

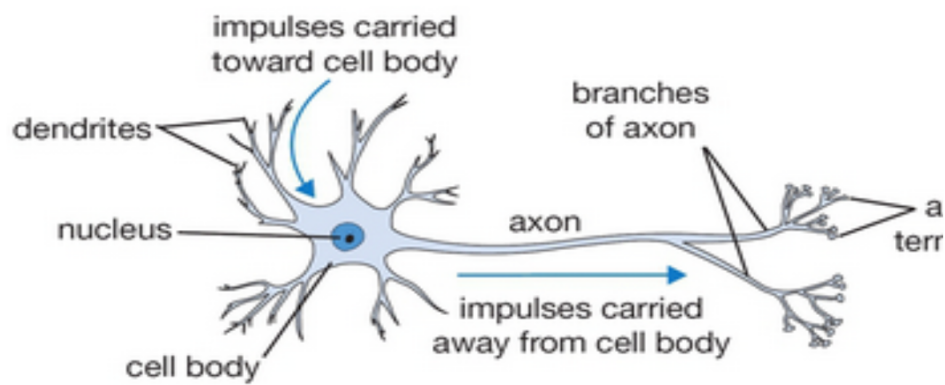
UNIVERSITÉ DE BORDEAUX

DEEP LEARNING

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## Deep Neural Networks ( lab2 )

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**One Neuron :** Following the course, we first used the architecture of one neuron :

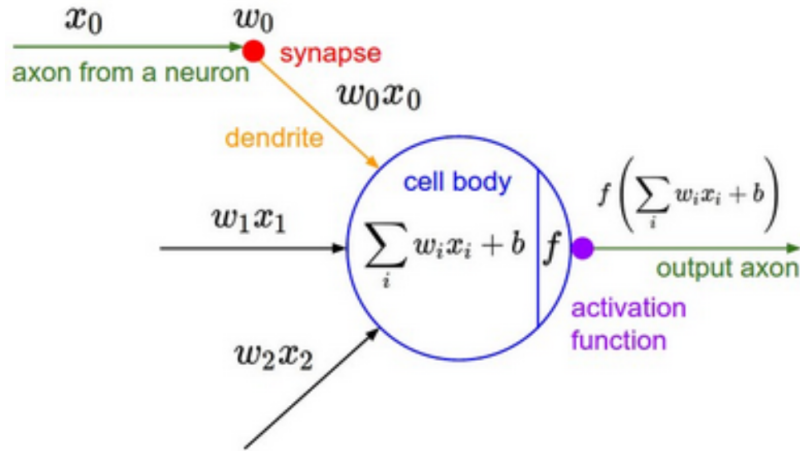


FIGURE 1 – A simple architecture of a neural network

Where we take the pixels of the image as the input, the weights are taken as a random vector while we  $f$  is the sigmoid functions :

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

And  $Y$  as the output as  $\sigma(w^T x + b)$

**Forward Propagation :** The mathematical expression for the loss function using the cross entropy is :

$$L(x) = - \sum Y \log(\hat{Y}) + \sum (1 - Y) \log(1 - \hat{Y})$$

**Backward Propagation :** The derivative of  $L$  in accordance to its component  $W$  ( using the chain rule, and  $m$  being the number of examples )

$$\frac{dL}{dW} = \frac{1}{m} (\hat{Y} - Y) \cdot X^T$$

We also need the derivative of  $b$  in which we get using the same rule :

$$db = \frac{1}{m} \sum (\hat{Y} - Y)$$

**Results :** Testing the model for 500 epochs we get the following result :

```

Epoch 0 cost : 0.6840801594808067
Epoch 20 cost : 0.05186953244269149
Epoch 40 cost : 0.04345341974736093
Epoch 60 cost : 0.04001850646588707
Epoch 80 cost : 0.03788701232477152
Epoch 100 cost : 0.036361610767339514
Epoch 120 cost : 0.03518929633334279
Epoch 140 cost : 0.034246544344964866
Epoch 160 cost : 0.03346366793236676
Epoch 180 cost : 0.032797787671564875
Epoch 200 cost : 0.03222085075151266
Epoch 220 cost : 0.03171361630399922
Epoch 240 cost : 0.03126237448599201
Epoch 260 cost : 0.030857042579288146
Epoch 280 cost : 0.030490004478422043
Epoch 300 cost : 0.03015537401286744
Epoch 320 cost : 0.02984851099454993
Epoch 340 cost : 0.029565693764617616
Epoch 360 cost : 0.029303891845031793
Epoch 380 cost : 0.02906060445396341
Epoch 400 cost : 0.02883374344583408
Epoch 420 cost : 0.028621546885045254
Epoch 440 cost : 0.028422514167297793
Epoch 460 cost : 0.028235356572606847
Epoch 480 cost : 0.028058959053090214
Final cost : 0.027900461855556963

```

FIGURE 2 – Test using the one Neuron model, the cost being calculated each 20th iteration

**A Hidden layer :** With the same activation function and the loss function, we can add another layer and calculate the derivative once again with the same method. We get then the following results :

```

[Running] python -u "c:\Users\lenovo\Documents\Backup\DL\lab2\lab2_2.py"
Using TensorFlow backend.
Epoch 0 cost : 0.9176984323708313 Accuracy : 0.09871666666666666
Epoch 25 cost : 0.16419012667928765 Accuracy : 0.9038666666666667
Epoch 50 cost : 0.08545743740673337 Accuracy : 0.9775333333333334
Epoch 75 cost : 0.06069805243002167 Accuracy : 0.9839833333333333
Epoch 100 cost : 0.05006480463222705 Accuracy : 0.98635
Epoch 125 cost : 0.0441043719734058 Accuracy : 0.9875333333333334
Epoch 150 cost : 0.040323492056701146 Accuracy : 0.9887166666666667
Epoch 175 cost : 0.037728950153895095 Accuracy : 0.9894
Epoch 200 cost : 0.03584432095490172 Accuracy : 0.98975
Epoch 225 cost : 0.03441543556194345 Accuracy : 0.9902
Epoch 250 cost : 0.033295596821026875 Accuracy : 0.9905
Epoch 275 cost : 0.03239443396802538 Accuracy : 0.9905833333333334
Epoch 300 cost : 0.031653143208007 Accuracy : 0.9908333333333333
Epoch 325 cost : 0.03103169185177597 Accuracy : 0.9909166666666667
Epoch 350 cost : 0.03050180599802011 Accuracy : 0.9909833333333333
Epoch 375 cost : 0.03004291505333011 Accuracy : 0.9911166666666666
Epoch 400 cost : 0.0296396902706477 Accuracy : 0.9912333333333333
Epoch 425 cost : 0.029280487418698126 Accuracy : 0.9912666666666666
Epoch 450 cost : 0.028956326891100982 Accuracy : 0.9912666666666666
Epoch 475 cost : 0.028660206128274673 Accuracy : 0.9913166666666666
Final cost : 0.028397191684057528 Accuracy : 0.9913833333333333 Elapsed : 645.9285306930542

```

FIGURE 3 – Test adding a Hidden layer of 64 elements achieving a 99,13 % accuracy

The results do not change drastically when adding more elements to the hidden layer :

```
[Running] python -u "c:\Users\lenovo\Documents\Backup\DL\lab2\lab_2.py"
Using TensorFlow backend.
Epoch 0 cost : 0.6662941976132445 Accuracy : 0.9012833333333333
Epoch 25 cost : 0.10248775920054211 Accuracy : 0.9697333333333333
Epoch 50 cost : 0.06325975019280071 Accuracy : 0.9827
Epoch 75 cost : 0.05044400373242353 Accuracy : 0.9859333333333333
Epoch 100 cost : 0.043872647135917264 Accuracy : 0.9873666666666666
Epoch 125 cost : 0.03990044870013563 Accuracy : 0.98855
Epoch 150 cost : 0.037255029502269964 Accuracy : 0.9893
Epoch 175 cost : 0.035371103848745 Accuracy : 0.9898666666666667
Epoch 200 cost : 0.03396259620316097 Accuracy : 0.9901666666666666
Epoch 225 cost : 0.03287034100654196 Accuracy : 0.9904833333333334
Epoch 250 cost : 0.03199872367742637 Accuracy : 0.99075
Epoch 275 cost : 0.031286594641276484 Accuracy : 0.99085
Epoch 300 cost : 0.030692831305238852 Accuracy : 0.9908666666666667
Epoch 325 cost : 0.03018865875365686 Accuracy : 0.9910833333333333
Epoch 350 cost : 0.029753304050867943 Accuracy : 0.9911666666666666
Epoch 375 cost : 0.02937140001688888 Accuracy : 0.9911
Epoch 400 cost : 0.02903136171671551 Accuracy : 0.9911833333333333
Epoch 425 cost : 0.028724332070374902 Accuracy : 0.9912333333333333
Epoch 450 cost : 0.028443474157282843 Accuracy : 0.9913333333333333
Epoch 475 cost : 0.02818348063370941 Accuracy : 0.99145
Final cost : 0.027949673620899257 Accuracy : 0.9915166666666667 Elapsed : 879.5334870815277
```

FIGURE 4 – Test adding a Hidden layer of 128 elements achieving a 99,15 % accuracy

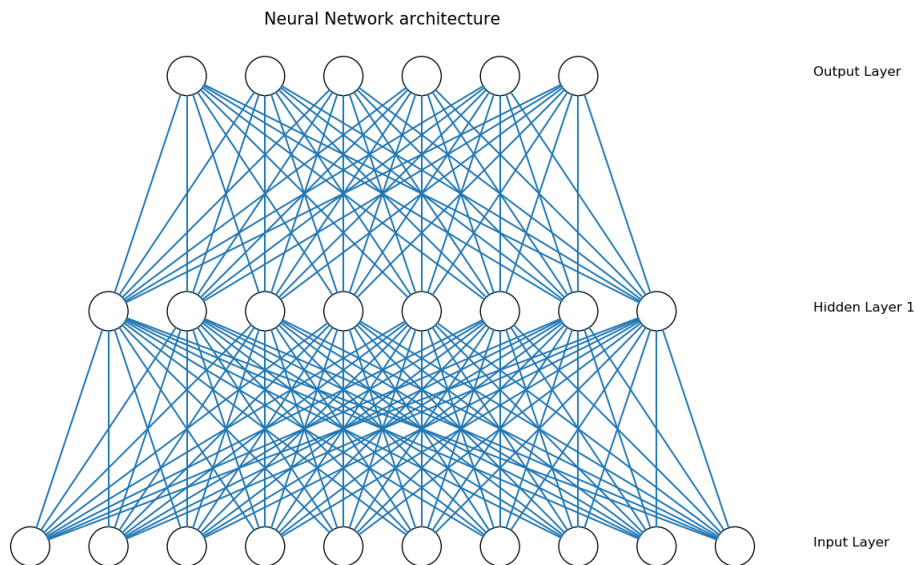


FIGURE 5 – Architecture of the neural network

**Multi neural network** Above is the architecture of our neural network, composing of an input of 728 elements, A hidden layer of 64 elements and an output of 10 elements ( representing the hot encoding of the numbers ranging from 0 to 9 )

After running the test we get the following result :

```
Epoch 0 cost : 0.695859881599633
Epoch 20 cost : 0.3221276640015437
Epoch 40 cost : 0.26354474965613894
Epoch 60 cost : 0.19569300680670426
Epoch 80 cost : 0.15557644128985854
Epoch 100 cost : 0.12839300460689002
Epoch 120 cost : 0.10993901819488014
Epoch 140 cost : 0.09697962020750063
Epoch 160 cost : 0.08755863984666772
Epoch 180 cost : 0.08062414947245229
Epoch 200 cost : 0.07542824206530536
Epoch 220 cost : 0.07141852370715623
Epoch 240 cost : 0.06821915964792905
Epoch 260 cost : 0.06558585225390691
Epoch 280 cost : 0.06336022986237452
Epoch 300 cost : 0.06143757961068539
Epoch 320 cost : 0.059746689147836346
Epoch 340 cost : 0.05823767890309995
Epoch 360 cost : 0.05687464245717217
Epoch 380 cost : 0.05563110144591778
Epoch 400 cost : 0.054487108608342834
Epoch 420 cost : 0.053427339340700215
Epoch 440 cost : 0.0524398017475197
Epoch 460 cost : 0.05151495115538194
Epoch 480 cost : 0.05064507518164788
Final cost : 0.04986384909601439 Elapsed : 549.150349855423
```

FIGURE 6 – test of multi neural network