Homework Assignment #7

Due Date: Tuesday, 26 November, 2013 at 11:59pm (MDT)

What to Submit

Please submit **ONE** appropriately-named **pdf file** via Learning Suite containing your solutions to both the WRITTEN and the PROGRAMMING exercises (include the necessary plots and all code that you've written to complete the programming exercises).

WRITTEN EXERCISES

1) Suppose that you are sampling a bandlimited signal whose highest frequency is 10 KHz. At what rate would you have to sample this signal assuming perfect reconstruction? At what rate would you have to sample it if the reconstruction filter was a low-pass filter with an imperfect cutoff at 10 KHz but allowed some frequencies up to 15 KHz?

2) Given the following image locations and values, calculate the value of the image at (2.7,4.8) using bilinear interpolation.

Location	Value
(2,4)	7
(2,5)	8
(3,4)	8
(3,5)	10

3) Use bilinear warping to produce a mapping from the quadrilateral (0,0), (1,0), (1.1, 1.1), (0,1) to the unit square.

   Note: You do not have to solve the resulting systems of equations manually. Feel free to use a calculator, Matlab, Mathematica, Octave, Maple, numerical linear algebra toolkits/libraries, etc. I want to see that you know how to set up the systems of equations rather than the process for solving them – I assume you learned that in linear algebra.

PROGRAMMING EXERCISES

For this assignment, you will need to code a few transformation routines yourself. **You may not use any library routines for resizing, rotation, or interpolation – you have to code these yourself**. Here is a help page on bilinear interpolation and mapping.

PART A: Image Resizing (Magnification)

Write a program that reads in an image and magnifies it by a specified (integer) factor using bilinear interpolation. That is, if the image you read in is N x M, and the magnification factor is f, the resulting image will be N f x M f. Test your program using parrots.png and factors f = 2 and f = 3.

PART B: Image Resizing (Reduction)

Write a program that reads in an image and reduces it by a specified (integer) factor. That is, if the image you read in is N x M, and the magnification factor is f, the resulting image will be N/f x M/f (round these if necessary). Test your program using parrots.png and the images in the provided (testImage2.png, testImage3.png, testImage4.png). Use reduction factors of f = 4 and f = 8. Is there anything you have to do differently from Part A in order to make this work well? (Think about the sampling theorem.)

PART C: Image Warping

Write a program that rotates an image around its center by a specified angle. The transformation for rotation by angle t around point (x_c, y_c) is

$$x' = (x - x_c)\cos(t) - (y - y_c)\sin(t) + x_c$$

$$y' = (x - x_c)\sin(t) + (y - y_c)\cos(t) + y_c$$

Use the backwards warping algorithm and bilinear interpolation as discussed in class. You may choose any image you wish to test and demonstrate your code.

Apply your method to the image in 15 degree increments to rotate the image by 120 degrees. Compare this to rotating directly by 120 degrees. What happens? Why?

Programming Exercise Write-up

Please prepare a written write-up (submitted as a PDF) which includes the following:

- All code that you wrote for the exercises (parts A-C).
- The relevant plots and answers to questions from parts A-C.
- A brief explanation of what you did, any challenges you encountered, things that were difficult, unclear, etc.
- How long did the different parts (written, programming) of the assignment take you?