Advanced Rendering Techniques

By Lucy Burton

In this article I will go into further detail about the varying procedures associated with rendering in the Autodesk® Softimage® application. Rendering is as nuanced a task as lighting is, and incorporates many of the principles we've already covered in previous articles. You don't want to spend hours of effort creating detailed models, and precise animation, only to create substandard imagery in the final output of your scene. There are many interrelated parameters and options to consider in this phase of your scene creation that you need to be cognizant of. As with lighting, rendering is often one of the least understood aspects of 3D, but one of it's most critical to achieving high quality animations.

Ambient Occlusion Shading

Several rendering techniques will help you achieve a higher degree of realism, and one of the best is the use of ambient occlusion. Ambient occlusion (Figure 1.) creates more defined and complex shading depth within a scene, by globally calculating the physical properties of light as it radiates off of non-reflective surfaces, adding a softness to a scene that more accurately mimics reality. Rays are cast from the object's surface with the densest areas of geometry represented by darker shading. It also helps to visually represent the relative proximity of objects via the shadows that they cast.

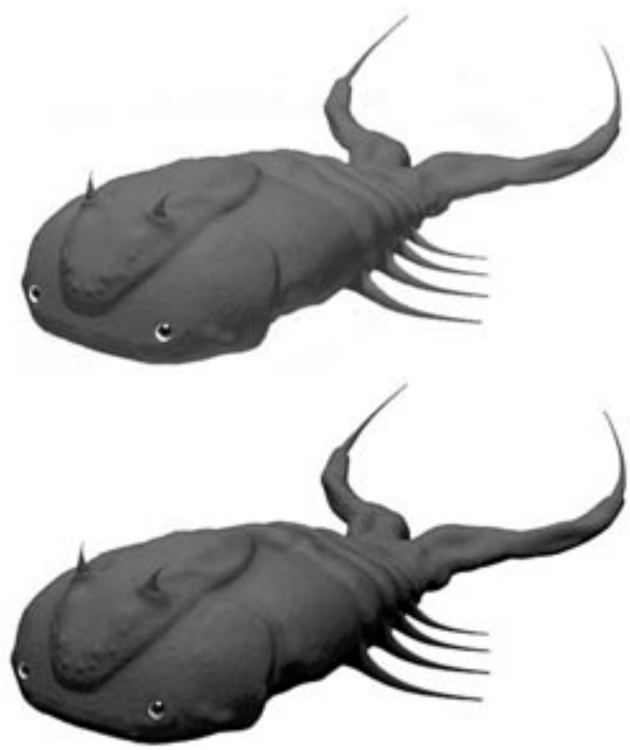

Figure 1. *The image on the left shows a prehistoric creature character with standard Lambert shading, whereas the image on the right has ambient occlusion shading parameters applied to it by adding that node in the Render Tree, providing much more nuanced shadow depth.*

Achieving Real-World Light Reflections: High Dynamic Range Imagery (HDRI) & Image-Based Lighting (IBL)

One thing that made CGI look different from so-called real world imagery in the past, was that the images themselves didn't have the same level of color depth that out eyes are used to seeing in nature. Though you are not consciously aware of how many secondary reflections your eye processes, when there are missing in an image, it makes the image feel less real, even when the viewer cannot readily identify why. High dynamic range images solve this problem.

A typical 8-bit image stores color component values in an integer range between 0-255, but HDR images store data in floating point values (ie 25.3874) that allow them a much greater range of tonal values from 0-100,000+ thereby more closely mimicking the range of radiance values you are used to seeing in nature. They are created by combining a number of photographs bracketed at varying exposures ranging from very dark to very light, into a single image that uses a higher number of bits per color channel (16-bit or 32-bit) than traditional device-referencing images. There are many applications that can help you create HDR images, like RealViz Stitcher®, or Paul Debevec's HDRShop®, and now there are even camera mounts designed to specifically produce these images like the GigaPan Epic® DSLR robotic camera mount system, but perhaps the most common would be Adobe® Photoshop®, which (as of version CS 3) natively includes HDR creation within the application. Simply bring your 16-32 bracketed images into Photoshop and from the File dropdown menu, select **Automate > Merge to HDR**, and the program will automatically create the merged image with each exposure representing a new layer within the main image, which you can then use in Autodesk® Softimage® for environment mapping.

Figure 2. *The image of the bell and vajra on the left is created using Final Gather, Global Illumination alone, whereas the image on the right has an HDR image mapped to the Environment Shader providing more realistic reflections on the surface of the metallic objects.*

In addition to the .hdr format, the Open EXR (.exr) format is supported by Softimage® and you have the added advantage of being able to modify these files directly in the embedded Softimage® compositing application FX Tree. Originally developed by Florian Kainz, Wojciech Jarosz, and Rod Bogart at Industrial Light & Magic®, the .exr format is especially helpful during the compositing phase of production, because it stores arbitrary channels such as specular, diffuse, alpha, etc., into one file. It also allows animators to annotate each image with additional data that will be helpful further down the production pipeline, such as color timing, tracking data, & camera position.

Image-Based Lighting uses these photographs to light a scene solely by reflection-mapping these photos onto the larger scene. To do so, you have to measure the illumination of your real-world scene via what is known as a light probe. Typically, this is an omnidirectional photograph made of a mirror-reflective sphere, whose data is used in combination with data obtained from another photograph of a diffuse white sphere. A background plate of that same scene is used as a reference plane behind other 3d objects, and then the light probe image or stitched HDRI image is used to light the scene via the **Environment Pass Shader** in Autodesk® Softimage®. When photo-based lighting calculations are made via Final Gather or Global Illumination, the probe itself will light the scene, casting reflections & shadows on all artificial 3D objects from the same direction as the original natural light source that was present in the real world. Because of this, your 3D characters and scene objects mesh better with the surrounding environment, and seem more real.

Global Illumination: Fine Tuning Photon-Based Rendering

Within Softimage, individual lights are set to allow for Global Illumination photon generation from the Visibility parameters that can be found via the Explorer. However, if you want to tell the software to actually create those photons, you'll need to double-click on the light to open it's dialog box and check the Global Illumination option. If you want to add caustics as well, you need to select that option both in the Visibility parameters, and in the shader dialog box as well. The number of Emitted Photons generated determines the quality of the render, but again, also increases render times the higher the number. Memory usage is proportional to the number of photons stored within the Photon Map.

In terms of optimization, you need to consider that even in a photorealistic scene, it may not be necessary to have all surfaces generating Global Illumination values. In some cases, you could for instance turn off GI effects on a particular object, and let Ambient Occlusion and/or Final Gather renders fill in the gaps.

Figure 3. *The top image was rendered with one non-photon generating infinite light (used for creating sunlight shadows and 2 spot lights generating 70,000 global illumination photons with a GI accuracy setting of 400, a photon search radius of 1.1, a combined trace depth on each light of 20, and Gauss filtering. This lower setting is useful to make sure that GI is functioning within the scene and that your photons are covering the space evenly, prior to increasing them for final render quality. The lower image shows the room with higher global illumination sampling applied. It has each spot generating 150,000 GI photons with a GI accuracy setting of 550, a photon search radius of 6, a combined trace depth of 24, and Mitchell filtering. It also has ambient occlusion applied to the walls, curtains, and furniture so the scene is noticeably smoother.*

Once the photons pass through the scene, a Photon Map is created, three-dimensionally representing where those photons are stored. Once a satisfactory version is generated, I recommend you save the map and uncheck "Rebuild Map" in the Global Illumination Tab, so that this is not rebuilt with every frame.

An important consideration is Trace Depth. As mentioned in the previous article "3D Lighting in Softimage" where caustics were discussed, if you want to make glass clear, you must allow the photons generated within the scene to bounce through the surface of the glass, typically reflecting and refracting a minimum of 5 times. However if you have a transparent object that is more complex, or you want additional reflections, you may need to increase those values, however this also increases render time.

Combining Final Gather with Global Illumination

Global illumination uses photon energy to calculate direct and indirect lighting, by simulating the real-world behavior of light itself as it's photons travel in a straight line from a light source until they bounce off some other medium. Final Gathering by contrast, calculates indirect illumination by measuring rays cast from all the illuminated points on the surface of a scene object itself. Final Gather can create photorealistic lighting faster than global illumination, however when used in conjunction with each other, your scenes become even more realistic.

There are a few adjustments you need to make if you are going to achieve crystal clear results. In Final Gather, high frequency noise appear like tiles on your scene. This can be reduced by increasing the number of rays and reducing the **Max Radius** value via the sliders in the Final Gather tab of your **Mental Ray Render Options Dialog Box**. By contrast, low frequency noise makes a scene appear blotchy. You can resolve this by decreasing the **Max Radius** value until that is eliminated. Anything below a value of 1 will increase your render times, however.

If artifacts like this persist, then increase the number of **Final Gather Rays** generated via that slider in the same dialog. In general, if you have a large scene with open spaces such as an aircraft hangar or stadium, it is wise to use a large Max Radius value, whereas scenes which show tighter spaces containing more detailed items should use a smaller Radius value.

To further smooth out the scene, go to the Rendering tab in the **Mental Ray Render Options Dialog Box** and change the **Min/Max** level sliders in the Aliasing section. You can also refine the look by going into the **Framebuffer Tab** and adjusting the **Sample Filtering Type**. Each of the terms listed describe a different kind of mathematical formulas that yield particular curves used by the software to reduce the jagged edges on images as they scale in size. **Box** value is the lowest quality, and the default is **Gauss**, which is a low-pass filter, that is non-negative and non-oscillatory, therefore causes no ringing artifacts. I tend to prefer **Mitchell**, because it's a happy medium between **Gaussian** and **Lanczos** filtering, but mileage may vary on that. **Lanczos** is excellent as well, however I've found it does tend to make for longer render times and depending upon the scene, and in some circumstances can cause clipping or ringing artifacts.

Figure 4. *The image above has all the global illumination parameters from the previous renders, but now has both Ambient Occlusion and Final Gather applied as well to further smooth out the scene. This greatly improves the lighting detail around the curtains in particular, and adding more subtle detail to the glossiness of the floor.*

When determining the level of accuracy, you should also be conscious of which Mode you're operating under within the **Mental Ray Render Options Dialog Box**. If you have an animation, **Multiframe** is the proper selection, but if you are seeking to render an extremely high quality single-frame render for a print advertisement for example, you're going to want to select the **Legacy** mode. You could also select **Exact** mode, however be aware that this will vastly increase render times, as this mode dispenses with any cached Final Gather data and calculates every single sample without interpolating information from the previously stored information you may have generated in previous test renders.

Once you've done an initial render with FG and GI, you can refine the lighting in one of two ways. First, within the Render Options dialog box, in the **Final Gathering Tab**, select "**Only use FG points from File**" in the Map File Settings dropdown menu This freezes that setting so that you can adjust other parameters, without having to re-render the entire FG calculations.

You can then either adjust the brightness of the scene via the **Intensity** slider bar in the **GI & Caustics Tab** of the lights themselves, or you can change it on the Pass level by selecting **Edit > Edit Current Pass** then in the **Pass Shaders Tab** select **Overwrite Lens Shader** from the **Lens** dropdown menu. Click on the **Add** button and select the **mia_Simple_Tone_Mapping Shader** (Figure 2.). Once that's been applied, click the **Edit** button and adjust the **Gamma** and **Gain** sliders in the dialog box that pops up to achieve the look you desire.

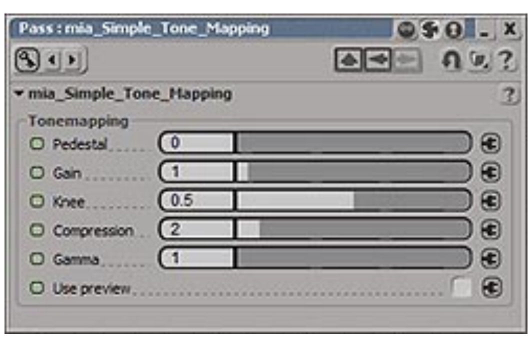

Figure 5. *Simple Tone Mapping Preset Dialog Box*

If you choose to alter the scene via the lights, first turn off final gather, then within the GI & caustics tab, make sure the **"Rebuild Map" checkbox** is selected, then change the intensity values. Your scene will temporarily look a bit too bright, but be mindful that when you add Final Gather to the mix, Global Illumination will be smoothed out and darkened somewhat. So next, **uncheck Rebuild Map**, return to the Final Gather tab, click the **Enable** checkbox, then select "**Overwrite existing file**" from the Map File Settings dropdown menu. The two should blend nicely.

Additionally, when creating Final Gathering animations, you must take steps to prevent flickering which can occur during rendering if you don't adjust your settings properly. First, change the **Map File Setting** to read "**Append new FG points to file**" and give the Map a unique name in the Map File. This way the computer isn't recalculating the all the Final Gather points from scratch on each frame. Next, under the **Optimization Tab**, select "**Final Gathering Only**". This will create a **Final Gather Pass** that you can work with later.

Once that is complete, open up a **Directory Browser Window (Hotkey 5)** and look for the FG_Animation folder inside the **Render_Pictures** folder of your scene. You will then find the **Final Gather Map File** you just generated. Next, switch your Map File Settings back to "**Only use FG points from file**", and go back to your **Optimization Tab** and select **Full Render**. The software then reads all the indirect illumination information data you generated previously, minus the flickering, and you've created a rock solid animation with all the indirect illumination extras.

The Future

In November 2009, Mental Images® released iray®, a mechanism specifically designed for creating “push-button” renders of photorealistic images with correct global illumination calculations. It is more intuitive and easier to set up, if you want to simulate real-world lighting and physically correct materials, so it is especially good for architectural visualization, where mia_materials shaders are most often used. This is not however a renderer you'd use for non-photoreal scenes, nor does version 1 support motion blur, though I suspect that will be upcoming soon. Still, this is an advance for photo real rendering as it more closely simulates the real-world behavior of light and its interaction with materials, whereas traditional raytracing methods could only approximate this through the use of a variety of algorithms.

Summary

There is of course much more that we could discuss about lighting and rendering, but I hope that this series of articles has given you a foundation of understanding upon which to build new ideas, and create fantastic new imagery. In truth, the technological limits fall by the wayside more with each passing day, and the only limits that remain are those of human imagination.

About the Author

Lucy Burton was raised in Europe and returned to the United States for college, graduating with honors from Seattle University with a degree in Drama/Political Science and obtaining Film Certification at New York University. She interned in Technical Direction at Intiman Theatre. Having worked professionally both in theater and in production on several films, she then moved into the postproduction/visual effects realm, first working on Softimage 3D Extreme at Mesmer FX. Lucy has been working with the XSI platform since its inception nearly a decade ago. After founding her own digital design studio in 2001, she went on to produce documentary videos on the humanitarian crisis in Indonesia following the tsunami and helped a nongovernmental organization that assists victims in Darfur, Afghanistan, and Uganda, among other crisis areas. She now is freelancing in and around Hollywood, California.