Screen Space Spherical Harmonics Occlusion Sampling

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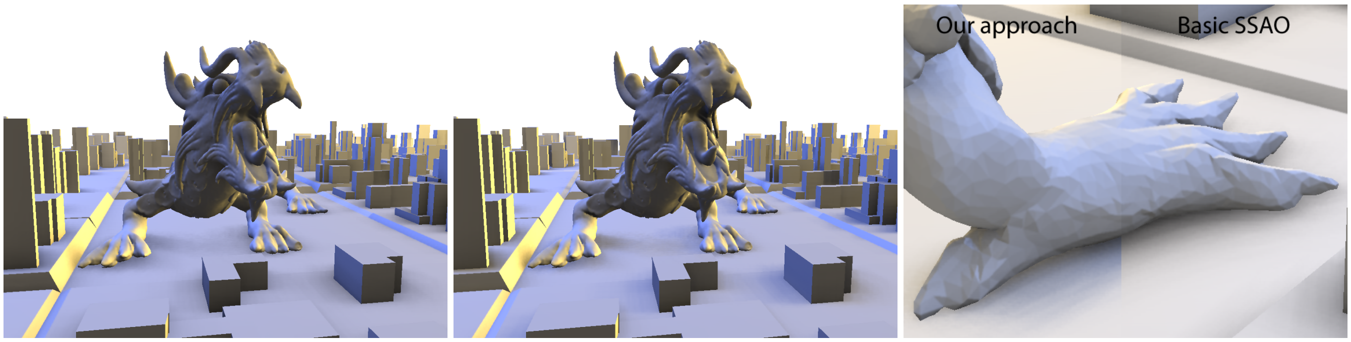

Figure 1: *Scene lit by a blue and yellow light source. Basic SSAO **(left)**, the proposed approach **(center)** and side-by-side comparison of a close-up **(right)**. Accounting for directional occlusion and incoming radiance leads to realistic colors and shapes of the shadows.*

1 Introduction

One objective of global illumination (GI) models is to solve the lighting integral of the upper hemisphere at a surface point. One particular effect of GI that has become very popular in the past years is Ambient Occlusion (AO), where, independently of the lighting, a coverage factor that indicates the amount of occlusion induced by its local neighboring geometry is calculated for every surface point. Screen Space Ambient Occlusion (SSAO) algorithms allow for the approximation of this occlusion factor in real time. Ritschel et al. [2009] proposed Screen Space Directional Occlusion (SSDO), combining the calculation of occlusion and lighting by simultaneously accumulating the light of unoccluded directions when sampling the occlusion. Contrary to AO this results in colored shadows simulating directional lighting effects. Green [2003] outlined techniques based on Spherical Harmonics (SH) that approximate global lighting models with the basic principle of representing both, the incoming radiance field and the occlusion, as functions defined on the sphere that can be efficiently represented in the spherical Fourier domain. Calculating the spherical occlusion function, however, remains computationally expensive since ray tracing methods have to be applied.

In this work we present the idea of combining SSDO with the concept of Spherical Harmonics Lighting evaluated per pixel in real time for dynamic scenes.

2 Directional Occlusion

To determine the directional occlusion of a surface point the volume of its upper hemisphere needs to be sampled. Since we want to perform the sampling in screen space we use a so-called G-Buffer containing the position and normal of each pixel in the camera coordinate system. Every sample is projected to screen space and compared to the corresponding position in the G-Buffer. We consider a sample occluded if this position is closer to the camera than the sample's and unoccluded otherwise. Using this sampling scheme, a vector of low-order SH coefficients representing the spherical occlusion function is created per pixel.

Only a relatively small number of samples can be evaluated in real-time. In order to minimize noise and aliasing effects resulting from the sampling process we use a 4×4 interleaved/jittered sampling pattern for the sampling directions. To eliminate remaining directional noise, fast low-pass filtering of the occlusion function is performed in the SH domain by applying the spherical equivalent of a Gaussian kernel represented as Zonal Harmonics.

3 Lighting

Using the occlusion SH coefficient vector in combination with the incoming radiance field represented in the SH basis, it is possible to compute dynamic diffuse lighting of a surface point in screen space by solving the integral over its upper hemisphere while taking into account its local occlusion. This is one of the key aspects of SH lighting, since it is easily done by calculating the scalar product of both SH coefficient vectors.

4 Conclusion

We presented an approach for calculating the SH representation of the local per-pixel occlusion in real-time with only marginally higher cost compared to a SSAO implementation with similar sampling. Projecting the occlusion function to the SH domain makes it possible to perform fast and efficient low-pass filtering of directional noise. The amount of directionality depends on the bandwidth of the SH projection decreasing gracefully to the non-directional effect of standard AO. Our approach for directional lighting results in colored shadow effects similar to SSDO, yet separating occlusion and lighting calculation. This separation allows the straight-forward integration of our method into modern 3D graphics engines that use SH lighting and SSAO for diffuse GI effects.

References

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RITSCHEL, T., GROSCH, T., AND SEIDEL, H.-P. 2009. Approximating dynamic global illumination in image space. In *Proc. of the 2009 Symposium on Interactive 3D Graphics and Games*, ACM, New York, NY, USA, 75–82.

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