

Homework #1

Displays, Image Processing, Affine Transformations, Hierarchical modeling

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Assigned: Friday, April 7th

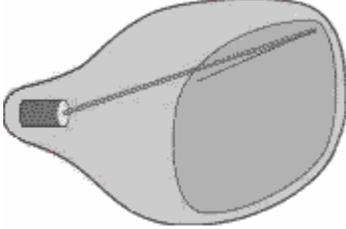
Due: Friday, April 21th @ 3:00 in Steve Seitz's box (main office)

Directions: Please provide short written answers to the questions in the space provided. If you require extra space, you may staple additional pages to the back of your assignment. Feel free to discuss the problems with classmates, but please *answer the questions on your own*.

Name: _____

Problem 1: Raster and Vector Displays

A Cathode Ray Tube (CRT) monitor produces images by shooting a beam of electrons to light up phosphors on the screen (see <http://electronics.howstuffworks.com/tv3.htm>), as illustrated below. The angle of the beam can be controlled to make it move very quickly over the surface of the screen, and the intensity is modulated to control brightness. You can use a CRT to create either a raster or a vector display. In this problem you'll consider both.



Suppose you have two identical monochrome CRTs, but one is controlled to produce a raster display and the other one produces a vector display. The screens are 300mm wide and 225mm high. The raster has a resolution of 1024x768 (width x height). For this problem, assume that for both displays, the electron beam can travel over the surface of the screen at 28,000,000mm/sec, and that the rate is the same whether the beam is on or off. Also assume that the beam always starts in the upper left hand corner.

Part 1. How long will it take to draw a vertical line from the top to the bottom of the screen on each display, occupying the far right column of the screen? Show your work.

Vector:

Raster:

Part 2. How long will it take to draw a line along the top of the screen on each display? Show your work.

Vector:

Raster:

Part 3. Give an example of a simple shape that will look better on the vector display. Why?

Give an example that will look better on the raster. Why?

Give an example that looks the same on both. Why?

Part 4. Suppose you wish to draw a starry sky where all the stars (points) are randomly distributed around the screen. About how many stars will you need to draw for the raster to get better performance than the vector display? Assume that the average distance between two consecutive stars is half the diagonal of the screen. Show your work.

Problem 2: Image Boundaries

When applying a convolution filter, there are many possibilities for handling pixels near image boundaries. For each sub-problem below, discuss the consequences of the given boundary filtering approach when applying a **mean filter** to the following simple images:



i.

ii.

iii.

Assume that the “right” answer is what you would get if you filtered the “infinite” version of each image as described below, and cropped the result to the image area above. The infinite version of each image is:

- i. A vertical and horizontal bar on an infinite black plane
- ii. Two diagonal bars on an infinite black plane
- iii. An infinite checkerboard.

Will a given approach below give the “right” answer all along the boundary? If not where does it give the “wrong” answer and in **what way**?

Part 1. Pad the edges of the original image (by adding extra rows, columns) with zeros before filtering.

i.

ii.

iii.

Part 2. Reflect the original image across each image boundary (left,right,top,bottom) before filtering. To fill the regions near the corners, reflect the top reflection to the left and right, and the bottom reflection to the left and right.

i.

ii.

iii.

Part 3. Perform a “toroidal wrap” before filtering. This kind of wrapping maps the original image onto a torus so that the left edge meets the right edge and the top edge meets the bottom edge. It is equivalent to tiling the plane with the original image.

i.

ii.

iii.

Part 4. Ignore pixels outside the image border, i.e., take the mean of the pixels that fall within both the image and the filter region.

i.

ii.

iii.

Problem 3: Affine Transformations

Please see

http://www.cs.brown.edu/exploratories/freeSoftware/repository/edu/brown/cs/exploratories/applets/transformationGame/transformation_game_java_browser.html

for the link to the applet used for this question.

Part 1. For the game applet above, write down the R, R*, S, T combinations that solve the following examples: (If you use R*, specify the range)

Level 4

Level 5

Level 9

Level 10

Level 11

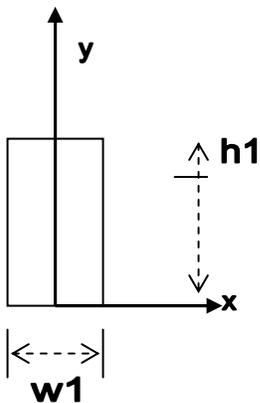
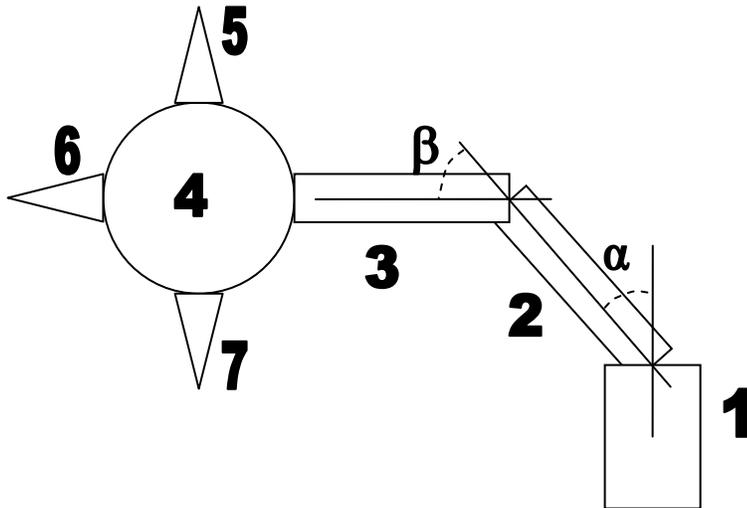
Level 12

Part 2. Specify the sequence of matrices used for level 5 (Note: Should have 4 matrices which are multiplied together – you do **not** need to show the result of multiplying the matrices together)

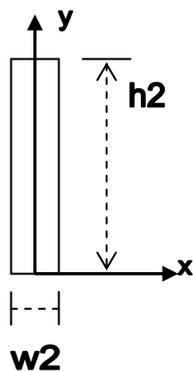
What is the sequences of matrices for level 12? Use θ to denote the time-varying angle.

Problem 4: Hierarchical Modeling Mace

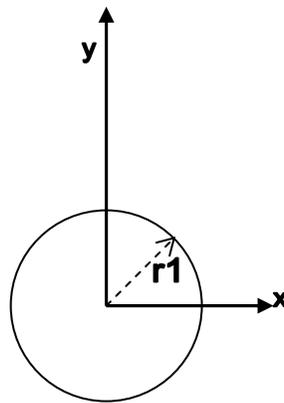
Suppose you want to model the mace shown below. The mace is made out of seven parts, and each part is drawn as one of the four primitives shown below.



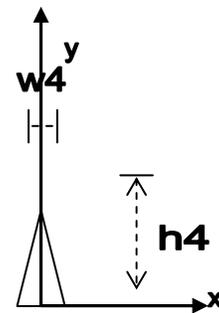
A
(Base)



B
(Chain Segment)



C



D
(Spike)

The following transformations are also available to you:

$R(t)$ – rotate by t degrees (counter-clockwise)

$T(a, b)$ – translate by (a, b)

Part 1. Construct a tree to specify the mace that is rooted at **1**. Along each of the edges of the tree, write expressions for the transformations that are applied along that edge, using the notation given above (you do not need to write out the matrices). Remember that order is important! (Hint/Note: Each spike (objects 5, 6 & 7) are attached to object 4, so you will need to reflect this fact in your tree.)

Part 2. Write out the full transformation expression for the part labeled **5** (you do not need to write out the matrices).