

Generic Radiometry Solver Documentation

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Overview

The Generic Radiometry Solver uses a novel four step sampling process. The core integration process is a simple, hemisphere quad structure that is uniformly sampled at a user defined resolution. Once the integral value within each quad is known, the integral is computed by summing the (equally sized) quads.

Certain directions are very important to sample, such as towards the Sun and the Moon. These directions are always sampled, provided the body lies above the horizon. The solid angles attached to each of these "specific" samples are independent from the rest of the integration process. These secondary samples assume that the center of the specific solid angle is a sufficient representation of the entire solid angle (the special objects are generally very small). The number of specific samples is taken from the number of full samples (see the next paragraph).

A tertiary sampling process determines how the quad values are computed, specifically by determining how many "full" samples each quad receives in order to compute its value. A full sample is a non-terminal ray, i.e. one that will be allowed to bounce indefinitely, or at least until stopping criteria are reached. The distribution of full samples is driven by an importance sampling of the surface reflectance. More samples are assigned to quads with higher reflectance. The final value of each quad is the average of all the samples that were computed within the quad.

A final sampling process is used in the case that a quad does not receive enough samples. Each quad is guaranteed to use a minimal number of samples, as given by the user-controllable `MIN_QUAD_SAMPLES` parameter (which can be set to zero to turn this process off). When the number of samples assigned to a quad is less than this value, terminal "direct-only" samples are sent out to get a value for the quad. A direct-only sample is a ray that is only allowed to collect *direct radiance* from the next hit (usually only

emitted radiance). This means that a quick ray will not create any new problems beyond this one and effectively terminates this path of the solution while making sure that important sources are incorporated into the solution.

Thresholds

Internally, the radiometry solver uses a series of thresholds to avoid unneeded computation. These thresholds are currently hard-coded to values established after extensive, though undocumented, testing. These thresholds are not user-modifiable, since they can easily be misunderstood and detrimentally used.

The following table indicates these preset values and gives a brief description of each.

Threshold	Value	Description
Target Weight Threshold	1e-7	A specific target's sample weight must exceed this threshold. Otherwise it is skipped entirely.
Full Background Weight Threshold	1e-5	A full sample must have a sample weight above this threshold. Otherwise it is downgraded to a direct-only sample.
Quick Weight Threshold	1e-8	A direct-only sample must have a sample weight above this threshold. Otherwise, it is skipped entirely.
Current Weight Threshold	1e-6	If the view ray's assigned weight is below this threshold, only the self-emission result is computed.
Raw Weight Threshold	1e-7	If the maximum unpolarized reflectance/transmission for a given quad sample is below this threshold, then the sample is skipped entirely

A **sample weight** is calculated as $rayWeight * maxReflectance * cosFactor$.

Behavior

Initialization

Two aspects of the solver's initialization are of interest to end users. During this phase, the solver determines the number of samples for each generation based on the sample decay rate. It also importance-samples the reflectance and transmittance properties. When computing energy propagating in a given direction, the solver uses this importance-sampling to determine where sample rays are cast.

Sample Decay Rate

The number of samples for each generation are calculated based on the decay rate:

$$S(g) = \lceil \frac{S_{init}}{\gamma^g} \rceil$$

Where $S(g)$ is the sample count for generation g . S_{init} is the initial sample count. γ is the sample decay rate.

Importance Sampling

The importance sampling involves doing a brute-force reflectance/transmittance calculation for each quad location. For each quad, the average, unpolarized value determines the quad importance.

When the entire hemisphere has been sampled, a matrix factorization process is used to store a simplified form of the importance information. This factorization will be used at compute time to drive the sampling process.

Energy Propagation

As mentioned in the overview, a multiple step sampling process is used to determine the energy propagating in a given direction. Note that the surface temperature is already known before the radiometry solver is called. (This temperature can be supplied via the geometry, the mapping mechanism, or using a built-in thermal model).

Self-Emission Calculation

If the surface temperature is greater than 0 [K], then self-emission is computed using the Planck Blackbody equation and the spectral emissivity. The Planck equation gives the exitance for an ideal self emitter. The emissivity is a ratio that relates this ideal self-emission to the actual self-emission of the surface.

Note that DIRSIG will derive the spectral emissivity from the reflectance property if necessary. (That is, if no emissivity property is supplied for the material). See the "DIRSIG4 Reflectance Properties" documentation for more details about this derivation.

Specific Target Sampling

The generic radiometry solver handles the Sun and Moon as "specific targets". These targets are always traced when they are above the horizon.

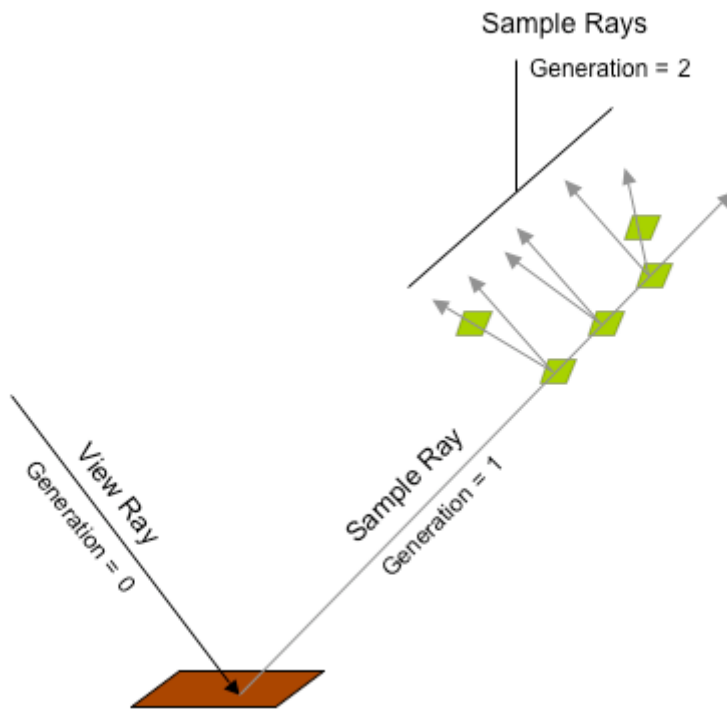
For each specific target, the center vector and associated solid angle is established. The solver will trace a single ray per target, choosing a random sample within that solid angle.

Background Sampling

As mentioned in the overview, the integration process uses a hemisphere subdivided using equally sized quads. There are two phases to this integration:

1. Determining how many and what types of samples to assign to each quad.
2. Generating the samples and computing each sample's radiance contribution.

Two types of samples can be assigned: *full* and *direct-only*. Both these samples repeat the ray tracing process. A sample ray is created with an incremented ray generation count. The surfaces and volumes intersecting the ray are geometrically determined. For direct-only samples, only the self-emitted radiance is included for each element. For full samples, each element uses its own radiometry solver to determine the path radiance contribution. (The recursive process halts when the maximum bounce count is reached).



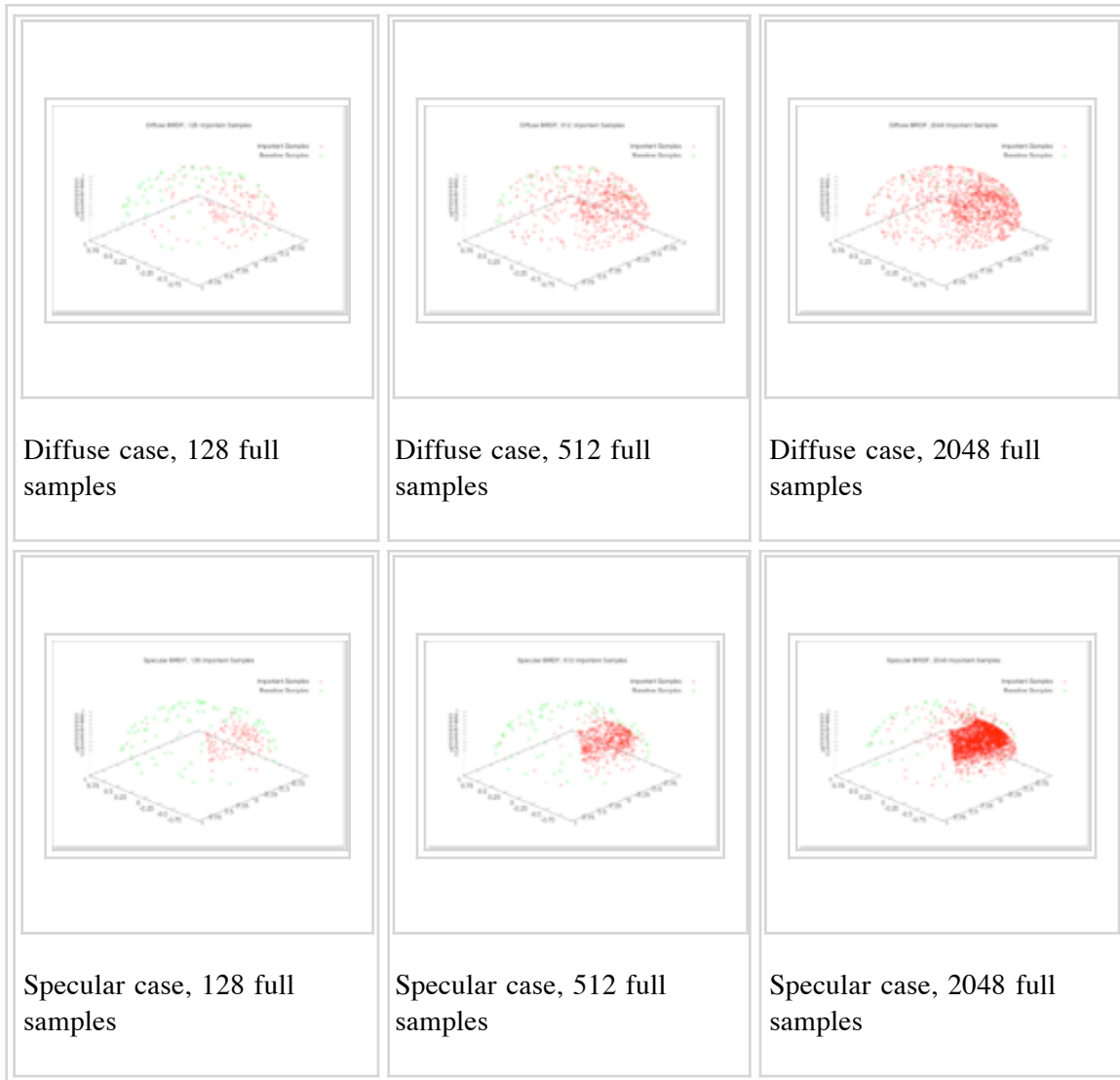
For both full and direct-only samples, the reflectance property determines how much sampled energy is reflected towards the view ray. The emissivity property is used to derive reflectance if no reflectance property is available.

The number of full samples is determined by the `initial sample count` and the `sample decay rate` parameters. These full samples are distributed based on the reflectance importance sampling that occurred during the solver's initialization. More samples are assigned to quads associated with a higher reflectance towards the view direction.

The number of direct-only samples is determined by the `minimum quad samples` parameter. If the full sample count for a quad is below this threshold, the remaining balance is met using direct-only samples. The following gallery illustrates the distribution of samples. ("Important Samples" are the full samples,

whereas "Baseline Samples" are the direct-only type).

Allocation of Samples



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