CS498 Computational Photography
Fall 2013, Midterm Exam
Example Questions

These are meant as samples of the kinds of questions you might see on the exam. You may see some of these particular topics, and you will see other topics as well. The "take-home questions" provides another set of example questions.

1. Filters

a) Compute the center four values of the filter response, using the filter and image given below.

Filter

-1	0	-1
0	4	0
-1	0	-1

*

Input Image

0	1	0	0
0	2	6	0
5	3	2	1
1	2	1	0

➔

Filter Response

x	x	x	x
x			x
x			x
x	x	x	x

b) The Efros and Leung texture synthesis involves computing the SSD of the visible pixels in a patch, with a Gaussian weighting so that pixels near the center have more weight. Suppose you have a template ***f*** and an image ***I***. Show how to compute a *weighted* sum of squared difference (SSD) for each position in image g, where the weights are specified by ***W***, with ***W*** having the same size as ***f***. Write an expression or algorithm that uses linear filtering to compute the weighted SSD response ***h***. Your solution may use basic operators, linear filtering, summation, and pointwise multiplication ".*"; it may not include for loops. If easier, you may write the solution in mathematical notation, using "*" to denote filtering.

```
function h = SSD_weighted(I, f, W)
```

2. Correspondence

To estimate a homography, you need at least four pairs of corresponding 2D points, because there are 8 free parameters.

a) Suppose you have 10 pairs of corresponding points, and you are confident that they are all roughly correct but with a small measurement error. How should you use them to estimate the homography (e.g., should you use all ten pairs or just four; describe the method)?

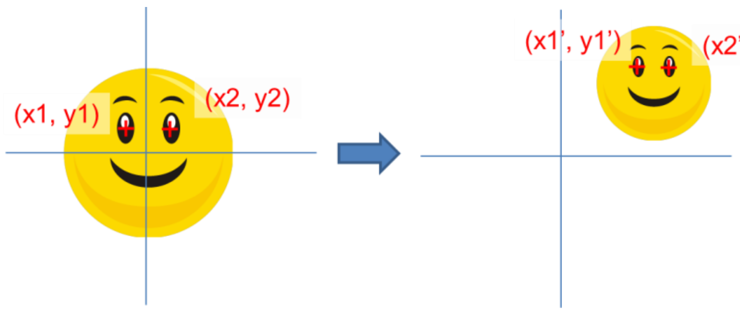
b) Now, suppose that you have 10 pairs of corresponding points, but some of them might be outliers (i.e., not even close to correct). How should you use them to estimate the homography (e.g., should you use all ten pairs; describe the method)?

3. **Pinhole camera**

Suppose that a camera's image plane is perpendicular to the ground (i.e., held at level with the ground). Given that the optical center is (u_0, v_0), provide the equation for the horizon line (the vanishing line of the ground plane), where u and v are the image coordinates.

4. **Transformations**

Suppose that the image of a face is scaled uniformly by factor *s* and translated in either direction by t_x and t_y.



(a) Write down the equation for a transformed point (x', y') as a function of the original point (x, y) in terms of t_x, t_y, and s.

(b) Write the transformation in matrix form in terms of t_x, t_y, s, x, y, x', and y':

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \qquad\qquad\qquad \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

(c) If you are given two pairs of corresponding points: (x1, y1) to (x1', y1') and (x2, y2) to (x2', y2'), how do you solve for the transformation parameters t_x, t_y, s? Write down the system of equations in a matrix form (you don't need to solve it):

$$\begin{bmatrix} \qquad\qquad\qquad \\ \\ \\ \\ \end{bmatrix} \begin{bmatrix} s \\ t_x \\ t_y \end{bmatrix} \cong \begin{bmatrix} \quad \\ \\ \\ \\ \end{bmatrix}$$

(d) Suppose that the corresponding points may have small random localization errors.

i. Will the above constraints be satisfied exactly? Why or why not?

ii. Would having more corresponding points with the same distribution of error make the transformation more or less accurate? Why?

5. Laplacian Pyramid

a) Write code (Matlab or detailed pseudocode) to downsample an image by a factor of 2 without aliasing. Include any necessary filtering and indexing steps; specify parameter values. You may not use "imresize". (4 pts)

```
function im_half = downsample(im)
```

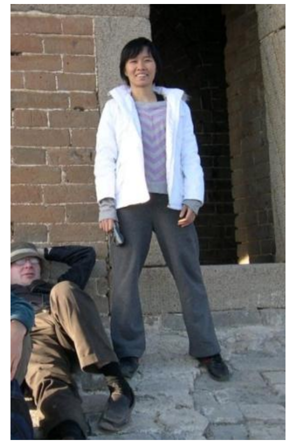
b) Draw a diagram to illustrate the procedure to create a one-level Laplacian Pyramid from an image. The one-level pyramid will consist of one high-pass image (H_0) and one low-pass image (L_1).

c) Write code (Matlab or detailed pseudocode) to compute a one-level Laplacian Pyramid of a grayscale image `im` of size 640x640 pixels. Make sure to specify any filter parameter values. In the function definition below, `H0` is the high-pass band, and `L1` is the low-pass band.

```
function [H0, L1] = LaplacianPyramid_Level1(im)
```

6. **Segmentation and Compositing**

Suppose I wanted to cut out the woman in the white jacket and paste her onto a blank blue background.



a. Explain how "intelligent scissors" could be used to cut out the region corresponding to the woman.

   i. What image cues (e.g., pixel colors, edges, gradients, texture) does intelligent scissors use?

   ii. How does the user interact?

   iii. What potential difficulties may require more interaction for this task?

b. Now, you want to composite her onto the background.

   i. Why is it a bad idea to directly copy and paste the pixels into the background image?

   ii. Which of the following methods is most appropriate for compositing in this case (good region mask, textured background): (1) alpha matting with feathering; (2) Poisson blending; (3) Laplacian pyramid blending. Explain your choice.