Renderman Screw Study

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Figure 1: Two Screws rendered in Renderman RIB format.

ABSTRACT

This project presents the process of constructing a realistic render of metal screws in the Renderman rib format. The modeling process is explored, as well as the methods used to create displacement, wear and colour variation.

CCS CONCEPTS

• **Applied computing** → **Media arts**.

KEYWORDS

Renderman, OSL shaders, photoreal rendering, rendering

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1 INTRODUCTION

This project aims to render a household object as realistically as possible using Pixars Renderman. A metal screw was been selected as the chosen object. Photos were taken of the screw for reference, these can be found below. RIB files are the native file type for Renderman and while often they are generated by DCC tools, they can also be created by hand (as was done here).

2 MODELING

Before modelling began, the shape of the screw itself was studied. The screw has a rounded top which extrudes down, the underside of which has 3 embossed circles that decrease in size. Inside the smallest of these is a cuboid shape with rounded corners. Coming from this is the main screw shaft which has approximately 22 screw

Figure 2: Reference photos of the screw.

Figure 3: Reference photos of two different screw tops.

threads. The join between the cuboid and the shaft has what appears to be soldering around the top.

These features were replicated in Renderman using simple primitives which were transformed to give the desired shapes. The key features were constructed as follows: The top of the screw is made using half of a sphere, a cylinder and a disk. The embossed circles are tori. The Cuboid shape is made of cylinders with flat planes used to join them. Finally the screw shaft was created using a cylinder surrounded by a series of tori. Using tori to represent the threads was not true to the screw itself as the rings did not connect, and would obviously not function as such. However, it provided a reasonable facsimile to the untrained eye.

To check the accuracy of the model it was overlaid with a picture of the screw. Upon doing this it became clear that the proportions were not accurate and needed to be adjusted. Most notably the screw shaft was given a slight bend and the screw top was made thicker and less wide. This second iteration of the model was again overlaid on the same photo of the screw and the outlines matched much more closely.

3 DISPLACEMENT

PxrDisplace was utilized in 3 areas of the screw to add displacement, making it look closer to the real object: a slight divot to the base of the shaft, some dirt on the embossed circles under the top section and the screw threads themselves.

Figure 4: The initial model.

Figure 5: The model after adjustments.

To add the divot to the bottom, a greyscale displacement map was created inside of image editing software GIMP. This was applied to the disk at the bottom of the shaft with negative displacement to evoke a dent in the bottom which was noted on all the screws observed. All of the screws had some dirt and grime coating the edge of the screw top and the embossed circles underneath. PxrVoronoise was used to create random displacement in the tori which gave a lumpy, dirt look.

In order to more accurately depict the threads of the screw it was decided that displacing them away from the screw shaft would look more convincing than stacking tori. To this end a procedural spiral texture was created in blender and baked using a cylinder of the same dimensions as the screw shaft. This worked, however there was an obvious seam in the texture, it lacked a taper to the threads and it would only work when applied to a cylinder of the exact right size.

As such a more complex approach was implimented using an OSL shader. The shader is adapted from Håkan "Master Zap" Andersson [1] who created a method for generating screw threads on a cylinder. His method uses a sin function to generate a spiral going down the length of the shaft which is tapered using a smoothstep driven by how far down the shaft the revolution is. A clamp was added to this taper to give the threads extra thickness, to better represent those seen on the reference screw object. User supplied parameters allow

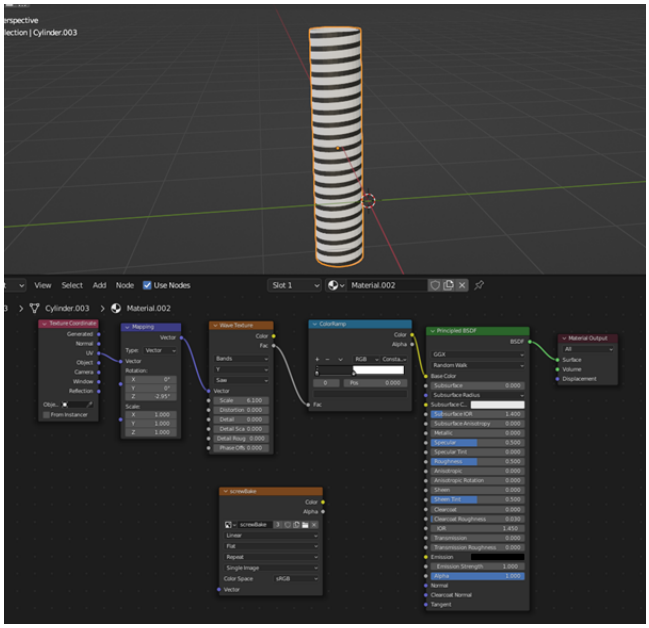

Figure 6: The screw thread displacement texture in blender.

for different widths or lengths of threads to be generated (Figure 12).

4 BXDF MODEL

Ignoring the weathering and dirt, upon inspection it was clear that the screw is made of a highly reflective metallic material, with a very slight blue reflective tint. A BXDF model was created to try and replicate this as closely as possible. The approach taken here was "if it looks right it is right", rather than trying to exactly replicate the physical properties of the metal the screw is made of. A PxrSurface was selected due to its array of specular parameters which can be easily tuned to create a convincing metal effect. A specularExtinctionCoeff of [3.3, 3.3, 3.8] was decided on after experimenting with various values. 3.3 gave a suitably metallic looking surface, and the additional 0.5 in the blue channel gave the slight blue tint observed in the screw. To start with a white diffuse colour was supplied and a roughness of 0, resulting in a clean shiny metallic effect which matched the unscathed parts of the screw.

The only parts of the screw which used a different BXDF are the embossed circles, which were given a simple PxrDisney BXDF with a brown/grey colour to evoke the dirt found on these parts of the screw.

5 NOISE AND TEXTURE VARIATION

When observing the object opportunities to add noise and texture variation were immediately apparent: The screw has scuffs all over, there is rusting on the top of the screw, and grime cakes the bottom part of the shaft.

Adding scuffs to the cuboid part was achieved by simply plugging in PxrVoronoise to the roughness. This is a combination of Perlin noise and Voronoi patterns which leads to hard edged "chunks" of different roughness, which looks similar to the scratches on the

Figure 7: The final screw model after displacement.

Figure 8: The screw model with base BXDF model applied.

screw itself. A similar method was used to add scratches to the underside of the screw, however PxrVoronoise looked unnatural and didn't match the wear on the underside of the screw object. As such a painted texture with lots of scuffs was created in an image editing software and used to drive roughness for the underside of the screw top.

Adding rust and grime to the top and shaft was achieved via the use of shaders, doing this procedurally allowed for the generation of different looking screws easily by changing the supplied shader parameters. Logic to add dirt to the shaft was added to the screw thread shader previously described. Two new outputs were added for roughness and colour. First the threads are set to a black colour, and the inner body white. The edges of the threads are given a lower roughness, this was to mimick the way the thread edges appeared shinier than the recesses on the real screw. The shader takes as input the start point for dirt on the inner part of the shaft and the start point for dirt on the threads. Threads above the dirty threshold are set to white. At this stage the dirty threads are set to black and the rest is white, this was then used to drive the colour. Small dots of dirt are added to the sections between threads (multiplying by Color ensures this is only applied to white). These dots of dirt are generated by subtracting some large perlin noise from a smaller one. This essentially masks out the smaller noise with the large noise, making the dirt less uniform. Dirt is similarly added to the black areas of threads themselves but with noise being used to subtract dirt rather than add. This colour is multiplied by (1 - Color) to ensure it is only applied to black sections. The v coordinate is used to fade this colour change so there is no hard edge to where the dirt starts and stops. This colour is then used to add roughness to areas of dirt. Finally, perlin noise is used to apply slight yellow and brown tones to the black areas to make it look more like dirt. Adding displacement to these areas of dirt was trialled but the effect looked unnatural and was subsequently scrapped.

The second shader, used for the screw top, is comparatively simpler. It first subtracts some perlin noise from the base white colour. This area of discolouration is given greater roughness. Next noise with larger frequency is used to add areas of roughness without discolouration. Noise with even greater frequency is then subtracted to add small dots to the areas of darkness. This is multiplied by (0.6, 0.72, 0.87) (the inverse of a brown colour) so that when it is

subtracted the spots are given a brown rusty colour. While the pattern itself is not arranged exactly as on the real life screw, the look is similar enough that they could convincingly be screws from the same set.

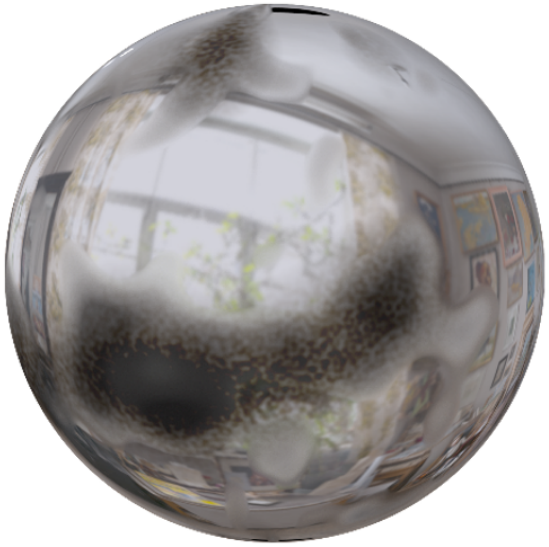

Figure 9: The default setting for the screw top shader.

Figure 10: The screw top shader with different parameters supplied.

Figure 11: The default setting for the screw thread shader.

6 HDRI

The idea for the scene was that the screws are placed in an artists workshop, on a workbench. In order to convey this an HDRI was used. To save time this was sourced from the internet [2]. Due to the depth of field effects that would be employed, it was not necessary for this HDRI to be saved in high resolution (keeping the file sizes as minimal as possible).

7 CONSTRUCTING THE SCENE

To finish off the scene a sphere light was added along with a textured plane representing a wooden workbench. To draw focus to the screws themselves, as well as sell the depth of the scene, a heavy depth of field blur was used with a narrow area of focus. Finally, after examining the screw one last time it was apparent that the base level of roughness for the screw top was far too low, given that reflections are not clearly visible in any of the reference screws. The roughness clamp in the screw top shader was adjusted to account for this. One render shows two screws with default shader tuning, the second shows a screw with custom set shader parameters.

Figure 13: Final scene render before roughness modification.

Figure 14: Final scene render after roughness modification.

Figure 12: The screw thread shader with different parameters supplied.

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