Generalization of Adobe's Fresnel Model

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1. Introduction

Schlick's reflectance model [Schlick 1994] is widely used, but does not model the "dip" seen in many metals at glancing angles. Lazányi and Szirmay-Kalos proposed a model [Lazányi and László 2005] to address this, but their model's parameters have no direct physical or visual meaning and thus their values are difficult to set directly. Hoffman proposed a reparameterization [Hoffman 2019] which adds to Schlick one parameter—reflectance at 82 degrees—which is easy to calculate or set visually, but cannot be easily set to a default value if no "dip" is desired. Hoffman's model may also exhibit undesirable clamping at certain parameter values [Hoffman 2020].

A modified reparameterization is included in the recently proposed Adobe Standard Material [Kutz et al. 2021] which addresses the remaining issues. The model's parameter is a *tint* applied to the Schlick model's color at 82 degrees, and as such if set to a default value of white the "dip" is removed and the model reverts to the original Schlick model.

However, Adobe's model does not support other commonly used generalizations of Schlick's model, such as the ability to specify reflectance at 90 degrees and the ability to control the interpolation exponent [Hoffman 2020]. This white paper will describe an extension to the Adobe model which adds these features.

2. Model

The Schlick reflectance model [Schlick 1994] is:

$$F(\theta) \approx r_0 + (1 - r_0)(1 - \cos\theta)^5. \tag{1}$$

The Lazányi–Szirmay-Kalos model [Lazányi and László 2005] extends it with an additional term:

$$F(\theta) \approx r_0 + (1 - r_0)(1 - \cos\theta)^5 - a\cos\theta(1 - \cos\theta)^\beta. \tag{2}$$

Following [Hoffman 2019], Adobe [Kutz et al. 2021] fix the value of β to 6. They compute the value of a from their tint parameter t, specified at the angle $\theta_{\max}$[1]:

$$a = \frac{\left(r_0 + (1 - r_0)(1 - \cos\theta_{\max})^5\right)(1 - t)}{\cos\theta_{\max}(1 - \cos\theta_{\max})^6}. \tag{3}$$

For artistic reasons, the Schlick equation is often generalized [Hoffman 2020] to specify the reflectance at 90 degrees and the interpolation exponent:

$$F(\theta) \approx r_0 + (r_{90} - r_0)(1 - \cos\theta)^\alpha. \tag{4}$$

The Adobe model can be easily generalized to include these features. First we incorporate the Lazányi term (still fixing β to 6):

$$F(\theta) \approx r_0 + (r_{90} - r_0)(1 - \cos\theta)^\alpha - a\cos\theta(1 - \cos\theta)^6, \tag{5}$$

then modify the computation of the a parameter:

$$a = \frac{\left(r_0 + (r_{90} - r_0)(1 - \cos\theta_{\max})^\alpha\right)(1 - t)}{\cos\theta_{\max}(1 - \cos\theta_{\max})^6}. \tag{6}$$

References

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[1]The angle $\theta_{\max}$ is the extremum of the Lazányi dip term. With β set to 6, it is equal to $\arccos(\frac{1}{7})$, or approximately 82 degrees (in general $\theta_{\max} = \arccos(\frac{1}{\beta+1})$).