

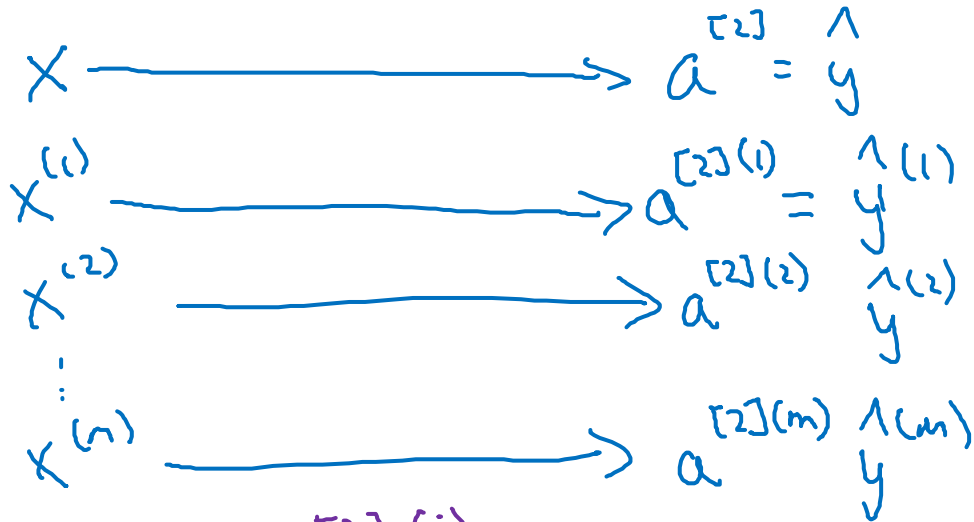
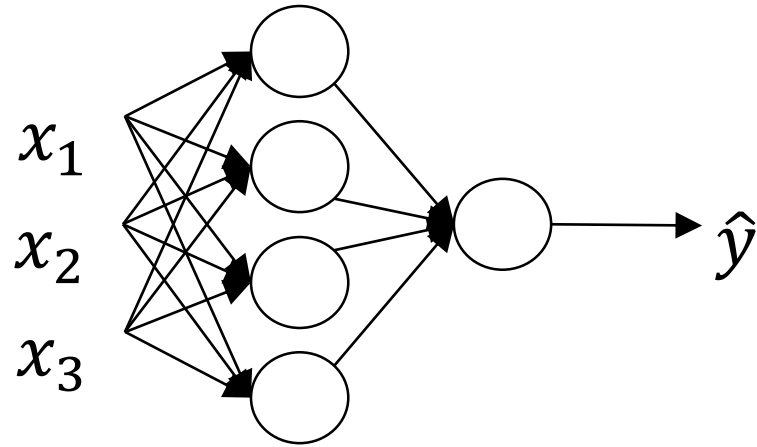


deeplearning.ai

One hidden layer Neural Network

**Vectorizing across
multiple examples**

Vectorizing across multiple examples



$a^{[2](i)}$
 $\nwarrow \nearrow$ example i
 layer 2

$$z^{[1]} = W^{[1]}x + b^{[1]}$$

$$a^{[1]} = \sigma(z^{[1]})$$

$$z^{[2]} = W^{[2]}a^{[1]} + b^{[2]}$$

$$a^{[2]} = \sigma(z^{[2]})$$

for $i = 1$ to m ,

$$z^{[1](i)} = W^{[1]}x^{(i)} + b^{[1]}$$

$$a^{[1](i)} = \sigma(z^{[1](i)})$$

$$z^{[2](i)} = W^{[2]}a^{[1](i)} + b^{[2]}$$

$$a^{[2](i)} = \sigma(z^{[2](i)})$$

Vectorizing across multiple examples

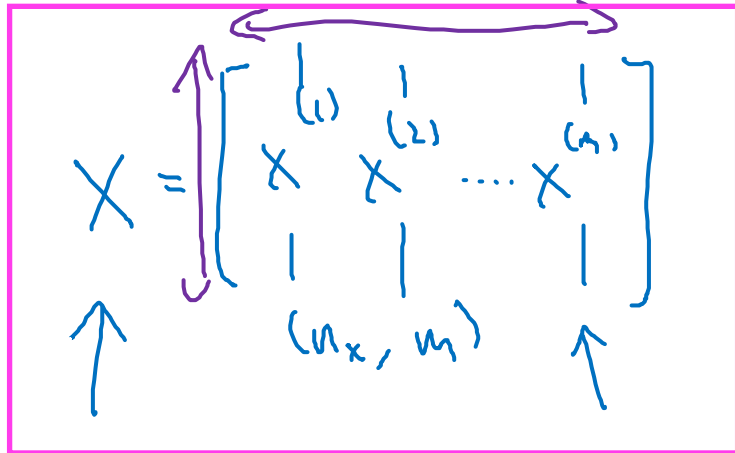
for $i = 1$ to m :

$$z^{[1]}(i) = W^{[1]}x^{(i)} + b^{[1]}$$

$$a^{[1]}(i) = \sigma(z^{[1]}(i))$$

$$z^{[2]}(i) = W^{[2]}a^{[1]}(i) + b^{[2]}$$

$$a^{[2]}(i) = \sigma(z^{[2]}(i))$$



training examples

hidden units.

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

$$\rightarrow A^{[1]} = \sigma(z^{[1]})$$

$$\rightarrow z^{[2]} = W^{[2]}A^{[1]} + b^{[2]}$$

$$\rightarrow A^{[2]} = \sigma(z^{[2]})$$

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

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

hidden units



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One hidden layer Neural Network

Explanation
for vectorized
implementation

Justification for vectorized implementation

$$z^{1} = \underbrace{w^{[1]} x^{(1)}}_{\text{purple}} + \cancel{b^{[1]}}_{\text{red}}, \quad z^{[1](2)} = \underbrace{w^{[1]} x^{(2)}}_{\text{green}} + \cancel{b^{[1]}}_{\text{red}}, \quad z^{[1](3)} = \underbrace{w^{[1]} x^{(3)}}_{\text{yellow}} + \cancel{b^{[1]}}_{\text{red}}$$

$$w^{[1]} = \begin{bmatrix} \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \end{bmatrix} \quad w^{[1]} x^{(1)} = \begin{bmatrix} \bullet \\ \bullet \\ \bullet \\ \bullet \end{bmatrix} \quad w^{[1]} x^{(2)} = \begin{bmatrix} \bullet \\ \bullet \\ \bullet \\ \bullet \end{bmatrix} \quad w^{[1]} x^{(3)} = \begin{bmatrix} \bullet \\ \bullet \\ \bullet \\ \bullet \end{bmatrix}$$

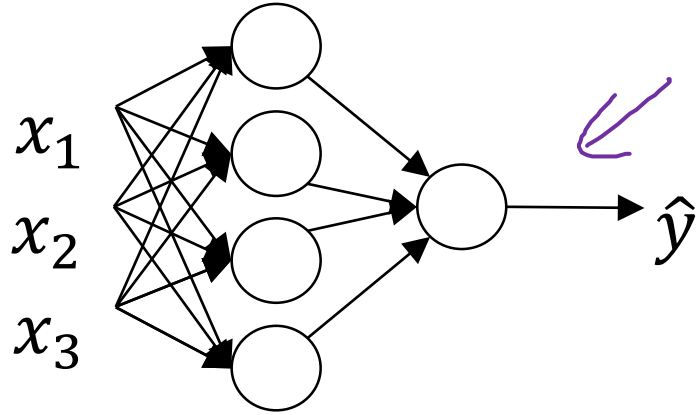
$$w^{[1]} \begin{bmatrix} | & | & | & \dots \\ x^{(1)} & x^{(2)} & x^{(3)} & \dots \\ | & | & | & \dots \end{bmatrix} = \begin{bmatrix} \bullet & \bullet & \bullet & \dots \\ \bullet & \bullet & \bullet & \dots \\ \bullet & \bullet & \bullet & \dots \\ \bullet & \bullet & \bullet & \dots \end{bmatrix} = \begin{bmatrix} | & | & | & \dots \\ z^{1} & z^{[1](2)} & z^{[1](3)} & \dots \\ | & | & | & \dots \end{bmatrix} = z^{[1]}$$

$\hat{X} \quad \quad \quad w^{[1]} \hat{X} = z^{[1]}$

$z^{[1]} = w^{[1]} X + b^{[1]}$

(Note: In the diagram, the bias term $b^{[1]}$ is shown as a vector of zeros, indicated by red arrows pointing to 0.)

Recap of vectorizing across multiple examples



$$X = \begin{bmatrix} | & | & | & | \\ x^{(1)} & x^{(2)} & \dots & x^{(m)} \\ | & | & | & | \end{bmatrix}$$

A purple arrow points from the matrix X towards the right.

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

A purple arrow points from the matrix $A^{[1]}$ towards the right.

for $i = 1$ to m

$$\rightarrow z^{[1]}(i) = W^{[1]}x^{(i)} + b^{[1]}$$

$$\rightarrow a^{[1]}(i) = \sigma(z^{[1]}(i))$$

$$\rightarrow z^{[2]}(i) = W^{[2]}a^{[1]}(i) + b^{[2]}$$

$$\rightarrow a^{[2]}(i) = \sigma(z^{[2]}(i))$$

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

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

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

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

Handwritten notes in blue:

- $x = a^{[0]}$
- $x^{(i)} = a^{[0]}(i)$

Handwritten note in blue:

$$W^{[1]}A^{[0]} + b^{[1]}$$