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# Deep Neural Networks

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Forward and backward  
propagation

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# Forward propagation for layer $l$



$$z^{[l]} = W^{[l]} \cdot a^{[l-1]} + b^{[l]}$$

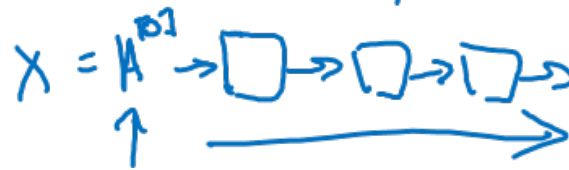
$$a^{[l]} = g^{[l]}(z^{[l]})$$

Vectorized:

$$Z^{[l]} = W^{[l]} \cdot A^{[l-1]} + b^{[l]}$$

$$A^{[l]} = g^{[l]}(Z^{[l]})$$


$a^{[0]}$   
 $A^{[0]}$



# Backward propagation for layer $l$

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$$\underline{dz}^{[l]} = \underline{da}^{[l]} * g^{[l]'}(z^{[l]})$$

$$\underline{dw}^{[l]} = \underline{dz}^{[l]} \cdot \underline{a}^{[l-1]}$$

$$\underline{db}^{[l]} = \underline{dz}^{[l]}$$

$$\underline{da}^{[l-1]} = W^{[l]T} \cdot \underline{dz}^{[l]}$$

$$\underline{dz}^{[l-1]} = W^{[l+1]T} \underline{dz}^{[l]} * g^{[l]'}(z^{[l]})$$

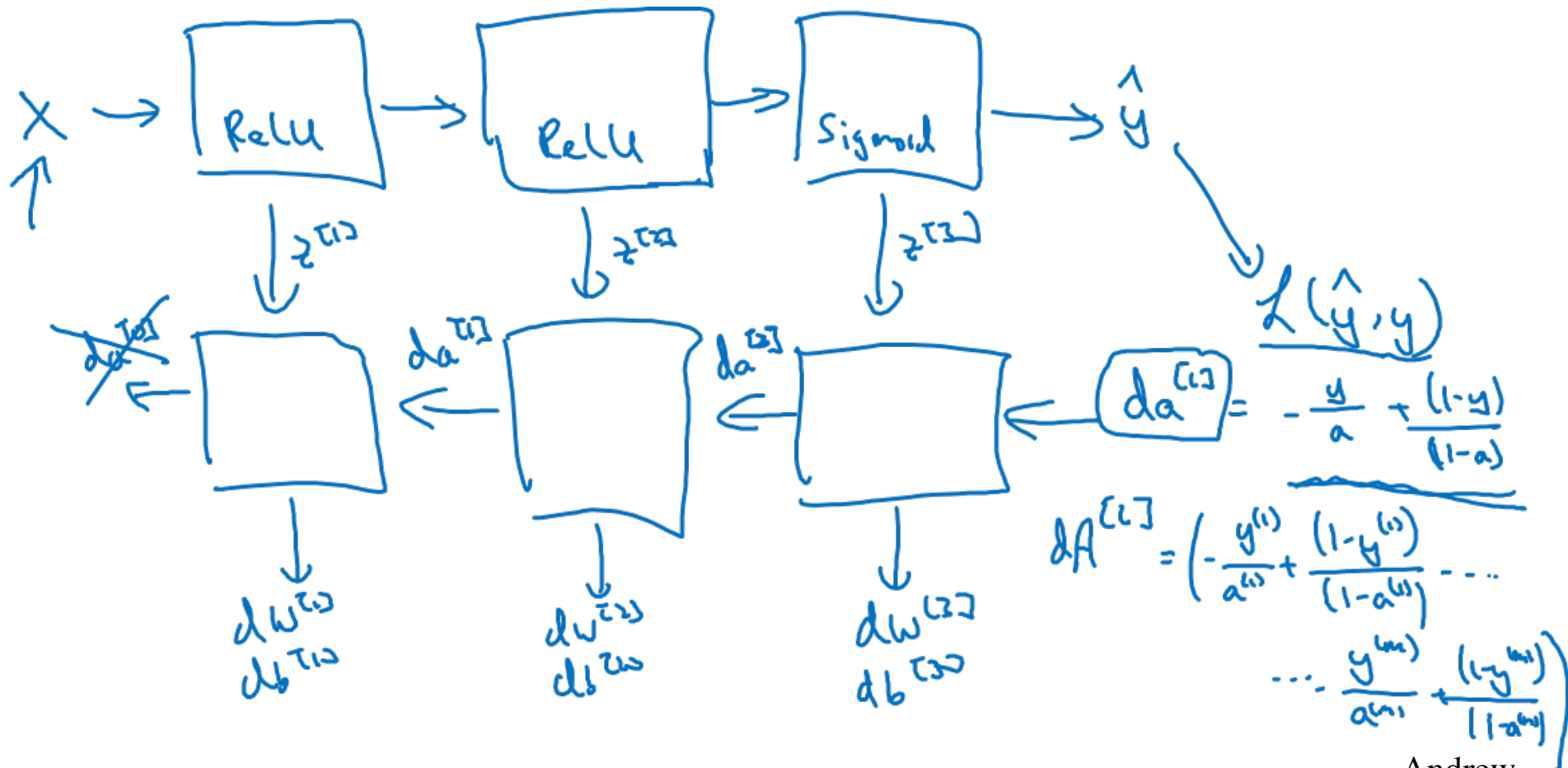
$$\underline{dz}^{[l]} = \underline{dA}^{[l]} * g^{[l]'}(z^{[l]})$$

$$\underline{dw}^{[l]} = \frac{1}{n} \underline{dz}^{[l]} \cdot A^{[l-1]T}$$

$$\underline{db}^{[l]} = \frac{1}{n} \text{np.sum}(\underline{dz}^{[l]}, \text{axis}=1, \text{keepdims}=\text{True})$$

$$\underline{dA}^{[l-1]} = W^{[l]T} \cdot \underline{dz}^{[l]}$$

# Summary





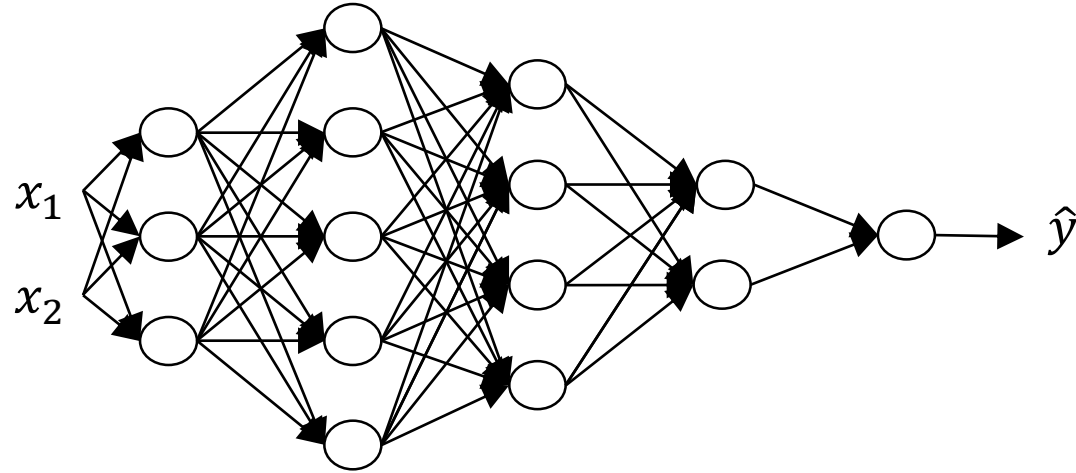
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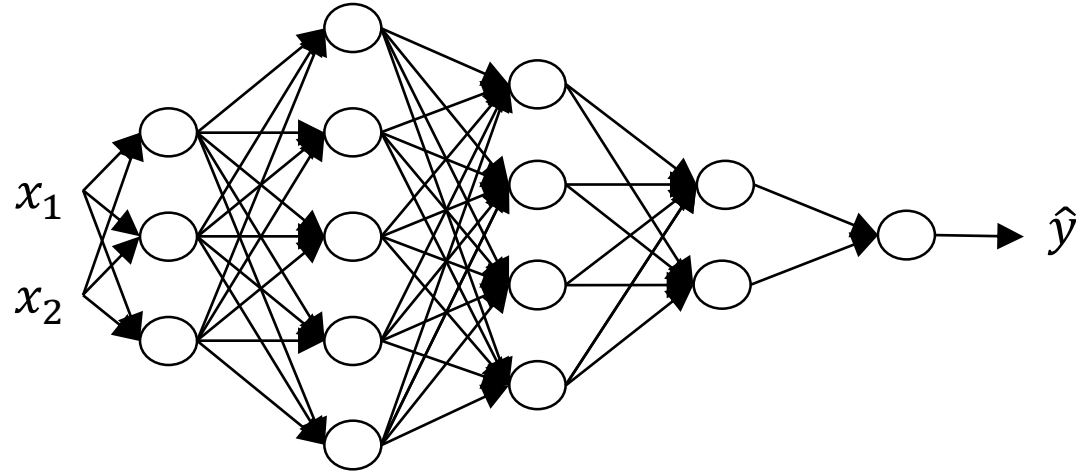
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Getting your matrix  
dimensions right

# Parameters $W^{[l]}$ and $b^{[l]}$



# Vectorized implementation





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# Deep Neural Networks

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What does this  
have to do with  
the brain?



# Forward and backward propagation

$$Z^{[1]} = W^{[1]}X + b^{[1]}$$

$$A^{[1]} = g^{[1]}(Z^{[1]})$$

$$Z^{[2]} = W^{[2]}A^{[1]} + b^{[2]}$$

$$A^{[2]} = g^{[2]}(Z^{[2]})$$

$$\vdots$$

$$A^{[L]} = g^{[L]}(Z^{[L]}) = \hat{Y}$$

$$dZ^{[L]} = A^{[L]} - Y$$

$$dW^{[L]} = \frac{1}{m} dZ^{[L]} A^{[L]T}$$

$$db^{[L]} = \frac{1}{m} \text{np.sum}(dZ^{[L]}, \text{axis} = 1, \text{keepdims} = \text{True})$$

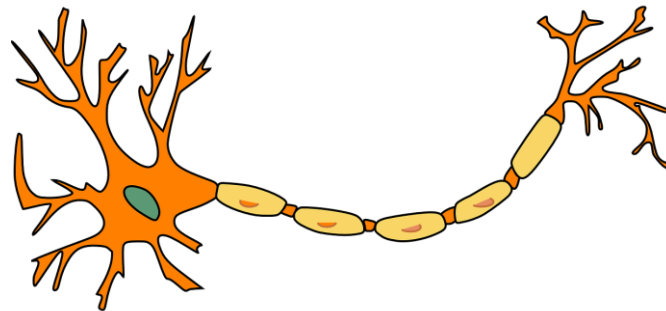
$$dZ^{[L-1]} = dW^{[L]T} dZ^{[L]} g'^{[L]}(Z^{[L-1]})$$

$$\vdots$$

$$dZ^{[1]} = dW^{[L]T} dZ^{[2]} g'^{[1]}(Z^{[1]})$$

$$dW^{[1]} = \frac{1}{m} dZ^{[1]} A^{[1]T}$$

$$db^{[1]} = \frac{1}{m} \text{np.sum}(dZ^{[1]}, \text{axis} = 1, \text{keepdims} = \text{True})$$





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## Parameters vs Hyperparameters

# What are hyperparameters?

Parameters:  $W^{[1]}$  ,  $b^{[1]}$  ,  $W^{[2]}$  ,  $b^{[2]}$  ,  $W^{[3]}$  ,  $b^{[3]}$  ...

# Applied deep learning is a very empirical process

