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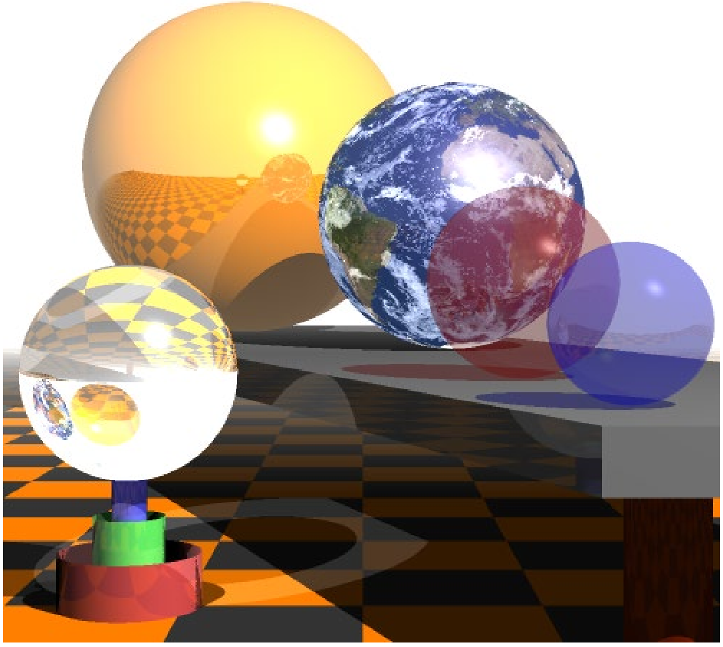
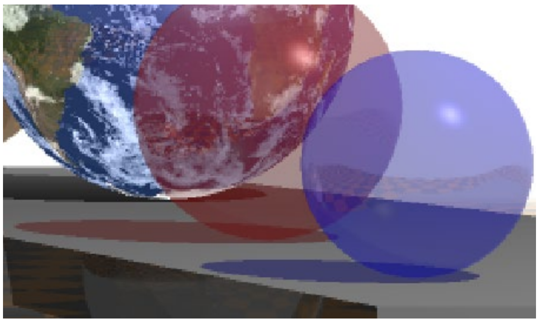
COSC363 Ray Tracing Assignment

Approximate time to generate output: 70 seconds

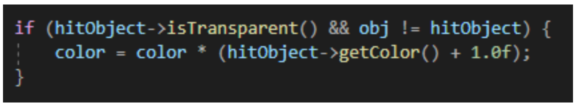
Output



Transparent objects cast coloured shadows



For the coloured shadows cast by transparent objects, the object that is hit by the shadow ray that is casted from the pixel in shadow is checked to see whether it is transparent. If it is transparent and not the same object as the source object, it will make the shadow lighter and takes some of the hit object's colour – making the shadow coloured.



```
if (hitObject->isTransparent() && obj != hitObject) {
    color = color * (hitObject->getColor() + 1.0f);
}
```

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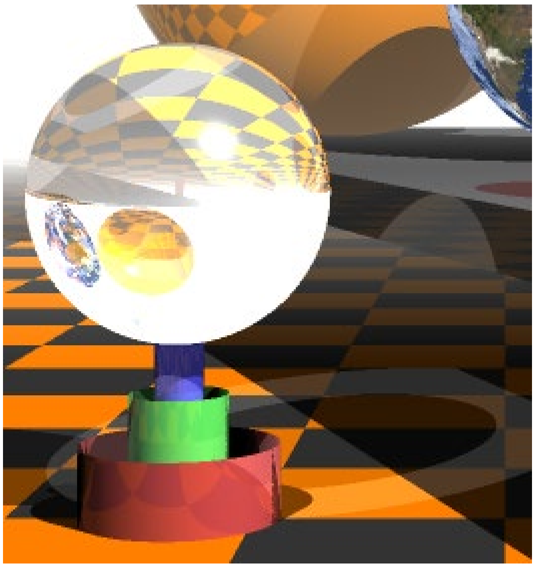
Cylinders



The use of three cylinders can be seen in the image to the right.

Cylinders were implemented solving for **t** in the following equation:

$$t^2\left(d_x^2+d_z^2\right)+2t\left\{d_x\left(x_0-x_c\right)+d_z\left(z_0-z_c\right)\right\} + \left\{\left(x_0-x_c\right)^2+\left(z_0-z_c\right)^2-R^2\right\}=0.$$

The closest intersecting point is then checked to see if it is within the specified base and height of the cylinder.

There is an additional check to see if the second intersecting point is within the specified base and height of the cylinder if the first intersection is not. This is the back of the cylinder.

Refraction of light through an object

A refractive sphere with a refractive index of 1.5 can be seen sitting on top of the cylinders. The refractive object casts a lighter shadow than solid objects.

The result colour computed was after the process of calculating the refracting ray through the sphere using the object's refraction index and calculating the resulting refracted ray. The closest object hit by this refracted ray is then mixed with the source object's colour.

The code reference slide 21 of the Ray Tracing lecture notes.

Spotlight / Multiple light sources (including multiple shadows generated)

A spotlight on the refractive sphere and the cylinders can be seen in the above image as well. It has a cut-off angle of 7 degrees or approximately 0.122173 radians.

The way the spotlight has been implemented is as follows:

- A shadow ray is cast at each pixel towards the spotlight light's position.
- If the shadow ray hits an object, check if the object it is supposed to be spot-lit and if it's transparent or refractive. Cast an appropriate shadow.

If the shadow ray does not hit an object:

- The angle between this vector and the spotlight's directional vector is calculated with:

$$\cos\boldsymbol{\theta} = \frac{\mathbf{u} \bullet \mathbf{v}}{||\mathbf{u}||\,||\mathbf{v}||}$$

- Where **u** is the vector from the spotlight to where the primary ray has hit the object and **v** is the spotlight's direction vector.
- This angle is checked if it is less than the spotlight cut-off angle. Make it lighter if it is.

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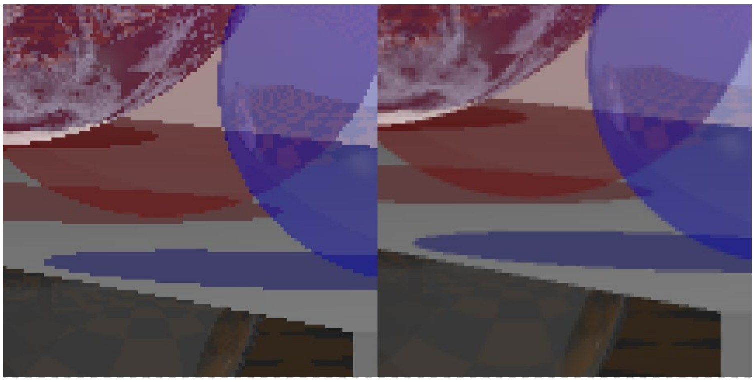
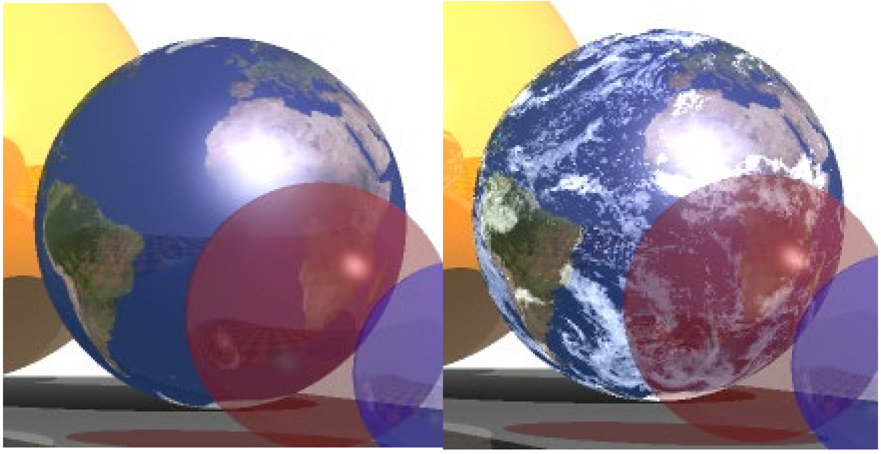
Basic Anti-aliasing



A basic method of anti-aliasing was used in this ray tracer. It simply segments each pixel into 4 segments and casts a ray through each segment. An average of the 4 colours is taken and used as the colour for that pixel. The purpose of this is to smooth the jagged edges that are sometimes the result of ray tracing.

I was unfortunately unable to get a recursive super-sampling (when the difference between the segments is great) working. However, the effect of the anti-aliasing can be clearly seen with the close-up comparison image above.

Non-planar object textured using an image



A UV mapping process was used to texture a sphere with an Earth texture and clouds. Above you can see the globe with and without the added clouds texture.

The equations used to find UV on a sphere is as follows:

$$u = 0.5 + \frac{\arctan2(d_x, d_z)}{2\pi},$$
$$v = 0.5 - \frac{\arcsin(d_y)}{\pi}.$$

These were then used to get the colour of the texture at those coordinates. The resultant colour is the average of the object’s current colour and the colour of the texture.

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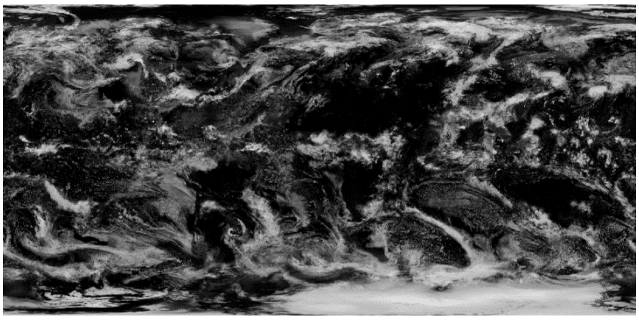
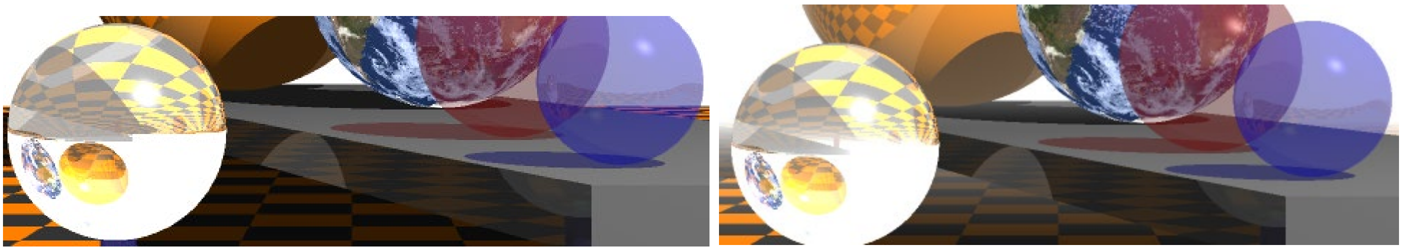


Additionally, a second texture that can be seen to the right was added onto the sphere. The same UV mapping process is applied. The colour of the texture is checked if it is above a set threshold and added if it is.

The result of this is the clouds that can be seen on the sphere with the Earth texture.

Fog



White fog was added to the scene between the **z** range of -60 and -200. The effect of this fog can be seen in the comparison images above. Essentially, more white is added to the resultant colour the further back the position of the hit object is.

Instructions to run (Using Microsoft Visual Studio 2019)

- Install Microsoft Visual Studio 2019. https://visualstudio.microsoft.com/downloads/
- Unzip the .zip and open the COSC363_Assignment2.sln file in Microsoft Visual Studio.
- Install/Download any workspaces that it suggests if you need to (May require a restart).
  - Reopen the COSC363_Assignment2.sln file if needed
- Press "Local Windows Debugger" at the top to run the program or press Ctrl + F5

External References + Sources

https://en.wikipedia.org/wiki/UV_mapping - For the equations used to do the texture mapping of the sphere

https://www.solarsystemscope.com/textures/ - Textures used for the globe

https://medium.com/@kevinsimper/how-to-average-rgb-colors-together-6cd3ef1ff1e5 - Averaging 2 colours