UNIVERSIDADE DE AVEIRO

DEPARTAMENTO DE ELECTRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA

Programming Elements (2023/24)

Lab work n$^{\circ}$ 2 — Due: 27 Nov 2023

Part I

1. Using the `nn_base` module developed before:

   - Change the function executed by the units of the neural network in order to implement a sigmoid function,
   $$f(x) = \frac{1}{1 + e^{-x}}.$$
   - In general, each unit of the neural network has an additional parameter, known as the bias. So, the output of unit j in layer l, i.e. o_j^l, should be
   $$o_j^l = f\left(\sum_i w_{i,j}^l o_i^{l-1} + b_j^l\right),$$
   where the $w_{i,j}^l$ is weight connecting the unit i in layer $l-1$ to the unit j in layer l, and b_j^l is the mentioned bias. For convenience, the bias is usually represented by an additional weight connected to a unit that is always outputing "1". Change your data structures accordingly, in order to incorporate the biases needed by the units.
   - Design a simple test to verify if the neural network is implementing what is expected. For example, define a small neural network (i.e., the values of `I`, `H` and `O`, as well as the connecting weights), propagate some vectors through it and find out if the output is the expected one (of course, you will have also to do the calculations by hand, in order to verify if the output of the neural network is correct).
   - Find out what is the *backpropagation* training algorithm and implement the required functions that will allow you to train your neural networks.
   - Train a neural network to implement a XOR boolean function.

Part II

2. Elaborate a small report, where you describe all the relevant steps and decisions taken in all the items of the work. Also, provide experimental results, such as the training evolution of your neural network (i.e., the number of errors that the neural network makes as a function of training time).