A curvature based lightning model for quasi-global diffuse illumination

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Abstract

In this paper we present extensions to local illumination models that take into account light transport and shadow-masking effects in the neighborhood of the surface point under evaluation. Central to our approach is the idea that local curvature represents geometric features in the surrounding neighborhood of this point which have an attenuating or enhancing effect regarding the diffuse illumination of this point. We introduce a lighting model that controls the amount of locally scattered light from the neighborhood based on a local curvature metric. The properties we aim at modeling with this curvature-based illumination model can be found in highly diffuse reflecting materials such as for example snow.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Color, shading, shadowing, and texture

1. Introduction and previous work

In local illumination the calculation of light reflected from a given point on a surface is mostly a function of local material properties and the directional relations between the surface orientation and viewing direction, as well as light directions. Although this simplistic approach of light transport does not take into account the various pathways of multiply scattered and attenuated light in a real environment, it allows to realistically render different types of materials given that their specific bi-direction reflection functions are known [KSS02]. Local illumination calculations following this traditional, single step light sampling approach fail to take into account global lightning effects such as ambient occlusion and shadows from nearby surface structures or other objects in the environment. In order to improve realism, various mapping techniques have been developed to evaluate global illumination effects by sampling from pre-computed buffers. In horizon mapping, light source visibility above the surface horizon is stored per pixel [SC00] for different azimuth angles. It allows to calculate local self-shadowing of bumped surfaces. In shadow mapping, surface visibility from the light position is pre-computed in a shadow map to determine shadows cast upon a surface by other objects in the scene [ERC02]. Other multi-pass rendering techniques employ ambient occlusion mapping, whereby incident light over a given aperture is pre-integrated and stored in a pixel-buffer which is subsequently used in the local illumination model to take into account for attenuation of diffuse light [SA07].

2. Curvature Based Illumination

We propose to integrate quasi-global effects into the illumination equations rather than sampling pre-computed maps in order to take into account for effects such as the enhancement or attenuation of incident light due to the shape of the nearby surrounding surface. To that end we determine these effects from evaluating local surface curvature as an aggregate measure for the relative slope angle in the surround of a surface point in question. Figure 1 illustrates the general

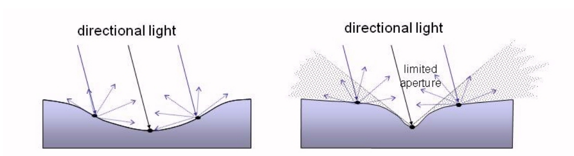

Figure 1: *Situations with varying positive curvature. Inscattering in medium curvature regions (left) and ambient occlusion in high curvature regions (right).*

idea which assumes that the amount of incident light from a light source at some point in question is increased by additional inscattering of diffuse light from nearby surface regions as long as the surface is moderately concave. On the other hand, as the amount of concavity increases, we assume that light contribution from ambient light is dampened due to ambient occlusion effects. Hence, in our lighting model we introduce two new factors that model the amount of diffusely reflected inscattered light as well as ambient occluded light as a function of the local curvature. The gain of diffuse light G_D is modeled as a Gaussian over the curvature C. This allows us to adjust the pitch μ, amplitude α and bell-width σ within a desired curvature range:

$$G_D(C) = 1 + \alpha \cdot e^{(-\frac{(C+\mu)^2}{\sigma})} \tag{1}$$

Similarly, the attenuation of the ambient light term A_A in very concave surface regions is described by a exponential function as follows:

$$A_A(C) = 1 - (\lambda \cdot C)^{2\gamma} \tag{2}$$

Similar to [KHWM09], we use in our current implementation the mean curvature κ as a measure for C. It is computed as the weighted sum of the lengths of the two principal curvature direction vectors. We derive those by fitting a second degree polynomial in the local vertex neighborhood of the polygonal mesh. The determined curvature κ is stored as a scalar attribute per vertex. Parameters α, σ, μ, λ and γ are manually tuned to obtain a satisfactory adaptation to the actual curvatures in the model which are scale dependent.

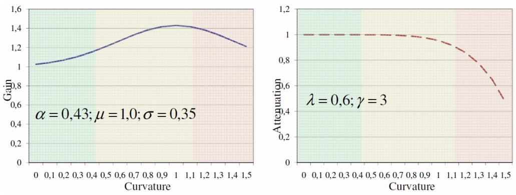

Figure 2: *The characteristics of G_D enhances diffuse reflection for medium curvature (left). Ambient light contribution decreases rapidly in very high curvature regions (righ).*

3. Results

Figure 2 shows the characteristic attenuation of the ambient light and diffuse gain for a given parameter configuration. The gain and attenuation terms according to (1) and (2) are subsequently used to scale the diffuse (lambertian) and ambient lighting terms of the standard illumination model. As this curvature modulated illumination model is intended to operate on highly diffuse materials there is no effect of curvature on the specular light term. Figure 3 shows an example of a rendered scene that illustrates the contribution of the diffuse gain and ambient attentuation factors in comparison to an unaltered illumination model. Our first results from this ongoing research show that local curvature can be integrated into local illumination calculations at minimal extra cost. Initial visual results indicate that our extensions can reveal more surface detail for bright and higly diffuse reflecting surfaces such as snow or sand.

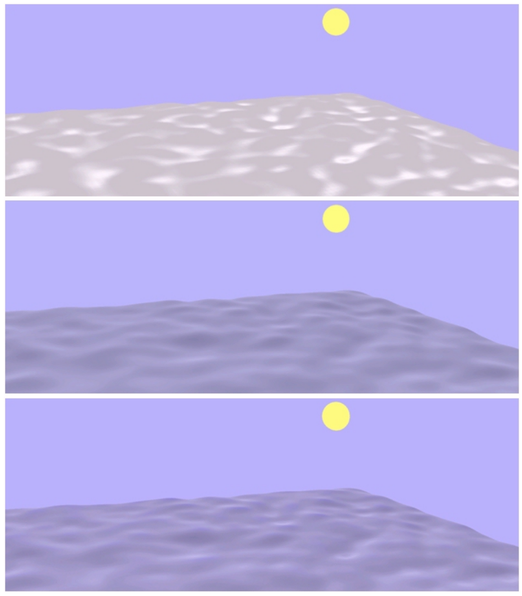

Figure 3: *Curvature dependent diffuse gain factor (top). Default ambient and diffuse shading (middle). Curvature dependent modulation of ambient and diffuse illumination (bottom).*

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