Vision and Perception
Assignment Image Processing

16 June 2021

1 Assignment Guide

- The final deadline for the assignment is 15 July 2021 11:59PM.
- Integrity and collaboration: this assignment is strictly individual.
- The assignment is composed by this pdf file with the exercises (where the starting data are specified for each exercise in **bold**), the library for the generation of the required data for each question (exGenerator.py), various utility folders and a draft Latex file to be used for the write-up (assignmentTemplate.zip).
- For each exercise you need to call the relative exercise function (e.g. ex1('1234567')) and you will obtain the starting data of each exercise. The script takes as input the number student ID number.
  N.B. The starting data (images and/or parameters) must be reported in the write-up at the beginning of each exercise answer.
- Mandatory items to be included in the write-up are mentioned in each question. Type your answers electronically unless otherwise specified in the text of the exercise.
- For exercises 10-13, you must attach the relative Jupyter Notebook file (*.ipynb) already run (i.e. by opening the file, the results of the latest execution must appear without running the code again, see ExampleGeneration.ipynb).
- In the first page of the write-up must be reported: your last name, first name and student ID number. For each exercise the starting data (images and other parameters) must be reported at the beginning of each answer and the final results and output images of the computation need to be reported and discussed. The reported images need to be referenced in relation to the number of the exercise.

- The document must be edited with the use of Latex. Check overleaf guides to implement the document correctly. A draft Latex file (assignmentTemplate.zip) is included in the assignment folder.
- A zip file, named surname_ID.zip, is required for the submission, composed of your write-up and all the above mentioned files. Do not hand in any files we distributed. Your final upload needs to be arranged as follows:
  - surname_ID.zip
    - surname_ID.pdf
    - exGenerator.pyc
    - notebooks/
      - *.ipynb files (notebooks), each one named exercise_number.ipynb (e.g. exercise_1.ipynb).

  The zip file must be uploaded within the deadline through the use of classroom.

2 Exercises

The first part of this assignment is composed by 7 exercises from 1 to 7 [1.5 points each]. Computations can be done on paper (clear handwriting), attached to the write-up as a figure. Discussions must be written on Latex.

- **Exercise 1.** Given an **image** and a **kernel**, apply the specified **padding** and compute the **convolution** of the **two given coordinates** in the image. Show all the intermediate steps. Discuss the possible problems and advantages of the particular padding strategy (max 3 lines).
- **Exercise 2.** Compute the LOG filter of dimension 3×3 given a $\boldsymbol{\sigma}$.
- **Exercise 3.** Given a **kernel** and an **image**, tell which filter is the provided one, apply it to the image, and discuss the activated features showing at least two coordinate computation and why did you choose them (discussion max 4 lines).
- **Exercise 4.** Show two different applications of binary opening on the given **image**. Compute the opening and discuss the results in max 5 lines.
- **Exercise 5.** Show two different applications of binary closing on the given **image**. Compute the closing and discuss the results in max 5 lines.
- **Exercise 6.** Show a comparison that highlights the difference between bilinear and bicubic interpolations, starting from a small matrix of your choice (the best for the sake of the comparison). Discuss the results in max 5 lines.

- **Exercise 7.** Perform Histogram Equalization on the given **image** considering a target maximum value of 1 (resulting pixel values $\in [0, 1]$). Discuss the resulting effects in max 3 lines.

Type your answers electronically we DO NOT accept handwritten scans from here on.

- **Exercise 8.** Suppose to have a simple shape detector that exploits black pixel separations to define the different instances of the objects. Shapes can be of the following types square, rectangle, circle and ellipse. How can you upgrade this algorithm to deal with connected shapes? (max 15 lines) [3 points].

- **Exercise 9.** Explain how the Fourier Transform is used for image enhancement by applying frequency domain filters, such as high-pass filtering, high-boost filtering , and homomorphic filtering (the last two were not covered in class). What are the main tasks for the above 3 filters as far as image processing is concerned?
  What information about the shape and orientation of an object can be inferred, and how, from the Fourier Transform operation applied to an image? [3.5 points]

From exercise 10 to 13 add in the write-up the reasoning and the discussion of the results along with the computed intermediate images. (we DO NOT accept handwritten scans)

- **Exercise 10.** Write a function that can extract informative edges (clear contours without too much noise, from the provided **images**). Describe the algorithm/filters used and report the processing images. After that implement a method to detect the main lines (i.e the cardboard folding lines) from the extracted edges. (max 20 lines) [4.5 points]

- **Exercise 11.** Take an **image** of your working environment containing a person and apply Harris detector pointing out the interest points on the image. Then apply SIFT descriptor to the same image and find the features. Apply another features extractor of your choice on the same image and extract another feature vector. Show the extracted features using the two different methods on the image. Apply both techniques to your dataset (select a small dataset composed by two classes (i.e. person, car or others) with 30 images each. Concatenate the features computed by both techniques to get a final feature vector. Apply class labels and then use any available classifier (an explanation on which classifier is chosen should be given in the report). Get classification results in terms of accuracy and confusion matrix presenting your results. (discuss max 20 lines) [4.5 points]

- **Exercise 12.** Face detector algorithm: Take a sample **template image** to detect faces in a **target image** using HOG descriptors. HOG descrip-

tors can be compared using the Normalized Cross Correlation (NCC). Extract the bounding box applying a certain threshold on the NCC (explain the chosen threshold) and use a method to detect the correct bounding boxes. Report the NCC scores between the bounding boxes and the template. (discuss max 15 lines) [4 points]

- **Exercise 13.** Exploiting the studied algorithms, define the main axis of the main object in the provided **picture**. Discuss and add a resulting image (discuss max 8 lines) [3 points].