Machine Learning - Assignment 3 (Due: 8-Nov-2024)

This assignment consists of 2 parts. Undergraduate students should complete part 1, while graduate students should complete all 2 parts. In addition, the assignment should be completed in Python 3, and individually. Please submit your python script (.py file) on D2L. Please note that if you submit your file in some other format besides .py, then your mark will at most be 60%. If you are a graduate student, please also include your redacted document (PDF file) in your submission D2L.

For this third assignment, a few blanks (____________) have been included to guide you in parts that might be challenging. However, in no way these blanks are representative of the number of commands, parameters, length of what to input, or anything else. You may write as little or as much code as what is required to achieve the goals.

PART 1: Implementing a neural network using Keras

This part of the assignment is based on the book "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", by Aurélien Géron

The goal is to get introduced to Keras. Keras is a high-level Deep Learning API that allows you to easily build, train, evaluate and execute all sorts of neural networks.
Your model should be able to recognize handwritten digits from the MNIST database of handwritten digits. Follow the instructions on the associated .py script.

Ensure you did not miss any instructions:

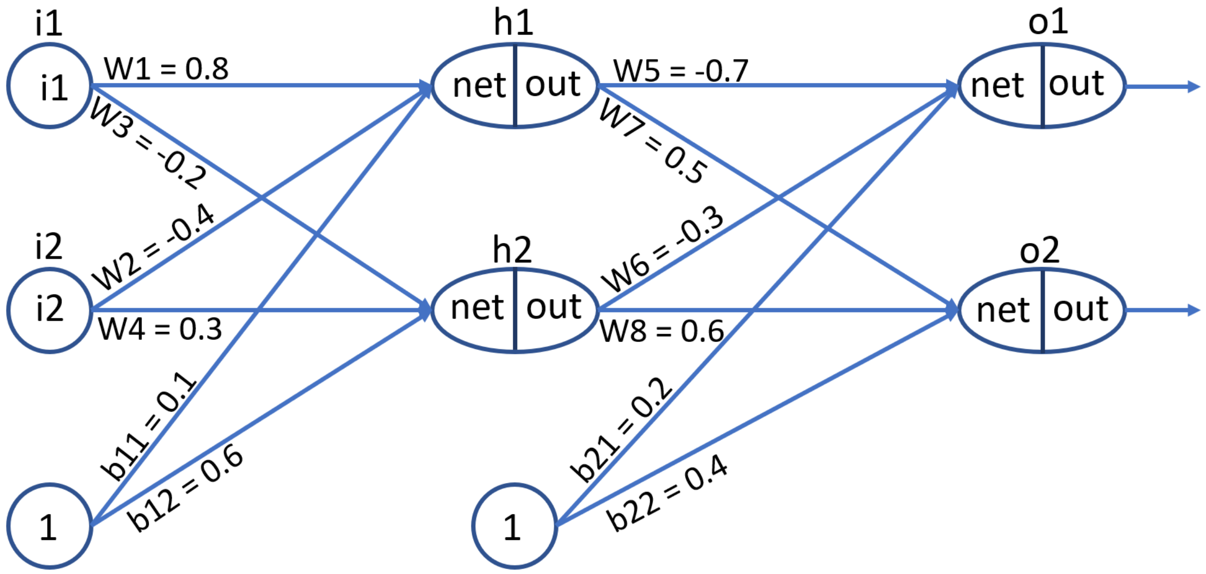
Line #	Points
20	5
26	5
31	5
37	5
38	5
42	5
46	5
51	5
55	5
59	5
62	5

67	8
72	8
75	6
79	6
84	6
88	6
89	6

PART 2 FOR GRADUATE STUDENTS ONLY: (Please note that the grade for part 1 counts for 50% of your total grade)

The goal is for you to research the backpropagation algorithm for neural networks and apply it to a given task. Start by reviewing thoroughly the following webpage to understand how backpropagation works, and answer the questions below:
https://mattmazur.com/2015/03/17/a-step-by-step-backpropagation-example/

For this question, a neural network with two inputs, two hidden neurons, and two output neurons is used. Additionally, the hidden and output neurons include a bias, and the activation function used is the logistic function. The learning rate alpha equals 0.5.
Please find below the basic structure of the neural network, with the initial weights. For consistency, please note that the notations are the same as in the mentioned webpage, except for the biases for each neuron in the hidden and output layers which are different.



Suppose that our training set has only one instance: given inputs i1=0.9 and i2 = 0.3, we want the neural network to output o1 = 0.01 and o2 = 0.99.

Question 1: How much is the error function E_{total} of this network? (5 points)

$$E_{total} = \sum \frac{1}{2}(target - output)^2$$

Question 2: After the first round of backpropagation, what are the optimized weights of the neural network? (80 points)

Question 3: After the first round of backpropagation, how much is the error function E_{total} of the network? (15 points)

Follow the step-by-step computations detailed on the webpage (https://mattmazur.com/2015/03/17/a-step-by-step-backpropagation-example/) and report your own computations (you can either type or handwrite them). Be careful, the computation of the biases' weights has not been detailed on the above-mentioned webpage – but you are expected to update and detail the computation of each bias weight separately.
In any case, please use your python IDE for all your computations (to avoid approximation errors).
Upload on D2L the detailed computations of all the weights. If you decide to handwrite your answers, please make sure that all your answers and computations can be easily read (50% for the write-up, 50% for the computations themselves).