

**CSE252 – Computer Vision – Final Exam**

Instructor: Prof. Serge Belongie.

<http://www-cse.ucsd.edu/~sjb/classes/sp02/cse252>

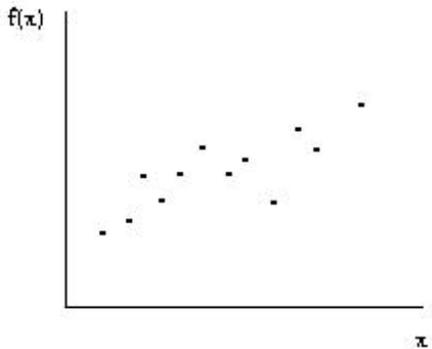
3:00pm-6:00pm Thurs. June 13, 2002.

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

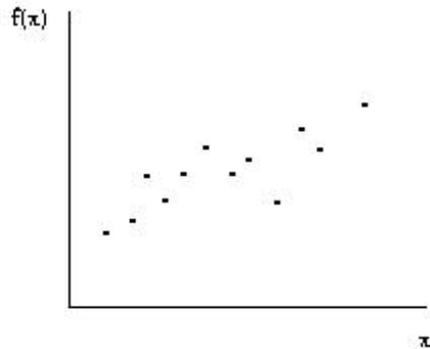
1. (2 pts) Under what conditions is the essential matrix  $E$  equal to the fundamental matrix  $F$ ?
2. (2 pts) Which eigenvector of the normalized affinity matrix  $P = D^{-1}W$  does Normalized Cut use to find an approximately optimal bipartition?
3. (4 pts) Prove that the rank of the essential matrix is 2.
4. (4 pts) Define and give a brief explanation of Helmholtz reciprocity.
5. (4 pts) Consider the distribution of responses of a Derivative-of-Gaussian filter to a natural image. Name and sketch the probability density function (pdf) that often provides a good fit to this distribution.
6. (4 pts) Sketch what the regularized cubic spline fit  $f(x)$  looks like for the scattered data  $v_i$  shown in the plots below for the following two cases:  $\lambda \rightarrow 0$  and  $\lambda \rightarrow \infty$ . Recall that the form of the cost functional is

$$H[f] = \sum_i (f(x_i) - v_i)^2 + \lambda \int_{\mathbb{R}} \left( \frac{\partial^2 f}{\partial x^2} \right)^2 dx$$

$\lambda \rightarrow 0$



$\lambda \rightarrow \infty$



7. (6 pts) Name six Gestalt factors of grouping.
8. (10 pts) Prove that 2 basis filters are needed to steer  $G_1$ , the 1st directional derivative of a Gaussian. Hint: use polar coordinates.
9. (10 pts) Given at least two motion field vectors, explain each step needed to estimate the focus of expansion (FOE) and the time to collision ( $t_c$ ).
10. (10 pts) Explain how to modify the Förstner corner operator to detect and localize the centers of circular features, e.g. the centers of polka dots.
11. (10 pts) Suppose you have been assigned the job of digitally replacing the advertisement appearing in a photograph of a rectangular billboard at the World Cup. Assume that the billboard is viewed under perspective projection and that it is unoccluded. In words, explain each step needed to perform this task.

For 1 bonus point: What is the plural of *Ansatz*?