Easier mental ray Rendering for Design Workflows

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Objectives
This white paper is intended for users of Autodesk® 3ds Max® Design* software (version 2010 or higher). The objective is to demystify mental ray® renderer rendering and present it in a simple way. The paper reviews common scenarios that architects, designers or engineers face when rendering with mental ray. It is targeted at users who have a good understanding of the 3ds Max Design interface and basic notions of rendering and photorealistic rendering workflows.

*If you are working with Autodesk® 3ds Max® software (version 2010 or higher), refer to Appendix 4: Settings for Users of 3ds Max Software before you start.
Section 1: Abstract and Background

In the real world, energy is emitted by light sources, bounces around, and is absorbed by surfaces until everything stabilizes. Substantially the same principles apply in global illumination rendering, and especially in Architectural Visualization. Users rendering for AEC usually need to create images which enable the design to be presented and evaluated as closely to the real space as possible; besides structure and surfaces, light is the one element that can significantly change the appearance of a room. This document summarizes the important aspects of producing photorealistic renderings in a “physically correct” way; every user should keep these in mind when exploring the world of rendering for creating presentation images, computer art, or physical analysis of lighting.

Transforming Digital Painting into Digital Photography

Unfortunately—or fortunately for persons working more towards art than towards simulation—physics rules can be bent to such extremes that the resulting image no longer looks physically accurate. Used intentionally, this technique is similar to painting a picture by mixing and overlaying paint layers until you get it “right” in terms of the look you are trying to achieve. Another approach involves staying as close as possible to real-world parameters and letting the software provide you with the “right” answer. This is closer to photography than to painting. In the field of AEC this is often referred to as “simulation”. Keep in mind that there is a blurred line between “photorealism” and “simulation”; an image taken by a photographer is of course completely physical, yet he retains the artistic freedom to create the mood he is looking for by choosing the right time of day, weather, lens, and aperture. The same is true for rendering. “Simulation” and “nice images” need not be considered as mutually exclusive options, but rather looked at as a photographer would do: taking the best of both worlds to create an image that suits his client’s needs. To help you achieve this balance, this white paper will identify the main areas involved in physically based renderings and provide guidance, as well as tips and tricks, on how to use them in 3ds Max Design.

Overview of Basic Concepts Associated with mental ray

mental ray is a production-quality rendering application developed by NVIDIA ARC GmbH. As the name implies, it uses ray tracing to generate images.

A key feature of mental ray is the achievement of high performance through parallelism on both multiprocessor machines and across render farms.

The mental ray renderer helps relieve you of the need to simulate complex lighting effects "by hand" or by generating a radiosity solution. It is optimized to use multiple processors and to take advantage of incremental changes for efficient rendering of animations.

What is Final Gather?

Final Gather is a technique for estimating indirect lighting effects (also known as global illumination). You can also achieve global illumination by using photon tracing or a combination of the two, but Final Gather is the recommended method to simulate indirect lighting (global illumination) for non-expert users. It is the method that will be discussed in this white paper.

How does Final Gather work?

When Final Gather is enabled, objects effectively become a source of indirect light, mimicking the natural world in which objects influence the color of their surroundings. When one Final Gather ray strikes an object, a series of secondary rays
are diverted at random angles around it to calculate the light energy contribution from the surrounding objects. The light energy is then evaluated during the ray tracing process to add the effect of the bounced light.

**Why do Users need it?**
Final Gather is a fast and easy way to achieve good global illumination results for architecture visualization. It helps add realism and photo quality to your images.

![Image with Final Gather](image1.png) ![Image without Final Gather](image2.png)

**Understanding Exposure Control**
When rendering in 3ds Max Design, think of yourself as a photographer. Are you a “point-and-shoot” photographer, or someone with more advanced knowledge who likes to play with the manual settings of your camera? Whichever type you are, exposure control adjustment will need to be processed in order to give you a properly exposed image. The mr Photographic Exposure Control is that process. It enables you to modify rendered output with camera-like controls: you can either use a general exposure value (like the automatic mode of your camera) or specify shutter speed, aperture, and film speed settings (like the manual mode of your camera). It also gives you image-control settings with values for highlights, mid-tones, and shadows.

![Over-exposed image](image3.png) ![Under-exposed image](image4.png)
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What is Ambient Occlusion?
Ambient Occlusion (AO) is a method spearheaded by the film industry for emulating the look of true global illumination using a shader that calculates the extent to which an area is occluded, or prevented from receiving incoming light.

Used alone, the mr Ambient/Reflective occlusion shader creates a grayscale output that is dark in areas that light cannot reach and bright in areas that it can. (To find out how to render an Ambient Occlusion pass, refer to the Interior Day-Time Rendering Tips and Tricks).

The following image illustrates the main results of AO: dark crevices and areas where light is blocked by other surfaces, and bright areas that are exposed to the environment.

For ease of use, select a preset (similar to “point-and-shoot” camera settings). Create a preview and adjust the exposure value to your needs. If you are more familiar with the concepts of photography, you can specify the Shutter Speed, Aperture, and Film speed manually.

The recommended Exposure Control plug-in to use with the mental ray rendering engine is the mr Photographic Exposure Control. It is designed to mimic real-world camera settings and assumes that the scene environment is physically based as well (Sun, Sky, Photometric lights, and proper scale).
Ambient Occlusion has the benefit of enhancing the small details and creates what are commonly called “contact shadows”.

Ambient Occlusion can also be enabled directly in the A&D (special effects section of the material parameters) and Autodesk Materials (Ambient Occlusion section of the material parameters). Typically you will want to enable it for floors, door frames, and other areas with fine geometric details.

*Without Ambient Occlusion*

Typically, light leakage arises due to a low density FG calculation. Objects appear to be floating. Ambient Occlusion can help solve this issue.
With Ambient Occlusion, edges are visually enhanced. The larger the distance, the more pronounced the effect. Usually, you want to use a distance of ~10 cm.
Section 2: The Basics

Recommended Material Types

The flexibility of the features in mental ray and the evolution of the differentiated 3ds Max and 3ds Max Design products created some confusion around which material should be used with mental ray. For ease of use, stick to the Arch & Design (A&D) material or the Autodesk Materials (Autodesk Materials are simplified interfaces driving the A&D material under the hood).

The other materials will work, but the A&D material contains mental ray specific optimizations that will result in higher speed and better quality than the traditional Standard material or the legacy Architectural material.

Units and Scale

Physically based lighting computation implies that light attenuates using the inverse square falloff law, which simply means that the intensity of light declines exponentially with the distance it travels. Therefore, it is crucial that the scale of your scene corresponds to real-world data—otherwise the results can be wrong.

A common mistake, for example, is to import or file link an airport at the size of a shoebox, or a room at the size of a stadium. In one case, the lighting computation will be too bright, and in the other, too dark.

To verify your scale settings, check the System Unit Scale settings in the Customize > Units Setup > System Unit Setup dialog box.

Modeling in General

mental ray computes light in a physical manner and therefore requires the geometry to accurately represent the objects being rendered. The results will depend on the quality of your geometry and the orientation of surfaces. Generally speaking, solid modeling solutions such as AutoCAD® software or Autodesk® Revit® Architecture software produce geometry suitable for photorealistic rendering but other types of modelers do not. Please refer to Appendix 1: Guidelines for Your Scene Geometry for some important tips on the topic.

Simplified mental ray Render Panel

The simplified mental ray render panel is designed to help reduce the learning curve for new users and accelerate test renders by providing fine-tuning knobs for Antialiasing, Shadows, Reflections, and Refractions. If you are rendering still images, most of the adjustments you need to fine-tune your rendering speed versus quality can be found in this window.
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Launch the render setup
Launch the Exposure Control

Glossy Reflection
Edge Antialiasing
Glossy Refraction
Soft Shadow

Enable/Disable Indirect Illumination
Cache Indirect Illumination to Disk
Section 3: Selecting a Lighting Scenario

These are the four main lighting scenarios most users will be required to render with mental ray:

A. Exterior scene during daytime
B. Exterior scene at dawn or dusk
C. Interior scene with sunlight entering through windows or doors
D. Interior scene using artificial light only
Lighting Scenario A: Exterior Scene During Daytime
This rendering scenario will require the use of Daylight System.

The 3ds Max Design Daylight System regroups two light sources in the same user interface: mr Sun and mr Sky. Their intensity and colors are determined by their orientation in 3D space, which is affected by the settings for date/time and geographical location. The blue gradient background is handled by a special shader (mr Physical Sky) that can be added automatically upon creation of the daylight system. Although the user has the option to do it manually, it is recommended to choose the automatic process:

1. Create a Daylight System; make sure it uses mr Sun and mr Sky and setup the Time and Date accordingly (daytime). The position (x,y,z) of the daylight system icon in your scene is not relevant. Light will always be calculated from the extents of your model so the daylight system can be inside geometry and it does not matter. The light intensity is driven by the date/time and geographical location settings of the Daylight System.

2. In the Environment and Effects window, make sure the mr Physical Sky shader has been automatically assigned in the Environment Map slot; this will add the blue gradient background that changes color based on the Sun angle automatically.

3. In the Environment and Effects window, enable the mr Photographic Exposure Control and use the Outdoor Daylight, Clear Sky preset (for the “point-and-shoot” type of photographer). Adjust the exposure intensity to achieve proper brightness. Or adjust the shutter speed, aperture, and film speed manually (for the “manual” type of photographer). To help with the adjustment of the exposure value, you can choose to render a preview directly in the Environment and Effects window.

4. Final Gather (FG) should be turned on by default and the Bounce value set to 0. For an exterior scene, since you already have indirect illumination coming from the sky, for most scenarios you won’t need to add any FG bounces; this will reduce rendering time. FG bounces are more relevant for interior space.

5. Keep the default rendering settings for now and click Render. You should get a result similar to the image below.
Refining mental ray Settings for an Exterior Scene

Exterior daytime rendering is probably the easiest scenario for you to achieve good results. For this type of render, you will find all the mental ray adjustment settings you need at the bottom of the simplified rendering window. For most cases, the mental ray default settings will give you a good balance between rendering speed and image quality. Adjusting the settings will depend on the nature of your scene. Decreasing the quality precision will decrease the rendering time and the inverse will increase the rendering time but give you finer quality result.

Most AEC scenes will have: glass that needs reflection/refraction and transparency; metals that need soft reflections; and soft shadows created by the sun. In these cases you will want the quality to be at least as high as the default settings. As an example for precision quality adjustment, if your project doesn’t have reflective (glossy) materials or refractive materials (such as glass or water), you will be able to reduce these precision settings, thus speeding rendering. Another good example would be that if the time of day is set at noon when the shadows are really sharp, you will be able to reduce the soft shadow precision settings. Evaluate the needs of your scene and make the adjustments accordingly.

The precision quality will also depend on the rendering output size (the larger the render, the finer the precision quality) and purpose (final presentation or in-progress studies). According to your output need, you will be able to increase or decrease the quality precision.
Exterior Daytime Rendering Tips and Tricks
1. Illumination on the surfaces is provided by the mr Sun and Final Gather and not the Environment Map, so intensity adjustments must be made in the Daylight System. The Environment Map Shader (mr Sky) only affects the background and reflections from specular surfaces like floors or water.

2. You do not need many Final Gather Bounces to have a meaningful effect; Final Gather Bounces are usually useful for interiors.

3. The ground has an effect on indirect illumination; for example, if you use a very bright green grass, your building will probably turn greenish as well.

4. The Sun and Sky intensity is affected by the time of the day. Therefore, you will need to adjust your Exposure™ lightening tool accordingly.
Lighting Scenario B: Exterior Scene at Dawn or Dusk

*This scene will need Daylight System + photometric lights*

This scenario is more challenging as it requires a combination of Daylight System (mr Sun and mr Sky) and artificial light (photometric lights). Artistic skills and lighting skills will be required to achieve realistic results. Because we are working in a physical environment, you will get great results if you understand what type of lighting you need.

Keep in mind that the more lights you add to your scene, the longer the rendering calculation will be. Thinking outside the box and finding the balance between reality and visual quality will save you rendering time.

1. Change the time of the day of the Daylight System to early morning or late afternoon so the sun is just below the horizon. This will make sure that you have a nice gradient of color in the mr Physical Sky.

   ![Daylight Parameters](image)

   **Sunlight and Skylight turned off** OR **Sunlight and Skylight intensity reduced to 0.01**

2. Turn off the Sunlight and Skylight sources in the Daylight System, or reduce their intensity to a minimum (0.01). Since the sun is below the horizon, the source of light will be coming from the artificial lighting. The exposure control is only able to balance one source of light, not both, so you need to decide which one takes priority. In this case, the artificial lighting does.

3. Lower the exposure value accordingly.

   You should get something like this:
4. Start adding photometric lights according to your needs. To understand more about the process of adding photometric lights to your scene, refer to Lighting Scenario D: Interior Scene Using Artificial Light Only.

You should get something like this:

Exterior Dawn or Dusk Rendering Tips and Tricks

1. As we adjust the time of day, the mr Sun and mr Sky stay at the same intensity of 1.0. You need to reduce the intensity manually to a lower level for dawn or dusk. This will take a bit of trial and error before you get the perfect balance. It is sometime easier to turn it off and light the scene solely with the artificial light.

2. Creating dawn or dusk rendering takes time and artistic skills to master. A lighting plan can help guide the position of lights but often, you will have to rely on artistic flair in order to achieve the look you want.

3. Instancing the light will help you adjust a series of lights that share the same parameters.

4. The use of the Light Lister will also help manage and fine-tune your lights.
Lighting Scenario C: Interior Scene with Sunlight Entering Through Windows or Doors
This scene will need Daylight System + Sky Portals + Final Gather with Multiple Diffuse Bounces

The strategy to adopt in this scenario is to identify windows and openings with a special light object that is called an “mr Sky Portal”. The purpose of the mr Sky Portal is to focus the rays from the environment through the windows and holes to make sure the rays are entering the space and not being wasted on the exterior of the building.

Go to http://bit.ly/k3wITq to read more about the mr Sky Portal functionality.

1. Start by setting up your exterior rendering. Refer to Lighting Scenario A: Exterior Scene During Daytime. Once you are satisfied with an exterior rendering, add an mr Sky Portal covering the same size then the opening of space. Make sure the arrow points inside the space as illustrated: this indicates the direction of the light flux.

2. Move your camera inside.

3. Change the Exposure Control to the Indoor Daylight preset: this will adjust the aperture of the camera to interior lighting conditions, which are darker than exterior spaces. The exposure value might need slight adjustment depending on your scene but this is a good place to start.

4. Increase the Final Gather diffuse bounces to ~3-4: this will bounce the light around inside the space.

5. Render again and you should get something like this:
Refining mental ray Settings for Interior Scenes with Sunlight Entering Through Windows or Doors

Interior spaces can be challenging scenes to render and fine-tune because of all the possible variables. Think about it this way: the light rays need to travel from outside of your space through the openings (windows and doors) of your space. So the easier the traveling path is (the wider the openings), the easier the calculation. If the openings are small, narrow, or partially covered with blinds and semi-transparent curtains, the calculation starts to be more complicated and refinement of your settings will be needed.

Let’s look at some challenges and solutions.

1. Any objects obstructing the window (blinds, curtains, or semi-transparent panels) become obstacles for the light paths. If the final gather rays are blocked, fewer rays are able to enter the interior spaces therefore resulting in less light coming through your interior space. To help solve this, a combination of things can be done, including:

   - Increase the amount of Rays per FG Point: this increases the chance of more rays passing through the opening of the blind bringing more light inside the space. (Review the Fine-tuning Indirect Lighting section of this document for more insights).

   - Increase the amount of Final Gather Bounce enabling the rays that are passing through the space to bounce more times, helping to increase the physical accuracy of the light calculation.

   - Move the mr Sky Portal object in front of the blinds, so that the rays are not blocked by the blinds; the blinds will still cast shadows but rays will enter the space from the mr Sky Portal as if the blinds were not there.

2. Should I use an mr Sky Portal Light for each window in my scene? Generally speaking you need to use an mr Sky Portal where you expect high quality shadows from those windows. mr Sky Portals act as helpers to find small holes...
in a building. If, for instance, you have an atrium where 60% of the surfaces are glossy, you don’t need to have portals since FG rays will find their ways easily inside the space.

3. There are cases where the window openings will be really small and won’t provide enough lighting for the size of your scene. This can also happen in reality. To put all the chances on your side, make sure that the sun is oriented properly so it enters your scene directly enabling maximum light to enter the space. But, as happens in reality, if the window is too small for your space, you might still need to turn the light on! Adjusting your exposure control might be a good place to start to help rebalance the brightness and contrast of your scene.

Interior Daytime Rendering Tips and Tricks

1. Use the Material Override from the Render Setup > Processing tab and apply a generic white material. This will help you understand the lighting distribution of your space and enable you to see the lighting effects on a neutral color, as opposed to being distracted by reflections, refractions, and textures.

Note: You will need to temporarily hide the glass panes in your windows, as this material override will turn them opaque as well, which will prevent the light from coming inside:

![Example of an interior rendering with the materials overridden by a neutral diffuse white material](image1)

2. Cache the Final Gather computation to disk: once it is baked to disk, you can re-render without recalculating indirect lighting (which can be time-consuming) during material tweaks.

3. Use very low-quality settings to tune your materials: the rendered image will be completed faster.
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Global quality knobs provide faster control on the scene materials and lights for faster tuning

4. The Shadow Samples value affects the quality (graininess) of the shadows from the mr Sky Portals. It is also controlled by the Global Soft Shadows Precision slider in the Rendering panel:

Lighting Scenario D: Interior Scene Using Artificial Light Only

This scene will need Photometric lights only.

We recommend using Photometric lights for interior renderings because their energy computation is physically based, which makes them ideal sources for indirect illumination calculations. The main reason for this is that the energy used in the indirect illumination process will always be in balance with the energy used for the direct illumination.

1. Turn off any mr Sky Portal that you have previously added in the windows or door openings.

2. Turn off the Daylight System; we no longer want any lights to come from the mr Sun or mr Sky. Remove the mr Physical Sky shader from the environment map. At this point, if you render, you should get a completely black
image. If bright highlights are visible in the reflections of the materials, you forgot to turn off some of these elements.

3. Start with the Exposure Control preset Indoor Nighttime. You will adjust some settings when you start adding artificial light sources, but it’s a good starting point.

4. Create Photometric Lights in the space. As a reference, here are typical intensities corresponding to real-world lighting values:

<table>
<thead>
<tr>
<th>Class</th>
<th>Wattage</th>
<th>Type</th>
<th>Intensity</th>
<th>Beam Angle</th>
<th>Field Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow</td>
<td>20 W</td>
<td>Spotlight</td>
<td>3300cd</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Narrow</td>
<td>20 W</td>
<td>Spotlight</td>
<td>9150cd</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>Medium</td>
<td>50 W</td>
<td>Spotlight</td>
<td>3000cd</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Wide</td>
<td>20 W</td>
<td>Spotlight</td>
<td>460cd</td>
<td>38</td>
<td>75</td>
</tr>
<tr>
<td>Wide</td>
<td>50 W</td>
<td>Spotlight</td>
<td>1500cd</td>
<td>38</td>
<td>75</td>
</tr>
</tbody>
</table>

5. Turn OFF Final Gather and click Render: you should get something like this where only the direct illumination is calculated:
6. Enable Final Gather, with 3-4 Diffuse bounces:

Indirect lighting is bounced from the contribution of the direct lights.

The “splotches” are caused by low quality final gather settings. See the Fine-Tuning Indirect Lighting section for more tips on how to solve this.

With a better FG solution, splotches disappear. See the Fine-Tuning Indirect Lighting section for more tips on how to achieve this.
Fine-Tuning Indirect Lighting

Basic Strategy
To fine-tune a Final Gather solution, follow these steps:

1. Bake the Final Gather solution to disk using your normal lighting conditions so you can reuse it later and lock it in Read Only mode.
2. Use a Material Override; with a diffuse white material creating a flat white surface, lighting is easier to visualize.
3. Render with the Final Gather Diagnostics Mode (Render Setup Dialog > Processing Tab) to visualize the location of the Final Gather points contained in the Final Gather Map file:

![Final Gather Diagnostics](image)

4. Fine-tune the interpolation settings: they can be changed even if your Final Gather solution has been locked.

Examples

Test A: Low Density, Low Interpolation

![Test A: Low Density, Low Interpolation](image)
Observations: The density of the Final Gather points is relatively low. The noticeable cloudiness is visible mainly where the Final Gather points are separated each other by a large distance (where the density is low). Since the Interpolation is also low, the result is the “cloudiness” effect.

Test B: Increased Interpolation

By increasing the interpolation, =more points are “blended” together, softening the solution.
Observations: Here, the Interpolation was simply increased. Final Gather points together ended up blending, a little bit like a “blur” in an image. The density of the Final Gather points is still relatively low which did not increase the computation time.

Tip: When a Final Gather solution is locked and read from disk, you can change the interpolation between each rendering without having to recalculate the Final Gather solution.

Test C: Increased Density

With a very large density of FG points, an Interpolation value of 150 is not enough. A larger Interpolation value is required to smooth out the results.
Observations: If the density of Final Gather points is increased to capture more subtle light effects and details, the Interpolation required is now larger: as there are more points, more points need to blend together to reach a smooth effect. Notice the “cloudiness” effect appearing again when an Interpolation value of 150 is used. To fix it, it needs to be increased up to 450!

Tip: The reason for the noise is usually caused by the stochastic nature (randomness) of Final Gather. To solve it you either have to cast more rays per FG points or increase the Interpolation. Note that the Interpolation parameter is essentially a “blur” which can remove or reduce the effect of subtle shadows.
Section 4: Rendering Animated Sequences

In examining various scenarios, so far only the still image has been considered. When rendering animated sequences, it becomes necessary to bake the Final Gather Map (FGM). For still images, a unique FGM file was rendered each time, unless locked for time-saving purposes. When rendering a sequence, if rendering a unique FGM for each image is kept, the render output result will be calculated based on a different FGM for each frame. When looking at each image individually there will be no problem, but when playing the consecutive frames in a sequence, there will be a noise effect created by the FGM uniqueness. To avoid this problem, different solutions are offered depending on the type of animated sequence you are dealing with.

These are the three main scenarios of animated sequence that most AEC users will be required to render:

A. Animated objects and a still camera  
B. Animated camera and still objects (walkthrough/fly-by)  
C. Animated camera and animated objects

Below is some background information to help you understand the logic behind the solutions.

Eliminating Indirect Illumination Flickering

In versions prior to 3ds Max Design 2010 software, animation flickering was caused by two main factors:

1. When the Final Gather points are not “locked” on the geometry, they “slide” along the surfaces as the camera moves.
2. Moving objects create Final Gather points that are “floating” or “ghosting” in the 3D space, introducing rendering glitches.

In 3ds Max Design 2010 and later, indirect illumination animation flickering is substantially eliminated by two main techniques:

1. To handle camera movements, Final Gather points are shot from several locations along the camera path. Final Gather points become “locked” on the geometry, thus removing the “sliding” effect of those points across frames. This is what is referred to as FG Projection Mode.
2. To handle moving objects, one Final Gather file per frame is processed in a first pass. When the beauty pass is rendered, Final Gather points are interpolated across multiple frames to “smooth out” the solution. This is what is referred to as Frame Interpolation for Final Gather Maps.
Animation Scenario A: Animated Objects and a Still Camera

For this type of animation, one Final Gather File per frame in a first pass (FGM pass) will need to be rendered. Then interpolate the FGM solution across multiple frames when rendering the final image (beauty pass) shot.

1. In the Render Setup window, Common tab, make sure that you have set the Time Output to be Active Time Segment, Range, or a series of Frames.

2. First, you need to render the FGM pass. Open the Render Setup window and navigate to the Indirect Illumination tab, then scroll down to the Reuse section. Set the Mode to One File Per Frame (Best for Animated Objects) and check Calculate FG/GI and Skip Final Rendering. This will enable you to only render the FGM at this point.

3. Under the Final Gather Map section, choose Incrementally Add FG Points to Map File and give a name and location to the .fgm file (by default it will be saved under the project folder renderassets; it is a good idea to leave it there).

4. Click Generate Final Gather Map File Now or Render. This will start the rendering process of the FGM only and save one .fgm per image. Note: this process may take some time to complete, depending on the length and complexity of your animation sequence.

5. Once the FGM rendering process is over, still under the Reuse section, uncheck Calculate FG/GI and Skip Final Rendering. In the Final Gather Map Section, choose Read FG Points Only from Existing Map Files. Click Render. The beauty pass will render using the already calculated FGM file and interpolating over two frames; this will usually take less time than rendering the FGM sequence.
Fine-Tuning a Sequence with Animated Objects

Of course, everything you’ve learned so far about fine-tuning the quality of mental ray rendering will apply to rendering a sequence with animated objects. The rendering quality tends to need higher quality precision when objects are moving. For example, if you have a really reflective material with blurred reflections, if that object is moving, you will need softness in the reflection to avoid buzzing effects. The same idea will apply to a really fine railing object or fine vertical post; you will need to increase the antialiasing quality in order to avoid flickering of fine objects. The fine-tuning of the FGM will also depend on the nature of your scene (exterior versus interior, daylight versus artificial lights). It is good practice to render a section of your sequence or a region to test the quality needed for your animation.

Frame Interpolation for Final Gather Maps Tips:

1. Interpolation over a number of frames works only if you bake a unique Final Gather map to disk per frame as a first pass, which are then read as “read only” mode in a second pass.
2. The first few frames and last few frames of your animation will not be able to interpolate to FG files that are missing (ex: frame 0 will expect frames -2 and -1 to be present). Therefore plan to pad your shots with a few extra frames in the beginning and in the end.
3. The mental ray message window will display warnings about missing FG maps if any.
4. As you load several FG maps in memory (one per frame to interpolate across), keep in mind that you also load a lot more FG points to interpolate across. You will need to increase the Interpolation value by a factor of maybe 3 to 5 to reduce the “cloudiness” that may appear.
5. You can define a “job” to bake FG Maps on a network farm by using the following combination of passes.

Pass 1: Enable this to prevent the beauty pass from being rendered. You can then submit this as a Backburner job and get your network nodes baking to disk one FG file per frame.

Pass 1: Enable this to set FG to be in Write mode.
Animation Scenario B: Animated Camera and Still Objects (Walkthrough/Fly-by)

For this type of animation, a Final Gather Projection pass first will need to be rendered and then render the beauty pass. This technique is faster to render since only the FGM needs to be rendered once instead of rendering it for every frame.

1. In the Render Setup window, Common tab, make sure that you have set the Time Output set to Active Time Segment, Range, or series of Frames.

2. First, you need to render the FGM pass. Open the Render Setup window and navigate to the Indirect Illumination tab, Final Gather section. Choose Project Points From Position Along Camera Path. By default the camera path gets divided into nine different segments into which the FG points will be projected and used to calculate the FGM.

3. Then, go to the Reuse section and set the Mode to Single File Only (Best for Walkthrough and Stills) and check Calculate FG/GI and Skip Final Rendering. This will render only the FGM at this point.
4. Under Final Gather Map, choose Incrementally Add FG Points to Map File and give a name and location to the .fgm file (by default it will be saved under the project folder renderassets; it is a good idea to leave it there).

5. Click either Generate Final Gather Map File Now or Render. You should get something like this:

![Image of rendered scene]

6. Once the FGM rendering process is over, still under the Reuse section, uncheck Calculate FG/GI and Skip Final Rendering. Under Final Gather Map, choose Read FG Points Only from Existing Map file. Click Render and the beauty pass will render using the already calculated FGM file.

![Image of reused FGM settings]
Fine-Tuning a Walkthrough/Fly-By
By default, the Camera path gets divided into nine different segments, into which the FG points will be projected and used to calculate the FGM. This assumes that the camera movement is slow and short. Depending on the distance and speed of your camera movement, you might want to increase or decrease this segment number. The longer or faster the distance covered by the camera, the higher the number of Segments needed to cover the distance and give you smooth results. In general, the more segments you have, the smoother the results.

Animation Scenario C: Animated Camera and Animated Objects
To render this type of animation, a combination of both of the techniques already have reviewed will be used, because both elements are animated: camera and objects. Let’s review it to make sure it is clear.

1. In the Render Setup window, Common tab, make sure that you have set the Time Output to Active Time Segment, Range, or series of Frames.

2. First, you will need to render the FGM file. Start by going to the Render Setup window and navigate to the Indirect Illumination tab, Final Gather section. Choose Project Points From Positions Along Camera Path.
3. Next go to the Reuse section further down the same tab. Set the Mode to One File Per Frame (Preferred for Animated Objects) and check Calculate FG/GI and Skip Final Rendering. This will render only the FGM at this point. Under Final Gather Map, choose Incrementally Add FG Points to Map File and give a name and location to the .fgm file (by default it will be saved under the project folder renderassets; it is a good idea to leave it there).

4. Click either Generate Final Gather Map File Now or Render. This will start the rendering process of the FGM only and save one .fgm per image. Each FGM file (one file per frame) will be divided into the number of segments you have set (nine by default). Remember, this is a combination of both techniques.

5. Once the FGM rendering process is over, still under the Reuse section, uncheck Calculate FG/GI and Skip Final Rendering. Under Final Gather Map, choose Read FG Points Only from Existing Map file. Click Render and the beauty pass will render using the already calculated FGM files.
Appendices

Appendix 1: Guidelines for Your Scene Geometry

“Air-Tight” Models
Sometimes, you can find models where walls and windows or roofs don’t touch each other properly. This can cause lighting from the exterior of your building to penetrate without attenuation (from glazing for example) and introduce errors in the lighting analysis results.

![Image](https://example.com/image1)

Windows panes not touching the curtain wall frame let direct sun rays inside the model.

![Image](https://example.com/image2)

This building is not “air-tight”. We can clearly see a hole above the windows under the ceiling.

Smoothing Angles
All 3D geometry—including both edged objects and rounded forms—is made up of polygons. To display them smoothly, 3ds Max Design interpolates between the surface normals to simulate a rounded form and not a faceted one. When
importing a file from another computer-aided design (CAD) or 3D application or when working with the Edit Poly modifier, you may find that the information about which normals to smooth by interpolation and which to keep sharp edged with no interpolation can sometimes get lost or corrupted. Instead of reimporting a file or asking your client to resend it, try the Smooth modifier. In most cases, the problems disappear.

The cube’s faces are smoothed with an angle that’s too high, the sphere’s faces with an angle that’s too low.

This is how the cube and the sphere should look according to smoothing groups.

Flipped Normal
Rendering the face of a geometric shape requires both the vertices that define it and information about its orientation. This can be seen as information about which is the front and which the back of the face, which is handled by the surface normal as well. For mental ray rendering, this is critical because light energy will be bounced in the direction of the surface normal.
Easier mental ray Rendering for Design Workflows

Light is bounced from the direction of surface normals. This is a critical aspect to understand for accurate lighting computations.

When importing a model from a CAD package, you may find that direction information for some face normals gets “lost” or “corrupted”. In many cases, the modeling package in which the geometry was created may not have provided this information as the entities were created. Use the xView feature to display the face orientation in 3ds Max Design 2010 and later.

If there are only a few faces with the wrong orientation, you can add an “Edit Poly” modifier in 3ds Max Design and use Flip on the affected faces.

The geometry is the same as in the preceding example, but some faces are flipped so they appear to be invisible. Orientation information can be lost or corrupted during import but usually, the modeling program did not take them into account.
Polygon Count
It is good practice to think about how many polygons an object should consist of before modeling it. This is true for all geometric objects, especially curved and round ones. Each face needs to be rendered, but using many polygons on a round object can quickly add up to inefficiencies, especially if objects are copied within the scene. On the other hand, using too few polygons makes an object appear segmented.

Unwelded Vertices
In some cases, a model might look as if it is closed, but instead each face is separated and the vertices of neighboring faces are unwelded—that is, not connected. Unwelded vertices can introduce many problems, including large file sizes due to thousands of unnecessary vertices, damage to the object when moving faces or altering the model, and even problems with proper smoothing and normal interpolation, since the faces appear unconnected to 3ds Max Design.

If the Smooth modifier doesn’t correct smoothing problems, check for unwelded vertices. To weld vertices, simply add the Weld Vertices modifier and choose an appropriate radius.
Both spheres look the same, but the right one has a row of unwelded vertices. This wastes memory (for example, instancing an object many times) and makes it difficult to modify geometry. Problems appear when moving half the faces with an “Edit Poly” modifier. Welding the vertices corrects the loose edges.

Under certain light conditions you can even see unwelded vertices by studying a render of the object.

Overlapping Surfaces
Watch out for faces that overlap precisely. The renderer cannot determine which one to put in front, and a black pattern artifact will appear.

Overlapping faces can be introduced by careless modeling or by importing a file, such as a CAD file with versioned geometry overlapping precisely on several layers or by creating a ground plane across your entire model at the same level of the floor finish. Use the xView feature of 3ds Max Design 2010 and later to help spot them.

Overlapping surfaces can produce artifacts.
Appendix 2: Linear Color Workflow (Gamma)

While Gamma is not the topic of this paper, knowing that a material expects “linear colors” as input means that you need to handle Gamma properties which are usually embedded in image files. It is important that you “linearize” or “de-gamma” textures as input.

Go to http://bit.ly/k1VHRR for more information on Gamma and LUT preferences in 3ds Max Design.

Gamma Pipeline for Texture Input

Typically, the Gamma pipeline for texture input works as follow:

A Low Dynamic Range Image is loaded from disk, Gamma corrected (linearized) prior to be passed to the Material

Gamma Pipeline for Rendering Output

Knowing that the Renderer operates in linear space (Gamma 1.0), the rendered image needs to be Gamma corrected (again) at the end prior to being saved on disk or displayed on screen:

An image is rendered in Linear Space. Depending on the target output, it is then Gamma corrected (Low Dynamic Range Images) or not (High Dynamic Range Images).

Gamma Workflow Tips

1. If you save your textures out of Adobe® Photoshop® software with an sRGB color profile, the closest matching Gamma value is 2.2: stick to this value.

2. Low dynamic range images such as jpeg files need to be Gamma corrected on input and output. When loading or saving them with 3ds Max Design, make sure that you load them with a Gamma correction of 2.2 as well.
3. High Dynamic Range Images should always be loaded and saved with a Gamma Value of 1.0. Since they are HDR, the convention is to assume is that they are always in Linear Space (Gamma 1.0).

Using the “System Default Gamma” option will take the value from the preferences dialog. The recommended default value is 2.2.


Appendix 3: Related Links
Additional links can help you understand more about working with mental ray and 3ds Max and 3ds Max Design in general.

Autodesk White Papers and Feature Videos
- Revit software to 3ds Max, Daylight Simulation and Analysis and more...
  [http://www.autodesk.com/designvisualization](http://www.autodesk.com/designvisualization)
- Online feature videos:
  [http://usa.autodesk.com/3ds-max/features/](http://usa.autodesk.com/3ds-max/features/)

3ds Max Design Online Documentation
Appendix 4: Settings for Users of 3ds Max Software

3ds Max Design users benefit from the DesignVIZ.mentalray default UI settings that include:

- mental ray as the default renderer
- Material editor populated with Arch&Design materials
- Photometric lights set to cast ray-traced shadows
- Daylight default to mr Sun and mr Sky
- Real-world texture coordinate support for all objects

If you are a 3ds Max user, the default UI settings are set to MAX UI and are therefore different. 3ds Max users can work with the same UI default settings assumed by this paper by switching the default setting to DesignVIZ.mentalray default UI.

To do this, from the main menu choose Customize > Custom UI and Default Switcher. Then choose the DesignVIZ.mentalray Default UI and click Set.
About the Authors

Marion Landry
Marion Landry has over 15 years of experience in Architectural Visualization, working with a wide range of software including Autodesk 3ds Max/ Autodesk 3ds Max Design and Autodesk® Maya® software. She has worked on numerous projects from concept design to high-end visualization.

As a Technical Marketing Manager for Autodesk PSEB, she now focuses on the creation of demonstrations for an AEC- wide audience as well as being involved in the development of Autodesk 3ds Max and Autodesk 3ds Max Design products.

Pierre-Felix Breton
Pierre-Felix Breton is senior software designer and lighting consultant specializing in the field of physically based and artistic lighting simulation. His professional background includes electrical engineering, computer programming, and theatrical lighting.

Currently employed by Autodesk Media & Entertainment, he participates in the creation of products such as Autodesk 3ds Max and software based on the Autodesk® Revit® platform where he focuses on the integration of the mental ray rendering engine as well as daylight simulation technologies.