EECS 442 Computer Vision, Fall 2014
Midterm Exam

This exam is released on Tuesday, October 28, 2014 at 4:30pm, and is due on **Thursday, October 30, 2014 at 3:00pm.** You should submit your midterm to ctools.

Please include all your source code,
text files (for RANSAC), final figures and submit it alongwith your final outputs and brief descriptions of your approach towards each question.

1 [40 points] Panoramic Imaging Problem

Assume that we have two cameras with camera matrices M_1 and M_2

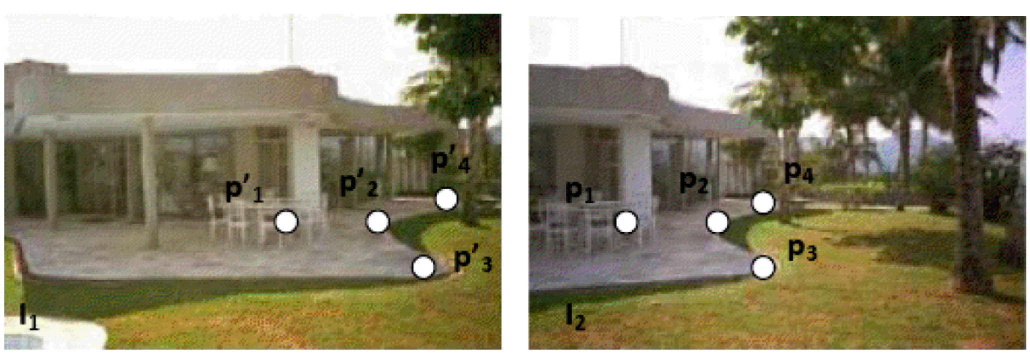
$$M_1 = K_1[R_1 \quad T_1] \quad \text{, and} \quad M_2 = K_2[R_2 \quad T_2],$$

where

$$\begin{aligned} K_1 &= K_2 = K \\ R_1 &= I = \text{Identity matrix} \\ R_2 &= R \\ T_1 &= T_2 = [0\ 0\ 0]^T \end{aligned}$$

Suppose that the cameras generate image 1 and 2 , respectively, as shown in the figure below, where p'_1, p'_2, p'_3, p'_4 and p_1, p_2, p_3, p_4 are corresponding points across the two images.

(a) [**10 pt**] Similarly to homework 3, prove that the homographic transformation H defined by p'_1, p'_2, p'_3, p'_4 and p_1, p_2, p_3, p_4 can be expressed as $H = KRK^{-1}$.



(a) Image 1

(b) Image 2

(b) [**1 0 pt**] Do $N > 3$ corresponding points necessarily need to belong to the same planar surface in 3D in order for the above result to be true? Justify your answer.

(c) [**1 0 pt**] Images taken under the above camera configurations give rise to a set of "panoramic" images. Show that it is possible to estimate the internal matrix K and external parameter R using the H.

(d) [**1 0 pt**] If we change, T_2 to $t = [t_x\ t_y\ t_z]^T$, then find the homography induced by a plane which is defined by $Z^T X = 0$ with $Z = [v^T\ 1]^T$. Explain the derivation.

2 [30 points] Computing H

Write a function `Homography` that takes a set of at least 4 image point correspondences between two images (manually selected) and returns an estimate of the homographic transformation between the images. Use the DTL algorithm to compute the homography.

What to return in this problem:

- Your code for the function `Homography` with comments.
- Numerical values for H if the point correspondences are as in file *4points.txt* (Take point correspondences from *4points.txt* file which can be read using *readPoints.m* function).

3 [30 points] Removing Outliers

Suppose an algorithm is available to compute feature correspondences between the two images above. Point correspondences are obtained from a state-of-the-art feature matching algorithm and are available in the file *200points.txt*. You can read this file using *readPoints.m* file. (See README for details)

Some of these correspondences are incorrect with an outlier population of roughly 12% (out of 200 point correspondences, 24 are outliers)

(a) [**5 points**] Use the algorithm in problem 2 to compute H by using all the feature correspondences. Because of the outliers, the computation of H will be unreliable. Is there a way to fix this issue if you want to stick with a least square fitting method?

(b) [**25 points**] Use RANSAC to compute H and to automatically detect the outliers. You may refer to [HZ or Wikipedia] for implementation details. Perform as many iterations (k) as needed in order to guarantee that algorithm selects a sample set with inliers only with probability **p=0.95** You may use the formula below (w^n is the probability that all n points are inliers) :

$$k = \frac{\log(1-p)}{\log(1-w^n)}$$

What to return in this problem:

- Your code with comments.
- Numerical values of H given by the DTL algorithm using all the correspondences.
- Two original images on top of which you plot the correct point correspondences using a green-cross mark.
- The same two images where you plot the *wrong* image point correspondences between two images using a red-circle mark. (See a demo in *ex_output.png*)

- A text file (generated by your code) where you report the last N iterations of RANSAC. At each iteration you need to print out a line reporting:
  - Iteration number.
  - Number of outliers.
  - Fitting error.
- Discussion of your results.

Report the line when RANSAC finds an outlier set of minimal cardinality (or, inlier set of max cardinality). This is the solution reached by the algorithm.

[Bonus 5 Pt] Solving the Image Panorama Problem

Consider the same cameras as in problem 1. Using the results in problem 1, write a **computer program** that estimates the internal matrix K and external parameter R using the H that is estimated in problem 3. (*Note: unlike in homework 3, do not use vanishing points/lines to estimate K and R.*)

You must return:

- An outline of the algorithm that you are using to compute R and K.
- The source codes.
- The numerical values of K and R.
- Comments about your results.