Project 1: Rasterizer

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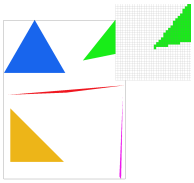
Overview

For this project we implemented rasterization in C++ that shows a visual representation of what different sampling and interpolation techniques look like. Rasterization takes an input image and converts it into output that appears as pixels on a display. This allows an easy compare and contrast of different methods.

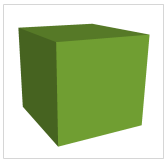
I found the idea behind the anti-alising technique Supersampling to be very interesting as it allows us to take multiple samples within one pixel and take the average of those values to output an intermediate color value which helps to blur sharp lines and angles.

Part 1: Drawing Single-Color Triangles

Test 3



Test 4



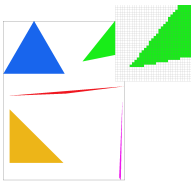
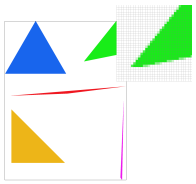
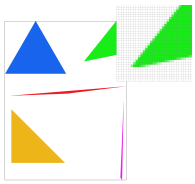
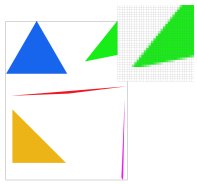
Test 5

Test 6

For this portion we iterate through all the points on the canvas and call a helper function point_triangle which takes the current x and y coordinates as well as those of the 3 vertices of the triangle and computes the dot product of the current point with the first vertex and second vertex, second and third, and third and first vertex. If the values of all three of these dot products have the same sign, it means that the point is within the triangle.

To make sure that this algoithm is no worse than one that checks each sample within the bounding box of the triangle, I computed the min/max x and y values of the 3 points. This allows us to narrow down the points we need to check to a rectangle around the triangle.

Part 2: Antialiasing by Supersampling

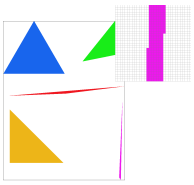
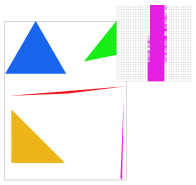
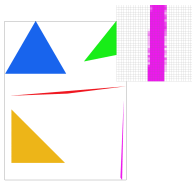
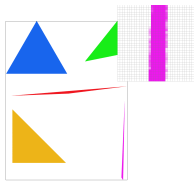





Sample Rate 1 Sample Rate 4 Sample Rate 9 Sample Rate 16

Supersampling is an antialiasing technique that involves taking multiple measurements within one pixel and setting the value of the pixel to the average of the subpixel samples. This blurs the sharp lines and edges you would see in rasterization otherwise. In other words, it decreases the appearance of jaggies.

I implemented this by changing the previous rasterization method to sample multiple times with the provided sample rate. For each pixel, the center of each of the subsections of the pixel are tested to determine if the section is within the triangle. If it is found that the point is within the triangle then sample_buffer is colored. Afterwards the average of the colors are calculated, which creates the burred line effect you see in the images above. To do that the resolve_to_framebuffer function was modified to calculate the averages of the colors.

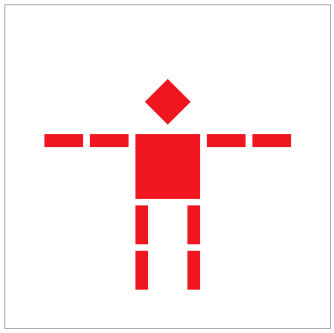
Extra Credit: Jittered Sampling

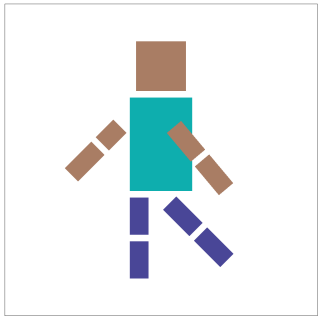
Sample Rate 1 Sample Rate 4 Sample Rate 9 Sample Rate 16

Jittered sampling is different from supersampling as it partitions the pixel into different regions then chooses one randomly from each. Compared to supersampling, the results are more random and unpredictable, however it smooths out with more samples.

Part 3: Transforms



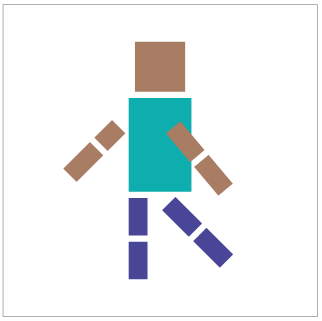
Default Robot



Robot Steve

I manipulated Mr. Robot to look like Steve from Minecraft. I changed the body proportions by moving the points so that his body would be longer and arms and legs would be thicker. His head was made bigger by scaling it and rotated. I also changed the colors to be Steve's classic colors with his teal shirt and dark blue pants. I rotated the arms and legs to make it look like Steve is walking. Small detail that I added, the left arm is slightly shorter because it's meant to be behind the body.

Extra Credit: Added to GUI



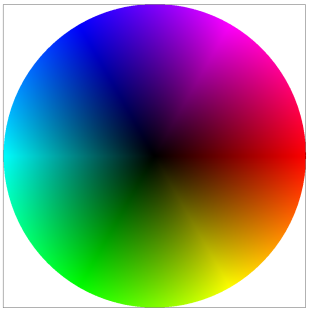
With Border

Without Border

I added another option to the GUI, by pressing b the border around the image will be removed, allowing for cleaner screenshots. I did this by modifying the redraw function.

Part 4: Barycentric Coordinates

Pastel Triangle



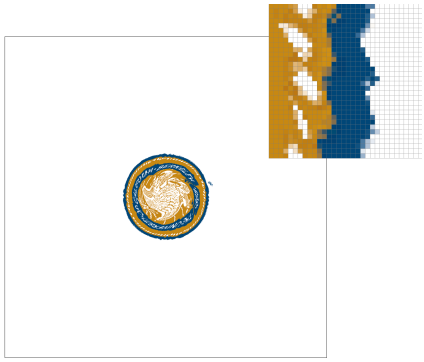
Test 7

The Barycentric coordinate system can be used to find the position of any point in a triangle by calculating its distance from each vertex. This can also be applied to determining the color of any point within the triange given the color of the three vertices by performing a weighed average based on its distances.

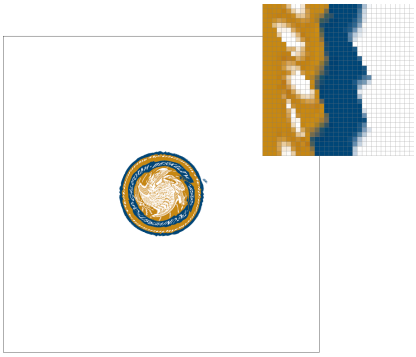
This was implemented by first transforming the given x and y values of the point into Barycentric coordinates. These values are then taken

and weighted by distance with the colors of the vertices and finally added together to get the final color of the pixel.

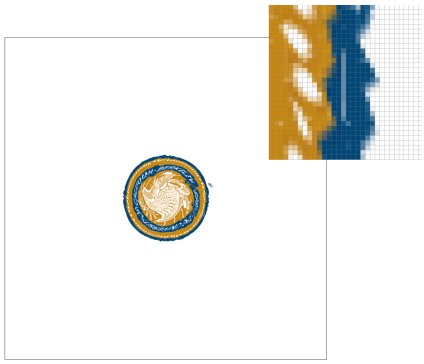
Part 5: Texture Mapping with Pixel Sampling



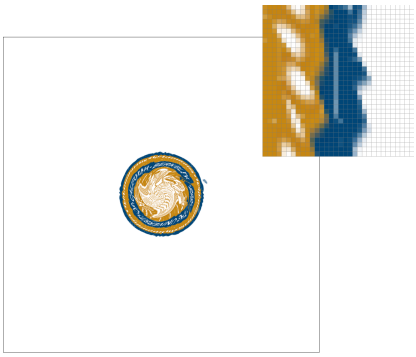
Nearest Pixel 1



Bilinear 1



Nearest Pixel 16



Bilinear 16

Pixel sampling allows us to add a texture to an image. To do this, we need to first transition from the point's x and y coordinates to the texture's coordinates, u and v. After sampling, we then apply the corresponding color value to the pixel.

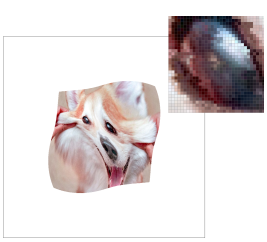
Two types of pixel sampling were implemented, the first one being nearest pixel sampling. This method choses the closest point to the pixel in the texture and applies it to the image. The other type is bilinear sampling which involves taking the closest four points in the texture and calculating a weighted sum of the color values before assigning it to the pixel color.

As you can see above, bilinear sampling produces better results as compared to nearest pixel sampling as it blurs the edges and differences between nearby colors more, allowing the image to look much smoother with less jaggies. However, this doesn't necessarily mean that the texture is accurate.

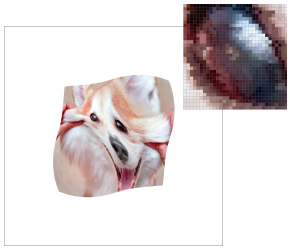
There would be a large difference between the two methods when the edges to the texture are sharp and the data isn't continous as this would cause nearest pixel sampling to produce results that look blocky and pixelated.

Part 6: Texture Mapping with Mipmaps

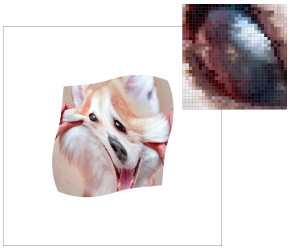
Nearest Sampling



Zero Level

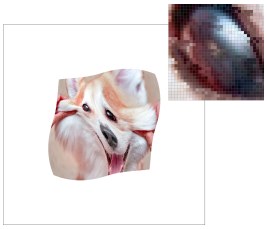


Nearest Level

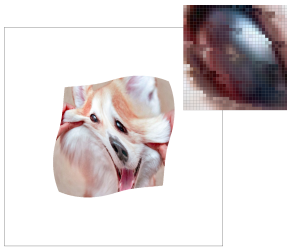


Bilinear Level

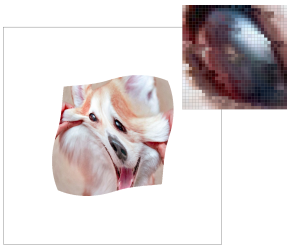
Bilinear Sampling



Zero Level



Nearest Level



Bilinear Level

Level sampling involves using screen information to determine the right resolution when sampling for the pixel's color value. For pixels that coorespond to further points in the texture, we can reduce the resolution to help reduce aliasing. Using this method we can choose the most suitable resolution for the pixels in our image when texture mapping.

Level Zero: Highest resolution, we sample at the zeroth level.

Nearest Level: Uses closest mipmap level as the pixel texture. We do this by rounding the level to the closest integer.

Bilinear: Uses actual mipmap level, sample the pixel twice with the nearest integer levels then interpolate the two colors depending on the difference between the values and the actual level to obtain the pixel value.