Single Bounce Indirect Illumination for Real Time Applications

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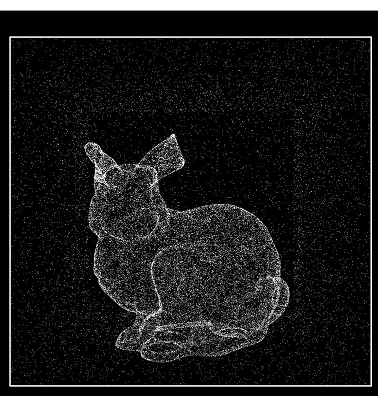
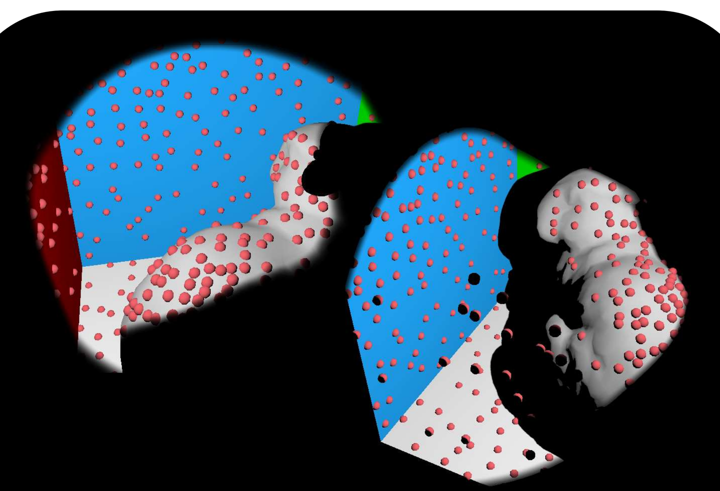
Abstract

This project is about simulating (single bounce) indirect illumination in real time. This includes indirect shadow as well. I have chosen to use virtual point lights [1] (splatting [2]) for this purpose. Light splatting performs on a global basis by sampling VPL positions using a reflective shadow map [3]. Nevertheless, the actual light accumulation performs completely in screen space using deferred rendering. This way the indirect light accumulation is reduced to a 2D domain which is easier to optimize and very independent of scene complexity.

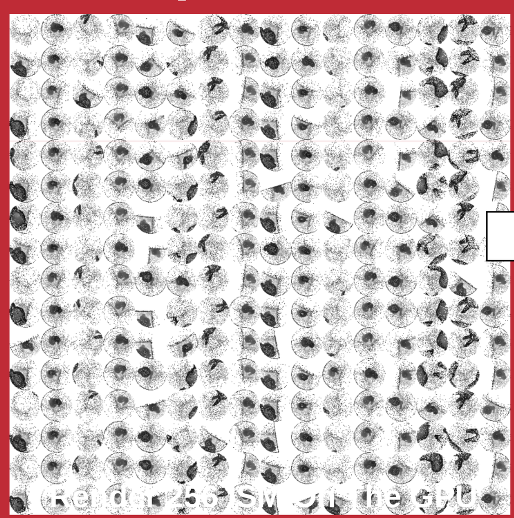


Point Representation Of Geometry

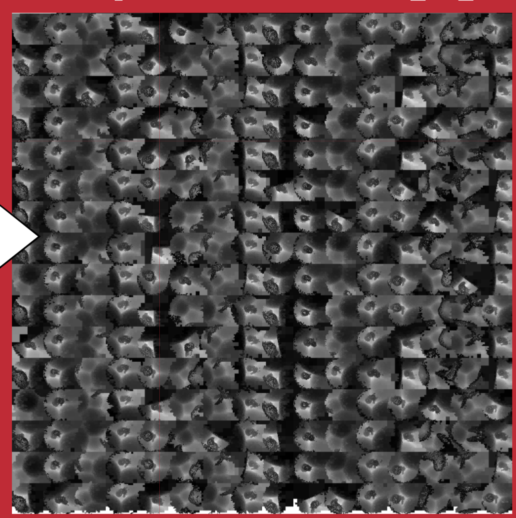


Distribute Virtual Point Lights Within Regions Of Direct Light

Imperfect Shadow Map Creation [4]

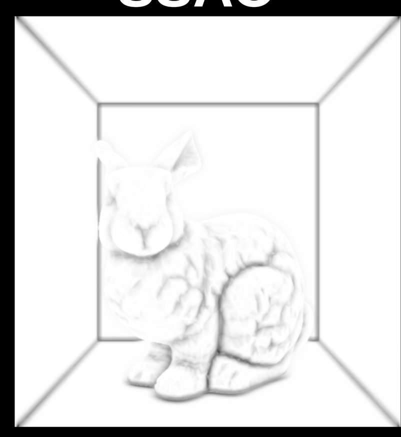


Using The Scene Point Representation And Reflective Shadow Map Sampling

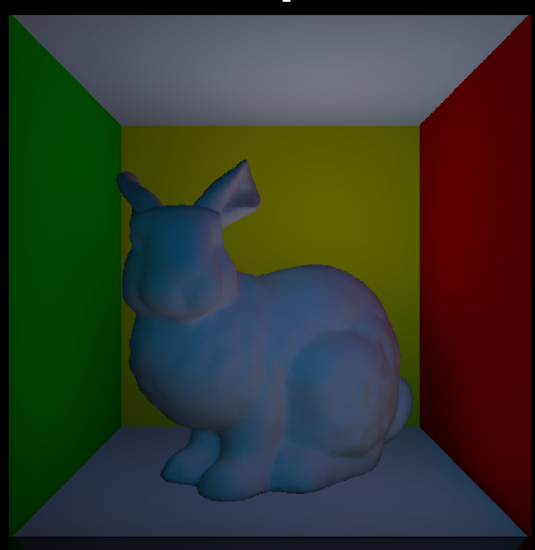


Perform Pull Push To Fill Gaps in The ISM

SSAO

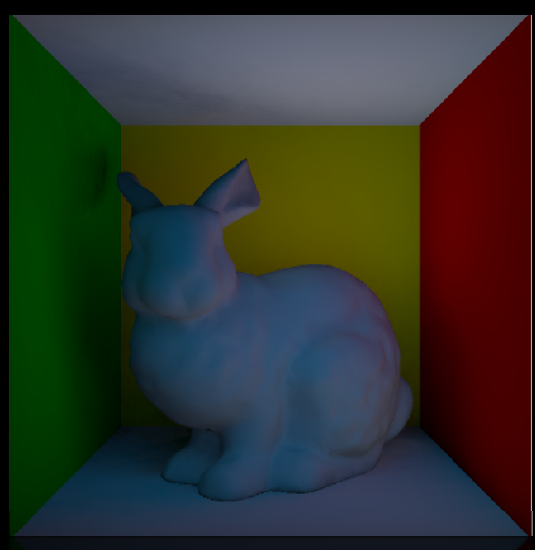


Step 1

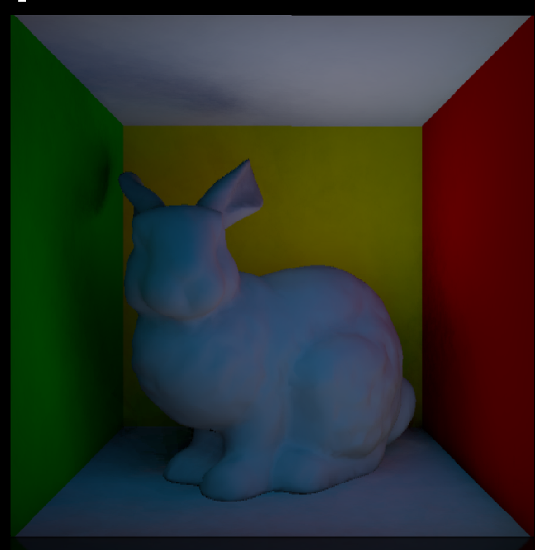


Accumulated Indirect Light

Step 2

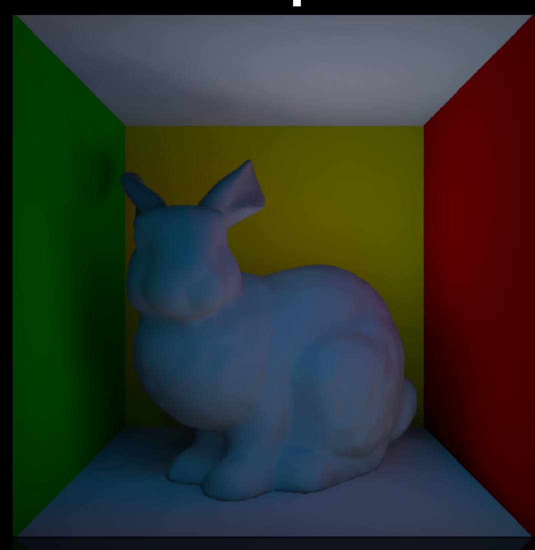


Indirect Shadows Without Using Pull Push

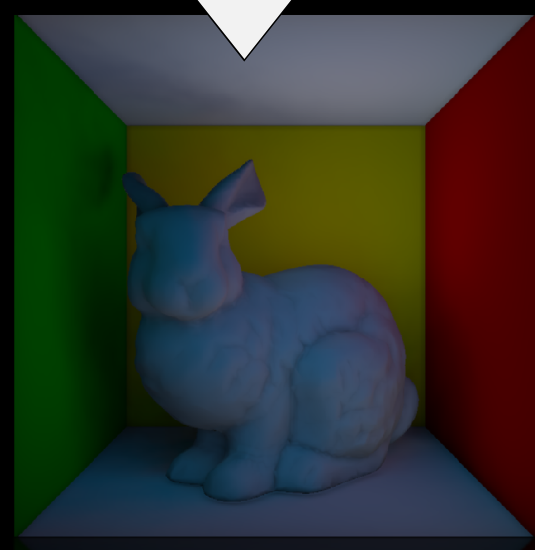


Indirect Shadows With Pull Push Applied

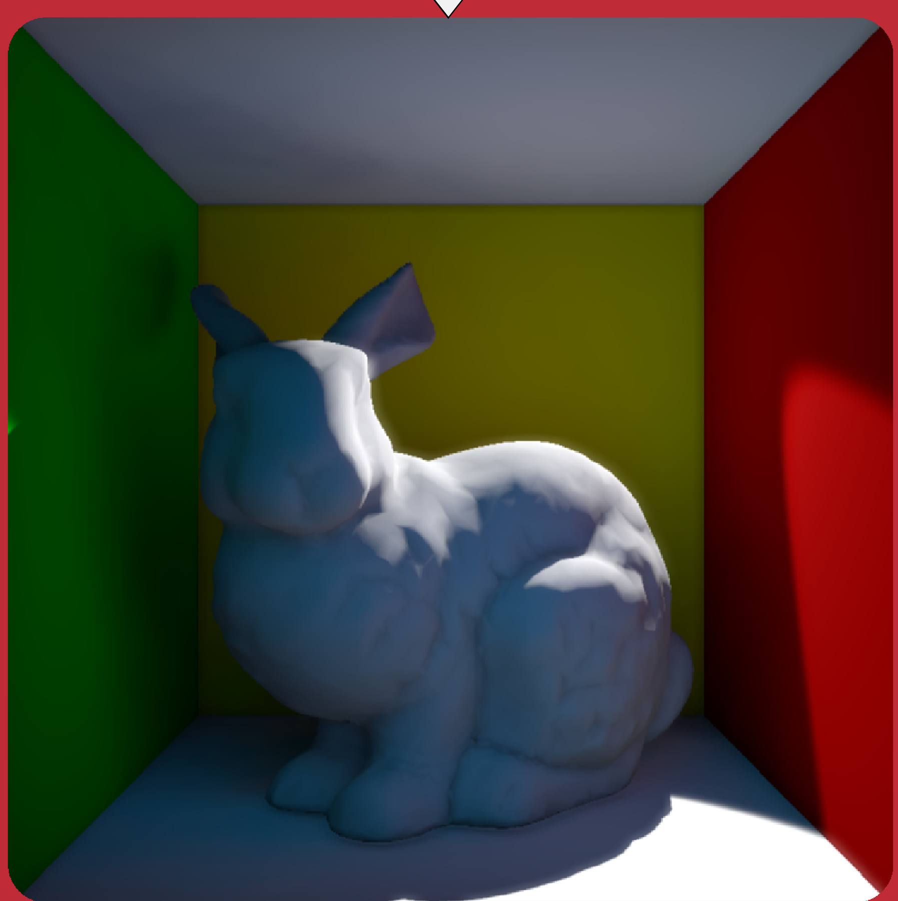
Step 3

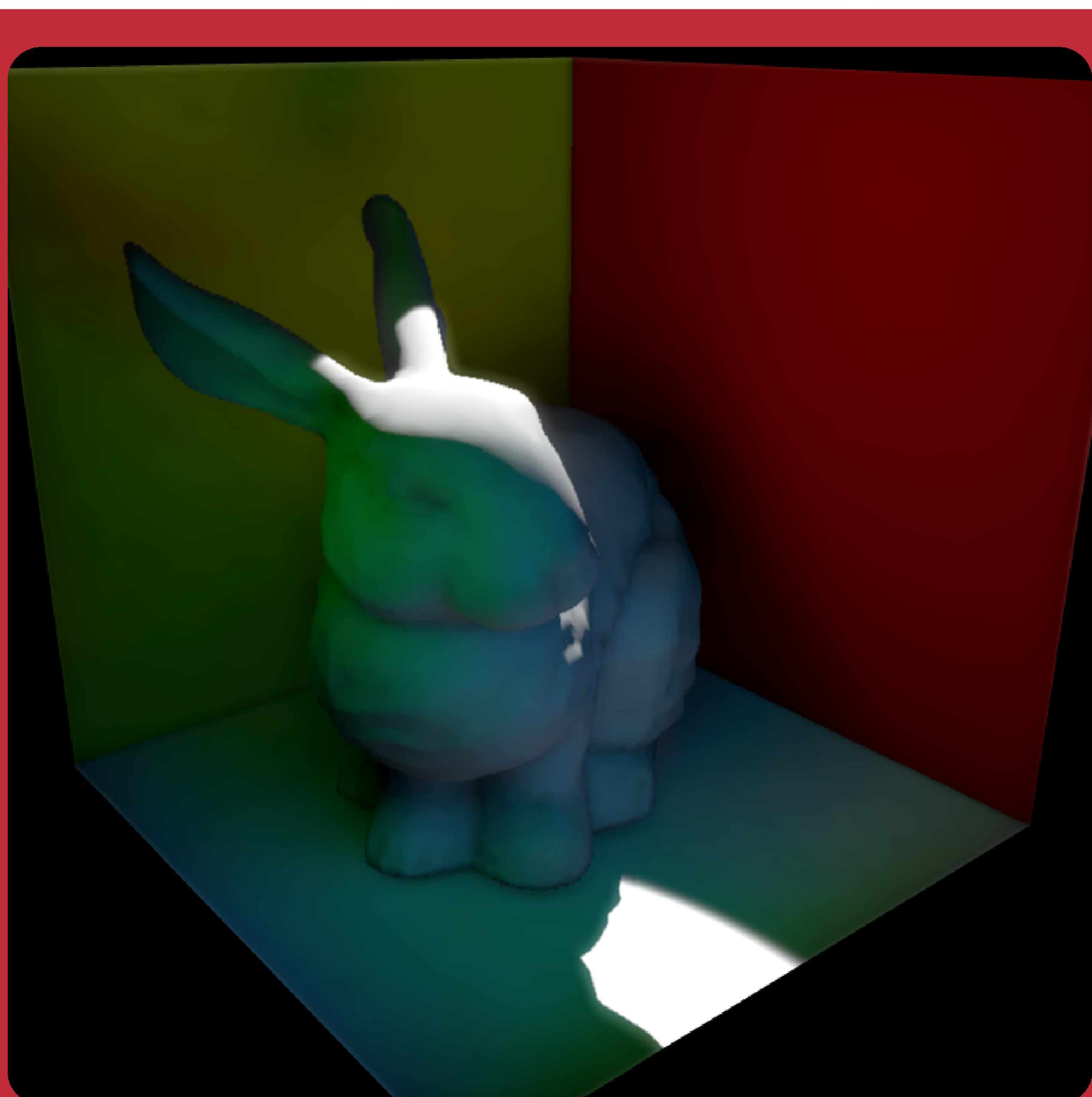


Indirect Light Smoothing using Bilateral Filtering



Multiply Indirect Illumination With SSAO Term For High Frequency Indirect Shadows





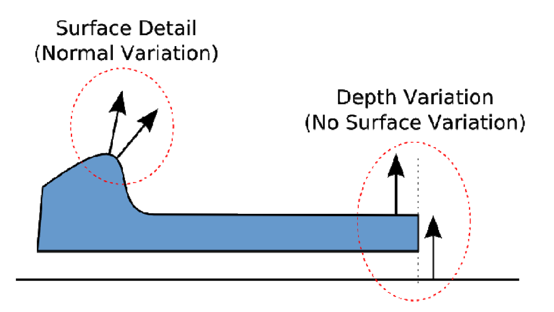
VPL Distribution

Currently no fancy method is used for distribution of VPLs. For these results a simple Halton sequence is used for the sampling the reflective shadow maps.

Bilateral Filtering

Indirect light is subject to a lot of noise using this approach. This include artifacts from the g-buffer interleaving, holes in the ISM, and minor discontinuities in the indirect illumination due to the discrete sampling. In order to average these artifacts Bilateral filtering [6] is applied on the indirect illumination render target.

In order to control the filtering of indirect light, properties of the g-buffer is utilized. Both normal variation and depth variation is taken into account when performing the filtering. The normal variations is required in order to not remove details in fully ambient regions. This is illustrated in the figure below together with the matematical formulation of the kernel. Increasing the value of α will penalize surface variation, and limit the degree of smooting.



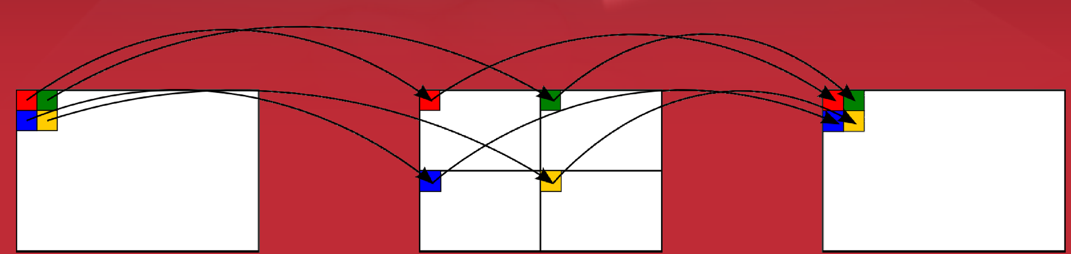
$$B_{\mathbf{p}} = \frac{1}{W_{\mathbf{p}}} \sum_{\mathbf{q} \in \mathcal{S}} G_{\sigma_s}(\|\mathbf{p}-\mathbf{q}\|) G_{\sigma_r}(D) I_{\mathbf{q}}$$

$$W_{\mathbf{p}} = \sum_{\mathbf{q} \in \mathcal{S}} G_{\sigma_s}(\|\mathbf{p}-\mathbf{q}\|) G_{\sigma_r}(D)$$

$$D = ((1 - (\vec{n}_{\mathbf{p}} \cdot \vec{n}_{\mathbf{q}})^{\alpha}) + |d_p - d_q|)\beta$$

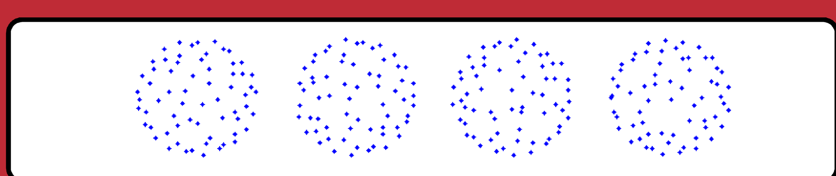
G-Buffer Intereleaving

Since all light is accumulated in screen space using deferred rendering, this method i very fill limited. Due to the low frequency of indirect light only a subset of pixels can be computed . This can be done using a interleaved g-buffer [5]. This is illustrated in the figure below.



Using a subset of the samples from the Halton sequence in each g-buffer tile, the fill rate limitations can be significant reduced. Due to the continious low-discrepancy properties of the Halton sequence it is important to use continious chunks of sampes for each g-buffer tile in order to get even results.

Samples from four such tiles can be seen beow (this is for sampling a spot light). This is indicies [1,64], [65,128], [129,192], and [193,256] from the Halton sequence.

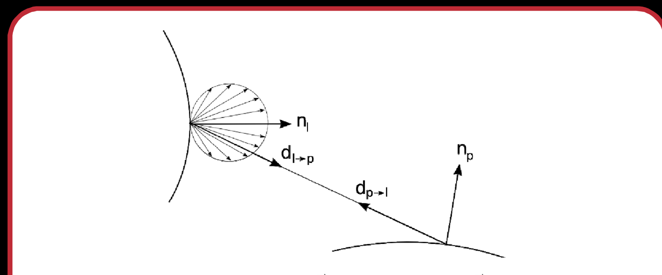


Future Work

This is work in progress, and only a subset of the entire project which is part of my masters thesis. I have a lot on my mind in terms of system scaling etc. For further questions please ask me, I will be around in the lobby ☺

Light Accumulation

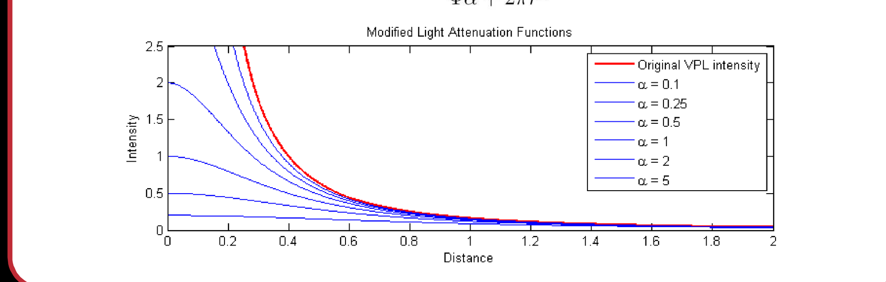
As mentioned in the abstract, light is completly accumulated in a deferred rendering pass. When rendering a VPL the VPL position, normal, and effect (flux) is sampled from a reflective shadow map. The world position and normal is sampled from the G-Buffer. This is illustrated in the figure below.



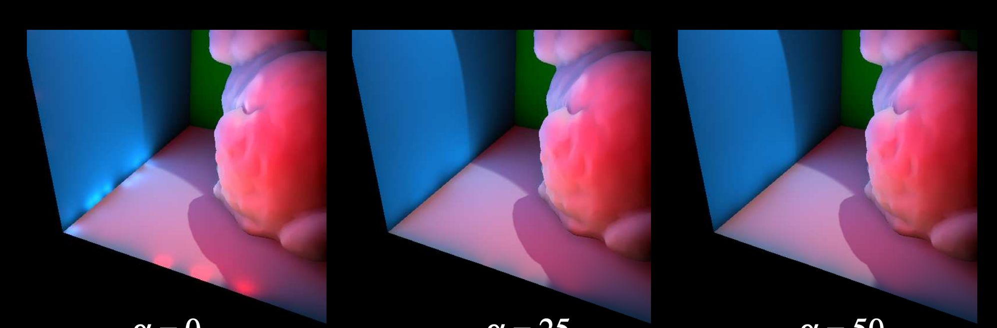
$$I(x_l, x_p) = \rho_l \rho_p \frac{max(\vec{d}_{l \to p} \cdot \vec{n}_l, 0) max(\vec{d}_{p \to l} \cdot \vec{n}_p, 0)}{2\pi \left|\vec{d}_{p \to l}\right|}$$

Due to the asymptotic behaviour of light atteniuation, a rewrite is needed in order to reduce noise (when VPLs are close to geometry). This is shown in the figure below.

$$E(r) = \frac{\Phi}{\Phi\alpha + 2\pi r^2}$$



The results using this simple modification can be seen in the figures below with varying value of α.



α = 0 α = 25 α = 50

With this simple modification a smaller amount of VPLs can be used without noisy results (by traiding some overall effect emmitted by the VPLs).

References

[1] Alexander Keller. Instant radiosity.

[2] Carsten Dachsbacher and Marc Stamminger. Splatting indirect illumination.

[3] Carsten Dachsbacher and Marc Stamminger. Reflective shadow maps.

[4] T. Ritschel, T. Grosch, M. H. Kim, H.-P. Seidel, C. Dachsbacher, and J. Kautz. Imperfect

shadow maps for efficient computation of indirect illumination

[5] B. Segovia, J. C. Iehl, R. Mitanchey, and B. P´eroche. Non-interleaved deferred shading of interleaved sample patterns

[6] Sylvain Paris, Pierre Kornprobst, Jack Tumblin, and Fr´edo Durand. A gentle introduction to bilateral filtering and its applications