CS 111: Digital Image Processing (Fall 2016)
Written Assignment 3

1) To find transformations between quadrilateral images (specifying four corresponding or tie points) you use a bilinear function of the form $c_1x+c_2y+c_3xy+c_4$ to define the functions relating (x, y) and (x', y'). If you were dealing with triangular images, what kind of equation would you use and why? **[10]**

   Since triangle to triangle gives max of three correspondences, we can solve for 6 parameters. Therefore, a linear equation would be used. They will be of the form $c_2x+c_3y+c_4$.

2) Consider a JPEG compression pipeline using 4x4 image blocks instead of 8x8. The coefficients you generate by doing a DCT on a 5x5 block of luminance values are given by **[5+5+4+3=17]**

3) 140	4) 20	5) 8	6) 5
7) 23	8) 18	9) 7	10) 8
11) 15	12) 10	13) 6	14) 2
15) 9	16) 5	17) 1	18) 2

   The quantization table you are given is

5	12	16	30
12	14	20	30
14	20	32	35
20	25	29	40

   a) Generate the values of the image after quantization?
      Written in scan line order, the values are 28, 2, 2, 0, 2, 2, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0
   b) This quantized table is then transmitted by linearly ordering the 4x4 matrix into a 16 element one dimension array. In what order will the quantized table transmitted and why? Write out the linearly ordered sequence.
      This will be the zigzag order as
      28, 2, 2, 2, 2, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0
   c) What will be the run length encoding of this 16 element one-dimensional array?
      28, (4, 2), 1, 0, 1, (8,0)
   d) When multiple such spatially neighboring 4x4 blocks are transmitted, what kind of additional compression schemes can be applied? Justify your answers.
      DPCM, Huffman coding

3) You are told that an image undergoes radial distortion, which can only be modeled by a polynomial of degree 2 of the form c1x2+c2y2+c3xy+c4x+c5y+c6. How many correspondences would you need to find the kind of distortion the image has gone through? **[5]**
   For x and y you will have total of 12 coefficients. Therefore, you will need total of 6 correspondences.

4) Consider four neighboring pixels of *I* denoted by *a=I(x,y), b=I(x,y+1), c=I(x+1,y)* and *d=I(x+1,y+1).* Let us consider a point in the image at location *(x+0.2, y+0.8).* We would like to compute the value of *I* at *P* using bilinear interpolation. **[5+3=8]**

   i. Write out the equation for this value in terms of *a, b, c,* and *d.*
      (0.2 d + 0.8 c)0.8 + (0.2c+0.8a)0.2

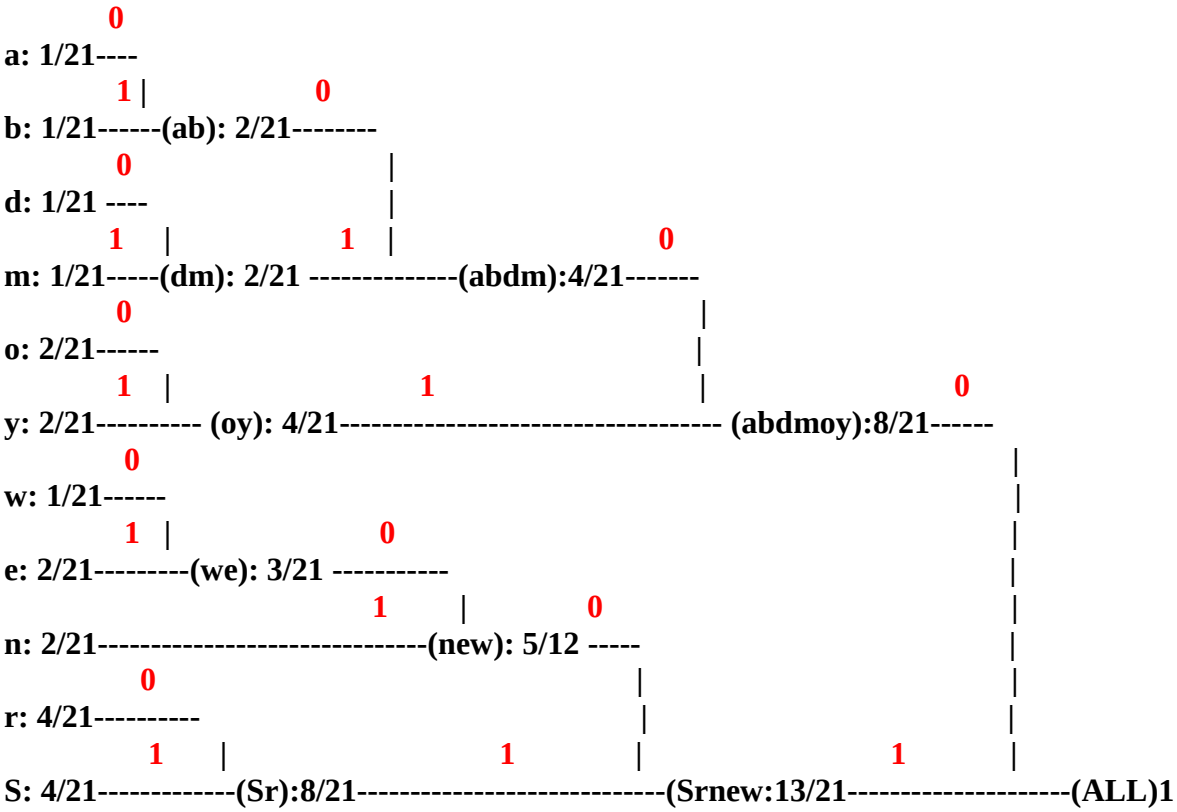
ii. What is the degree of this equation?
It is linear in terms of the pixel locations, but quadratic in terms of the coefficients used. Therefore, if p = 0.2 and q=0.8, then the equation is
(pd + (1-p)d)(1-q) + (pc+(1-p)a)q.
This is a quadratic equation in terms of p and q

5) Consider the text "No worry and be merry". **[2+5+10+3=20]**

i. How many characters (including space) does this text have?
11

ii. What is the probability of occurrence of each character?
n: 2/21, o: 2/21, space: 4/21, w:1/21, r: 4/21, y:2/21, a:1/21, d:1/21, b:1/21, e:2/21, m:1/21

iii. Using these probabilities, construct the Huffman coding table for transmitting this text?

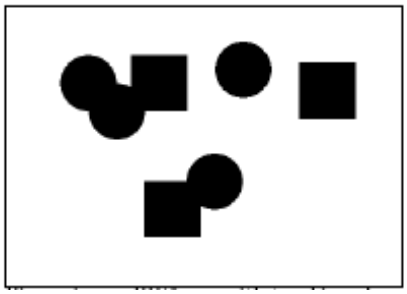


Codes:
A: 0000
B :0001
D : 0010
M: 0011
O: 010
Y: 011
W: 1000
E: 1001
N: 101
R: 110
Space: 111

iv. What will be the final code that will be transmitted using this table for this text?

10101011110000101101100111110000101001011100011001111001110011101100 11

6) Shown below is a binary image with some disks and squares, some of which overlap. How would you achieve the answers to the following questions on this image using morphological operators? For each question provide an algorithm that uses morphological and logical operations to answer the questions. The answers may be in the form of pseudocode with a block diagram. Assume all disks are the same size and all squares are the same size. **[3+3+4=10]**



a) How many disks are there in this image?
Erode with a structuring element similar to the circle to create A. This will make the circles become 1 pt. The squares being bigger will be reduced to a few collection of pixels.
Find the connected component in A. The number of components with single pixels give the number of circles and the number of components with more than one pixels give the number of squares.

b) How many pixels form the boundary of a disk or a square?
In C and S respectively, apply connected component and take the smallest size component and do boundary extraction to find the number of pixels in the boundary of a single circle or a square.

c) Which pixels lie in the overlap region of two different objects?
Remove the components with multiple pixels from A.
Dilate the resulting image with the circle structuring element. This will create an image C with only the circles.
Erode the original image with the square structuring element. The circles will be removed and only one pixel at the center of each square will be left. Dilate this image with the same square to create an image S which has only the squares.
The overlap of circles and squares is given by S intersection C