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# Basics of Neural Network Programming

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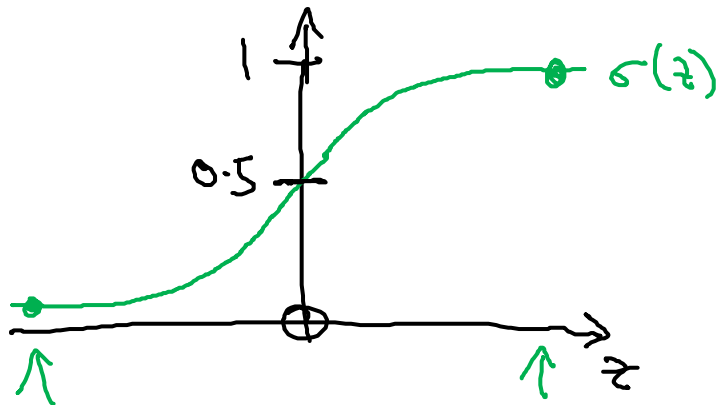
## Logistic Regression

# Logistic Regression

Given  $x$ , want  $\hat{y} = \frac{P(y=1|x)}{0 \leq \hat{y} \leq 1}$   
 $x \in \mathbb{R}^{n_x}$

Parameters:  $\underline{w} \in \mathbb{R}^{n_x}$ ,  $\underline{b} \in \mathbb{R}$ .

Output  $\hat{y} = \sigma(\underbrace{w^T x + b}_z)$



$$x_0 = 1, \quad x \in \mathbb{R}^{n_x+1}$$
$$\hat{y} = \sigma(\theta^T x)$$

$$\theta = \begin{bmatrix} \theta_0 \\ \theta_1 \\ \theta_2 \\ \vdots \\ \theta_{n_x} \end{bmatrix} \quad \left. \begin{array}{l} \} b \leftarrow \\ \} w \leftarrow \end{array} \right\}$$

$$\sigma(z) = \frac{1}{1 + e^{-z}}$$

$$\text{If } z \text{ large } \sigma(z) \approx \frac{1}{1+0} = 1$$

If  $z$  large negative number

$$\sigma(z) = \frac{1}{1 + e^{-z}} \approx \frac{1}{1 + \text{Big num}} \approx 0$$



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## Logistic Regression cost function

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$$\rightarrow \hat{y}^{(i)} = \sigma(w^T \underline{x^{(i)}} + b), \text{ where } \sigma(\underline{z^{(i)}}) = \frac{1}{1+e^{-z^{(i)}}} \quad z^{(i)} = w^T x^{(i)} + b$$

Given  $\{(x^{(1)}, y^{(1)}), \dots, (x^{(m)}, y^{(m)})\}$ , want  $\hat{y}^{(i)} \approx y^{(i)}$ .

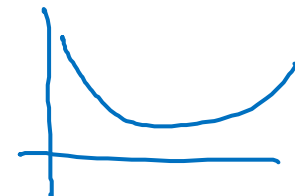
$x^{(i)}$   
 $y^{(i)}$   
 $z^{(i)}$

i-th  
example.

**Loss** (error)  
function:

$$\underline{\mathcal{L}(\hat{y}, y)} = \frac{1}{2} (\hat{y} - y)^2$$

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$$\underline{\mathcal{L}(\hat{y}, y)} = - \left[ \underline{y \log \hat{y}} + \underline{(1-y) \log (1-\hat{y})} \right] \leftarrow$$

If  $\underline{y=1}$ :  $\mathcal{L}(\hat{y}, y) = -\log \hat{y} \leftarrow$  Want  $\log \hat{y}$  large, Want  $\hat{y}$  large

If  $\underline{y=0}$ :  $\mathcal{L}(\hat{y}, y) = -\log (1-\hat{y}) \leftarrow$  Want  $\log (1-\hat{y})$  large ... Want  $\hat{y}$  small

**Cost** function:  $\underline{J(w, b)} = \frac{1}{m} \sum_{i=1}^m \mathcal{L}(\hat{y}^{(i)}, y^{(i)}) = \frac{1}{m} \sum_{i=1}^m \left[ y^{(i)} \log \hat{y}^{(i)} + (1-y^{(i)}) \log (1-\hat{y}^{(i)}) \right]$