# PGCA009 –Inteligência Computacional
# Aula 2 Introdução a RNA

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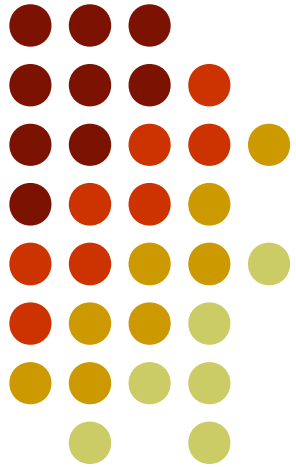
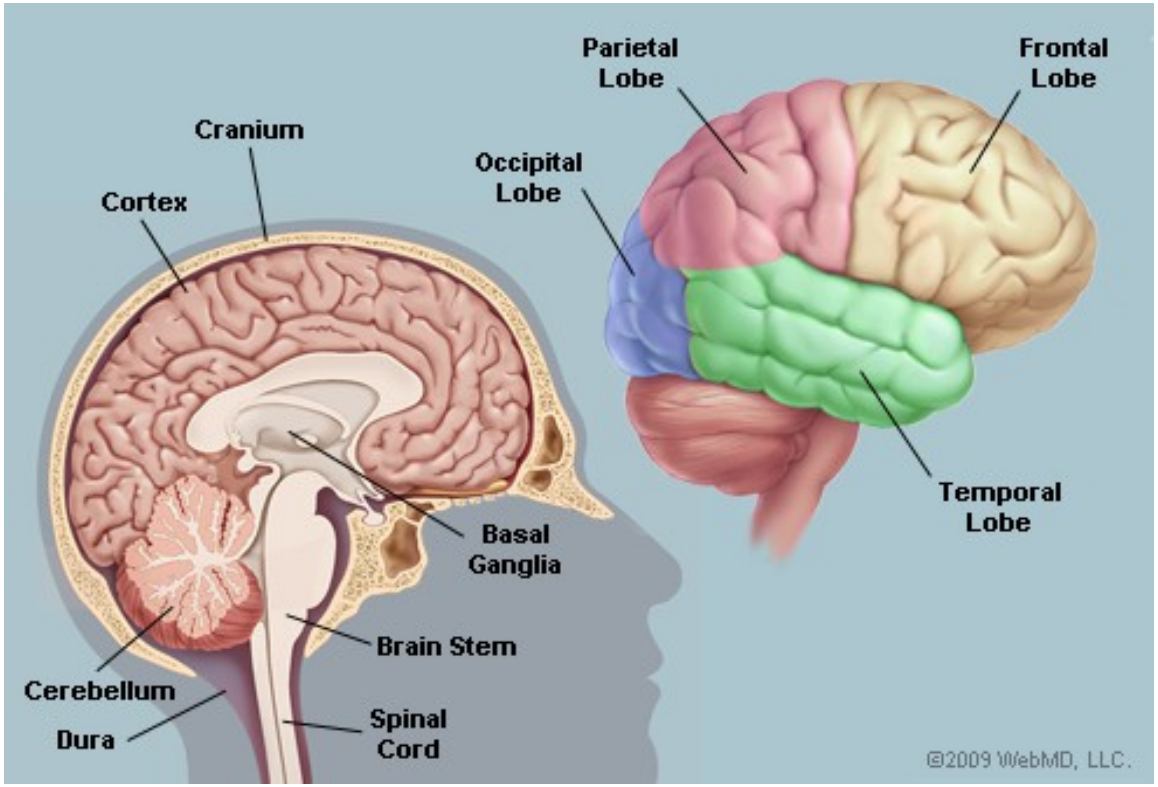
Mestrado em Computação Aplicada (UEFS)



# Cérebro

- Parte do Sistema Nervoso Central



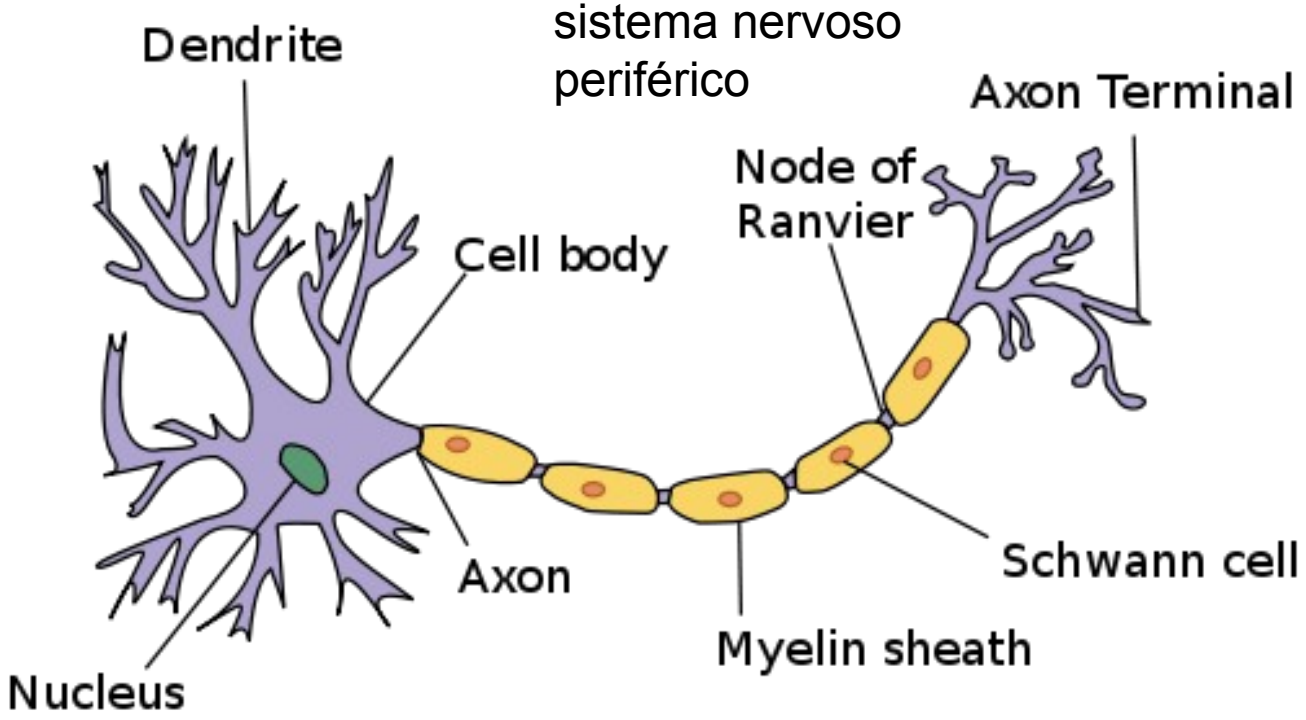
# Cérebro

- “Brain evolution, from the earliest shrewlike mammals through primates to hominids, is marked by a steady increase in encephalization, or the ratio of brain to body size. The human brain has been estimated to contain 50–100 billion ($10^{11}$) neurons, of which about 10 billion ($10^{10}$) are cortical pyramidal cells. These cells pass signals to each other via as many as 1000 trillion ($10^{15}$) synaptic connections . ”

  http://www.news-medical.net/health/The-Human-Brain.aspx

# Neurônio

Neurônio do sistema nervoso periférico

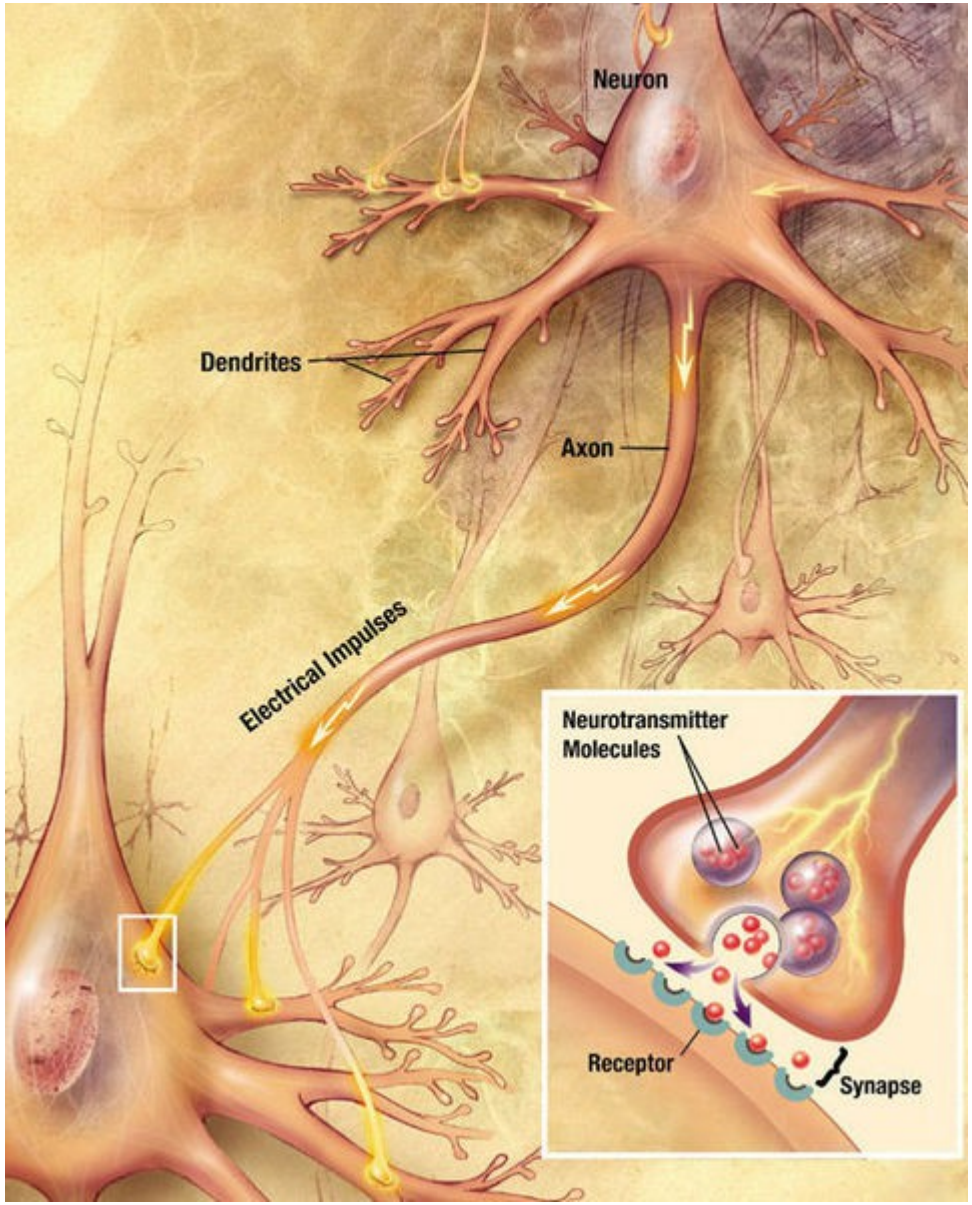



**Dendritos** → **Corpo Celular** → **Axônio**

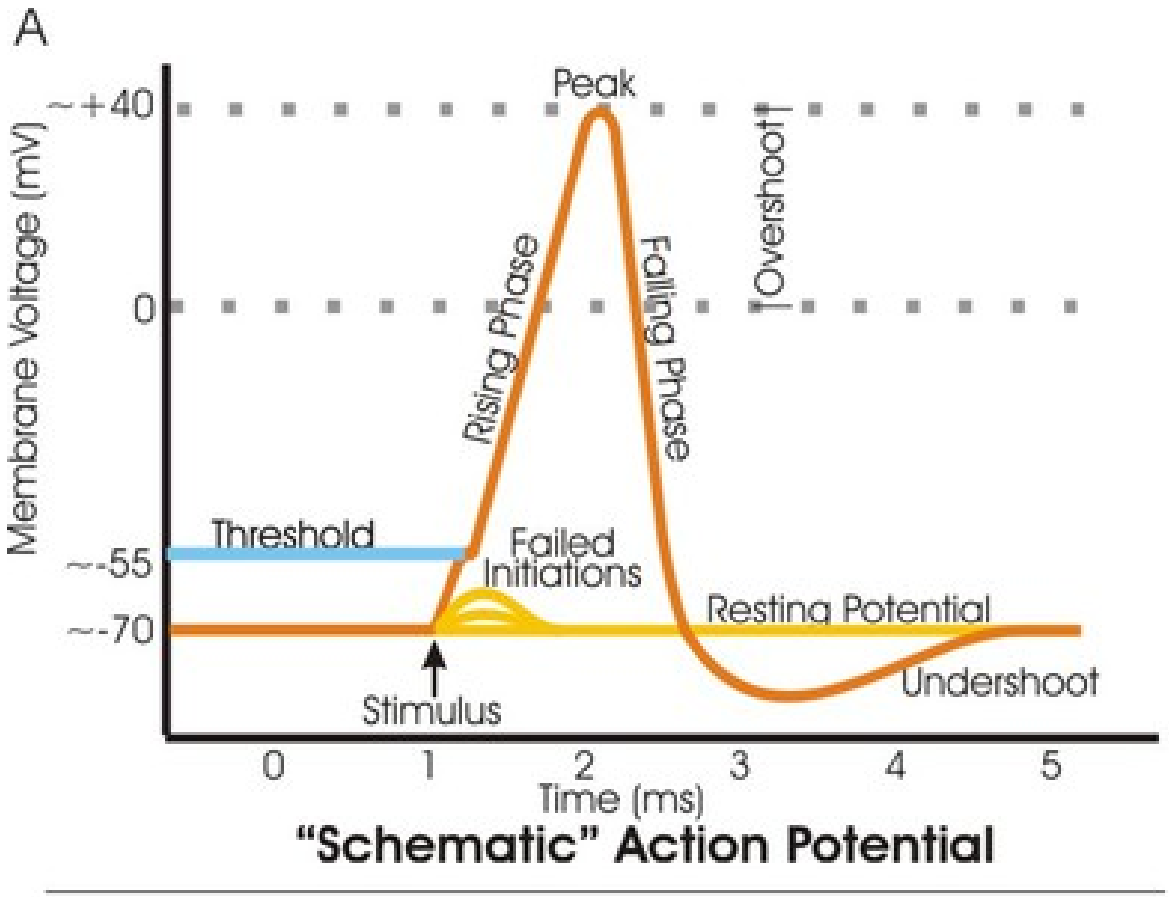
Condução dos impulsos eletro-químicos

# Sinapse

- Plasticidade: modificações das conexões sinápticas



# Potencial de Ação



# Redes Neurais

- Neural models of intelligence emphasize the brain's ability to adapt to the world in which it is situated by modifying the relationships between individual neurons. Rather than representing knowledge in explicit logical sentences, they capture it implicitly, as a property of patterns of relationships.
  - George F. Luger

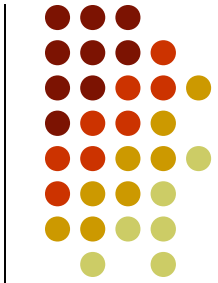
# Redes Neurais

- From NeuroSolutions. "A neural network is a powerful data modeling tool that is able to capture and represent complex input/output relationships. The motivation for the development of neural network technology stemmed from the desire to develop an artificial system that could perform 'intelligent' tasks similar to those performed by the human brain. ... The true power and advantage of neural networks lies in their ability to represent both linear and non-linear relationships and in their ability to learn these relationships directly from the data being modeled."

# Conexionismo

- Paradigma da IA que vê inteligência como um fenômeno emergente de uma rede de múltiplas unidades simples interconectadas
- IA Distribuída
- Parallel Distributed Processing, PDP
- Abordagem Bottom-Up

# Conexionismo



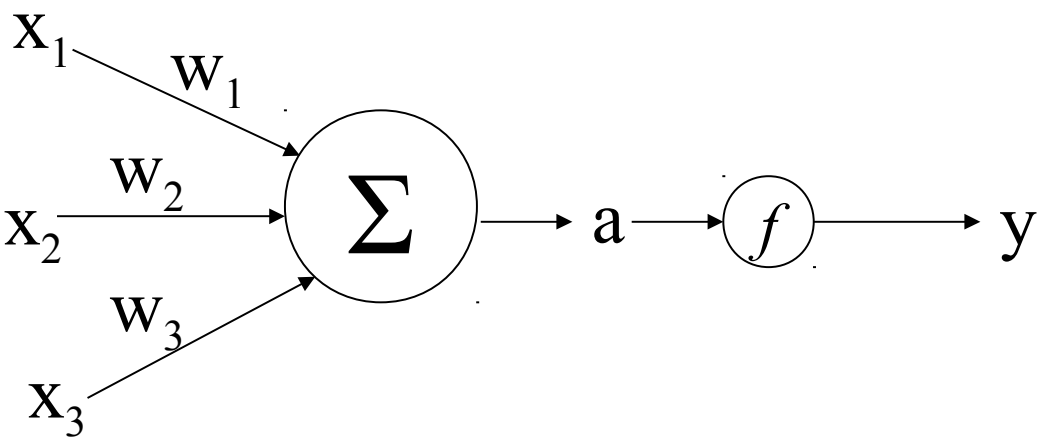
- By Michael Swaine. "The word 'connectionist' was first used in the context of mental models by D.O. Hebb in 1949, but its influence on AI researchers dates to Rosenblatt's use in his Perceptrons paper in 1958. Minsky and Papert killed the nive perceptron model stone dead in 1969 and more or less interred connectionism along with it, until *Parallel Distributed Processing* resurrected it in 1987.
  'The idea behind connectionism,' [Larry] Yaeger says, 'is that key aspects of brain behavior simply cannot be modeled at the symbolic level, and by working closer to the physical system underlying human thought -- the brain and its neurons and synapses -- we stand both a much greater chance of succeeding at producing AI and of understanding how it relates to real human thought.'"

# Neurônios Artificiais

- Modelo (simplificado) do neurônio biológico, natural
  - McCulloch & Pitts, 1943: primeiro modelo computacional
- Sem preocupação atualmente em modelar de fato o neurônio real
  - Modelos mais representativos são estudados pela neurociência computacional

# Neurônios Artificiais

$x_i \in \{0, 1\}$

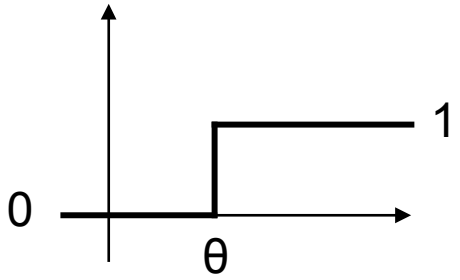



Threshold Unit or Threshold Logic Unit (TLU)

$$a = x_1 w_1 + x_2 w_2 + x_3 w_3$$

$$y = f(x_1 w_1 + x_2 w_2 + x_3 w_3)$$

$$f(a) = \begin{cases} 1, & a => \theta \\ 0, & a < \theta \end{cases}$$




limiar

# Neurônios Artificiais

$$X = (x_1, x_2, x_3)$$
$$W = (w_1, w_2, w_3)$$
$$a = X \cdot W$$
$$y = f(a)$$

$\cdot$ é o operador de produto escalar ou produto interno

Se X = (1, 1, 0), W = (0.5, 1.0, 1.2) e θ é 0, qual valor de y?

# Neurônios Artificiais

- Robustez

E se houver ruído na entrada e assim X = (0.8, 0.9, 0), qual valor de Y?

# Neurônios Artificiais

- Projeto de um neurônio

Considere a seguinte função e projete um neurônio para realizar esta função!

| $x_1$ | $x_2$ | y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

# Neurônios Artificiais

- Projeto de um neurônio

Alterando para a seguinte função, projete um neurônio para realizar esta função!

| $x_1$ | $x_2$ | y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

# Neurônios Artificiais

$$y = f(x_1 w_1 + x_2 w_2)$$

$$y = \begin{cases} 1, & x_1 w_1 + x_2 w_2 >= \theta \\ 0, & x_1 w_1 + x_2 w_2 < \theta \end{cases}$$

A decisão y muda para cada lado de $x_1 w_1 + x_2 w_2 = \theta$

# Neurônios Artificiais

- Projeto de um neurônio

| $x_1$ | $x_2$ | y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

$$y = \begin{cases} 1, x_1 w_1 + x_2 w_2 >= \theta \\ 0, x_1 w_1 + x_2 w_2 < \theta \end{cases}$$

# Neurônios Artificiais

- Projeto de um neurônio

| $x_1$ | $x_2$ | y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

$0<\theta$

$w_2<\theta$

$w_1<\theta$

$w_1+ w_2>=\theta$

$$y = \begin{cases} 1, & x_1w_1+ x_2w_2>=\theta \\ 0, & x_1w_1+ x_2w_2<\theta \end{cases}$$

# Neurônios Artificiais

- Projeto de um neurônio

| $x_1$ | $x_2$ | y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

$0<\theta \rightarrow \theta = 2$

$w_2<\theta \rightarrow w_2 = 1$

$w_1<\theta \rightarrow w_1 = 1$

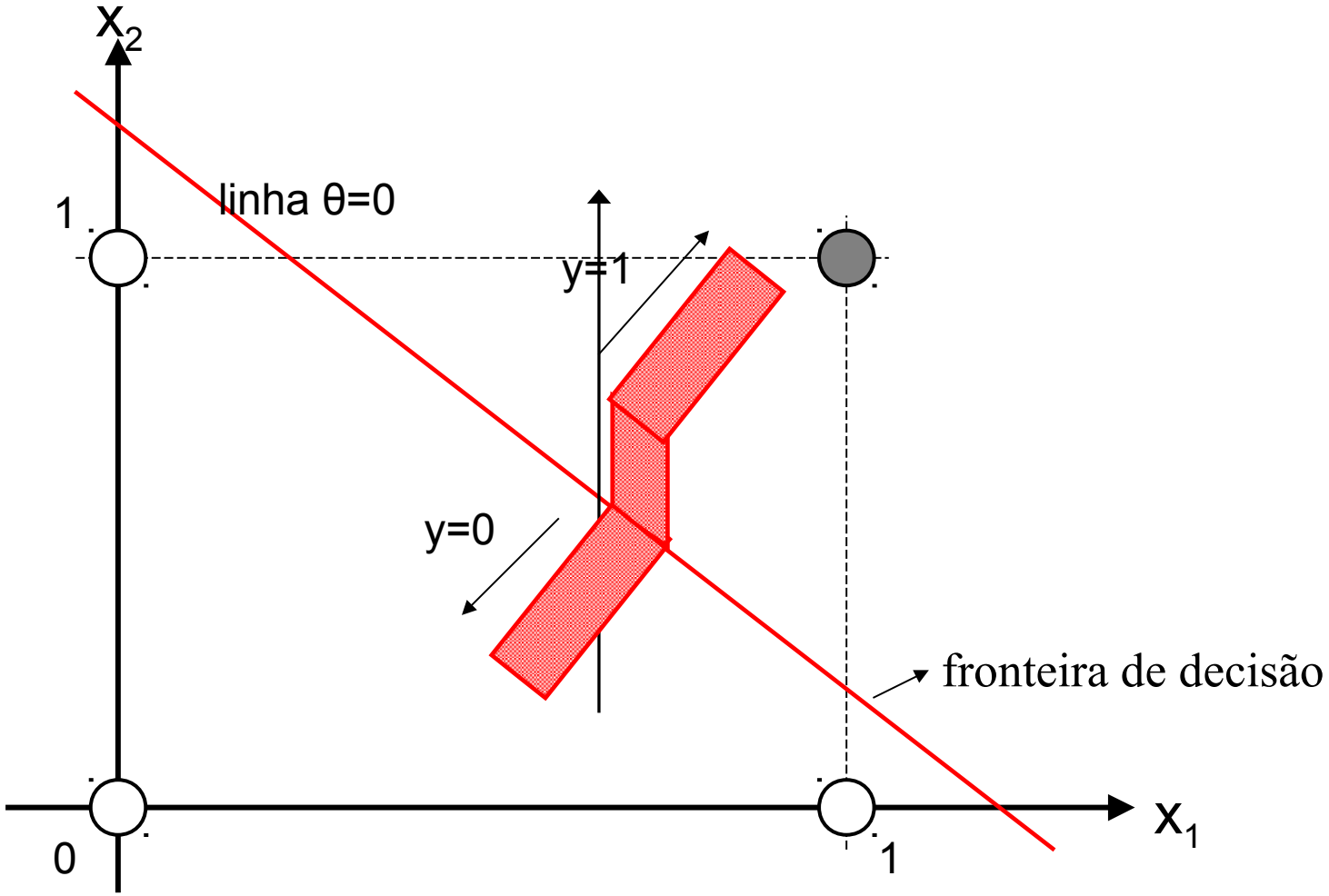
$w_1 + w_2 >= \theta \rightarrow 2 >= 2$

$$y = \begin{cases} 1, & x_1 w_1 + x_2 w_2 >= \theta \\ 0, & x_1 w_1 + x_2 w_2 < \theta \end{cases}$$

# Neurônios Artificiais

- Qual a robustez de sua solução?

# Neurônios Artificiais



# Neurônios Artificiais

$x_1 w_1 + x_2 w_2 = \theta$ fronteira de decisão

$x_2 w_2 = \theta - x_1 w_1$

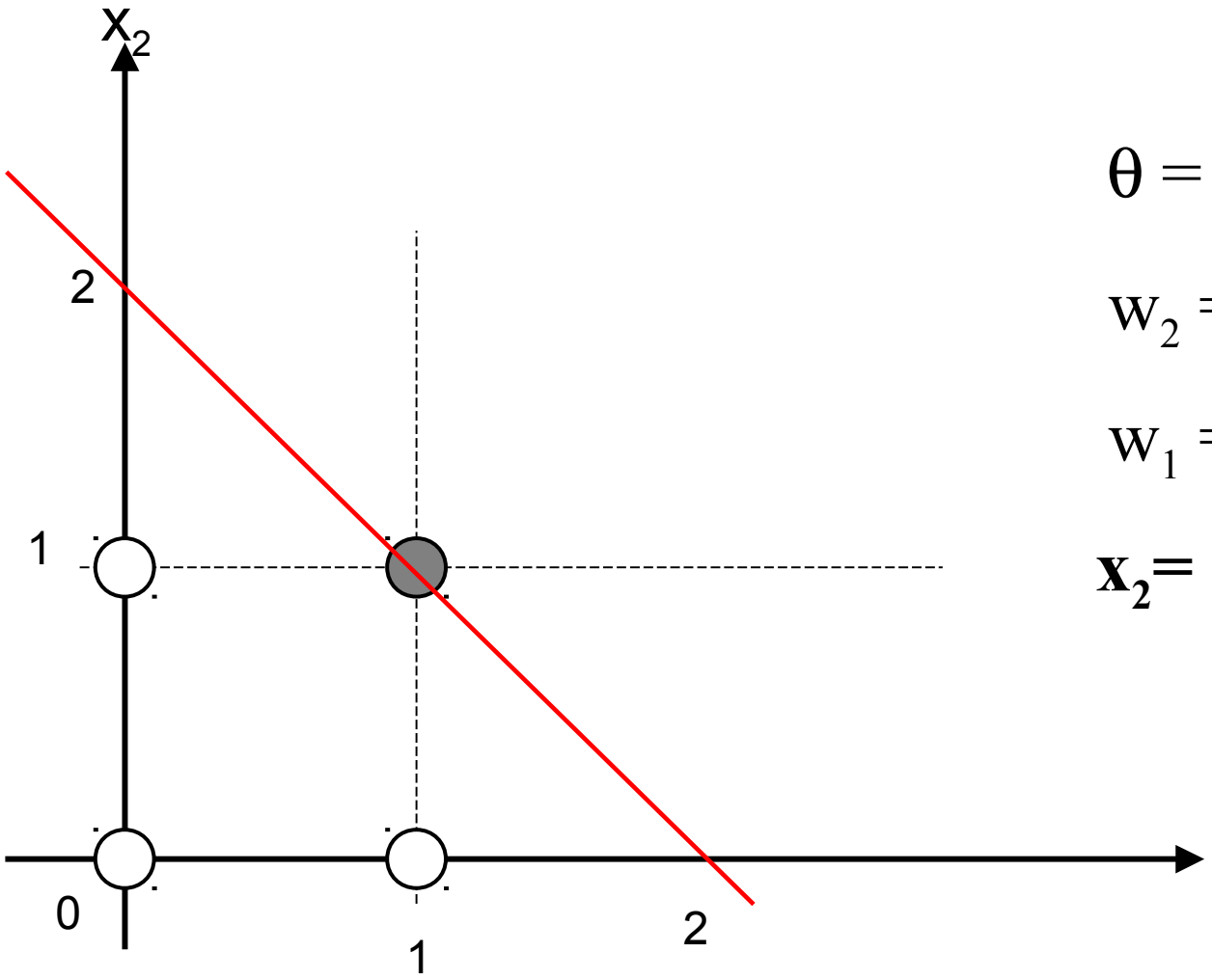
$x_2 = \theta/w2 - x_1(w_1/w2)$

**$x_2 = (-w_1/w2)\, x_1 + \theta/w2$**

inclinação da reta

intersecção com eixo $x_2$

# Neurônios Artificiais




$\theta = 2$

$w_2 = 1$

$w_1 = 1$

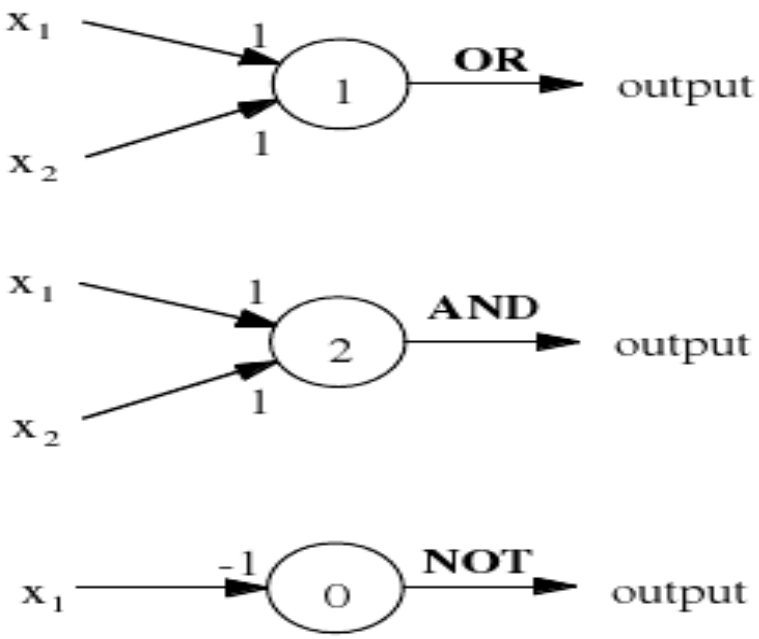
$\mathbf{x_2 = - x_1 + 2}$

# Neurônios Artificiais

- Qual a robustez de sua solução?

# Redes Neurais Artificiais

- Um neurônios sozinho pode representar qualquer função linearmente separável

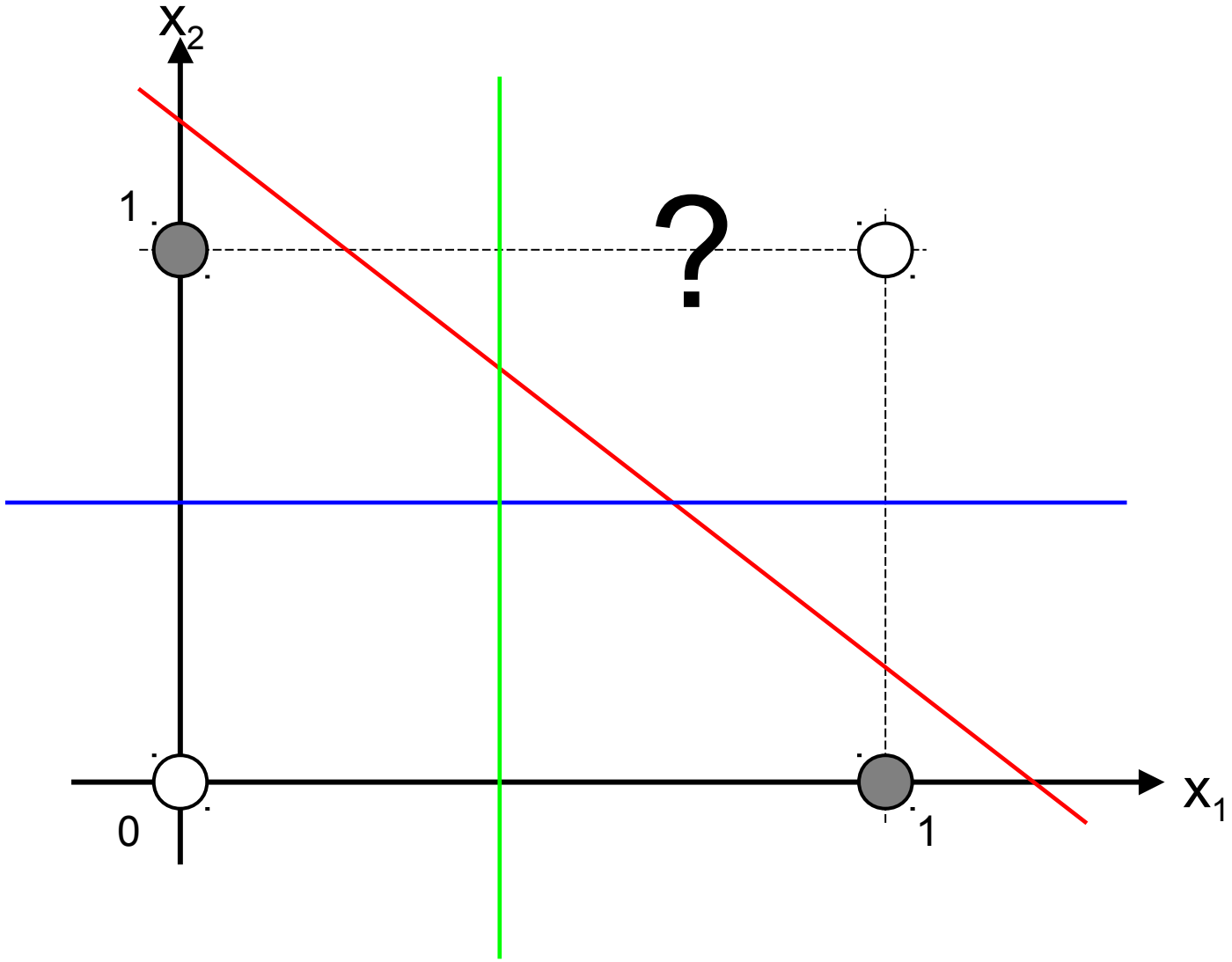


# Redes Neurais Artificiais

- Mas se tivermos uma porta XOR?

| $x_1$ | $x_2$ | y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

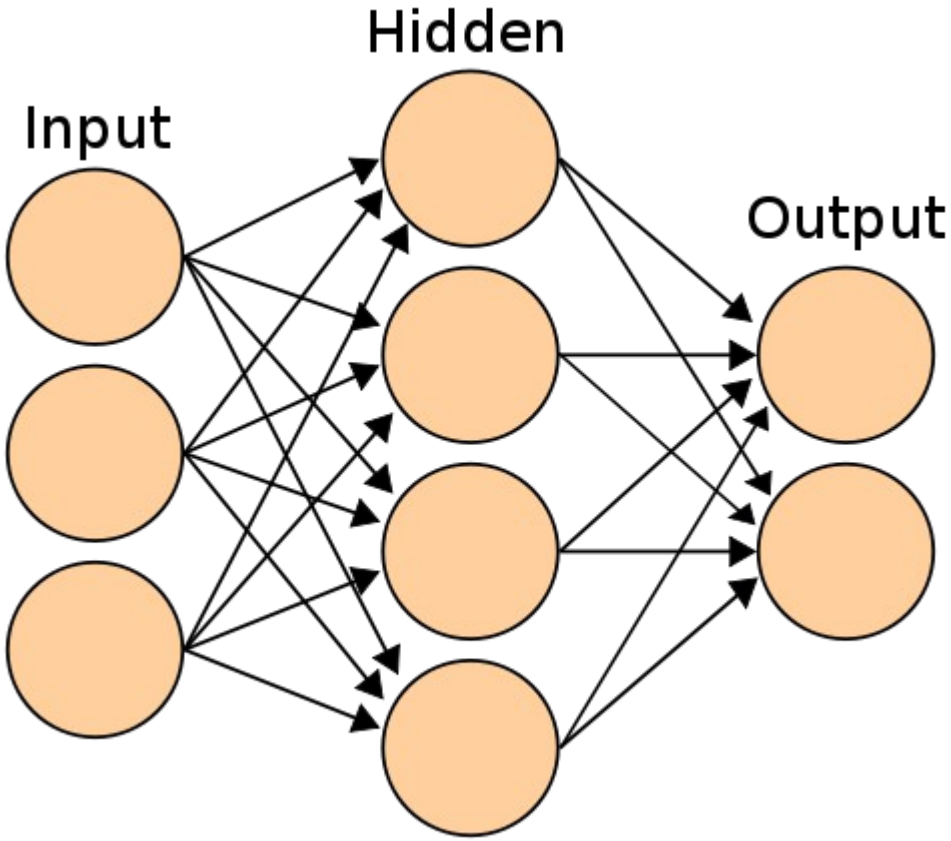
# Neurônios Artificiais



# Redes Neurais Artificiais

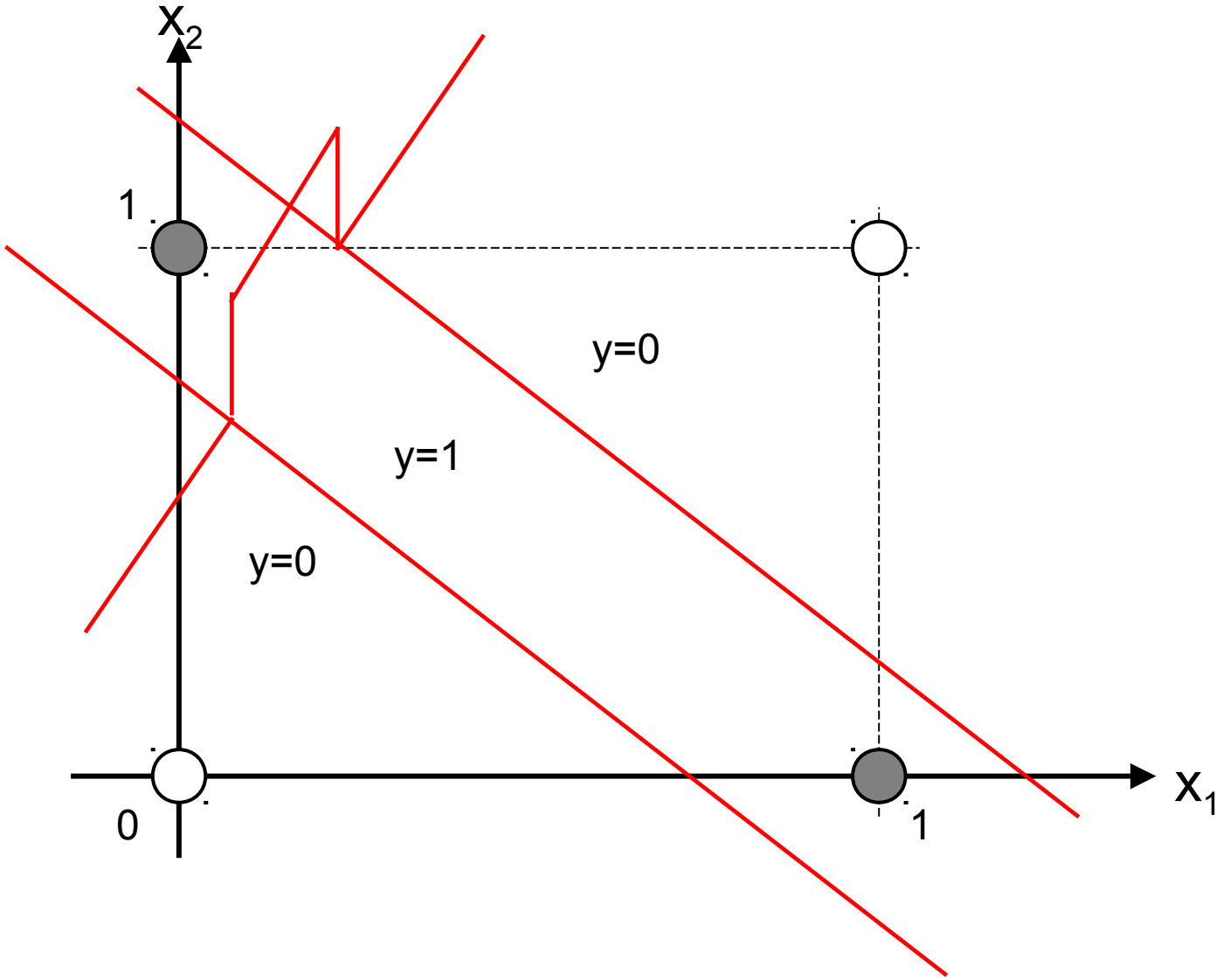
- Vamos precisar de uma RNA mais sofisticada!
- Uma RNA com mais neurônios pode ser uma solução
- RNA com múltiplos neurônios e múltiplas camadas

# Redes Neurais Artificiais




- Mas como obter os pesos? Projeto? Aprendizado?

# Neurônios Artificiais



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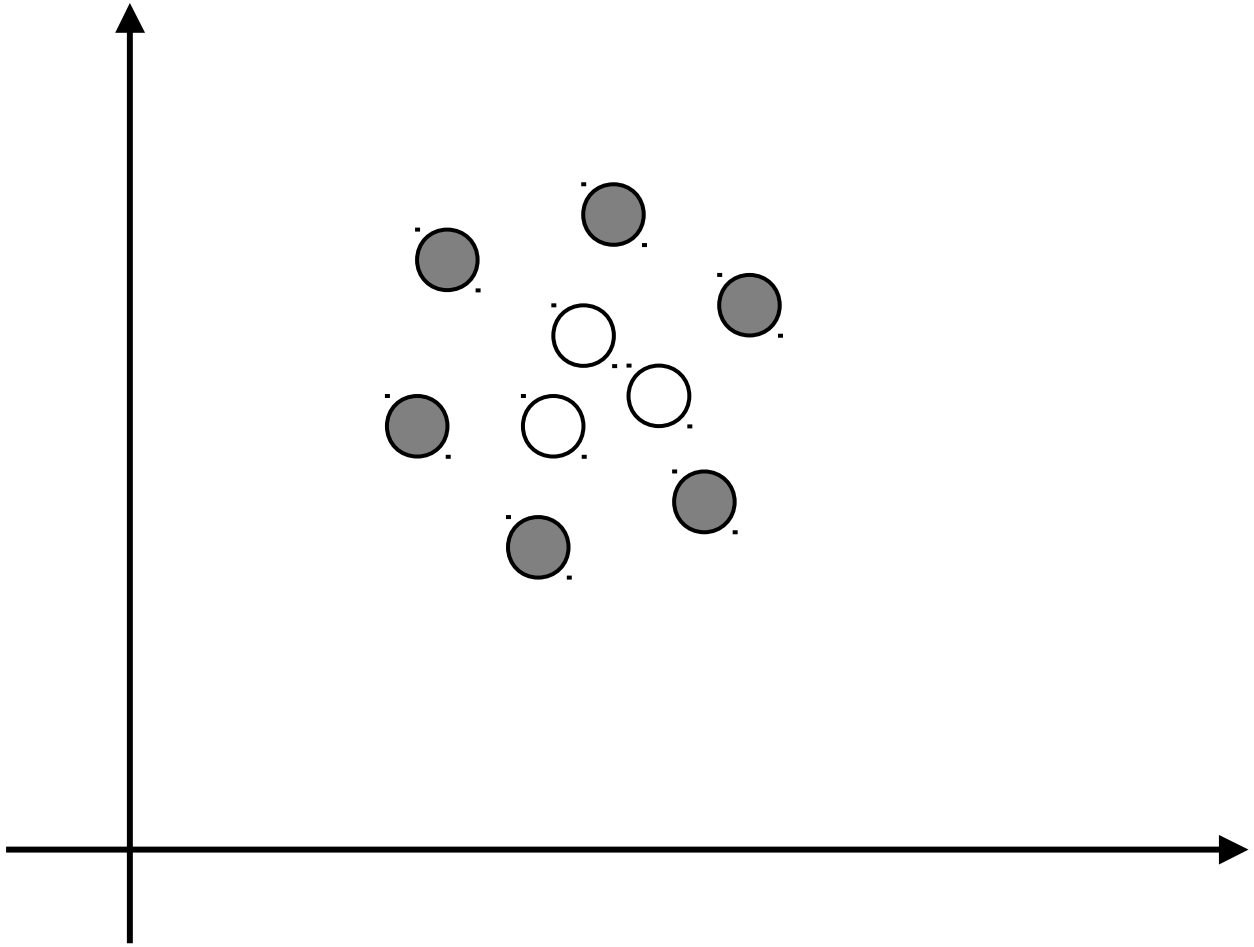

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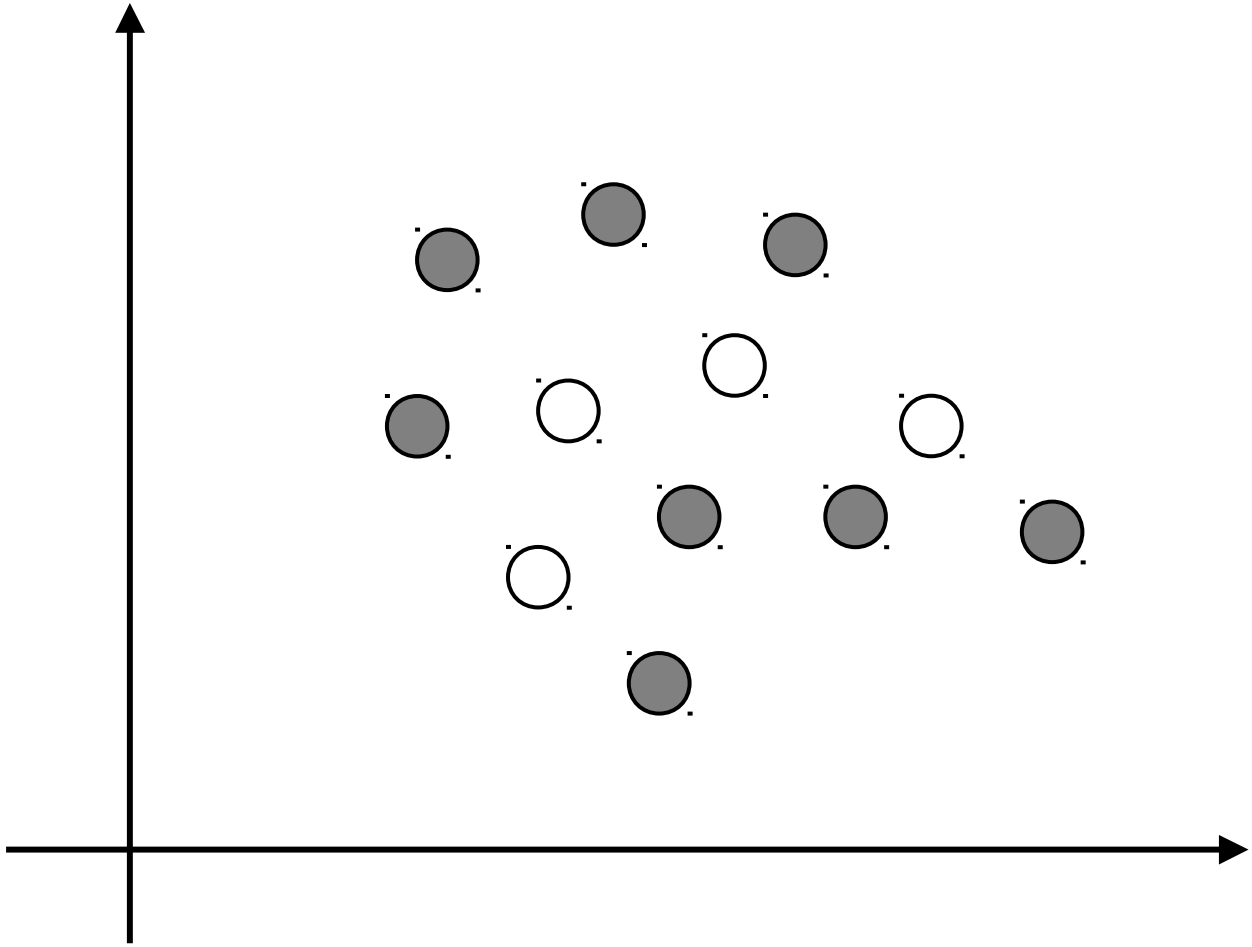
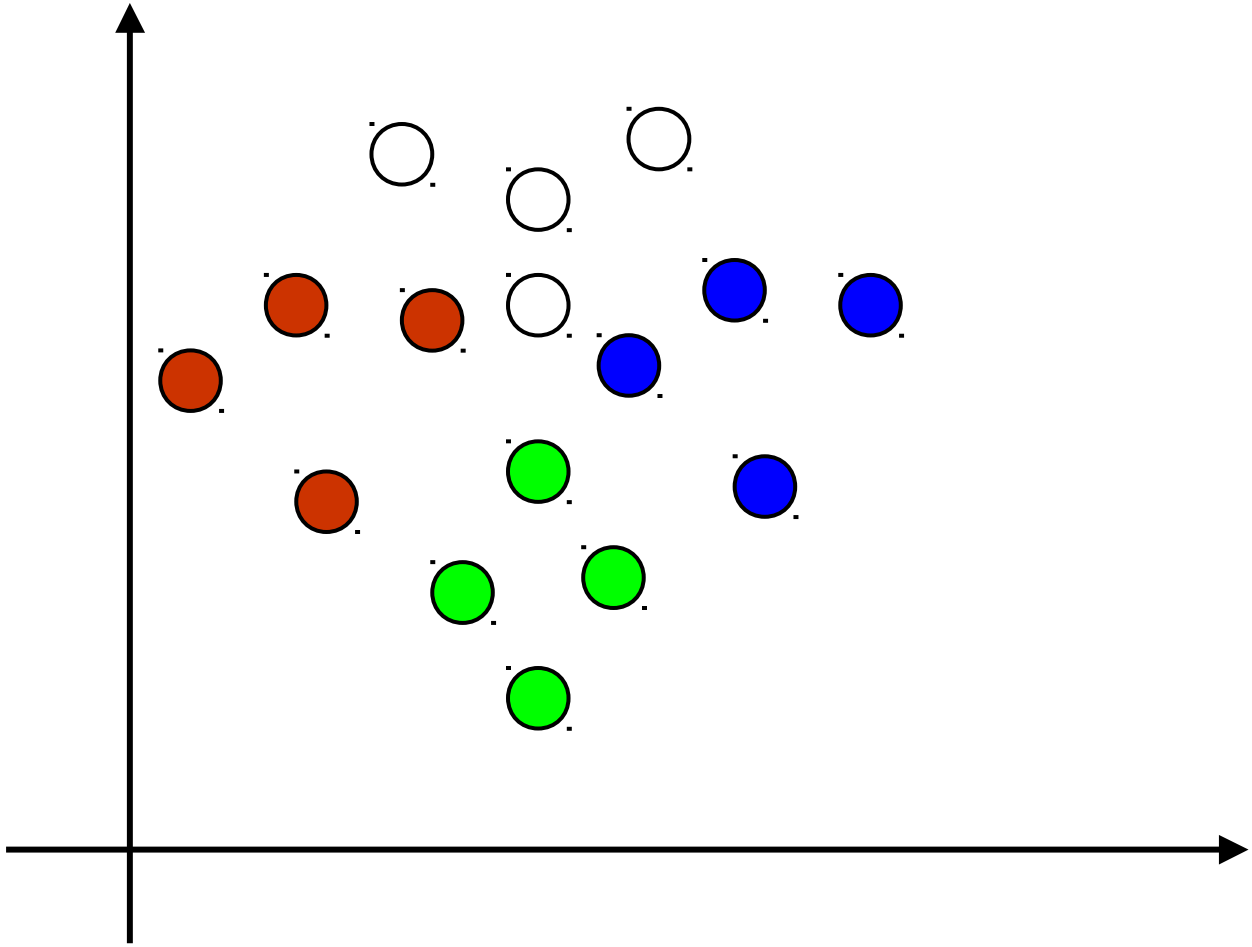


# Neurônios Artificiais



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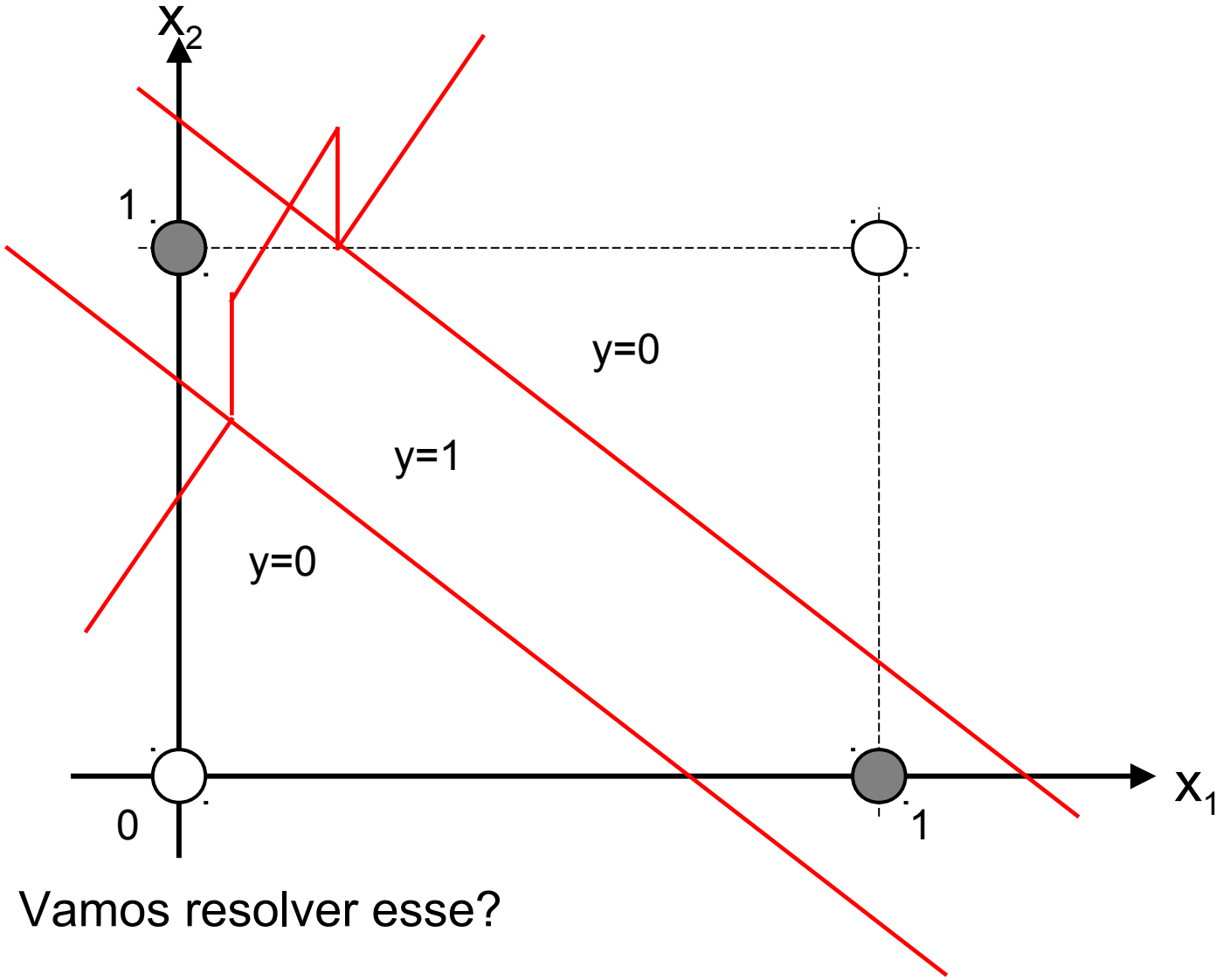
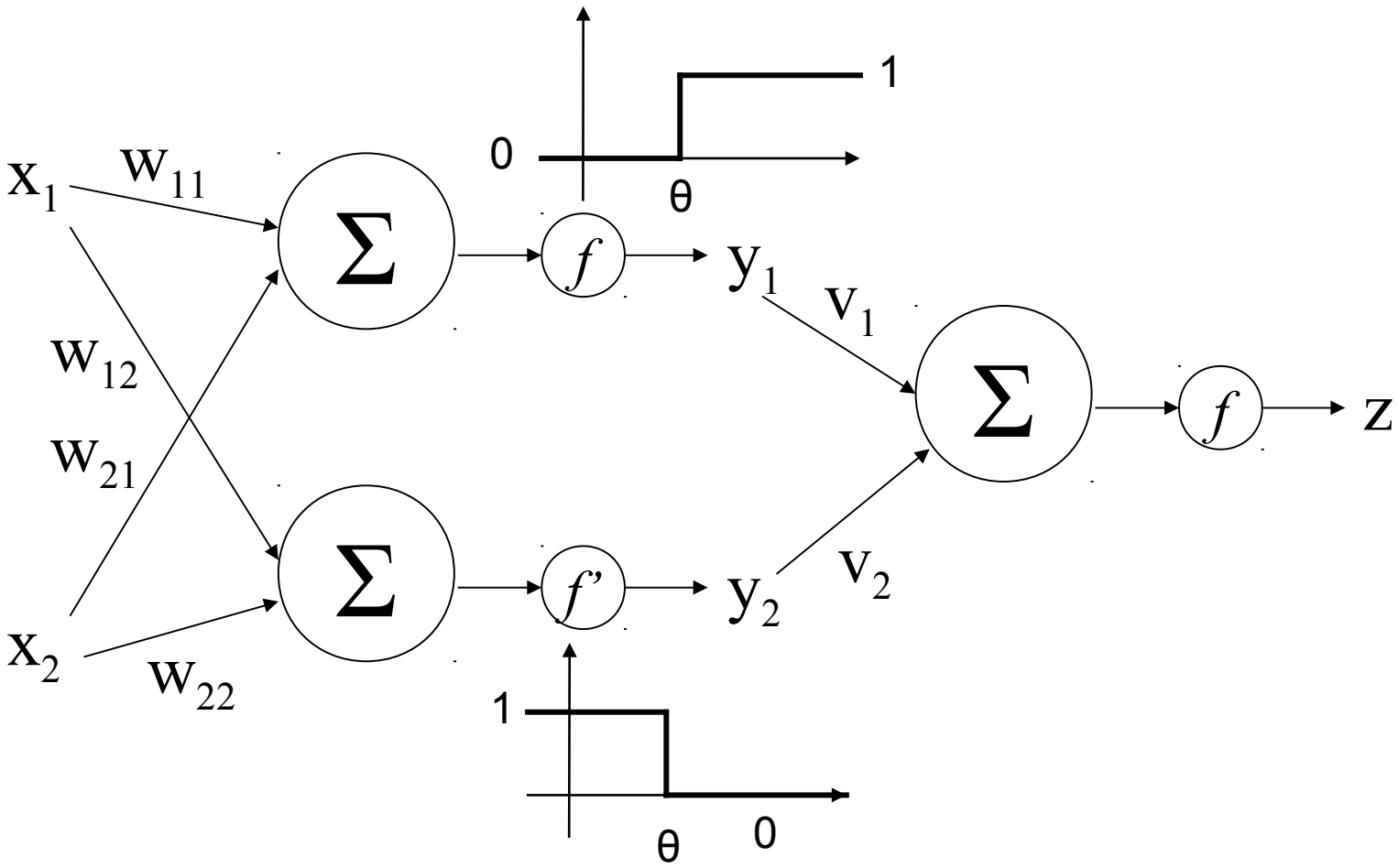



- Vamos resolver esse?

# Redes Neurais Artificiais




- Vamos resolver esse?

# Redes Neurais Artificiais

| $x_1$ | $x_2$ | $y_1$ |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |

$0<\theta_1 \rightarrow \theta_1=1$

$w_{21}>=\theta_1 \rightarrow w_{21}=1$

$w_{11}>=\theta_1 \rightarrow w_{11}=1$

$$y_1 = \begin{cases} 1, x_1 w_{11} + x_2 w_{21} >= \theta_1 \\ 0, x_1 w_{11} + x_2 w_{21} < \theta_1 \end{cases}$$

| 1 | 1 | 0 |
|---|---|---|

$y_1=1?$

# Redes Neurais Artificiais

$$y_2 = \begin{cases} 0, & x_1 w_{12} + x_2 w_{22} >= \theta_2 \\ 1, & x_1 w_{12} + x_2 w_{22} < \theta_2 \end{cases}$$

| $x_1$ | $x_2$ | $y_2$ |
|---|---|---|
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

$w_{22} < \theta_2 \rightarrow w_{22} = 1$

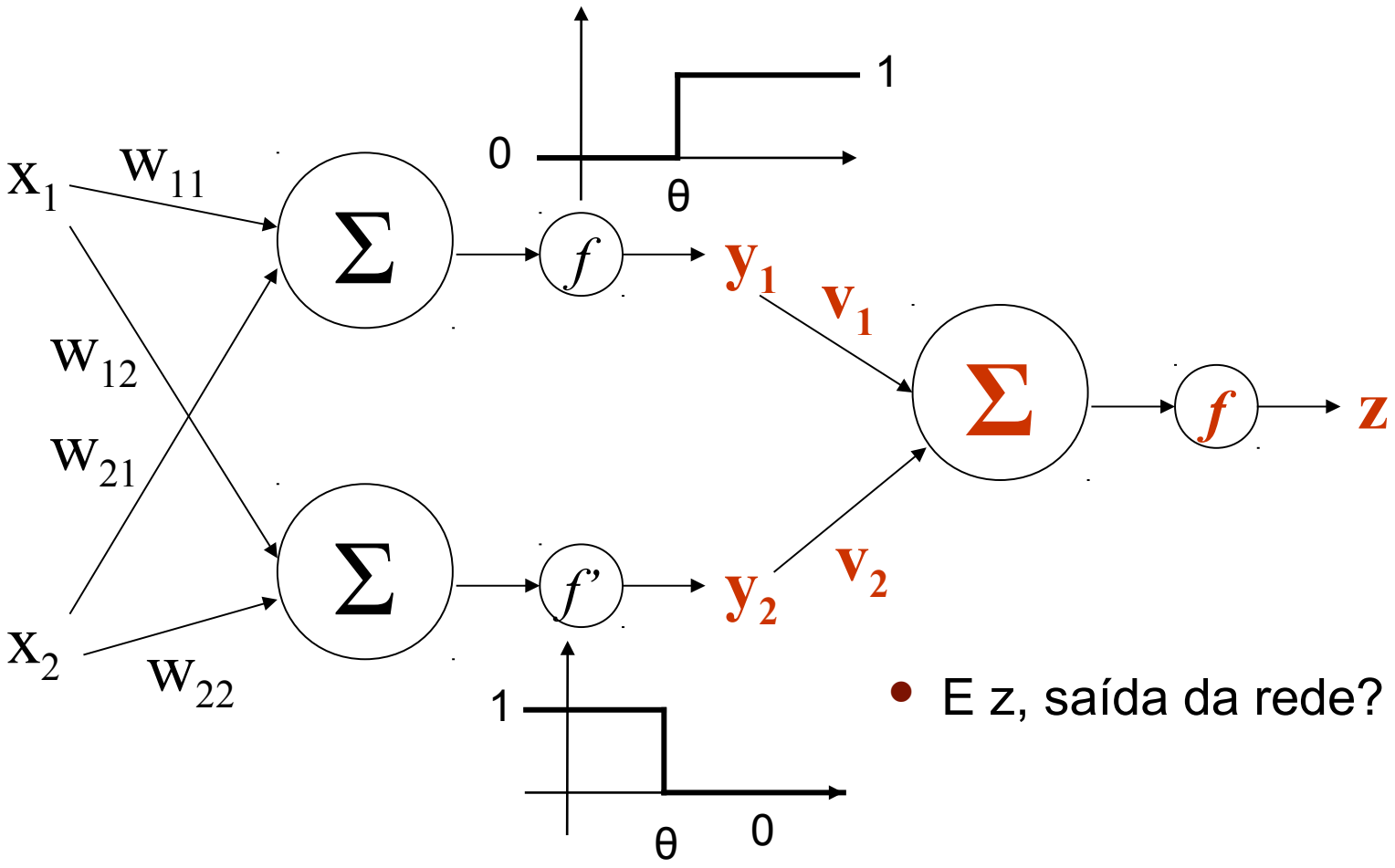
$w_{12} < \theta_2 \rightarrow w_{12} = 1$

$w_{12} + w_{22} >= \theta_2 \rightarrow \theta_2 = 2$

| | | |
|---|---|---|
| 0 | 0 | 0 |

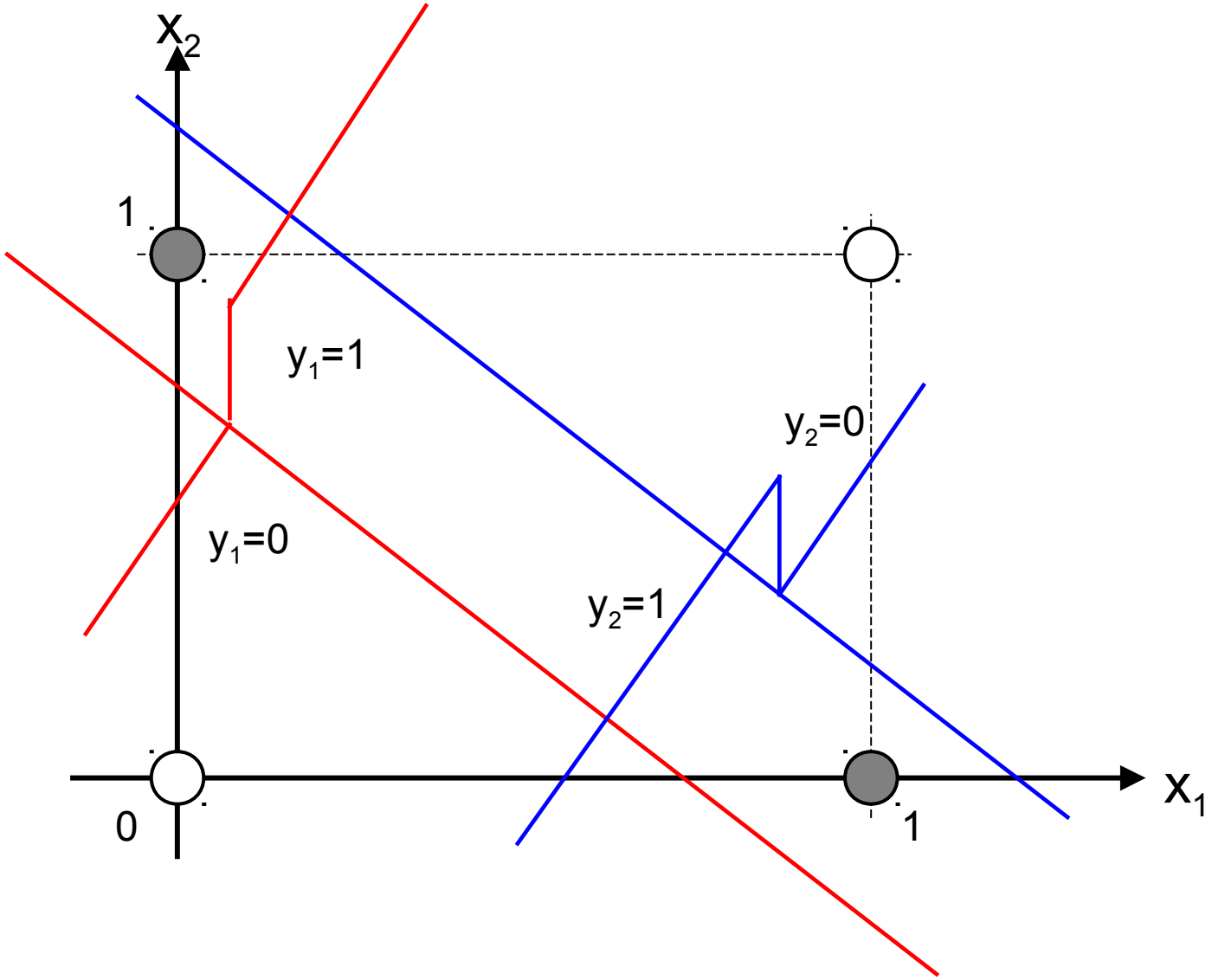
$y_2 = 1$?

# Redes Neurais Artificiais




- E z, saída da rede?

# Redes Neurais Artificiais



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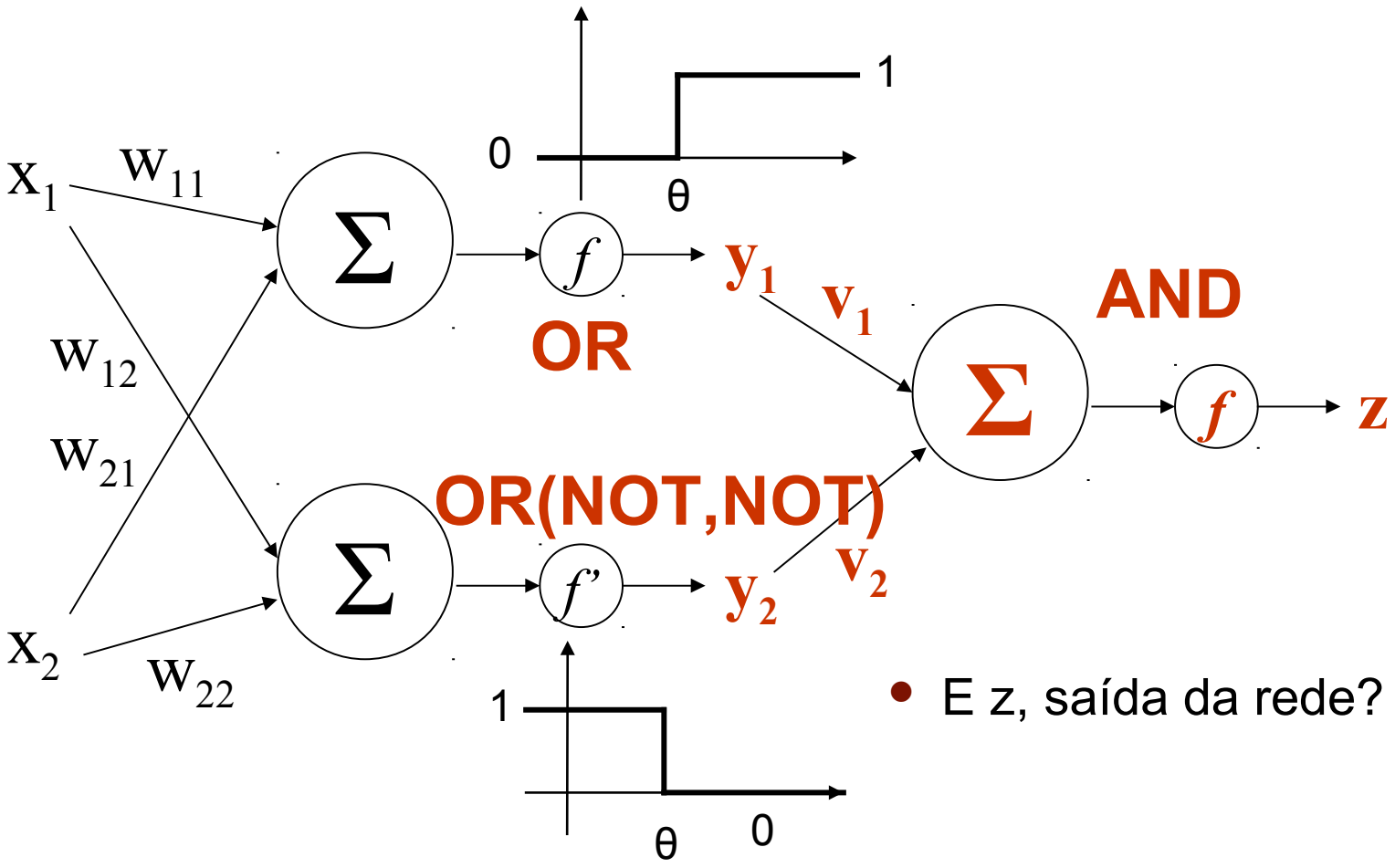
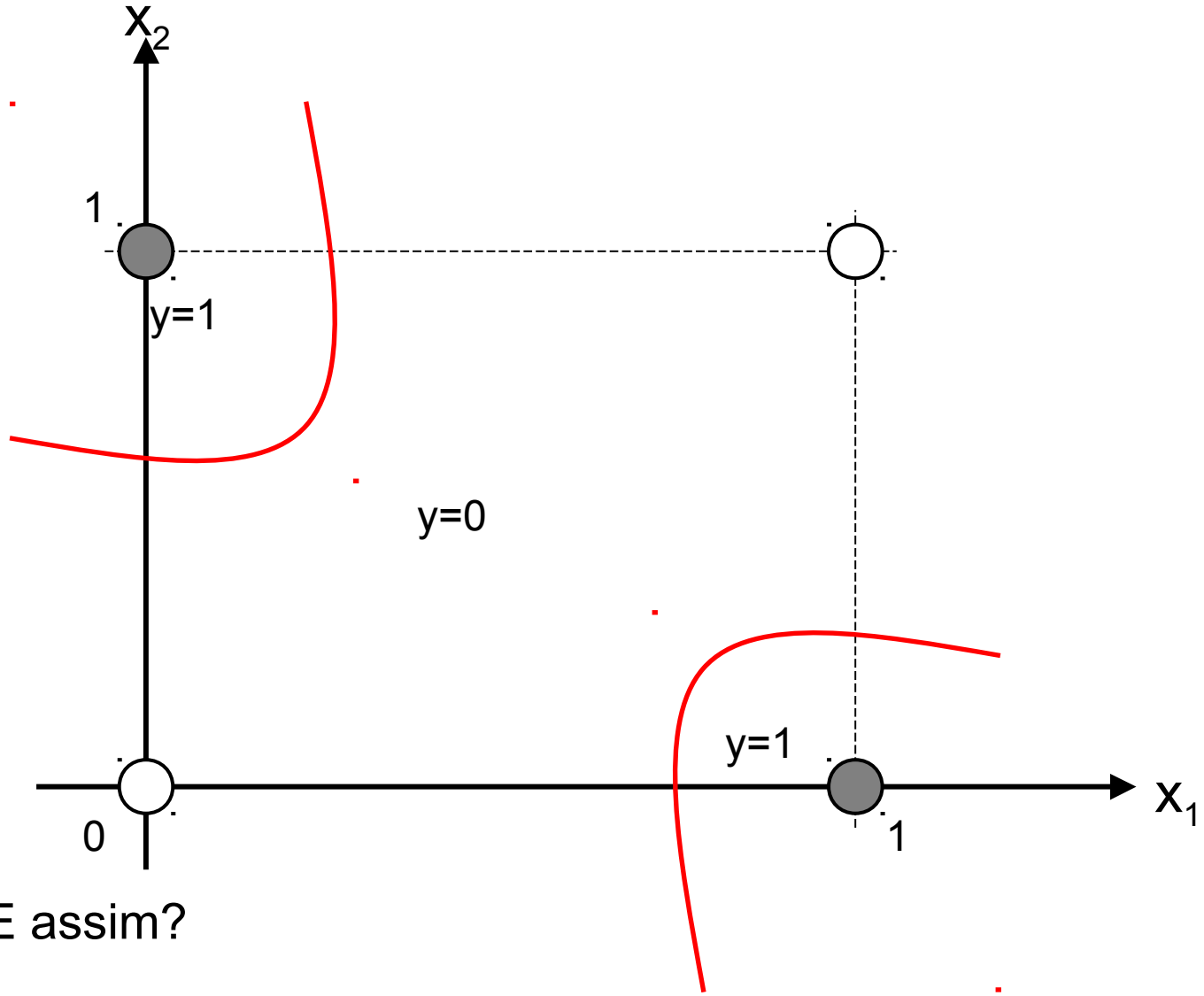


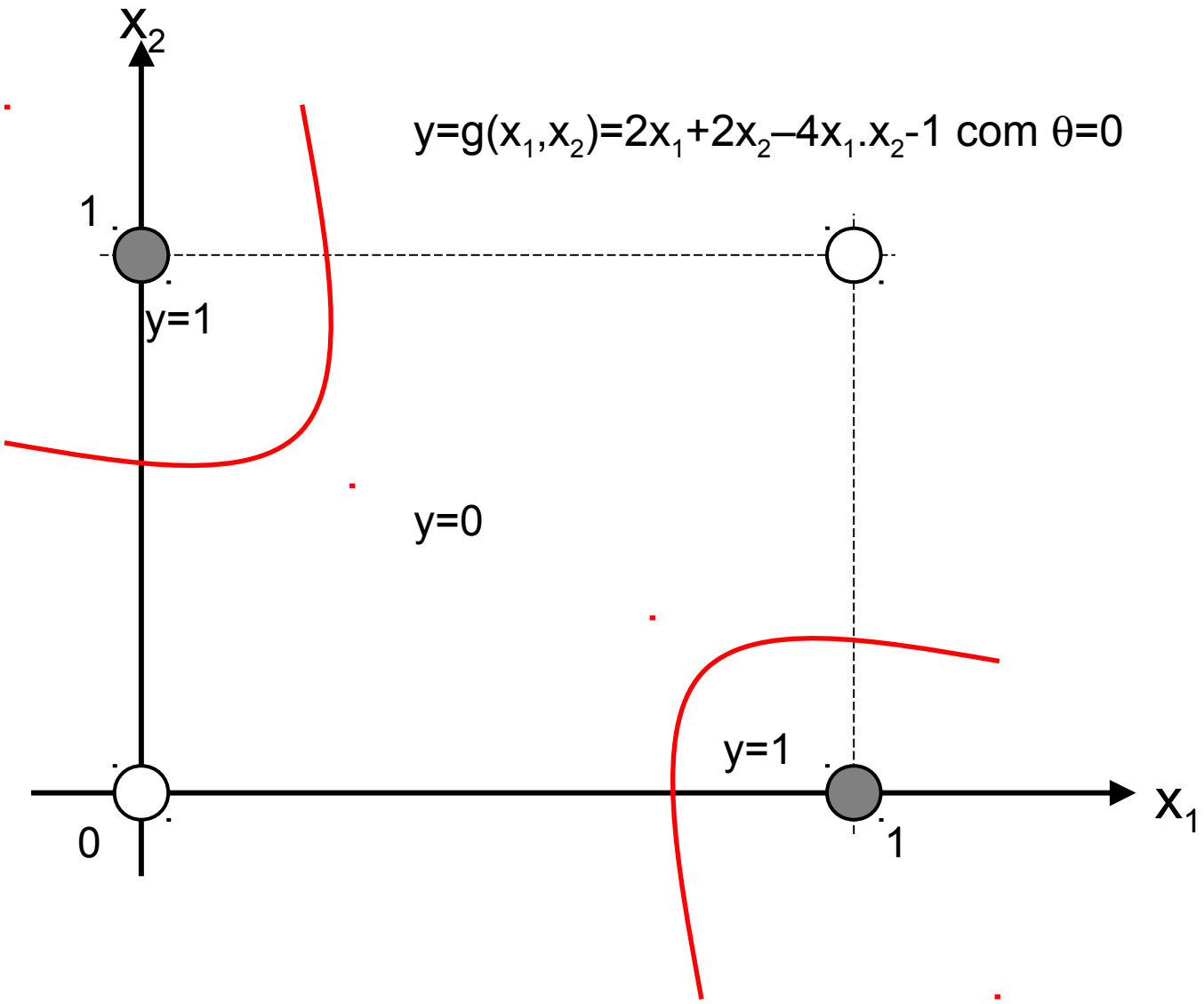

- E z, saída da rede?

# Redes Neurais Artificiais




- E assim?

# Redes Neurais Artificiais



# Redes Neurais Artificiais

$y=g(x_1,x_2)=2x_1+2x_2-4x_1.x_2-1$