

# Backpropagation Algorithm

"Backpropagation" is neural-network terminology for minimizing our cost function, just like what we were doing with gradient descent in logistic and linear regression. Our goal is to compute:

$$\min_{\Theta} J(\Theta)$$

That is, we want to minimize our cost function  $J$  using an optimal set of parameters in  $\Theta$ . In this section we'll look at the equations we use to compute the partial derivative of  $J(\Theta)$ :

$$\frac{\partial}{\partial \Theta_{i,j}^{(l)}} J(\Theta)$$

To do so, we use the following algorithm:

**Backpropagation algorithm**

- Training set  $\{(x^{(1)}, y^{(1)}), \dots, (x^{(m)}, y^{(m)})\}$
- Set  $\Delta_{ij}^{(l)} = 0$  (for all  $l, i, j$ ). *(use to compute  $\frac{\partial}{\partial \Theta_{ij}^{(l)}} J(\Theta)$ )*
- For  $i = 1$  to  $m \leftarrow (x^{(i)}, y^{(i)})$ .
  - Set  $a^{(1)} = x^{(i)}$
  - Perform forward propagation to compute  $a^{(l)}$  for  $l = 2, 3, \dots, L$
  - Using  $y^{(i)}$ , compute  $\delta^{(L)} = a^{(L)} - y^{(i)}$
  - Compute  $\delta^{(L-1)}, \delta^{(L-2)}, \dots, \delta^{(2)}$
  - $\Delta_{ij}^{(l)} := \Delta_{ij}^{(l)} + a_j^{(l)} \delta_i^{(l+1)}$  *( $\delta^{(l)} := \Delta^{(l)} + \delta^{(l+1)} (a^{(l)})^T$ )*
- $D_{ij}^{(l)} := \frac{1}{m} \Delta_{ij}^{(l)} + \lambda \Theta_{ij}^{(l)}$  if  $j \neq 0$
- $D_{ij}^{(l)} := \frac{1}{m} \Delta_{ij}^{(l)}$  if  $j = 0$

$\frac{\partial}{\partial \Theta_{ij}^{(l)}} J(\Theta) = D_{ij}^{(l)}$

## Back propagation Algorithm

Given training set  $\{(x^{(1)}, y^{(1)}) \dots (x^{(m)}, y^{(m)})\}$

- Set  $\Delta_{i,j}^{(l)} := 0$  for all  $(l, i, j)$ , (hence you end up having a matrix full of zeros)

For training example  $t=1$  to  $m$ :