CSE252B – Computer Vision II – Final Exam
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`http://www-cse.ucsd.edu/classes/sp04/cse252b`
7:00pm-10:00pm Fri. June 11, 2004.

On this exam you are allowed to use a calculator and two 8.5" by 11" sheets of notes. The total number of points possible is 40. In order to get full credit you must show all your work. Good luck!

1. Consider the two lines $y = x - 1$ and $y = x + 1$.
   (a) (1 pt.) Write down the expression for each line ($\boldsymbol{l}_1$ and $\boldsymbol{l}_2$) in homogeneous coordinates.
   (b) (1 pt.) Solve for their point of intersection.
2. Let $\boldsymbol{l} = (0, 0, 1)^\top$ denote the homogeneous coordinates of a line in $\mathbb{P}^2$ and let $C = \text{diag}\{1, 1, -1\}$ be the coefficient matrix for the conic $\boldsymbol{x}^\top C \boldsymbol{x} = 0$.
   (a) (1 pt.) What is the special name for $\boldsymbol{l}$?
   (b) (1 pt.) What do you get if you intersect $\boldsymbol{l}$ and C?
3. Rectified stereo.
   (a) (2 pts.) Write down the normalized essential matrix (E) for a rectified stereo rig.
   (b) (2 pts.) What are the epipoles ($\boldsymbol{e}_{1,2}$) in this case?
   (c) (1 pt.) Why is this configuration desirable for computing stereo disparity?
4. Essential matrix.
   (a) (1 pt.) How many degrees of freedom does E have?
   (b) (3 pts.) Explain where the degrees of freedom come from.
5. Suppose you capture two frames by rotating a camera about its optical center.
   (a) (1 pt.) Can you use the eight point algorithm to estimate E in this case?
   (b) (1 pt.) If yes, state the conditions under which it is possible. If no, explain why.
6. Suppose you are designing a system for automatic projective distortion correction (also known as "keystone correction") for an LCD projector. In this problem, assume you are able to extract the lines forming the bounding box of the image on the projection screen.
   (a) (2 pts.) Explain how to identify the image of the line at infinity (call it $\boldsymbol{l} = (a, b, c)^\top$).
   (b) (1 pt.) Give the entries of the matrix $H \in GL(3)$ needed to perform an upgrade from projective to affine.
   (c) (1 pt.) In general, what will the shape of the upgraded image be?
   (d) (1 pt.) What approach could you use to upgrade directly from projective to Euclidean?
7. Hartley normalization.
   (a) (1 pt.) Explain the practical implications of Hartley normalization.
   (b) (2 pts.) If we regard the Hartley normalization matrix H as a guess of the calibration matrix K, what assumptions is it making about the calibration parameters?
8. (1 pt.) What can be seen in three dimensions from an uncalibrated stereo rig?

9. (2 pts.) Referring to the expression for a 3D point imaged by a general camera, i.e., $\lambda \boldsymbol{x} = \Pi \boldsymbol{X}$, with $\Pi = KR[I, \boldsymbol{T}]$, explain why distant points (e.g., on the moon or a mountain) appear stationary when viewed from a translating vehicle.

10. Corner detection.

    (a) (2 pt.) Describe two situations in which a corner detected by the Förstner interest point operator does not correspond to a physical corner in the 3D scene.

    (b) (1 pt.) What problem do these 'false corners' present?

    (c) (1 pt.) Name a practical tool can be used to get around this problem.

11. Both the Lucas-Kanade optical flow method and the Förstner operator require the computation of a special 2×2 symmetric matrix in a window around each pixel as an intermediate step.

    (a) (1 pt.) Give the name of this matrix.

    (b) (3 pt.) What are the entries of this matrix?

    (c) (3 pts.) How does one interpret this matrix in terms of different types of image neighborhoods?

12. The orthographic camera model.

    (a) (1 pt.) Describe the conditions under which the orthographic camera model is reasonable.

    (b) (2 pt.) Define the "Hitchcock zoom" effect and explain how to produce it using a video camera with a zoom lens. You can assume you have a tripod with wheels, or a very steady hand.