Vision and Perception
Assignment 1: Image Processing

29 March 2021

1 Assignment Guide

- The deadline for the assignment is 11 April 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.pyc), 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.
- 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** or the **correlation** 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 Gaussian 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 (discussion max 3 lines).
- **Exercise 4.** Compute a morphological operation **(opening/closure)** on a given **binary image**. Discuss the results in max 3 lines.
- **Exercise 5.** Compute a morphological operation **(erosion/dilation)** on a given **gray-scale image**. Discuss the results of the operation in max 3 lines.
- **Exercise 6.** Double the size of the given **1D vector** using a Bilinear Interpolation.
- **Exercise 7.** Perform Histogram Equalization on the given **image**. Discuss the resulting effects in max 3 lines.

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

- **Exercise 8.** Discuss possible applications and advantages of using Entropy and Fourier Transform in combination on the provided **images**. (max 15 lines) [3 points].

- **Exercise 9.** Discuss two methodologies to deal with noise in order to improve the performances of the studied algorithms (e.g. Sobel, downsampling and so on) in max 20 lines. [2 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.** Starting from the provided implementation of Bag of Visual Words algorithm with SIFT, implement one of the requested methods (**HoG or Harris** ex10(IDnumber)) and another method at your choice (not explained during lectures). Compare SIFT with (HoG or Harris) and SIFT with the new method. The dataset is provided in the assignment zip. Report the features extraction phase and discuss the results. Show the extracted features using the three different methods on sample image from the dataset. Furthermore, the three confusion matrices as output of the BOW algorithm must be provided (max 20 lines) [4.5 points].

- **Exercise 11.** Write a code to segment simple shapes (the **images** are given) showing the reasoning behind your choices (max 5 lines).
  Discuss the limits and strengths of your proposed approach (max 5 lines).
  Then exploiting the Optical Flow algorithm on the given images, define which object that you segment with the previous code is moving to the center and which is diverging to the borders. Discuss and report the estimated optical flow usage (max 5 lines) [5.5 points].

- **Exercise 12.** Taking two given **images**, compute and discuss the texture gradients. Which filters perform better *w.r.t.* on which effects? (max 15 lines) [3.5 points].

- **Exercise 13.** Discuss and implement at least two algorithms to decrease the size of an image with a minimum content loss and discuss in max 8 lines each. How can you estimate the content loss before applying your functions? (max 5 lines) [4 points].