CSE185 Midterm exam 2 Name: Melanie R.

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Name: Melanie Rubalcaba

Signature: Melanie R.

Note: 14 questions on both sides, maximum 100 points.

1. [5 points] Let f be an image and g be a Gaussian filter. When we compute x image gradient, why do we want to apply Gaussian filter first, i.e., $\frac{\partial}{\partial x}(f * g)$?

Gaussian filter helps by reducing the amount of noise making it easier to detect edges within images later.

2. [5 points] Let f be an image and g be a Gaussian filter. When we compute x gradient, why can we first compute $\frac{\partial}{\partial x}g$ and then convolve an image f with $\frac{\partial}{\partial x}g$? What are the advantages?

The advantage of this is that is more time efficient. This would allow the ability to save time on at least one operation

3. [5 points] Let f be an image and g be a Gaussian filter. When we find the zero crossing on the x image gradient, why can we convolve an image f with $\frac{\partial^2}{\partial x^2}g$ directly? What are the advantages?

Zero crossings are useful in localizing edges They are used as declared edge points but must be able to go from a high threshold to a lower one

4. [5 points] Canny edge detector. Which of the following statement is true? Explain your answers for full credits.
   a. Non-maximum suppression is used to select a pixel that is close to the true edge
   b. The edges found by a Canny edge detector are determined by the Gaussian kernel scale
   c. In hysteresis process, we start with low thresholds and then high thresholds
   d. a, b and c are correct
   e. a and b are correct

In hysteris, you start from high thresholds and then low thresholds. Non-maximum suppression acts by thinning out edges to find the closest true edge. Gaussian kernel scale is important because it is what filters out noise of an image.

5. [10 points] For Harris point detector, the second moment matrix at a pixel p is computed by $M = \begin{bmatrix} I_x^2 & I_x I_y \\ I_y I_x & I_y^2 \end{bmatrix}$ where I_x, I_y are x and y image gradients. Let the first and second eigenvalues of M be $\lambda_1, \lambda_2, \lambda_1 \geq \lambda_2$. Explain why the eigenvalues can tell us the whether we find an edge, corner, or flat region at pixel p?

Eigenvalues help determine corner response by looking at intensity change. Very large eigenvalues typically yield corners. If λ_2 is significantly larger than λ_1 & vice versa then it's an edge. If λ_1 & λ_2 are very small then it is a flat region.

6. [10 points] For Harris point detector, the corner response $R = \det(M) - 0.04\ tr(M)$ where det and tr are the determinant and trace of a matrix. For a point where $M = \begin{bmatrix} I_x^2 & I_xI_y \\ I_yI_x & I_y^2 \end{bmatrix} = \begin{bmatrix} 0.8 & 0.2 \\ 0.2 & 0.9 \end{bmatrix}$ where I_x, I_y are x and y image gradients, is this point on an edge? a corner? or a flat region?

0.8(0.9) − (0.2)(0.2)

0.72 − 0.04 = 0.68 = det(M)

tr(M) = 0.8 + 0.9 = 1.7

0.68 − 0.04(1.7) = R

0.68 − 0.068

R = 0.612

I believe this is a flat region because it isn't much greater than 0 to be a corner and it isn't smaller than 0 to be an edge.

7. [5 points] Hough transform. Given one points (x, y) = (2, 6) in the image plane, write down the corresponding line in the Hough parameter space (describe a line in terms of m and b, your answer should be m=____).

$y = mx + b$

$\frac{y-3}{x} = m$

$\frac{6-b}{2} = m$

$m = 3 - \frac{b}{2}$

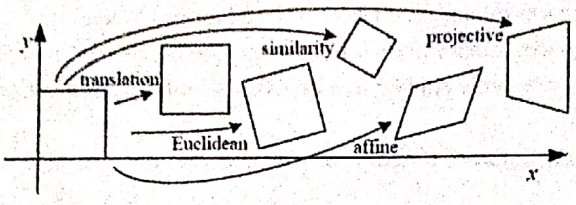
8. [5 points] Which of the following statements regarding line fitting is true?
   a. Line fitting with least squares minimization gives a closed form solution.
   b. Line fitting with least squares minimization is not sensitive to outliers.
   c. Hough transform can be efficiently applied to model fitting with a large number of parameters.
   d. Model fitting with RANSAC does not the same answer every time.
   e. a and d are correct

Ransac outputs are nearly identical each iteration. Hough transform is only suitable with fewer parameters.

9. [5 points] Which of the following statements is true when we use RANSAC to fit data points with an objective function?
   a. Applicable to an objective function with more parameters than the Hough transform
   b. Optimization parameters are easier to choose than Hough transform
   c. Computational time grows quickly with fraction of outliers
   d. Not good for getting multiple fits
   e. a, b, and d are correct

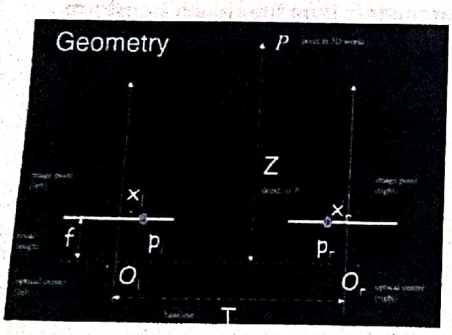
Hough transform is less applicable because of its large amount of parameters. Hough transform is sensitive to noise & thus not as easy to choose optimization parameters. RANSAC is not good at getting multiple sequences of the best fit for alignments

10. [5 points] Which of the following statements regarding 2D transformation are correct?



a. Euclidean transformation has 3 parameters
b. Similarity transformation has 4 parameters
c. Affine transformation has 6 parameters
d. a, b, and c are true
e. a and c are true

11. [10 points] Given a pair of stereo images. Show every step on how to compute depth $Z = f\frac{T}{x_r - x_l}$



$$Z = f\frac{T}{x_r - x_l}$$

$$\frac{T}{Z} = \frac{T + x_l - x_r}{Z - f}$$

$$T(Z - f) = (T + x_l - x_r)Z$$

$$TZ - Tf = TZ + Zx_l - Zx_r$$

$$-Tf = Z(x_l - x_r)$$

$$Z = \frac{-Tf}{x_l - x_r}$$

$$Z = \frac{Tf}{-x_l + x_r}$$

12. [10 points] Which of the following statements are true? Explain your answers.

a. Given a pair of images from a calibrated stereo camera, for each pixel in one image, we can use the essential matrix to compute the corresponding epipolar line in the other image

b. Give a pair of images from an uncalibrated stereo camera, for each pixel in one image, we can use the essential matrix to compute the corresponding epipolar line in the other image.

c. Epipolar lines are always horizontal lines on an image

d. When we use larger window for search correspondence, we can capture more details

e. a and c are correct

Such as in photography, to preserve detail a smaller window is typically used. After the projection of images onto the image plane, epipolar lines are always horizontal. An uncalibrated camera uses another method for computing epipolar lines called fundamental matrix.

13. [10 points] Given a pair of left and right images for a calibrated stereo camera, which of the following statements for the calibrated stereo camera are true? Explain your answers.

a. Given one point in one image, the corresponding point in the second image of a stereo par is on a line passing through its epipole.

b. We can use the essential matrix to map a point in the left image to a line in the right image.

c. Depth is inversely proportional to disparity

d. a and c are correct

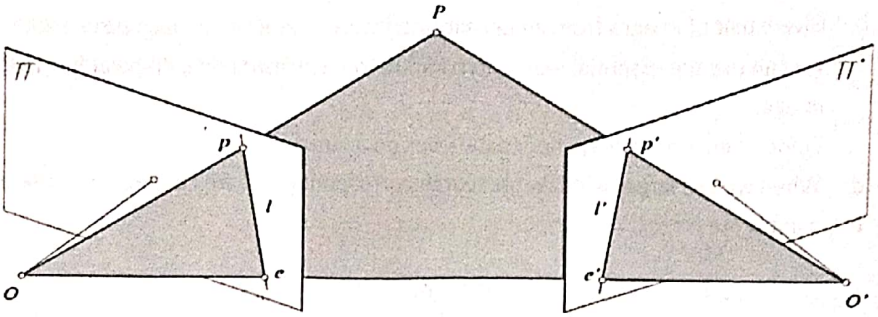
e. a, b and c are correct

A stereo pair is defined by being able to have a point on one image with a corresponding point on a line passing through its epipole. Because of calibration, essential matrix is used.

depth = z
disparity = d

$z = \frac{1}{d} = \frac{1}{x - x'}$

14. [10 points] Epipolar geometry. Given a point P in the world coordinate with two mapped points p and p' on two image planes with two optical centers O and O'. Derive the following equations.



$$\overrightarrow{Op} \cdot [\overrightarrow{OO'} \times \overrightarrow{O'p'}] = 0$$

Explain every step (what does the cross product of two vectors do and what does the inner product of two vectors do?) to earn full credit.

The cross product of the function is used to determine the perpendicular vector of both $\overrightarrow{OO'}$ and $\overrightarrow{O'p'}$. The outer dot product helps find the magnitudes of the calculated vectors.