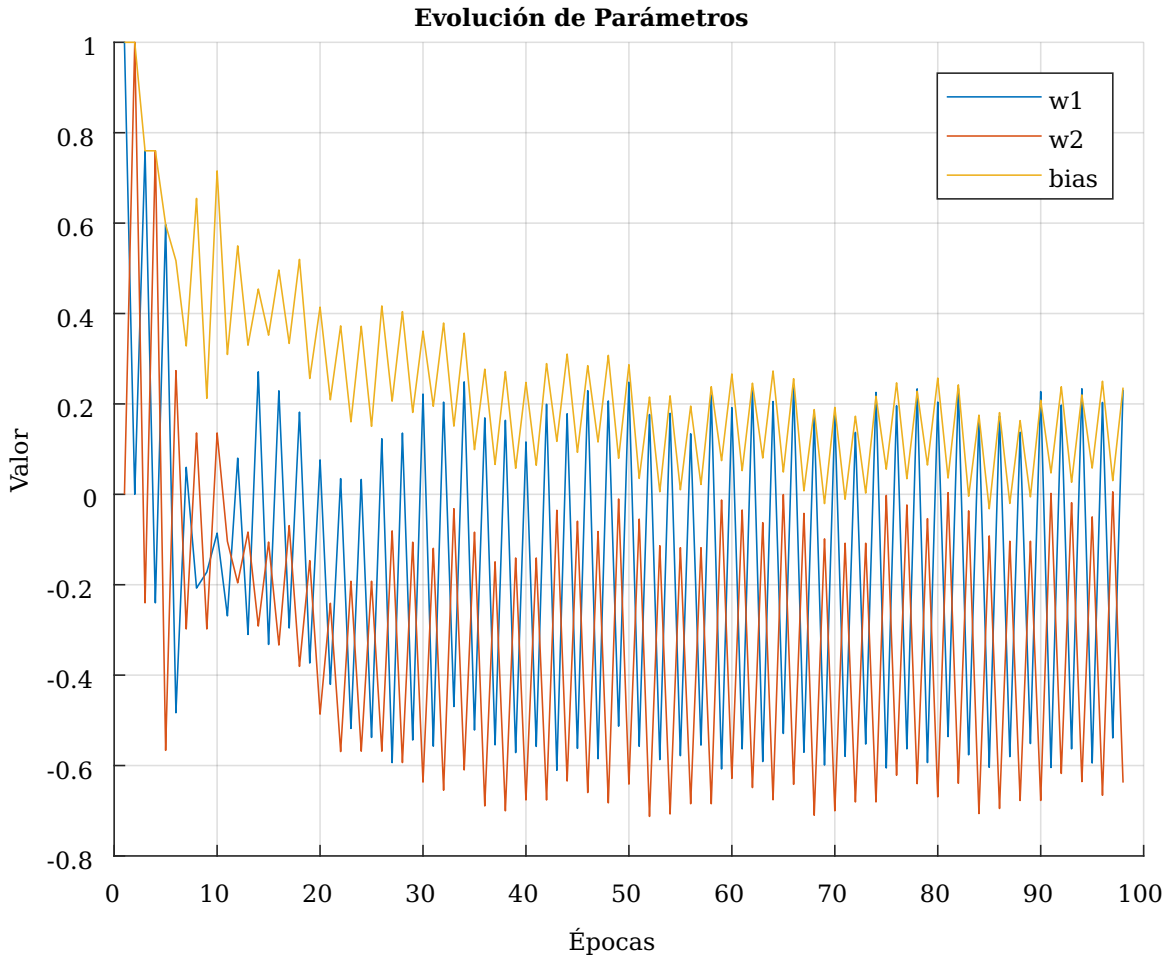


Figura 4: Gráfica 1.2

3.6. Ejemplo 2

3.6.1. Datos

$$p_1 = \begin{bmatrix}1\\1\end{bmatrix}, t = 1$$

$$p_2 = \begin{bmatrix}1\\0\end{bmatrix}, t = -1$$

$$p_1 = \begin{bmatrix}0\\1\end{bmatrix}, t = -1$$

$$p_1 = \begin{bmatrix}0\\0\end{bmatrix}, t = -1$$

$$W_0 = \begin{bmatrix}0{,}7798\\0{,}0028\end{bmatrix}$$

$$p_0 = \begin{bmatrix}-0{,}4460\end{bmatrix}$$

3.7. Resultado

3.8. Consola

```
Elija un modo: 1–>Sin bias, 2–>Con bias
>>>2
Ingrese epochmax: >>>20
Ingrese E epoch: >>>.01
Ingrese el factor de aprendizaje: >>>.12
W =
         0.7798      0.0028


b =

−0.4460

La red convergió

W =

0.7928      0.9528


b =

−1.4564
```

3.9. Parametros Finales

Pesos
0.7928 0.9528

Bias
−1.4564

3.10. Imágenes

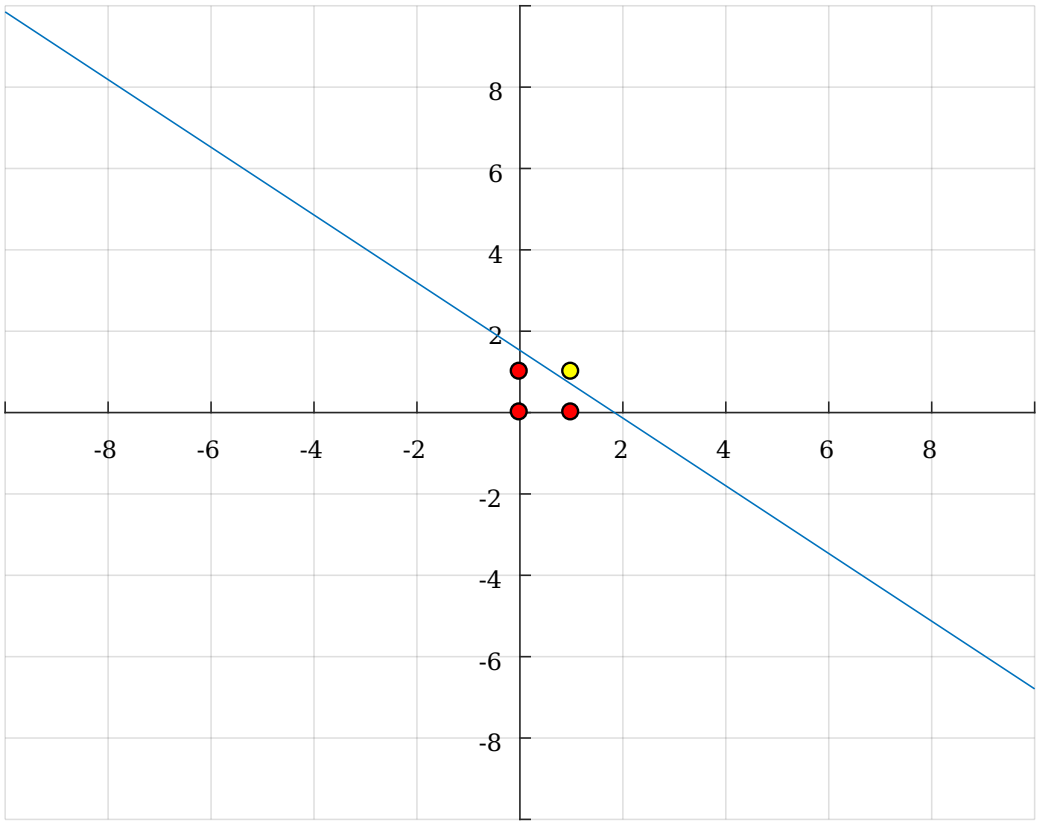


Figura 5: Gráfica 2.1

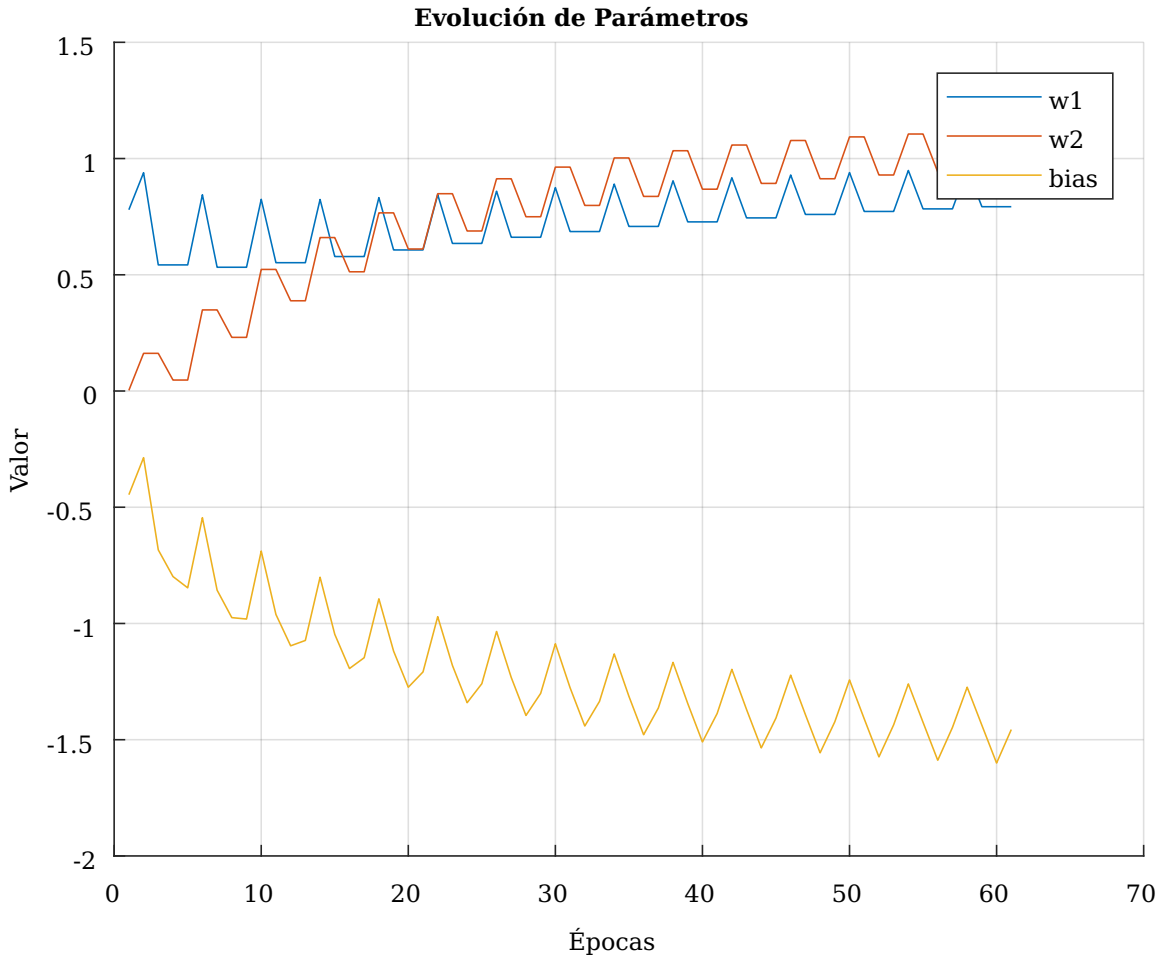


Figura 6: Gráfica 2.2

3.11. Ejemplo 3

3.11.1. Datos

$$p_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, t = 1$$

$$p_2 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, t = 1$$

$$p_1 = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, t = 1$$

$$p_1 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}, t = -1$$

$$W_0 = \begin{bmatrix} 0{,}0679 \\ 0{,}1485 \end{bmatrix}$$

$$p_0 = \begin{bmatrix} -0{,}1744 \end{bmatrix}$$

3.12. Resultado

3.13. Consola

```
Elija un modo: 1–>Sin bias, 2–>Con bias
2
Ingrese epochmax: 20
Ingrese E epoch: .01
Ingrese el factor de aprendizaje: .1

W =

0.0679     0.1485


b =

−0.1744

La red convergió

W =

1.0749     0.9590


b =

−0.4566
```

3.14. Parametros Finales

Pesos
1.0749 0.95904

Bias
−0.45656

3.15. Imágenes

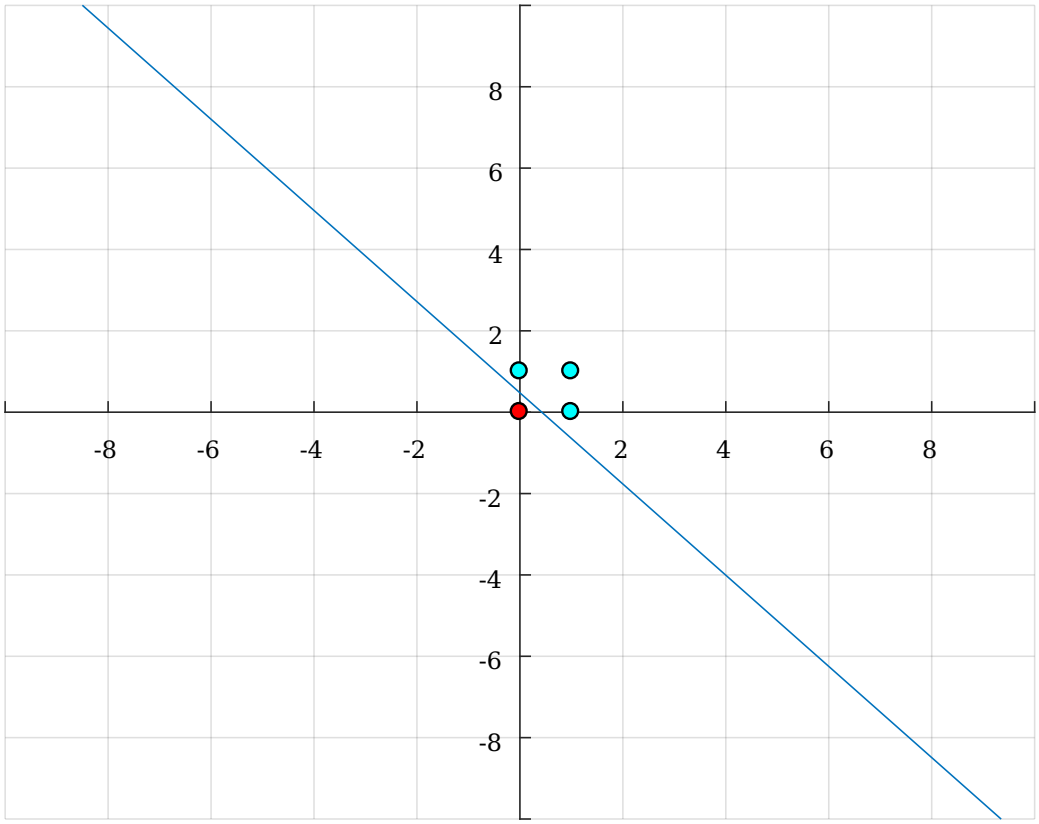


Figura 7: Gráfica 3.1

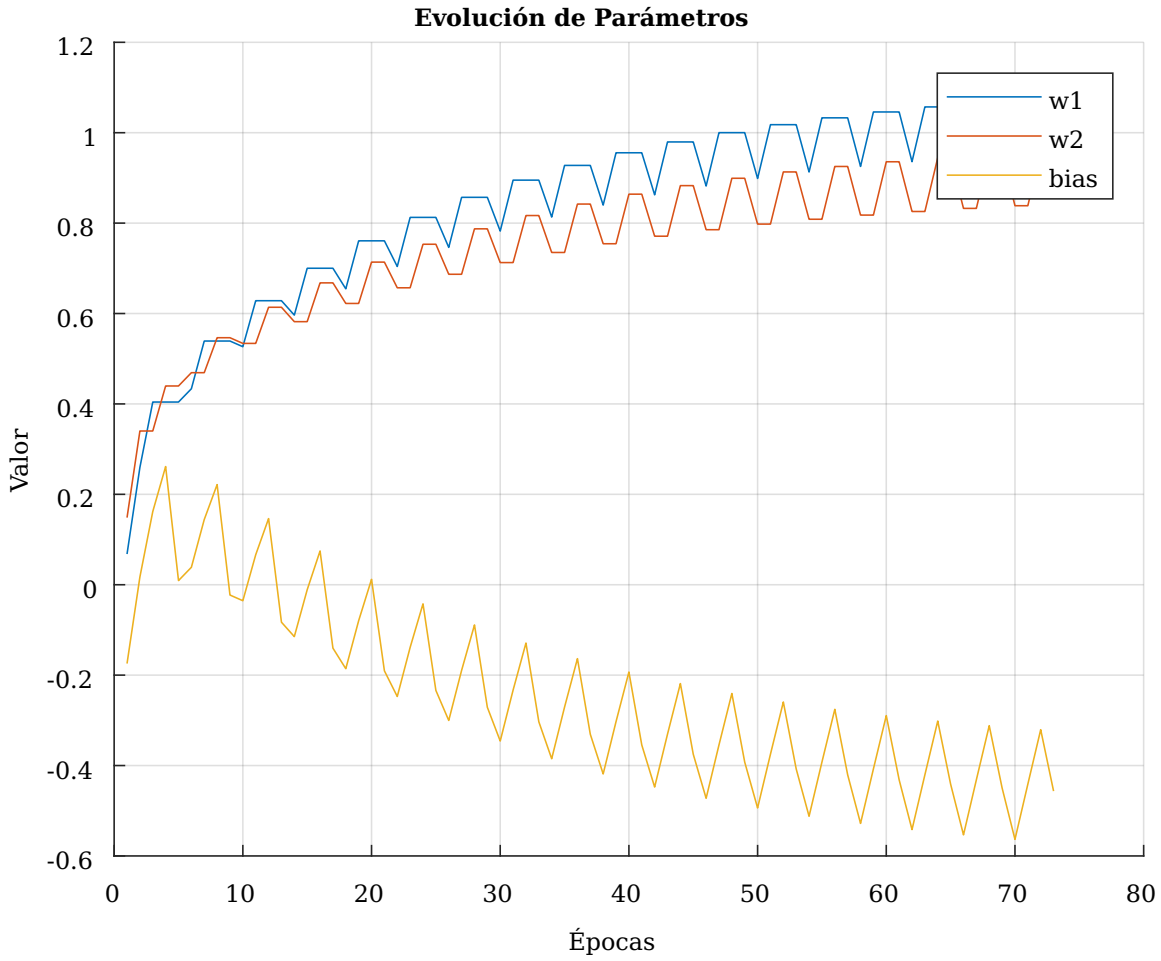


Figura 8: Gráfica 3.2

3.16. Ejemplo 4

3.16.1. Datos

$$p_1 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, t = 0$$

$$p_2 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}, t = 1$$

$$p_3 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}, t = 2$$

$$p_4 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 1 \end{bmatrix}, t = 3$$

$$p_5 = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \end{bmatrix}, t = 4$$

$$p_6 = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \end{bmatrix}, t = 5$$

$$p_7 = \begin{bmatrix} 0 \\ 1 \\ 1 \\ 0 \end{bmatrix}, t = 6$$

$$p_8 = \begin{bmatrix} 0 \\ 1 \\ 1 \\ 1 \end{bmatrix}, t = 7$$

$$W_0 = \begin{bmatrix} 0{,}6276 \\ -0{,}2131 \end{bmatrix}$$

$$p_0 = \begin{bmatrix} -0{,}8928 \end{bmatrix}$$

3.17. Resultado

3.18. Consola

```
Elija un modo: 1->Sin bias, 2->Con bias
1
Ingrese epochmax: 10
Ingrese E epoch: .01
Ingrese el factor de aprendizaje: .3

W =

0.6276   -0.2131


b =

-0.8928


total_matrix =

0     0     0     0
0     0     1     1
0     1     0     2
0     1     1     3
1     0     0     4
1     0     1     5
1     1     0     6
1     1     1     7

La red convergió
W =

3.9964    1.9980    1.0010
```

3.19. Parametros Finales

Pesos
3.9964 1.998 1.001

3.20. Imágenes

4. Discusión de Resultados

Para cada uno de los resultados se muestra:

1. Los datos con los cuales fue realizado el ejemplo.
2. Los pesos y bias iniciales.
3. La gráfica del “historial” de la evolución de los parámetros del perceptrón

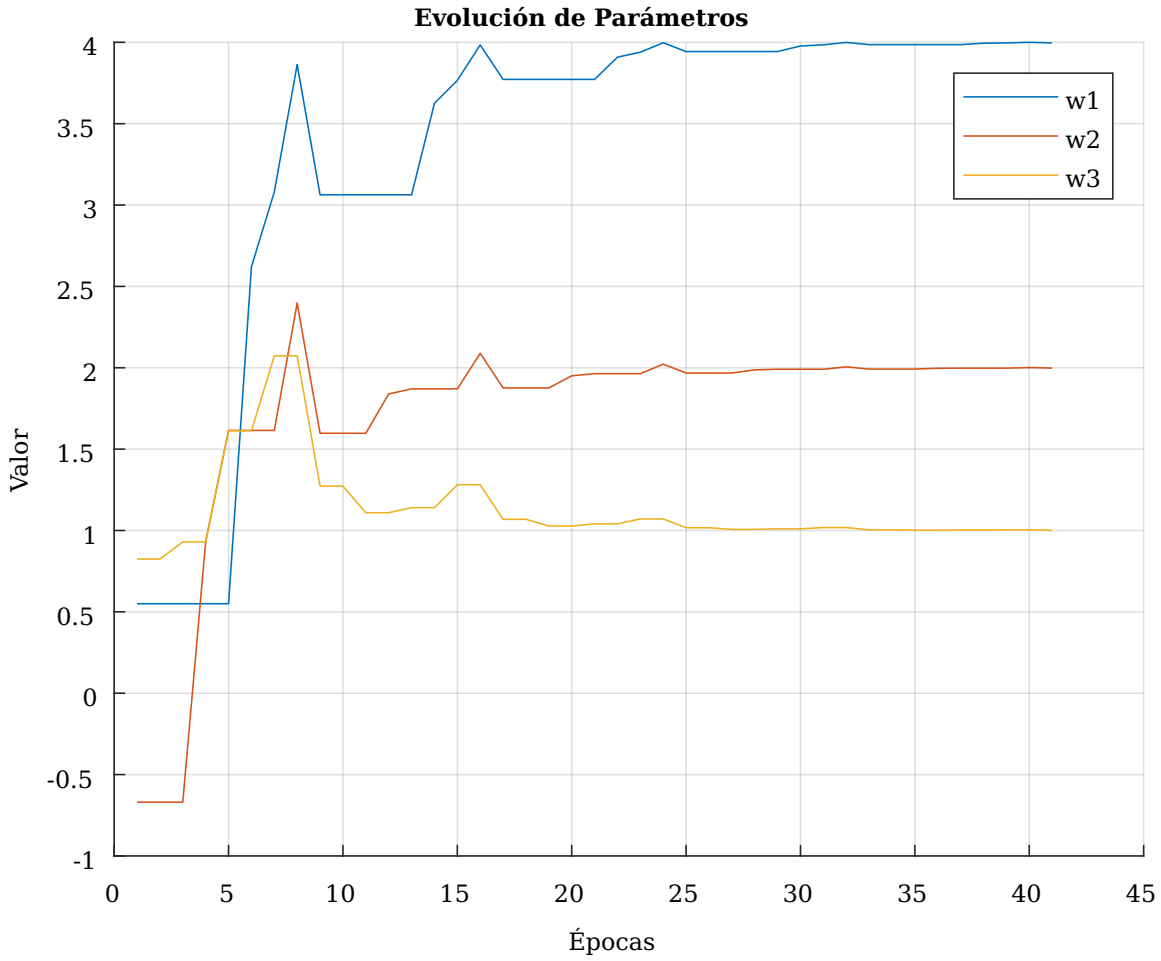


Figura 9: Gráfica 4

4. La gráfica de los vectores de entrada con su target y la frontera de desición final.

5. Conclusiones

El perceptrón es la unidad básico de las redes neuronales que se usan hoy en día, su creador, Frank Rosenblatt, hizp una muy importante aportación para el campo de las redes neuronales artificiales. La práctica estuvo mucho más corta de lo que esperaba, la regla de aprendizaje es “magia”.

6. Referencias

Martin T Hagan. Machine Learning, Neural Network Design (2nd Edition), 2014.
https://medium.com/@thomascountz/calculate-the-decision-boundary-of-a-single-perceptron-visualizing-

7. Apéndice

Listing 1: Código

```
mode = input('Elija un modo: 1->Sin bias, 2->Con bias\n', 's');
epoch_max = input('Ingrese epochmax: ');
e_epoch = input('Ingrese E epoch: ');
alpha = input('Ingrese el factor de aprendizaje: ');
inputs = importdata('inputs.txt');
targets = importdata('targets.txt');
max_it = epoch_max;
% merged the matrixes
total_matrix = [inputs targets];
max_random_range = 1;
min_random_range = -1;
% Weight and bias initialization
W = rand(size(targets, 2), size(inputs, 2))*(2*max_random_range) + min_random_range
b = rand(size(targets, 2), 1) * (2*max_random_range) + min_random_range
Wevo = [];
bevo = [];
% For plotting the evolution of the parameters
Wevo = [Wevo; W];
bevo = [bevo; b];
if(mode=='1')
        r_value = randi([3 7],1,1);
        total_matrix = logicalModel(r_value)
        Wevo = [];
        W = rand(1, r_value)*(2*max_random_range) + min_random_range;
        Wevo = [Wevo; W];
        for i = 1:max_it
                Eepoch_values = [];
                for row = total_matrix.'
                        % Array Indexing
                        p = row(1:r_value);
                        target = row(r_value + 1: end);
```

```
                        a = purelin(W*p);
                        % Calculate the error
                        e = (target - a);
                        % Convergence Checking
                        Waux = W;
                        baux = b;
                        % Weight update
                        W = W + 2*alpha*e*p';
                        % Save the values
                        Wevo = [Wevo; W];
                        Eepoch_values = [Eepoch_values; e];
                end
                Eepoch = abs(sum(Eepoch_values)/ size(total_matrix, 1));
                if(Eepoch == 0 || Eepoch < e_epoch)
                        fprintf("La red convergió");
                        break;
                end
        end
        W
        plotHistoryNoBias(Wevo);
        dlmwrite('parametrosFinales.txt','Pesos', 'delimiter', '');
        dlmwrite('parametrosFinales.txt',W,'delimiter',' ', '-append');
elseif(mode=='2')
        % Begin the iterations
        for i = 1:max_it
        Eepoch_values = [];
        for row = total_matrix.'
        % Array Indexing
        p = row(1:size(inputs, 2));
        target = row(size(inputs, 2) + 1: end);
        a = purelin(W*p + b);
        % Calculate the error
        e = (target - a);
        % Weight update
        W = W + 2*alpha*e*p';
        % Bias update
        b = b + 2*alpha*e;
        % Save the values
        Wevo = [Wevo; W];
        bevo = [bevo; b];
        Eepoch_values = [Eepoch_values; e'];
        end
        Eepoch = abs(sum(Eepoch_values) / size(Eepoch_values, 1));
        if(all(Eepoch == 0) || all(Eepoch < e_epoch))
        fprintf("La red convergió\n");
        break;
        end
        end
        W
```

```
        b
        dlmwrite('parametrosFinales.txt','Pesos', 'delimiter', '');
        dlmwrite('parametrosFinales.txt',W,'delimiter',' ', '-append');
        dlmwrite('parametrosFinales.txt','Bias', '-append',  'roffset', 1, 'delimiter'
            , '');
        dlmwrite('parametrosFinales.txt',b,'-append', 'delimiter', ' ');
        plotHistory(Wevo, bevo);
        if (size(inputs, 2) == 2)
        plotAdaline(total_matrix, W, b);
        else
        fprintf("Solo impresiones en 2 dimensiones soportada");
        end
else
        fprintf("Opción no reconocida\n");
end

function h = circle(x ,y, r, color)
        hold on
        h = plot(x, y, '-o', ...
        'MarkerSize', r, ...
        'MarkerEdgeColor', 'black',...
        'Color', color, ...
        'MarkerFaceColor', color);
        hold off
end

function h = plotAdaline(matrix, W, b)
        % Plot the perceptron desicion boundary and the inputs
        figure
        ax = gca;                       % gets the current axes
        ax.XAxisLocation = 'origin';    % sets t1hem to zero
        ax.YAxisLocation = 'origin';
        hold on
        grid on
        % plot the desicion boundary
        x = -10:10;
        for i=1:size(W, 1)
                slope = -(b(i) / W(i, 2)) / (b(i) / W(i, 1));
                intercept = -b(i) / W(i, 2);
                y = slope * x + intercept;
                plot(x, y);
        end
        ylim([-10 10])
        xlim([-10 10])
        r = 5;
        colors = 'ymcrgbwk';
        i = 1;
        M = containers.Map('KeyType','char','ValueType','char');
        for row = matrix.'
```

```
                target = row(size(W, 2) + 1:end);
                M(mat2str(target)) = colors(i);
                i = i + 1;
        end
        for row = matrix.'
                p = row(1:size(W, 2));
                target = row(size(W, 2) + 1:end);
                h = circle(p(1), p(2), r, M(mat2str(target)));
        end
        hold off
end

function plotHistory(Wevo, bevo)
        % Plot the values
        hold on
        grid on
        title('Evolución de Parámetros');
        legends = [];
        x = 1:size(Wevo, 1);
        for i = 1:size(Wevo, 2)
                colW = Wevo(:, i);
                plot(x, colW);
                legends = [legends, sprintf("w%d", i)];
        end
        plot(x, bevo);
        legends = [legends, "bias"];
        legends = mat2cell(legends,1, ones(1,numel(legends)));
        legend(legends{:});
        xlabel('Épocas')
        ylabel('Valor')
        hold off
end

function plotHistoryNoBias(Wevo)
        % Plot the values
        hold on
        grid on
        title('Evolución de Parámetros');
        legends = [];
        x = 1:size(Wevo, 1);
        for i = 1:size(Wevo, 2)
                colW = Wevo(:, i);
                plot(x, colW);
                legends = [legends, sprintf("w%d", i)];
        end
                legends = mat2cell(legends,1, ones(1,numel(legends)));
                legend(legends{:});
                xlabel('Épocas')
                ylabel('Valor')
```

```
                hold off
end

function [table] = logicalModel(i)
        % logicalModel(I, gate) returns a matrix representing a truth table and
        % the last column represents the oupot base on all the previous columns
        % based on the (gate) parameter
        % INPUT: (I) shall be an integer >= 1
        % INPUT: (gate) shall be 'and' or 'or'
        % OUTPUT: logicalModel is a binary matrix of size [2^I,I + 1]
        % Heavily inspired in Paul Metcalf's CONDVECTS
        % Acknowledgements: Paul Metcalf

        g = 2;
        i2 = 2^i;
        table = false(i2,i + 1);
        for m = 1 : 1 : i
                m2 = 2^m;
                m3 = (m2/2)-1;
                i3 = i-m+1;
                for g = g : m2 : i2
                        for k = 0 : 1 : m3
                                table(g+k,i3) = true;
                        end
                end
                g = m2+1;
        end
        table = table * 1;
        for row_index = 1:size(table, 1)
                row = table(row_index,:);
                res = row(1);
                table(row_index, end) = row_index - 1;
        end
end
```