FACULTAD DE
INGENIERIA ECONOMICA,
ESTADISTICA Y
CIENCIAS SOCIALES

INTRODUCCIÓN AL MACHINE LEARNING Y DESARROLLO DE REDES NEURONALES EN C++

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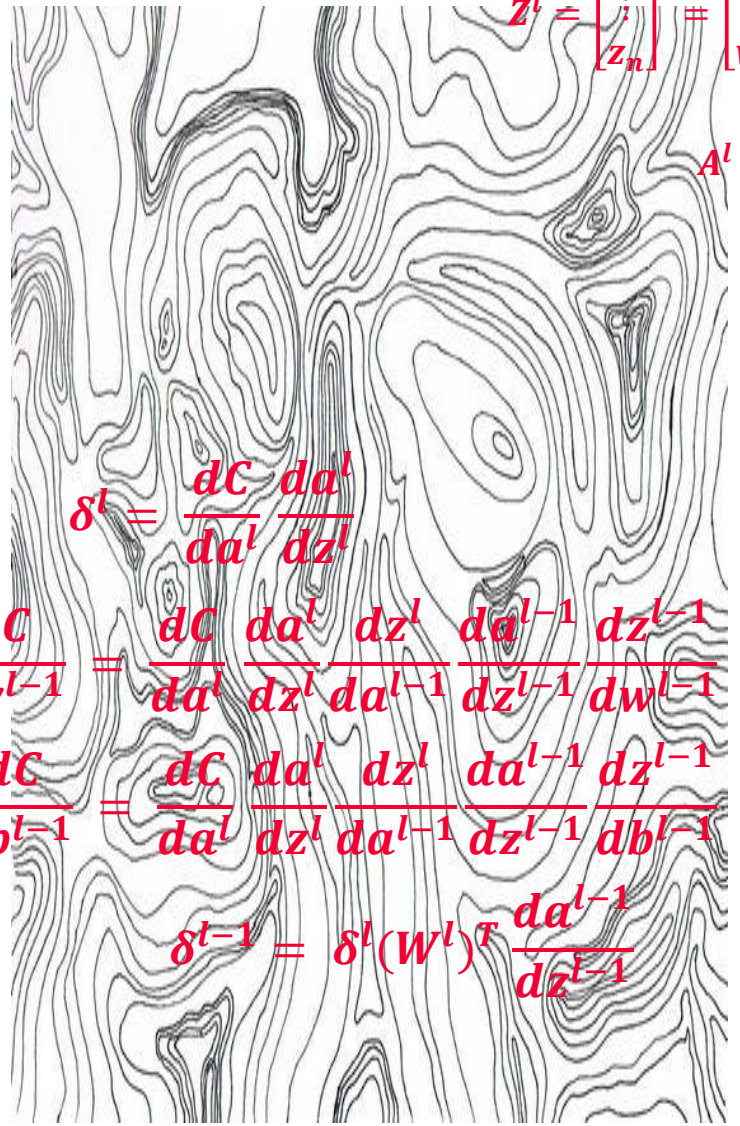
LLACSA MACAVILCA JHONATAN

LLANA ARROYO ALDAIR

$$Z^l = W^l A^{l-1} + b^l$$

$$Z^l = \begin{bmatrix} z_0 \\ \vdots \\ z_n \end{bmatrix}^l = \begin{bmatrix} w_{00} & \cdots & w_{0m} \\ \vdots & \ddots & \vdots \\ w_{n0} & \cdots & w_{nm} \end{bmatrix}^l \begin{bmatrix} a_0 \\ \vdots \\ a_m \end{bmatrix}^{l-1} + \begin{bmatrix} b_0 \\ \vdots \\ b_n \end{bmatrix}^l$$

$$A^l = \begin{bmatrix} A_0 \\ \vdots \\ A_n \end{bmatrix}^l = \sigma\left(\begin{bmatrix} z_0 \\ \vdots \\ z_n \end{bmatrix}^l \right)$$

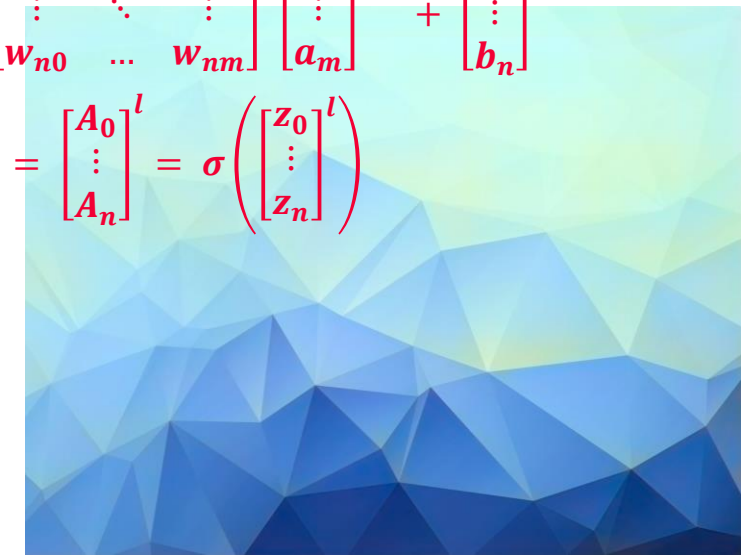


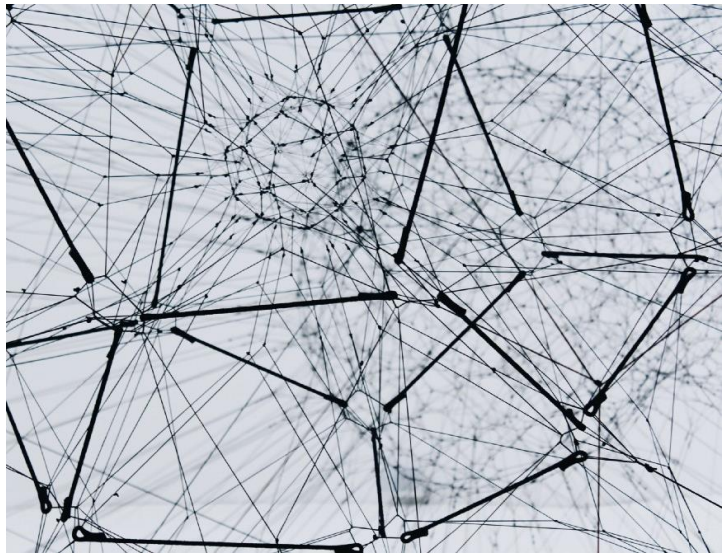
$$\delta^l = \frac{dC}{da^l}\frac{da^l}{dz^l}$$

$$\frac{dC}{dw^{l-1}} = \frac{dC}{da^l}\frac{da^l}{dz^l}\frac{dz^l}{da^{l-1}}\frac{da^{l-1}}{dz^{l-1}}\frac{dz^{l-1}}{dw^{l-1}}$$

$$\frac{dC}{db^{l-1}} = \frac{dC}{da^l}\frac{da^l}{dz^l}\frac{dz^l}{da^{l-1}}\frac{da^{l-1}}{dz^{l-1}}\frac{dz^{l-1}}{db^{l-1}}$$

$$\delta^{l-1} = \delta^l (W^l)^T \frac{da^{l-1}}{dz^{l-1}}$$





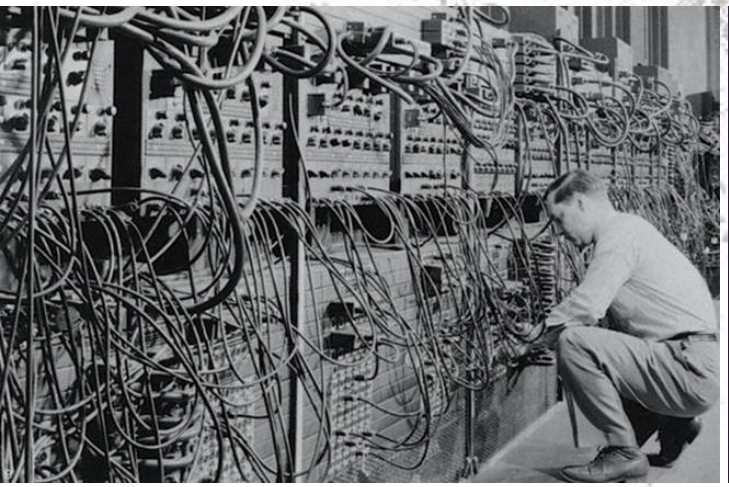
A

PRESENTACIÓN

- INTRODUCCIÓN
- OBJETIVOS

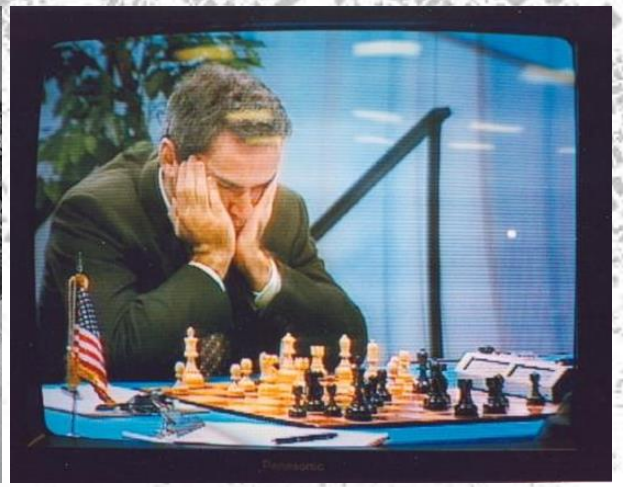
ARTIFICIAL INTELLIGENCE

1950



Alan Turing:
“Computing Machinery and Intelligence”

1997



IBM Deep Blue vs. Garri Kaspárov

2011

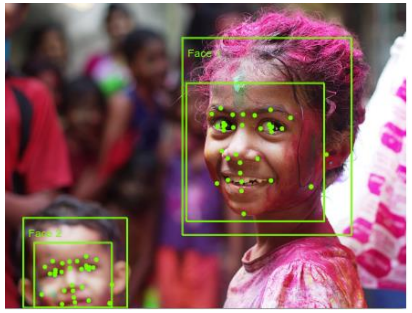
IBM Watson gana Jeopardy!

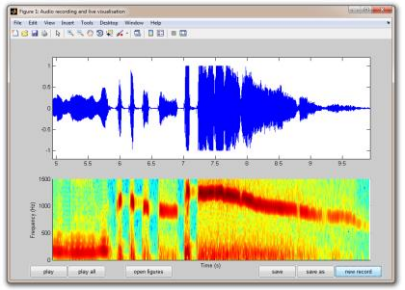
2016

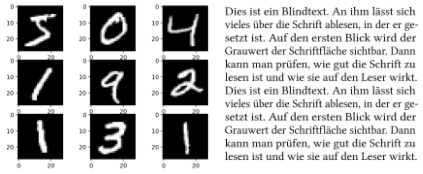
Google AlphaGo vence al campeón mundial de Go

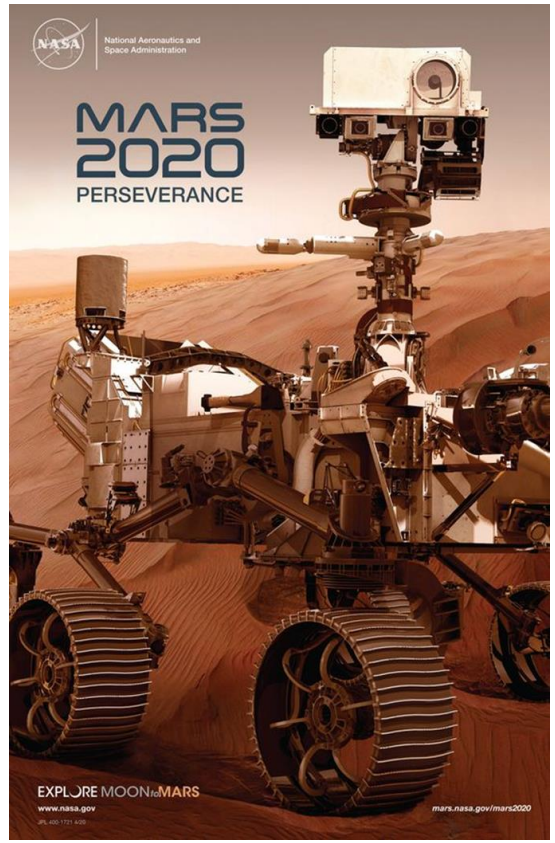
MACHINE LEARNING

- RECON. DE IMÁGENES
- RECON. FACIAL
- RECON. DE CARACTERES
- RECON. DE VOZ
- GENERACIÓN DE TEXTO
- PROS. DE LENGUAJE NATURAL
- GENERACIÓN DE IMÁGENES
- TRADUCCIÓN DE IDIOMAS
- CONDUCCIÓN AUTÓNOMA
- ROBÓTICA
- ANÁLICIS GENÉTICO
- PRONÓSTICO DE ENFERMEDAD
- PREDICCIÓN BURSÁTIL
- PREVENCIÓN DE FRAUDE
- AUTOMATIZACIÓN DE PROCESOS
- MOTORES DE BUSQUEDA









endeavour. Crucially, CASP chooses protein
that have only very recently been experime
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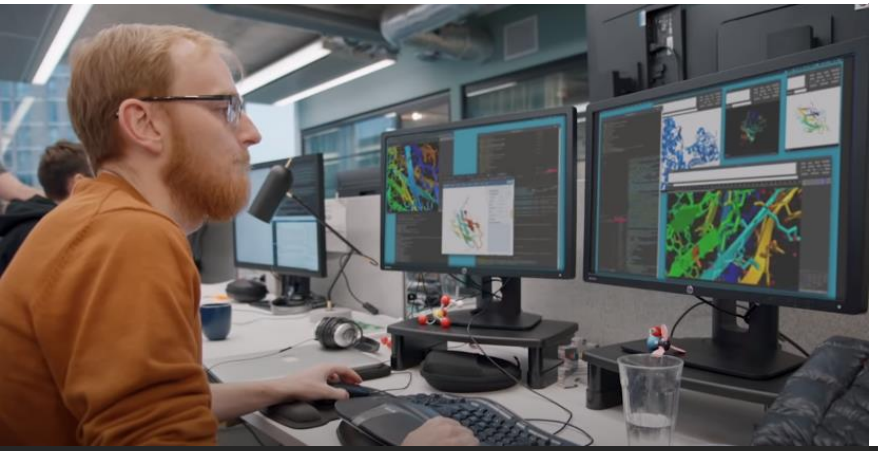
BLOG POST
RESEARCH

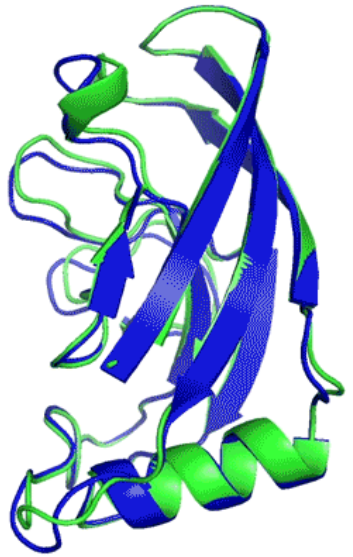
30 NOV 2020

AlphaFold: a solution to a 50-year-old grand challenge in biology

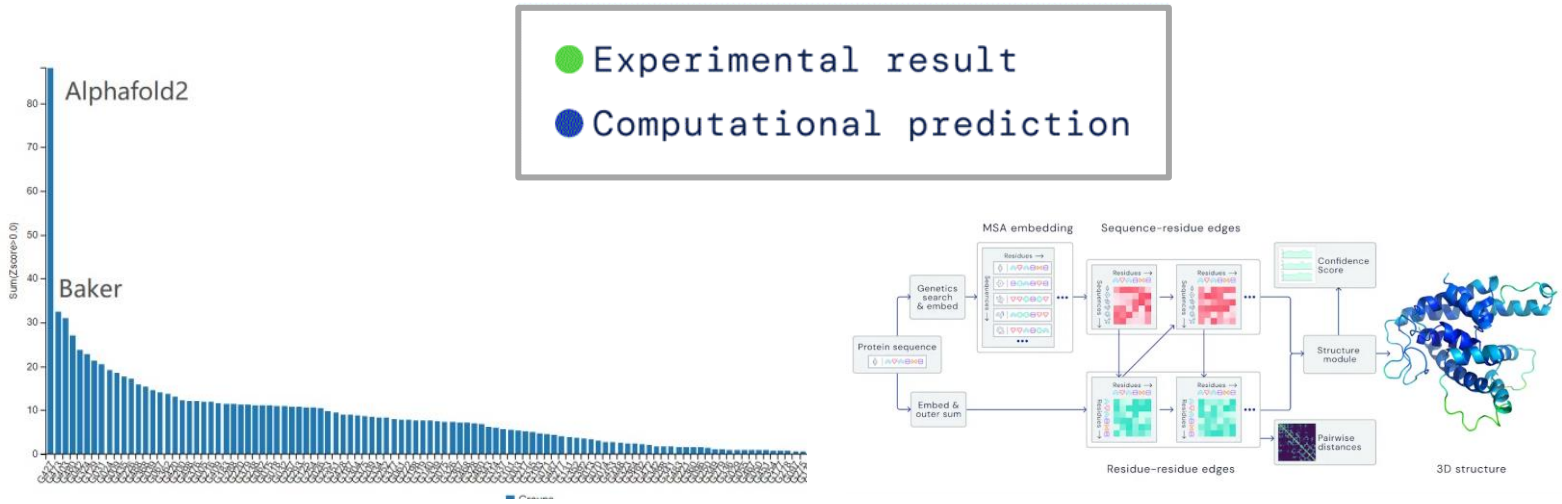
We're indebted to CASP's organisers and th
community, not least the experimentalists
structures enable this kind of rigorous asse



T1037 / 6vr4
90.7 GDT
(RNA polymerase domain)



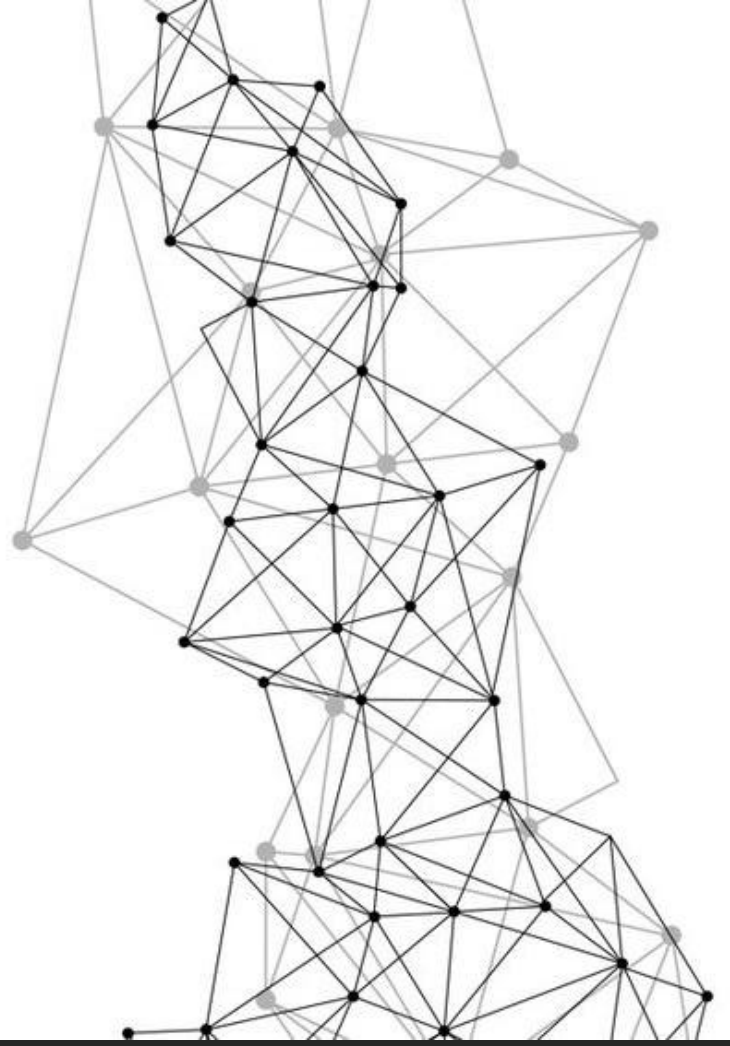
T1049 / 6y4f
93.3 GDT
(adhesin tip)



En Qué consiste ?

Porque este proyecto?

DESARROLLO DE REDES NEURONALES EN C++



- PONER EN PRÁCTICA LO APRENDIDO
- COMPARTIR LO APRENDIDO
- CONOCER EL CAMPO DE APRENDIZAJE AUTOMÁTICO
- DIVERSIFICAR CONOCIMIENTO

- ENTENDER LOS FUNDAMENTOS TEÓRICOS
- EMPLEAR LO APRENDIDO HACIA UN ENTORNO REAL
- INVESTIGACION
- BUSCAR SOLUCIONES

```
package multiLayer;

public class Neural_network {

    private double n;

    public Neural_network(int input0_Num, int layersNum, int[] neuronsNum, double n){
        initNeural_network();
    }
```

OBJETIVOS

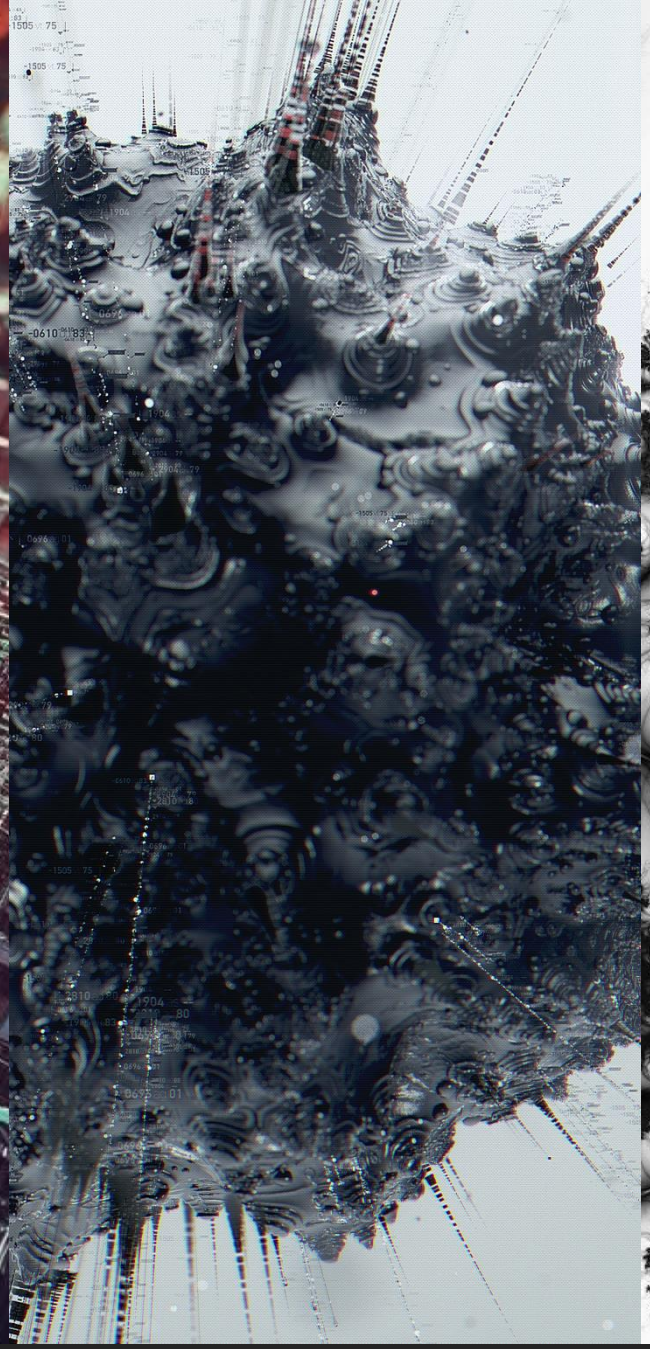
SER INGENIERO ES PROPONER SOLUCIONES INNOVADORAS
PARA UN MUNDO MEJOR

@hannakdraws

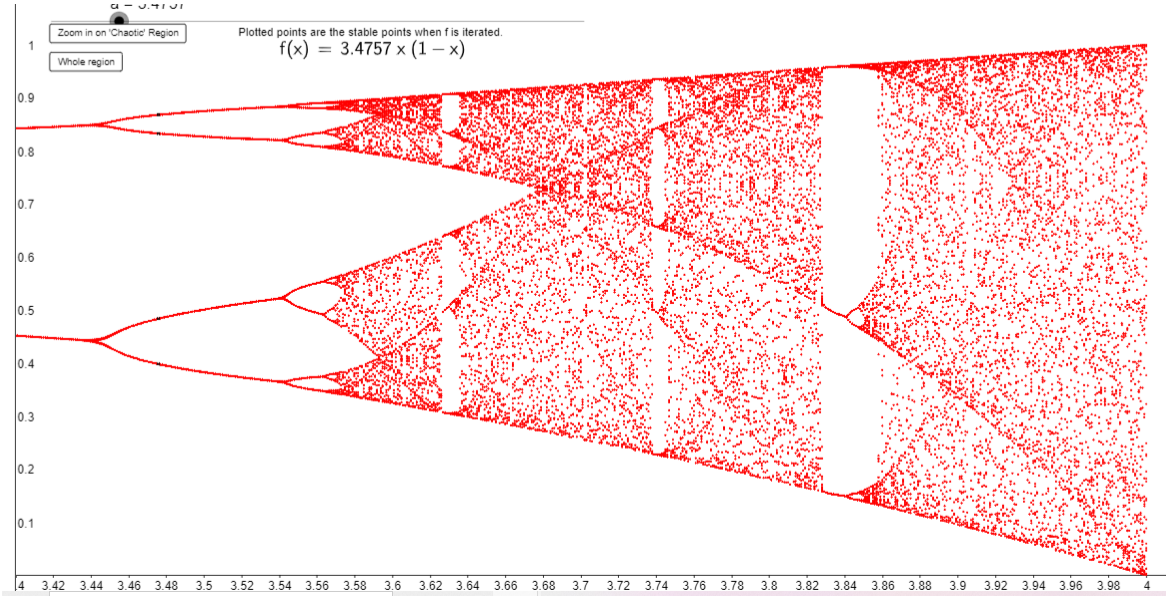
B

DESAROLLO

- FUNDAMENTOS
- DISEÑO



```
#include <iostream>
#include <math.h>
#include "And_Perceptron.h"

using namespace std;

And_Perceptron::And_Perceptron(do
this->w1=w1;
this->w2=w2;
this->b=b;
this->n=n;

cout<<"   Successful creation of the n
}

// ---- Natural Functions ----------
double And_Perceptron::trainNeuron
double error = 0;
0; i<4; i++){
 a = runNeuron(data[i][0],data[i][1]);
-= 50*pow(data[i][2]-a, 2);
endl<<"-------------------------------";
em.out.println("  w1: "+w1);
em.out.println("  w2: "+w2);
em.out.println("bias: "+b);
endl<<"case "<<i<<": "<<a;
 cout<<endl<<a;
<<endl<<"  w1: "<<w1,
<<endl<<"  w2: "<<w2,
<<endl<<"  b: "<<b,
em.out.println("error : "+error);
Error(a, data[i][2], data[i][0], data[i][1]);

 return error;
```



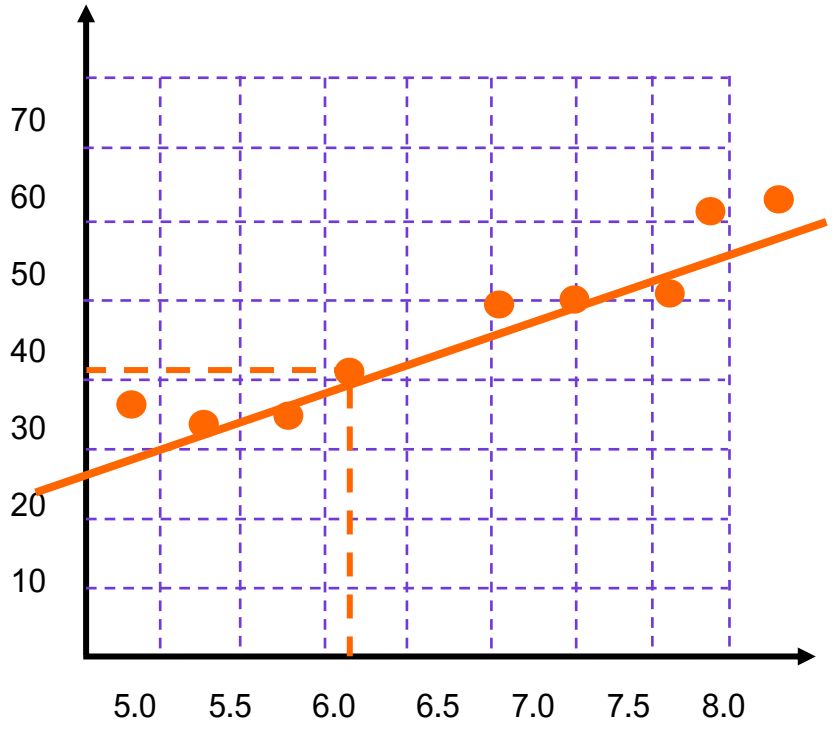
$$x_{n+1} = r x_n (1 - x_n)$$

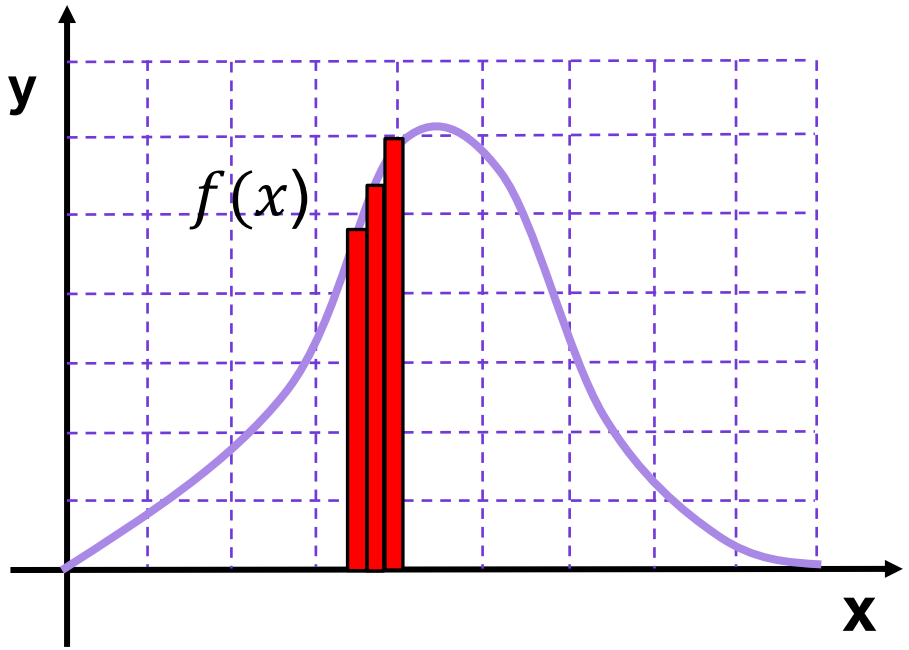
</ realidad >

- Caótico
- Indeterminado
- Complejo

</ modelo >

- Definido
- Intenta acercarse a la realidad
- Comprensible





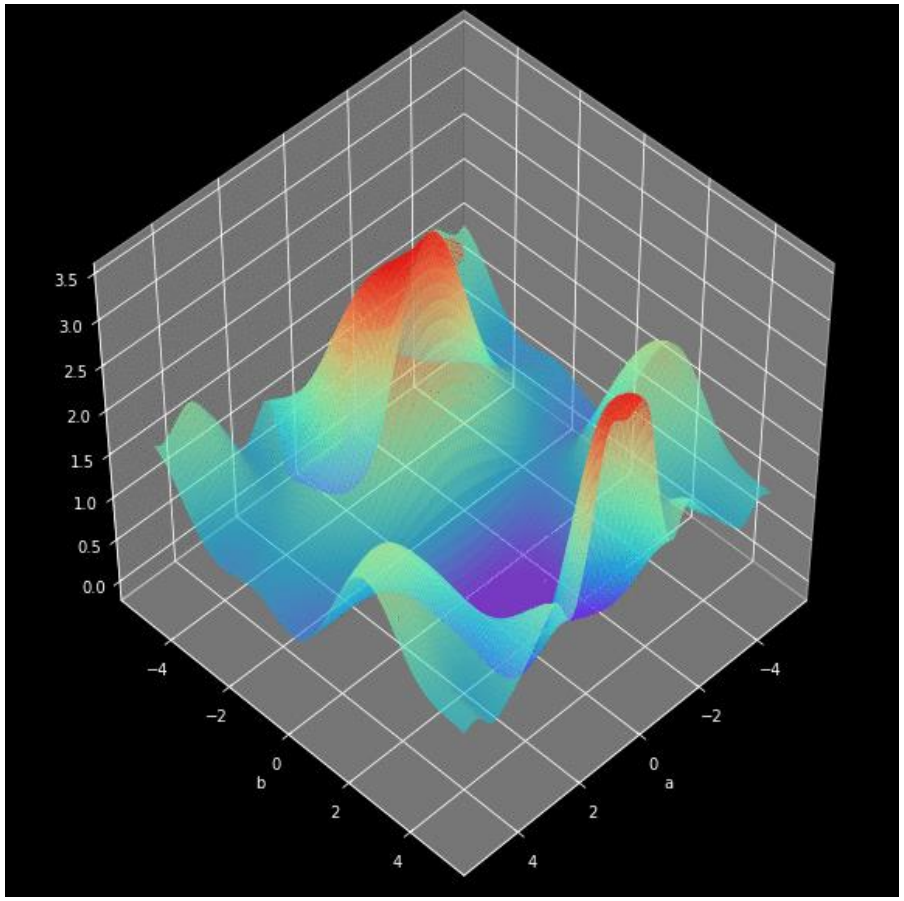
</ regresión >

</ probabilidad >

$$y = w_0 + w_1 x$$

Probabilidad de que un ave vuele

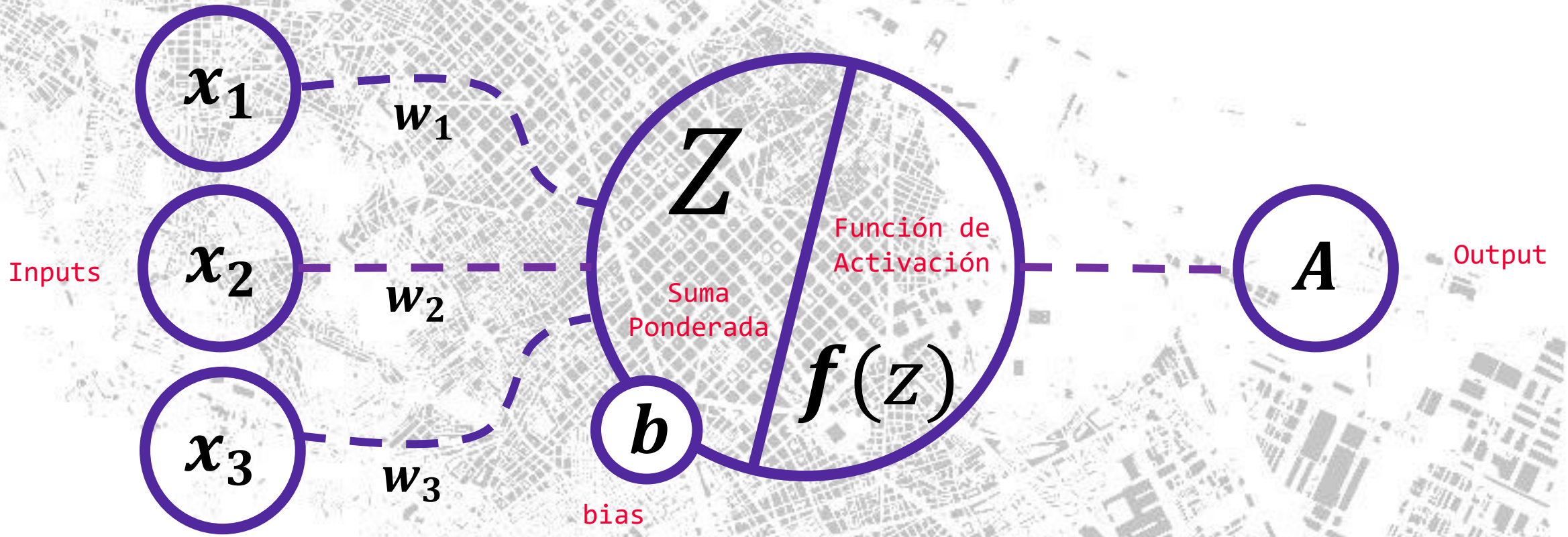
❖ generalización



</ regresión múltiple >

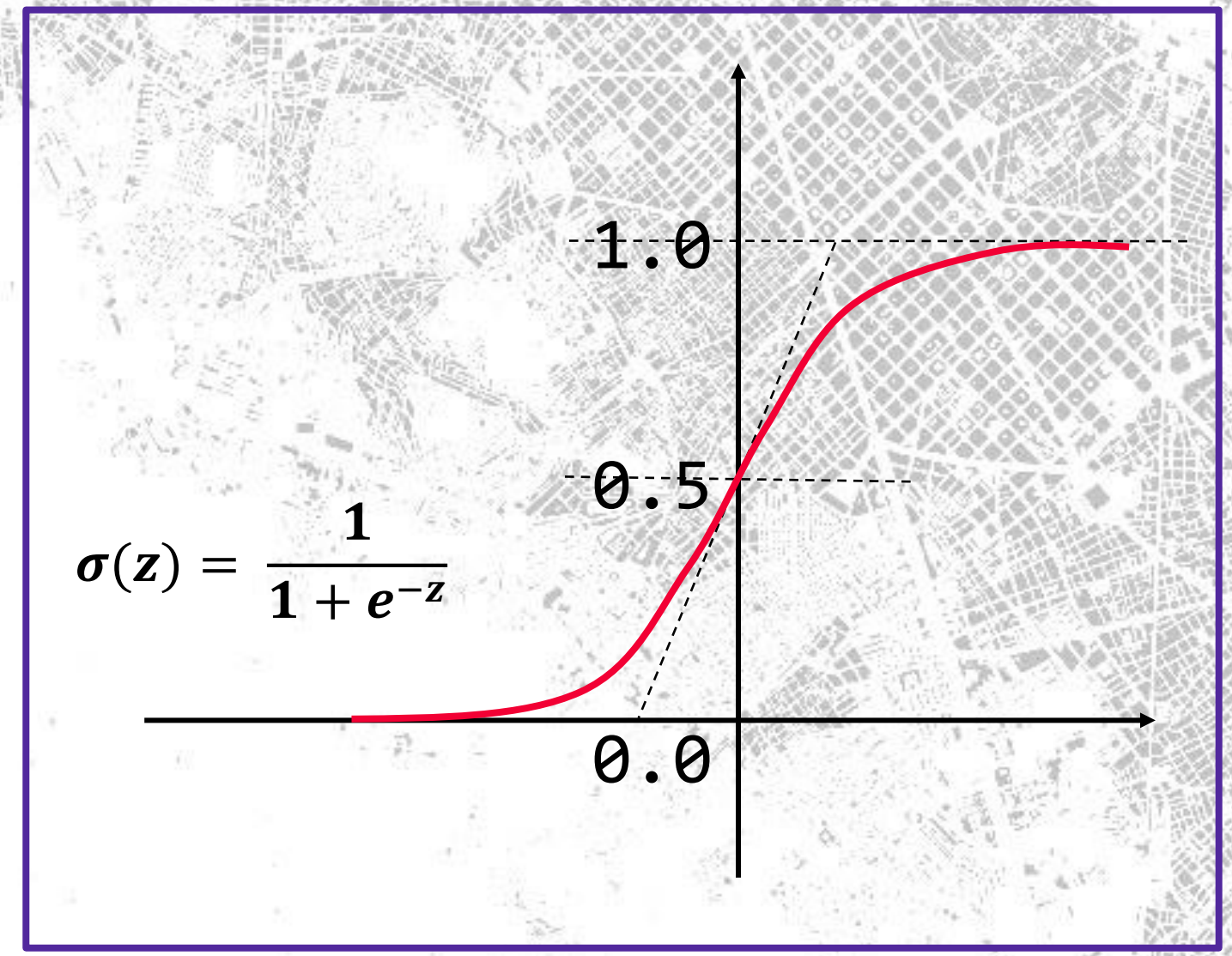
Red neuronal, un modelo matemático

$$\boldsymbol{\theta} = \{\boldsymbol{w_1}; \boldsymbol{w_2}; \ldots; \boldsymbol{w_n}; \boldsymbol{b_1}; \boldsymbol{b_2}; \ldots; \boldsymbol{b_n}\}$$

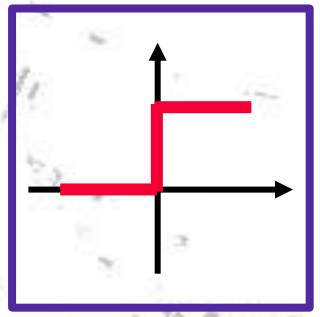


$$z = w_1x_1 + w_2x_2 + w_3x_3 + b$$

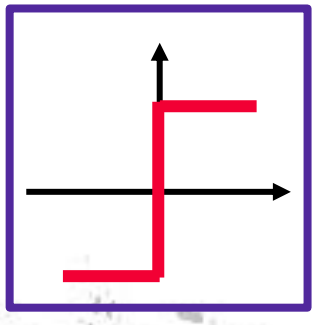
$$A = f(z)$$



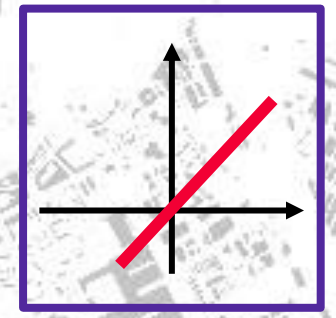
Sigmoide



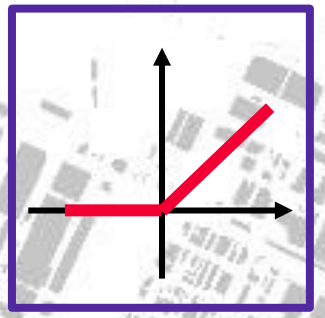
Escalón unitario



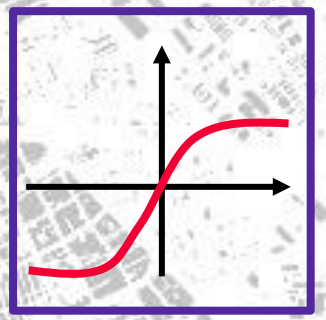
signo



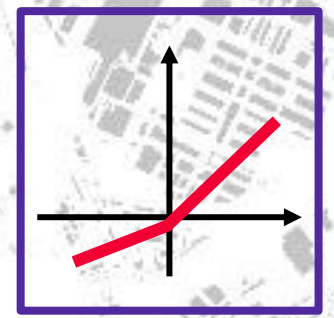
lineal



ReLu

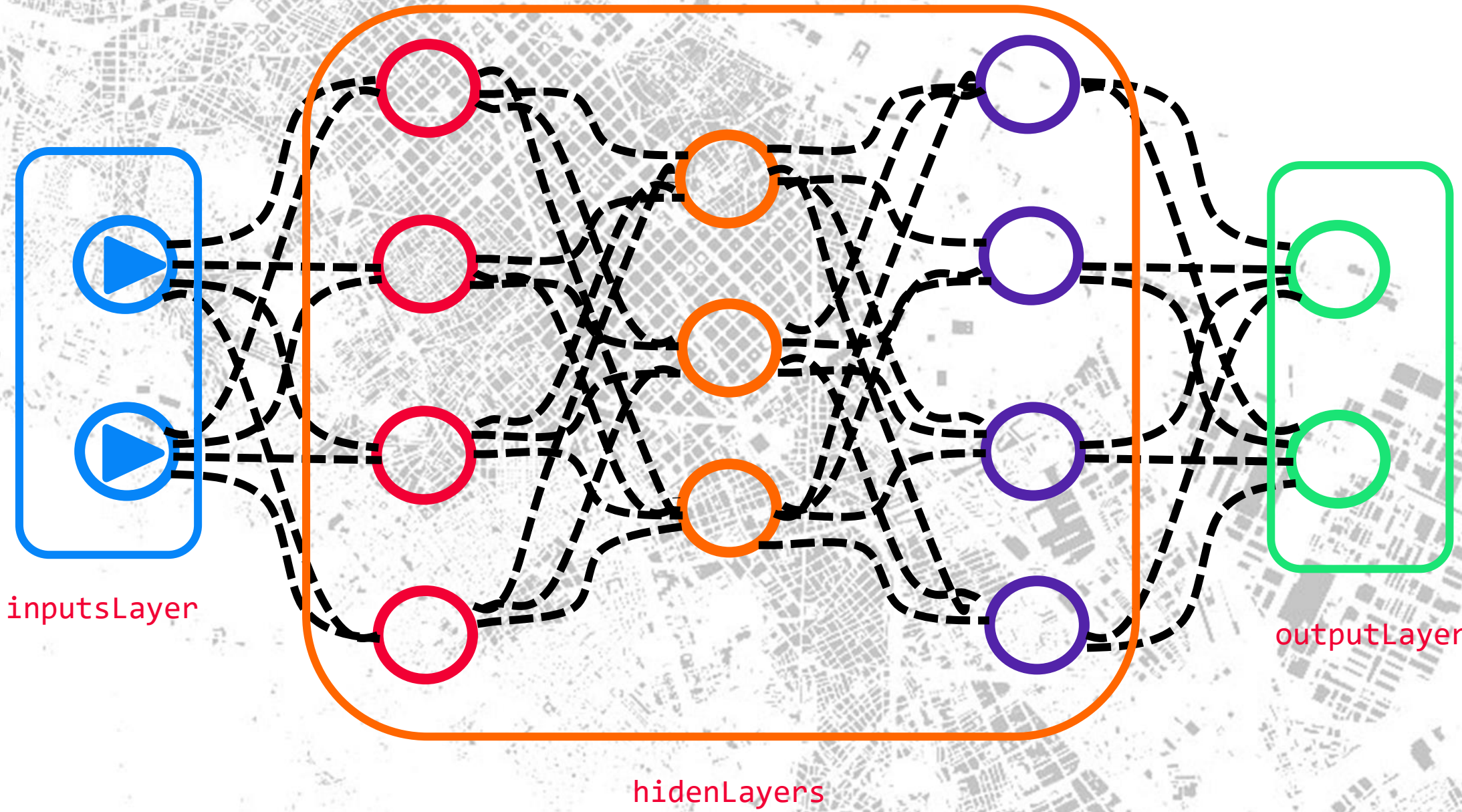


Tangente Hyperbolica

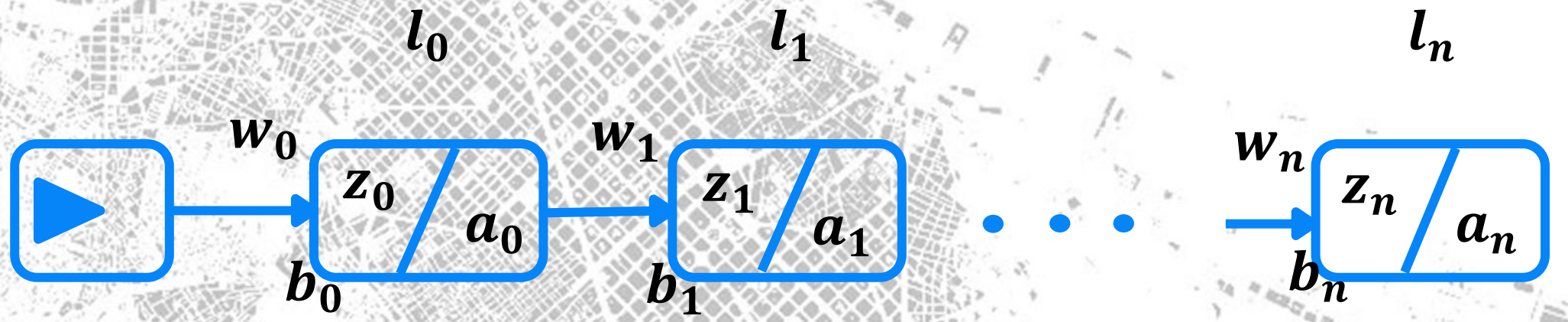


PReLu

</ función de activación >



</ red neuronal >

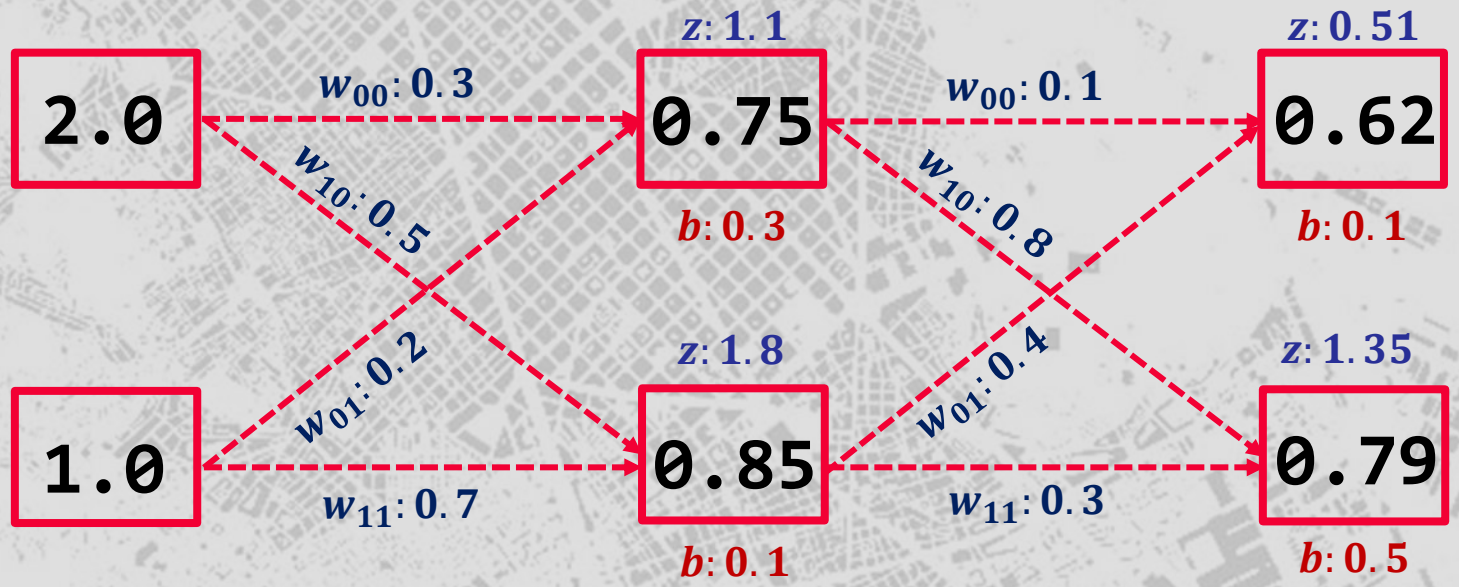


$$Z^l = \begin{bmatrix} z_0 \\ \vdots \\ z_n \end{bmatrix}^l = \begin{bmatrix} w_{00} & \cdots & w_{0m} \\ \vdots & \ddots & \vdots \\ w_{n0} & \cdots & w_{nm} \end{bmatrix}^l \begin{bmatrix} a_0 \\ \vdots \\ a_m \end{bmatrix}^{l-1} + \begin{bmatrix} b_0 \\ \vdots \\ b_n \end{bmatrix}^l$$

$$Z^l = W^l A^{l-1} + b^l$$

$$A^l = \begin{bmatrix} A_0 \\ \vdots \\ A_n \end{bmatrix}^l = \sigma\left(\begin{bmatrix} z_0 \\ \vdots \\ z_n \end{bmatrix}^l \right)$$

$$A^l = \sigma(Z^l)$$



$$Z^1 = W^1 A^0 + b^1$$

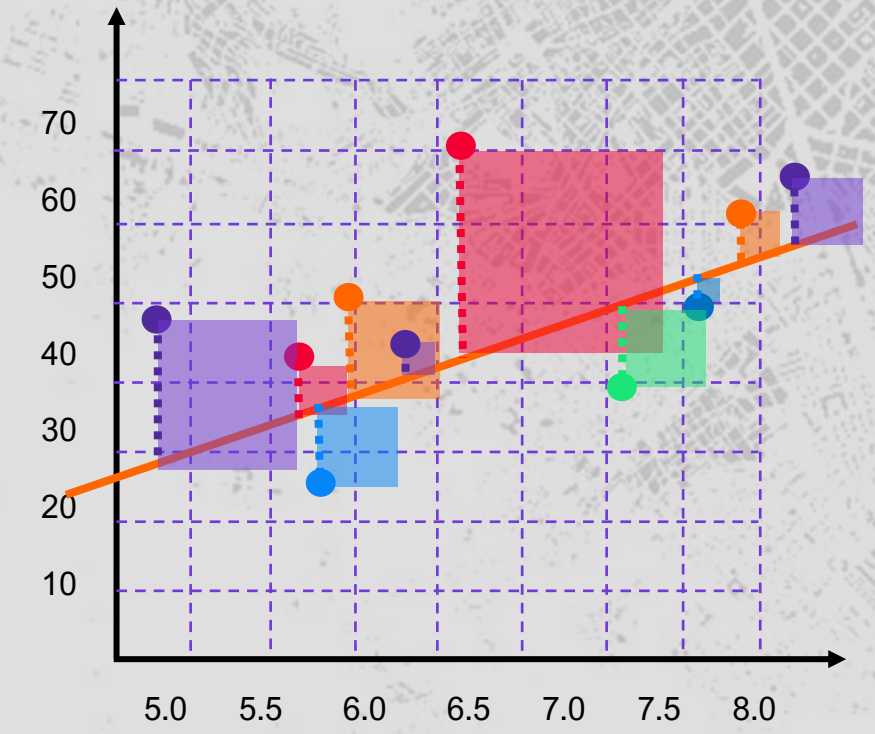
$$A^l = \sigma(Z^l)$$

$$Z^1 = \begin{bmatrix} 0.1 & 0.4 \\ 0.8 & 0.3 \end{bmatrix} \begin{bmatrix} 0.75 \\ 0.85 \end{bmatrix} + \begin{bmatrix} 0.1 \\ 0.5 \end{bmatrix} = \begin{bmatrix} 0.51 \\ 1.35 \end{bmatrix}$$

$$A^1 = \begin{bmatrix} \sigma(0.51) \\ \sigma(1.35) \end{bmatrix} = \begin{bmatrix} 0.62 \\ 0.79 \end{bmatrix}$$

Error cuadrático medio

</ mean square error >



$$\theta = \{w_1; w_2; \ldots; w_n; b_1; b_2; \ldots; b_n\}$$

$$\hat{y} = f(\theta)$$

$$\varepsilon = (y_i - \hat{y}_i)^2$$

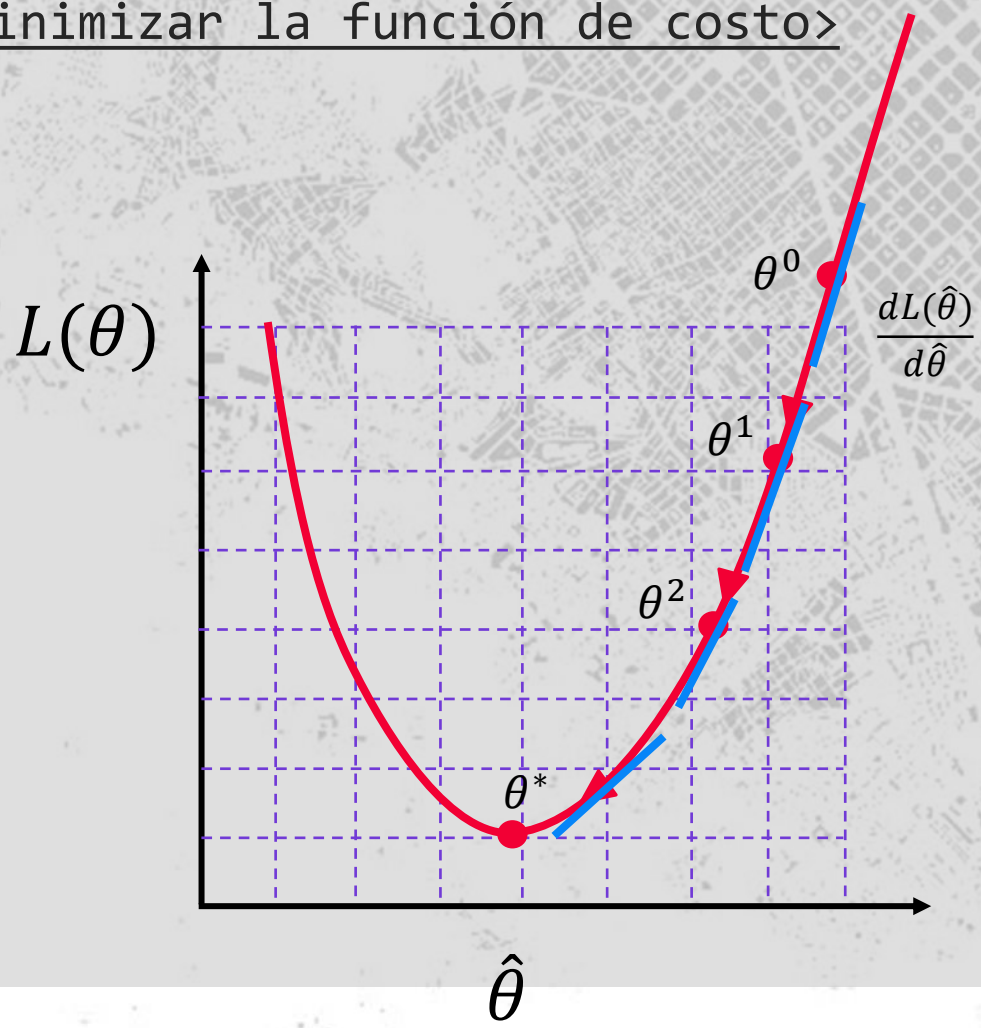
$$MSE(\theta) = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

loss function

</ función de costo >

Descenso de Gradiente

</ minimizar la función de costo>



$$\theta = \{w_1; w_2; \ldots; w_n; b_1; b_2; \ldots; b_n\}$$

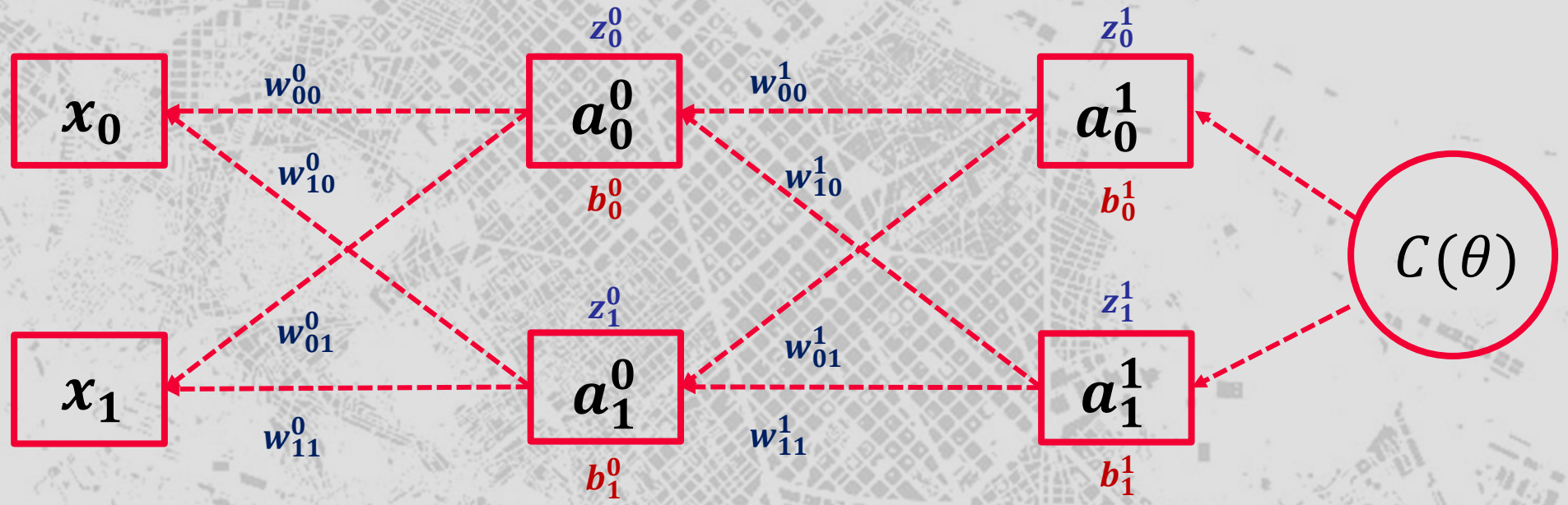
$$\boldsymbol{L(\theta) = \sum_{i=1}^{n} C^n(\theta) \quad \Rightarrow \quad \frac{dL(\theta)}{dw} = \sum_{i=1}^{n} \frac{dC^n(\theta)}{dw}}$$

$$\boldsymbol{\nabla L(\theta) = \begin{bmatrix} \frac{dC(\theta_0)}{dw_0} \\ \frac{dC(\theta_1)}{dw_1} \\ \vdots \\ \frac{dC(\theta_0)}{db_0} \\ \frac{dC(\theta_1)}{db_1} \\ \vdots \end{bmatrix}}$$

$$\boldsymbol{\theta_0 = \theta_0 - n\nabla L(\theta_0)}$$
$$\boldsymbol{\theta_1 = \theta_1 - n\nabla L(\theta_1)}$$
$$\vdots$$

Update parameters

</ gradient descent>



$$\frac{dC}{dw^{l-1}} = \frac{dC}{da^l}\frac{da^l}{dz^l}\frac{dz^l}{da^{l-1}}\frac{da^{l-1}}{dz^{l-1}}\frac{dz^{l-1}}{dw^{l-1}}$$

$$\frac{dC}{db^{l-1}} = \frac{dC}{da^l}\frac{da^l}{dz^l}\frac{dz^l}{da^{l-1}}\frac{da^{l-1}}{dz^{l-1}}\frac{dz^{l-1}}{db^{l-1}}$$

$$\delta^{l-1} = \delta^l (W^l)^T \frac{da^{l-1}}{dz^{l-1}}$$

$$\frac{dC}{dw^{l-1}} = \delta^{l-1} a^{l-1} \qquad \frac{dC}{db^{l-1}} = \delta^{l-1}$$

$$\frac{dC}{dw^l} = \frac{dC}{da^l}\frac{da^l}{dz^l}\frac{dz^l}{dw^l}$$

$$\frac{dC}{db^l} = \frac{dC}{da^l}\frac{da^l}{dz^l}\frac{dz^l}{db^l}$$

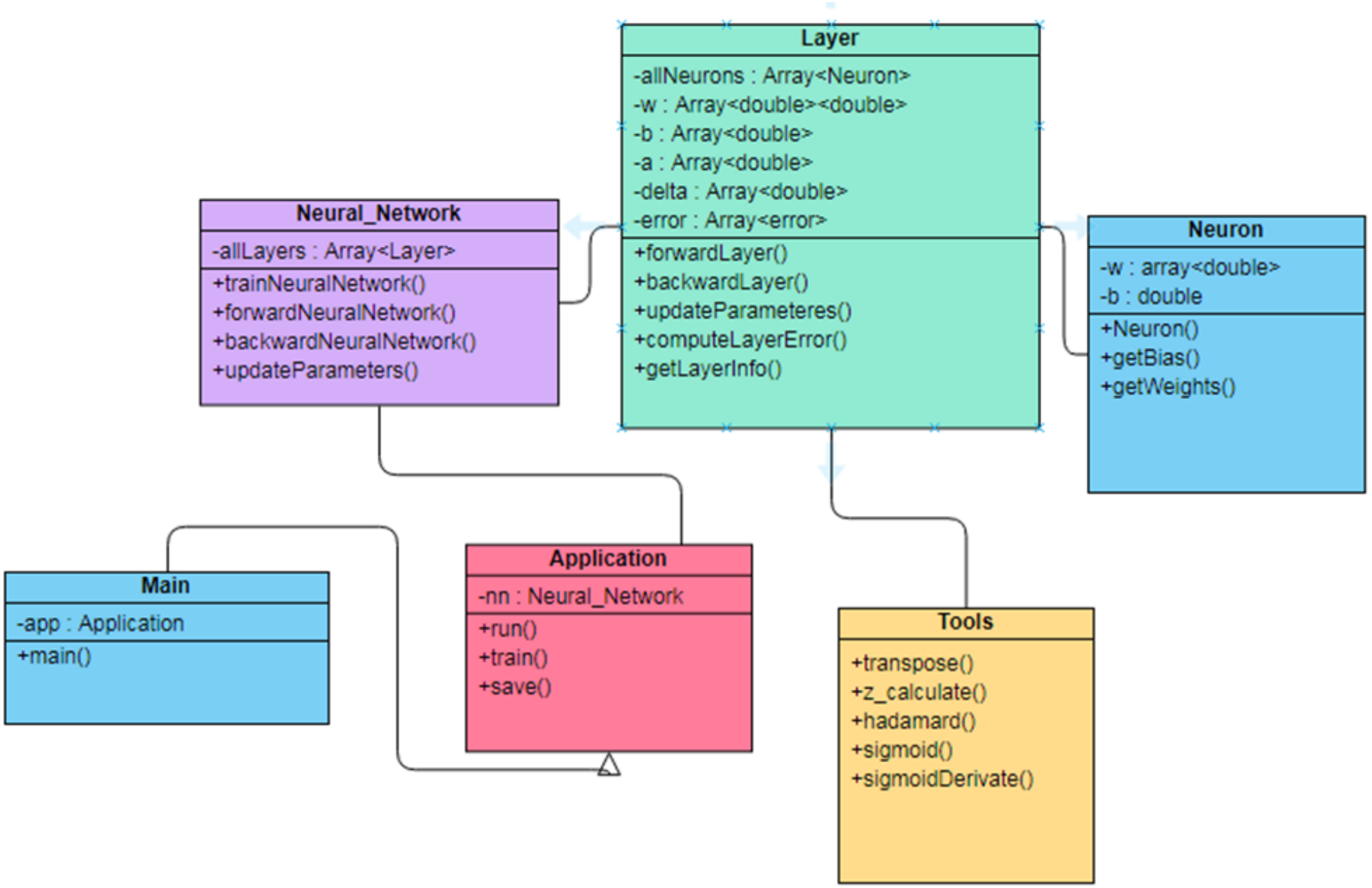
$$\delta^l = \frac{dC}{da^l}\frac{da^l}{dz^l}$$

$$w^n = \widehat{w^n} - n\frac{dC}{dw^n}$$

$$\Delta w^n = -n\frac{dC}{dw^n}$$

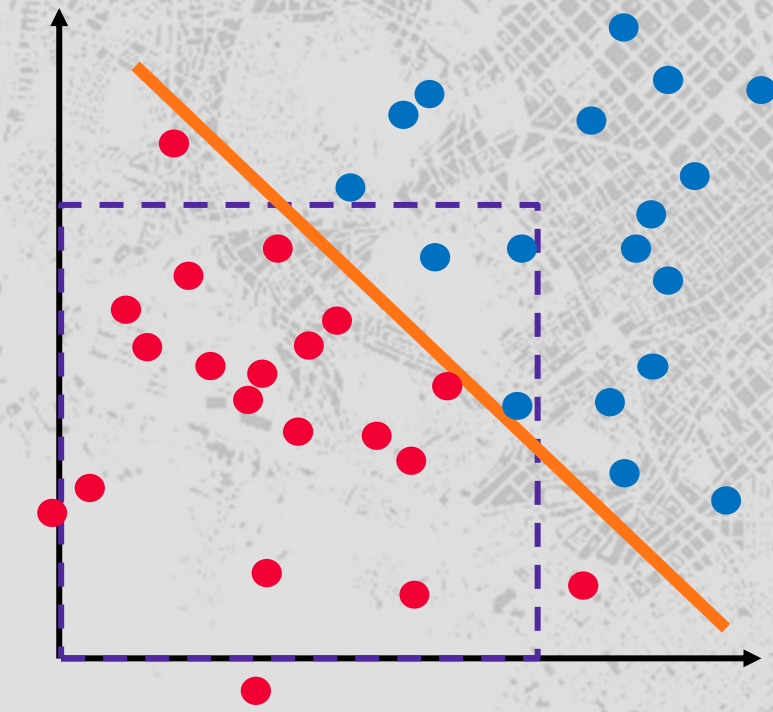
$$\Delta\theta_n = -n\frac{dC}{d\theta_n}$$

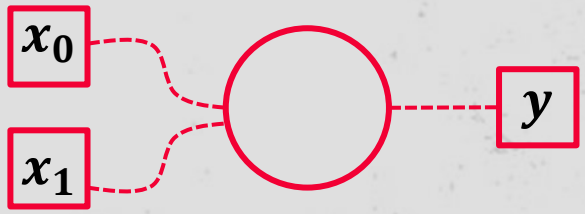
n : *learning rate*


Layer
-allNeurons : Array<Neuron>
-w : Array<double><double>
-b : Array<double>
-a : Array<double>
-delta : Array<double>
-error : Array<error>
+forwardLayer()
+backwardLayer()
+updateParameteres()
+computeLayerError()
+getLayerInfo()
Neural_Network
-allLayers : Array<Layer>
+trainNeuralNetwork()
+forwardNeuralNetwork()
+backwardNeuralNetwork()
+updateParameters()
Neuron
-w : array<double>
-b : double
+Neuron()
+getBias()
+getWeights()
Main
-app : Application
+main()
Application
-nn : Neural_Network
+run()
+train()
+save()
Tools
+transpose()
+z_calculate()
+hadamard()
+sigmoid()
+sigmoidDerivate()

</ diseño >

</ and >





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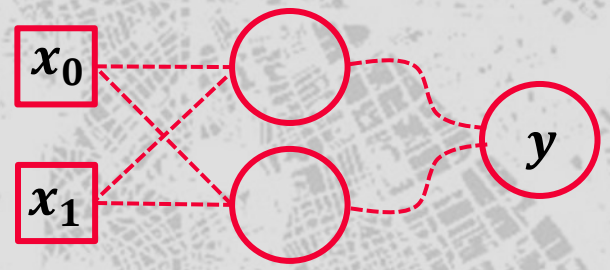
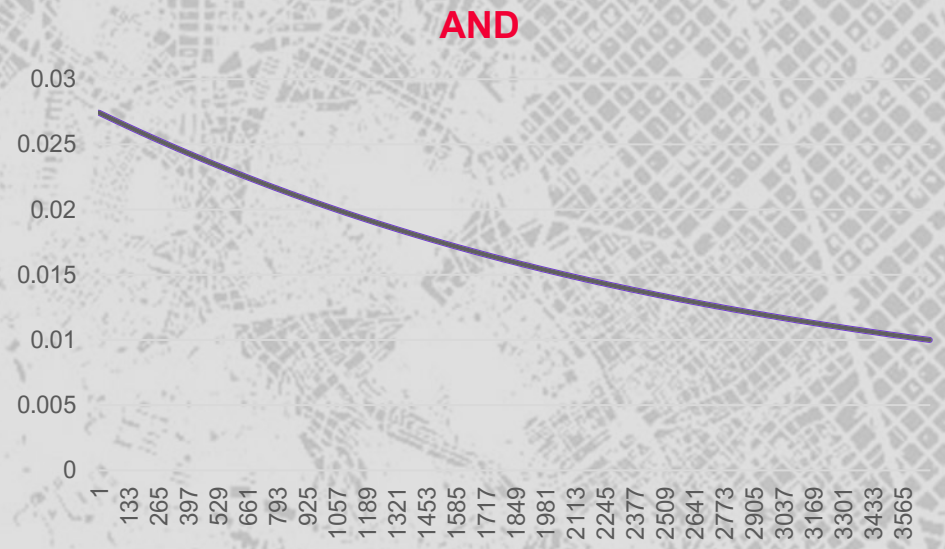


</ test >

C

RESULTADOS

- RESULTADOS
- CONCLUSIONES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0.005
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1189
1321
1453
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1981
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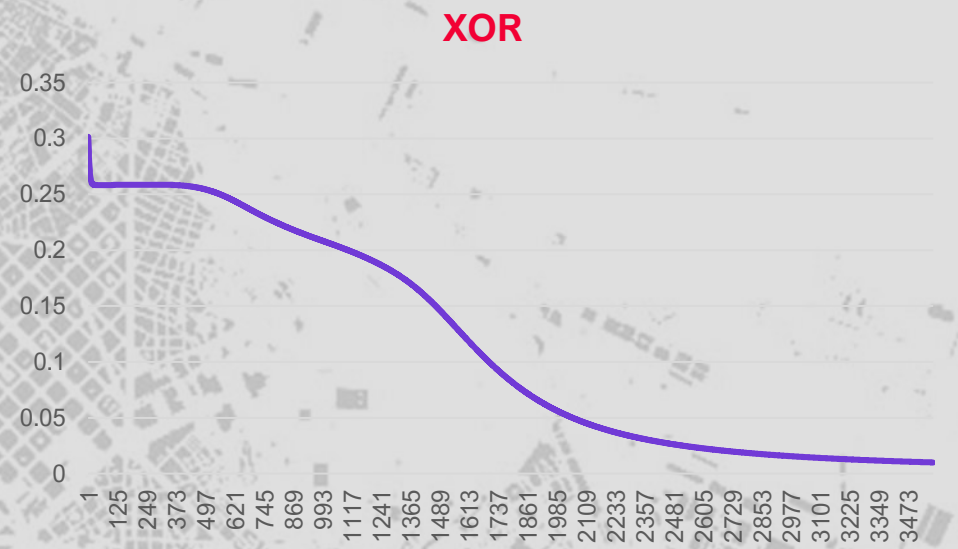
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869
993
1117
1241
1365
1489
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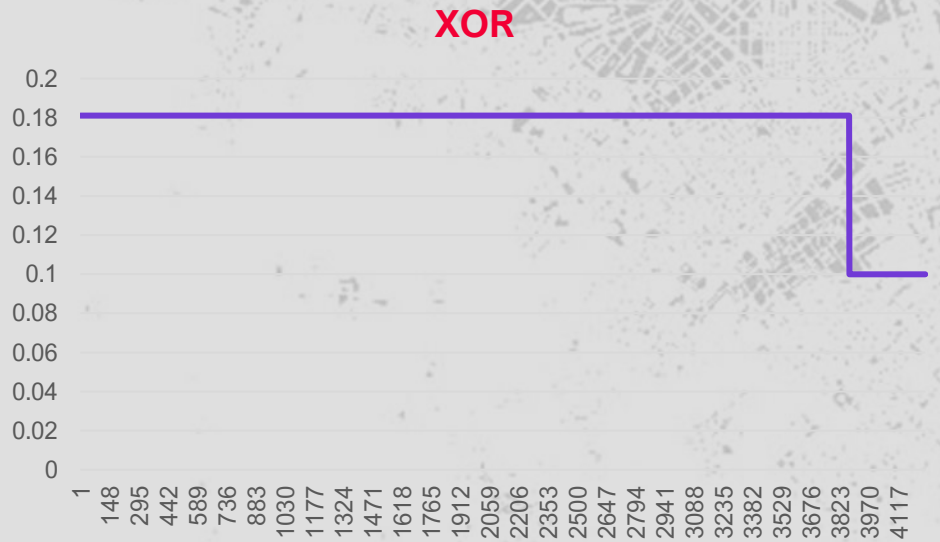
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0.02
0
1
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295
442
589
736
883
1030
1177
1324
1471
1618
1765
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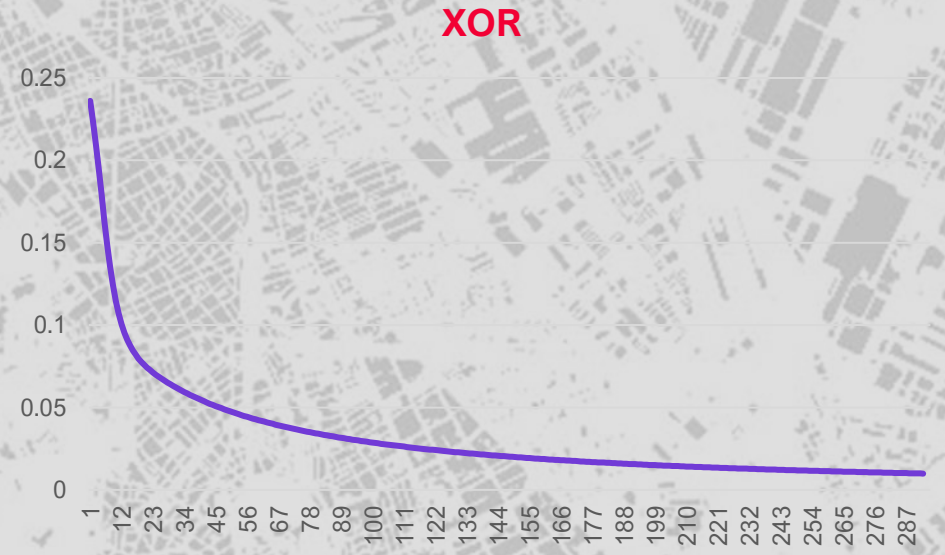
XOR
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0.1
0.05
0
1
12
23
34
45
56
67
78
89
100
111
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133
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177
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199
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221
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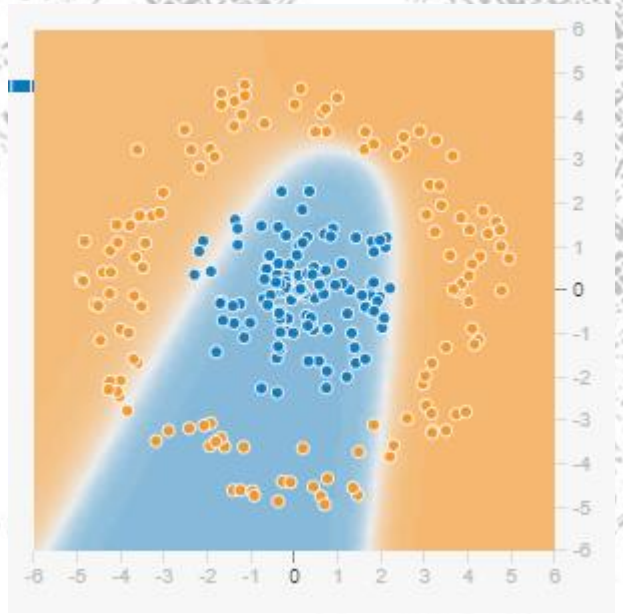
265
276
287

</ resultados >

</ conclusiones>



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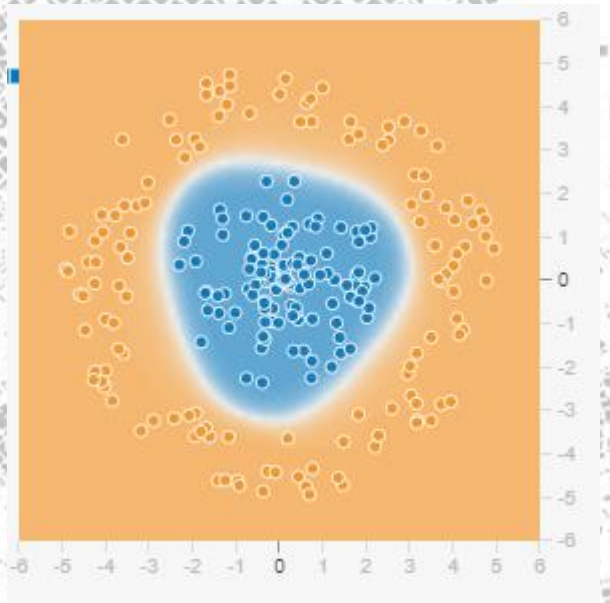

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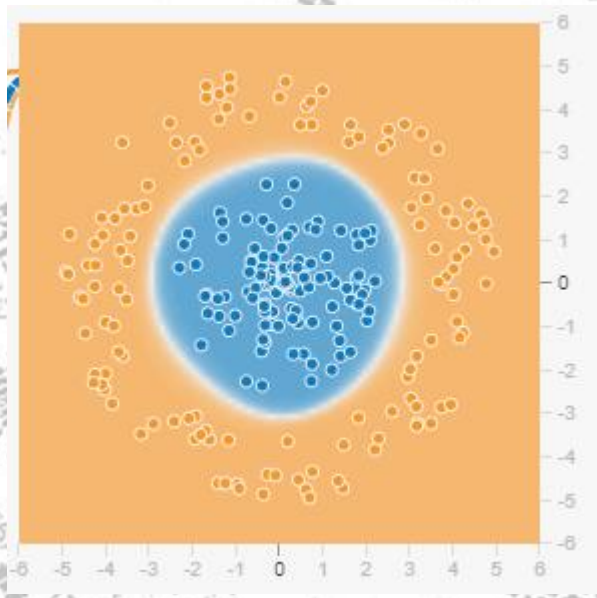

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