Stanford CS248A: Computer Graphics
Written Assignment 1

Mapping Pixel Centers to Screen Coordinates

Problem 1: (Graded for Correctness - 30 pts)

A. (10 pts) Assume you are rendering an image to a screen that is 5000 pixels wide and 2000 pixels tall. In lecture 2 we talked about 2D screen coordinates where (0,0) was the top left of the image, and (5000,2000) was the bottom-right corner of the image. In this coordinate system, what are the coordinates for the center of the top-left pixel of the screen?

B. (10 pts) Now image the screen is the same size (in pixels) as in part A, but now we are going to define the top-left of the image to be at the coordinate (1000,1000) and the bottom-right of the image to be at (2000, 3000). In this new coordinate system what are the coordinates for the center of the top-left pixel of the screen?

C. (10 pts) [This one is a little trickier.] Just like in the previous problem, assume you are rendering an image to a screen that is 5000 pixels wide and 2000 pixels tall. We change the coordinate system so that the top-left corner of the image is at coordinate (0,0) and the bottom-right corner of the image is at coordinate (1000,1000). Assume that the 5000$\times$2000 image is displayed on a monitor that has pixels that are actually 1 mm$\times$1 mm in size in the real world. (Each pixel is a square in the real-world.) Consider a quadrilaterial that is a square ($X \times X$) in image space. What does this square look like when displayed on this monitor? Is it square? Is it a rectangle? Does it taller than it is wide? Why?

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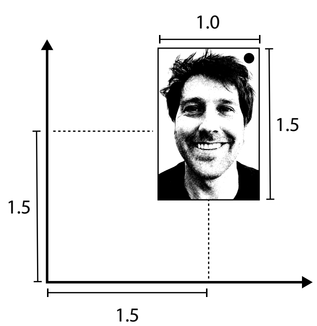
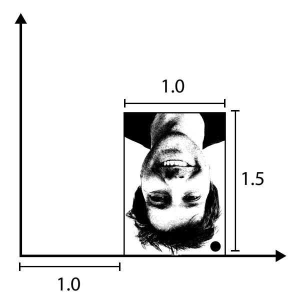
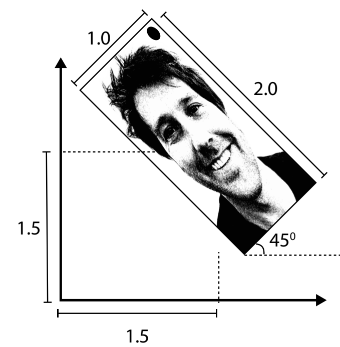
Problem 2: (Graded for Correctness - 20 pts)

A. (10 pts) Please describe a sequence of basic transforms needed to transform the rectangular object on the left (a rectangle of width 1.0 and height 1.5, and centered at the point (1.5, 1.5)) into its position in (A). Also describe the transformations needed to take its position on the left into its position in (B). (These are separate questions). You may assume that basic transforms available to you include: rotate(X), translate(X,Y), scale(X,Y), shear(X,Y). **Be careful, rotations and reflections can sometimes look similar, so we placed a dot on the object to help to disambiguate!**



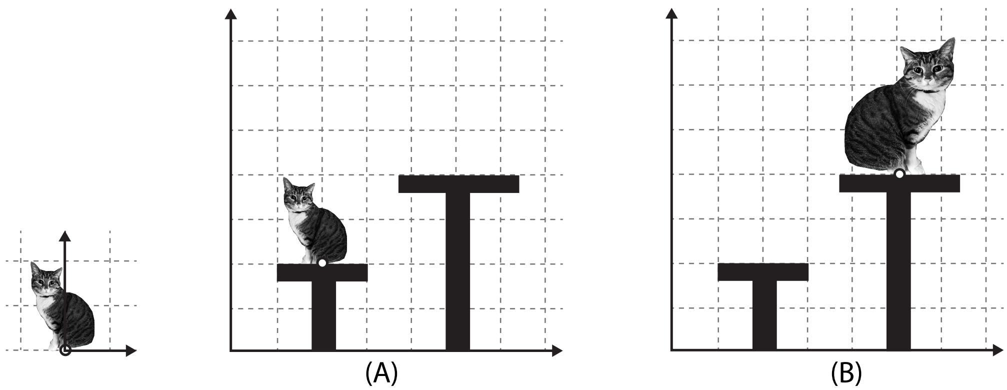


(A)



(B)

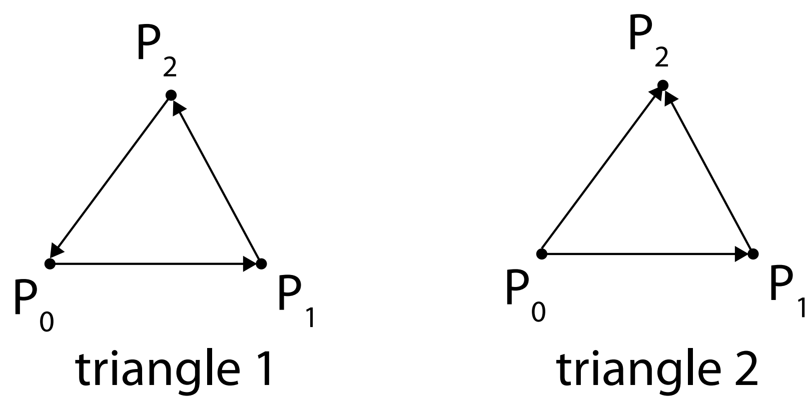
B. (10 pts) When he brought a new cat home from the animal shelter, Prof. Kayvon took a photo of the cat sitting on a cat tree. As you can see in Figure A below, the cat is 2 units tall, and its base is at coordinate (2,2). A year later, Kayvon's cat has grown by 50%, and he takes a second photo (photo B) of his cat sitting on a taller cat tree. Also notice that in Figure B the cat is mirrored in its position. **Please provide a sequence of transformations that moves the cat from its position in image (A) to its position in image (B). (You only need to consider the cat, not the cat trees.)** The catch is that you can ONLY USE two transforms: `translate(x,y)` and `scale(x,y)`. Please keep in mind that the arguments to these functions can be negative. For convenience, the left-most part of the figure illustrates the cat image from Figure A with its base at the origin.



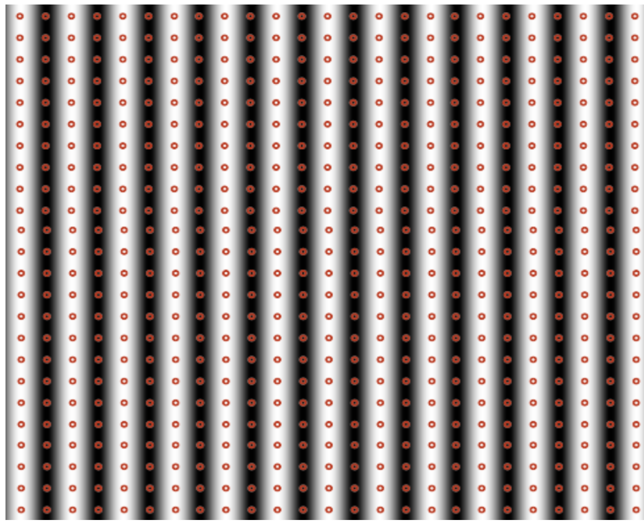
Miscellaneous Problems

Problem 3: (Graded on Effort Only - 30 pts)

A. (15 pts) You might have noticed that when implementing point in triangle tests in Assignment 1, it's not just the position of vertices that define a triangle, but the order of vertices can matter as well. Consider the points P_0, P_1, P_2 below. Consider triangle 1 with edges $e_0 = P_1 - P_0$, $e_1 = P_2 - P_1$, and $e_2 = P_0 - P_2$. also triangle 2 with edges $e_0 = P_1 - P_0$, $e_1 = P_2 - P_1$, and $e_2 = P_2 - P_0$. Why does the algorithm for `inside_triangle(x,y)` given in class (where the sample point (x,y) should be on the negative half plane of all edges), not work for triangle T_2? In other words, why is it important for your triangles to have *"consistent winding"*. Note triangle 1 is using a counter-clockwise winding. How would you change your edge tests if you knew triangles were supposed to have a consistent, but clockwise winding?



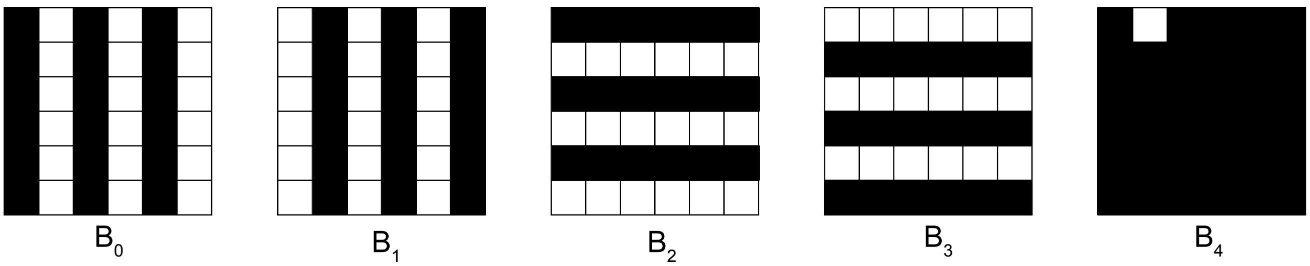
B. (15 pts) Say you wanted to sample the intensity of a 2D signal $f(x, y)$ that is given by a sign wave with a period 64 units in x, $f(x, y) = \sin(2\pi(x/64))$. Assume that we sample the signal at evenly spaced intervals of 32 units in x and y, and then attempt to reconstruct the signal with **piecewise constant interpolation** (also called nearest-neighbor interpolation). Please describe what your reconstruction looks like? Now consider the case were the signal is sampled every 64 pixels! (not shown in the picture). What will the result reconstructed image look like in this case?



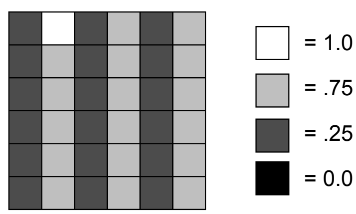
Making Sure You Understand the Image Basis

Problem 4: (Graded on Effort Only - 20 pts)

In class we talked about how all images can be represented in the 2D *cosine basis*. Now consider a very different image representation scheme that represents 6×6 pixel patches in terms of a linear combination of the five $6{\times}6$ basis images given below:



A. Consider representing the following 6×6 image in terms of the base patches above. What are the coefficients of the image under this representation? Explain why, **for the specific case of this image**, we have devised a very efficient image compression scheme. (Hint: what is the size of the 6×6 image in the pixel basis? What about the size of the representation in terms of the image patches above?)



B. Although the scene in part A can be a very efficient encoding for some 6×6 images (only 5 numbers to represent an image!), the problem with the scheme is that is cannot accurately represent all 6×6 images. Draw one example of an image that cannot be represented as a combination of the provided "basis" images.