# CS 4495/7495 Computer Vision Final Exam

Wednesday December 14 2005



**Instructions:**

- There are 7 pages. Ensure your exam is not missing any. Write your name *on every page*.
- If you make a mess, clearly indicate your final answer. Write clearly and be concise.
- The exam has a maximum score of 100 points.
- This exam is OPEN BOOK. You may use any books or notes you like.
- This exam is NO ELECTRONICS (laptop, pda, calculator, phone, etc..).
- If you feel a question is ambiguous or unclear, make an assumption and write that assumption down with your answer.

# 1 Homographies

A homography $H$ is used to transform image 1 into image 2.

a) While warping, do we use

$$p = Hp'$$

or

$$p' = Hp$$

where $p$ and $p'$ are homogeneous coordinates in image 1 and 2, respectively. Circle the correct equation and explain briefly.

b) Give the two 3*3 matrices $H$ corresponding to a translation of image 1 by 10 pixels to the right, and a uniform zoom of image 1 by a factor of 2, leaving the point $(0,0)$ at the same place. Briefly explain your answer.

# 2 RANSAC

a) What is the minimum number of points $s$ needed in RANSAC to fit a 2D translation of an image?

b) Say there are 50% outliers. How many times do we need to sample in that case to have a 50% chance of getting all inliers ?

# 3 Fundamental Matrix

a) If a robot, driving straight ahead, takes two successive pictures of the environment in front of it, explain the configuration of the epipole and epipolar lines in the first (earlier) image.



b) Now assume the robot stops, takes a picture, rotates a small amount, and takes another picture. again, explain the configuration of the epipole and epipolar lines in the first (earlier) image.

# 4 Trifocal Tensor

a) Assume you have already obtained a trifocal tensor $T_C^{AB}$ describing the geometry of three views, where $A$, $B$, and $C$ index the first, second, and third view, respectively. Suppose a number of points all project to a line $l_A$ in the first view, how then are these points related in the two remaining views $B$ and $C$ ?

b) Describe a real-life situation (a scene + 3 camera poses) where that would occur.

c) How many of these line-point-point triplets do we need to linearly estimate $T_C^{AB}$ using SVD?

# 5 Structure from Motion

If I observe 20 points in 5 orthographic views, give (and briefly explain) the dimensions of the measurement matrix $U$, motion matrix $M$ , and structure matrix $S$ and show their relationship.

## 6 Hough Transform

Suppose I want to fit quadratics instead of lines using the Hough transform.

a) What is the dimension of the parameter space in that case ?

b) What does one point induce in this space ? (no need to be very detailed)

## 7 Classifiers

Suppose I use a segmentation algorithm to segment red blood cells in an image taken with a microscope, and measure their area in the image. I have 5 healthy cells, with areas 3,5,5,7,5, and three unhealthy ones, with areas 7,7,9.

a) what is a good estimate for $P(healthy)$ ?

b) Sketch $P(area|healthy)$ and $P(area|unhealthy)$, using a histogram density estimate with 5 bins from 0 to 10. Use two different graphs.

c) For those estimates, sketch $P(healthy|area)$ and $P(unhealthy|area)$. Use one graph for both.

d) Sketch $P(area|healthy)$ and $P(area|unhealthy)$ using a box-based Parzen window density estimate, with boxes that are **four** units wide. Use two different graphs.

# 8 Expectation Maximization

Compare EM with RANSAC in coping with outliers. In particular, how would an EM-based fundamental matrix estimator work? Outline the E and M-step, respectively. What are the advantages/disadvantages wrpt to RANSAC?