

CRYSTAL EXPLORER

CS148 Final Project¹

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Track: Blender Cycles



My final image was rendered at 3840x2160 resolution, with 1024 path tracer samples.

Inspiration:



Fig 1: Link opening a treasure chest in The Legend of Zelda: Ocarina of Time



Fig 2: A crystal from Final Fantasy III



Fig 3: Mog the Moogle from Final Fantasy XIII

This scene was inspired by various elements from video games I played as a child, shown above in the three figures². I wanted to capture the gleeful moment of opening a treasure chest full of sparkling coins and shiny items (a staple of many games) in a way that was magical and relatable. I took inspiration from the old Legend of Zelda games, which portray a chest opening and flooding the screen with scintillating light. I also took influence from the

¹ Final Fantasy font taken from <https://www.dafont.com/final-fantasy.font>

² Fig 1 - <https://www.zeldadungeon.net/wp-content/uploads/2011/04/Chest.png>, Fig 2 - <https://wallpapers.etherealgames.com/final-fantasy-iii-wallpaper-007-crystal/>, Fig 3 - [https://finalfantasy.fandom.com/wiki/Mog_\(Final_Fantasy_XIII-2\)?file=Mog_FMV.png](https://finalfantasy.fandom.com/wiki/Mog_(Final_Fantasy_XIII-2)?file=Mog_FMV.png)

Final Fantasy series – I have always thought the various crystals portrayed in the games were beautiful and figured a crystal would look great in a photo-realistic render. I wanted to include a single character but decided to be more adventurous than creating a human like Link (the protagonist of the Zelda series). Running with the Final Fantasy theme, I eventually settled on a Moogles – a cute, fluffy creature that accompanies the player throughout many of the games. Putting the setting, items and character together, I envisaged a scene where a Moogle explorer chances upon a sparkling crystal in a dark cave, and stares in awe at their amazing find.

Contributions:

I worked alone on this project and did everything myself.

Assets:

I obtained the following four textures from Texture Haven (shown in Fig 4):

- Bark Brown 02³
- Green Metal Rust⁴
- Planks Brown 10⁵
- Rock 08⁶

I also used rock brushes from Blendswap⁷ to sculpt the cave surface. I used the following reference image shown in Fig 5 to model my Moogles⁸:



Fig 4: Visualization of the textures I used from Texture Haven



Fig 5: Front and back reference images for a generic Moogle

I created all other objects, materials and textures from scratch within Blender (some of the materials and textures were created using tutorials, which are listed in Documents/Videos Referenced section)

Project Requirements:

In this section I detail how I met each of the common and Cycles-specific project requirements.

One Geometry from scratch (common) and main geometry from scratch (Cycles):

³ https://texturehaven.com/tex/?c=wood&t=bark_brown_02

⁴ https://texturehaven.com/tex/?c=metal&t=green_metal_rust

⁵ https://texturehaven.com/tex/?c=wood&t=planks_brown_10

⁶ https://texturehaven.com/tex/?c=rock&t=rock_08

⁷ <https://www.blendswap.com/blend/20195>

⁸ <https://www.pinterest.co.uk/pin/240520436322266802/>

I modeled all of the objects in my scene from scratch. There are 1128 objects that I modeled in total, 1011 of which are duplicates of a single coin object and 99 of which are stalactites with the same geometry. Thus, I modeled around 30 unique objects for this scene. Most of these objects were created using object mode and then modified in edit and sculpt mode. The most complex sculpting operation was the Moogle, which took hours of tweaking before a realistic look and proportion was achieved. Some of the geometry creation entailed more sophisticated processes that I wish to highlight in the following paragraphs.

Moogle fur:

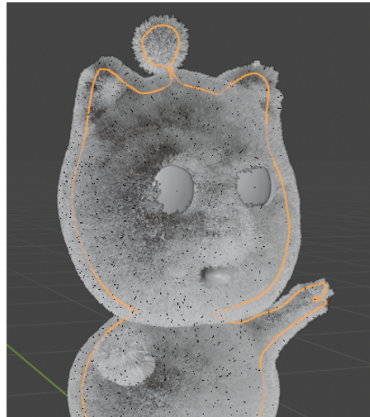


Fig 6: Moogle's fur and antenna hair shown in particle edit mode



Fig 7: An earlier iteration of the Moogle that looked more like a towel

I used Blender's hair particle system to create the Moogle's fur. I went through many iterations throughout this process, during which I refined the length, shape and appearance of the hair, as well as its distribution on the Moogle's body and its antenna. I started off with coarse, clumped hair, and slowly made my way to much finer hair pointing radially outward from the faces of the Moogle model to create a fluffier look. As can be seen in Fig 7, the original Moogle's fur looked more like a towel than fluff. I also added fur to the Moogle's antenna. I made this much longer and more erratic to give it an interesting visual contrast with the more uniform hair of the body. The hair was rendered with a Principled Hair BSDF to make it look more realistic.

Cape:

I used a cloth simulation to fashion the Moogle's cape. This involved creating a trapezium-shaped plane, pinning two of the corners with constraints, and then letting the cloth fall over the Moogle's body (which I approximated with a sphere to make the collision calculations faster). Once that was done, I went in with manual adjustments in edit and sculpt mode to the join the corners of the cape together and make it fit the contours of the Moogle's body. In addition to the cloth simulation, I also added a hair particle system to create the fur lining the cape's edges. In contrast to the Moogle's fur, this fur was more chaotic and curlier.

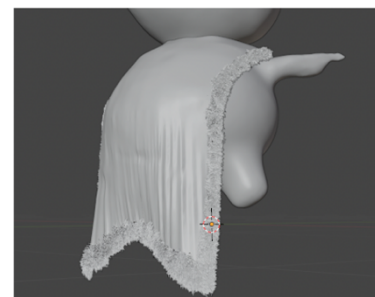


Fig 8: The cape draped around the contours of the Moogle's body

Crystal and Coins:

After modeling the coins and the crystal I created 1011 coins and ran a rigid body simulation of them falling into the treasure chest with the crystal sandwiched between them. I approximated the shape of the chest with five cuboids joined together, since I wanted to use convex hulls to make the simulation faster, and the treasure chest had a large opening inside that would make its collision shape non-convex. I ran this simulation many times with different numbers of coins and friction values until I arrived at an aesthetically pleasing final state. I also had to adjust the collision margin to get the coins to lie close to each other without intersecting.

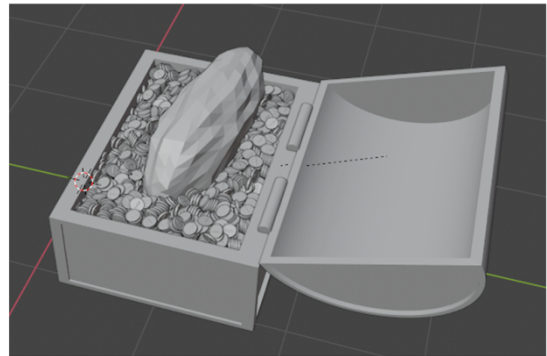


Fig 9: The crystal and coins after the rigid body simulation

Staff and Staff Orb:

I created the staff from a simple cylinder by extruding the top face many times at different angles and then refining the curved shape in sculpt mode. The orb, which was designed to look like the sun, was crafted from a sphere. I extruded seven square-shaped regions along the perimeter of the orb and then smoothed them in sculpt mode to make them more pointed.

Cave and Stalactites:

I modeled the cave using a cylinder that I stretched and scaled in edit mode. I then used special rock brushes that I found online to sculpt the cave surface (linked in the Assets section). These rock brushes were used in draw mode to carve out rock shapes in the wall. I also used slightly different rock brushes to carve out stalactites from a cylinder. When adding them to the cave, I modified their scales and rotations individually to create a visually interesting look.

UV mapping and texturing from scratch (Cycles):

I UV-unwrapped most of the objects in the scene in the process of adding textures. A UV map of the Moogles' staff that I created is shown in Fig 10 below:

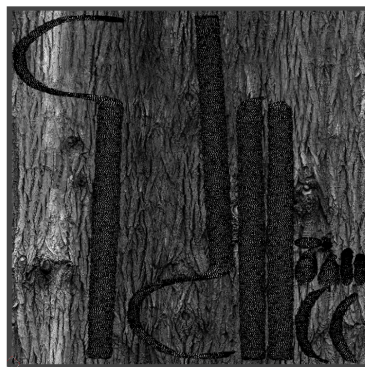


Fig 10: The UV map of the Moogles' staff, overlaid on a bump map of a bark texture

I hand-painted a single texture from scratch for the Moogles' skin and fur using texture paint mode. The resulting texture is shown below in Fig 11 (note that I set the background to be the same color as the Moogles' skin, so you can't clearly see the UV islands):



Fig 11: Hand-painted Moogles skin and fur texture

I also generated multiple procedural textures for various objects in the scene:

- Voronoi texture for crystal volume emission
- Voronoi texture for crystal surface
- Voronoi texture for the surface of the stalactites
- Voronoi texture for bumps in the coins and Moogles amulet (on the cape)
- Voronoi texture to create the wood grains of the Moogles' staff
- Voronoi and noise textures to create the iris of the Moogles' eye
- Musgrave texture for the glowing sun-shaped orb on top of the Moogles' staff

Some of these textures are described in more detail in the subsequent section on materials.

Create a custom/procedural material (Cycles):

Almost all of the materials I created are custom/procedural, ranging from simple to very complex. Some highlights include:

Crystal – the crystal is composed of two separate objects: an inner and outer crystal. The inner crystal has an Emission shader for its volume and a Glass BSDF for its surface. The strength of the emitted light is controlled by a Voronoi texture that is multiplied by a large scalar (using a Math Multiply node), and the color of the glass surface is modulated by a Voronoi texture that controls the FAC between white and a light-gold color. The outer crystal only has a surface shader, whose color is modulated by a Voronoi texture in a similar way to the inner crystal material.

Coins – The coins have two materials: an emissive material for the small crystal offset from each coin face, and a surface material for the coin itself. The emissive material is the same as the one used in the inner crystal, just with a lower emission strength. The coin surface uses a Mix node combining gold ambient occlusion with a solid gold color as the base color of a Principled BSDF. I also use a Voronoi texture plugged into a Bump node to modulate the normal of the coin, giving it a very unique pattern of grooves that look quite striking in the final image.

Staff – The staff surface uses a Voronoi texture modulating the FAC of a color ramp from dark silver to white, along with a bark bump map to create a nice-looking wood surface.

Antenna – The antenna has only a surface shader, which is a mixture of a red principled BSDF with high metallic, specular and metallic values, and a weak Emission shader whose color is modulated by a Voronoi texture feeding into the FAC node of a color ramp. The scale is set all the way up to 500 to add some texture to the antenna, without creating large blotches of different color.

Staff Orb – I wanted to make the orb on the Moogoo's staff look like the surface of the sun. To do this I created a Musgrave texture, multiplied it by a large scalar, and used that as the FAC input in a Mix node modulating between orange and yellow. This was then used as the input to an Emission shader, which I fed into the volume material of the orb.

Eyes – I followed a YouTube tutorial on creating Disney eyes to make my Moogoo look surprised and adorable at the same time (linked in the Documents/Videos Referenced section below). After creating the eye materials based on the video, which involved using a Gradient texture for the cornea/sclera and a Noise texture for the iris, I spent a long time adjusting the size and shape of the eyes to make them as aesthetic as possible.

Blender/Cycles feature (Cycles):

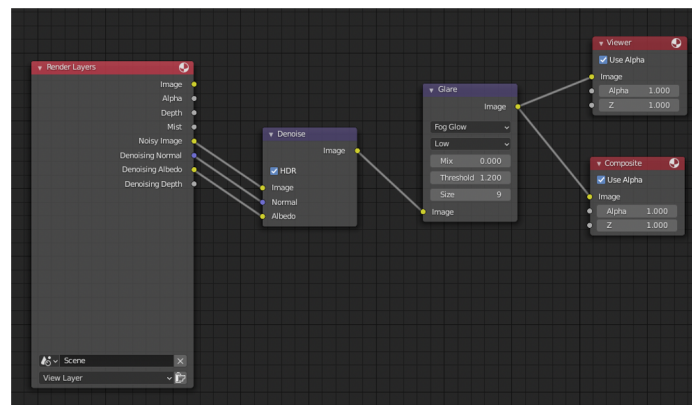


Fig 12: Final compositor setup

I used multiple advanced features to create my final image:

- 1) I added depth of field. I set the focus point of the camera to be an empty object lying between the Moogoo's face and the crystal, so both would be crystal clear in the final product. I then played with the F-number until I settled on a value of 3, which allowed me to clearly see everything in the foreground, while blurring out the stalactites in the background.
- 2) I used the compositor to add denoising and post-processing effects (shown in Fig 12 above). I fed the noisy image, denoising normal and denoising albedo into a denoising node with HDR enabled. I then fed this denoised output into a glare node with fog glow. I ended up using a high threshold of 1.2 with a relatively large fog size of 9 to create a warm, atmospheric glow around both the Moogoo's staff and the crystal. The fog also resulted in a nice glow around the stalactites bathed in sunlight.

Documents/Videos Referenced:

Resources for making hair:

- <https://www.youtube.com/watch?v=9DUievrHo0Q> - learned about creating animal fur
- <https://www.youtube.com/watch?v=LCghBIUZyuM> – how to make fluffy hair
- <https://www.artstation.com/godstepson/blog/3QG8/006-hair-in-blender-part-2-procedural-grooming-tools-1> - explanation of Blender's hair system
- <https://www.blendernation.com/2019/08/05/daily-blender-tip-338-how-to-use-the-principled-hair-shader/> - how to use the Principled Hair BSDF

Resources for making advanced shaders:

- <https://www.youtube.com/watch?v=gfEyhPXsOCM> - Disney-style eye tutorial
- <https://www.youtube.com/watch?v=hccqcCIGGUw> - rust shader for treasure chest rim
- <https://i.stack.imgur.com/0EXuT.png> - velvet shader for cape

Resources for rigid body simulation:

- <https://www.dummies.com/web-design-development/dropping-objects-in-a-scene-with-blenders-rigid-body-dynamics/> - basics of dropping rigid bodies in Blender

Resources for post-processing:

- <https://www.youtube.com/watch?v=W5KqXPCKBuI> - explanation of different compositor effects

Technical/Other Contributions:

Many of these have already been discussed in the Project Requirements section above, I but thought I would restate some of the key technical contributions of the project.

- 1) **Simulation of cloth and rigid bodies (coins and crystals)** - The cloth simulation was performed using a trapezoidal plane with two pinned corners. The coins and crystals were all assigned convex hulls with small collision margins (on the order of 1mm), and I created a special collision shape for the treasure chest consisting of 5 cuboids joined together. I created a 3D grid of 1011 coins and placed the crystal inside the coins. Then I set them up a few meters above the chest collision shapes and let them fall. I stopped the simulation after around 250 frames, at which point the coins and crystal had settled in place. This rigid body simulation took many iterations to get right, as I had to tweak the number of coins, friction and collision margin multiple times to get a realistic final look.
- 2) **Procedural textures** - I made extensive use of Voronoi and Musgrave textures throughout the scene to create natural-looking textures that did not depend on external images. In fact, I only used 4 external textures and 1 hand-painted texture to create the scene – the rest was created through procedural texture generation in Blender's node editor. Please see the section on custom/procedural materials for more details on the types of materials I created using these noise generators.

Scene Evolution:

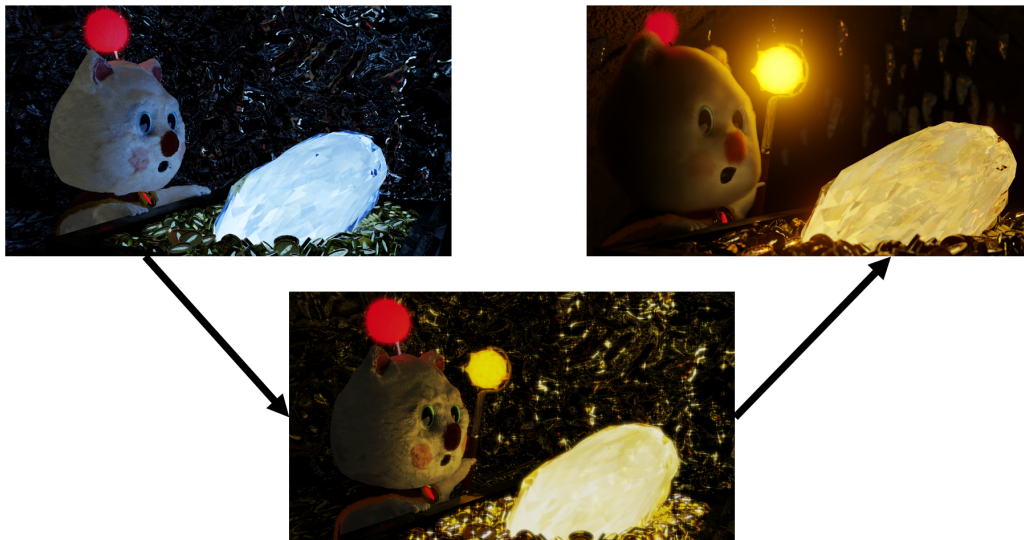


Fig 13: Development of final image – first the crystal was blue and there was no staff, then I made the color scheme gold, and finally I added in the cave

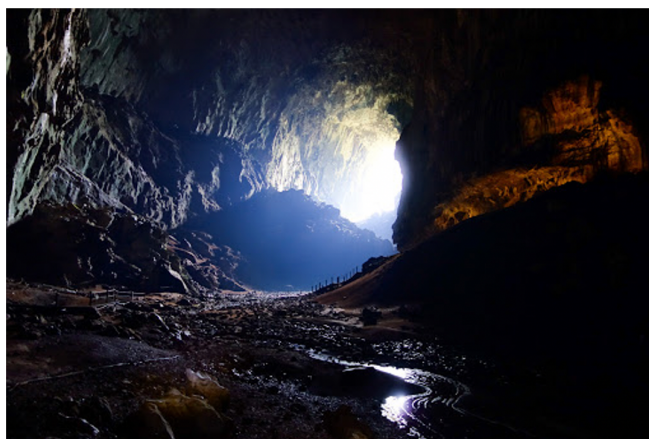


Fig 14: I realized it would be very striking to have light pouring into the cave through a small entrance, like in the photo above



Fig 15: This was my first attempt to add light at the cave entrance – the lighting was further refined over successive renders until I reached my final image