Centre for Mathematical Sciences, Mathematics, LTH, October 2023

Image Analysis, Assignment 4

1 Color correction of images

In this task you will investigate ways of changing, correcting and enhancing images, and work with simple algorithms and color spaces described in the course. I

1) In the file `michelangelo_colorshift.jpg` an image by Michelangelo is given. There is an undesirable color cast in the image. Implement the "gray world" and "white world" assumption to automatically white balance the image.
Also download and use the Matlab method from:
`https://github.com/mahmoudnafifi/WB_sRGB/`
More information on this method can be found here:
`https://cvil.eecs.yorku.ca/projects/public_html/sRGB_WB_correction/index.html`

2) In the file `michelangelo_correct.jpg` the correctly white balanced image is given. For your three outputs, from the three methods, calculate both the *PSNR* and *SSIM* metrics, compared to the correct image (you may use the built-in Matlab implementations, but make sure that you understand roughly how these metrics are calculated). In the task folder you will also find a folder with the Matlab implementation of the perceptual metric ꟻLIP. You can calculate the error for two images with the function:
`err = computeFLIP(im_ref,im_test);`
Calculate the ꟻLIP-error for the three output images.

> For the report: Describe your implemented methods and supply both your code (e.g. matlab code) and the three resulting output images. Also provide the $3 \times 3-$table with the computed errors.

2 Segmentation with Graph Cuts

You are given the task of segmenting out two heart chambers in an image by Graph-Cuts. In `heart_data.mat` you are given two vectors, with a number of intensities that have been observed inside the two chambers (`chamber_values`) and a number of intensities observed in the background (`background_values`). You are also given the image of Figure 1, denoted by f below.

In `task2.m` there is a script that shows how you can use the Matlab function `maxflow.m` to solve the min-cut problem. Study the material in the lectures and also read the chapter on Graph Cut segmentation in Szelisky "Computer Vision: Algorithms and Applications", and modify the script according to the following tasks:

1) Assume that the pixel intensities in the two classes are generated by two different Gaussian distributions. In other words, for pixel i, the likelihoods of observing intensity f_i, $P(f_i \,|\, \text{chamber class})$ and $P(f_i \,|\, \text{background class})$, respectively, are Gaussians. Recall, a Gaussian is given by $P(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$. Estimate the means and the standard deviations for the chamber class and the background class, respectively, using the provided ground truth values in the data file.

2) Given the theoretical assumptions on the distributions (Gaussian), what is the negative log likelihoods for the two classes (it should be a simple expression, and you can ignore the term arising from the normalizing constant in the Gaussian). Construct a graph of the heart image with a data-term consisting of the negative log likelihoods for the two classes. Solve it via max-flow/min-cut. Experiment with the prior/regularization weight (denoted by ν in the lectures) in order to obtain a reasonable segmentation. (Note: it is hard to get a perfect segmentation.)

3) Optional. Fine tune the segmentation by adding ground truth. This can be done by changing the data-term to ∞ (or a large number) for the pixels you know which region they belong to. This will force certain pixels to belong to a particular class. Such pixels can be obtained by manual inspection of the image.

Notes: Both 2) and 3) can be seen as adjustments a medical doctor could perform. In 2) a slider could be added to give interactive response to different weights. Then a pen tool can be used to introduce the ground truth of 3).

For the report: supply both code (e.g. matlab code) and a printout of the results of using your algorithm, i.e. supply examples of input data (as an image) and result after applying your segmentation algorithm (also as an image).

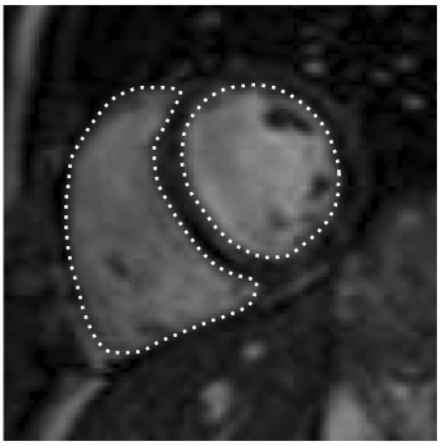

Figure 1: The data given in the task. A slice of a heart imaged by a MRI camera. This view is known as the "short-axis view" taken in a direction where the left and the right heart chambers are visible at the same time. The two chambers are shown inside the dotted lines, the left chamber is to the right in the image and vice versa.

3 Computer Vision

Assume that the camera matrices for two projections are

$$P_1 = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

and

$$P_2 = \begin{pmatrix} 1 & 2 & 3 & 3 \\ 1 & 2 & 0 & -2 \\ 1 & 1 & 2 & 0 \end{pmatrix} .$$

The so called fundamental matrix is then

$$F = \begin{pmatrix} 2 & 2 & 4 \\ 3 & 3 & 6 \\ -5 & -10 & -6 \end{pmatrix} .$$

The following three points are detected in image 1:

$$a_1 = (-4, 5), \quad a_2 = (3, -7), \quad a_3 = (-10, 5).$$

In image 2 the following three points are detected:

$$b_1 = (3, 2), \quad b_2 = (6, -1), \quad b_3 = (2, -2).$$

Which points can be in correspondence?

For the report: Provide your calculations, your answer and your motivation.

4 OCR system construction and system testing

Here we will finish the work on our OCR system. From the three previous assignments you have constructed

- `S = im2segment(Im)` - a segmentation algorithm that takes an image to a number of segments.
- `x = segment2features(S)` - an algorithm for calculating a feature vector x from a segment S.
- `y=features2class(x,classification_data)` - an algorithm for classifying a feature vector x as class y using machine learning.

The data files for this assignment contain both new test examples as well as a benchmark script. Try running `inl4_test_and_benchmark` on all of the five datasets (short1, short2, home1, home2, home3). Write down the results before modifying your code. Then try improving your code to make it as good as possible.

- Test your system version 1 from Assignment 3 on the five datasets (short1, short2, home1, home2, home3).
- Try to change your system and produce a version 2 that works better on the five datasets.

Print the overall hitrate for version 1 on the five datasets in the report and describe with your own words the results in your report. If it went well, describe why. If it didn't go well describe why. Do the same for version 2 of your system. Describe what modifications you did in version 2 and why. You should aim at hitrates higher than 50% for all datasets. If you don't reach this level, describe what attempts you have made to increase the hitrate for version 2. Also include the Matlab code of your final system.