DATA.ML.300 Computer Vision
Exercise Round 2

For these exercises you will need MATLAB, which should be available on university computers. Submit all your answers and output figures in a PDF file. For pen & paper tasks, the submitted PDF file should include a screenshot of your handwritten solutions, or text converted from Word or LaTeX format. In addition, submit runnable .m files, where you have filled in your codes to the given template files. Do not copy all the code from these runnable files into the PDF.

All submissions should be uploaded to Moodle. Exercise points will be granted after a teaching assistant has reviewed your answers. Submissions made before the deadline can earn up to 4 points. After the deadline, no partial points will be awarded; only submissions with fully correct solutions to all tasks will receive 1 point.

Task 1. Neural networks and backpropagation. (Pen & paper problem) (1 points)
In Figure 1 below you see a very small neural network, which has one input unit, one hidden unit (logistic), and one output unit (linear). The nonlinear function in the logistic unit is defined by the formula $\sigma(x) = \frac{1}{1+exp(-x)}$. Let's consider one training case. For that training case, the input value is 1 (as shown in the figure) and the target output value t is 1. We are using the standard squared loss function: $E = \frac{1}{2}(t-y)^2$, where y is the output of the network.

a) What is the output of the hidden unit and the output unit, for this training case?
hidden output = 0.5, output unit = 2.0
b) What is the loss, for this training case?
Loss = 1.0
c) What is the derivative of the loss with respect to w_2, for this training case? *Hint: Use chain rule*
dL/dW2 = 1.0
d) What is the derivative of the loss with respect to w_1, for this training case? *Hint: the derivative of logistic function is defined as* $\frac{d}{dx}\sigma(x) = \sigma(x) \cdot (1 - \sigma(x))$
dL/dW1 = 2.0

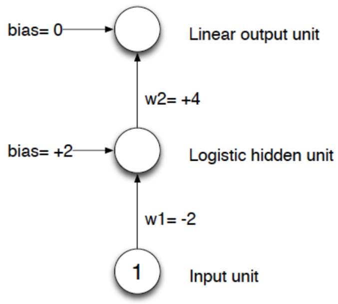

Figure 1: A small neural network with one hidden unit. The values for the weights and biases are given in the figure

Task 2. Matching images based on similarity (Pen & paper problem) (1 point)

We have three feature vectors which are defined as

$$\mathbf{Q} = \begin{bmatrix}2 & 1 & 6 & 4 & 2\end{bmatrix}^T,$$
$$\mathbf{A} = \begin{bmatrix}1 & 2 & 3 & 4 & 1\end{bmatrix}^T,$$
$$\mathbf{B} = \begin{bmatrix}3 & 1 & 4 & 1 & 5\end{bmatrix}^T,$$

where **Q** is a feature vector extracted from a query image Q, and **A** and **B** are feature vectors extracted from random images A and B in a dataset.

a) Calculate the Euclidean distance and cosine similarity between **Q** and **A** and between **Q** and **B**.

Euclidean distances: Q and A = sqrt((QiAi)^2) = $sqrt(1^2 + (-1)^2 + 3^2 + 0^2 + 1^2) = sqrt(12) = 3.464...$

Q and B = sqrt((QiAi)^2) = $sqrt((1)^2, 0^2, 2^2, 3^2, (3)^2) = sqrt(23) = 4.795...$

Cosine similarities:

Q and A => QA=21+12+63+44+21=2+2+18+16+2=40

||Q||=sqrt$(2^2 + 1^2 + 6^2 + 4^2 + 2^2) = sqrt(4 + 1 + 36 + 16 + 4) = sqrt(61)$

||A||=sqrt$(1^2 + 2^2 + 3^2 + 4^2 + 1^2) = sqrt(1 + 4 + 9 + 16 + 1) = sqrt(31)$

=> 40/(sqrt(61)*sqrt(31))=0.919

Q and B => QB=23+11+64+41+25=6+1+24+4+10=45

||Q||=sqrt$(2^2 + 1^2 + 6^2 + 4^2 + 2^2) = sqrt(4 + 1 + 36 + 16 + 4) = sqrt(61)$

||B||=sqrt$(3^2 + 1^2 + 4^2 + 1^2 + 5^2) = sqrt(9 + 1 + 16 + 1 + 25) = sqrt(52)$

=> 45/(sqrt(61)*sqrt(52))=0.798

b) Based on the feature vectors and similarity metrics calculated in a), which image from the dataset is more similar to query image Q? Why?

Euclidean distance indicates the distance of two vectors in vector space. Image A is more closer to Q, thus indicating more similarity.

Cosine similarity indicates similarity in vector direction. Since A has also a greater cosine similarity, it is more aligned to the same direction as Q.

Thus image A is more similar to Q.

Task 3. Observing different parts of a simple CNN. (Programming exercise) (2 points)
Download the material and open the exercise.m file. Each section observes different building blocks of a convolutional neural network. Your task is to progress one section at a time, fill any missing code and answer questions asked in each section. **Questions can be answered in the code by inserting comments below the questions; however, if you prefer PDF, include the questions also.**