CSE185 Midterm exam 2 Name: David Wang________________________________

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Name: ______David Wang_____________________________

Signature: David Wang____

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., $\frac{\partial}{\partial x}(f * g)$?

   Applying a Gaussian filter first allows us to reduce noise and remove unwanted details and textures, smoothing the image out.

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?

   An advantage of computing and then convolving is that we would save a step compared to convolving an image with g and then taking the derivative of the image. We are allowed to do this because convolution is associative.

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?

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

T**he answer is e: a and b are correct. c is false since with the hysteresis process we start with high then low thresholds, thus d is false as well since it assumes c is true. a and b are both true, therefore the answer is e.**

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?

If the eigenvalues are λ2 >> λ1 or λ1 >>λ2 then there will be an edge at pixel p.

If the eigenvalues of λ1 or λ2 are large and not close to zero, then it is a corner at pixel p.

If the eigenvalues are close to zero, then there will be a flat region at pixel p.

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 $M = \begin{bmatrix} I_x^2 & I_x I_y \\ I_y I_x & I_y^2 \end{bmatrix} = \begin{bmatrix} 0.8 & 0.2 \\ 0.2 & 0.9 \end{bmatrix}$ where I_x, I_y are x and y image gradients, is this point on an edge? a corner? or a flat region?

   R = det(M) - 0.04tr(M)

   det(M) = λ1λ2 = (0.8)(0.9) = 0.72
   tr(M) = λ1 + λ2 = (0.8) + (0.9) = 1.7

   R = 0.72 - 0.04(1.7) = 0.652

   The point is not on an edge, since R is not less than 0. R is close to 0, so it is a flat region.

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=____).

   Haugh Space: m = (-1/x)b + (y/x)

   Plugging in the point (2, 6) should give m = (-1/2)b + 3

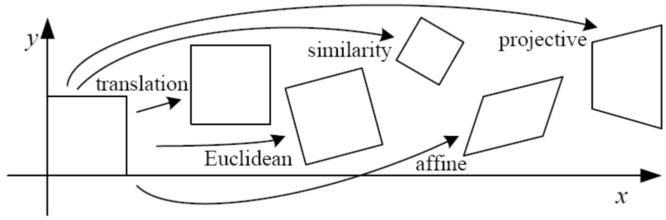
8. [5 points] Which of the following statements regarding line fitting is true?
    a. Line fitting with least squares minimization gives a closed form solution.
    b. Line fitting with least squares minimization is not sensitive to outliers.
    c. Hough transform can be efficiently applied to model 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

    The answer is e : a and d

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

    The answer is e: a, b and d are correct.

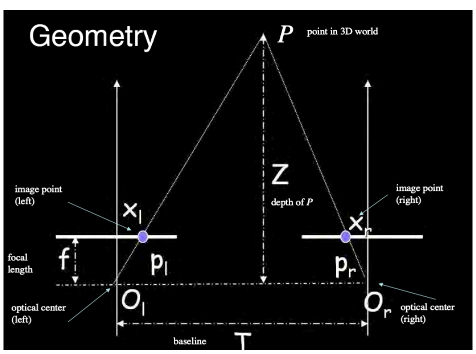
10. [5 points] Which of the following statements regarding 2D transformation are correct?



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

The answer is d: since a, b, and c are all true.

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



Disparity is represented by Xr - X1

Assuming that the axes are parallel, we can assume that the triangles formed by (p1, P, pr), and (O1, P, Or) are similar triangles.

Since they are similar triangles we can set them equal to each other

$$\frac{T + (x1 - xr)}{Z - f} = \frac{T}{Z}$$

solving for Z gives us

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

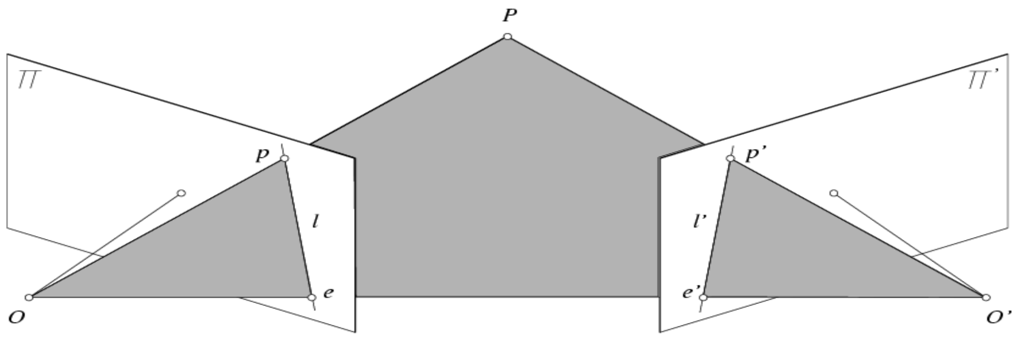
12. [10 points] Which of the following statements are true? Explain your answers.
    a. Given a pair of images from a calibrated stereo camera, for each pixel in one image, we can use the essential matrix to compute the corresponding epipolar line in the other image
    b. Give a pair of images from 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

    The answer is a. b is false because it should be a calibrated stereo camera, using an essential matrix. c is false because epipolar lines are horizontal after rectifying, therefore they are not always horizontal. A smaller window is required for capturing more details therefore d is false as well. Thus, e is false since c is not correct.

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

    The answer is e. Essential matrices allow you to map a point from one image to a line in another image, so b is true. d is false since b is true. c is true because the equation for depth has disparity in the denominator thus it is inversely proportional.

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, N, of vectors OO' and O'p' gives a surface perpendicular to the plane OO'p, and the inner product of vector Op and the cross product N gives 0 since they are perpendicular to each other.