Deep Learning

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https://github.com/safayani/deep_learning_course

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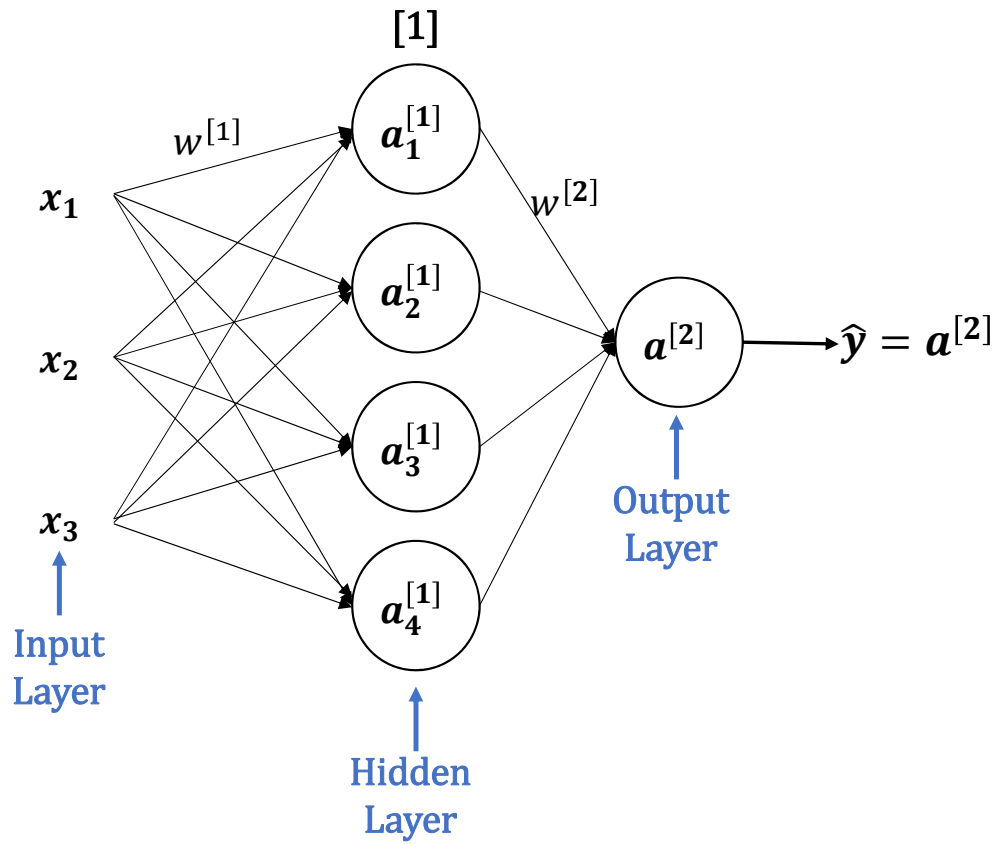
Neural Network Representation

Neural Network Representation



2 layer NN

$w^{[1]}$ $, b^{[1]}$

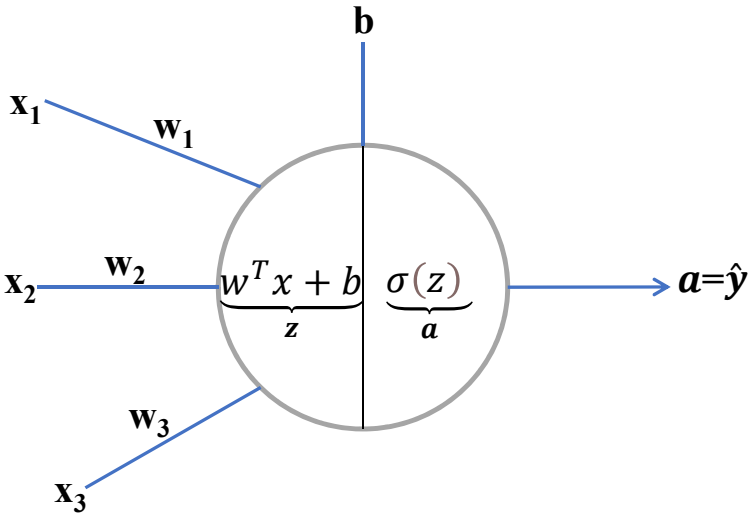
(4×3) (4×1)

$w^{[2]}, b^{[2]}$

(1,4) (1,1)

$$a = \begin{bmatrix} a_1^{[1]} \\ a_2^{[1]} \\ a_3^{[1]} \\ a_4^{[1]} \end{bmatrix}$$

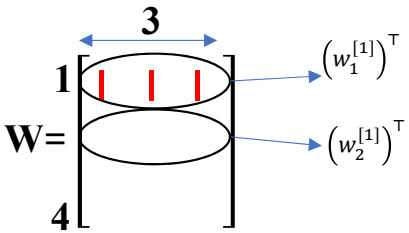
Neural Network Representation

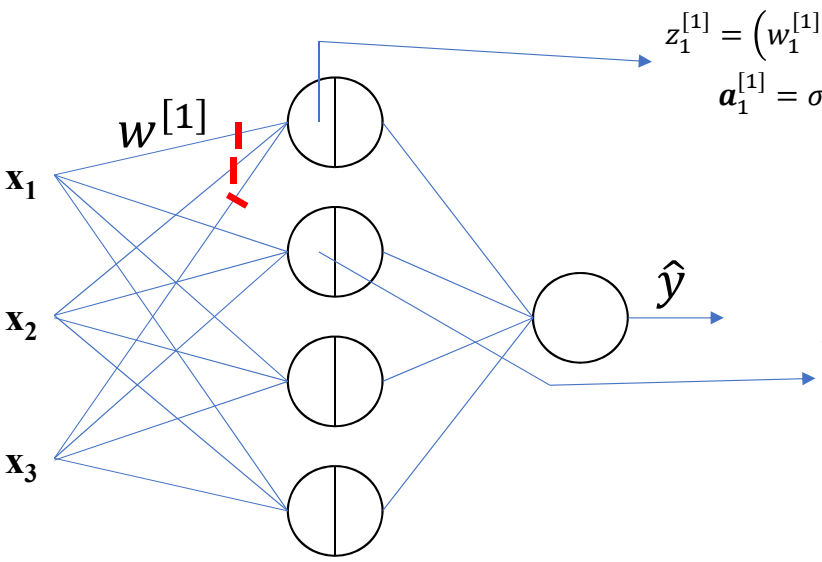


$$z = w^T x + b$$

$$a = \sigma(z)$$

Neural Network Representation





$$z_1^{[1]} = \left(w_1^{[1]}\right)^T x + b_1^{[1]}$$
$$\boldsymbol{a}_1^{[1]} = \sigma\left(z_1^{[1]}\right)$$

$$z_2^{[1]} = \left(w_2^{[1]}\right)^T x + b_2^{[1]}$$
$$\boldsymbol{a}_2^{[1]} = \sigma\left(z_2^{[1]}\right)$$

$$z_3^{[1]} = \left(w_3^{[1]}\right)^T x + b_3^{[1]}$$
$$\boldsymbol{a}_3^{[1]} = \sigma\left(z_3^{[1]}\right)$$

$$z_4^{[1]} = \left(w_4^{[1]}\right)^T x + b_4^{[1]}$$
$$\boldsymbol{a}_4^{[1]} = \sigma\left(z_4^{[1]}\right)$$

Neural Network Representation

- $$Z^{[1]} = \begin{bmatrix} w_1^{[1]T} \\ w_2^{[1]T} \\ w_3^{[1]T} \\ w_4^{[1]T} \end{bmatrix}_{(4,3)} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}_{(3,1)} + \begin{bmatrix} b_1^{[1]} \\ b_2^{[1]} \\ b_3^{[1]} \\ b_4^{[1]} \end{bmatrix}_{(4,1)} = \begin{bmatrix} w_1^{[1]T} x + b_1^{[1]} \\ w_2^{[1]T} x + b_2^{[1]} \\ w_3^{[1]T} x + b_3^{[1]} \\ w_4^{[1]T} x + b_4^{[1]} \end{bmatrix} = \begin{bmatrix} z_1^{[1]} \\ z_2^{[1]} \\ z_3^{[1]} \\ z_4^{[1]} \end{bmatrix}$$

- $$a^{[1]} = \begin{bmatrix} a_1^{[1]} \\ a_2^{[1]} \\ a_3^{[1]} \\ a_4^{[1]} \end{bmatrix} = \sigma(z^{[1]}) = \begin{bmatrix} \sigma\left(z_1^{[1]}\right) \\ \sigma\left(z_2^{[1]}\right) \\ \sigma\left(z_3^{[1]}\right) \\ \sigma\left(z_4^{[1]}\right) \end{bmatrix}$$

Neural Network Representation

- $z^{[1]}_{4\times 1} = w^{[1]}_{4\times 3}\ \overbrace{x}^{a^{[0]}}_{3\times 1} + b^{[1]}_{4\times 1}$
- $a^{[1]}_{4\times 1} = \sigma\left(z^{[1]}_{4\times 1}\right)$
- $z^{[2]}_{1\times 1} = w^{[2]}_{1\times 4} a^{[1]}_{4\times 1} + b^{[2]}_{1\times 1}$
- $a^{[2]}_{1\times 1} = \sigma\left(z^{[2]}_{1\times 1}\right)$
- For i=1 to m

$$z^{[1](i)} = w^{[1]} x^{(i)} + b^{[1]}$$
$$a^{[1](i)} = \sigma\left(z^{[1](i)}\right)$$
$$z^{[2](i)} = w^{[2]} a^{[1](i)} + b^{[2]}$$
$$a^{[2](i)} = \sigma\left(z^{[2](i)}\right)$$

Neural Network Representation

- $X = \begin{bmatrix} x^{(1)} x^{(2)} & \dots\dots\dots & x^{(m)} \end{bmatrix}_{(n_x, m)}$

- $Z^{[1]}{}_{4 \times m} = W^{[1]}{}_{4 \times 3} X_{3 \times m} + \underbrace{b^{[1]}}_{broadcasting}{}_{4 \times 1}$

$$Z^{[1]} = \begin{bmatrix} z^{[1](1)} z^{[1](2)} & \dots\dots\dots & z^{[1](m)} \end{bmatrix}$$

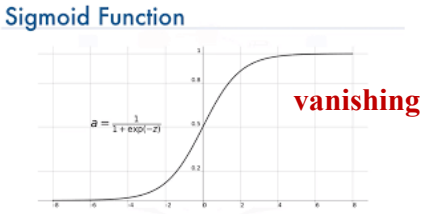
- $A^{[1]}{}_{4 \times m} = \sigma\left(Z^{[1]}{}_{4 \times m}\right)$

$$A^{[1]} = \begin{bmatrix} a^{[1](1)} a^{[1](2)} & \dots\dots\dots & a^{[1](m)} \end{bmatrix}$$

- $Z^{[2]}{}_{1 \times m} = W^{[2]}{}_{1 \times 4} A^{[1]}{}_{4 \times m} + b^{[2]}{}_{1 \times 1}$
- $A^{[2]}{}_{1 \times m} = \sigma\left(Z^{[2]}{}_{1 \times m}\right)$

Activation function

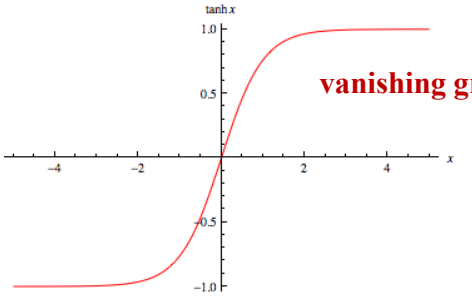
- $sigmoid(z) = \frac{1}{1+e^{-z}}$ **don't be used except for output**



vanishing gradients

https://medium.com/

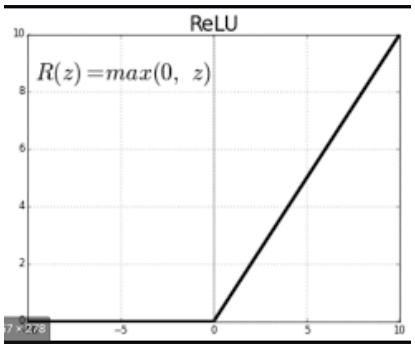
- $\tanh(z) = \frac{e^{z}-e^{-z}}{e^{z}+e^{-z}}$ **don't be used except for output**



vanishing gradients

https://mathworld.wolfram.com/

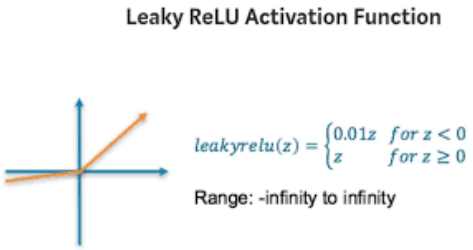
- $Relu(z) = \max(0, z) = \begin{cases} z & z \geq 0 \\ 0 & z < 0 \end{cases}$ **default**



https://medium.com/

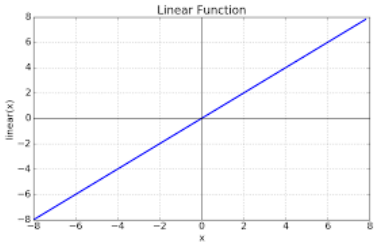
Activation function

- $Leaky\ Relu(z) = \begin{cases} z & z \geq 0 \\ 0.01z & z < 0 \end{cases}$

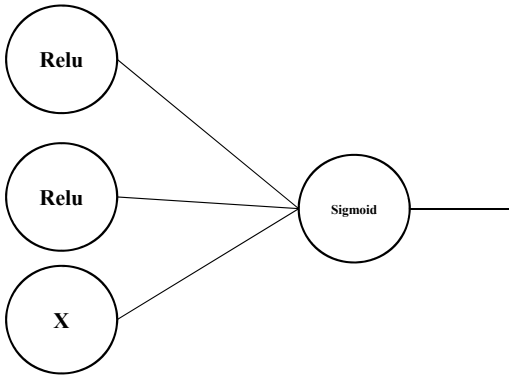


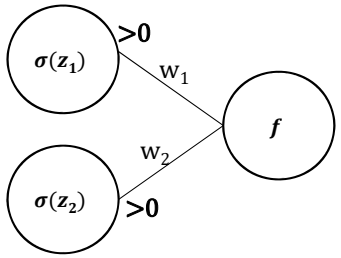
https://medium.com/

- $Linear(z) = z$



https://towardsdatascience.com/





Same sign

$$dw_1 = \partial\, \underbrace{\sigma(z_1)}_{>0}$$

$$dw_2 = \partial\, \underbrace{\sigma(z_2)}_{>0}$$