Redes neurais artificiais

Jones Granatyr

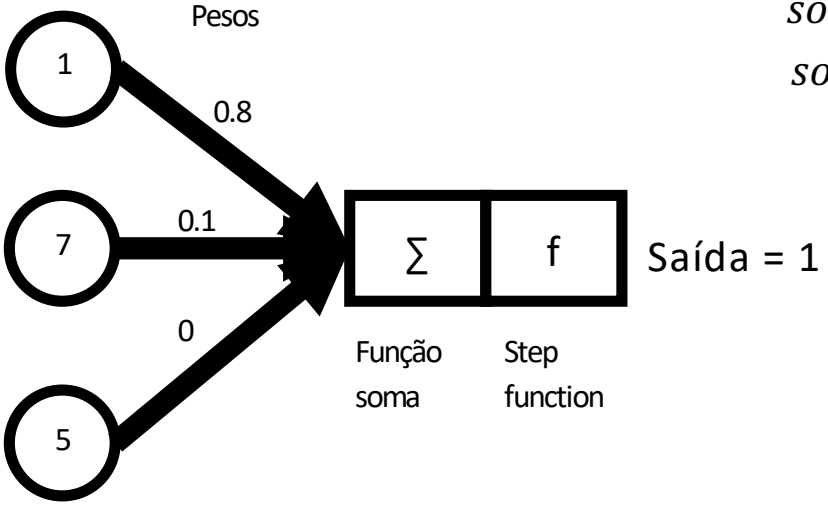
Neurônio artificial

$$soma = \sum_{i=1}^{n} xi * wi$$

$soma = (1 * 0.8) + (7 * 0.1) + (5 * 0)$

$soma = 0.8 + 0.7 + 0$

$soma = 1.5$



Step function (função Degrau)

Maior do que zero = 1
Caso contrário = 0

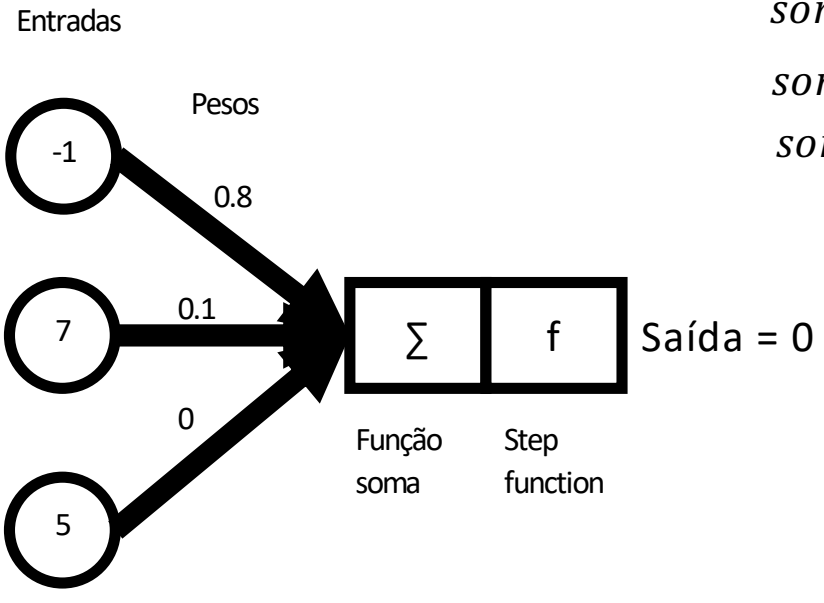
Neurônio artificial

$$soma = \sum_{i=1}^{n} xi * wi$$

$soma$ = (-1 * 0.8) + (7 * 0.1) + (5 * 0)

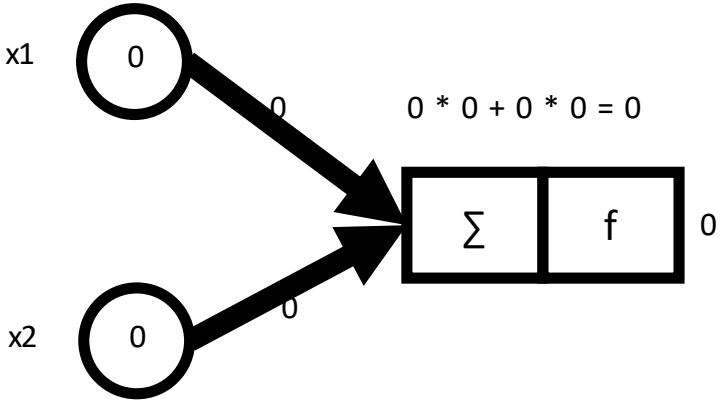
$soma$ = -0.8 + 0.7 + 0

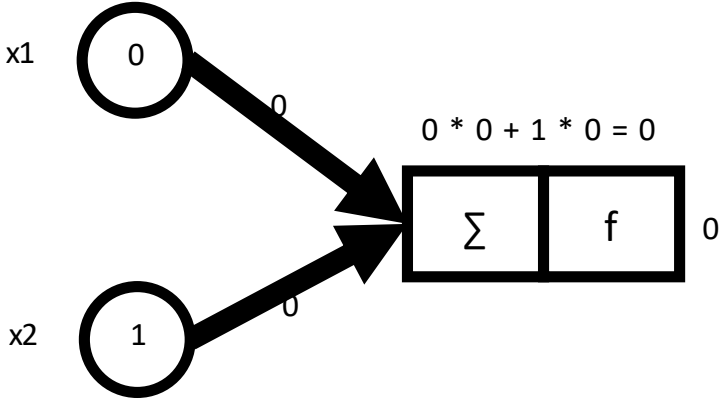
$soma$ = -0.1



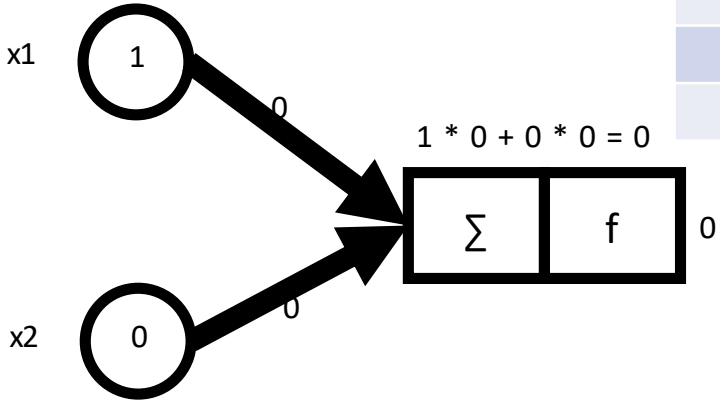
Operador E

x1	x2	Classe
0	0	0
0	1	0
1	0	0
1	1	1

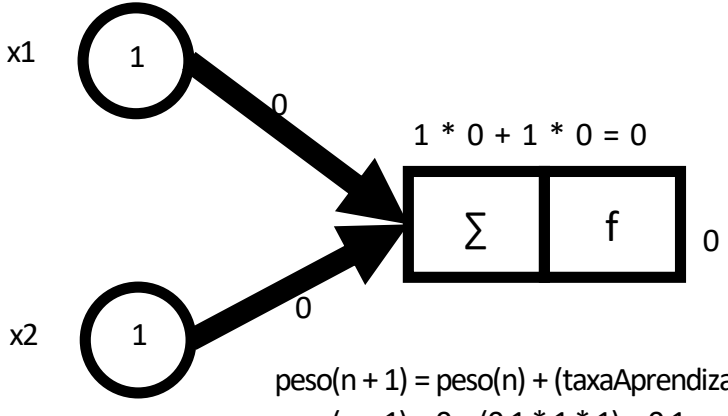




x1	x2	Classe
0	0	0
0	1	0
1	0	0
1	1	1

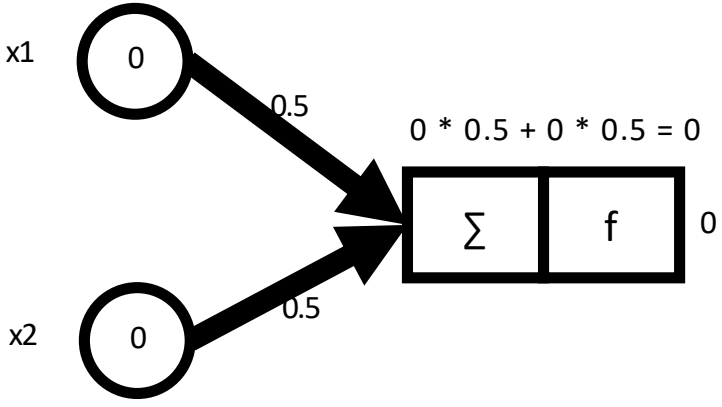


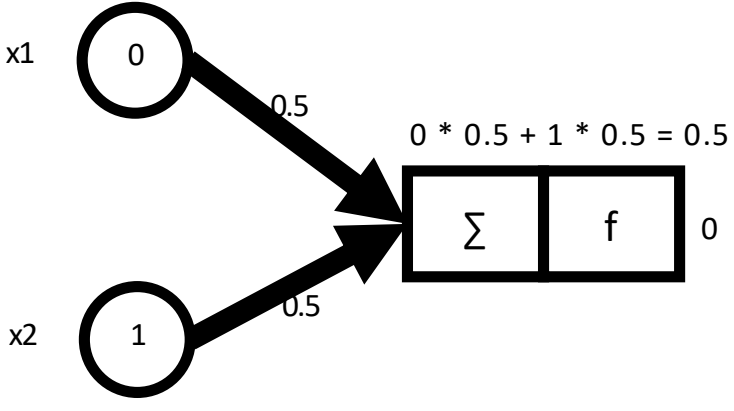
0 – 0 = 0
0 – 0 = 0
0 – 0 = 0
1 – 0 = 1

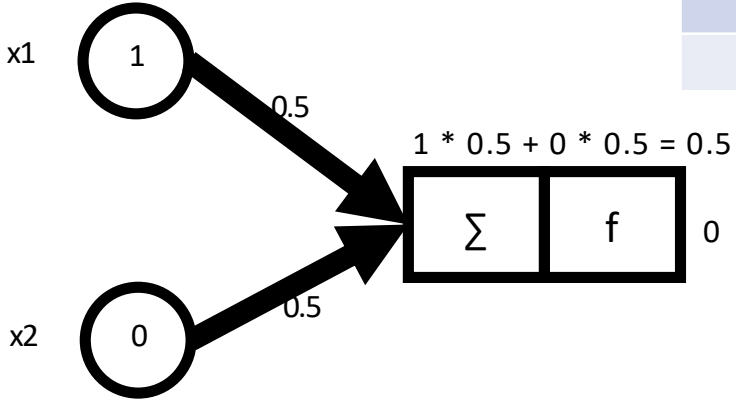


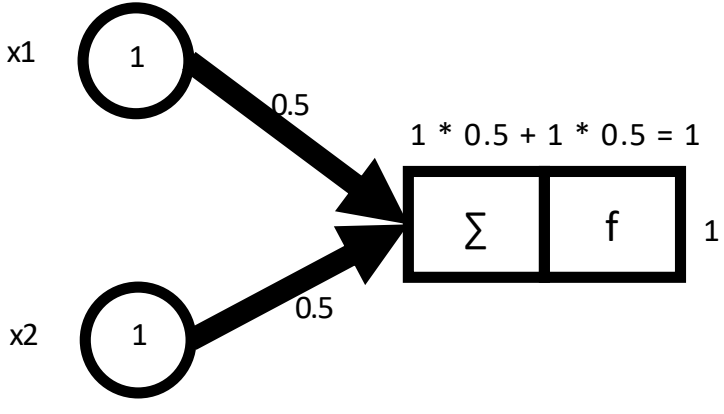
peso(n + 1) = peso(n) + (taxaAprendizagem * entrada * erro)
peso(n + 1) = 0 + (0.1 * 1 * 1) = 0.1

x1	x2	Classe
0	0	0
0	1	0
1	0	0
1	1	1

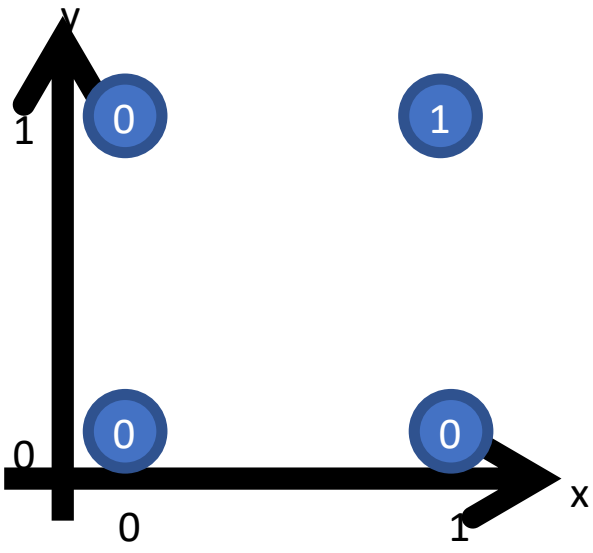


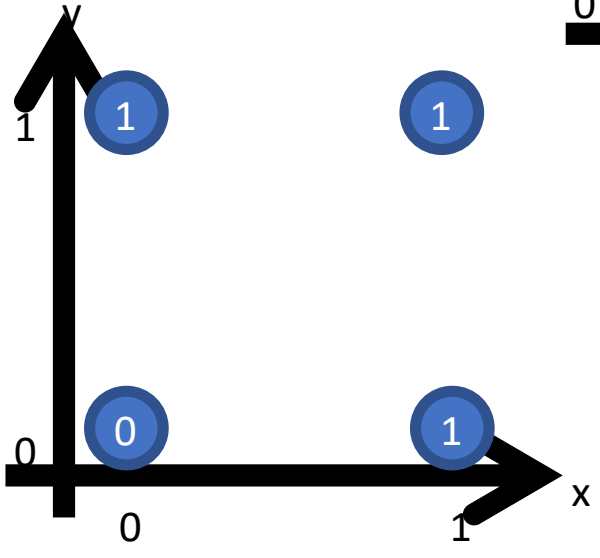


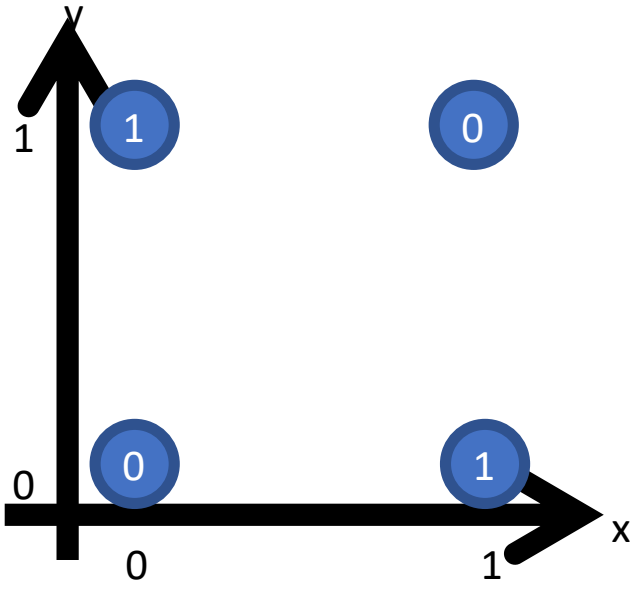




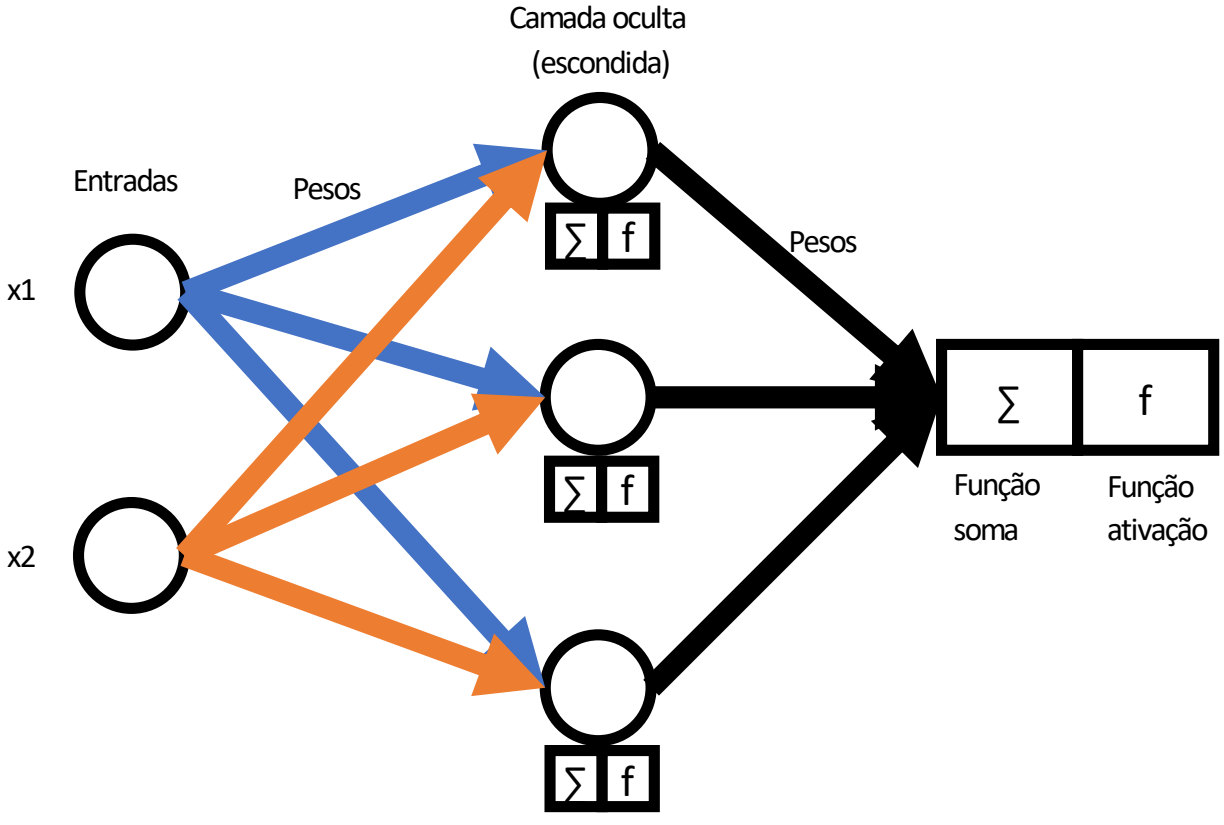
0 – 0 = 0
0 – 0 = 0
0 – 0 = 0
1 – 1 = 0


y
1
0
1
0
0
0
1
x


y
1
1
1
0
0
1
x

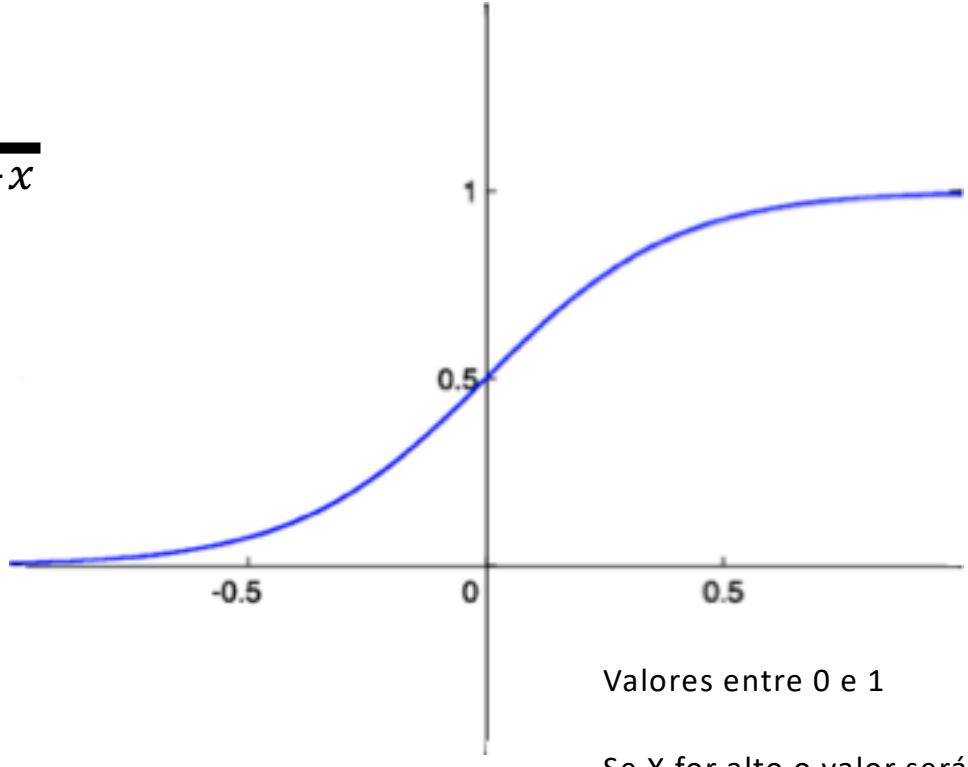

y
1
1
0
0
0
1
x

Redes multicamada (multilayer perceptron)



Sigmoid (função sigmoide)

$$y = \frac{1}{1 + e^{-x}}$$



Valores entre 0 e 1

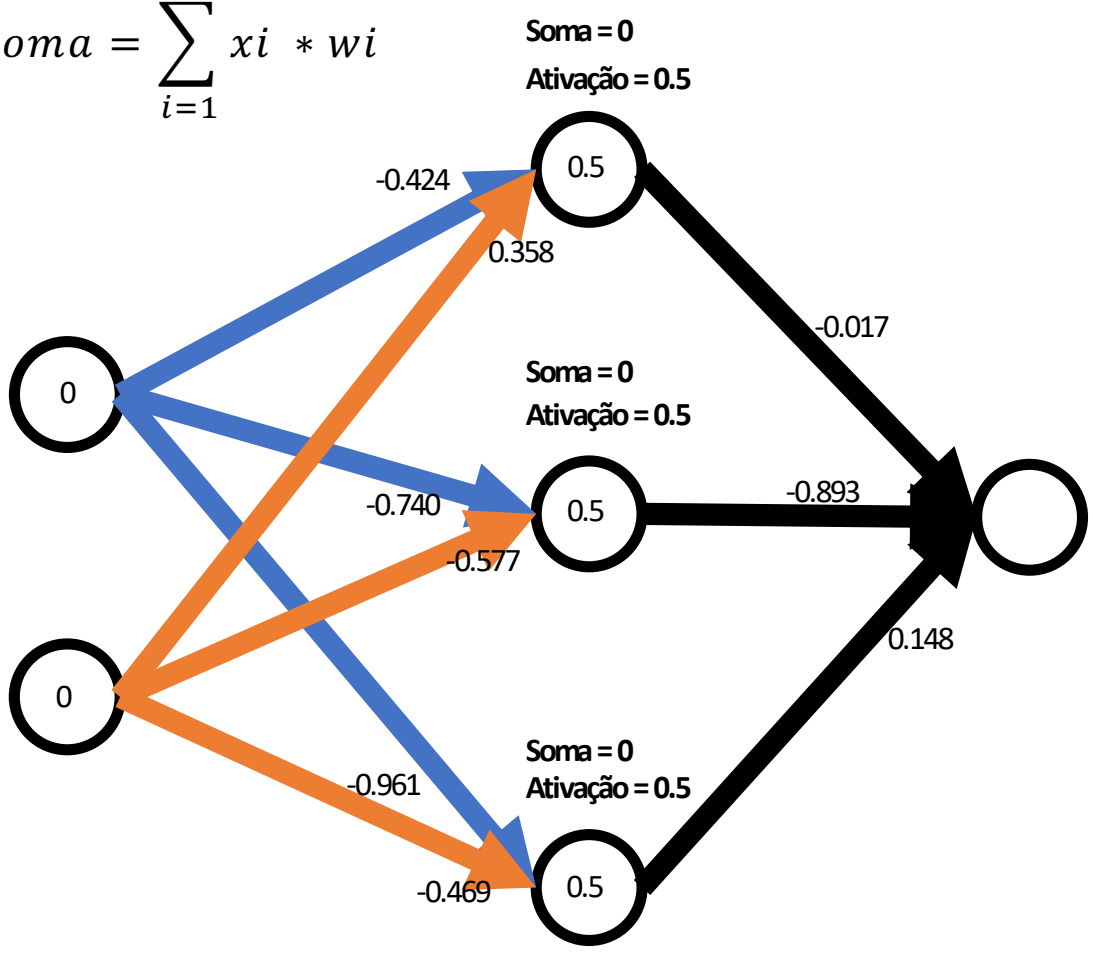
Se X for alto o valor será aproximadamente 1
Se X for pequeno o valor será aproximadamente 0
Não retorna valores negativos

Operador XOR

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0

Cálculos camada entrada para camada oculta

$$soma = \sum_{i=1}^{n} xi * wi$$



$$y = \frac{1}{1 + e^{-x}}$$

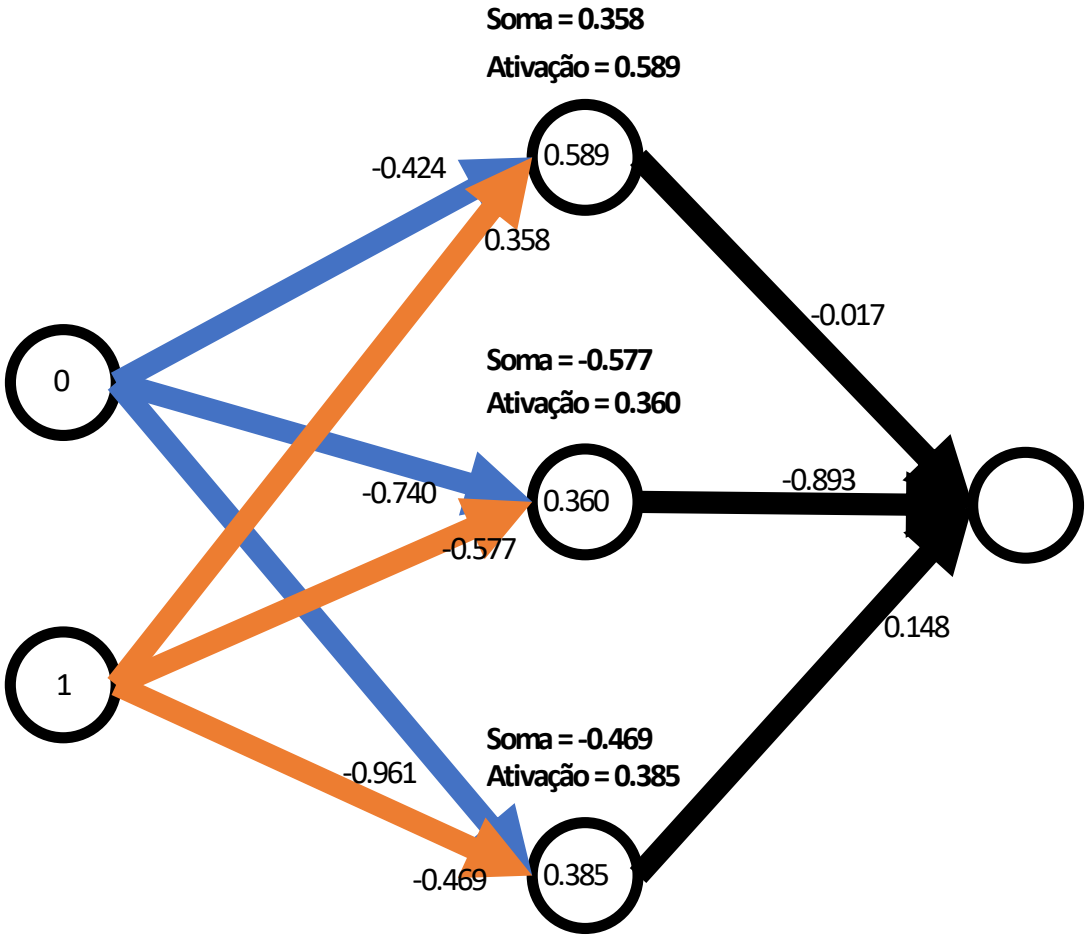
x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0

0 * (-0.424) + 0 * 0.358 = 0

0 * (-0.740) + 0 * (-0.577) = 0

0 * (-0.961) + 0 * (-0.469) = 0

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0

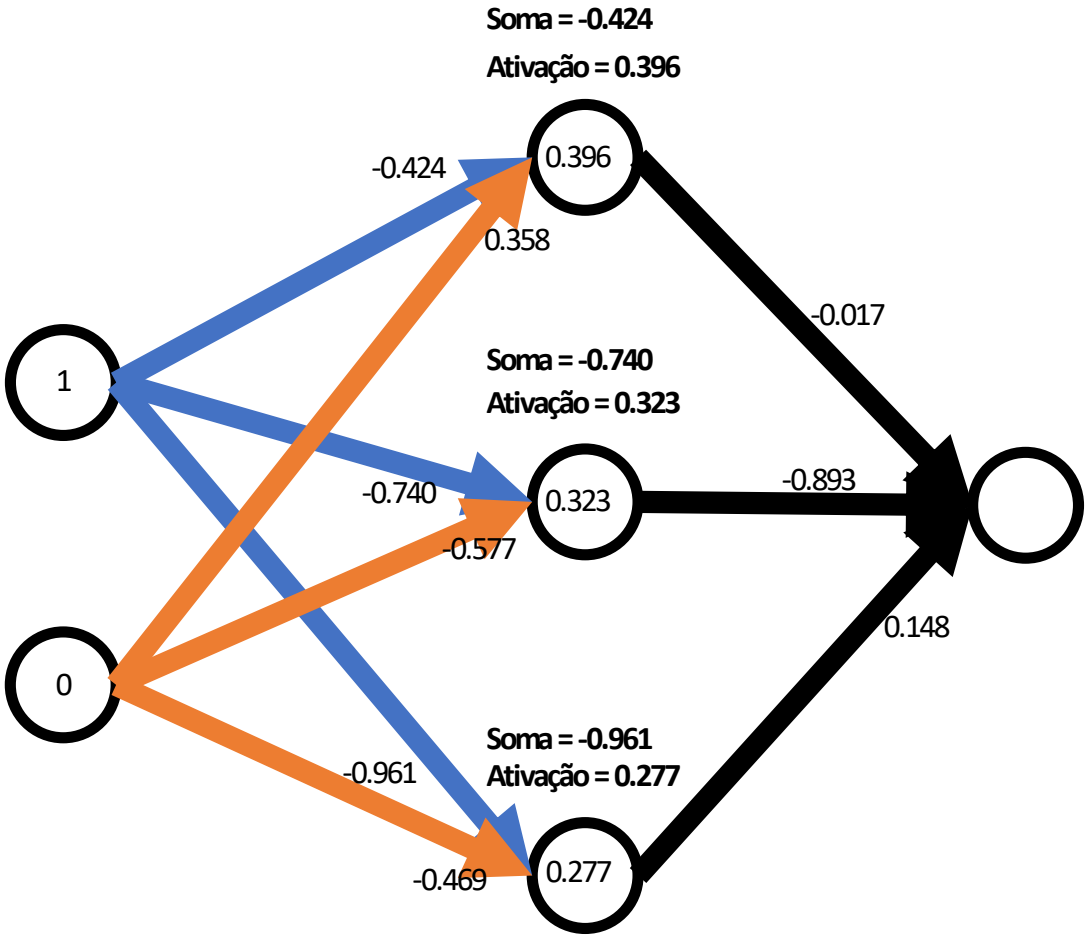


0 * (-0.424) + 1 * 0.358 = 0.358

0 * (-0.740) + 1 * (-0.577) = -0.577

0 * (-0.961) + 1 * (-0.469) = -0.469

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0

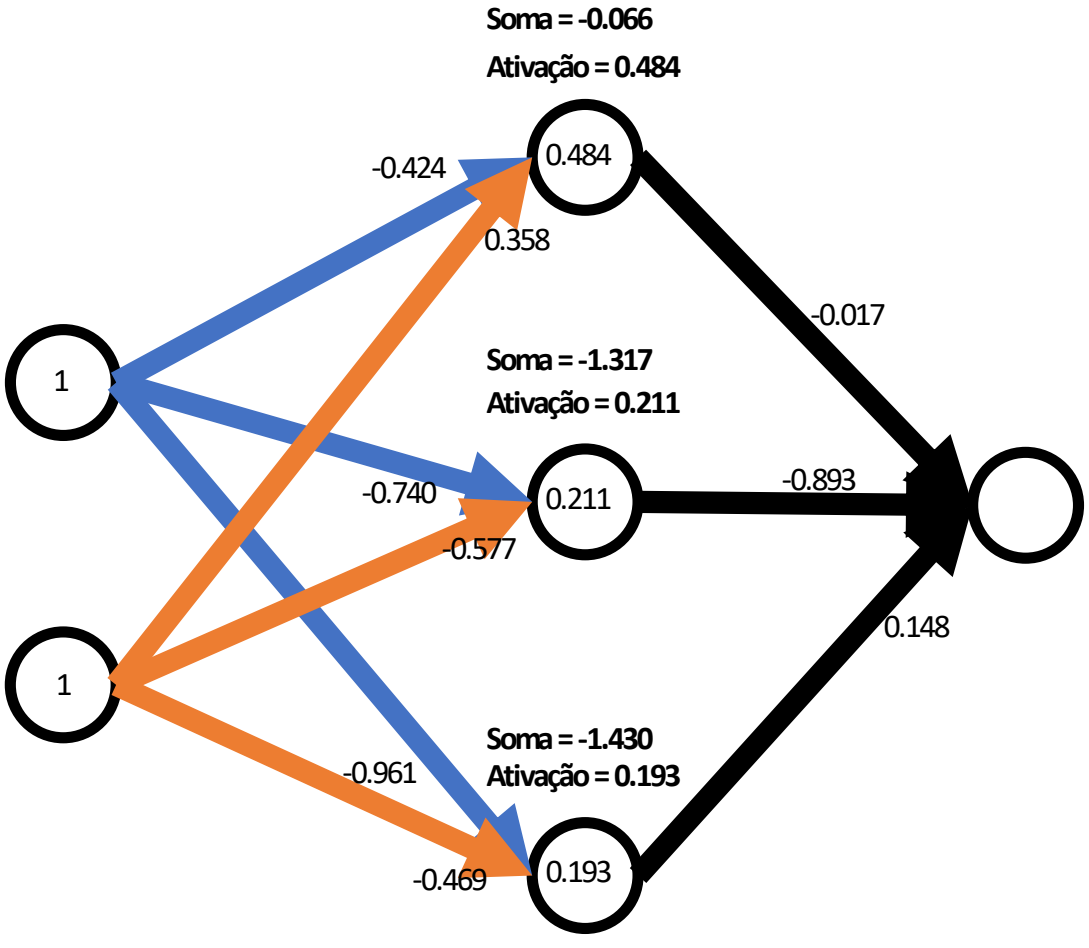


$1 * (-0.424) + 0 * 0.358 = -0.424$

$1 * (-0.740) + 0 * (-0.577) = -0.740$

$1 * (-0.961) + 0 * (-0.469) = -0.961$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0



$1 * (-0.424) + 1 * 0.358 = -0.066$

$1 * (-0.740) + 1 * (-0.577) = -1.317$

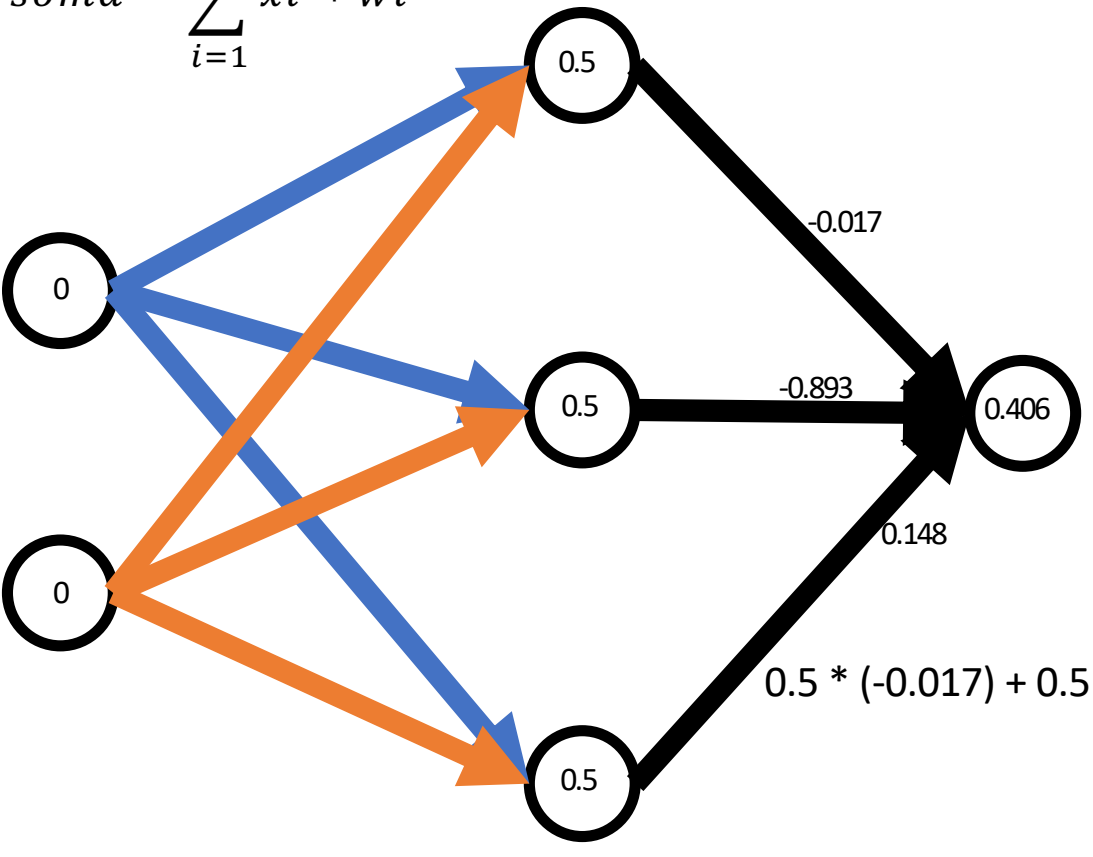
$1 * (-0.961) + 1 * (-0.469) = -1.430$

Cálculos camada oculta para camada de saída

$$soma = \sum_{i=1}^{n} xi * wi$$

$$y = \frac{1}{1 + e^{-x}}$$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0

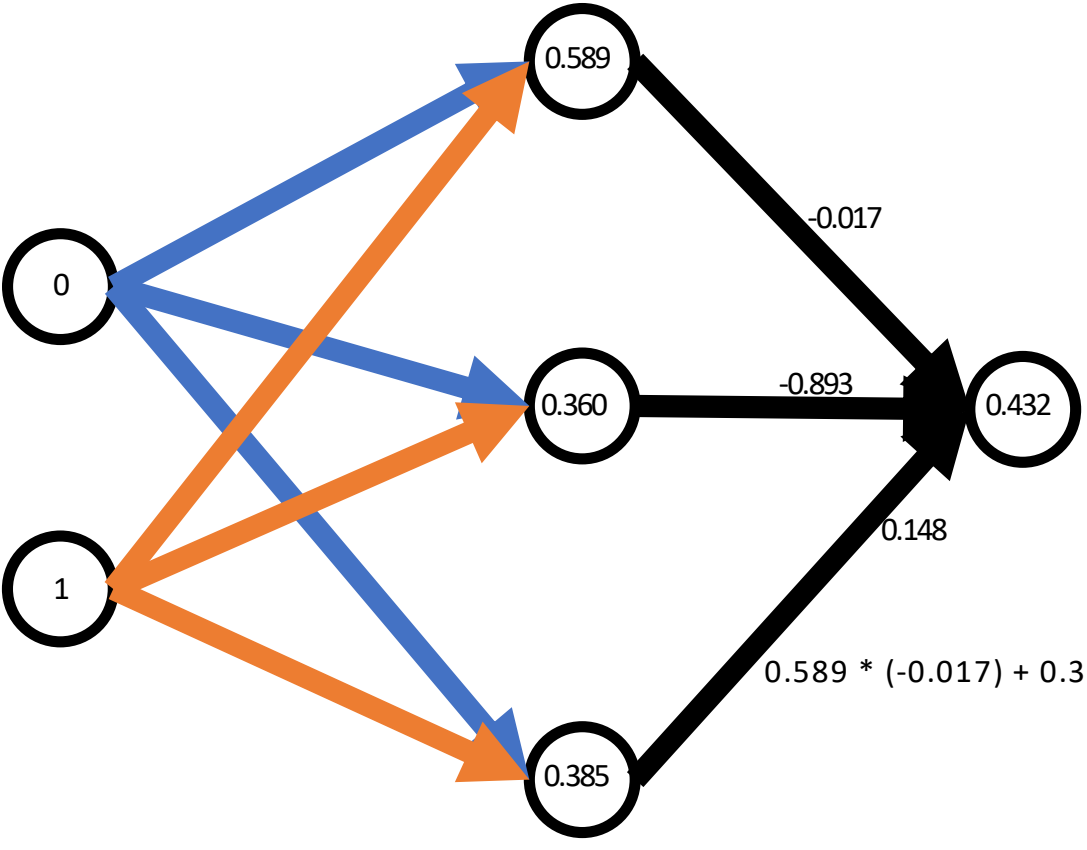


Soma = -0.381

Ativação = 0.406

0.5 * (-0.017) + 0.5 * (-0.893) + 0.5 * 0.148 = -0.381

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0

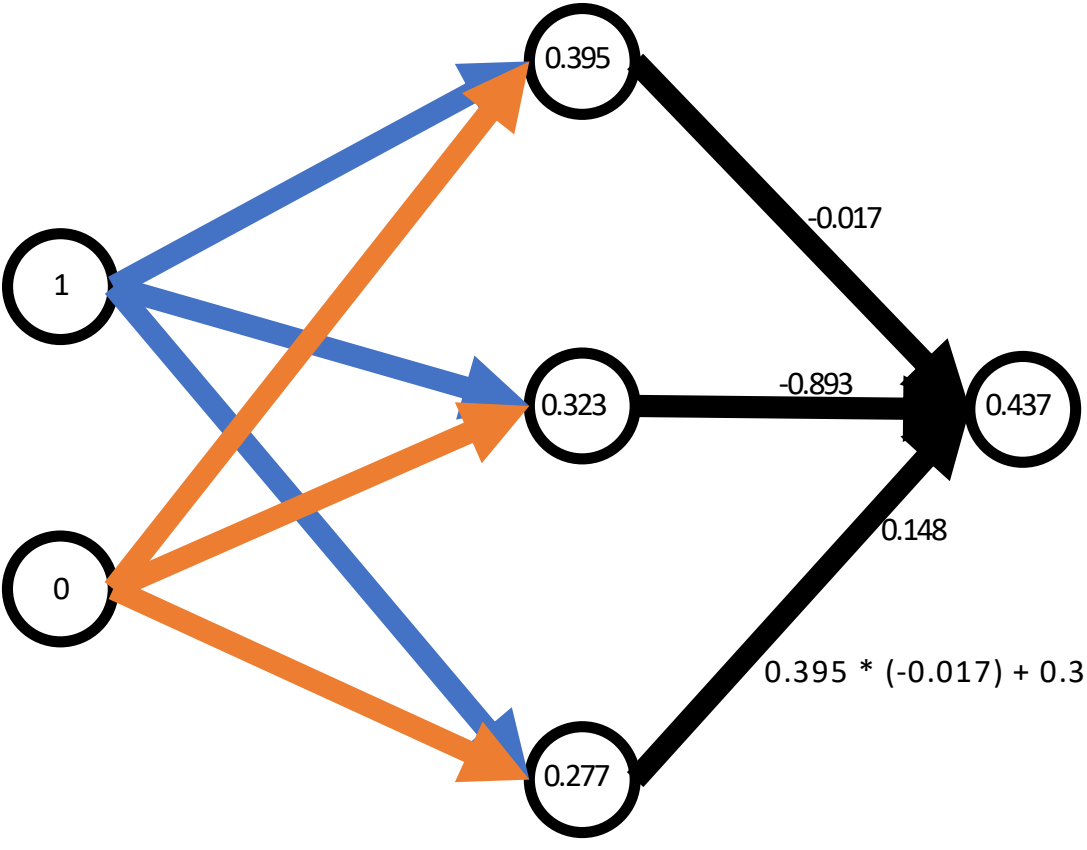


Soma = -0.274

Ativação = 0.432

0.589 * (-0.017) + 0.360 * (-0.893) + 0.385 * 0.148 = -0.274

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0

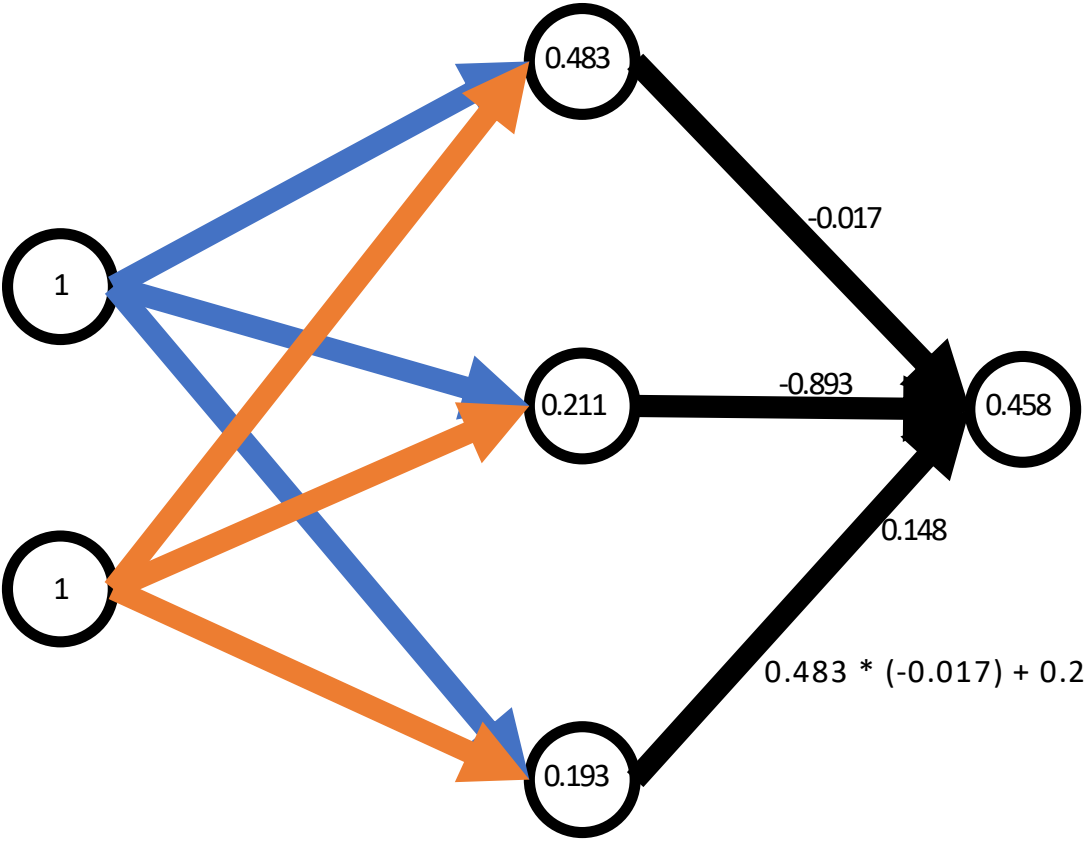


Soma = -0.254

Ativação = 0.437

0.395 * (-0.017) + 0.323 * (-0.893) + 0.277 * 0.148 = -0.254

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0



Soma = -0.168

Ativação = 0.458

0.483 * (-0.017) + 0.211 * (-0.893) + 0.193 * 0.148 = -0.168

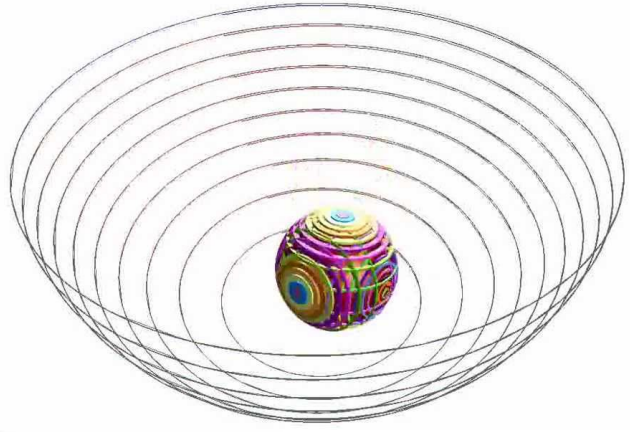
Erro

- Algoritmo mais simples
  - erro = respostaCorreta – respostaCalculada

x1	x2	Classe	Calculado	Erro
0	0	0	0.406	-0.406
0	1	1	0.432	0.568
1	0	1	0.437	0.563
1	1	0	0.458	-0.458

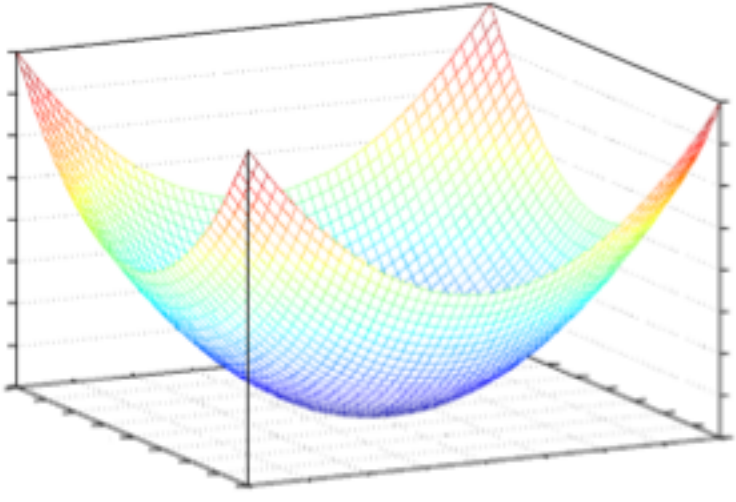
Média absoluta = 0.49

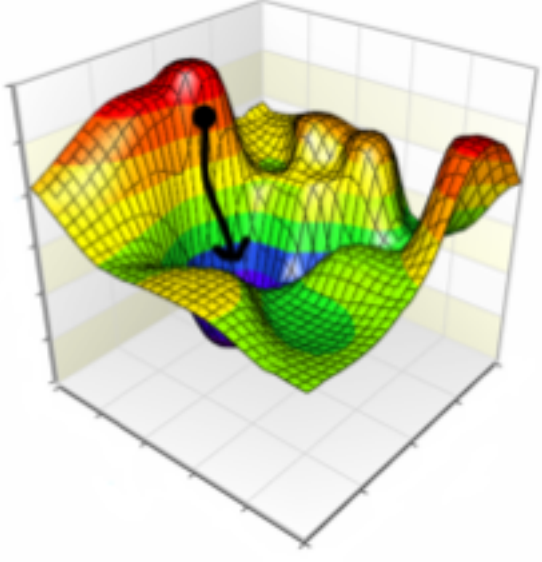
Gradiente



min C(w_1, w_2 ... w_n)

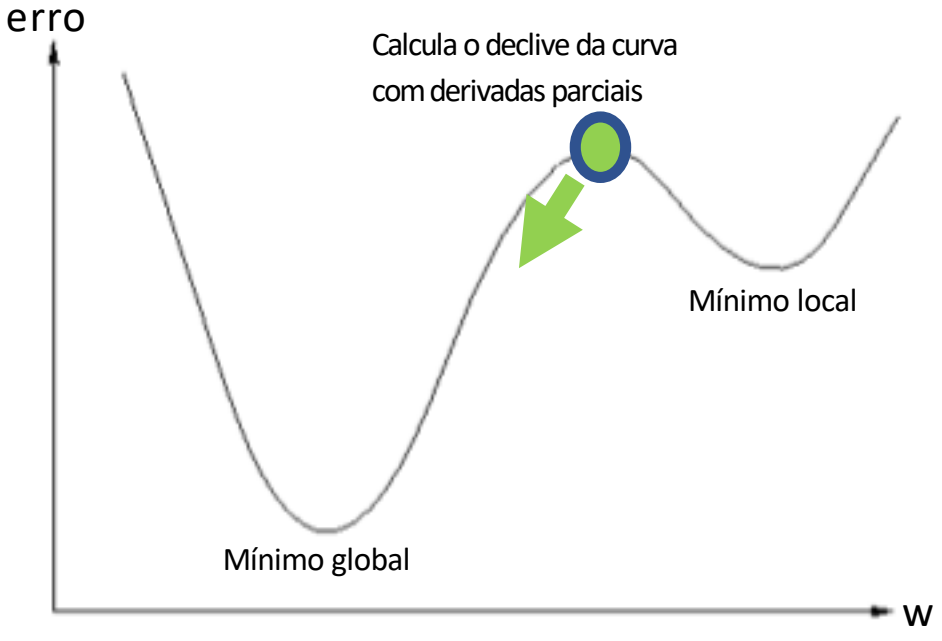
Calcular a derivada parcial para mover para a direção do gradiente





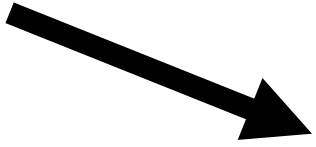
Gradiente

- Encontrar a combinação de pesos que o erro é o menor possível
- Gradiente é calculado para saber quanto ajustar os pesos



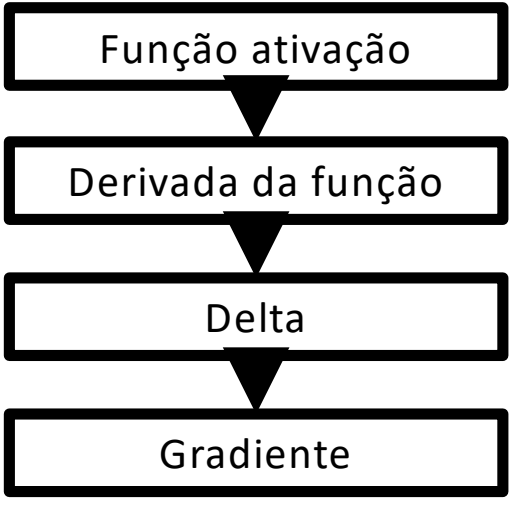
Gradiente (derivada)

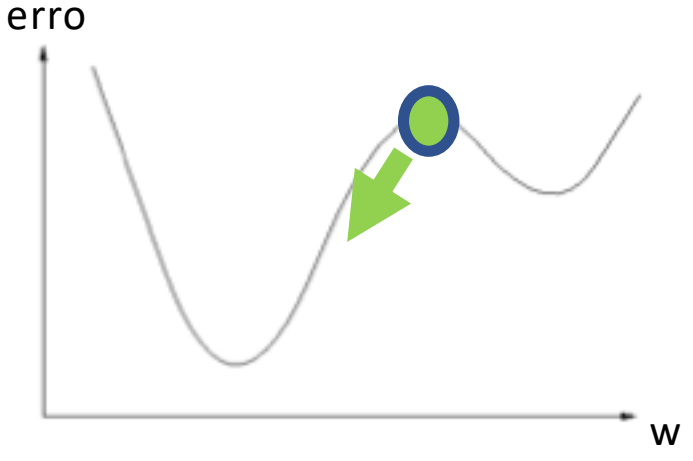
$$y = \frac{1}{1 + e^{-x}}$$



$$d = \mathrm{y} * (1 - \mathrm{y})$$

Cálculo do parâmetro Delta

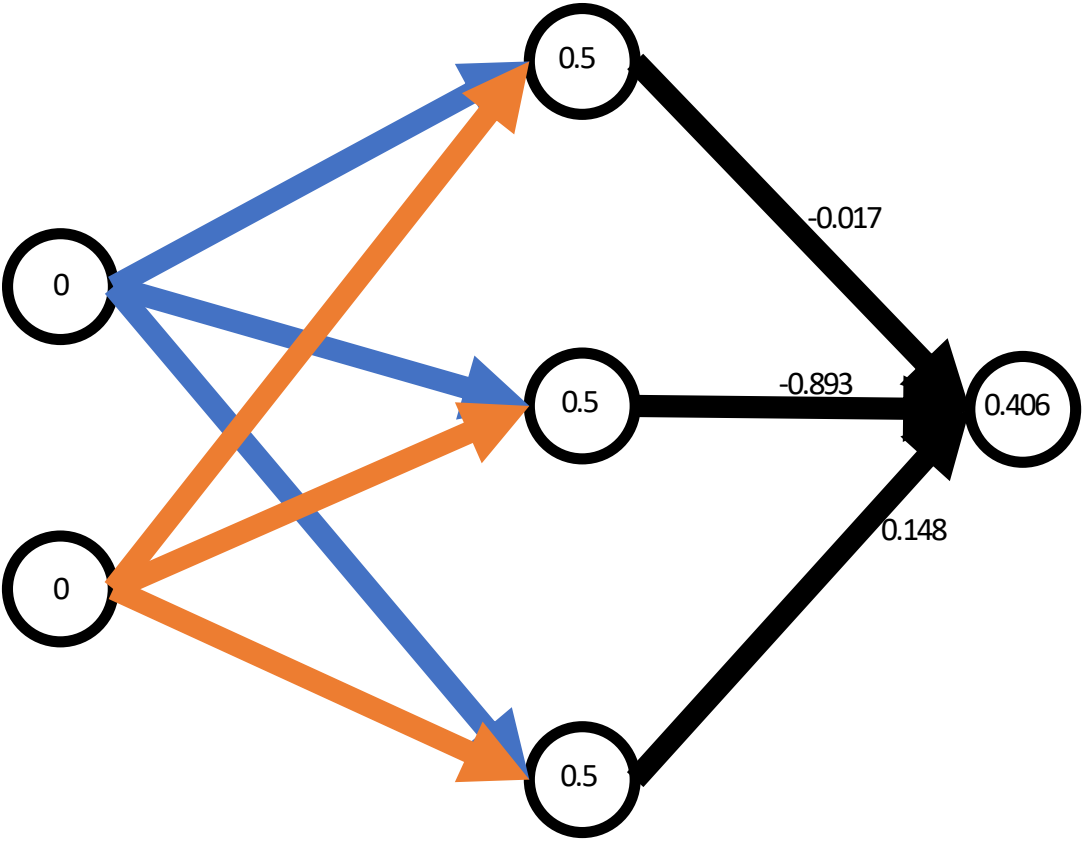




Delta camada saída

$$DeltaSaída = Erro * DerivadaSigmoide$$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0



Soma = -0.381

Ativação = 0.406

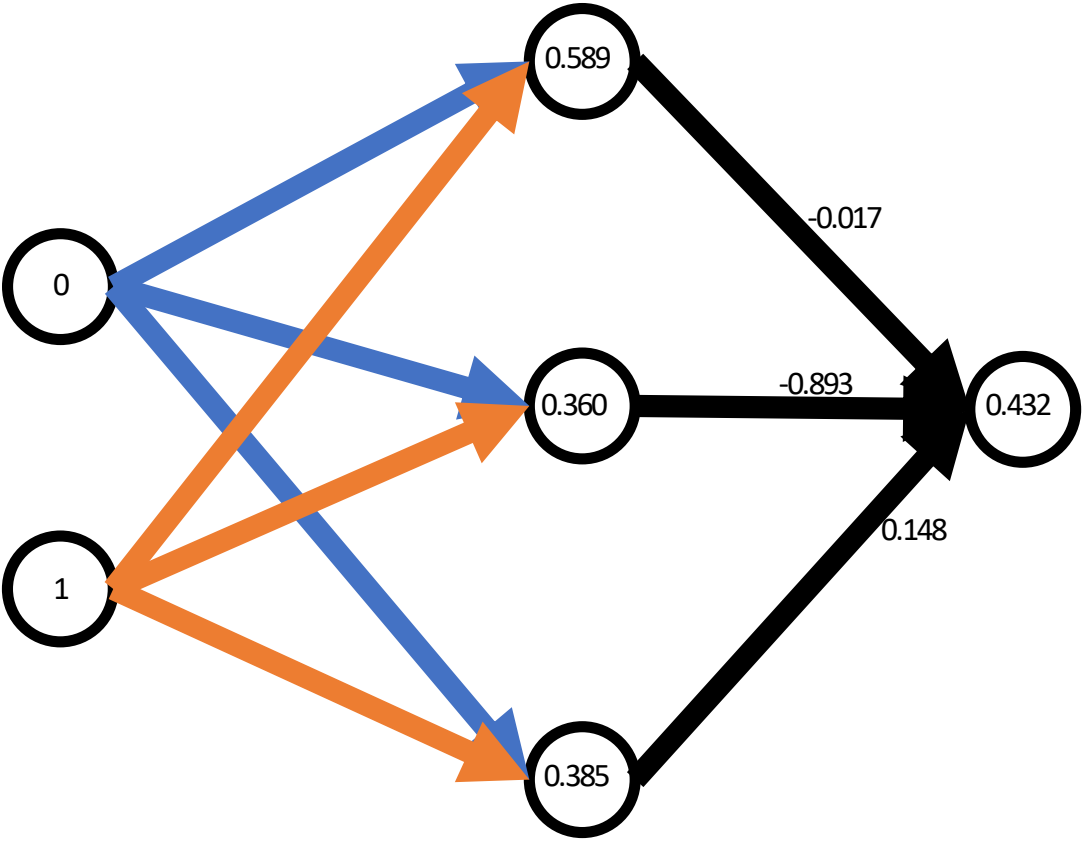
Erro = 0 – 0.406 = -0.406

Derivada ativação (sigmoide) = 0.241

DeltaSaída = -0.406 * 0.241 = -0.098

$$DeltaSaída = Erro * DerivadaSigmoide$$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0



Soma = -0.274

Ativação = 0.432

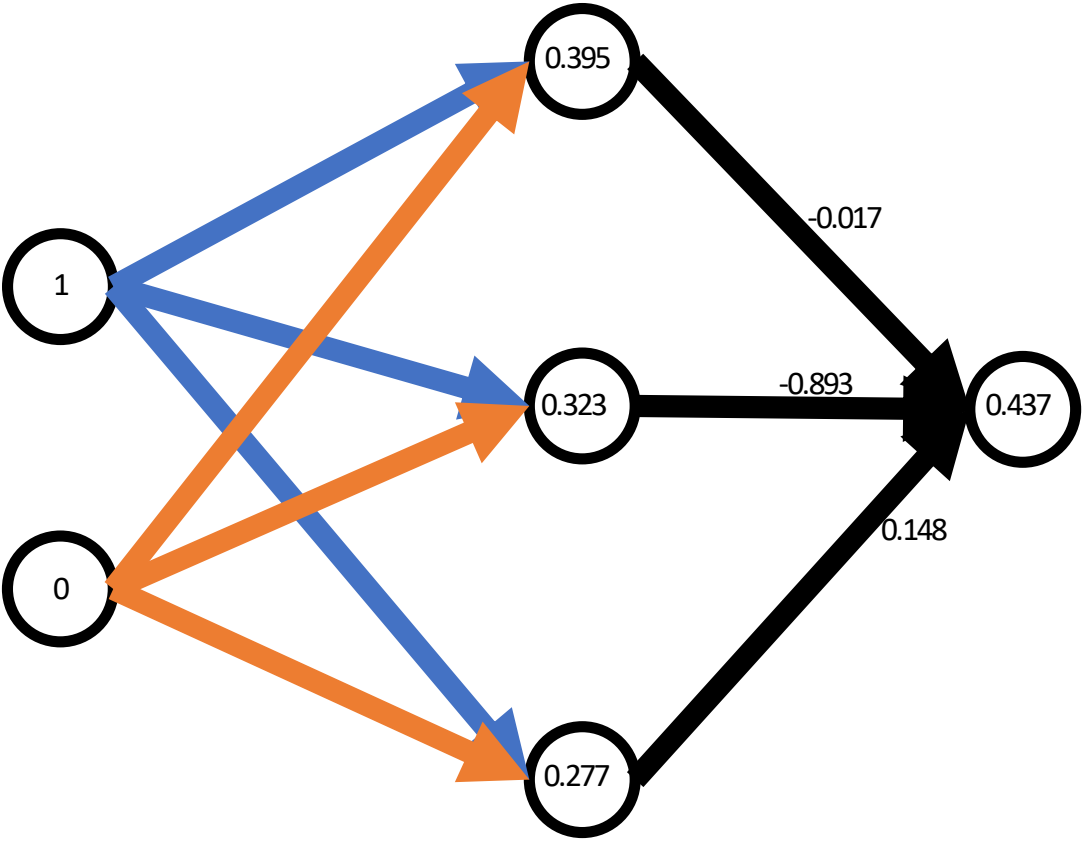
Erro = 1 – 0.432 = 0.568

Derivada ativação (sigmoide) = 0.245

DeltaSaída = 0.568 * 0.245 = 0.139

$$DeltaSaída = Erro * DerivadaSigmoide$$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0



Soma = -0.254

Ativação = 0.437

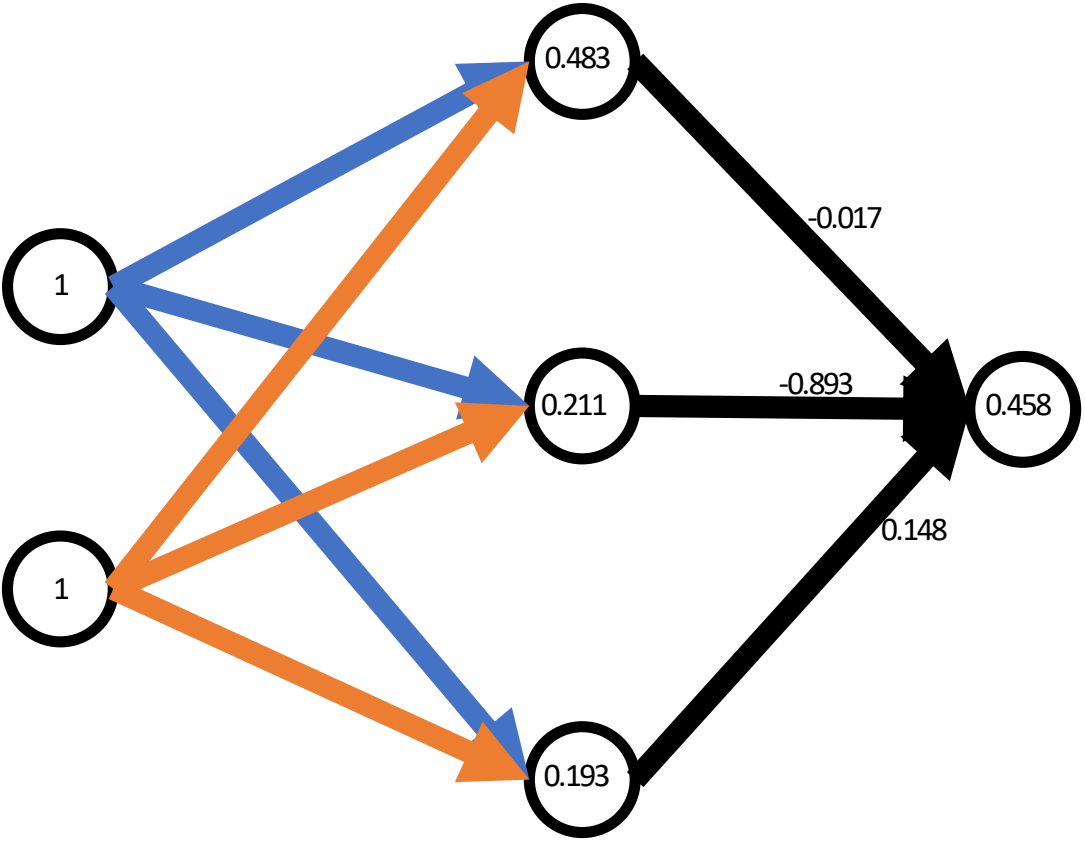
Erro = 1 – 0.437 = 0.563

Derivada ativação (sigmoide) = 0.246

DeltaSaída = 0.563 * 0.246 = 0.139

$$DeltaSaída = Erro * DerivadaSigmoide$$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0



Soma = -0.168

Ativação = 0.458

Erro = 0 – 0.458 = -0.458

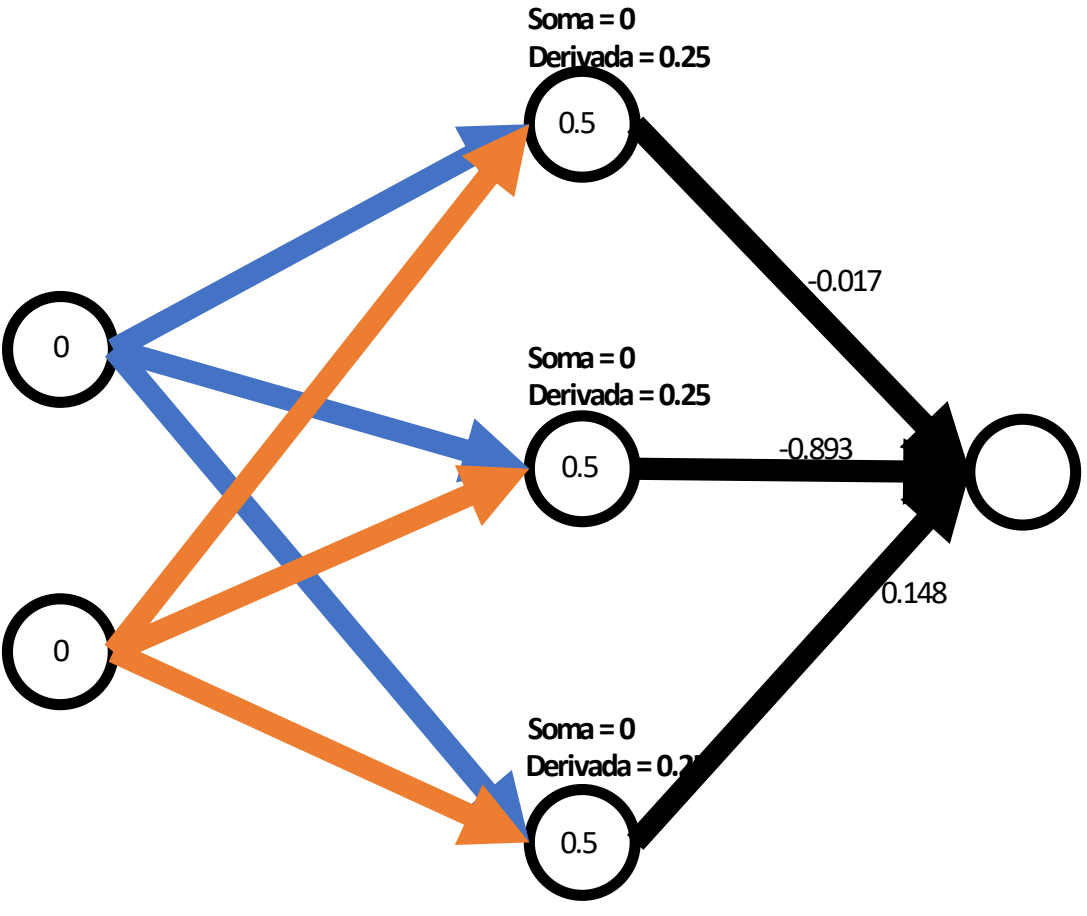
Derivada ativação (sigmoide) = 0.248

DeltaSaída = -0.458 * 0.248 = -0.114

Delta camada escondida

$$DeltaEscondida = DerivadaSigmoide * peso * DeltaSaída$$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0



DeltaSaída = -0.098

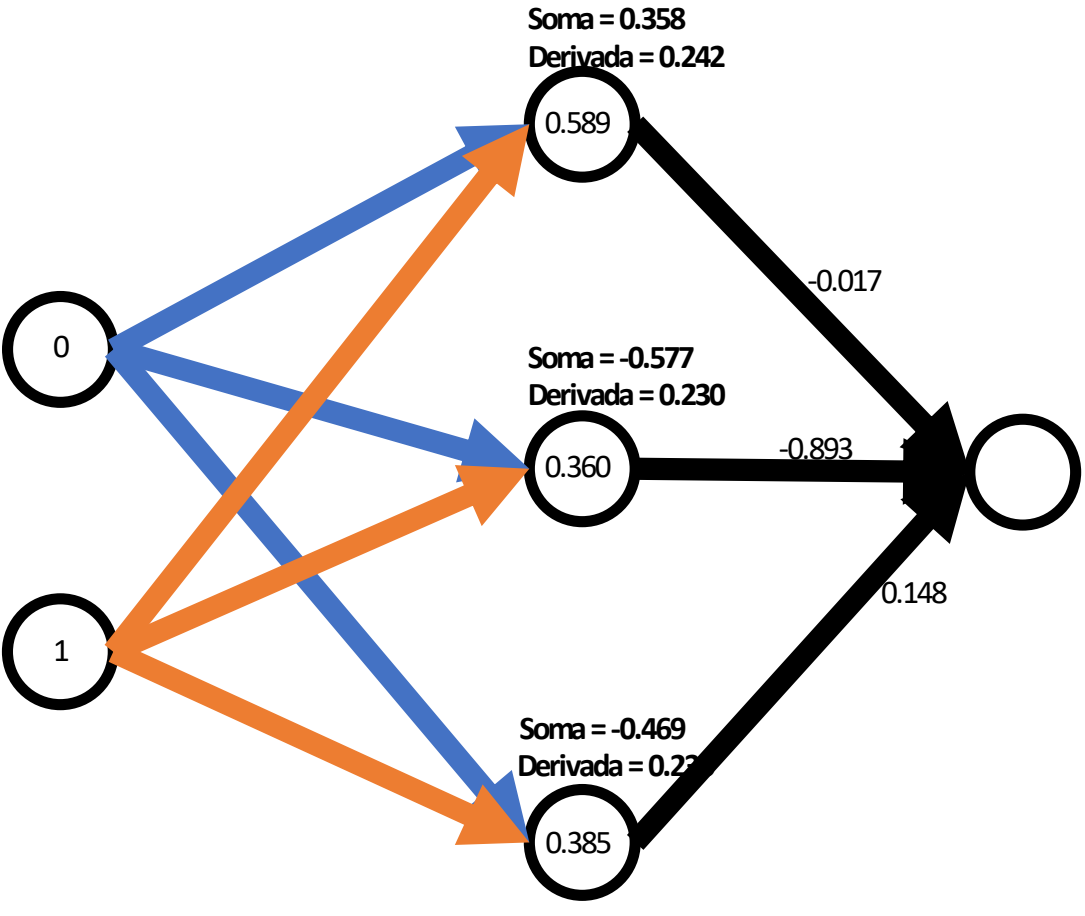
0.25 * (-0.017) * (-0.098) = 0.000

0.25 * (-0.893) * (-0.098) = 0.022

0.25 * 0.148 * (-0.098) = -0.004

$$DeltaEscondida = DerivadaSigmoide * peso * DeltaSaída$$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0



DeltaSaída = 0.139

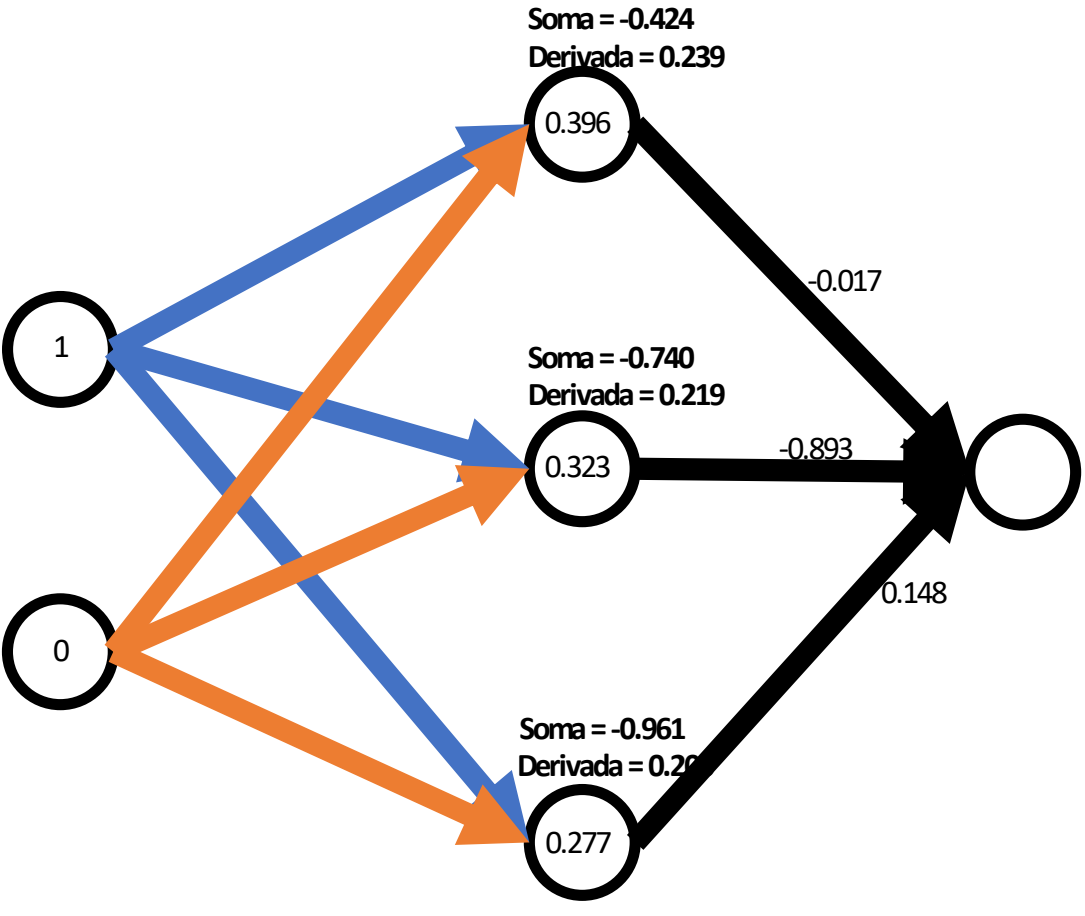
0.242 * (-0.017) * 0.139 = -0.001

0.230 * (-0.893) * 0.139 = -0.029

0.236 * 0.148 * 0.139 = 0.005

$$DeltaEscondida = DerivadaSigmoide * peso * DeltaSaída$$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0



DeltaSaída = 0.139

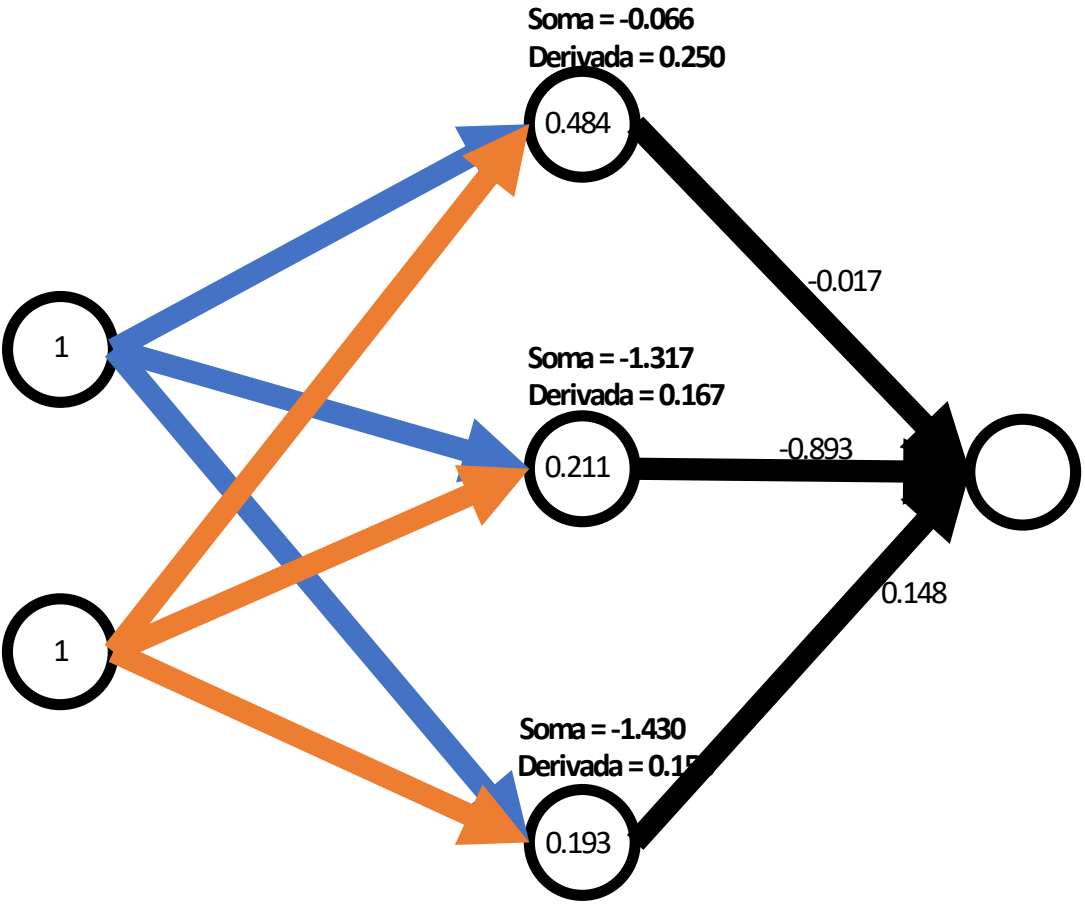
0.239 * (-0.017) * 0.139 = -0.001

0.219 * (-0.893) * 0.139 = -0.027

0.200 * 0.148 * 0.139 = 0.004

$$DeltaEscondida = DerivadaSigmoide * peso * DeltaSaída$$

x1	x2	Classe
0	0	0
0	1	1
1	0	1
1	1	0

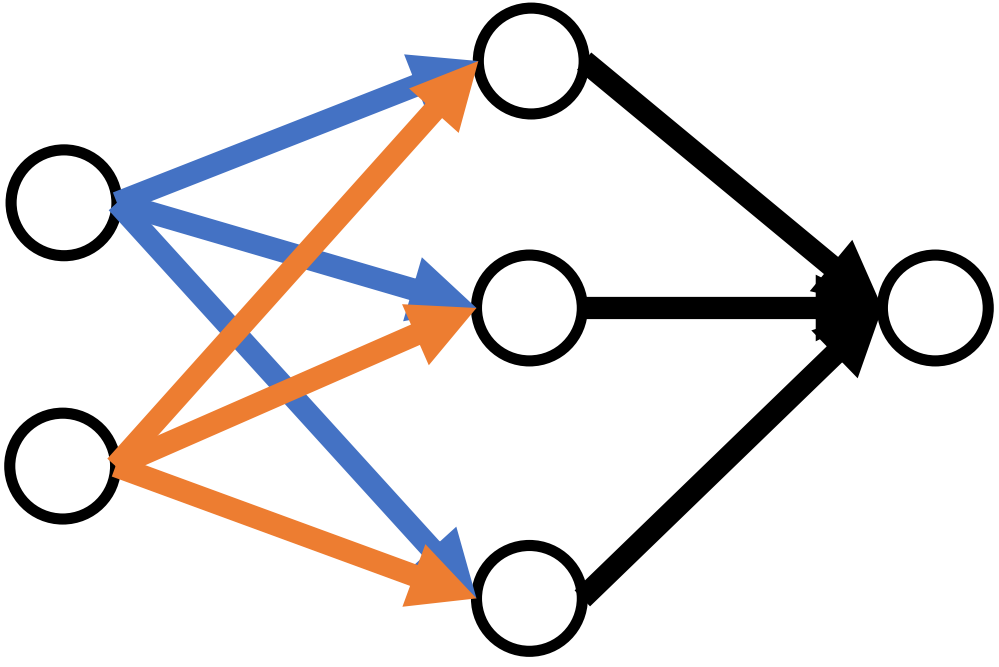


DeltaSaída = -0.114

0.250 * (-0.017) * (-0.114) = 0.000

0.167 * (-0.893) * (-0.114) = 0.017

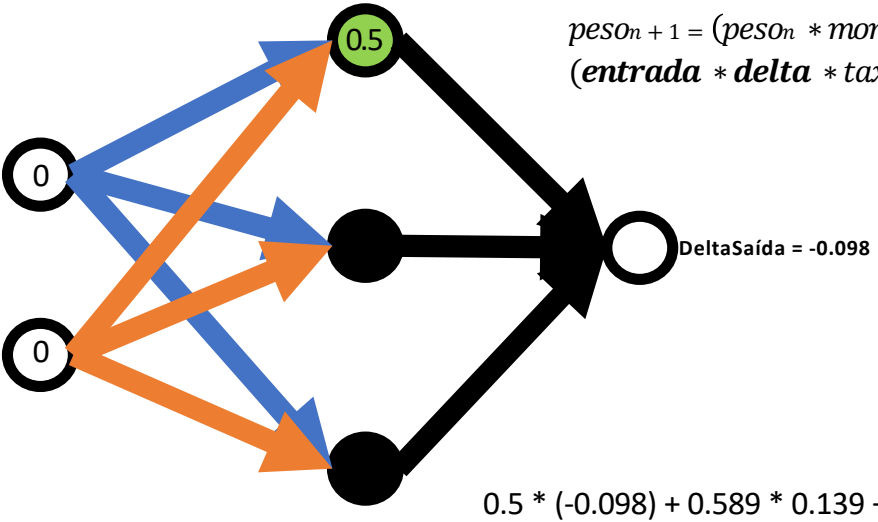
0.156 * 0.148 * (-0.114) = -0.003

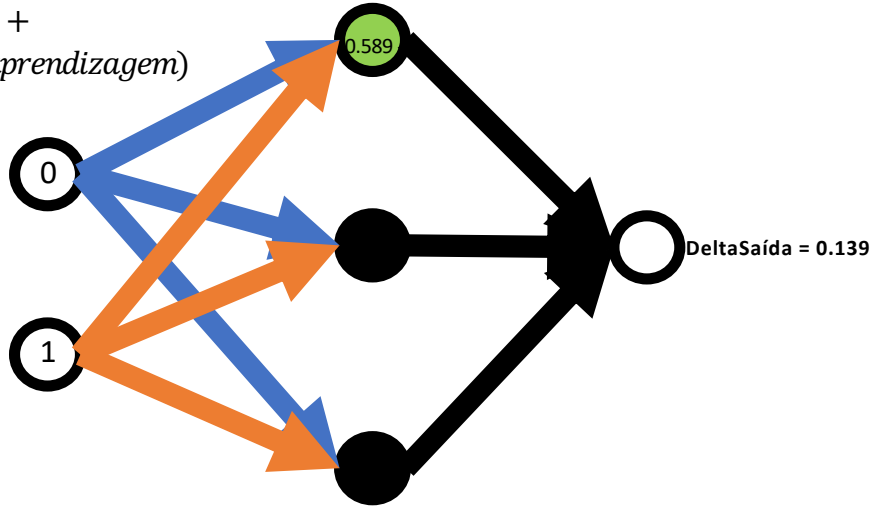


$$peso_n + 1 = (peso_n * momento) + (entrada * delta * taxa\ de\ aprendizagem)$$

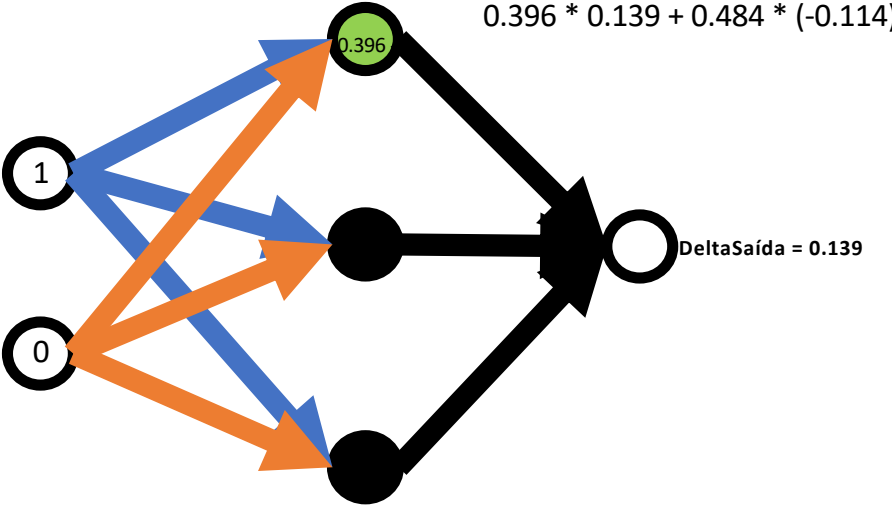
Ajuste dos pesos da camada oculta para a camada de saída

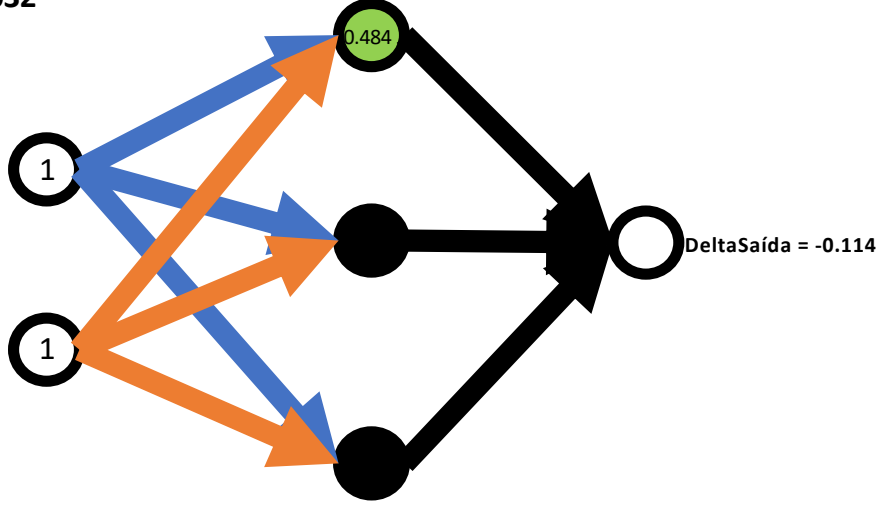
$$peso_{n+1} = (peso_n * momento) + (\boldsymbol{entrada} * \boldsymbol{delta} * taxa\ de\ aprendizagem)$$



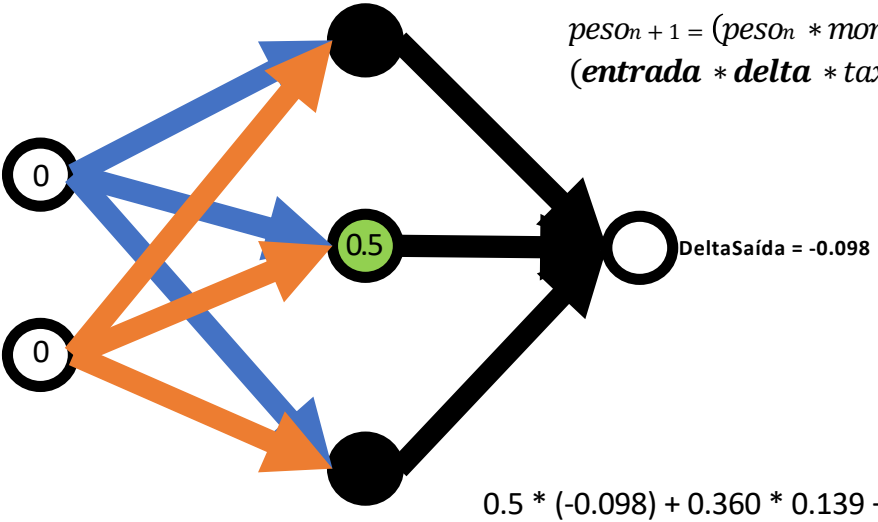


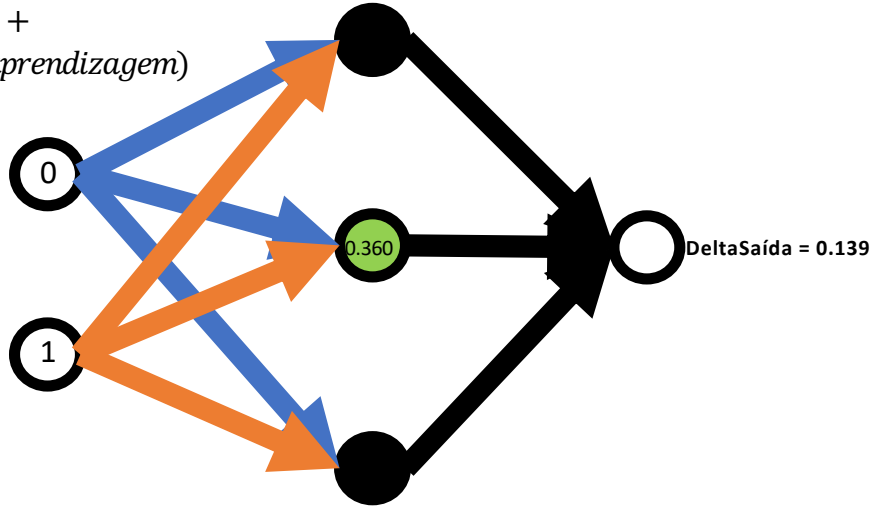
0.5 * (-0.098) + 0.589 * 0.139 +
0.396 * 0.139 + 0.484 * (-0.114) = **0.032**



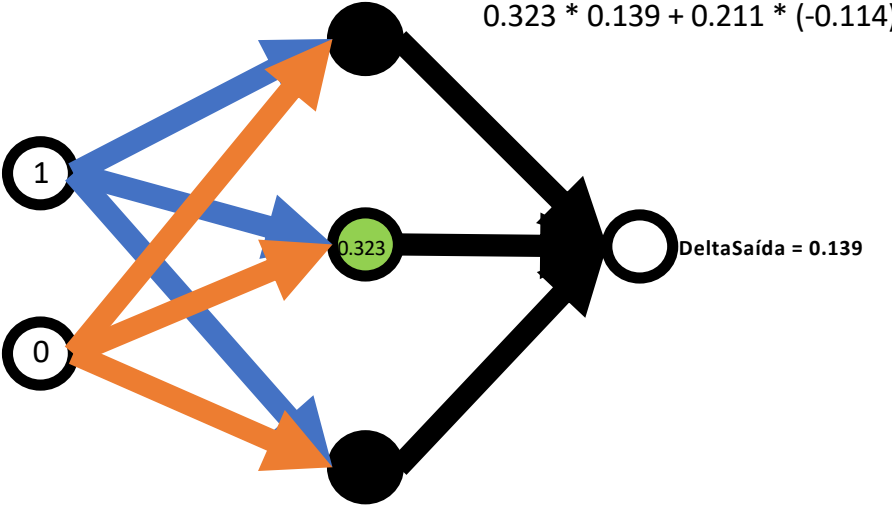


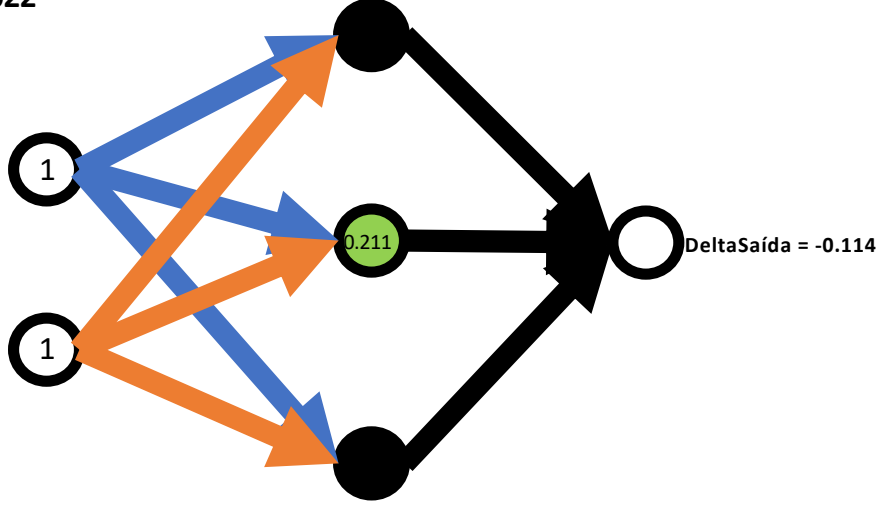
$$peso_{n+1} = (peso_n * momento) + (\boldsymbol{entrada} * \boldsymbol{delta} * taxa\ de\ aprendizagem)$$



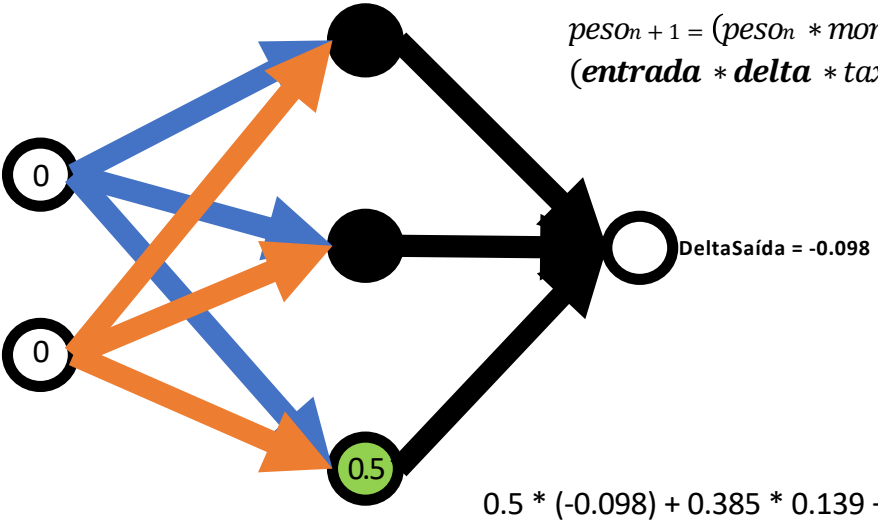


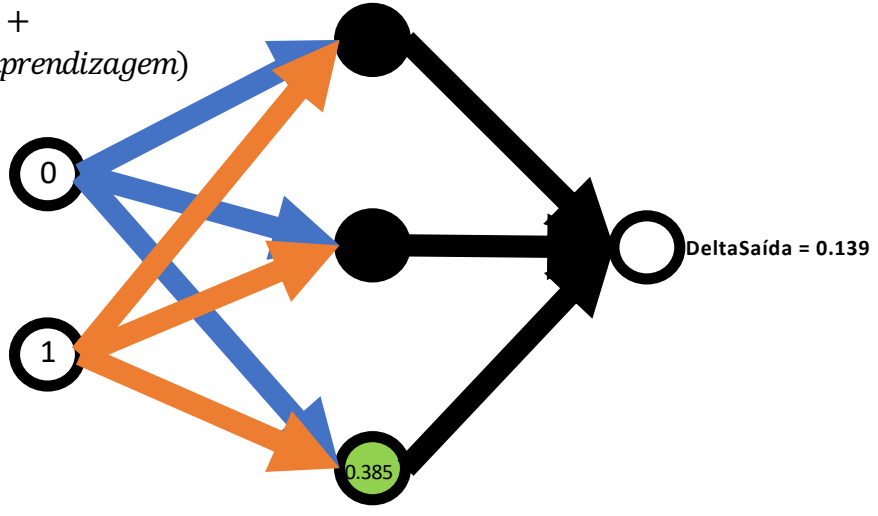
0.5 * (-0.098) + 0.360 * 0.139 +
0.323 * 0.139 + 0.211 * (-0.114) = **0.022**



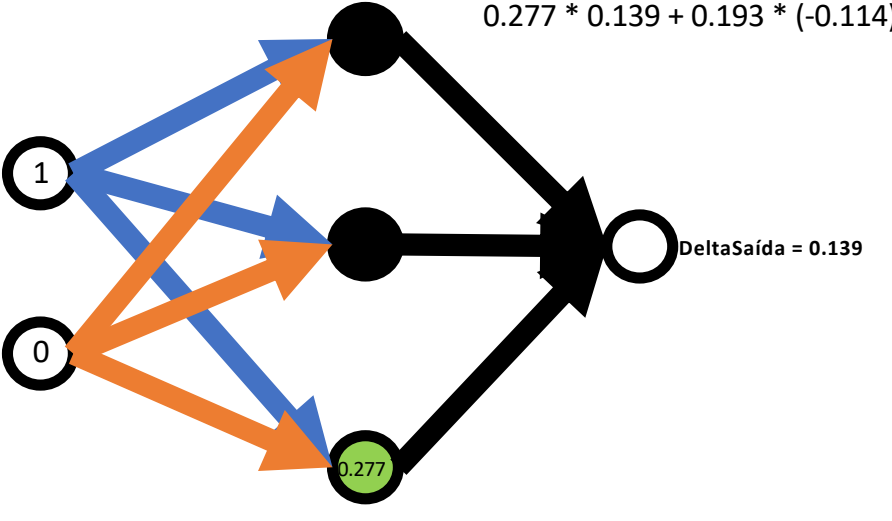


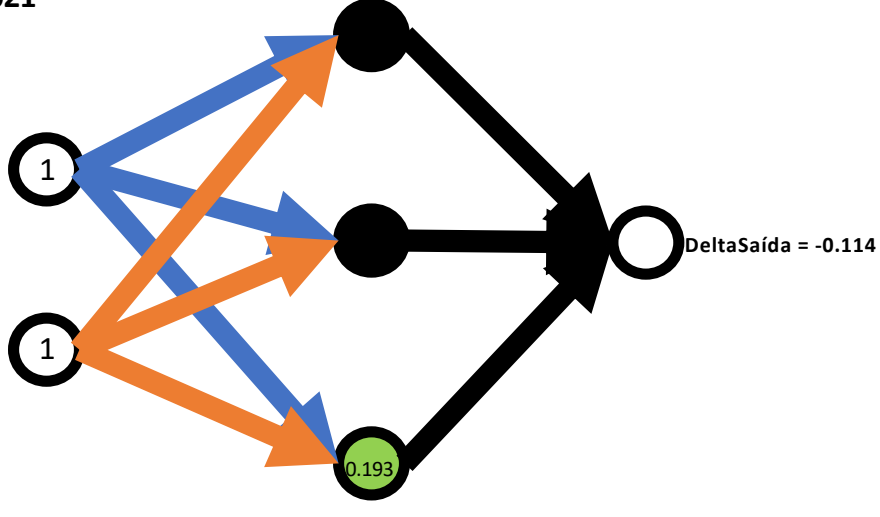
$$peso_{n+1} = (peso_n * momento) + (\boldsymbol{entrada} * \boldsymbol{delta} * taxa\ de\ aprendizagem)$$





0.5 * (-0.098) + 0.385 * 0.139 +
0.277 * 0.139 + 0.193 * (-0.114) = **0.021**





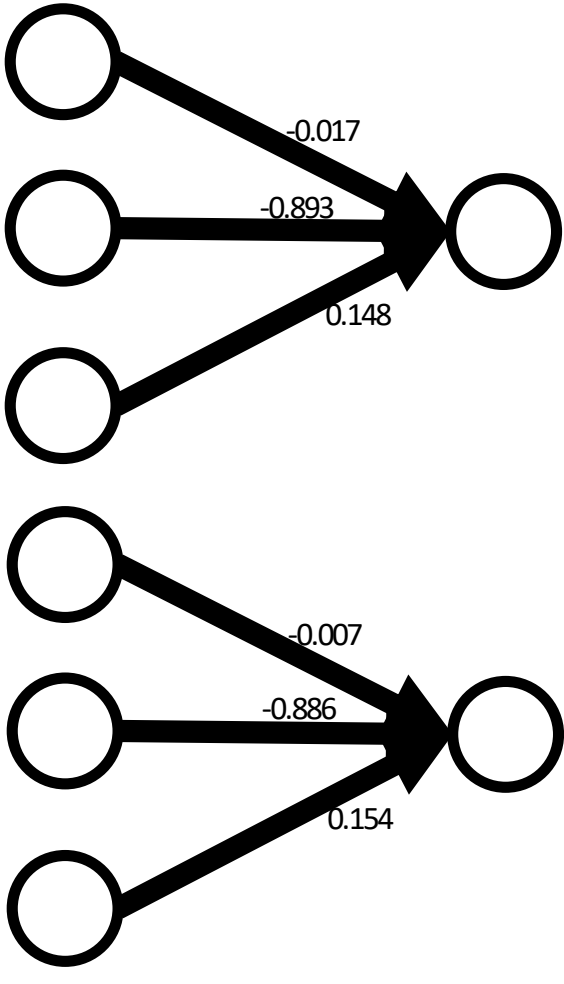
Taxa de aprendizagem = 0.3
Momento = 1
Entrada x delta
0.032
0.022
0.021

$$Peso_{n+1} = (peso_n * momento) + (entrada * delta * taxa\ de\ aprendizagem)$$

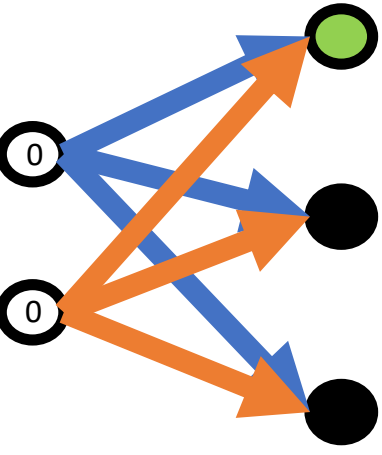
(-0.017 * 1) + 0.032 * 0.3 = **-0.007**

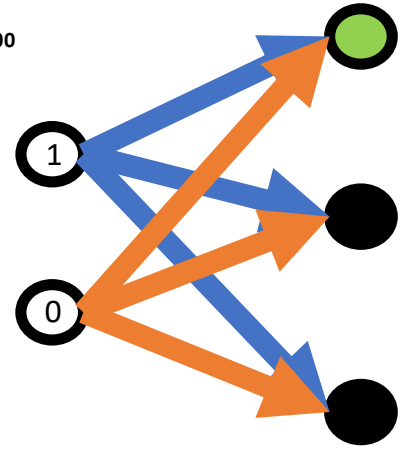
(-0.893 * 1) + 0.022 * 0.3 = **-0.886**

(0.148 * 1) + 0.021 * 0.3 = **0.154**

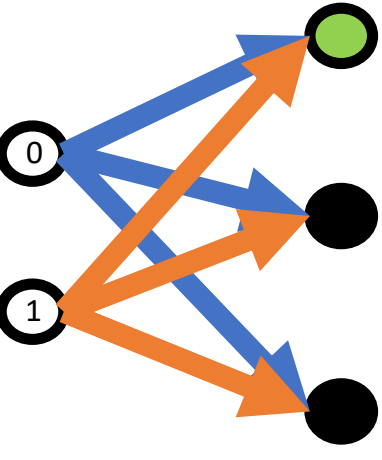


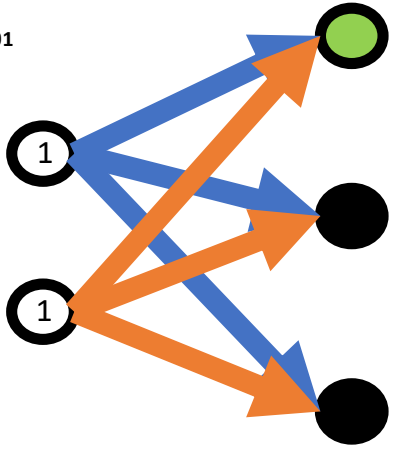
Ajuste dos pesos da camada de entrada para a camada oculta





$$peso_{n+1} = (peso_n * momento) + (\boldsymbol{entrada} * \boldsymbol{delta} * taxa\ de\ aprendizagem)$$

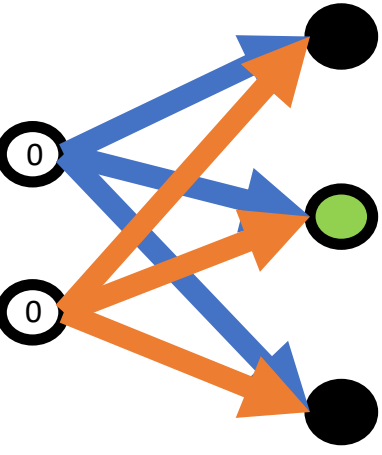




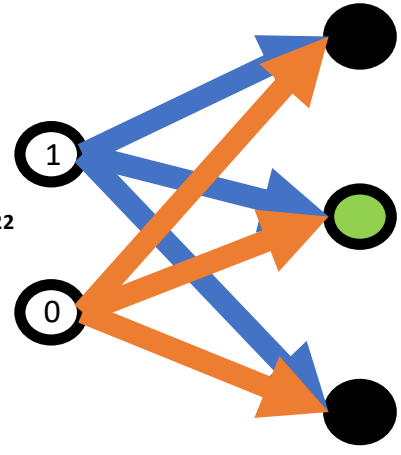
0 * 0.000 + 0 * (-0.001) + 1 * (-0.001) + 1 * 0.000 = -0.000

0 * 0.000 + 1 * (-0.001) + 0 * (-0.001) + 1 * 0.000 = -0.000

Arredondado!

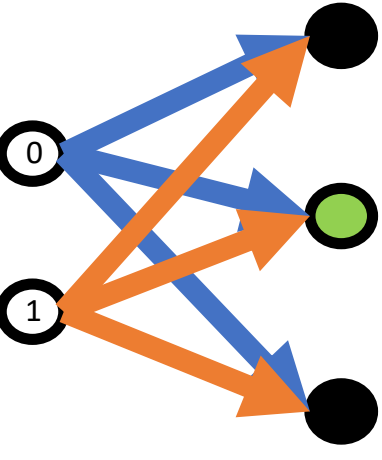


Delta = 0.022

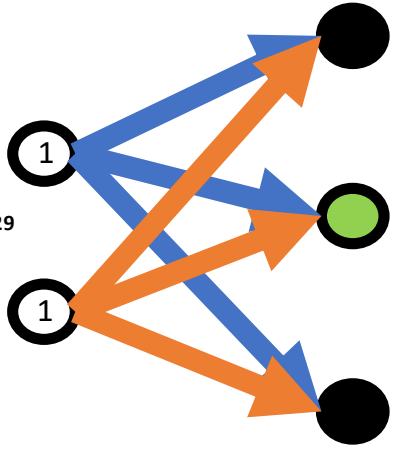


Delta = -0.027

$$peso_{n+1} = (peso_n * momento) + (\boldsymbol{entrada} * \boldsymbol{delta} * taxa\ de\ aprendizagem)$$



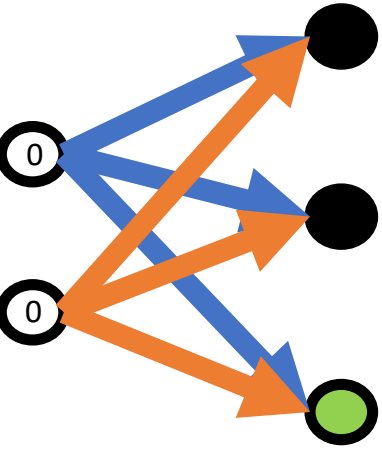
Delta = -0.029



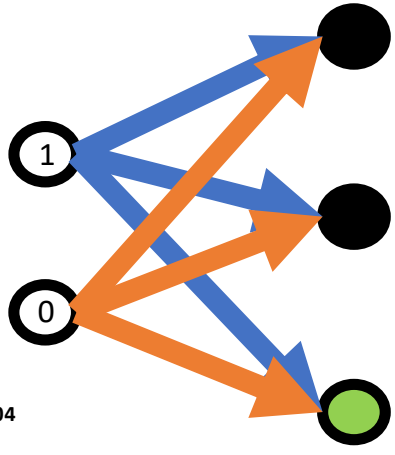
Delta = 0.017

0 * 0.022 + 0 * (-0.029) + 1 * (-0.027) + 1 * 0.017 = -0.010

0 * 0.022 + 1 * (-0.029) + 0 * (-0.027) + 1 * 0.017 = -0.012

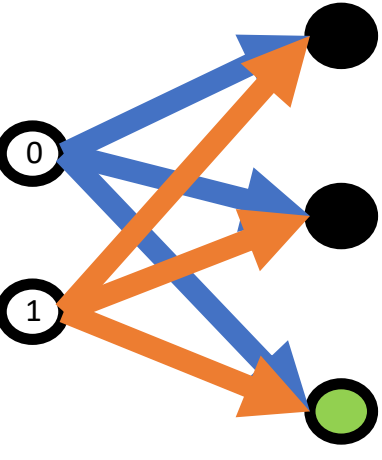


Delta = -0.004

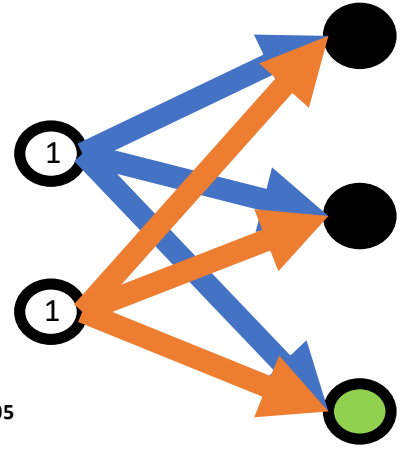


Delta = 0.004

$$peso_{n+1} = (peso_n * momento) + (\boldsymbol{entrada} * \boldsymbol{delta} * taxa\ de\ aprendizagem)$$



Delta = 0.005



Delta = -0.003

0 * (-0.004) + 0 * 0.005 + 1 * 0.004 + 1 * (-0.003) = 0.001

0 * (-0.004) + 1 * 0.005 + 0 * 0.004 + 1 * (-0.003) = 0.002

Taxa de aprendizagem = 0.3

Momento = 1

Entrada x delta

-0.000 -0.010 0.001

-0.000 -0.012 0.002

$$Peso_{n+1} = (peso_n * momento) + (entrada * delta * taxa\ de\ aprendizagem)$$

(-0.424 * 1) + (-0.000) * 0.3 = **-0.424**

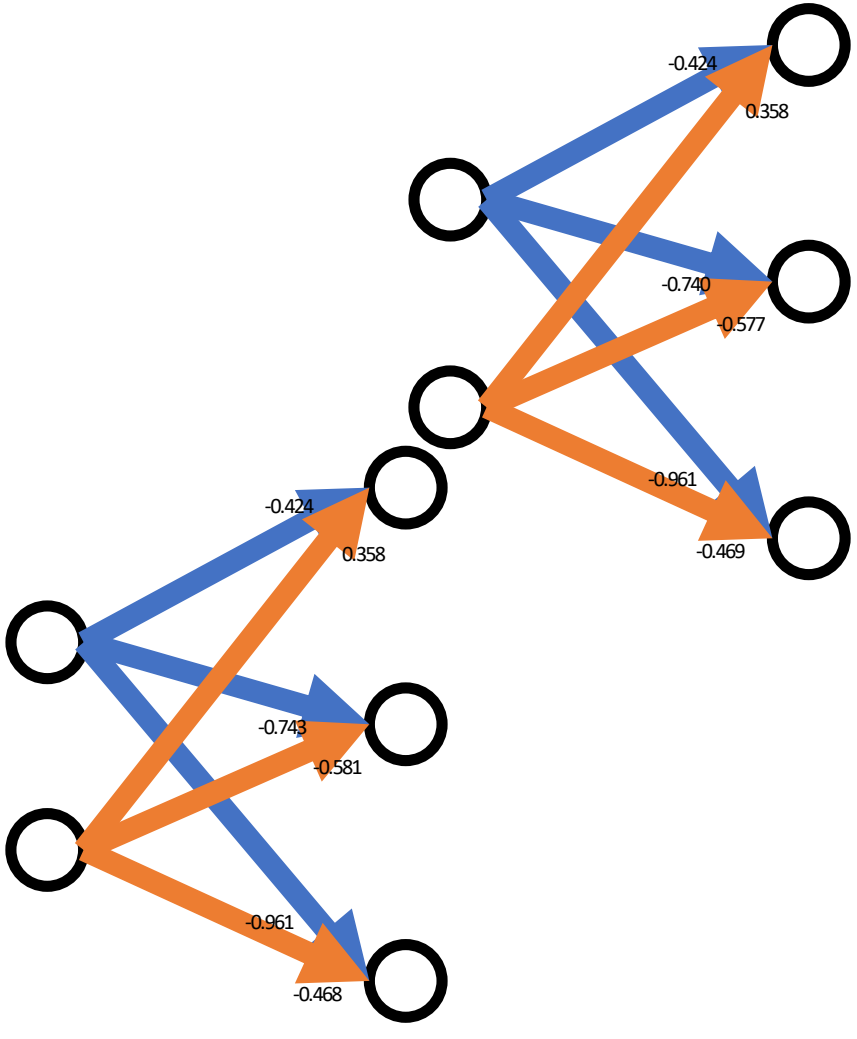
(0.358 * 1) + (-0.000) * 0.3 = **0.358**

(-0.740 * 1) + (-0.010) * 0.3 = **-0.743**

(-0.577 * 1) + (-0.012) * 0.3 = **-0.581**

(-0.961 * 1) + 0.001 * 0.3 = **-0.961**

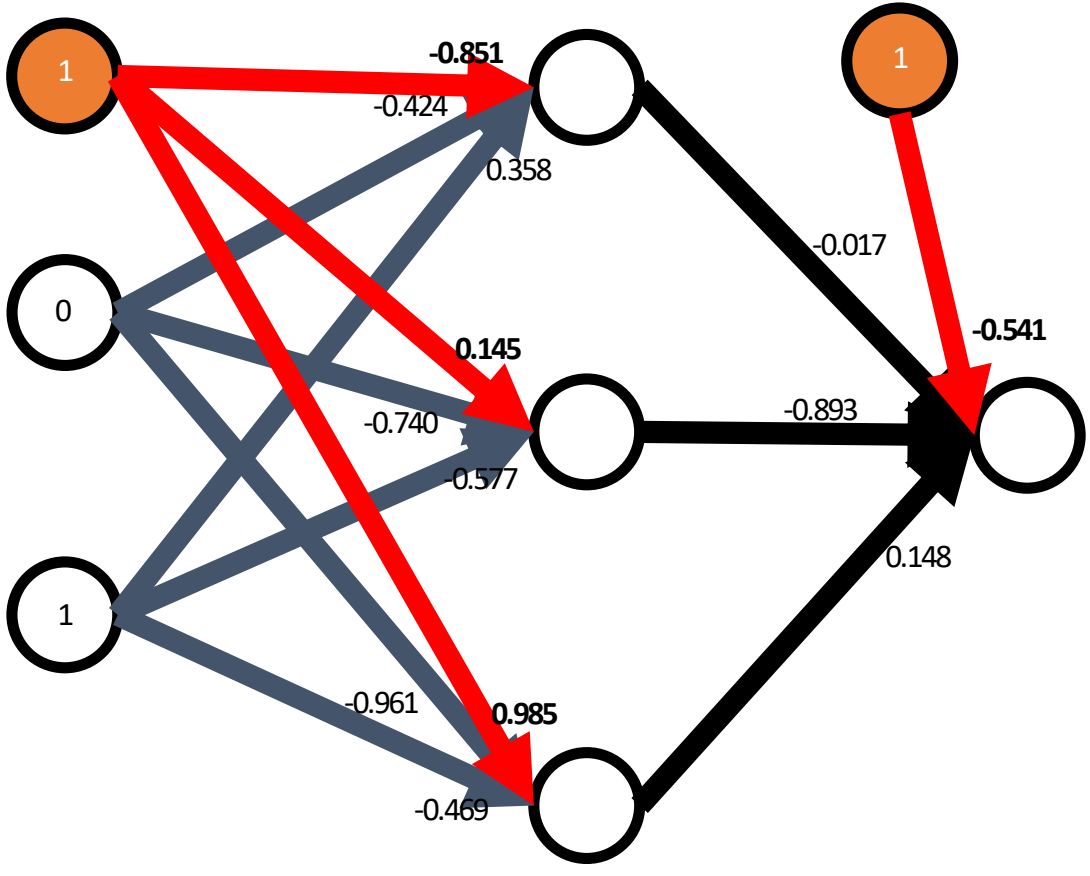
(-0.469 * 1) + 0.002 * 0.3 = **-0.468**



Bias

Valores diferentes mesmo se todas as entradas forem zero

Muda a saída com a unidade de bias



Erro

- Algoritmo mais simples
  - erro = respostaCorreta – respostaCalculada

x1	x2	Classe	Calculado	Erro
0	0	0	0.406	-0.406
0	1	1	0.432	0.568
1	0	1	0.437	0.563
1	1	0	0.458	-0.458

Mean square error (MSE) e Root mean square error (RMSE)

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(f_i - y_i)^2$$

$$\text{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(f_i - o_i)^2}$$

x1	x2	Classe	Calculado	Erro
0	0	0	0.406	$(0 - 0.406)^2 = 0.164$
0	1	1	0.432	$(1 - 0.432)^2 = 0.322$
1	0	1	0.437	$(1 - 0.437)^2 = 0.316$
1	1	0	0.458	$(0 - 0.458)^2 = 0.209$

Soma = 1.011

MSE = 1.011 / 4 = 0.252

RMSE = 0.501

História do crédito	Dívida	Garantias	Renda anual	Risco
3	1	1	1	100
2	1	1	2	100
2	2	1	2	010
2	2	1	3	100
2	2	1	3	001
2	2	2	3	001
3	2	1	1	100
3	2	2	3	010
1	2	1	3	001
1	1	2	3	001
1	1	1	1	100
1	1	1	2	010
1	1	1	3	001
3	1	1	2	100

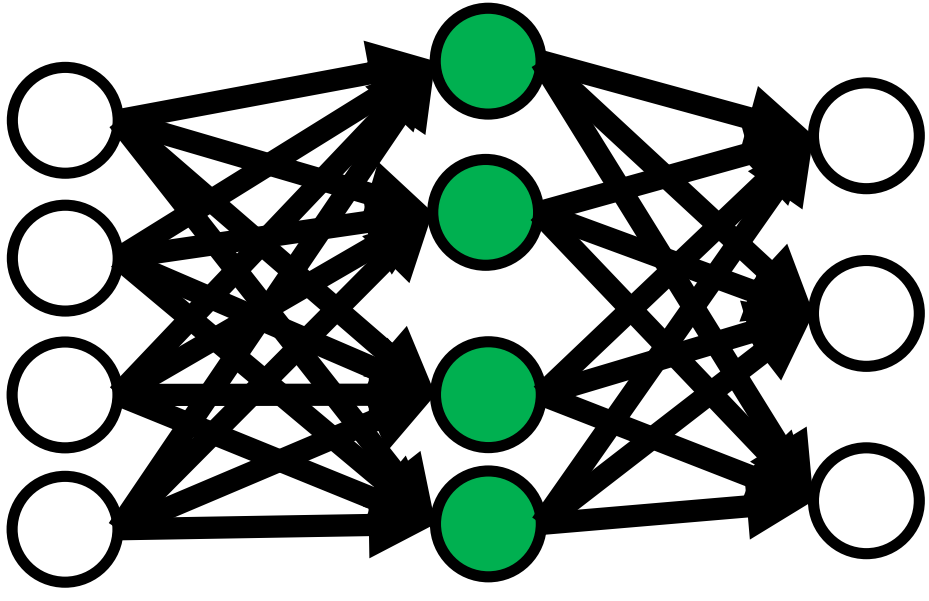
Calcula o erro para todos os registros e atualiza os pesos

Batch gradient descent

História do crédito	Dívida	Garantias	Renda anual	Risco
3	1	1	1	100
2	1	1	2	100
2	2	1	2	010
2	2	1	3	100
2	2	1	3	001
2	2	2	3	001
3	2	1	1	100
3	2	2	3	010
1	2	1	3	001
1	1	2	3	001
1	1	1	1	100
1	1	1	2	010
1	1	1	3	001
3	1	1	2	100

Calcula o erro para cada registro e atualiza os pesos

Stochastic gradient descent



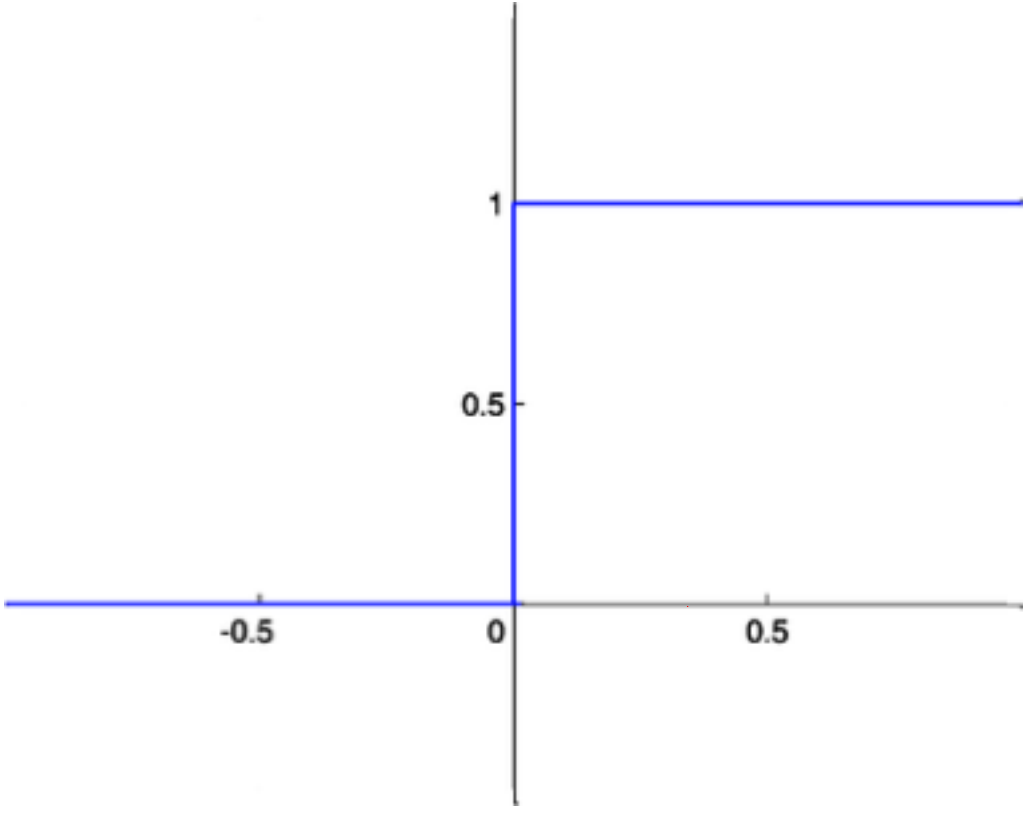
Gradient descent

- Stochastic
  - Ajuda a prevenir mínimos locais (superfícies não convexas)
  - Mais rápido (não precisa carregar todos os dados em memória)
- Mini batch gradient descent
  - Escolhe um número de registros para rodar e atualizar os pesos

Parâmetros

- Learning rate (taxa de aprendizagem)
- Batch size (tamanho do lote)
- Epochs (épocas)

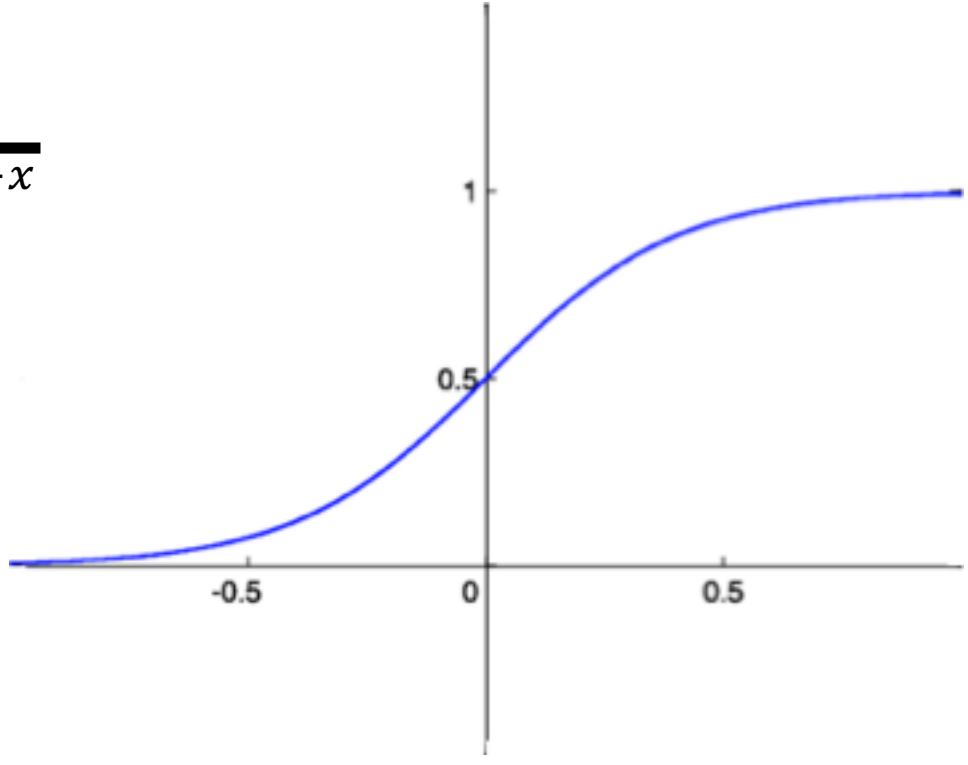
Step (função degrau)



Valor 0 ou 1

Sigmoid (função sigmoide)

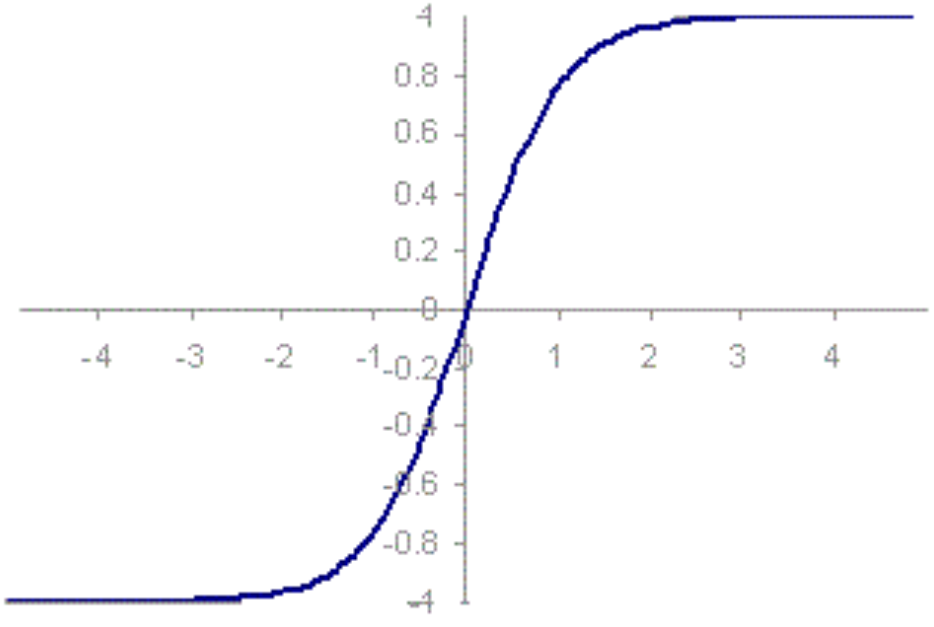
$$y = \frac{1}{1 + e^{-x}}$$



Valores entre 0 e 1

Hyperbolic tanget (função tangente hiperbólica)

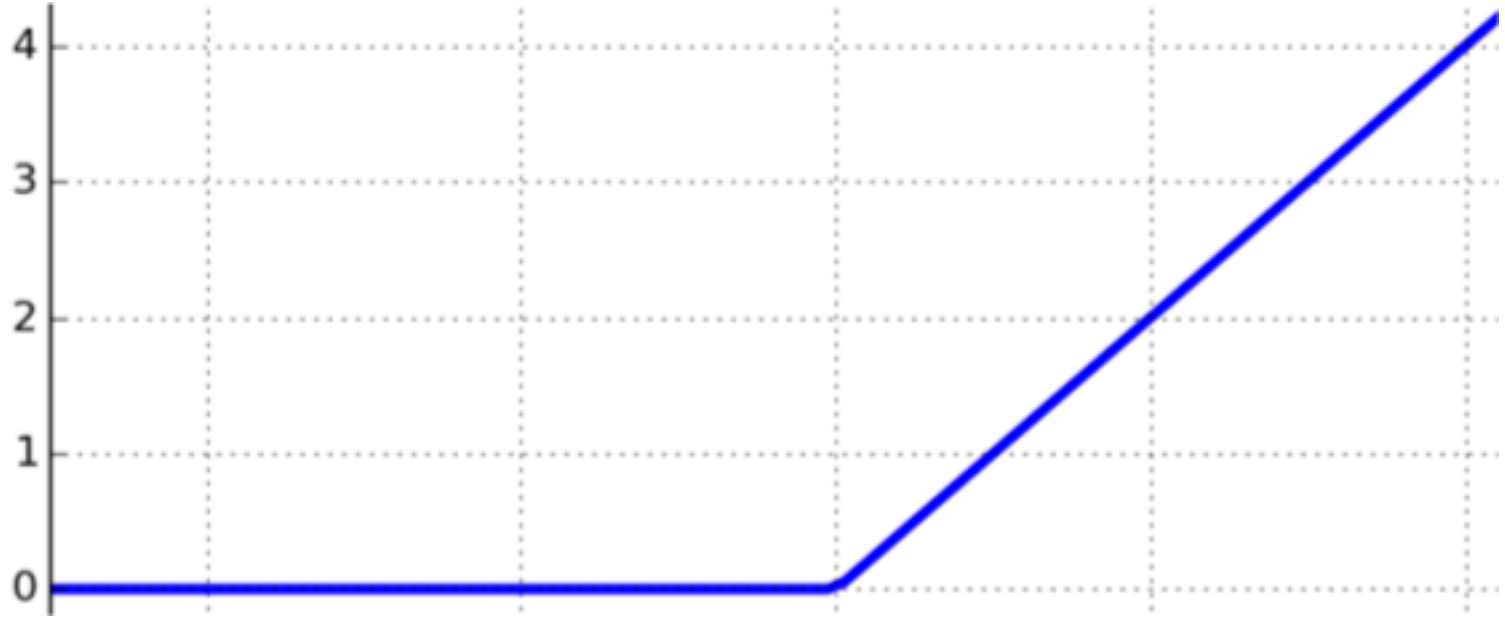
$$Y = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}$$



Valores entre -1 e 1

ReLU (rectified linear units)

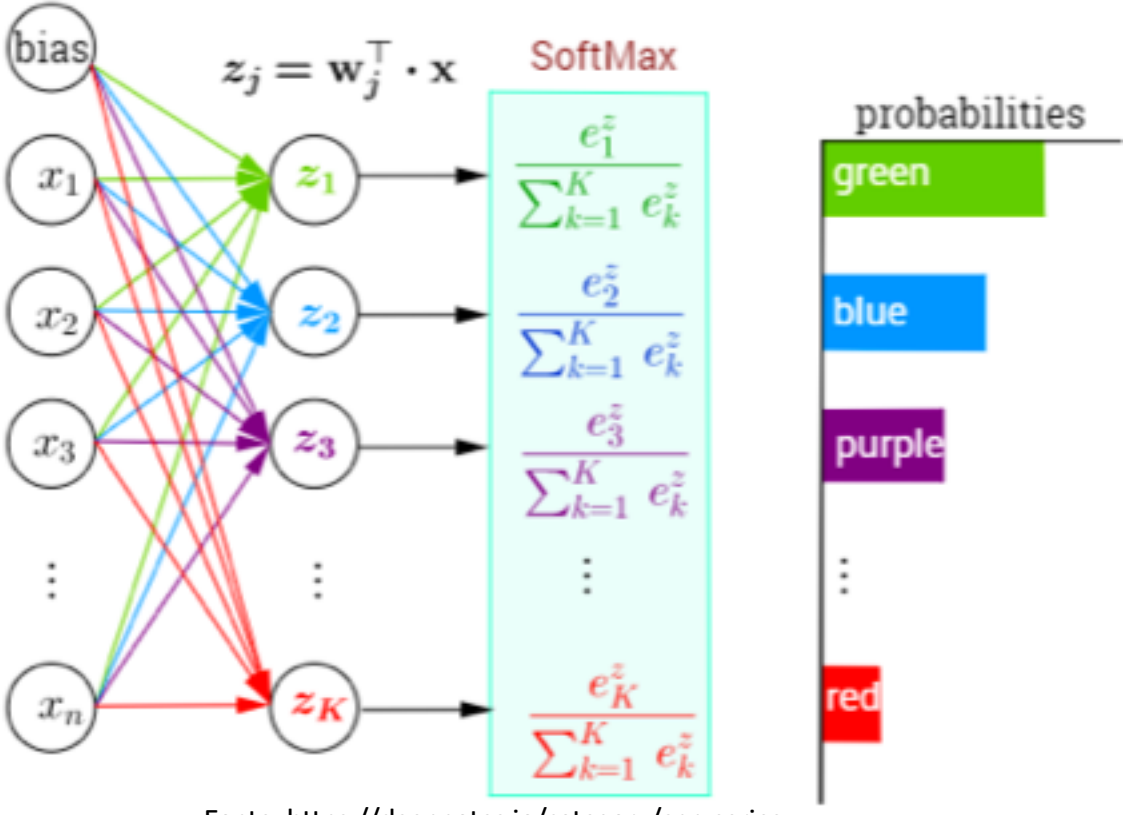
$$Y = \max(0, x)$$



Valores >= 0 (sem valor máximo)

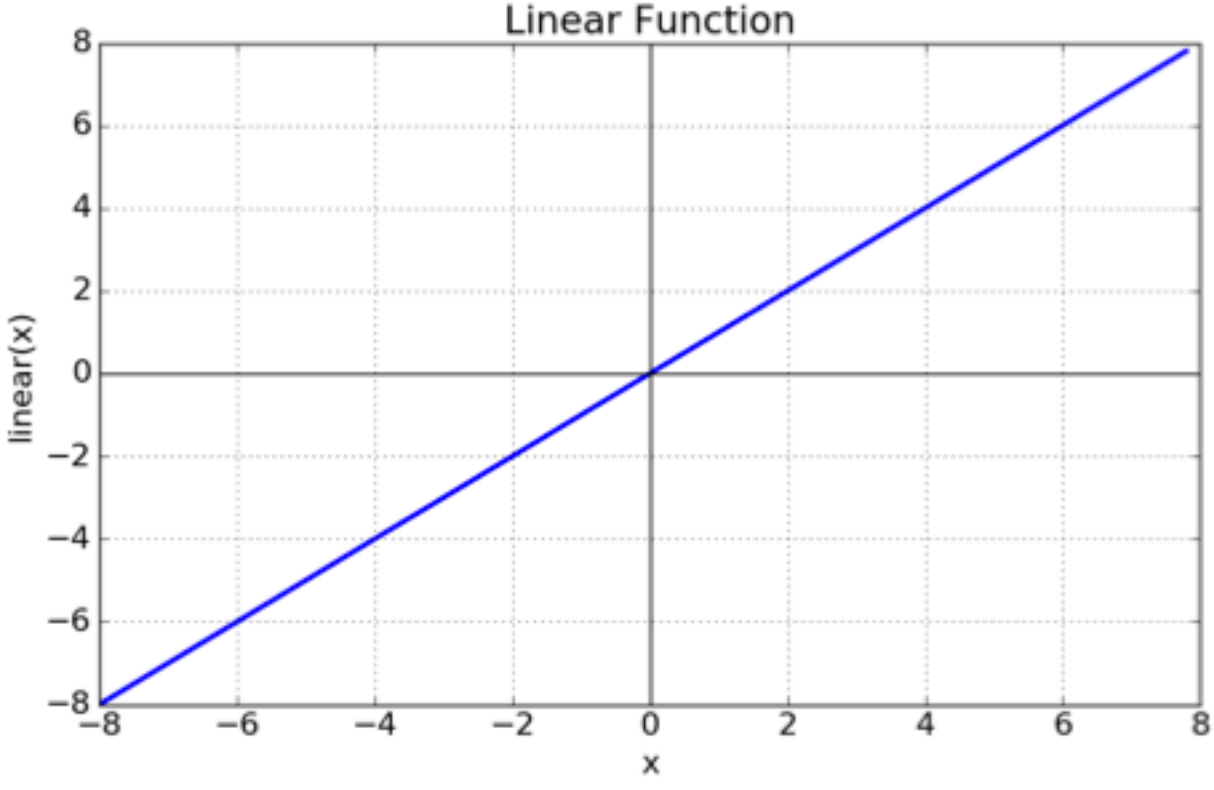
Softmax

$$Y = \frac{e(x)}{\sum \quad e(x)}$$



Fonte: https://deepnotes.io/category/cnn-series

Linear



Conclusão