Computer Graphics
Coursework One:

"The Fruit Basket"

by s1832137

Step One - *"Organise an Interesting Scene"*.

I wanted my scene to showcase some more complexity (in terms of the geometries that reflect and cast shadows) than the example scene given in the coursework document. To that end, I placed my rounded flask and a chess rook into the scene.

I have a reading lamp that has a high temperature, low area light. This allowed for some sharp shadows, but mainly I could easily measure the relative position of the light and camera. In the future, however, I would light my scene with a light that is larger as the renders later on suffered from a lot of 'fireflies' - an effect that can be created by having a light source that is too small.

I knew the rook would be far too hard to texture, so I placed this where its shadow would be more emphasised instead. I placed the entire scene around my notebook as this was a flat plane with an easy to texture surface - a perfect area to place rendered objects.

Overall, I believe my scene is good. To improve upon it, I would like a more interesting background, and the aforementioned larger light.

"Record the Positions of Interesting Objects " - **Step Two**

To make this step easier for myself, I considered my camera's sensor the origin, and measured from there. I used a protractor to ascertain the angles of the objects also. I measured the dimensions of all the objects as well. However, I did this measurement naively. Blender considers an objects position to be it's centre of mass, which admittedly is hard to determine with just a ruler, but did mean that my measurements to the corners of objects was meaningless.

It is exceedingly difficult to 'eyeball' where objects should go in order for them to look right. If I was to do this step again, I'd use a tape measure rather than a ruler and attempt to measure to the centre of mass rather than to the corner.

Step Three - *"Take a photo"*.

I used my Panasonic DMC-FZ72EB DSLR camera to capture the scene. A better camera means better results, but I had also found the specs for the camera online, making the rendering stage a bit easier [2]. I set my focal length to the minimum and aperture to a high value to keep as much of the image in focus as possible. I'm happy with how this turned out.

Figure 1: Original Photograph.

"Take Pictures of Interesting Textures " - **Step Four**

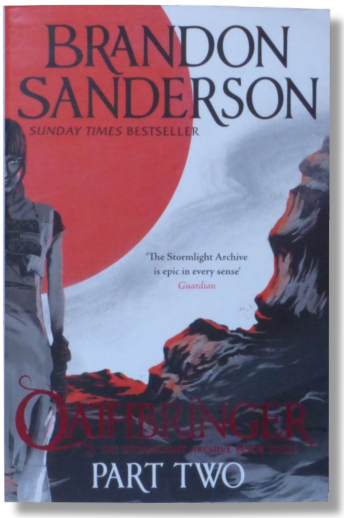

Figure 2: Orthographic Photograph of Book.

I knew that I would require images as close to orthographic as possible in order to put the images into the UV maps of the planes in Blender. To that end, I set up my objects as far as I could from my camera as possible, zoomed as far as possible, and then used the same light that was used to light the scene. I removed the backgrounds using GIMP's line selection tool, turning the background to alpha and cropping to fit.

This worked great for most of the textures, but I hadn't set my light at the same angle as I had in the scene. This only affected my flask and its reflection in the pyramid of my final scene, which appeared to be lit differently in the reflection than in the photo. I solved this by taking the original photo and using GIMP to extract the flask's face which I used instead. This worked out okay, but I would much rather it been an orthographic image as the UV editing was rather difficult.

All in all, I had the right idea, but the light needed to be at the same angle and if it had been the later steps would have been somewhat easier.

Step Five - *"Roughly Model the Interesting Objects"*.

I modelled the rook by taking an orthographic image of the rook, removing the background using GIMP, and placing this image into Blender as a reference image. I placed those reference images on the x and y axis as guides. Using a plane I subdivided the edges and transformed the edges to a circle. I then extruded this plane up the rook, taking care to change the radius of this circle to keep in line with the reference images. At the top, I removed the top face and extruded the faces forming the top circle to create thickness. Then I added 3 cubes and used the Boolean difference modifier in Blender to produce the hexagonal cuts. This worked fantastically. I am very pleased with this *admittedly* un-rough model.

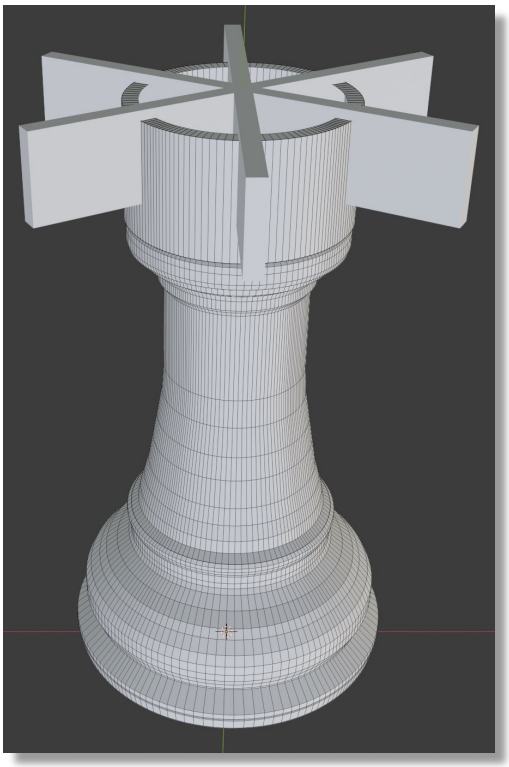

Figure 3.1: Blender model of a rook chess piece.

Figure 3.2: Orthographic photo of rook.

The other special texture I used was the flask. I downloaded the flask from CGTrader [3]. Everything else is either a cube or plane.

The rook has been textured by using the PBRT Matte shader - I chose not to texture it with an image as it's spherical shape would make this very difficult at the least. This meant it could not be used for reflections later in the project. The other objects were textured using UV Maps. The result of this worked mostly fine, but I had a lot of issues mapping the flask as it has many sides, and the notebook seemed to be squished in the render as opposed to the photo. UV Maps have proven to be quite confusing, as changing something often had the opposite effect as intended for me and this resulted in a lot of trial and error.

I'm not sure how to improve upon this, however. I feel UV Mapping is the best approach to texturing these objects. I think given more experience doing UV maps this step would be easier and produce better results.

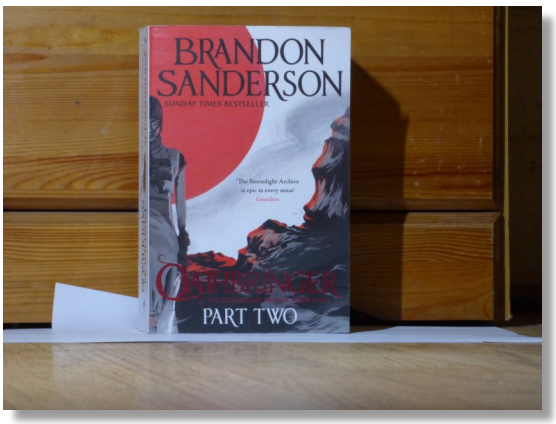

Figure 3.3: Orthographic photo of book.

Step Six - *"Place a Virtual Camera in the Scene".*

Having ascertained my camera's specs from the aforementioned website [2], and having measured everything as if my camera was the origin, this step was made easier. I did have to do some tweaking throughout the workflow to get the view to match, however, and my camera in my blender scene is a non-insignificant distance away from the origin. The view is not exact and I had to later fix this using GIMP. This could be solved by more precise measurements as mentioned earlier.

Step Seven - *"Choose Virtual Models to Insert into the Scene".*

I used the website CGTrader [3] for my models. I wanted to select objects that were low poly as I believe this can lower the issues (i.e. fireflies) that rendering complex shapes can have. I also wanted there to be something of a theme, so I found an apple, orange and banana.

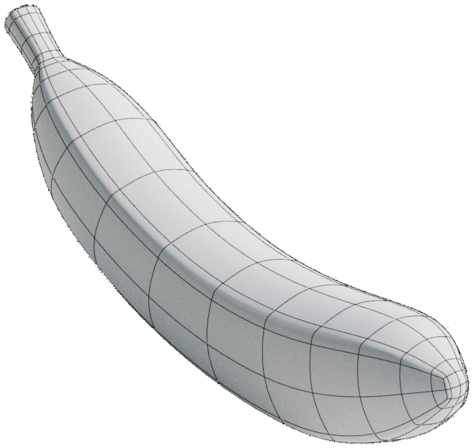

Figure 4: Banana Model (modified) [1].

These shapes are low poly but not trivial in terms of their geometry. There is a lot of opportunity to show reflections and shadows. You can see in my final image, the orange and apple showcase a lot of effects, for instance, the apple and orange reflect the banana within themselves, and also cause a reflection into the shadow of the rook.

That being said, I realised after the scene was done, the models look quite simple. If I was to do this again, I would add at least one high-poly model to show a bit more complexity.

In addition to these imported models. I also include a transparent cylinder mesh and mirror cube mesh. The cube mesh has been turned into a bevelled pyramid by using Blender to merge the top 4 vertices and then applying the bevel modifier to the mesh. I did this so the shape could cause some interesting reflections and capture as much of the scene I had prepared as possible.

Overall I'm satisfied that the models I chose showcase enough of the requirements of the coursework.

Step Eight - *"Place the Models into the Scene"*.

I placed my models with one goal in mind: I wanted to showcase as many effects as possible.

I placed the orange and apple in the direct shadow of the rook, but so that they were partly inside and out of this shadow. This took some trial and error to get them where I wanted them. The apple and orange intentionally showcase many effects due to their position: their shadow on the notebook, the rook's shadow on them, and their reflection of each other and the banana.

The banana I placed so that its reflection could be seen in the apple and orange, but mainly so that it would both be reflected into the pyramid, but that it's shadow would be reflected also.

The pyramid was placed to reflect as many different things at once. It reflects the banana, flask, book, notebook and wall. The proximity of the banana to the pyramid was an issue, as the renderer outputted a lot of noise in this area, especially in the banana's reflection and banana's shadow's reflection.

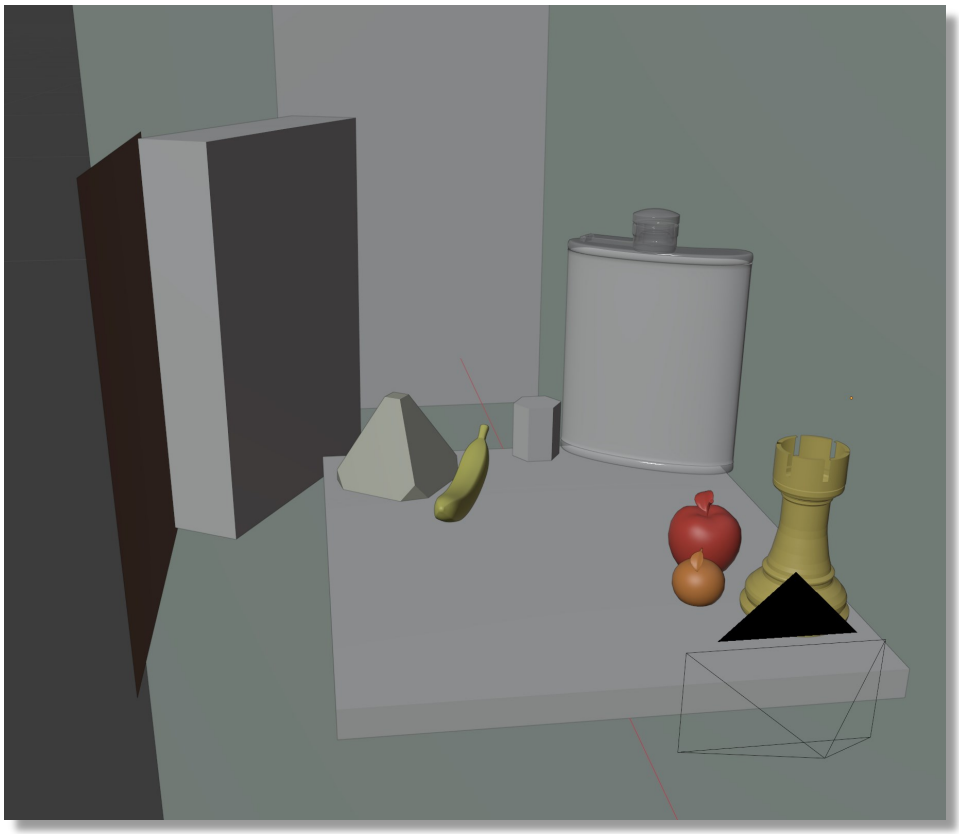

Figure 5: Blender Screenshot.

The cylinder I placed to show translucency of the background. There was an excessive amount of noise in its shadows, though, and this took a lot of post-processing to solve.

Taking everything together, the models are all too small, especially the cylinder. They don't take up enough of the scene. I'm happy that their placement showcases all of the requirements of the coursework, however.

If I was to do this again, I would have larger models, and they would be further apart to reduce noise.

Step Nine - *"Export the Scene"*.

PBRT proved itself quite cumbersome to use. Whenever I exported the scene directly into the 'Release' folder, it broke and would immediately shut without an error message after starting. I would have to re-install PBRT all over again. To prevent this, I had to export into another folder and copy the output files into the Release folder whenever I wanted to render.

Tweaking the settings of PBRT was a *learning experience* also, the settings carry no descriptions next to them, and I did not know the settings in menus outwith the PBRT Render Settings dropdown menu (such as ambient occlusion or sampling) didn't actually affect the render, I spent a lot of time trying to tweak these settings before I realised they don't matter. A lot of searching on the internet was required to understand the renderer and different light settings. I feel it is likely I exported my scene greater than a thousand times.

Step Ten - *"Check the Export File"*.

My export file was always correct and required no tweaking.

Step Eleven - *"Render the Scene"*.

Figure 6.1: Raw PBRT Render.

As mentioned previously, tweaking the renderer was the primary time sink of this project for me. I spent a lot of time trying to remove noise and fireflies in the final render before submitting to the fact it must be done in post-processing. My final render took around 4-5 hours, I used 1500 samples per pixel over an equal resolution to my original photograph (4608 x 3456). The resulting render was actually more clear than the photograph and this posed an issue in compositing - the areas in the render are clearer than in the photograph. You can see this most in the letters on the Oathbringer book, where you can read the word 'archive' but not the preceding word 'stormlight'.

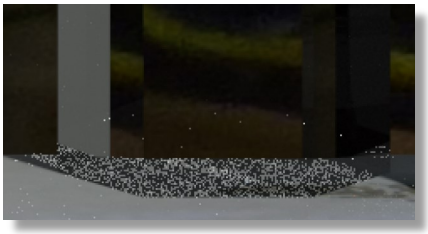
Figure 6.2: Noise.

There are a lot of issues with the render, such as fireflies and noise. I wasn't able to solve these using PBRT and they had to be fixed later. I believe these issues are unavoidable.

Additionally, because of small errors in measurement and the difference between my UV maps and the original photo, some things are exactly how they should be. The notebook is slightly squashed and this caused a lot of issues later on when compositing in GIMP as I had to scale and warp my layers to fit.

All this being said, I am happy with the render. All the issues can be solved in post-processing and the colouring and lighting looks close to perfect - I had measured the light precisely beforehand. It is a little bit too bright, however. The render is close enough to the photo that no tone mapping was required.

Step Twelve - *"Composite the Render with the Photo".*

Having previous experience with GIMP was very useful in this step. I began by using a convolution matrix to remove single-pixel fireflies. This matrix is shown on the right. This causes a small blur over the whole image, but considering the resolution this small blurring is visually imperceptible. It makes every pixel the sum of its neighbours, which eliminates fireflies and even reduces some noise. Next, I went through areas with high noise, like the area shown on the left, using GIMP's noise reduction tool and a soft Gaussian blur to soften these abnormalities into something much more acceptable.

1	1	1
1	0	1
1	1	1

Figure 7.1: Convolution Matrix.

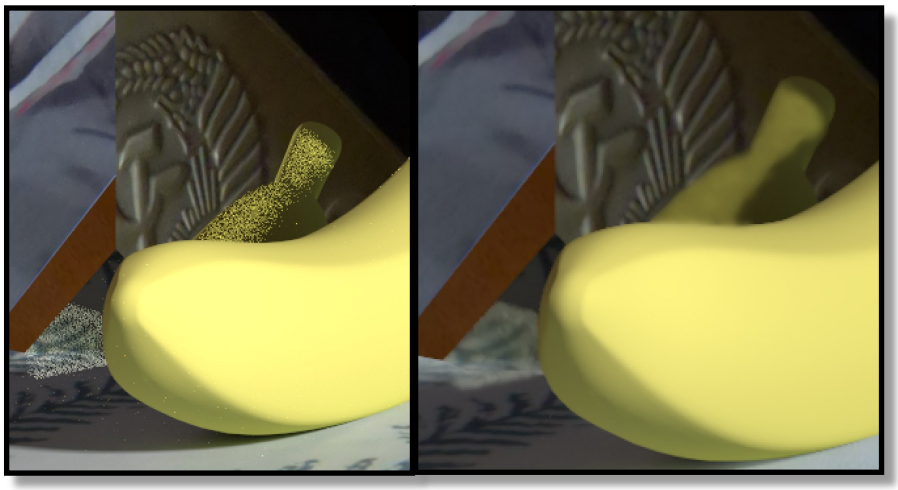

Figure 7.2: Noise Removal.

I then went object by object, with each object on its own layer. I used the line selection tool to cut out each object, feathered this selection to smoothen the cut, and the placed this on top of the target photo. These selections were warped and scaled to account for any edge mismatching.

Finally, I went through areas I was still unhappy with, adjusting brightness, airbrushing etc.

This resulted in something I am quite proud of. The final composite looks close to realistic and I am very happy with it. Obviously there are areas that aren't perfect, such as the banana's reflection in the pyramid, but as this came from the output of the render it is difficult to fix - it's hard to know what it really should look like.

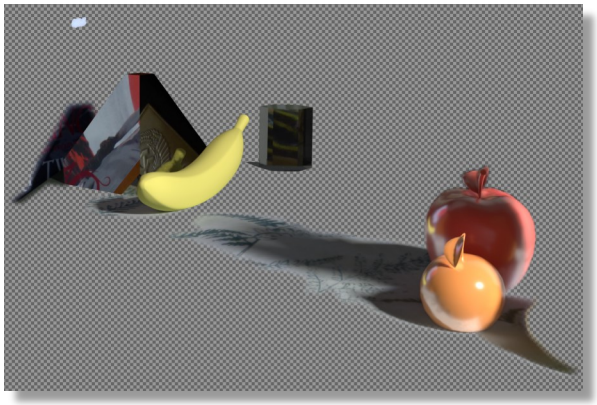

Figure 7.3: Render Layers.

I learned a large amount when creating the composition. The smallest differences in the render and the original photo cause obvious differences that are hard to solve.

And Now, the Conclusion:

I think the final image looks fantastic. It showcases all of the effects we were asked for in the coursework document while still looking as close to photorealistic as I could manage. I have reflections, shadows, translucency, and it all looks as if it should be there. I think there are things I could have done differently, such as sizes, measurements etc. but I am happy with my results.

References

Sources:

[1] toss90 (2021), *Banana Free low-poly 3D model*. Available at: https://img-new.cgtrader.com/items/3006011/1122ac8f81/banana-3d-model-low-poly-obj-fbx-blend.jpg. (Accessed: 10 October 2021).

[2] Panasonic (2021), *DMC-FZ72EB Great Moments Near and Far*. Available at: https://www.panasonic.com/uk/support/discontinued-products/cameras-camcorders/dmc-fz72eb.specs.html. (Accessed: 10 October 2021).

[3] CGTrader (2021), *3D Model Marketplace*. Available at: https://www.cgtrader.com/. (Accessed 10 October 2021).

Models:

Banana:

[4] toss90 (2021), *Banana Free low-poly 3D model*. Available at: https://www.cgtrader.com/free-3d-models/food/fruit/banana-3a7b0ea3-4e36-49c5-bffc-87e914a79957. (Accessed: 10 October 2021).

Apple:

[5] Baria3DAsset (2020), *Apple Fruit Free low-poly 3D model*. Available at: https://www.cgtrader.com/free-3d-models/food/fruit/apple-fruit-afa5e664-8ff8-4598-9568-a21c35520ca3. (Accessed: 10 October 2021).

Orange:

[6] Baria3DAsset (2020), *Orange Free low-poly 3D model*. Available at: https://www.cgtrader.com/free-3d-models/food/fruit/orange-d759be12-8ff2-40c0-aaaf-be04a4fe7531. (Accessed: 10 October 2021).

Flask:

[7] jaypepe, (2020), *English XXth century vintage flask Free 3D model*. Available at: https://www.cgtrader.com/free-3d-models/interior/house/english-xxth-century-vintage-flask. (Accessed: 10 October 2021).