

深度学习基础课程

Deep Learning Foundation Course



<https://www.streamingnology.com>



<https://github.com/streamingnology>



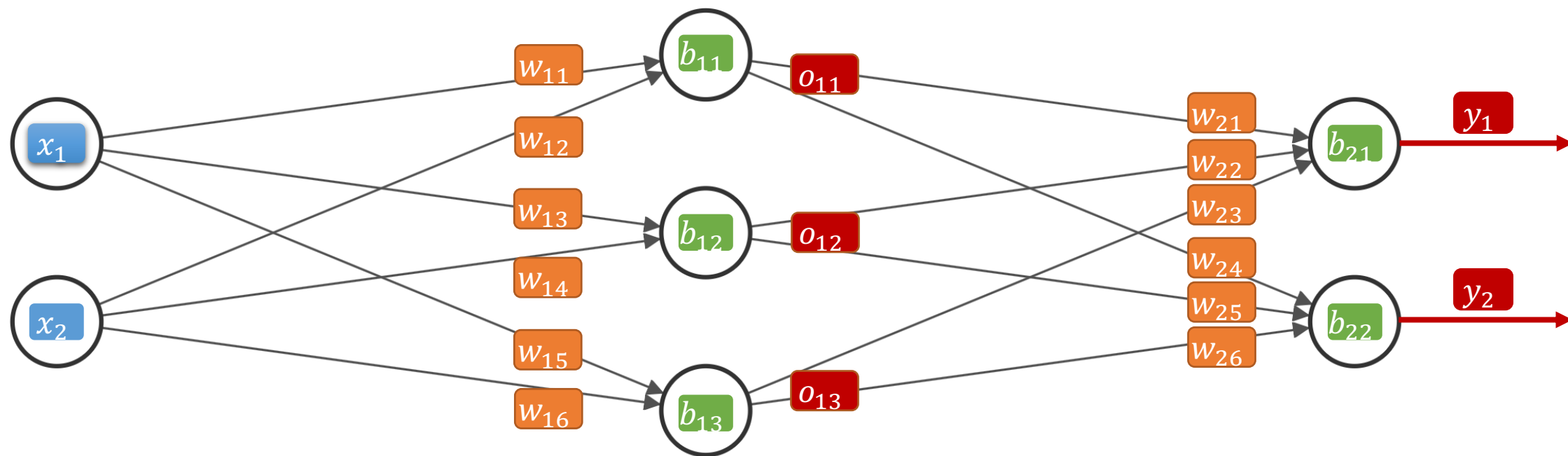
@streamingnology



@streamingnology



streamingnology



Input Layer $\in \mathbb{R}^2$

Hidden Layer $\in \mathbb{R}^3$

Output Layer $\in \mathbb{R}^2$

第一层神经元计算

输入 $X = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

权重 $W1 = \begin{bmatrix} w_{11} & w_{13} & w_{15} \\ w_{12} & w_{14} & w_{16} \end{bmatrix}$

偏置 $b1 = [b_{11} \quad b_{12} \quad b_{13}]$

$$o_{11} = f(x_1 w_{11} + x_2 w_{12} + b_{11})$$

$$o_{12} = f(x_1 w_{13} + x_2 w_{14} + b_{12})$$

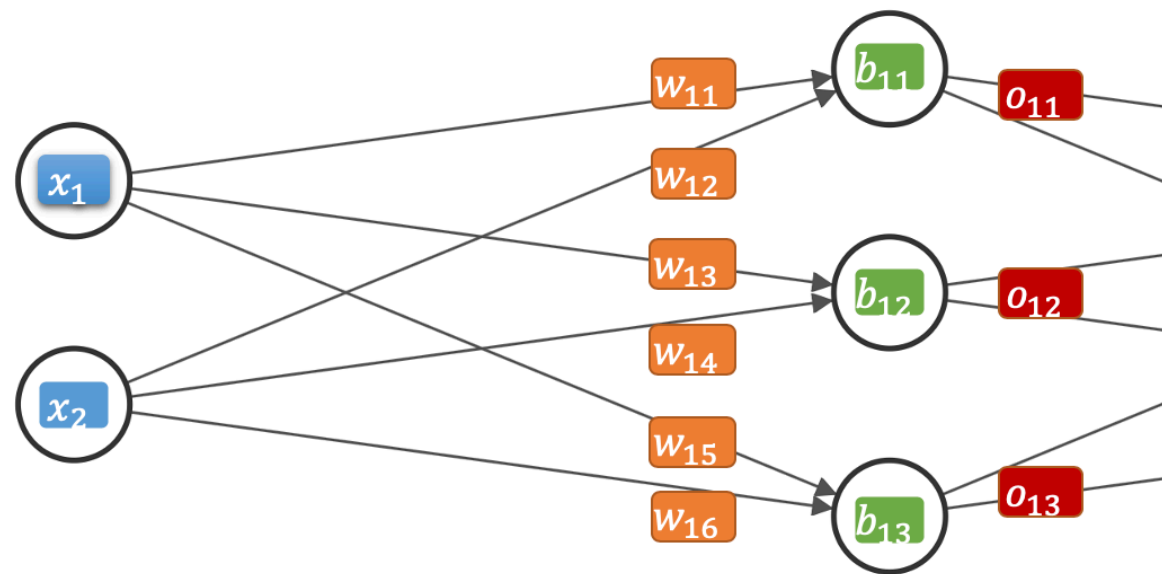
$$o_{13} = f(x_1 w_{15} + x_2 w_{16} + b_{13})$$

$O_1 = f([o_{11} \quad o_{12} \quad o_{13}]) = f(X^T W1 + b1)$

$$= f\left(\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}^T \begin{bmatrix} w_{11} & w_{13} & w_{15} \\ w_{12} & w_{14} & w_{16} \end{bmatrix} + [b_{11} \quad b_{12} \quad b_{13}]\right)$$

$$= f([x_1 w_{11} + x_2 w_{12} \quad x_1 w_{13} + x_2 w_{14} \quad x_1 w_{15} + x_2 w_{16}] + [b_{11} \quad b_{12} \quad b_{13}])$$

$$= f([x_1 w_{11} + x_2 w_{12} + b_{11} \quad x_1 w_{13} + x_2 w_{14} + b_{12} \quad x_1 w_{15} + x_2 w_{16} + b_{13}])$$



f 为非线性函数

第一层神经元计算

输入 $X = \begin{bmatrix} 0.1 \\ 0.2 \end{bmatrix}$

权重 $W1 = \begin{bmatrix} -3 & -2 & -1 \\ 0 & 1 & 2 \end{bmatrix}$

偏置 $b1 = [-0.2 \quad 0.3 \quad -0.1]$

$$o_{11} = \text{ReLU}(0.1 \times (-3) + 0.2 \times 0 + (-0.2)) = \text{ReLU}(-0.5) = 0$$

$$o_{12} = \text{ReLU}(0.1 \times (-2) + 0.2 \times 1 + 0.3) = \text{ReLU}(0.3) = 0.3$$

$$o_{13} = \text{ReLU}(0.1 \times (-1) + 0.2 \times 2 + (-0.1)) = \text{ReLU}(0.2) = 0.2$$

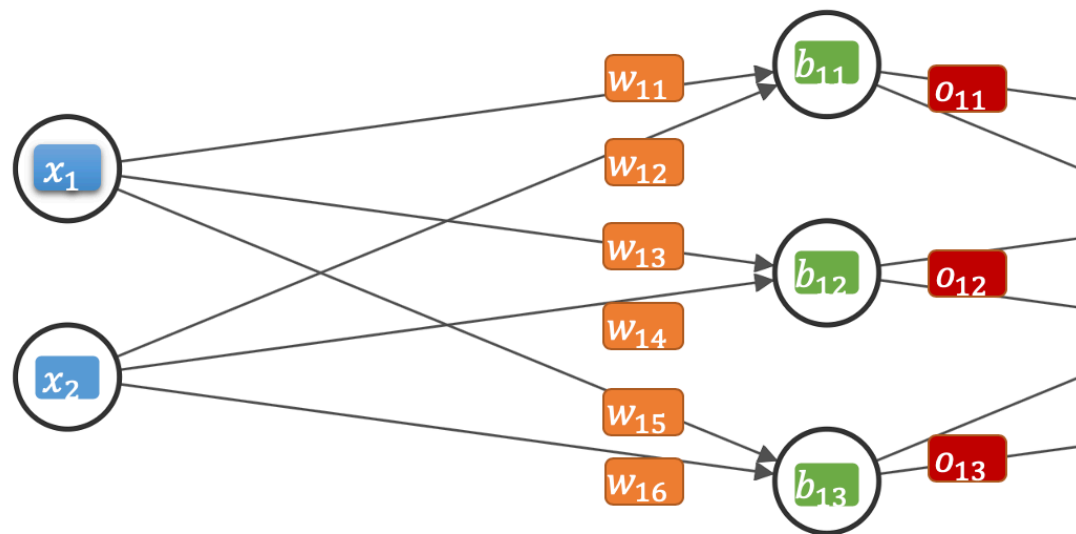
$$O_1 = \text{ReLU}(X^T W1 + b1)$$

$$= \text{ReLU}\left(\begin{bmatrix} 0.1 \\ 0.2 \end{bmatrix}^T \begin{bmatrix} -3 & -2 & -1 \\ 0 & 1 & 2 \end{bmatrix} + [-0.2 \quad 0.3 \quad -0.1]\right)$$

$$= \text{ReLU}([0.1 \times (-3) + 0.2 \times 0 \quad 0.1 \times (-2) + 0.2 \times 1 \quad 0.1 \times (-1) + 0.2 \times 2] + [-0.5 \quad 0.3 \quad 0.2])$$

$$= \text{ReLU}([-0.5 \quad 0.3 \quad 0.2])$$

$$= [0.0 \quad 0.3 \quad 0.2]$$



非线性函数选ReLU

第二层神经元计算

$$\text{输入 } X = \begin{bmatrix} o_{11} \\ o_{12} \\ o_{13} \end{bmatrix}$$

$$\text{权重 } W2 = \begin{bmatrix} w_{21} & w_{24} \\ w_{22} & w_{25} \\ w_{23} & w_{26} \end{bmatrix}$$

$$\text{偏置 } b2 = [b_{21} \quad b_{22}]$$

$$y_1 = f(o_{11}w_{21} + o_{12}w_{22} + o_{13}w_{23} + b_{21})$$

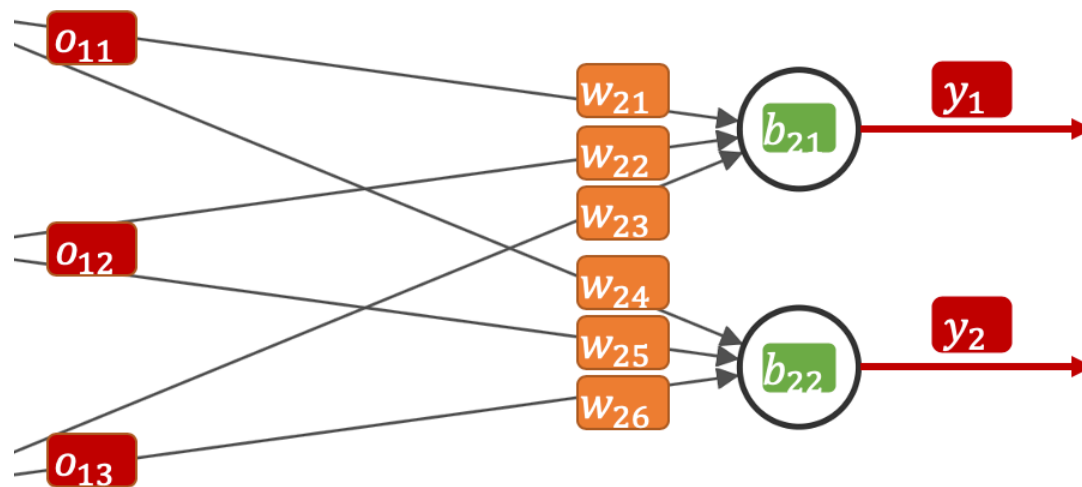
$$y_2 = f(o_{11}w_{24} + o_{12}w_{25} + o_{13}w_{26} + b_{22})$$

$$Y = f([y_1 \quad y_2]) = f(X^T W2 + b2)$$

$$= f\left(\begin{bmatrix} o_{11} \\ o_{12} \\ o_{13} \end{bmatrix}^T \begin{bmatrix} w_{21} & w_{24} \\ w_{22} & w_{25} \\ w_{23} & w_{26} \end{bmatrix} + [b_{21} \quad b_{22}]\right)$$

$$= f([o_{11}w_{21} + o_{12}w_{22} + o_{13}w_{23} \quad o_{11}w_{24} + o_{12}w_{25} + o_{13}w_{26}] + [b_{21} \quad b_{22}])$$

$$= f([o_{11}w_{21} + o_{12}w_{22} + o_{13}w_{23} + b_{21} \quad o_{11}w_{24} + o_{12}w_{25} + o_{13}w_{26} + b_{22}])$$



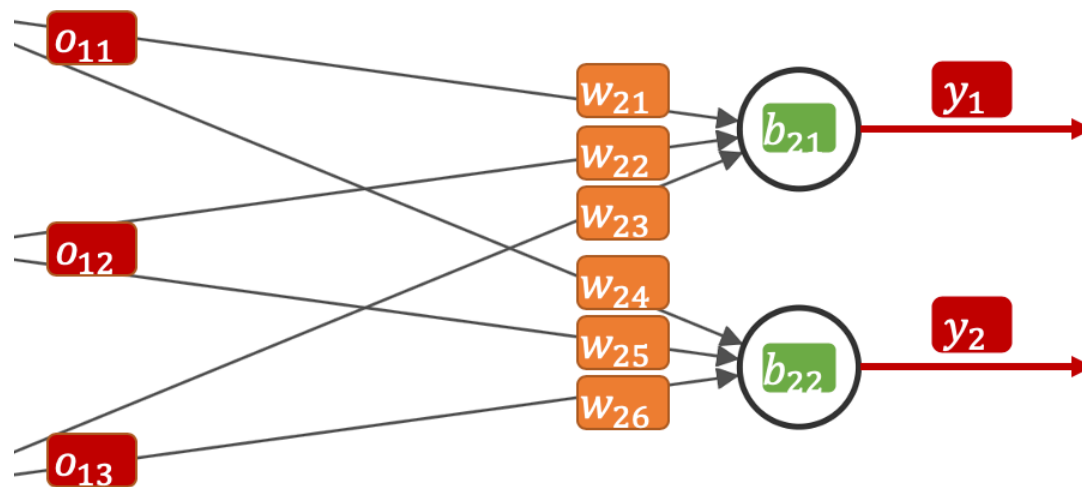
f 为非线性函数

第二层神经元计算

$$\text{输入 } X = \begin{bmatrix} 0.0 \\ 0.3 \\ 0.2 \end{bmatrix}$$

$$\text{权重 } W2 = \begin{bmatrix} -2 & -1 \\ 0 & 1 \\ 2 & 3 \end{bmatrix}$$

$$\text{偏置 } b2 = [0.1 \quad -0.1]$$



$$y_1 = \text{ReLU}(0.0 \times (-2) + 0.3 \times 0 + 0.2 \times 2 + 0.1) = \text{ReLU}(0.5) = 0.5$$

$$y_2 = \text{ReLU}(0.0 \times (-1) + 0.3 \times 1 + 0.2 \times 3 + (-0.1)) = \text{ReLU}(0.8) = 0.8$$

非线性函数选ReLU

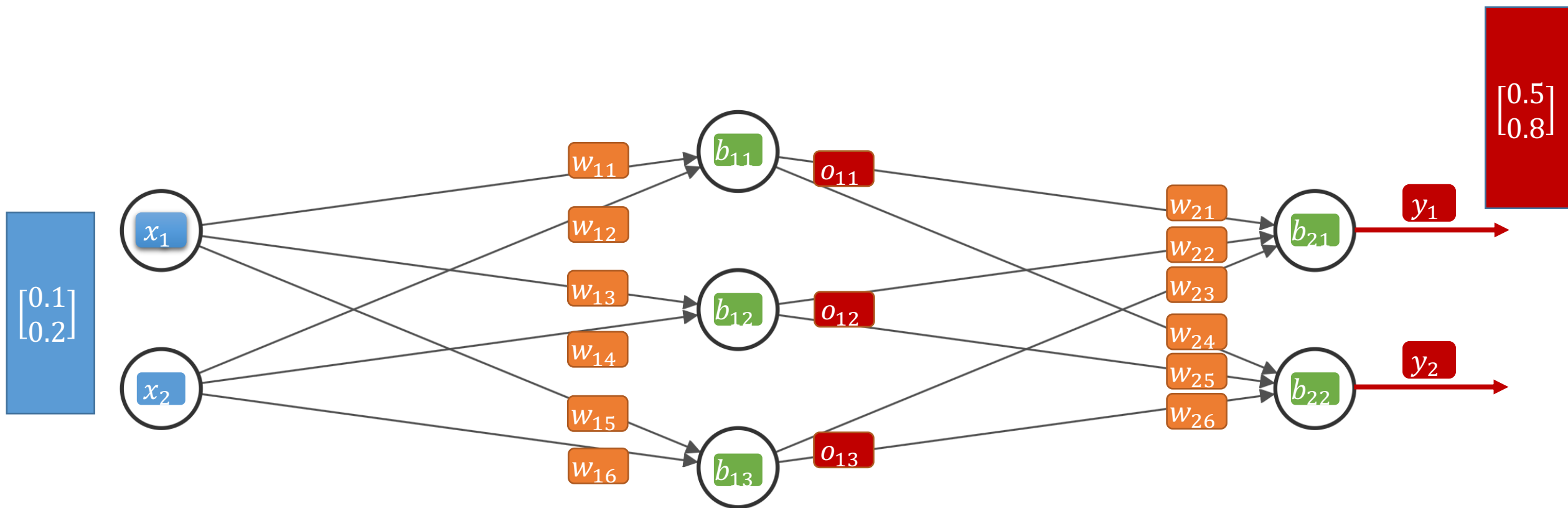
$$Y = \text{ReLU}([y_1 \quad y_2]) = f(X^T W2 + b2)$$

$$= \text{ReLU}\left(\begin{bmatrix} 0.0 \\ 0.3 \\ 0.2 \end{bmatrix}^T \begin{bmatrix} -2 & -1 \\ 0 & 1 \\ 2 & 3 \end{bmatrix} + [0.1 \quad -0.1]\right)$$

$$= \text{ReLU}([0.0 \times (-2) + 0.3 \times 0 + 0.2 \times 2 \quad 0.0 \times (-1) + 0.3 \times 1 + 0.2 \times 3] + [0.1 \quad -0.1])$$

$$= \text{ReLU}([0.5 \quad 0.8])$$

$$= [0.5 \quad 0.8]$$



Input Layer $\in \mathbb{R}^2$

Hidden Layer $\in \mathbb{R}^3$

Output Layer $\in \mathbb{R}^2$