Name: _____

CS4442/9542: Artificial Intelligence II
Winter 2014: Quiz 3 Solutions

Instructions:

Show all the work you do. Use the back of the page, if necessary. Calculators are allowed, laptops, cell phones, or any other communication devices are not allowed. This is an open notes exam, but the sample quiz solution is not allowed.

1. (20%)

   (a) (10%) Apply mask M to the highlighted (filled in with gray) pixel in the image f, where

$$M = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

50	**50**	**1**	**50**	**1**	**1**
50	**1**	**50**	**1**	**50**	**1**
1	**50**	**50**	**1**	**1**	**50**
1	**50**	**50**	**1**	**1**	**50**
50	**1**	**50**	**1**	**50**	**1**
50	**50**	**1**	**50**	**1**	**1**

f(x,y)

   Solution: -1-50-50+1+1+1 = -98.

   (b) (10%) At which *non-border* pixel (circle it) does mask H have the largest negative response in the image f above?

$$H = \begin{bmatrix} 1 & -1 & -1 \\ -1 & 1 & -1 \\ -1 & -1 & 1 \end{bmatrix}$$

   Solution: Mask has the highest response at the location that "looks" like the mask. Since we want a large negative response, the diagonal should be as small as possible, and off-diagonal as large as positive. This happens at the location circled above.

2. (10%) Design a mask of size 5 by 5 for detecting a white square of size 3 by 3 on a dark background. Assume a large positive mask response corresponds to detection of a square.

-1	**-1**	**-1**	**-1**	**-1**
-1	**1**	**1**	**1**	**-1**
-1	**1**	**1**	**1**	**-1**
-1	**1**	**1**	**1**	**-1**
-1	**-1**	**-1**	**-1**	**-1**

3. (20%) For the energy image below, compute the M and P arrays according to the seam carving algorithm. Mark the optimal vertical seam.

1	**7**	**5**	**6**
2	**4**	**1**	**4**
4	**5**	**1**	**2**
1	**2**	**1**	**5**

energy E

1	**7**	**5**	**6**
3	**5**	**6**	**9**
7	**8**	**6**	**8**
8	**8**	**7**	**11**

M

null	null	null	null
0	**0**	**2**	**2**
0	**0**	**1**	**2**
0	**2**	**2**	**2**

P

4. (20%)

(a) (10%)With $\lambda = 10$, and the data terms as below, what is the figure-ground segmentation energy $E(s)$ for s below on the right? Assume all discontinuities have the same cost 1.

10	**10**	**5**
5	**5**	**15**
10	**5**	**10**

background ***D***

15	**5**	**10**
10	**10**	**5**
15	**10**	**15**

foreground ***D***

0	**1**	**1**
0	**1**	**1**
1	**0**	**1**

segmentation ***s***

Solution: $E(s) = E_{data} + \lambda \cdot E_{smoothness} = (10 + 5 + 10 + 5 + 10 + 5 + 15 + 5 + 15) + \lambda \cdot$ 6 discontinuities $= 80 + 60 = 140$.

(b) (10%) What is the best segmentation according to the energy above?

Solution: To see that this is the best solution, first pick for each pixel the best label individually, without looking at other pixels (i.e. discontinuity costs). You will see that most pixels want to have label 0, and only two want label 1 (namely the middle pixel in the first row and the last pixel in the second row). If we take this solution, there will be 6 discontinuities with cost 60. The cost of assigning these two pixels to label 1 is 10, and to label 0 is 25. So if we switch them to label 0, we have to pay 15 extra, but we subtract discontinuity cost of 60. The total energy is 75.

0	**0**	**0**
0	**0**	**0**
0	**0**	**0**

5. (15%) Suppose we have 4 feature vectors, currently clustered as follows:

$$D_1 = \left\{ \begin{bmatrix} 1 \\ -1 \\ 3 \end{bmatrix}, \begin{bmatrix} 3 \\ 1 \\ 5 \end{bmatrix} \right\}, D_2 = \left\{ \begin{bmatrix} 3 \\ -1 \\ 1 \end{bmatrix}, \begin{bmatrix} 1 \\ -3 \\ 5 \end{bmatrix} \right\}$$

What is the value of J_{SSE} criterion function for this clustering?

Solution: The means in clusters 1 and 2 are, respectively,

$$\mu_1 = \begin{bmatrix} 2 \\ 0 \\ 4 \end{bmatrix}, \mu_2 = \begin{bmatrix} 2 \\ -2 \\ 3 \end{bmatrix}.$$

The squared distances from μ_1 to each point in D_1 are 3 and 3. The squared distances from μ_2 to each point in D_1 are 6 and 6. Adding these up, we get $J_{SSE} = 18$.

6. (15%) Let the left and right images of a stereo pair be as below, and assume maximum disparity is 2. Use the window matching algorithm with a 3x3 window and SAD window cost. What is the disparity that will be assigned to the highlighted pixel?

10	10	10	10	10	10
10	10	10	10	10	10
10	10	20	30	40	10
10	10	20	30	40	10
10	10	20	30	40	10
10	10	10	10	10	10

left image

10	10	10	10	10	10
10	10	10	10	10	10
10	20	30	40	10	10
10	20	30	40	10	10
10	90	30	40	10	10
10	10	10	10	10	10

right image

Solution: SAD costs for disparities 0,1,2, are, respectively, 150, 70, and 140. Therefore, disparity 1 is chosen.