# Image Analysis, Assignment 4

## 1 Find the errors

Two images depict the same scene. However (apart from slight image variations) there are five distinct differences between them. Design a method for automatic detection of such differences and test them on the given images. The images are stored in the variables `femfel1` and `femfel2` respectively.

Your method does not have to be general in the sense that it works for every possible example of such images. It is enough that it kind of works for the two example images given.

> For the report: Except for the five differences, in what way are the two images different? How does these changes make the comparison more difficult? Describe in the report the main idea of your method. Visualize also in the report, what the results are of your method, by automatically marking the detected differences by bounding boxes in the image.

## 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 a number of intensities which have been observed inside the two chambers (*chamber class*) and a number of intensities observed in the background (*background class*). You are also given the image of Figure 1, denoted by $f$ below.

**Hint:** You can use the matlab routines given in laboratory session 3 to solve the min-cut problem. You will need to study the material in the lectures and also read chapter 5.5 in Szelisky "Computer Vision: Algorithms and Applications". You can then prepare by doing the 'Image Segmentation' part described in `lab3en.pdf` on the homepage.

**1)** Assume that the pixel intensities in the two classes are generated by two different Gaussian distributions. In order 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 mean and the standard deviation for these two distributions.

**2)** 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 $\nu$ 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 $\infty$ (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 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).

In the written solution to these problems, supply both code (e.g. matlab code) and a printout of the results of using your algorithm, i.e. supply examples of input data (e.g. as an image) and result after applying your segmentation algorithm (e.g. also as an image).

# 3 Computer Vision

Assume that the camera matrices for two projections are

$$P_1 = \begin{pmatrix} 3 & 2 & 1 & 0 \\ 2 & 2 & 3 & 0 \\ 2 & 2 & 2 & -1 \end{pmatrix}$$

and

$$P_2 = \begin{pmatrix} 2 & 4 & 3 & 3 \\ 1 & 2 & 0 & -2 \\ 1 & 1 & 3 & 0 \end{pmatrix} .$$

The so called fundamental matrix is then

$$F = \begin{pmatrix} -3 & 3 & 6 \\ 6 & -31 & 9 \\ -8 & -42 & 58 \end{pmatrix} .$$

The following three points are detected in image 1:

$$a_1 = (1,2), \quad a_2 = (16,10), \quad a_3 = (4,2).$$

In image 2 the following three points are detected:

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

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.

On the course home page there is a zip-file `inl4_to_students.zip`, which contains 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 you 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). 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.
- Tro to change your system and produce a version 2 that works better on the five datasets. Print the overall hitrate for version 2 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.

In the written solution to the segmentation problem, supply both code (e.g. matlab code). Provide error rates for your system (both version 1 and version2) on the five datasets. Discuss the results.

# 5 Optional: OCR using deep learning

This exercise is optional, but for those of you who are interested in deep learning it might be both interesting and useful.

On the homepage `http://www.robots.ox.ac.uk/~vgg/practicals/cnn/` you can find an introduction to convolutional neural networks (CNN) for classification.

Download the data and the code according to the instructions.

Then do exercise 4 on the homepage and answer all questions.

If you have time, try to integrate the final classifier in your own ocr code.

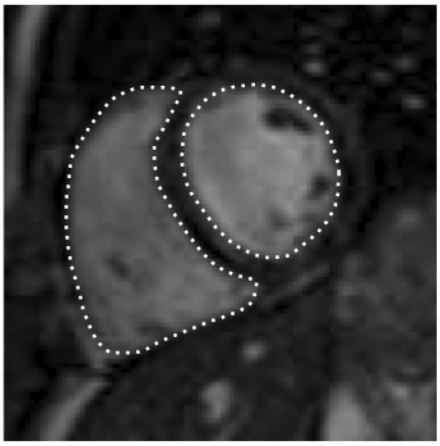

Figure 1: The data given in the task. A slice of a heart imaged by a MRI camera. This view is known as the “short-axis view” taken in a direction where the left and the right heart chambers are visible at the same time. The two chambers are shown inside the dotted lines, the left chamber is to the right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

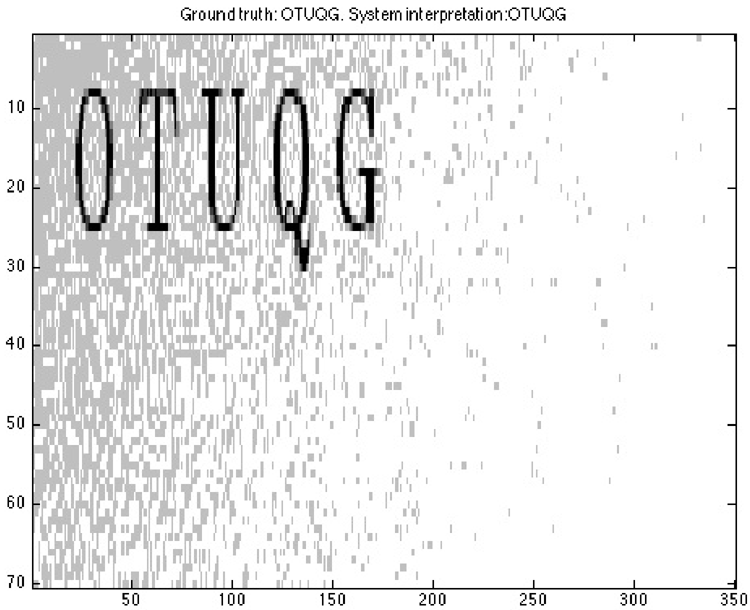


Figure 2: One image with corresponding ground truth and system response.