CSE252B – Computer Vision II – Final Exam
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`http://www-cse.ucsd.edu/classes/sp09/cse252b`
3:00pm-6:00pm Tue. June 9, 2009.

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 41. In order to get full credit you must show all your work. Good luck!

1. Consider the matrix $A \in GL(3)$. For each question, answer yes or no, and explain why.
   (a) (2 pts.) Could A be a valid essential matrix?
   (b) (2 pts.) Could A be a valid fundamental matrix?
2. Write down an example of a conic matrix C corresponding to each of the following cases and solve for the points of intersection with $\boldsymbol{l}_\infty$.
   (a) (2 pts.) Ellipse.
   (b) (2 pts.) Parabola.
   (c) (2 pts.) Hyperbola.
3. Suppose you capture two images related by a pure translation in the X direction, i.e., sideways camera motion.
   (a) (1 pt.) Where is the epipole in this case?
   (b) (1 pt.) What would be the result of applying epipolar rectification to this pair of images?
4. This problem pertains to Tomasi and Kanade's Factorization algorithm.
   (a) (2 pts) What is the minimum number of frames and tracked points required for this method to work?
   (b) (1 pt) After factoring the centered measurement matrix as $\tilde{W} = RS$, how much is known about the 3D structure of the scene?
   (c) (3 pts) What two properties of R do they exploit? What purpose does this serve?
5. (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.
6. 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) (3 pt.) What are the entries of this matrix?
   (b) (2 pts.) Prove that this matrix is positive semidefinite.
   (c) (3 pts.) How does one interpret this matrix in terms of different types of image neighborhoods?
7. (3 pts.) What is the normal vector of the plane at infinity? What is the motivation for identifying its image under perspective projection? Show how to estimate the image of the plane at infinity by solving a null space problem.
8. (1 pt.) What is the name of the curve given by the intersection of a unit sphere with the plane at infinity?

9. (2 pts.) How does a 2D similarity transform H_S differ (qualitatively) from a 2D affine transform H_A? What is the significance of the eigenvectors of H_S?

10. Consider the two lines $y = 2x + a$ and $y = 2x - b$, where $a, b \in \mathbb{R}^+$.

    (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.

11. Suppose you capture two frames by rotating a camera about its optical center.

    (a) (1 pt.) Can you use the four point algorithm to estimate H in this case?

    (b) (1 pt.) If yes, explain a practical use for H. If no, explain how the motion would have to change to make this possible.

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.