

# Standard notations for Deep Learning

This document has the purpose of discussing a new standard for deep learning mathematical notations.

## 1 Neural Networks Notations.

### General comments:

- superscript (i) will denote the  $i^{th}$  training example while superscript [l] will denote the  $l^{th}$  layer

### Sizes:

- $m$  : number of examples in the dataset
- $n_x$  : input size
- $n_y$  : output size (or number of classes)
- $n_h^{[l]}$  : number of hidden units of the  $l^{th}$  layer

In a for loop, it is possible to denote  $n_x = n_h^{[0]}$  and  $n_y = n_h^{[\text{number of layers} + 1]}$ .

- $L$  : number of layers in the network.

### Objects:

- $X \in \mathbb{R}^{n_x \times m}$  is the input matrix
- $x^{(i)} \in \mathbb{R}^{n_x}$  is the  $i^{th}$  example represented as a column vector

- $Y \in \mathbb{R}^{n_y \times m}$  is the label matrix

- $y^{(i)} \in \mathbb{R}^{n_y}$  is the output label for the  $i^{th}$  example

- $W^{[l]} \in \mathbb{R}^{\text{number of units in next layer} \times \text{number of units in the previous layer}}$  is the weight matrix, superscript [l] indicates the layer

- $b^{[l]} \in \mathbb{R}^{\text{number of units in next layer}}$  is the bias vector in the  $l^{th}$  layer

- $\hat{y} \in \mathbb{R}^{n_y}$  is the predicted output vector. It can also be denoted  $a^{[L]}$  where  $L$  is the number of layers in the network.

### Common forward propagation equation examples:

$a = g^{[l]}(W_x x^{(i)} + b_1) = g^{[l]}(z_1)$  where  $g^{[l]}$  denotes the  $l^{th}$  layer activation function

$$\hat{y}^{(i)} = \text{softmax}(W_h h + b_2)$$

- General Activation Formula:  $a_j^{[l]} = g^{[l]}(\sum_k w_{jk}^{[l]} a_k^{[l-1]} + b_j^{[l]}) = g^{[l]}(z_j^{[l]})$

- $J(x, W, b, y)$  or  $J(\hat{y}, y)$  denote the cost function.

### Examples of cost function:

$$J_{CE}(\hat{y}, y) = - \sum_{i=0}^m y^{(i)} \log \hat{y}^{(i)}$$

$$J_1(\hat{y}, y) = \sum_{i=0}^m |y^{(i)} - \hat{y}^{(i)}|$$

## 2 Deep Learning representations

**For representations:**

- nodes represent inputs, activations or outputs
- edges represent weights or biases

Here are several examples of Standard deep learning representations

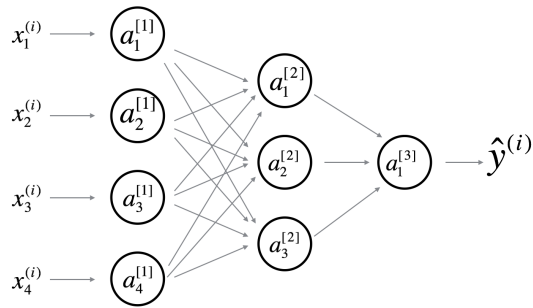


Figure 1: Comprehensive Network: representation commonly used for Neural Networks. For better aesthetic, we omitted the details on the parameters ( $w_{ij}^{[l]}$  and  $b_i^{[l]}$  etc...) that should appear on the edges

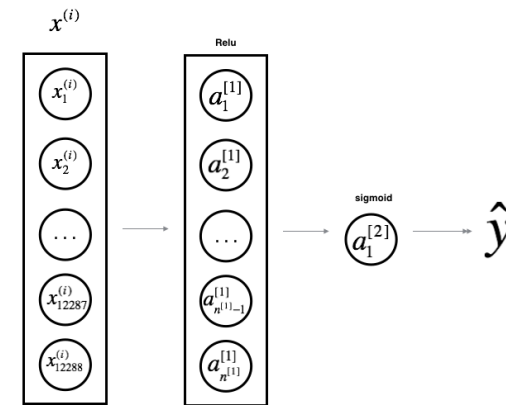


Figure 2: Simplified Network: a simpler representation of a two layer neural network, both are equivalent.