CSE252 – Object Recognition – Exam
Instructor: Prof. Serge Belongie.
`http://www-cse.ucsd.edu/classes/sp07/cse252c`
3:00pm-6:00pm Thursday December 13, 2007.

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

1. (2 pts.) Which eigenvector of the normalized affinity matrix $P = D^{-1}W$ does Normalized Cut use to find an approximately optimal bipartition? What is the significance of the corresponding eigenvalue?

2. (4 pts.) Name two algorithms that solve for correspondences between two pointsets of cardinality M and N, respectively. Explain how each algorithm handles spurious/missing points.

3. (4 pts.) Write down the expression for an N-dimensional, full-covariance Mixture of Gaussians (MoG) with K components. Name an algorithm that can be used to solve for the maximum likelihood estimates of its parameters. What is a potential drawback of this algorithm?

4. (5 pts.) Sketch examples of pdfs for the genuine and impostor distance distributions for an object detector. Assume that there is some overlap between the two classes. Call the two pdfs $p_g(d)$ and $p_i(d)$, respectively. Mark a sample threshold on the plot and indicate how to compute the following quantities: True Positives, False Positives, False Negatives, True Negatives. Write down the formula for the ROC curve and make a sketch of it, including axis labels.

5. (3 pts.) Write down the expression for the Mahalanobis distance between two vectors $\boldsymbol{x}^i$ and $\boldsymbol{x}^j$. Show that this is equivalent to the squared Euclidean distance between appropriately defined vectors $\boldsymbol{y}^i$ and $\boldsymbol{y}^j$.

6. (3 pts.) Write down the expression for the χ^2 distance between two normalized histogram vectors $\boldsymbol{x}^i$ and $\boldsymbol{x}^j$. Prove or disprove the following: (a) $\chi^2_{ij} \in [0, 1]$, (b) χ^2_{ij} is a metric.

7. (4 pts.) Suppose you are given a labeled 2D dataset with two classes: a clump (class 1) surrounded by an annulus (class 2). Explain how a kernel based approach could be used to find a decision boundary between the two classes, and name an example of a kernel that would be suited to this task.

8. (4 pts.) Using the same clump/annulus dataset as above, suppose you now wish to use AdaBoost to train a strong classifier $H(\boldsymbol{x})$. Assume each class has an equal number of data points. What is a suitable weak learner $h(\boldsymbol{x})$ for this purpose? Sketch what $H(\boldsymbol{x})$ might look like after 8 iterations.

9. (4 pts) Given the cubic spline $U(x) = \frac{1}{6}|x|^3$, prove that in order for the function

$$f(x) = a + bx + \sum_{i=1}^{n} w_i U(x - x_i)$$

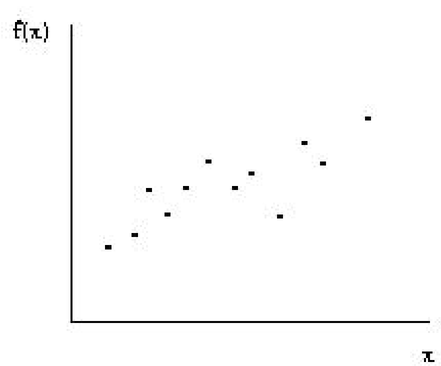
to have a square integrable second derivative, the following constraints must be satisfied:

$$\sum_{i=1}^{n} w_i = 0 \quad \text{and} \quad \sum_{i=1}^{n} w_i x_i = 0.$$

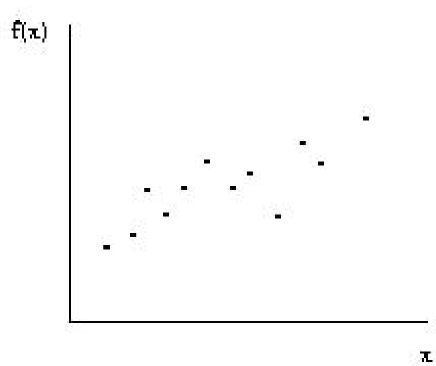
10. (4 pts) Sketch what the regularized cubic spline fit $f(x)$ looks like for the scattered data v_i shown in the plots below for the following two cases: $\lambda \to 0$ and $\lambda \to \infty$. Recall that the form of the cost functional is

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

$\lambda \to 0$



$\lambda \to \infty$



11. (3 pts) What function is the 2D counterpart to the cubic spline? (Technically, it is a pair of functions.) In its regularized form, name the type of 2D transformation it reduces to as $\lambda \to \infty$, and the number of correspondences needed to estimate its parameters.