

T2S_illumination

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T2S_Illumination is dedicated to CG artists looking for a single Illumination node to be used as a basic building block for a great variety of materials.

This shader brings together different illumination models, as well as some of the last Mental Ray functions for optimized glossy scattering. New features, such as Coating surface effects, custom Lafortune settings, or Fresnel Mask are proposed here.



We separate the illumination components into 5 features :

- Diffuse
- HighLights
- Scattering
- Fresnel Mask
- Surface Effects

Two other Tabs are added for custom adjustments :

- Anisotropy
- Weights

The idea of this shader has arised from discussions with Christian Goetzinger and Harry Bardak, who also helped us as beta-testers.

The Anisotropy settings are based on Daniel Rind "Deriver" Shader.

The Lafortune parameters were given by the Cornell University Program of Computer Graphics.

Tek2Shoot thanks all of the above for their valuable help.

DIFFUSE

The diffuse component of the reflected light corresponds to the fraction which is emitted homogeneously in all possible directions. The amount of diffuse light depends however on the incidence of incoming light, as in a Lambertian model.

However, Lambert doesn't describe the roughness of a material, considering it as a perfectly planar surface. In order to simulate **Roughness**, the Oren-Nayar model represents a surface as a collection of micro-facets. This model accounts for complex phenomena such as masking, shadowing and interreflections between these microscopic Lambertian facets. Setting Roughness to 0 leads to a simple Lambertian diffuse color.

Wrap Lighting is also implemented in the shader, which affects the incidence of incoming light, making it tend to 0° . This effects gives a kind of global illumination look by "wrapping" the light around the object. You can thus have a 180° illumination with a single light source.



HIGHLIGHTS

In Computer Graphics, HighLights (or Specular term) correspond to the glossy reflection of light sources. Since the radiosity coming from a light source is much higher than indirect illumination, even low-reflective materials may show a small highlight at mirroring angles in addition to the diffuse color. However, Mental Ray doesn't rely on radiosity, and has indeed to consider separate "artificial" highlight properties.

The amount of light reflected for each couple of viewing / lighting angles is determined by the *Bidirectional Reflectance Distribution Function* (BRDF). This BRDF is responsible of the appearance of an object, and allows us to differentiate the different materials surrounding us.

The T2S_illumination shader includes 4 BRDF models :

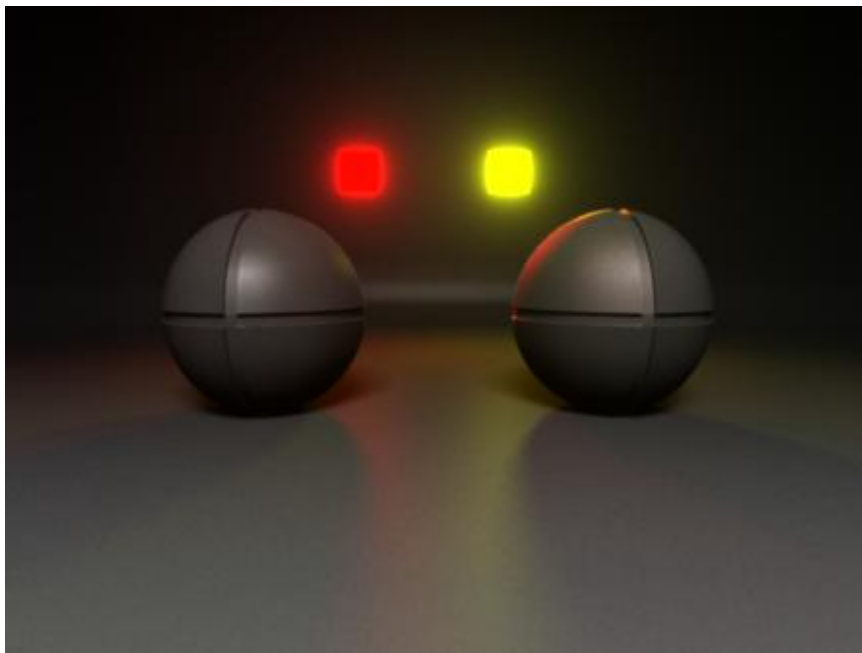
- Phong
- Blinn
- Ward Anisotropic
- Lafortune

These models can here be enabled and mixed with separate parameters and weights. Custom highlights can therefore be easily created.

Gollum had a subsurface term mixed with a straight lambertian term and 4 specular terms, one of which was a LaFortune which is essentially 3 specular calls.

-Kevin Smith

The Lafortune model is extremely interesting since it is based on experimental BRDF measures . This model uses separate coefficients for Red, Green and Blue components, making the specular coloration change as a function of the viewing and lighting angles.



Comparison between Phong (left) and Lafortune (right) highlights

The **Lafortune** presets contain the parameters provided by the Cornell University Program of Computer Graphics for the following materials :

- Blue Paint
- Matte Steel
- Gray Primer
- Caucasian Male

- Indian Male
- Red Clay

In addition, we implement the possibility of using new material data (.t2s files), which contain the Lafortune coefs. Anisotropic materials and highly complex BRDF (> 3 lobes) can therefore be used.

For more details concerning the Lafortune model and the t2s file format, please refer to T2S File Format

Roll Off affects the HighLight intensity.

If Enabled, the **Ward Anisotropic** parameters can be **linked to the scattering settings**, giving them the same color and shiny values. This is similar to Mental Ray "dgs_material" scheme.

SCATTERING



The Scattering Tab refers to Reflection / Refraction properties. It includes some of the features present in "mib_glossy_reflection" and "mib_glossy_refraction", as well as several additions.

The Scattered rays can either be **Specular**, **Isotropic**, **Anisotropic**, or **Angular Dependent**. Specular scattering will only allow "mirror-like" reflected and refracted rays.

For isotropic scattering, a single **Shiny** parameter defines glossiness. Low values will here increase the glossy spread. Anisotropic scattering gives separate shiny values on the **U** and **V** axis (see Anisotropy).

Angular dependent scattering gives different shiny values depending on the viewing incidence. Surfaces facing the viewer will thus have a **Base_Shiny** value, whereas grazing angles will have an **Edge_Shiny** value. The **Edge_falloff** determines the falloff rate towards the edge. This property allows for example to create blurred reflections which become specular at grazing angles.

The Reflection settings allow to choose a **Reflection Color**, as well as the number of glossy reflected rays with the **Reflection Samples** parameter. In addition, **Reflection Exposure** (0 by default) modifies the reflection weight depending on the reflected ray luminance. This allows to "filter" the reflections depending on their intensity. An **Optimization** parameter may enable Environment Only reflections.

Contrarily to Mental Ray dgs_material, user don't have to worry about the physical accuracy ($D+G+S=1$ in dgs_material).

In T2S Illumination, reflection has priority over the diffuse component. So a maximum "white" reflection (without Fresnel Mask) will make the diffuse color vanish completely. A Reflection color of 0.3 0.3 0.3 will divide the diffuse color by 3, etc..... in order to keep physical consistency.

Transparency

T2S_Illumination gives realistic transparency, depending on the object's thickness. Transparent objects absorb a certain amount of light depending on its wavelength. This means that certain wavelengths are absorbed and some other are not, which gives the transparency "tint".

The **Refraction Color** corresponds in this shader to the remaining color after an "infinite thickness". The light absorption follows an exponential decay, where the "mean life time" is controlled here by an **Attenuation Distance**. The refractive Glossy samples can be set separately than reflections with **Refraction Samples**



FRESNEL MASK

The Fresnel Laws describe the behaviour of light at the interface between two different media. A part of the incoming light is reflected, while another part is transmitted (i.e. refracted or absorbed). The proportion of reflected light only depends on the (complex) refractive index and on the angle of incidence.

For more details concerning the Fresnel equations, please refer to http://www.odforce.net/wiki/index.php/ReflectanceFunctions#The_Fresnel_Effect

In the T2S_Illumination shader the Fresnel Mask can be evaluated by one of the following **Modes** :

- [Physical](#)
- [Custom](#)
- [Preset](#)
- [T2S File](#)

- **Physical** Mode will evaluate the Fresnel equations to determine the Reflection coefficient **R** and the Transimission coefficient **T = 1 - R**..

$$R_p = \left[\frac{\tan(\theta_i - \theta_t)}{\tan(\theta_i + \theta_t)} \right]^2 = \left[\frac{n_2 \cos(\theta_i) - n_1 \cos(\theta_t)}{n_2 \cos(\theta_i) + n_1 \cos(\theta_t)} \right]^2 \quad \text{and} \quad R_s = \left[\frac{\sin(\theta_i - \theta_t)}{\sin(\theta_i + \theta_t)} \right]^2 = \left[\frac{n_1 \cos(\theta_i) - n_2 \cos(\theta_t)}{n_1 \cos(\theta_i) + n_2 \cos(\theta_t)} \right]^2$$

where n_1 and n_2 are the "In" and "Out" complex refractive index, (**IOR** and **MediaIn** in the shader)
 θ_i is the incident angle and θ_t the transmitted angle deduced by the Snell Law ($n_1 \sin(\theta_i) = n_2 \sin(\theta_t)$)
 R_s and R_p correspond therefore to the fraction of s-polarized and p-polarized light which is reflected (here an average of these two waves is used)

If the refractive index are **complex**, an absorbtion coefficient k , which determines how fast the light is absorbed, needs to be determined.

The **Schlick** approximation can also be chosen for fast calculations.

- **Custom** mode allows to set manually the **Base Weight** for facing angles and **Edge Weight** for grazing angles. **An Edge Falloff** parameter is used to control the Fresnel Falloff (this mode is similar to what is included in `mib_glossy_reflections`)
- **Preset** Mode will allow to choose among a list of predetermined Materials, which contain the Refractive Index for Red, Green and Blue light. A Physical "Complex Fresnel" Calculation is then performed. This procedure tints the reflections depending on the Fresnel Reflectivity.
- **T2S Files** can be used to input user-defined complex Fresnel parameters (IOR and Absorbion Coef) for R, G and B. For more details concerning the T2S File Format, please click [here](#).

- The first image has been rendered with a simple Lambert with a Reflectivity of 0.5.
- The second image has been rendered with the **T2S_FresnelMask** plugged into the reflectivity port of the Lambert node, using a refractive index of 5 with Schlick's approximation. It can be seen how the grazing angles become much more reflective, adding realism to the scene.



SURFACE EFFECTS

The T2S_Illumination shader allows to obtain multiple Surface Effects, such as UnderLayer Noise, Selective Layer Bump, or Iridescent Coating Surfaces.

- **Input Noise** can be added to the Material UnderLayer Surface, by plugging a fractal (or any other texture) to the *InputNoise* port, and activating it in the Noise Settings. The **Noise Weight** adjusts the Noise strength, while the **Noise Brightness** enhances the Noise luminosity. Two **Modes**, *Simple* and *Desaturated*, allow to create different effects.
- **Bump** can be added to the object, without needing a bumpmap generator, by plugging any texture to the *bump* port. When increasing the **Inbut Bump Factor** above 0, the user may choose to apply the bumpmap independantly to the **Diffuse**, **HighLight** and **Scattering** Illumination components. The bump will only be used by this shader without affecting the normals for XSI.
- **Interference Coating** allows to create Iridescent phenomena to reflections by adding a very thin coat to the object's surface. This Coat creates interferences in the reflected light, and may tint the reflections by impressive rainbows. This feature is similar to the T2S_Coating shader effect. The **Coat IOR** and the **Coat Thickness** define the interference appearance, while the **Interference Weight** adjusts the impact of Iridescence to the reflections.



ANISOTROPY

Anisotropic properties are defined as being "directional dependent". Rotating an object may indeed modify its illumination properties.

For such properties, UV derivatives are needed to define the U and V directions.

The Anisotropic Settings determine the U,V directions which will be used by any anisotropic properties in T2S_Illumination, i.e. anisotropic reflections or Ward Anisotropic HighLights. The parameters present in this table were adapted from Daniel Rind "BigMuh" Deriver.

A **North Vector** defines wether a **North Direction** or a **North Pole**, depending on which mode is selected.

The **rotation** allows then to give a custom adjustment to the anisotropic direction.

WEIGHTS

After all settings have been done, a final Weight Tab allows to give custom adjustments to the following illumination components :

- Diffuse
- HighLights
- Reflection
- Refraction
- Irradiance

These weights are evaluated at the very end of the process, therefore modifying them may lead to non-physically accurate results.