Sample of Chapter 3

jim coe's

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Chapter 3 – Lighting Your Images

Why create your own custom lighting?

Most 3D and some 2D software tools have decent default lighting. And textures come with their own "default lighting", or they'd be black. Some image makers leave it at that.

That's a great shame, since skilled texturing and lighting are critical to an outstanding image. Without excellent simulated lighting and materials, your shapes will lack form and your images will lack realism, communicative power and drama.
Here is a simple 3D scene, with and without custom lighting.

Custom models, materials, scene and atmosphere, each with their own default lighting
No scene default lighting was used

Same, after custom scene lighting
(Note: Moving the "sun" position rotated the sky, so sky and clouds look different)

Obviously custom simulated lighting adds a lot of realism, form, depth, meaning and feeling. Even though modern 3D scene production software may produce decent default lighting, to get the most out of your scenes, you need to carefully do the lighting yourself.

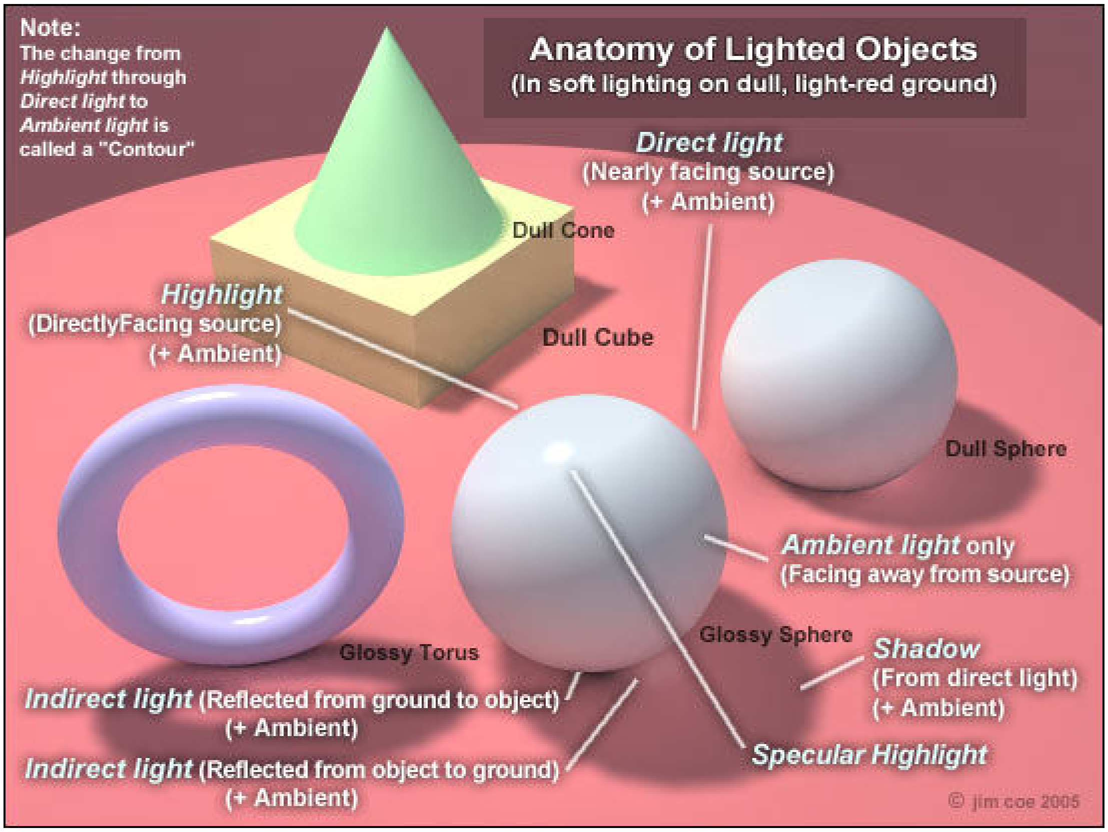
Light Rendering Basics

Before doing renderings, you need to understand the basics of lighted objects – the classic light effects that simulate realistic 3D form.

The demo image below should help. I made it using one simulated spotlight and a light red colored ground surface. A very glossy sphere might be expected to reflect the scene like a mirror, but I left off reflections for the sake of clarity.

Please recall that ambient light is the "background" light level that permeates the whole scene, due to many reflections. It's like the background sound level in a busy room.

Radiosity type light rendering is required to show these subtle indirect light reflections.



Anatomy of a typical lighting render – the visual effects that simulate 3D form.

To clarify a few things:
A specular highlight is a special type of highlight which indicates surface smoothness or gloss, including reflections of the environment for ultra smooth (mirror-like) materials.

There is a somewhat gradual transition from a Highlight, where the light source is more or less ***normal to*** (at a 90° angle to) the surface, to Direct Light, where the source barely reaches the surface directly, to Ambient Light, where the surface is shadowed from direct light. This transition is called a ***Contour***. This method of showing form by gradual shading, especially in classical manual drawing, is called "***Contouring***".

Please notice that this "typical" lighting is not necessarily the best for any particular scene. It's an idealized painter's studio "North light", which is itself a simulation of open shade on a sunny day in a reflective environment. As in every other aspect of image making, your image may dictate a much different lighting style – such as a harsher or darker or more dramatic setup.

There are also lighting “special effects” not shown above, like volumetric lighting, different types of cast shadows, glowing materials and materials with shadow casting light sources inside them, such as simulated light fixtures, flames or explosions.

Also, the rather new HDRI images can be used as your scene’s light source in some 3D software, for a different kind of scene lighting look.

Light Rendering Methods

Calculating the complex way light behaves is a huge computational task. It’s done by a very specialized software tool called a “render engine” in your 3D program. The render engine works with your computer’s display hardware, where a lot of display processing is done nowadays.

There is a heavy trade off between lighting realism and the time required for the render engine and display hardware to complete your image. We are potentially talking about hours or even days of render time! It seems the more desirable a rendering option, the more expensive it is in computing time, computer memory size and display card cost.

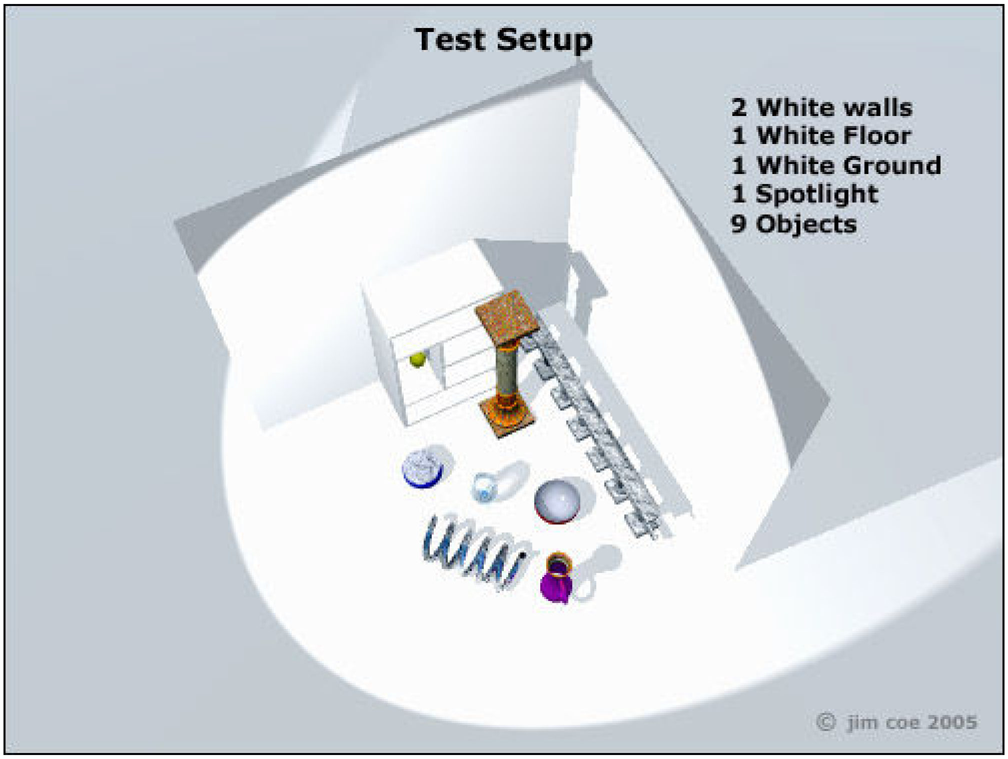
To get the most from your renders in the least time, you need to be familiar with all the render engine options your software offers. You should test them all to find out how to control each one, what each does to your image and what each costs in render time. You can then discover tricks to save render time and you’ll know how to get the look your image needs - without waiting any longer than necessary.

Render types

Historically, a few mathematical approaches were developed to simulate lighting. Each creates a different appearance and has unique strengths and weaknesses. The two major methods left standing today are Ray Tracing and Radiosity.

Most 3D software products nowadays offer their own proprietary render engine, blended from the latest Ray Tracing and Radiosity advances. You can also find stand-alone programs intended solely for rendering. Render controls typically let you get quick but sketchy preview renders or slow and beautiful final renders.

Here are some renders with different options from e-on Software's ***Vue 5 Infinite™***



The render demo setup

Ray Tracing demo

The principle in Ray Tracing is to start at the camera lens and follow each ray of light back to its source, adding together all the effects it experienced along the way and deciding whether it qualifies as part of a shadow. This also eliminates having to calculate lighting for any surfaces which are hidden from the viewer's point of view

This ray tracing must be done for every pixel in the image, maybe even for multiple rays per pixel! You can see why older PCs lacked the power to do this and why a final quality ray traced scene can take hours to render.

Ray Tracing was the first method allowing optical effects like caustics and mirrors to be rendered accurately. But it was never able to simulate indirect lighting from multiple surface reflections.

Below, you see two Ray Traced renders. The first is a faster, low quality basic preview render. It renders objects decently, with caustics, reflections and transparencies, and renders the chrome spring's faked environment reflections. But this basic render does a poor job on the shadows and shows no light from reflecting surfaces.

A low quality but faster basic Ray Traced preview render

The second Ray Traced render below was set for high quality, although I didn't do anything to improve the shadow edges, which should really be softer.

The shadows of the chrome spring object appear angular because that 3D model isn't very high resolution. That is, it's not made with very many polygons. The render engine can smooth the object's faceted surface, to make it appear smooth, but it can't do the same for the spring object's edges or shadows.

Notice that the distribution and balance of light and shadow are now more accurate. But notice also that light is not being reflected indirectly from any surfaces onto nearby surfaces, as it would be in the real world. For example, you can barely see the yellow ball inside the white bookshelf.

Better, but the yellow ball in the bookshelf is barely visible

Radiosity demo

Radiosity lighting calculations deal with light as power, not as rays. Radiosity attempts to account for all the light energy in a scene. Thus Radiosity is able to render indirect lighting much better than Ray Tracing can. But it can't deal with refraction, caustics and other such optical effects that Ray Tracing does so well.

In the example below (where I exaggerated the Radiosity for clarity), you can see that Radiosity calculations allow the objects to reflect some of the light they receive onto nearby surfaces, just as in the real world. You can see this most clearly in the colored light reflected onto the ground from colored objects and in the brighter yellow ball inside the white bookshelf. Notice also how the marble railing top receives extra light from the white back wall.

Caustics and reflections are still present here because this render engine is a modern version which includes Ray Tracing along with the Radiosity rendering.

The Radiosity render took about 10 times longer than the already long high quality Ray Tracing. Increased lighting realism always comes at a price. You should keep in mind though that this long render time is still an amazing engineering feat for a personal computer. Modern render engines bring image quality levels available only to large corporations a few years ago to even the home image worker on a tight budget.

Notice the slight "grainy" or "dirty" look of the reflected light. Further increasing the render quality, and therefore render time, would clean that up.

Radiosity: The yellow ball is now illuminated indirectly with light reflected by the bookshelf. All the objects are reflecting light onto adjacent surfaces. The marble railing top is receiving light reflected from the back wall.

Radiosity is so expensive in computer resources, that smart digital artists don't use it for outdoor scenes when there is little visible indirect light, such as in distant landscapes.

Lighting Render Bells and Whistles

Soft Shadows

In the real world, shadows are very complex, with edges which have varying sharpness - depending on the distance to the shadow receiving surface, the type of light source and other variables.

Simulating shadows realistically is a new feature of consumer priced render engines which requires lots of extra computation. For example, to get soft shadows the sky and sun might have to be calculated as many light sources, instead of being treated as only one. Soft shadows are not only more realistic, but also make the image less confusing for viewers. Note how the snake is harder to confuse with its shadow in the right image.

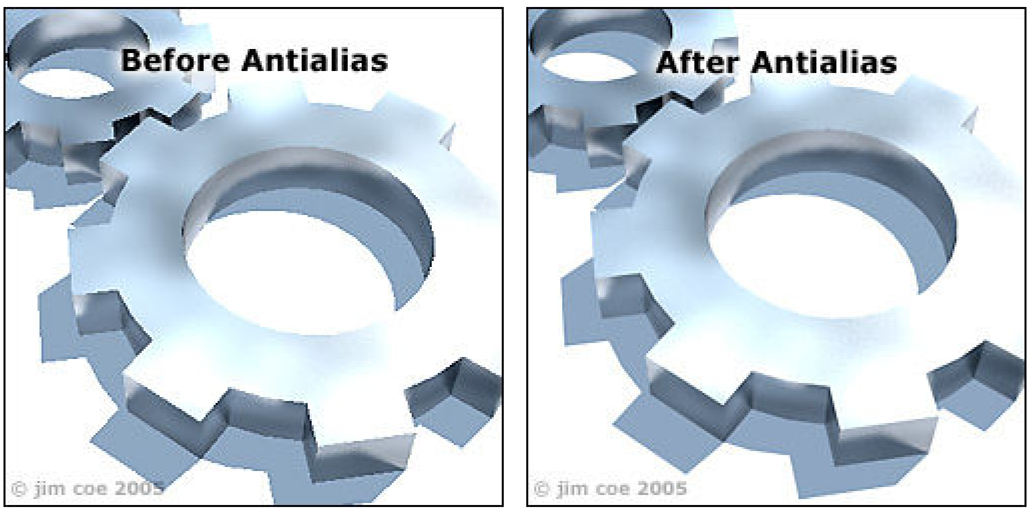
Soft shadows add realism and combat image confusion

Volumetric Lighting

Visible beams of light, convincing layers of cloud and realistic underwater lighting are cases where simulating suspended and illuminated particles produces beautiful results. This is another desirable light effect that takes lots of extra render time.

Antialiasing

Any realistic render has to have visible digital artifacts smoothed away, especially at the edges of your objects. This is another time and resource expense for a good final render.



Notice the smoother edges on the objects and shadows of the right image

HDRI

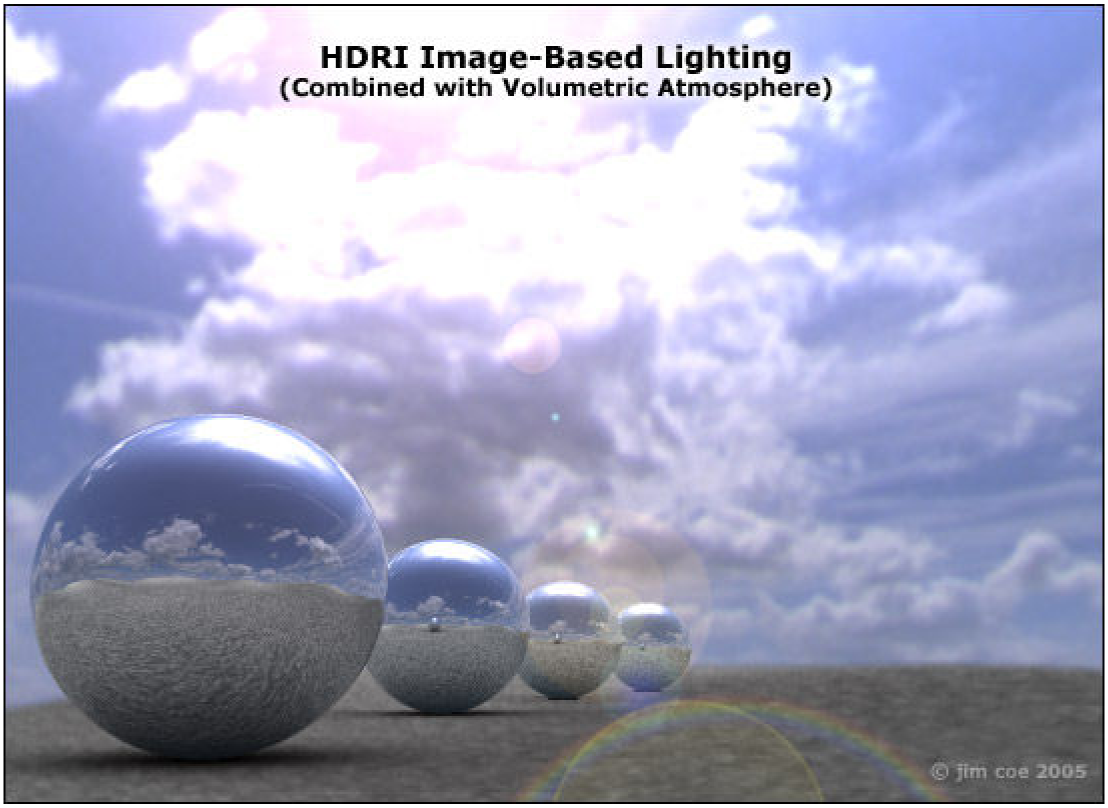
As you saw elsewhere, the dynamic range of human vision far exceeds the range of even the best camera film or digital sensor.

We often use three separate loudspeakers to cover the full human hearing frequency range for music reproduction. In the same way, newer photo techniques use three or more photos, each exposed to capture different brightness ranges of the same scene, to cover the full dynamic range of human vision.

Such images are called ***High Dynamic Range Images*** (***HDRI***) and are stored in special image files that support more bits of brightness value than previous formats. Their dynamic range is such that, if you had a display capable of showing it to you, a picture of a sunny day would light your real world viewing room with a beam of artificial sunshine! This is quite an advance, and one I expect (please excuse the pun) we'll be seeing a lot more of.

Some 3D programs allow you to use HDRI 2D images as backgrounds and even to integrate your 3D scenes with this background by using the HDRI image as the scene's light source! This use of an HDRI to light your scene is called ***Image-Based Lighting*** (***IBL***) and can give you very realistic scenes. Making the HDRI photos yourself is challenging, but has become possible for any 3D worker with some photography experience, a high precision mirror surface ball (to produce the required spherical photos) and a good digital camera.

The HDRI/IBL image below can't be appreciated on today's low dynamic range displays, but may give you a bit of a feel for this render option.



A High Dynamic Range environment photo is used to illuminate a 3D scene

In the above scene, I used volumetric lighting and atmosphere methods, plus the HDRI/IBL, to do an exercise from the *Vue 5 Infinite*™ manual. This allowed me to match the model scene's atmosphere with that of the HDRI background, further increasing realism. Notice this makes the farther spheres less contrasty and lightens their shadows. Simulated lens flares emphasize the sun position at 12 o'clock high. HDRI/IBL is another rendering option available only to those with big budgets, until recently.

You can use HDRI/IBL very effectively on complex glossy surfaces like auto bodies. Some workers are also experimenting with IBL for Poser figures.

Realism in lighting

To remind you again: light is your medium. It's as if your scene is a theatre stage and you're lighting director. Good lighting really is critical. If you light well, all else being sufficient, your image will succeed. Light poorly and your image will fail.

Lighting Tips

Here are a few guidelines for setting up your scene lighting.

- Less is more:
  - One or two lights, if well placed and painstakingly adjusted, usually look better than a lot of light sources. Using many lights can disrupt object edges, add conflicting highlights or shadows and otherwise make your image harder to read and less dramatic. This doesn't apply to secondary lights, which act more like props, only to those light sources which actually illuminate your main objects.
- Place, setup and adjust your lights one-at-a-time, with other lights turned off. Once all major lights are done, adjust them again for the total effect with all on.
- Where you need more indirect lighting, place white planes outside the camera's viewport as reflectors and/or increase the light parameters of your material.
- Take advantage of the ability to turn light and shadow on or off for individual materials, objects or lights.
- Use invisible lights inside lighting props: lamps, fires and such.
- Try adding a glow or glare effect to visible light sources.
- Use subtle colors for your light sources to enhance drama. Making all light sources white can be boring.
- Use soft shadows where appropriate.
- Place gels or masks in front of lights to cast colored beams or shadow shapes.
- Vary the brightness of your lights for dynamic composition, dramatic negative space or to emphasize certain areas of your image.
- Do a Google search on "Rembrandt" to see an early master of dramatic lighting

Common lighting errors

I see these common problems often in online galleries.

Inconsistent lighting

Example: A landscape is lighted from one direction, but a planet seen in the sky is lighted from a different direction. Even if somehow physically correct, this looks wrong.

Ambiguous light source

Example: A room interior is lighted, but no source of the light is shown. You don't always have to show light sources, but they can add a lot of drama and realism. If you don't include lights, make that a conscious decision driven by your image and goals, not an oversight.

Black shadows

Example: A sunny outdoor scene with dead black shadows. Most real world shadowed areas, especially in daylight, are lighted by skylight or reflection and are bright enough to show texture, color and detail.

No shadows, minimal form

Example: A human figure is shown with little or no form enhancing lighting. The figure looks flat and unreal. It casts and receives no shadows and has little or no contouring. It looks like a pasted-in cutout – which may be exactly what it is.

 © Jim Coe 2005

Wrong lighting for the environment

Example: A science fiction scene in outer space with diffuse lighting. Lighting in space is usually extremely contrasty, what with the vacuum and nothing to dim the sun or fill the shadows. And the shadows will probably be hard-edged as well.

Lighting for realism

Here are some excellent examples of adding realism, meaning and drama to images by way of great lighting.

Identify your subjects

With care in lighting, you can make your main objects or characters stand out. Then you can get away with having complex props and backgrounds all around, without your image being hard to read. Complexity in a scene often makes it more like the real world and therefore more believable.

Good lighting simplifies a complex scene, controls eye movement and accents your characters

"Metal Maiden" by Tony Hayes

Notice how the background lighting is brighter than the foreground, placing the subjects in a frame. It even creates a semi-silhouette, which emphasizes their edges, shape and form.

Notice also the lack of color in the background. Color is reserved for the subjects, making them stand out even more.

Control the viewing experience

Use light to control your composition, by selectively revealing your centers-of-interest, by setting the viewer's perception of what is most important and by controlling the viewer's eye movement.

"Echoes" by [Tony Hayes]

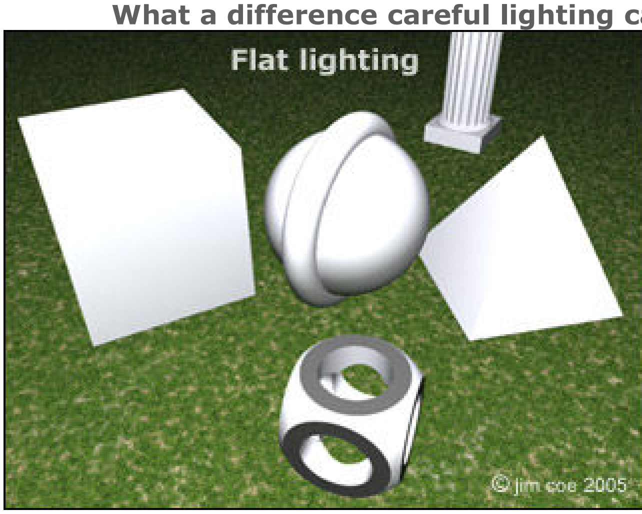
Enhance Form

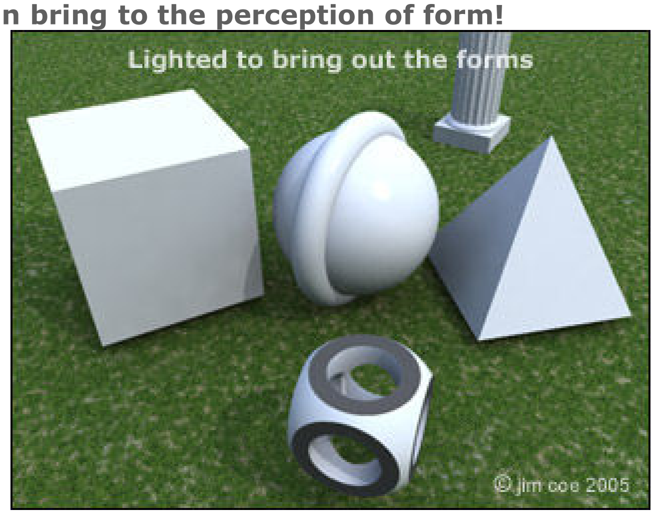
Use lighting to support and enhance the 3D form of your objects, not to diminish it. Using flat lighting minimizes form while form lighting emphasizes it.

Effective form lighting doesn't necessarily require more than one light, if skylight or a very reflective environment acts as a second light source. But it does require careful placement of light sources and adjustment of light and shadow intensities.

Form lighting makes textures more effective too, if your textures are the kind that can cast small shadows and show highlights – for example because they use a bump map.

What a difference careful lighting can bring to the perception of form!





Anti-Form lighting - camouflage

An instructively backward way to think about lighting for form is to turn the problem upside down. Think about how you would light an object to defeat the perception of form.

For instance, you might want to make it hard for your enemies to see you. Many animals have evolved "anti-form lighting" for survival. Lighting can be a matter of life or death.

3 lightings of a 3D Gazelle model by Lyne's Creations.

In the left image above, there is only ambient light, such as skylight in the shade on a sunny day.

The Gazelle's natural coloring compensates for the fact that most light comes from above by being dark on top, medium value on the sides and light underneath. These values are opposite to the natural lighting and do a pretty good job of making the Gazelle visually neutral. Therefore the Gazelle automatically blends visually with its environment, especially when its position shows little symmetry.

When sunlight is directly from above, as in the middle image, the Gazelle's natural camouflage still works well.

In the unlikely event that the Gazelle is lit from underneath, the right image shows that its natural camouflage works against it. The Gazelle's coloration is amplifying the lighting, instead of neutralizing it.

Newer ways to define your materials with light

As mentioned above, in a traditional 3D workflow you first sculpt your forms in a 3D modeling program, then add 2D texture images to surfaces, then light them.

Procedural Materials and Shaders replace image textures

But if you want maximum surface realism and render efficiency these days, you can usually do better by using newer 3D Materials and Shaders to detail your surfaces.

These new 3D ***Materials*** are complete sets of 3D surface properties designed to simulate one particular material realistically.

They may include surface properties such as:

- **Light Color**
- **Light Type** and **Amount**
  - Ambient light
  - Diffuse light
  - Subsurface scattering
  - Specular reflections
  - Emissive glows
  - Cast shadows
  - Received shadows
- **Images** of the surroundings to be reflected back (e.g. from a glossy car body)
- **Textures**
- **Transparency**
- **Animations**

And you can create and blend together several such layers, each with one or more of the above properties and partial transparency, to make complex materials.

These materials are created or edited inside a 3D modeling or 3D lighting program's ***Material Editor*** or ***Shader***. Material Editors and Shaders are specialized tools whose only purpose is to create such hyper-realistic materials. Some advanced Material Editors are really the same as Shaders.

There are two kinds of Shaders. ***Software Shaders*** create 2D texture images of your finished material, just like any other 2D graphics program. More advanced ***Hardware Shaders*** create small programs to be run inside your display card, creating virtual materials for you in real time. These materials are virtual because they only exist at render time.

Besides the extreme realism of these newer methods, you'll find another advantage. Advanced Material Editors or hardware Shaders often don't need traditional 2D picture files at all, though they sometimes use one as a texture layer. The older methods can require many large picture files and handling them is slow and inefficient. This is especially problematic if Web downloading is involved in your image efforts.

This new way of making programmed Materials is also called ***Procedural Materials***. ***Procedural*** means "programmed".

Procedural Materials are supported best on the latest display cards, so a ***Fallback*** rendering method is usually included, such that older display hardware will still show an acceptable, though inferior, texture in place of the Procedural Material. As new display hardware continues to penetrate the market, such fallbacks will become less important.

You should note that these new 3D graphics technologies are accelerating the "have/have not" split in the population of personal computer users.

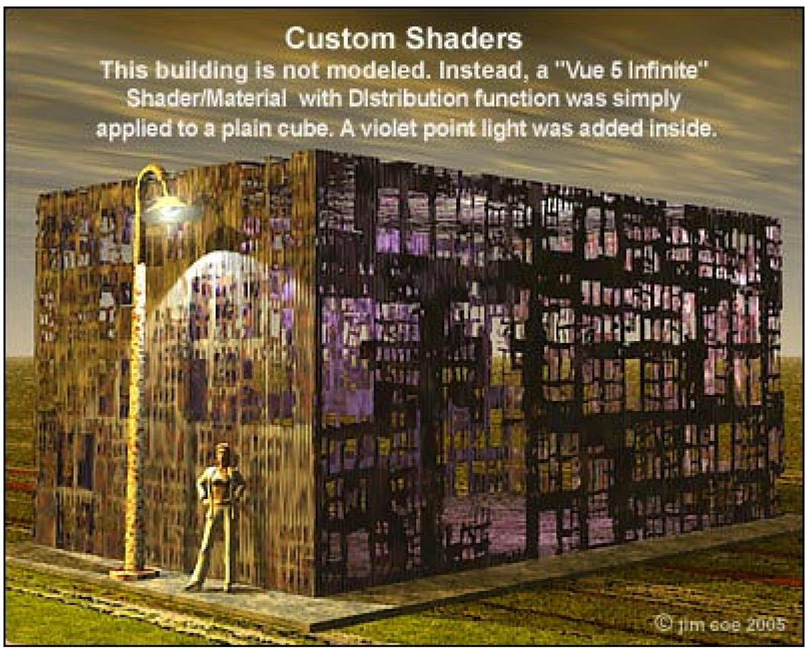
Third world users, and others with older equipment, will not benefit from such advanced 3D technology for some time. This is an ethical issue content creators need to consider when thinking about their audiences.

In any case, Procedural Materials, Procedural 3D Objects and Procedural Terrains point the way to a future of fast, efficient, photo-realistic 3D modeling and 2D image creation.

Example of a modern 3D material

Here is an example of a Procedural Material. In this simple test scene I used only one primitive 3D cube to represent a building. Then I applied a Procedural Material called "*Full Scale Destruction*" to my cube. Since this material makes parts of the cube transparent, I was even able to install and view a violet colored light inside my normally solid and opaque cube.

With the quick and easy application of one Procedural Material, I got an effect very similar to spending a long time creating and texturing a building model. Such a model would also have had a large file size and many polygons to render.

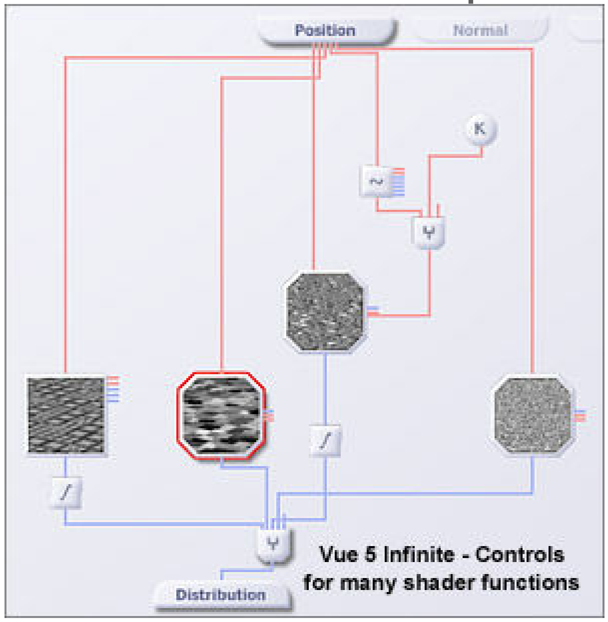


The procedural material I used is one of many in the *Vue 5 Infinite™* program's materials library. A powerful Function Editor, along with the Material Editor, allows me to make my own complex procedural materials from scratch, or to edit theirs. This is equivalent to a powerful Shader and I've had excellent results using it.

Since Vue 5 Infinite is a good example of the creative power available for building your own simulated materials in the better 3D programs, let's take a quick look at its Function Editor.

By creating your own functions, or modifying existing ones, you can make "smart" materials, such as ocean water which changes color and turns to breakers where the water is shallow and gets foam on top where it encounters rocks and the like. You can even animate your ocean waves and adjust the effect according to simulated winds, without having to create manual animation frames.

Part of Function Editor control panel



One section of the Function Editor panel is shown above. This image shows the "*Full Scale Destruction*" 3D material's function. This particular function controls how the textures will be distributed on your 3D object's surface.

The Function Editor looks and is complex. But it allows non-mathematically inclined, non-programmers to create complex and powerful image modifying functions fairly easily. You do this by dragging "widgets", like the 10 shown above, onto the panel. Then you connect them in diverse ways. Finally, you add a few value settings to your widgets and watch a preview display of your new or modified material.

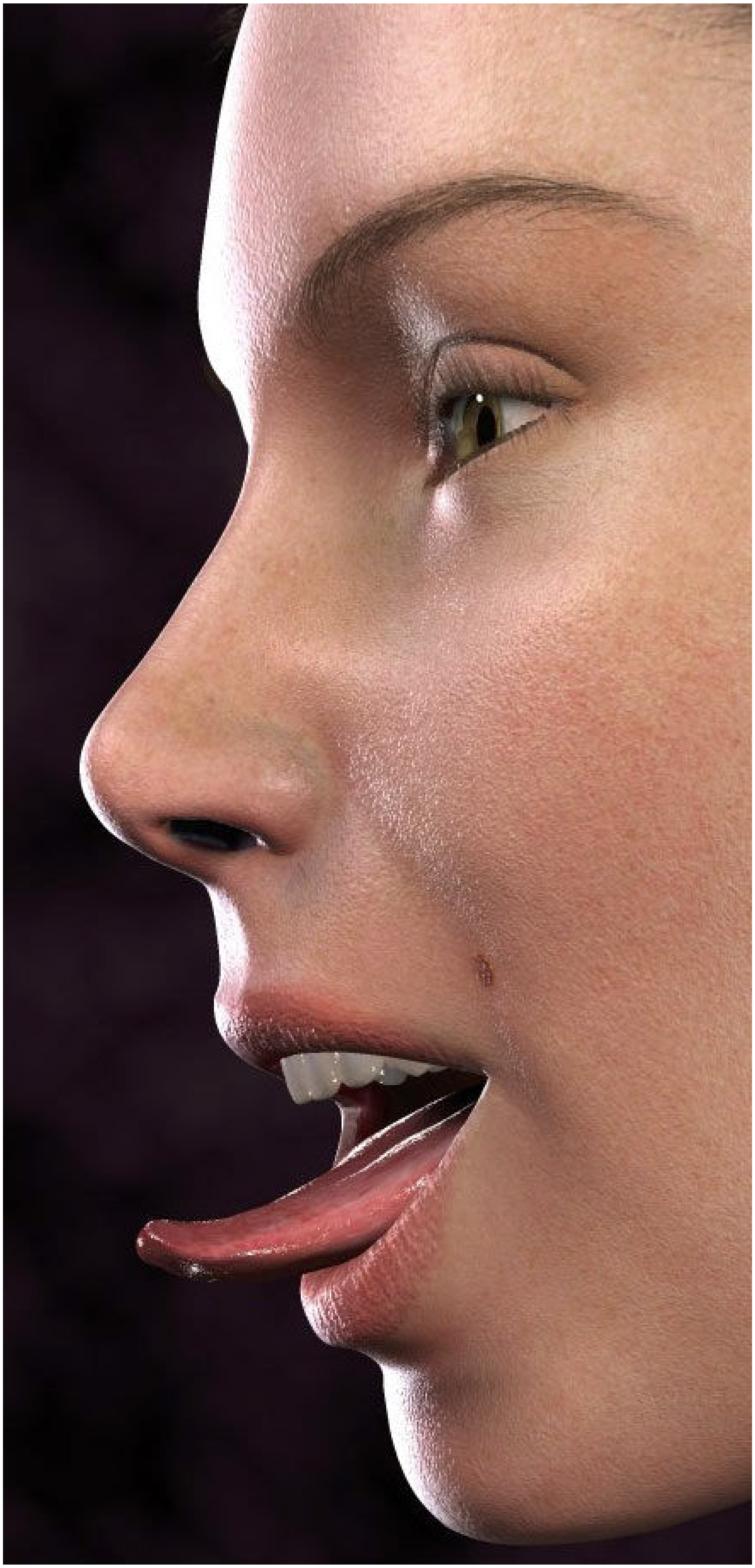
Instantly, complex mathematical manipulations of your images, textures and lighting are created for you automatically. In other words, this Function Editor writes small custom graphics programs for non-programmers!

To clarify a bit: The "*Position*" node at the top is the input from the render engine into your custom function. The "*Distribution*" node at the bottom is the output, where the results of your custom distribution function go back into the render engine. Naturally there is a library of many input/output nodes and widgets which you can use to create an unlimited number of custom effects.

Human skin – a shader challenge

An example of a shader tackling a very difficult material simulation is a ***skin shader***. As you know, human skin was a waxy, slightly glossy appearance, with a distinct surface texture and some visible depth effects, called ***Subsurface Scattering***. It has many subtle colors and little imperfections. We are all aware of exactly what human skin looks like, so skin shaders have a lot of expert critics!

All this makes skin very difficult to simulate realistically. But by combining layers of light effects and texture attributes, a skilled user can create quite realistic simulated human skin. Here's an example of a commercial skin shader meant to enable users to edit human skin materials.



***"Say ahhhh"* by Paul Kinnane of Face_Off**

Assert a 'feeling of place' with your lighting

Good lighting helps you define place, time, weather and mood.

Excellent use of color and lighting cues to create a strong sense of place

"Visitation" **by [Tony Hayes]**

More Ways to Improve your scene Lighting

Learn lighting by keen observation

Keen observation has always been vital to artists. Just looking is not enough for you. You have to really see. The average person might be excused for protecting themselves from today's bombardment of visual pollution by letting their seeing grow dull. But you can't do that.

You should instead develop habits of visual attention, immersing yourself in the everyday magic of light, color and texture. Keep your vision fresh like a child's. Enjoy, investigate and understand the details of lighting all around you.

Make realistic skies

Rayleigh Scattering – blue skies, skylight and red sunsets

Remember Rayleigh Scattering, from our exploration of light and color? Recall that it causes blue skies and red sunsets and sunrises. And the blue sky acts like a big blue second light source on sunny days. These effects are important for realistic and dramatic atmospheres and lighting.

Skylight

Shadows in areas that are open to the sky are somewhat blue. You may want to light objects outdoors with direct sunlight that is somewhat yellow and ambient light that is somewhat blue. Also remember that the minimum number of lights to realistically simulate daylight scenes is two – one for the sun and one for the skylight.

 © Jim Coe 2005

Shadow realism

Besides shadows being somewhat blue outdoors, shadows have other important properties. They're usually not dead black and they don't usually have sharp edges when viewed from nearby.

Sharp edged shadows are cast only by a ***Collimated*** light source. One with all light waves normal to the direction of travel – a cylinder of parallel light rays, not the usual expanding cone of rays. In nature, all light sources have at least a little "spread" or diffraction, even a laser beam. For example, the sun shows some spreading of its Earth received beams over the 93 Million miles they travel. And the sun is not a point source in our sky, but a small disk. This is why sunlight shadows are not hard edged if cast over a distance of more than a few feet. The light comes from more than one point in the sky

While you're learning about shadows is a great time to practice your visual attention and keen observation – that important artist's habit you need to develop.

Stand on a sidewalk on a clear sunny day. Notice exactly how dark your shadow is on the pavement and how much surface detail is visible inside the shadow. Note the difference in sharpness of the shadow's edges for your head, compared to the shadow of your feet and compared to the shadow of your hand raised to various heights. Observe the same shadows at night by the light of first a spotlight and then a diffuse light. Note the differences between those and sunlight.

A later section on the Light Cone goes into the subject of shadow edges a bit more, and there are also the previous examples of soft shadow rendering. Shadow rendering is technically challenging, but the better renderers provide fairly realistic shadows now, matching the type of light source.

Light source types in graphics

You'll find that the types of light sources and possible controls in lighting programs vary a lot. But most have at least the types shown below.

Light sources can be invisible

Often your light source itself is not visible – only the light from it shows. Let's say you want to simulate a street light. You can place an invisible light source near where the actual lamp would be in the street light model to do this. Invisible light sources are also handy in fires, explosions, sparks, energy fields, mystical effects, glowing materials and, most often, as fill lights or key lights - as we'll see below.

You can use large invisible light emitting shapes to get realistic lighting effects like ceiling light panels or hidden indirect cove lighting.

Ambient light

Ambient Light is the omnidirectional, diffuse "background" light that exists in most scenes. Although you can change its level and color, it is not actually a simulated light source – it's just added mathematically during the render.

Ambient light is light from all sources which has reflected around the scene from many reflective surfaces and now lights everything evenly at a low level. Ambient light is equivalent to the background noise you hear in a busy restaurant from multiple sound reflections.

Point or Omni Light

A ***Point Light*** radiates from a point source outward spherically in all directions. Point lights are used where you want even, diffuse light over a large area. For example you could use a point light near a ceiling to simulate a large area of fluorescent lighting.

Some 3D programs allow you to control which objects cast or receive shadows and which objects receive light from any given light source. This gives you flexibility with all lights.

Distant Light

Distant Light is a more or less collimated type. They have more or less parallel light rays, like any light that is very far away. Other types of more or less collimated light are those with focusing lenses or mirrors, like searchlights or flashlights.

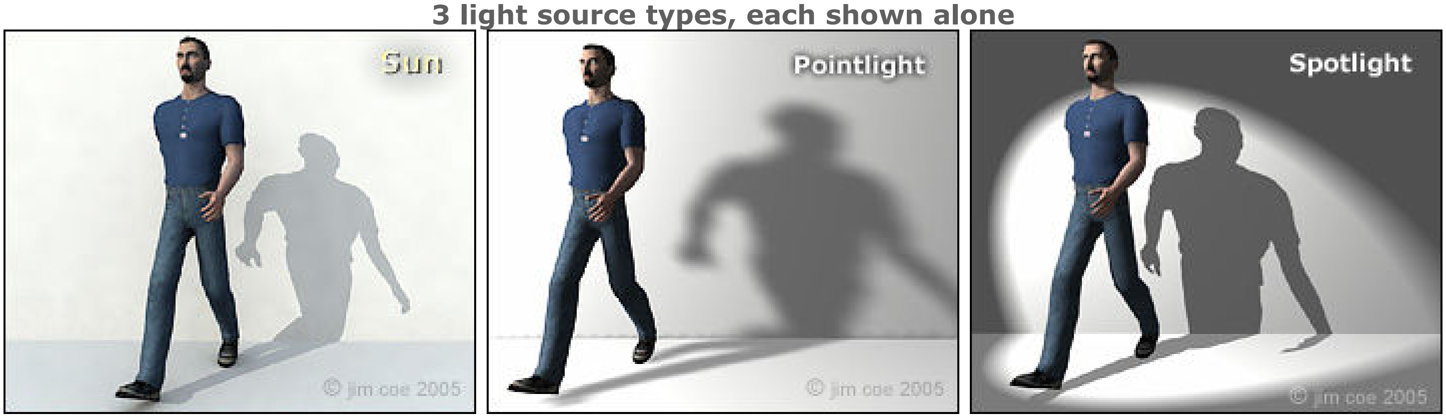
Use distant lights where you want to simulate moonlight, sunlight or do special effects. But don't use them as spotlights. Distant lights lack the useful controls and the cone of illumination of spotlights. Depending on your renderer, it might be best to substitute a distant light source for your program's default sun, if that gains you more adjustments.

Spot Light

Spot Light types are not completely collimated, so their light is in the shape of an expanding cone. The great thing about spot lights is all the control most programs give you over them. Typically, you can control the size of the circular area they cover, usually as a ***Cone Angle***, as well as how sharply the light falls off outside of this area, which is often called the ***Falloff***. Both the distance of the spot light from the subject and the cone angle are under your control. So you can make your spot light broad or narrow.

Here are some examples of light types. The left image uses the *Vue 5 Infinite*™ default sun, which is almost the same as a Distant Light type. The spot light has a Cone Angle of 20% and a Falloff rate of 30%.

3 light source types, each shown alone



Special lights

Sometimes you need to customize your light sources for special effects. Some renderers will let you put simulated colored gels in front of your lights, or make light masks from shapes or planes with holes. The more realistic the lighting simulation is the more you can mock up things very much like you would in the real world.

In this effects light example, I placed a 3D model of a window frame between the spot light and the character, in a position that puts half of his face in deep shadow. I also set the ambient color more blue and the spot light color more yellow.

I could have also added colored gels to the window frame or used volumetric lighting, like this example or this one. A popular use of shadow masks is to simulate the shadows of tree leaves or clouds in outdoor scenes, when such trees or clouds are outside the viewer's point-of-view. This saves the expense of using accurate models of trees or clouds, just to caste shadows. Some programs don't do cloud shadows or realistic leaf shapes, so you need to simulate them with customized light sources.

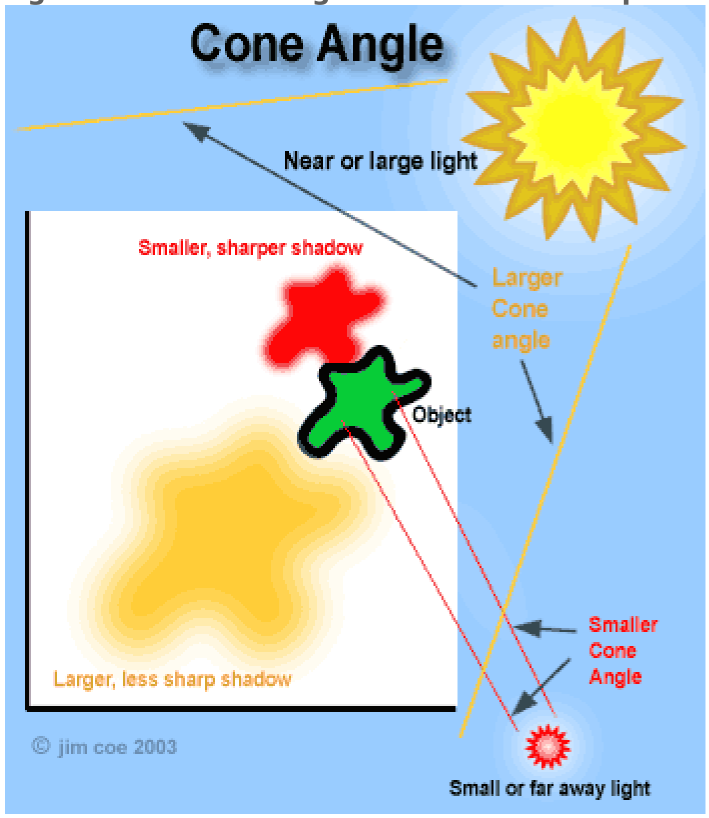
A custom special effects light source

The Light Cone

In the real world, collimating a light source is difficult and expensive, except for lasers, whose light is created in a very different way. Therefore, real world light sources have beams that spread out over distance. Since their expanding light makes a cone shape, this is called a ***Light Cone*** and the amount of expansion of the light beam is called the ***Cone Angle***. A light source with a small cone angle casts shadows which have sharper edges than one with a large angle.

In this way, shadows give us visual clues to the type of light source illuminating objects and their distance. Light types and their distinct shadow types can also carry an emotional message to the viewer, so you need to align light types and adjustments with your image's meaning, feelings and story, to help reinforce those qualities.

Light source cone angle and shadow sharpness



Light Attenuation over distance

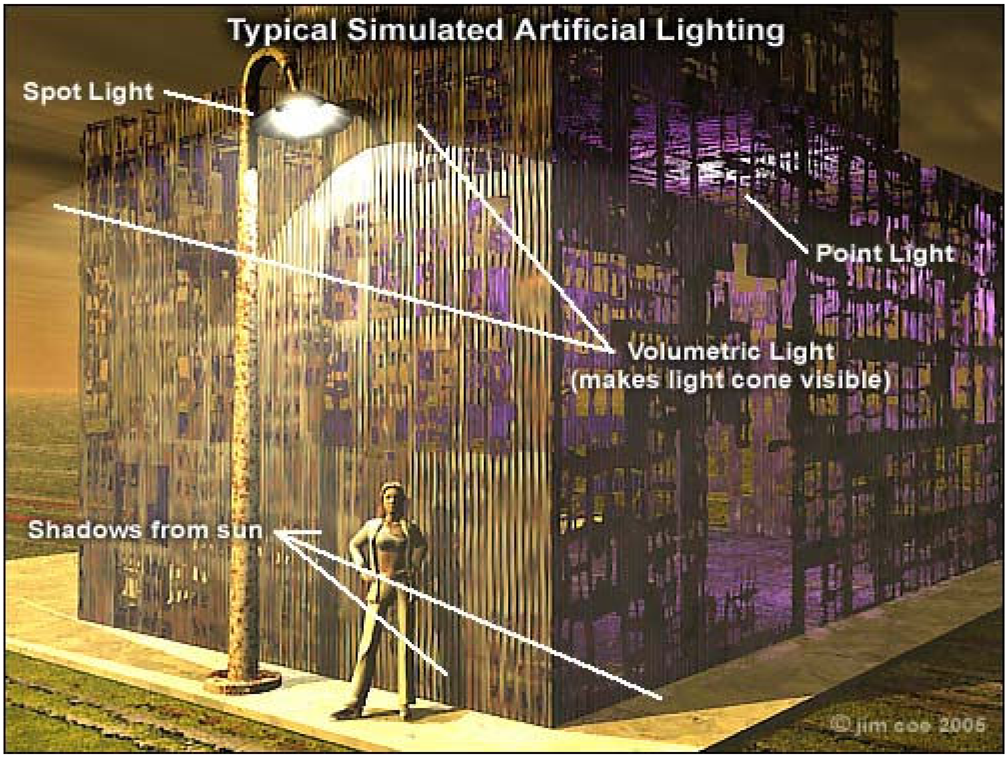
Most people assume that the light energy at twice the distance from a point source (non - collimated) light will be half as great. That's incorrect in 3D space. The light source has to cover four times the area at twice the distance, because the beam is expanding both vertically and horizontally. So, twice the distance gives ¼ the light level, all else being equal. This is called the ***Inverse Square Law***. This means that a light source may not be as bright at a distance as you expect.

Square Law attenuation over distance, for magnetism, light, sound, or other point source forms of radiation, is often illustrated by visualizing a partly inflated balloon with a square shape drawn on the surface. If the balloon is inflated to twice its former size, the square will be four times as big. Some 3D programs give you control over the amount of such light attenuation with distance, which helps you get just the lighting effect your image requires.

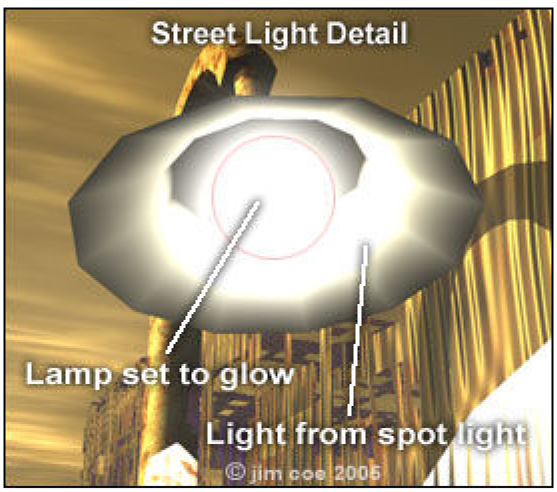
Of course collimated light sources, and other radiation focusing devices like loudspeaker horns or stacks and antennas, are designed specifically to overcome the Inverse Square Law by focusing the energy into a more or less narrow beam. They are not point sources that radiate in all directions.

Lighting a simple night scene

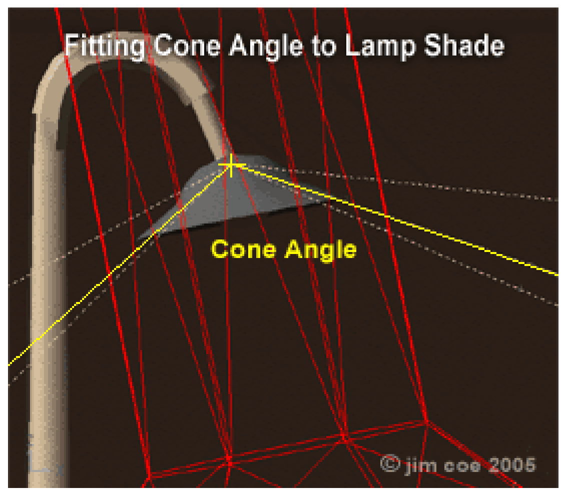
The example below is typical of simulating artificial lighting in a simple night scene. This is a "simple" scene because it has only 3 light sources: Sun (outside the image), a Volumetric Illumination spot light and a point light. All are invisible.



3 sources light an early evening scene: Sun, Spot Light and Point Light



The light bulb object is set to glow



Spot Light cone must match shade

The features of this lighting setup are:

- **Realistic street lamp**
  - Light cone follows lamp shade accurately
  - Inside of lamp shade shows form
  - Lamp bulb is visible and glows
  - Realistic shadows
  - Volumetric light makes visible light cone, shows dust in the air
- **Both setting Sun and street lamp cast shadows**
- **Point Light gives form to building**
- **Lighting colors are interesting compliments**

The tricky task in this example was to precisely adjust the position of the spot light inside the lamp shade and to get the spot light cone angle and falloff just right to match the geometry of the lamp shade. Then it was a matter of adjusting the light levels and Volumetric Illumination carefully. *Vue 5 Infinite*™ provides an editable curve for the distance from the light source at which the light becomes visible, making the tricky task above into a simpler adjustment.

Here is another streetlight, with an invisible point light placed inside each lamp, above each modeled light source.

Lights are "expensive"

In computer graphics, "expensive" means that a lot of ***CPU Cycles*** of required computations, or a lot of electronic memory space or a lot of physical storage space, or all three, are consumed. An "expensive" process, method or property takes lots of time and resources.

So, you should use as few lights in your scenes as possible. Rendering an extremely realistic and complex scene with several light sources can take days on one PC.

How to minimize your number of lights

You don't always need ambient lights or other texture illuminators, since your textures or backdrops already have default lighting. Your model's texture images are not black, so it may be possible to set them appear to receive light, without you having to provide it.

I know of two such tricks. One uses a texture as if it was a light. The other is the ancient trick of using pictures of lights as actual lights. Not all programs can support the first.

Self-illuminated textures

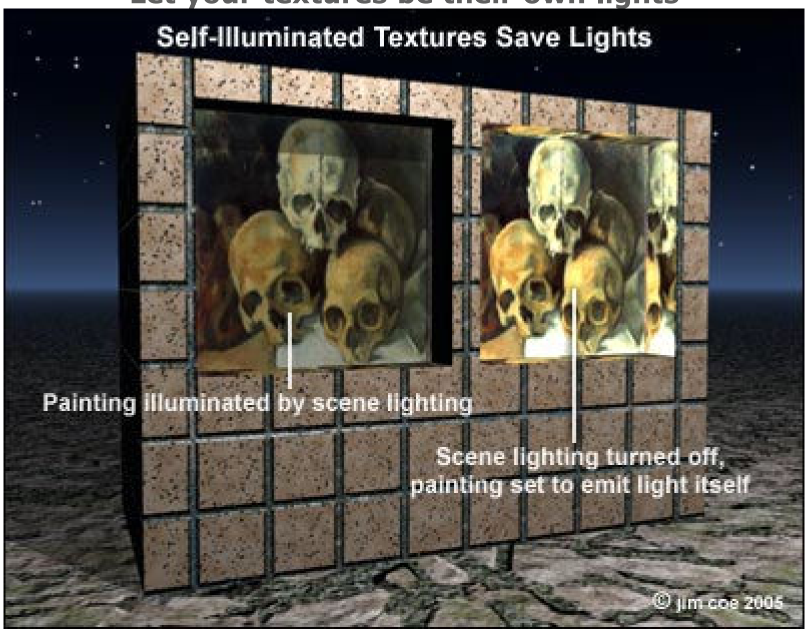
To use the first method, you turn off your scene's lights on a particular texture or surface, provided your software allows lighting control per object.

Then that texture will not be rendered either darker or lighter by your scene lighting. If it is naturally lighter than the general scene, it may even appear to glow.

This is useful for simulating illuminated pictures in a gallery. The pictures can look like they have rectangular spotlights aimed at them, if the rest of the scene is fairly dark. Also, some 3D programs will allow you to set materials to appear to glow (emit light), even though that glow will not light up other objects.

Here's an example. The wall has 2 boxes inset into it. Each box has the same Cezanne painting textured onto all the inside box surfaces. The left box is lighted only by the single point light of the scene. The right box has scene lighting turned off for its inside surfaces, which are set to glow. This saves you one light. It also removes the shadows seen on the left inset box.

Let your textures be their own lights

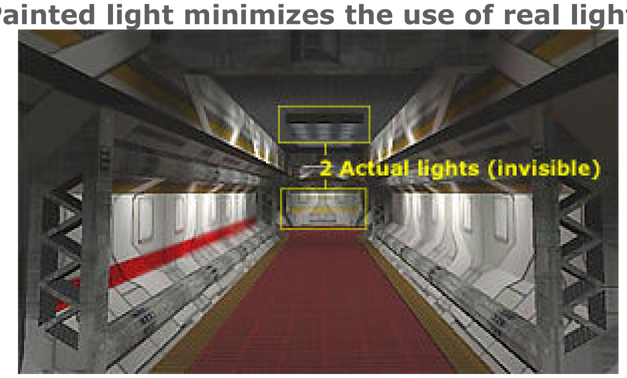


Paint your lighting

The second trick mentioned above is to "paint in" much of your lighting as part of your textures. Theatre set designers, museum display painters and Hollywood backdrop artists have always done this.

Below is a 3D scene where there are only two actual light sources.

Painted light minimizes the use of real lights



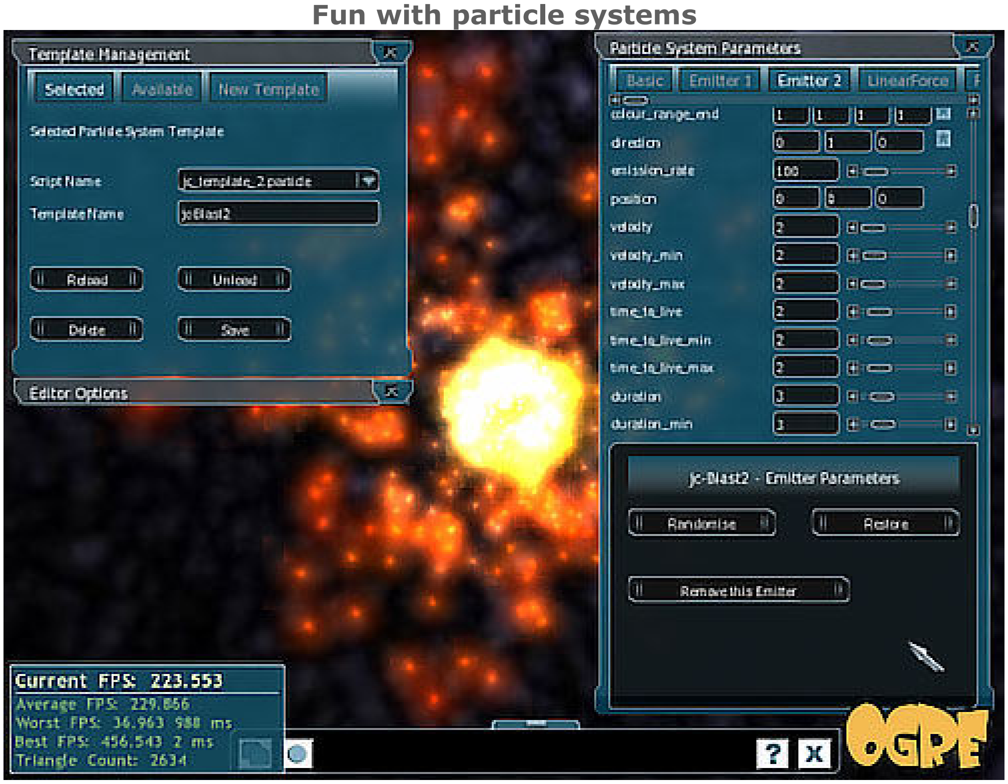
by jbezorg

Particle Systems

A ***Particle System*** is a cloud of tiny 3D objects, often glowing, that are programmed to form clumps, clouds or streams. You use them to simulate clouds, rain, snow, waterfalls, fountains, fires, explosions and such. Particle Systems are often animated and used in films or games. They can help with your still images too. Because particle systems are often light emitters, I list them here as a type of light source. The particles are usually small 2D objects, such as transparent camera-facing planes with simple attached alpha plane textures.

In the screen shot below, I'm making an animated 3D space explosion with the Particle Editor of the 3D render engine called "Ogre".

Fun with particle systems



Credit: Ogre 3D

3D object lighting example – A model head

Here is a practical example of lighting a 3D modeled head. You photographers may recognize the similarity to standard photographic portrait studio lighting. Many 3D objects are lighted like this. I made and rendered these examples using the free DAZ|Studio™ program and its included female model.

The goal in traditional portrait lighting is usually to simulate sunlight. So basic portrait studio lighting is a good start for your lighting practice. Remember, the main goal of all lighting is to bring out the form of your forms.

So let's start by looking at a poor "formless" lighting setup. Here the scene is flooded with equal light from all directions. This is how models without custom lighting might look! You have to wonder why anyone would create 3D forms, only to then flatten them like this.

You can imagine form here, but you can't see it

Main light

1. First, we use a main light source to simulate the sun. I put it overhead, slightly in front of the model and to the right. A Distant Light type could be used to mimic sunlight. But I used a spotlight in order to have more control. Real photo studio lights may not be much like the sun either.

Just one light, representing the sun, gets us visible form

Now we have visible form. But there's a problem. One side of her face is mostly black. This might be good for a dramatic look, but it's not how sun light usually looks. We need a ***Fill Light*** to simulate the ambient skylight of outdoor scenes.

Fill light

2. We add a low intensity fill light to bring out shadow detail.

We add a fill light to the shadows

With only the fill light on, you can see how it reveals the form not covered by the main light. With both lights on (below), you get a much better sun simulation.

With more than one light, you need to make a final adjustment while both are on. Otherwise you can't judge the combined effect. Be careful to keep the shadowed side of your subjects dark enough. You don't want an "over lighted" look.

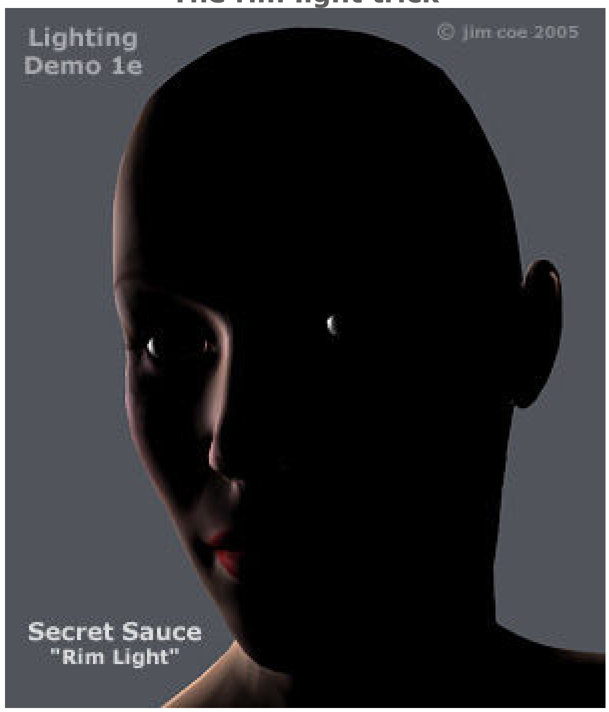
Result with main and fill lights

These 2 light sources are the minimum to simulate sunlight. But you can use a popular portrait lighting trick for further improvement and drama. Use a ***Rim Light*** from behind the model to light just the edge of her face. This "anti-contour" is very effective when it contrasts with the background like this.

Rim light trick

3. A Rim Light is added for extra definition and drama.

The rim light trick



All lights on

Now, with all 3 lights on, we adjust the final levels again.

Results with balanced rim, fill and main lights

You can add more detailing lights. In portrait studios, one or more ***Key Lights*** (small, local spotlights) are often used to make the hair shine and so on.

We have a decent lighting now, but lets have a bit of fun with the old Hollywood cliché' "Horror Lighting". That's where you light from below for a sinister look. I'll use red light.

Horror light effect

4. A red "Horror Light".

Upside down lighting

With the other lights dimmed a bit, the red light does look pretty exotic.