Creating a Lemon Shader In Pixar's Renderman

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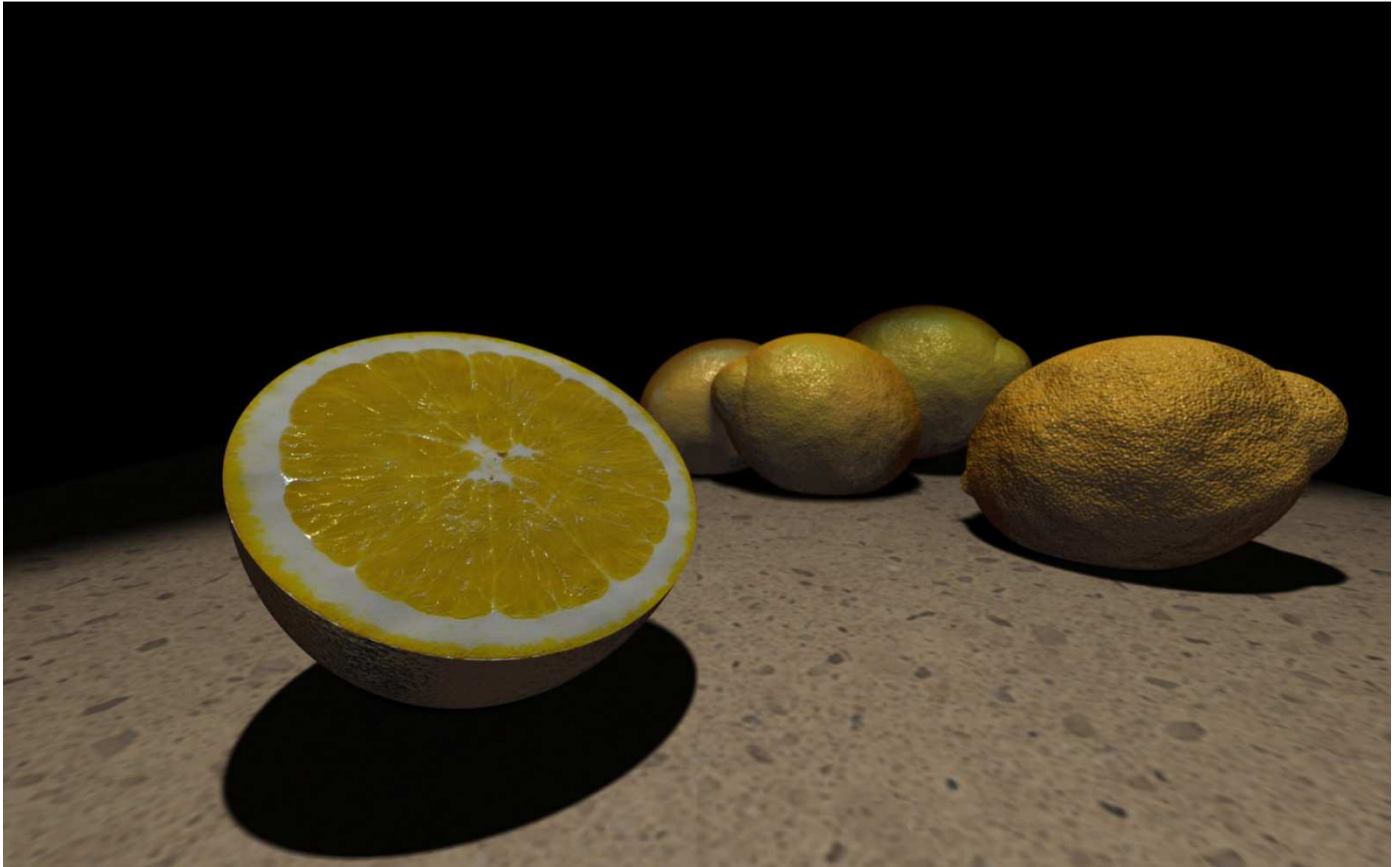
Fig.1: *Lemon shaders created in Renderman RSL*

Abstract

This document aims at explaining the methods used for creating Renderman RSL shaders that can be used for rendering lemons. The aim was to provide a very natural look to the objects. The same shaders were used to create multiple lemons, each different from the other regarding the shape, age and color variation. A separate shader was created for the "cut lemon" that also supports parameters.

All the effects were achieved using procedural generation and texture maps depending on the circumstance. The last part was focused on creating the scene to be rendered, adding shadows and camera artifacts to enhance the realism.

1. Introduction

The most common description of a lemon is that it has an ovoid form, is yellow, juicy, has smooth skin when touched and the surface presents some pore-like irregularities. However, even if this description might be valid for some specific lemons it is not completely true. Like any fruit or organic being, it has a living cycle. Based on this cycle the aspect of a lemon also changes. In the following paragraphs we will take a closer look on all the things that make a lemon look particular, like the visual differences that appear based on its age or the ones dictated by the natural diversity.

2. Reference images

Comparing different images of "mature" lemons we can clearly see that even if the age of the lemons is the same, each lemon looks a bit different than the other. All of them have the same generic ovoid form and yet they display different irregularities.

Fig.2.1 *Lemon color and shape variation.*

Fig.2.2 *Lemon shape variation.*

Another important visual element comes from its age. A lemon that is younger has a more smoother skin with fewer pores. The skin reflectivity is also high compared with an older one. The color also differs: a younger lemon has a more greenish color than an older one which starts to be orange. The known yellow color exists only when is mature.

Fig.2.3 *Young lemons. The color has a very pronounced green tint.*

Fig.2.4 *An aged lemon. The skin display pronounced wrinkles. The skin's reflectivity is also gone.*

Fig.2.5 *The difference of color and reflectivity between the skin and interior of a lemon.*
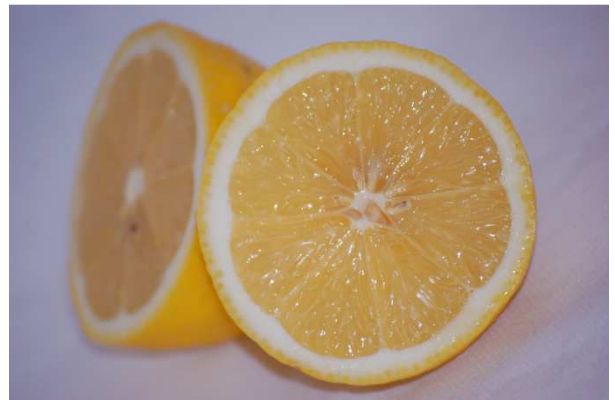
Fig.2.5 *An aged lemon. The skin color has a major transformation from a yellow color to an orange one.*

Fig.2.6 *The difference of color and reflectivity between the skin and interior of a lemon.*

The last important aspect is in the visual difference between the skin of the lemon and the inside. When a lemon is cut, its interior is more reflective than its skin, the organic texture is completely different, and the diffuse coloring also changes a bit.

Another important factor is the angle of reflectivity as is totally different from that of a smooth surface.

3. Modeling using primitives

Based on the reference images we can clearly see that the overall shape is an oval one. Another important aspect is that a lemon presents two smaller ovoid shapes around its extremities.

In order to obtain a very close visual representation of the real object the model consists of 3 sphere primitives. The first sphere are scaled more on one axis in order to create the overall oval form, the second and the third spheres are scaled down equally on all three axis, then scaled a bit more on one

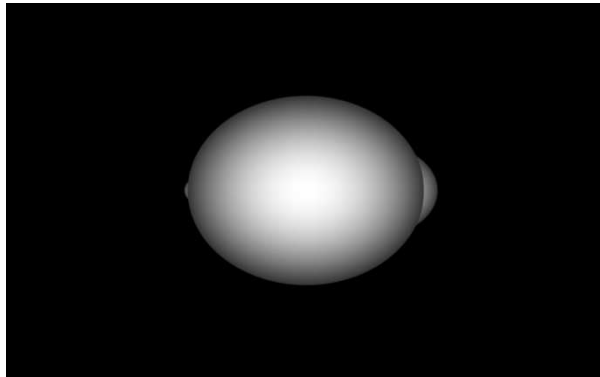axis to make it oval and lastly moved into position to create the tips of the lemon.

Fig.3.1 *The lemon model.*

The cut lemon was modeled using a disk and a sphere with a sweep parameter of 180 degrees. The disk was moved into position and acts as a cap on top of the half sphere.
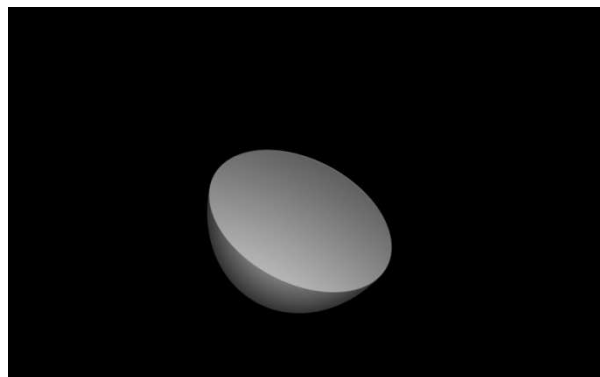

Fig.3.2 *The cut lemon model.*

4. BRDF Models

Since both the skin and the inside of the lemon provide a somewhat plastic look with high specularity, the BRDF model for both objects was selected to be the Phong model. Each parameter of the Phong model was tweaked for the two shapes differently:

- The specularity of the skin is significant lesser than that of the lemon's inside.
- The specularity of the lemon's inside is higher than the lemon's skin, but in the same time is not evenly distributed across the surface like in the first case.

In order to successfully apply the correct and desired specularity effect, the approach was to use a specularity texture map and a diffuse texture. The specularity texture was created from the diffuse one.
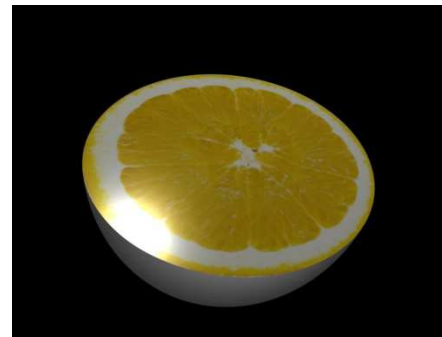

Fig.4.1 *Default surface specularity.*

Fig.4.2 *Specularity from specular map.*

5. Patterns and Displacement

For the overall imperfections in the shape of the lemon the "Fractional Brownian motion" noise method was used. For the pores present in the skin of the lemon the

same method was used a second time but with a very high frequency factor (50).

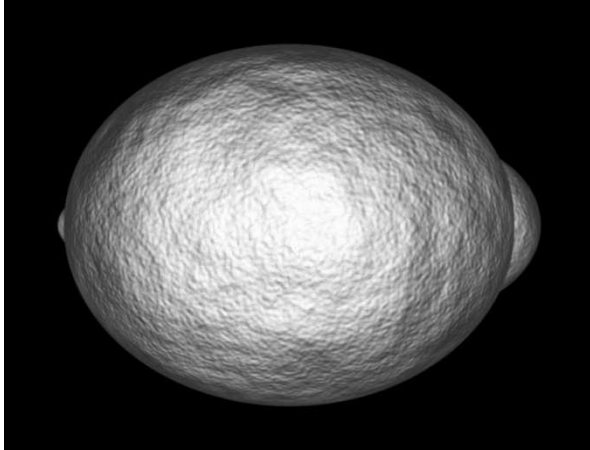The control of the amount of noise to be added was exposed in the shader.

Fig.5.1 *Young lemon using fBm displacement.*

This parameter can be used to influence the age of the lemon: a lower factor gives an overall smooth skin; a higher factor gives a more wrinkled skin that also affects the specularity of the skin and thus resulting in a more aged lemon.
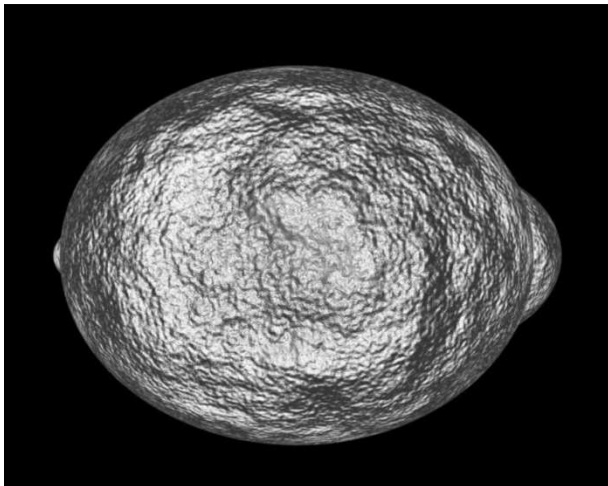

Fig.5.2 *Aged lemon using fBm displacement.*

For the cut lemon a displacement texture was created starting from the diffuse

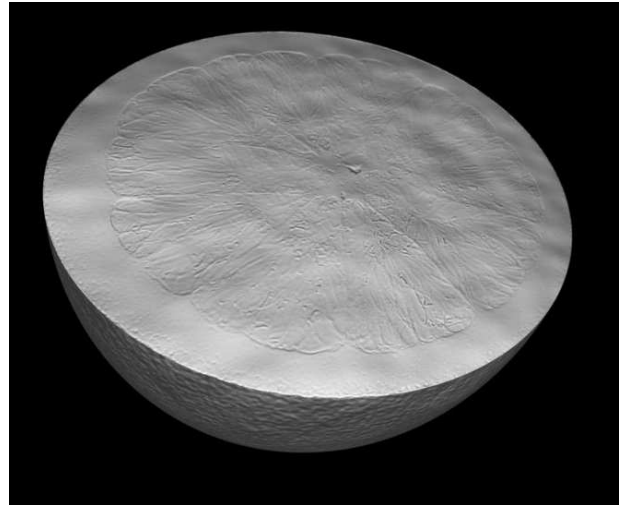one and was applied to the disk. The results are very close to the surface of a real lemon that is cut in two.

Fig.5.3 *Cut lemon displacement using fBm displacement for the surface and displacement texture map.*

6. Natural Color Variation

For the base color of the lemon a color ramp from yellow to orange was used. This can be used in order to specify the color representation of the lemon's age.

Another layer of noise mixed with a green color was added in order to be able to create younger lemons.

Both these parameters along with the displacement shader can be used to create any type of lemon either young or old.
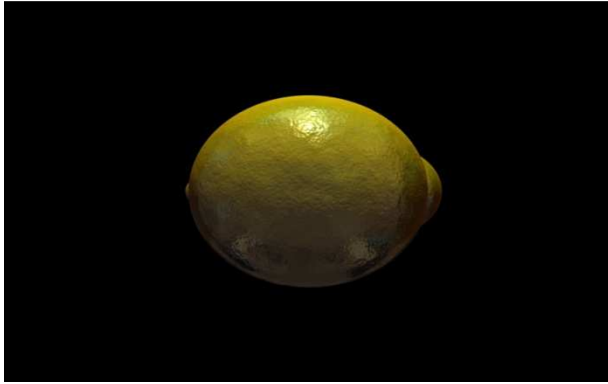
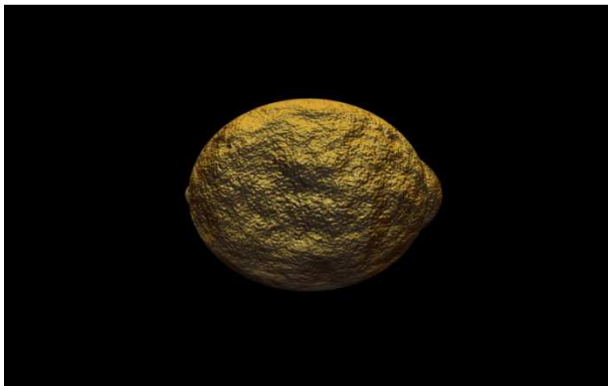Fig.6.1 *Young lemon color variation and displacement.*

Fig.6.2 *Aged lemon color variation and displacement.*

7. Environment Lighting

In order to add realism to the scene an HDRi texture was used to create an environment texture map and later was added in the scene.

Fig.7.1 *Scene without environmental light*

Fig.7.1 *Scene with environmental light*

8. Scene Creation

For the final scene a composition was created containing a textured plane, multiple lemons with different ages and color variation and a cut lemon in the foreground.

Later it was decided to add shadows in the scene. Rather than creating shadow maps which require an extra pass and the textures saved, the raytracing method was used.

9. Camera Artifacts

In order to achieve the desired realism of an image shot in low light conditions with an average focal length and distance, a depth of field effect was used with the following parameters:

- *focal ratio 6.8*
- *focal length 55mm*
- *focal distance 1.5m*

Even if this picture cannot be considered a true "macro shot" the decision to select a 55mm focal length was made in order to avoid the lemons in the background to be completely blurred.

10. Conclusion and Further work

Based on the results it can be clearly seen that achieving realistic results writing RSL shader is not difficult. However, going to hyper realism using the standard methods can become problematic. In our case, the Phong lighting model is far from optimal. Based on different tests made so far, it can sometimes give a more metallic look than plastic.

Another problem that can be seen in the final render is the cut lemon's edge is too perfect. Displacing it would be trivial. However, the edge of the half-sphere would need to be displaced by the same values in the other direction in order to avoid any holes or problems. This would drastically increase the realism of the model.

Another improvement would be to remove the textures used in the cut lemon altogether and create the pattern procedurally. This would ensure that if another cut lemon is added to the scene it would look totally different than the current one.

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