Taming the Shadow Terminator

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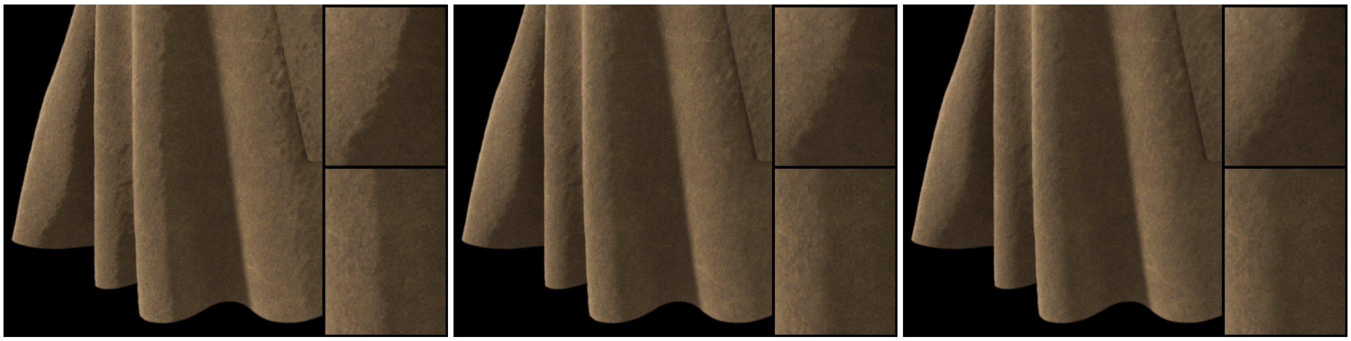

(a) Only Shading Normals (b) Estevez et al. [2019] (c) Ours

Figure 1: (a) the shadow terminator appears harsh when using shading normals. (b) Estevez et al. [2019] softens the terminator but still appears somewhat harsh. (c) Our modified shadowing function fully softens the terminator without otherwise compromising the look.

ABSTRACT

A longstanding problem with the use of shading normals is the discontinuity introduced into the cosine falloff where part of the hemisphere around the shading normal falls below the geometric surface. Our solution is to add a geometrically derived shadowing function that adds minimal additional shadowing while falling smoothly to zero at the terminator. Our shadowing function is simple, robust, efficient and production proven.

CCS CONCEPTS

• **Computing methodologies → Rendering**; **Ray tracing**.

KEYWORDS

ray tracing, global illumination, shading normals

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1 INTRODUCTION

Shading normals are a widely used technique in computer graphics for simulating the visual appearance of fine detail. Shading normals are produced by using a bump or normal map to perturb an existing geometric surface normal without changing the underlying geometric surface; the shading normal is then used in place of the surface normal for shading and lighting calculations. Shading normals are relatively computationally inexpensive and use much less memory compared to displacement mapping, but decoupling the shading normal from the geometry can introduce artifacts such as a pronounced shadow terminator as shown in Figure 1 and explained in Figure 2.

The harsh terminator can be distracting and can affect the visual interpretation of the surface material. To alleviate this problem, artists today typically have to either fall back to displacement or use larger area lights to soften the shadow. To eliminate the harsh terminator, we add an additional shadowing factor that smoothly falls off to zero at the geometric terminator while preserving a shape close the original cosine falloff.

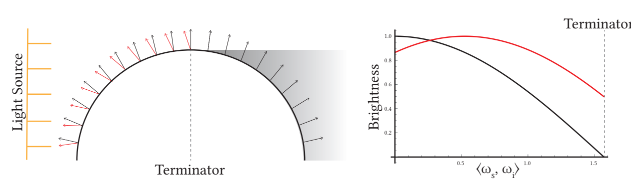

Figure 2: With geometric normals (black), brightness follows a smooth cosine falloff to zero at the shadow terminator. With shading normals (red) bent towards the light, brightness does not reach zero at the shadow terminator, resulting in a hard cutoff.

2 RELATED WORK

To address energy loss when rendering with shading normals, Schüssler et al. [2017] imagined an additional microfacet at each shading point perpendicular to the geometric surface, and then accounted for inter-reflections between the two facets. Unfortunately, the added multiple scattering significantly alters the overall surface appearance and also requires a random walk to evaluate. But

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without the multiple scattering, the shadowing from the additional microfacet is overly dark as shown in Figure 4.

In recent concurrent work, Estevez et al. [2019] addressed the hard terminator problem with an added GGX shadowing factor with roughness parameter α estimated from the shading normal deviation measured from the geometric normal. The resulting function softens the terminator less than our approach as shown in Figures 1 and 4. We contrast this method further in the next section.

3 APPROACH

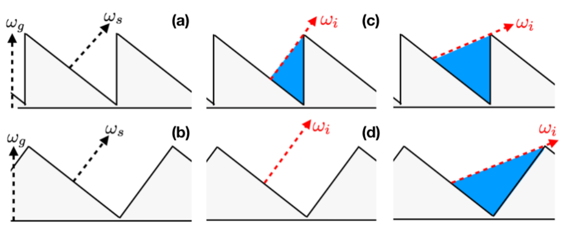

Figure 3: Micro-surface profile from Schüssler et al. [2017] (top) vs. ours (bottom). Instead of adding a facet perpendicular to the geometric surface (a), we add a facet perpendicular to the primary facet (b). When the incoming light is aligned with the shading normal, their method incurs shadowing (c) whereas ours does not. As the light moves toward the geometric horizon, both methods gradually reduce the incident illumination to zero (e) and (f).

Inspired by Schüssler et al. [2017], we propose a modified configuration, illustrated in Figure 3, where the added facet is oriented to maintain peak brightness when the light is aligned with the shading normal, falling smoothly to zero at the geometric terminator. The shadowing resulting from the added facet is:

$$G = \min\left[1, \frac{\langle \omega_g, \omega_i \rangle}{\langle \omega_s, \omega_i \rangle \langle \omega_g, \omega_s \rangle}\right] \tag{1}$$

Importantly, when the light is on the geometric side of the shading normal (i.e. when $\langle \omega_g, \omega_i \rangle > \langle \omega_g, \omega_s \rangle$), then $G = 1$ and no additional shadowing is incurred. However, if G is simply multiplied into the BRDF as-is then a C^1 discontinuity would be introduced at the point where the light direction reaches and moves beyond the shading normal. To alleviate the discontinuity, we use Hermite interpolation going from a slope of 1 to 0 over the range of G from 0 to 1, resulting in our final shadowing factor:

$$G' = -G^3 + G^2 + G \tag{2}$$

In Figure 4 we briefly contrast our method with the shadowing functions from [Schüssler et al. 2017] and [Estevez et al. 2019]. The original bump mapping has a harsh terminator compared to the version without bump mapping. The shadowing function from Schüssler et al. adds significant darkening well beyond the terminator whereas that of Estevez et al. is still somewhat harsh. In comparison, our function softens the terminator while retaining the overall look of the surface away from the terminator.

Though our shadowing function produces results often similar to that of Estevez et al., there are significant differences which we

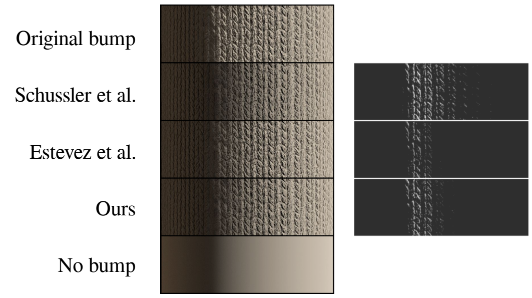

Figure 4: Bump mapped cylinder rendered with various shadowing functions. The (thresholded) difference from the original is shown to the right.

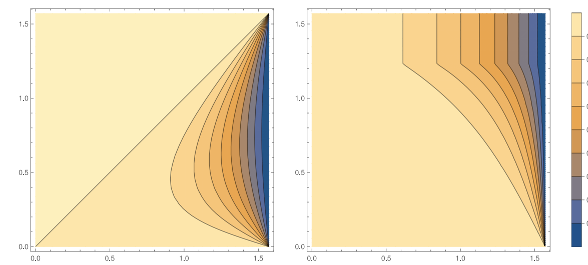

Figure 5: Contour plots comparing our shadowing function (left) with the one by Estevez et al. (right). The horizontal axis is the light angle as measured from the geometric normal. The vertical axis is the deviation of the shading normal from the geometric normal towards the light direction.

illustrate in Figure 5. For an unperturbed shading normal (bottom of contour plot), both functions produce no attenuation. However, when the shading normal is perturbed beyond the light direction (upper left triangle of contour plot) our function adds no attenuation whereas theirs adds significant attenuation. Generally, for small shading normal deviations (lower right of plot), their function has less shadowing, and for large deviations (upper right), theirs has more shadowing, and thus their method generally has higher contrast near the terminator which may explain why our method appears softer.

4 CONCLUSIONS AND FUTURE WORK

We proposed a method to create soft bump map shadow terminators. Our method is artistically pleasing and produces natural cosine-like falloff for the terminator while maintain the classic normal/bump map look elsewhere. Our method is also efficient to compute and easy to implement, and has been used successfully in production. In the future we would like to look into how to get a closer match to displacement mapping.

REFERENCES

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