Virtual Spherical Gaussian Lights for Real-Time Glossy Indirect Illumination (Supplemental Material)

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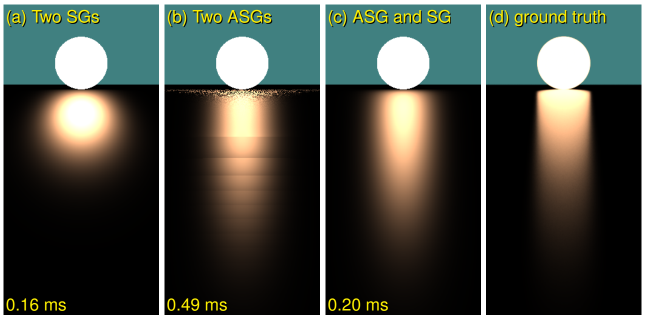

Figure 1: *Approximated direct illumination of a sphere light on a glossy plane (Closeups of 1920×1080 resolution, GPU: AMD Radeon™ HD 6990). The plane has a microfacet BRDF with an isotropic Phong NDF (Phong exponent: 1000). The reflection lobe and incident radiance are approximated using two SGs (a), two ASGs (b), and an ASG and SG (c).*

A Comparison of ASGs and SGs

Fig 1 shows direct illumination from a sphere light. In these experiments, reflection lobes and incident radiance are approximated with SGs or ASGs ($K = 1$), and thus the illumination integral is analytically solved. The floor has an isotropic Phong NDF. As shown in the ground truth image (d), reflection lobes have high anisotropy for shallow grazing angles, even if the BRDF has an isotropic NDF. Therefore, when both reflection lobes and incident radiance are approximated using SGs (a), noticeable approximation error is produced for such grazing angles. Instead of SGs, ASGs can be used (b), but it is more expensive. In addition, it can produce large precision errors for such high anisotropy in our implementation using single-precision floating points. Approximating reflection lobes and incident radiance using an ASG and SG respectively has reasonable performance and no noticeable precision errors (c). Therefore, this paper employs ASGs only for reflection lobes at the first bounce.

B Radiance Evaluation of a VSGL

This section explains an analytical solution of $\int_{S^2} \acute{G}_j(\boldsymbol{\omega}) G_l(\boldsymbol{\omega}) G_V(\boldsymbol{\omega}) d\boldsymbol{\omega}$ for radiance evaluation of a VSGL. The product of two SGs is closed in SG basis as follows:

$$G_l(\boldsymbol{\omega}) G_V(\boldsymbol{\omega}) = c_m G\left(\boldsymbol{\omega}, \frac{\boldsymbol{\xi}_m}{\|\boldsymbol{\xi}_m\|}, \|\boldsymbol{\xi}_m\|\right), \quad (1)$$

where $c_m = e^{\|\boldsymbol{\xi}_m\| - \eta_l - \eta_V}$, $\eta_V = \frac{4\pi}{\|\Omega_i\|}$, and $\boldsymbol{\xi}_m = \eta_l \boldsymbol{\xi}_l + \eta_V \boldsymbol{\omega}_i$. The approximate product integral of the ASG and SG is derived in [Xu et al. 2013] and given by:

$$c_m \int_{S^2} \acute{G}_j(\boldsymbol{\omega}) G\left(\boldsymbol{\omega}, \frac{\boldsymbol{\xi}_m}{\|\boldsymbol{\xi}_m\|}, \|\boldsymbol{\xi}_m\|\right) d\boldsymbol{\omega} \approx \frac{c_m \pi \acute{G}\left(\frac{\boldsymbol{\xi}_m}{\|\boldsymbol{\xi}_m\|}, [\boldsymbol{\xi}_{x,j}, \boldsymbol{\xi}_{y,j}, \boldsymbol{\xi}_{z,j}], \left[\frac{\lambda_j \nu}{\lambda_j + \nu}, \frac{\mu_j \nu}{\mu_j + \nu}\right]\right)}{\sqrt{(\lambda_j + \nu)(\mu_j + \nu)}}, \quad (2)$$

where $2\nu = \|\boldsymbol{\xi}_m\|$. Evaluating this ASG, we can calculate glossy interreflections from a VSGL. For diffuse surfaces, $\acute{G}_j(\boldsymbol{\omega}) = 1$ or $G_l(\boldsymbol{\omega}) = 1$ can be used. Therefore, when both BRDFs are diffuse models, it is given as:

$$\int_{S^2} \acute{G}_j(\boldsymbol{\omega}) G_l(\boldsymbol{\omega}) G_V(\boldsymbol{\omega}) d\boldsymbol{\omega} = \int_{S^2} G_V(\boldsymbol{\omega}) d\boldsymbol{\omega} = \frac{\|\Omega_i\|}{2}. \quad (3)$$

If $\|\Omega_i\| \approx \frac{\pi r_i^2}{\|\mathbf{x}_i - \mathbf{x}_s\|^2}$ similar to [Xu et al. 2014], it derives the same formulation as VPLs which produce spiky artifacts. Therefore, $\|\Omega_i\| = 2\pi(1 - \cos\theta_i)$ is employed in this paper based on the original VSL method.

References

Xu, K., Sun, W.-L., Dong, Z., Zhao, D.-Y., Wu, R.-D., and Hu, S.-M. 2013. Anisotropic spherical gaussians. *ACM Trans. Graph. 32*, 6, 209:1–209:11.

Xu, K., Cao, Y.-P., Ma, L.-Q., Dong, Z., Wang, R., and Hu, S.-M. 2014. A practical algorithm for rendering interreflections with all-frequency brdfs. *ACM Trans. Graph. 33*, 1, 10:1–10:16.

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