DATA.ML.300 Computer Vision
Exercise Round 2

For these exercises you will need Matlab which should be available on the university computers. Return your answers as a pdf, output images, and your modified code to Moodle. Provide your Matlab code as runnable m-file, and do not embed your code to the pdf. Exercise points will be granted after a teaching assistant has checked your answers. Returns done before the deadline will result in maximum of 4 points, whereas returns after the deadline will result in maximum of 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?
b) What is the loss, for this training case?
c) What is the derivative of the loss with respect to w_2, for this training case? *Hint: Use chain rule*
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* $\frac{d}{dx}\sigma(x) = \sigma(x) \cdot (1 - \sigma(x))$

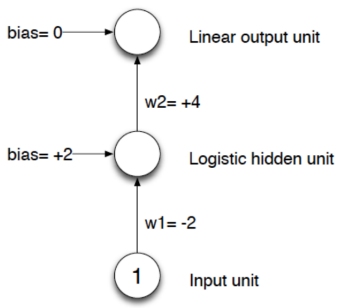

Figure 1: A small neural network with one hidden unit. The values for the weights and biases are given in the figure

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 $\mathbf{Q}$ is a feature vector extracted from a query image Q, and $\mathbf{A}$ and $\mathbf{B}$ are feature vectors extracted from random images A and B in a dataset.
a) Calculate the Euclidean distance and cosine similarity between $\mathbf{Q}$ and $\mathbf{A}$ and between $\mathbf{Q}$ and $\mathbf{B}$.
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?

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 please also include the questions.**