CS 484/555
Spring 2022
Homework Assignment 1

Due: 10th March 23:59

1 Question 1 [40 pts]

In this question, you will write your own implementations of the two fundamental morphological operations, namely *dilation* and *erosion*. You will write a separate function for each operation. These functions will take as input a binary image (as a matrix) and a structuring element (also as a matrix), and produce a binary image (another matrix) corresponding to the result of the operation.

$dilated\_image = dilation(src\_img, struct\_et)$
$eroded\_image = erosion(src\_img, struct\_et)$

You should generate the structuring element as a binary image with an arbitrary shape. Given the structuring element, your code should implement the dilation and erosion operations using the definitions given in the course slides. Note that the structuring element should be created (as a matrix) outside and given as an input to the dilation/erosion codes so that your code can work with any kind of structuring element.

After your implementation, for the image given below, you are expected to apply a sequence of morphological operations to come up with a cleaner version of the car plate where the noise is removed and the characters are readable.

Figure 1: Noisy Car Plate

2 Question 2 [20 pts]

Implement a function to generate histogram of a gray scale image. Your method should take an arbitrary gray scale image (a matrix) as an input and plot the histogram of pixel intensities. Your method should have the following declaration:

$histogram(source\_image)$

Your implementation should be generic for any given grayscale image. That is, it should be able to work with image of any size. Note that, you can use additional built-in functions or libraries to read an image as a matrix and for plotting histograms. However, your function should only take the image matrix as an input. No image processing libraries are to be used for the implementation of the histogram function. Please

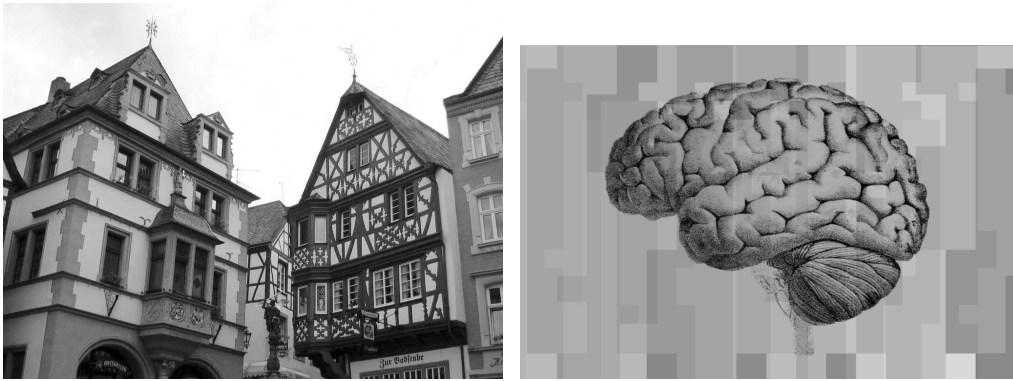Figure 2: Images for Histogram Generation

Figure 3: Images for Otsu's threshold

test your results on the images provided in Fig. 2. (HINT: compare your results with MATLAB's built-in histogram function.)

3   Question 3 [20 pts]

Implement automated thresholding by Otsu's Method. As in the first question, you must use your own implementation and avoid using any image processing libraries (except for reading and plotting images). Your function declaration should take a grayscale image (a 2D matrix) as an input and produce a binary image (also a 2D matrix) of the same dimensions as in the input image. Use the format below:

$binary\_image = otsu\_threshold(source\_image)$

Separate the background from the foreground using your implementation of Otsu's algorithm. Show your results on two different images shown in Figure 3 (both of those images are also provided as a part of this homework). Discuss your results, are they always perfect? Why so, why not?

4 Question 4 [20 pts]

In this question, you are going to implement a two-dimensional convolution operation. The function you write for convolution should take as input an image as its first argument and the filter as its second argument and output the result of convolving the image with the given filter in the spatial domain. Your function should be generic to accept any given filter or image. However, we assume that the images are represented as 2D matrices, i.e. multi-channel images (e.g. colour images) are not allowed. Likewise, filters are also 2D matrices. While implementing your function, take care about boundaries. Use your convolution operator for edge detection using the Sobel and Prewitt operator for the image below.

Figure 4: Image for Sobel and Prewitt filter

Submission: FOR EACH QUESTION in this assignment, you need to submit a report and an implementation (the asked function).

1. A report (pdf file) that includes the results from all four questions, your discussions, generated plots and etc. Remember that slightly imperfect results are quite likely due to method limits. As long as you are able to provide analytical explanation for such results, and as long as these results are similar in quality to results from MATLAB/PYTHON libraries, you are OK. In fact you are encouraged to compare your implementation to that of MATLAB/PYTHON libraries, but please DO NOT INCLUDE these comparisons in your report! In parts of the assignment where you are allowed to use external libraries, specify the library and the method that you are using.

   2. A script that runs the particular sequence of operations and reproduces the result presented in your report.

   3. You will upload a zip file on Moodle. For any questions, please contact *salman.mohammad@bilkent.edu.tr* via email.