# **Introduction to Computer Vision**

## **Exercise 5 (last exercise)**

**Due Date**: Sunday, Feb 5, 2017
**Submission:** in pairs

## General Instructions

**How and what to submit?**

Please submit your solutions electronically as .zip to regular link (both .mat and .pdf files)

## Part 1 – One plane scene

In this part, you will compute the homography between image1 to image2 (placed in directory 'part1').

### 1.1- Sample corresponding points

- Select corresponding points between the two images in order to recover the homography matrix (how many do you need?)
- You may find the function ginput() helpful

### 1.2- Recover the Homography matrix

Implement the function **H = get_homography(P1, P2)** where P1, P2 are each a matrix 4X3 where each row corresponds to the homogeneous coordinates (x,y,1) of each selected point from the step 1.1.

Guidance:

- From each pair of corresponding points construct 2 equations where the 8 parameters of H are unknown.
- Recall, when applying an homography :

$$\begin{pmatrix} x' \\ y' \\ 1 \end{pmatrix} \propto H \cdot \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$$

$$\begin{pmatrix} x' \\ y' \\ 1 \end{pmatrix} = \frac{1}{h_7 x + h_8 y + h_9} \begin{pmatrix} h_1 x + h_2 y + h_3 \\ h_4 x + h_5 y + h_6 \\ h_7 x + h_8 y + h_9 \end{pmatrix}$$

- Define: $h_9 = 1$
- Formulate all the equations above as:

$$A \begin{pmatrix} h_1 \\ . \\ . \\ . \\ h_8 \end{pmatrix} = b \text{ where } A \text{ is an } 8 \times 8 \text{ matrix}$$

## 1.3- Apply the Homography to align the 2 images

Use the recovered homography to **backward warp** the second image toward the first one.

- Implement the function **- I_backwarp = apply_homography(I, H)**, where H is the recovered homography and I, **I_ backwarp** are the source (i.e. image2) and target images respectively.
- To do that, create a grid of all pixels in target image using **meshgrid()** and then calculate for all coordinates their matching coordinates in source image.
- Most of the calculated source coordinates will not be integers, so you will need to use **interp2()** to interpolate the values in these locations.
- Please do not use some readymade MATLAB warping function, the goal here is that you implement this yourselves.
- Avoid using loops over the coordinates. Use matrix manipulations instead, note that **interp2()** can be activated on meshgrids.

Please flicker between the two aligned images after the warping, to view the quality of the alignment.

## 1.4- For the report

- Derive the matrix P from section 1.2
- Apply steps 1.1 -1.3 where in step 1.1 choose points that are **close** to each other. Attach
    - The warped image with the points taken for the reconstruction marked on (use scatter()).
    - The absolute differences image
- Repeat steps 1.1-1.3, but this time in step 1.1 choose points that are **far** from each other. Attach
    - The warped image with the points taken for the reconstruction marked on (use scatter()).
    - The absolute differences image
- Write in your report
    - Which approach is better
    - Explain why it is better
    - What would happen if you choose points that are close to be on a common line?

# Part 2 – Two planes scene

In this part you will use the two images from directory 'part2' to compute the fundamental matrix

## 2.1 Compute two Homographies

Repeat steps 1.1-1.2 for each of the two planes (wall and table) in the image to calculate the homography from image3 to image4.

## 2.2 Plane + Parallax

Apply both homographies (wall and table) calculated to **backward warp** image4**. Your report should contain the following:**

- One figure with the following 4 images (use subplot()) For each of the cases:
  - Image3
  - Image4
  - New aligned image (warped Image4)
  - Absolute differences image between the aligned image and image3.
  - Points used for the homography calculation should be marked on all of the above images except the last one.
- Flicker between the two images before alignment, and flicker between the two images after aligning the wall. Explain what happened to the rest of the image after aligning the wall plane. Repeat the same experiment after aligning the table.
- How is the epipole related to the transformed locations of the non-planar points?
- For both cases, use corresponding points that are not on the aligned plane to calculate the coordinates of the epipole (can be out of image range).

## 2.3 Fundamental matrix

Use both homographies from the previous sections to calculate the fundamental matrix.

- Hint: use your solution from exercise 3, question 6. How many equations did you get from the skew-symmetricity claim? How many equations then, will you get from two such homographies?
- Another hint: when you need to solve a homogenous overdetermined linear system, the non-trivial solution will be the singular vector corresponding to the smallest singular value. You can use MATLAB's **SVD()** to recover it.
- For the report:
  - Include the theoretic process for recovering the fundamental matrix in you report. Specify the linear equations system that needs to be solved.
  - Calculate the fundamental matrix and attach it to the report.
  - Think of a way to check that your calculation is good enough, explain it in the report and add some documentation of how you applied it in your case and the result.
  - Think of a way to verify the epipole extracted in 2.2, add the result.

**Good Luck!!!**