Computer Science and Engineering 4422.03

Final
Dec. 19 2011

Answer all questions in the space provided

Make sure that you have 9 pages

Student Last Name: ______________________________

Student Given Name: ______________________________

Student Id. No: ____________________________________

Question	Value	Score
1	75	
2	60/75	
Total	130	

Question 1. [75 points]

1. [5 points] Name the area of the retina that functions very well in the day but poorly at night.

2. [5 points] Name the learning algorithm used in the Viola and Jones face detection.

3. [5 points] The epipolar equation was encountered when trying to solve which problem?

4. [5 points] What would be the difficulty with using Hough transform to find ellispes in an image?

5. [5 points] What is the advantage of methods like RANSAC and M-estimators?

6. [5 points] The corner estimator we descibed in class uses a 2×2 matrix. Where else did we encounter this same matrix?

7. [5 points] In two occasions we factored a matrix. In the one we factored it in a product of a rotation matrix and a symmetric matrix and the other in a product of a rotation matrix and a skew symmetric matrix. What were these occasions?

8. [5 points] Name a situation where we need to factor a matrix into a product of a rotation matrix and a triangular matrix.

9. [5 points] What is a practical approximation for the Laplacian of Gaussian of an image.

10. [5 points] What algorithm was the integral image used in?

11. [5 points] What is the apperture problem?

12. [5 points] In the least squares formulation of the optical flow problem we added some extra terms. These were the squares of the derivatives of the flow. What was the purpose?

13. [5 points] Name the two observations that allow us to reduce the eight solutions to the Structure from Motion problem to a single solution.

14. [5 points] What series of two morphological operators do we use to eliminate small holes in an object in a binary image?

15. [5 points] What problem did we use iteratively re-weighted least squares for?

Question 2.

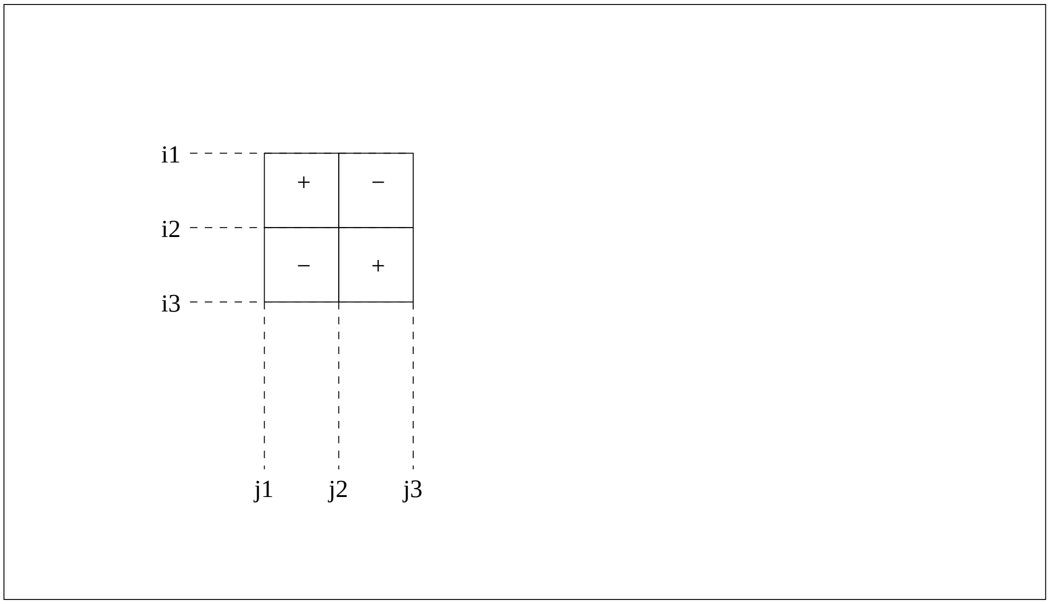
[60/75 points]

1. [15 points] The fundamental constraint for an optical flow system for a certain application is that the gradient (the vector of the spatial derivatives) of the intensity remains constant (as opposed to the intensity remaining constant).

(1) Write the flow equation(s) for this application.

(2) How many equations and how many unknowns?

2. [15 points]



Consider the above feature (in Viola-Jones style). If you are given the integral image, compute the feature. The weights are +1 or −1.

3. [15 points] An alternative way to derive the optical flow equation is to start from the requirement of constant intensity expressed as

$$I[x+u, y+v, t+1] = I[x, y, t]$$

We want to decrease the sensitivity of the optical flow equation to large interframe motion and we use a symmetric version of the above:

$$I[x+\frac{u}{2}, y+\frac{v}{2}, t+1] = I[x-\frac{u}{2}, y-\frac{v}{2}, t]$$

Derive this "new" optical flow equation using Taylor series expansion.

4. [15 points] In a 2-D world, the rigidity equation and the structure from motion look slightly different. First of all we cannot recover the motion and depth from two cameras

1 Explain very briefly why we cannot recover motion and depth from two cameras.

We will consider three cameras (or one camera three frames). The rigidity equations for a 2-D world point P are

$$P_2 = R_1 P_1 + T_1$$
$$P_3 = R_2 P_1 + T_2$$

where R_1 and T_1 is the motion between the first and the second camera, R_2 and T_2 the motion between the first and the third camera and P_1, P_2 and P_3 are the 2-D coordinates of the world point in the corresponding camera coordinate systems.

2 Eliminate the depths from the above equations. Since there is no cross product in two dimensions, you can use p_2^+ and p_3^+ to denote vectors perpendicular to p_2 and p_3.

5. [15 points, GRADS] The Cholesky factorization decomposes any symmetric positive definite matrix A into

$$A = LL^T$$

where L is an upper triangular matrix. Use this to decompose matrix Q, where

$$Q = CR$$

and C is a calibration matrix and R a rotation matrix.