GA2211 — Class Notes – Supplemental
Software VS Hardware Rendering

Software Rendering is the process of applying complex lighting and material algorithms to produce single rendered images, or series of images, which can be chained together to form movie clips. This rendering technique can produce unlimited detail, as the process of rendering one image can fully utilize all of the resources of the computer for an open-ended time period. In software rendering, the CPU(s) is used to render the image. It is not unheard of for single frames of CG movie sequences taking a day to render. The brute-force approach is used, with hundreds of machines rendering a given sequence (Render Farm,). In this way, CG film producers can get images and sequences for evaluation daily.

At right, a typical "Render Farm" of hundreds of blade computers. Below, a modern Video Card with dual GPUs.

Hardware Rendering, on the other hand, is done on the video card's GPU (Graphics Processing Unit). This dedicated chip has its own memory resource and is optimized to perform certain operations for graphics much quicker than the CPU. As such, many features that where once only available through software rendering can be done on the GPU. This has paved the way for video games and 3D viewport technology. All video games use hardware rendering, with the console's GPU quickly outputting new images at 30-60 frames per second as you interact and react to the game world.

However, because the Hardware Rendering must happen in Real-Time (generally at 30-60 re-draws per second) it is limited in what it can do. Because of this limitation, some of the advanced rendering algorithms of Software Rendering are just too much for Hardware Rendering.

GPU power and technology is increasing yearly, but as game developers, it will fall upon you to simulate much of this complexity in a cheaper texture. One technique to get advanced lighting into your textures is to use an **Ambient Occlusion** pass in your textures.

Ambient Occlusion/Global Illumination:

Ambient Occlusion is a rendering method used to quickly simulate complex Global Illumination lighting. The term *Global Illumination (GI)* is broadly used to define hyper-realistic renderings that simulate lighting as it appears in the real world. Various algorithms are used to provide indirect lighting through bounces of light and subtle variation in light quality. Often, this will lead to soft shadows in corners and crevices and a general non-directionality of light, as in an overcast day.

Ambient Occlusion (AO) attempts to produce this effect, but in a faster and non-directional way. In an Ambient Occlusion rendering pass, rays are fired in a random hemispherical distribution out from a surface and their collisions with the neighboring geometry is recorded. Each hit is recorded as a value of grey, from white to black. Depending on the distance to a hit, the grey value is recorded at the origin of the ray. If nothing is hit, the ray returns white. If a hit occurs very quickly, as would happen in a corner or crevice where the face is near another face…the result is dark grey. At the end of an AO pass, all the results are blended together. The resulting pattern appears to take on the subtle gradation of non-directional lighting on a cloudy day. While not absolutely correct, the effect is very convincing…and when mixed with directional lighting, can produce a very "GI" look at a fraction of the rendering time.
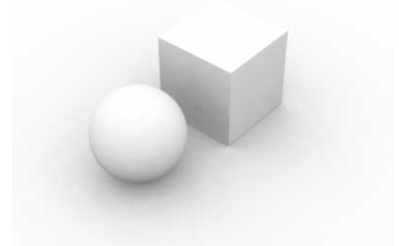
For games, this information can actually be baked into a texture map – which can be directly used or layered into a texture map. This texture information can be re-used and is no more expensive than a standard texture.

Rendering an Ambient Occlusion Map in 3DS Max

Follow these steps to produce an Ambient Occlusion Map in 3DS Max:

A) Set your rendered to "**Mental Ray**". This feature is only available with the Mental Ray renderer.

- [icon] Open Render Settings by clicking in the top-right main menu.

- You'll be presented with another menu.

- Go to the bottom of the "**Common**" Tab…

- … to "**Assign Renderer**" sub-menu. Open this menu.

- Choose the "**Production**" Renderer by clicking the button […] next to this slot.

- Choose "**Mental Ray**" as the renderer.

- Once Mental Ray is your renderer, close this window.
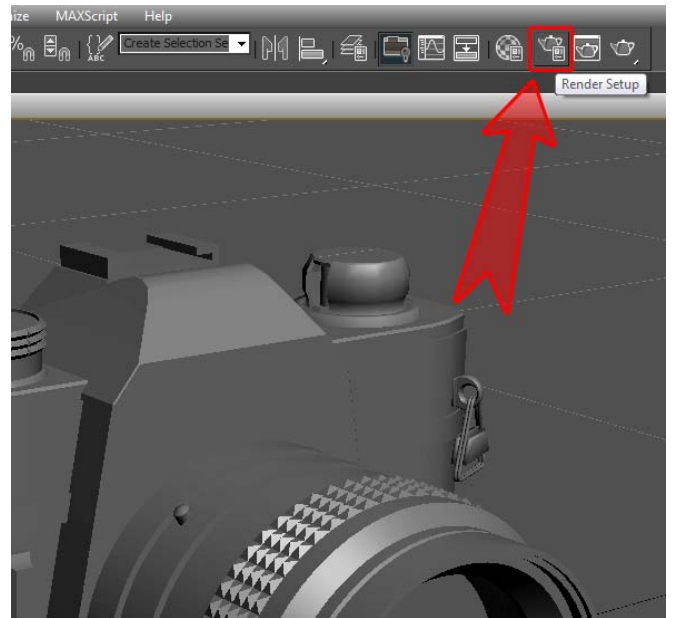
B) Open the "Render to Texture" Dialog:

- This can be found in the "Render" main menu.

- Choose "Render to Texture…" from the drop-menu:
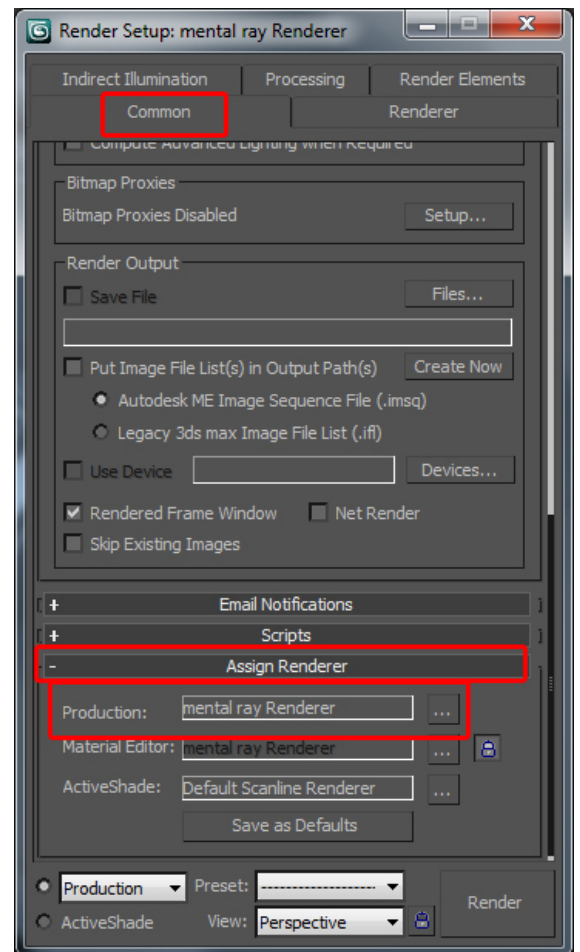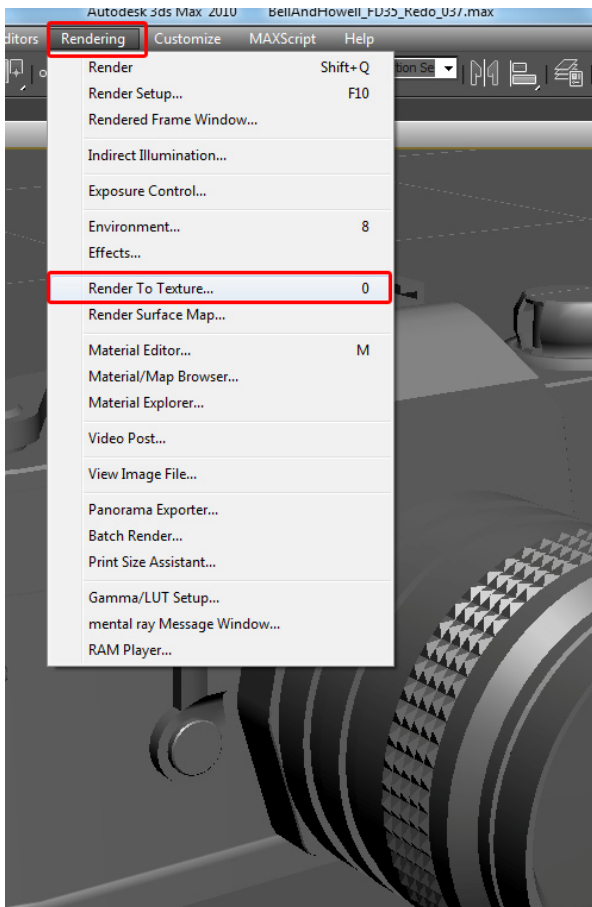
C) Render to Texture Options and Settings:

This powerful feature of 3DS Max lets you render details of your model into a texture map. You will be using it to render an Ambient Occlusion pass. This menu has many settings, but if you work from the top-down, you will soon see that everything is arranged neatly.

From the top:

1) This is where you can set the output path for your texture. Click the button […] to point to a path where you'd like Max to save this texture after it is done rendering.

2) Select your mesh in the viewport to add it to this list.

3) Disable Projection Mapping. We won't be using this feature, which usually maps detail from one model to another. Here, we just want to sample this single model.

4) It is important that you **lay out your UVs in a non-overlapping fashion**. Since every face of your model must get a unique lighting solution, no UV shells can overlap. Hopefully, you've taken care to avoid UV shells that overlap, which can produce long render times and errors in the final map (dark areas where 2 lighting solutions tried to bake to the same texture space).

Having spent all this time carefully laying out your UVs, we don't want Max to stomp on them. Set this to "**Use Existing Channel**" and set the channel to UV channel 1 to use your careful mapping.

5) Select the type of map to *Render to Texture* by clicking "**Add**".

You will be given a menu.

Select "**Ambient Occlusion (MR)**" and hit OK.

> [NOTE] *If you do not see that item on the list, please go back to step A and enable the Mental Ray Renderer.*

6) You will notice your map has been added to the list of items to render. You can chain up multiple render passes here, rendering one after the other. However, it is best to isolate one map at a time until you get a good result, then move on to other map types.

7) You can name the texture output here. Choose a name that has an incremental number at the end, example "Camera_AOmap_001". This way, you can save multiple versions and compare results from previous renders.

8) This is what channel Max will attach the map for your preview, once it is rendered. This is for preview purposes only, set to "Diffuse" so that you can see it in the diffuse channel.

9) This is the final size of the map. You should always start by rendering several small test maps. It can take upwards of 15 minutes for a final bake, and you don't want to wait 15 minutes for every iterative render as you dial in the settings. Start small, maybe 128x128 and when you are happy, move to the full texture resolution. Also, render in "power of two" combinations for efficiency…32, 64, 128,256,512,1024,2048,4096, etc.
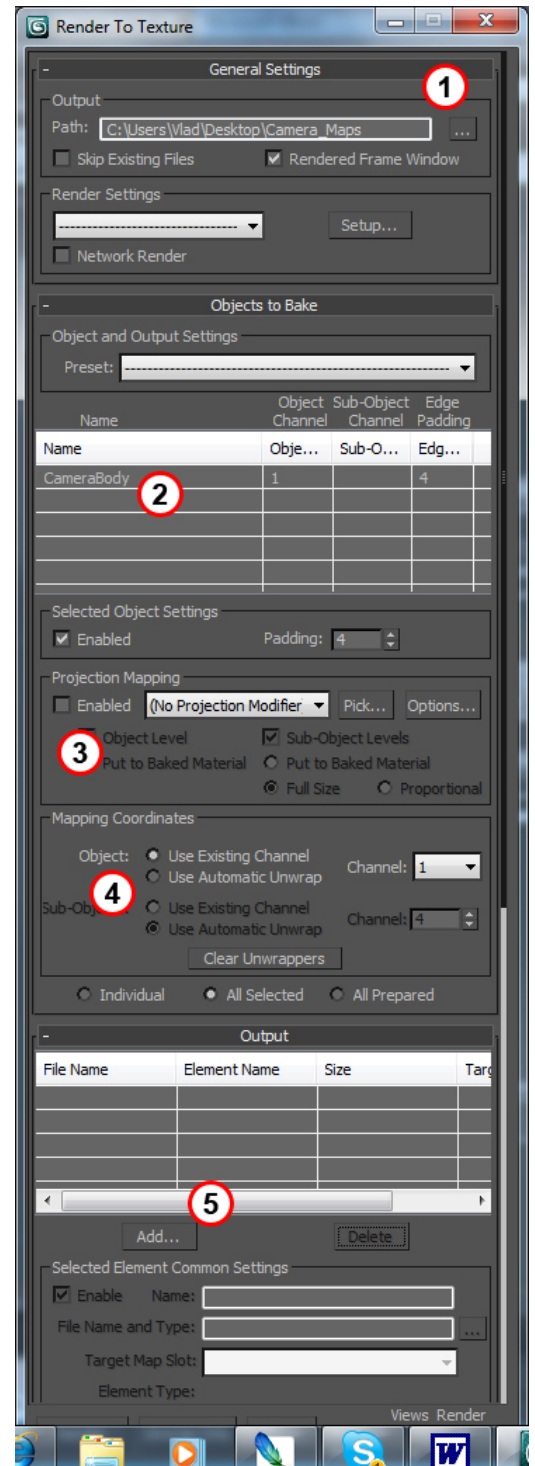
10) These settings affect the quality of the *Ambient Occlusion* Map.

     Be advised, that they also affect the length of time required for a render. The goal is to put the settings high enough for clean results, but not too high to wait forever for a render.

| **Samples:**	*The number of Rays fired off. Generally, more rays mean a smoother result with finer speckles.*
Max Distance:	*The distance at which to stop looking for occlusion. This can be used for closed surfaces, where at some point every AO returns darkness.*
Spread:	*Affects how far the shadows come out from the crevices and creases.*
Falloff:	*Similar to spread, a cutoff distance from the dark areas.*

     Do multiple bakes to see the results of each setting. Increment the names of the maps so that you can compare previous results…and work small! Only when you are happy with the results should you render at full resolution.

     Your final rendering should show off your modeled detail and can be used as a base layer in your texture (with blend mode "Multiply") or as a stand-alone texture for model demonstration in your portfolio.
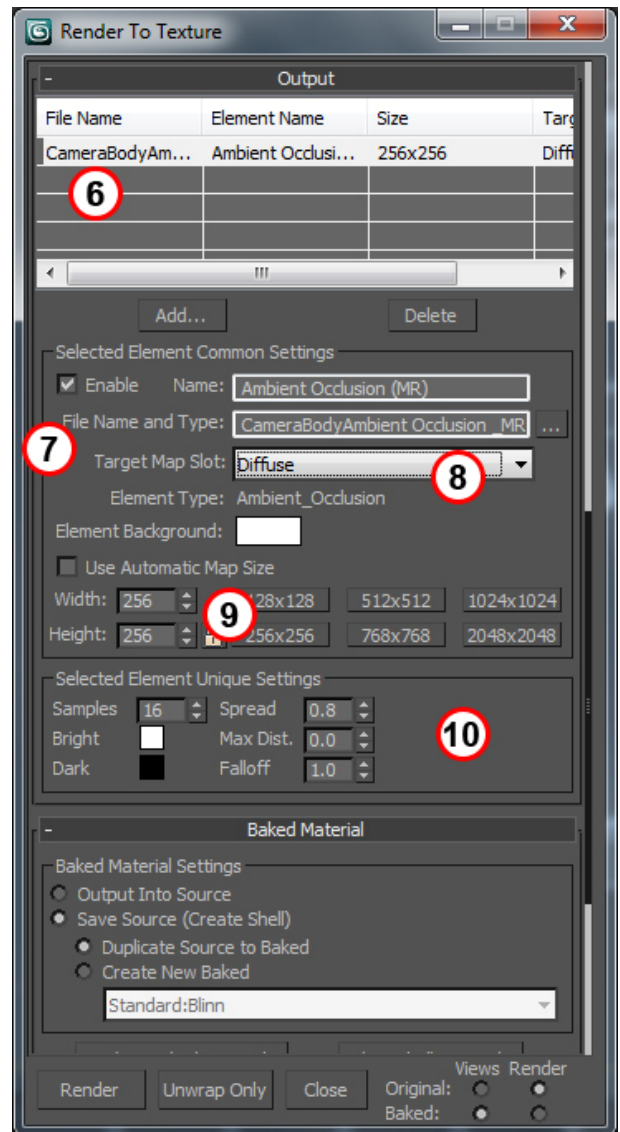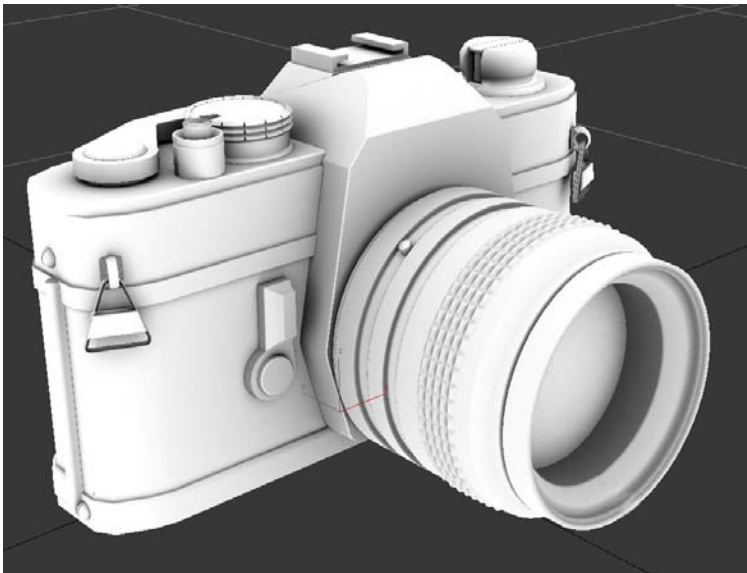
The image to the left is simply displaying the baked in shadowing of the *Ambient Occlusion* map as a diffuse texture. This will mix nicely with any lighting scheme to provide an extra layer of realism.