CSE252B – Computer Vision II – Final Exam

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`http://www-cse.ucsd.edu/classes/sp05/cse252b`

7:00pm-10:00pm Wed. June 8, 2005.

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

1. (1 pt) When estimating the Fundamental matrix from noisy data we set its third singular value to zero. Let F and F' denote the Fundamental matrix before and after this operation. How are the epipolar lines produced by F different from those produced by F'?

2. (2 pts) Prove that all epipolar lines in an image plane intersect at the epipole.

3. (2 pts) The epipolar rectification algorithm returns two 2D homographies, H_1 and H_2, which are applied to image 1 and image 2, respectively. What equivalent 3D transformation can be applied to camera 1 and camera 2 to produce the same effect?

4. Recall the general expression for a conic in homogeneous coordinates $(x, y, z)^\top \in \mathbb{P}^2$:

$$ax^2 + bxy + cy^2 + dxz + eyz + fz^2 = 0$$

   Let $a = -1$, $e = 1$, $f = 2$, and $b = c = d = 0$.

   (a) (1 pt.) What kind of curve is this?

   (b) (1 pt.) Compute its intersection with the line at infinity.

5. (1 pt) What is the significance of the eigenvectors of a 2D similarity transform (i.e., a rigid transformation with a constant scale factor)?

6. Consider a pair of images of a Rubik's Cube captured using an uncalibrated stereo rig.

   (a) (1 pt) Without making any assumptions about the Rubik's Cube, what can we determine about its 3D structure?

   (b) (2 pts) Suppose you determine the three vanishing points in the two images. What do they allow you to compute, and how is it useful?

   (c) (3 pts) Once the epipolar geometry is known, one could estimate the vanishing points in each image and solve for their projective depths. H&Z advise against this, however. Why is it not a good idea? What do they suggest as an alternative?

   (d) (2 pts) How many ground truth points are needed to perform a Euclidean upgrade? Make a sketch to indicate acceptable locations for this set of points.

7. (4 pts) Suppose you have two rectified stereo rigs, one with orthographic cameras and one with projective cameras. Can both be used to perform 3D reconstruction? For each case, answer yes or no; if yes, explain why, if no, explain what modification to the rig would fix the problem.

8. (2 pt) What kind of transformation in $\mathbb{P}^2$ leaves the line at infinity unchanged? Apply this transformation to $\boldsymbol{l}_\infty$ and show that it is not affected.

9. This problem pertains to the Tomasi and Kanade's Factorization algorithm.

   (a) (1 pts) What kind of camera model do they assume?

   (b) (2 pts) What can you do in practice to approximate this model using a regular camera?

(c) (2 pts) What is the minimum number of frames and tracked points required for this method to work?

(d) (1 pt) After factoring the centered measurement matrix as $\tilde{W} = RS$, how much is known about the 3D structure of the scene?

(e) (3 pts) What properties of R do they exploit? What purpose does this serve?

10. (2 pts) What is the intersection of a sphere with the plane at infinity? Explain how its image is used in practice.

11. (1 pt) Consider a pair of images related by a homography $H \in GL(3)$. Given a line $\boldsymbol{l}_1$ in image 1, what expression gives the corresponding line $\boldsymbol{l}_2$ in image 2?

12. (1 pt) The eight point algorithm is based on a 'stacked' version of the essential or fundamental matrix, i.e., $E(:)$ or $F(:)$. What potential problem does this cause?