Assignment 4: Neural Networks and Deep Learning

Submission: October 31st
2 students per group

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Machine Learning - 2016-II
Maestría en Ing. de Sistemas y Computación

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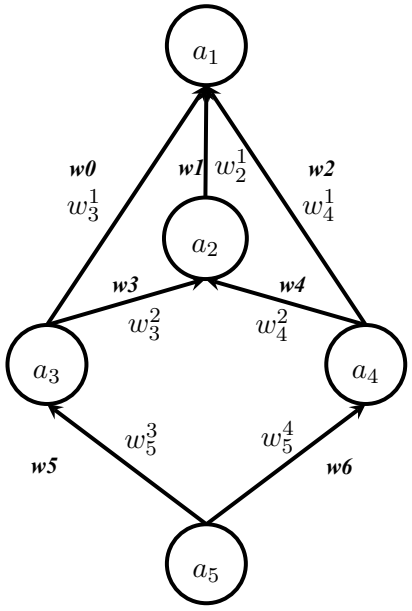
1. Consider the following neural network:



where $a_i = \sum_j w_j^i z_j$, $z_i = f_i(a_i)$ for $i = 1, 2, 3, 4$, $z_5 = a_5$ (an input neuron), $f_2(x) = \text{relu}(x)$, and $f_1(x) = f_3(x) = f_4(x) = \text{sigmoid}(x)$. relu$(x)$ corresponds to a rectifier linear unit transfer function defined as:

$$\text{relu}(x) = \begin{cases} x & \text{if } x \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

   (a) Write a function to simulate the neural network.

   (b) Deduce the equations to calculate δ_i (the error value per neuron) for all the neurons. Write a function that given a training sample and the weights of the network calculate δ_i for each neuron.

   (c) Assuming that the weight matrix is:

	1	2	3	4
2	3			
3	-4	1		
4	-1	-3		
5			2	-10

use the functions from items (a) and (b) to calculate the output of each neuron, z_i, and the error, δ_i, for the following training samples:

x	y
0.0	0.5
1.0	0.1

(d) Write a function to train the neural network using stochastic gradient descent.

(e) Use the function to train the network with the following training samples[1]:

x	y
-3.0	0.7312
-2.0	0.7339
-1.5	0.7438
-1.0	0.7832
-0.5	0.8903
0.0	0.9820
0.5	0.8114
1.0	0.5937
1.5	0.5219
2.0	0.5049
3.0	0.5002

Plot the evolution of the error and the predictions of the trained network. Write down the weights of the trained network.

2. Bird classification.

(a) Download the dataset *birds* from http://www-cvr.ai.uiuc.edu/ponce_grp/data/.

(b) Use Keras and the code in the project convnets-keras along with the [2] pre-trained model, to classify the images in the birds dataset. Construct a confusion matrix that relates the bird classes with the 10 most frequent classes from ImageNet predicted by the model.

(c) Transfer learning:

i. Modify the two last layers of the model (`dense_2` and `dense_3`) to have 256 and 6 neurons respectively.

ii. Change the attribute `trainable` of the other layers to be `False`. This will prevent the weights of these layers to be changed during training.

iii. Train the model with the training images from the bird dataset.

iv. Evaluate the performance over the test dataset reporting the results in a confusion matrix. Discuss the results.

(d) Fine tuning:

i. Repeat the experiment from the last question, but this time allow all the layers to be trained.

ii. Compare and discuss the results.

[1] There are additional samples in the class website

[2] Alexnet

3. The assignment must be submitted as an IPython notebook through the following Dropbox file request, before midnight of the deadline date. The file must be named as `ml-assign4-unalusername1-unalusername2.ipynb`, where `unalusername` is the user name assigned by the university (include the usernames of all the members of the group). If there are several files, please put them in a zip file.