An Anisotropic Phong Light Reflection Model

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Abstract.
We present a new BRDF model that attempts to combine the advantages of the various empirical models currently in use. In particular, it has intuitive parameters, is anisotropic, energy-conserving, reciprocal, has an appropriate non-Lambertian diffuse term, and is easy to use in a Monte Carlo framework.

1 Introduction

Physically-based rendering systems describe reflection behavior using the *bidirectional reflectance distribution function* (BRDF) [3]. At a given point on a surface the BRDF is a function of two directions, one toward the light and one toward the viewer. The characteristics of the BRDF will determine what "type" of material the viewer thinks the displayed object is composed of, so the choice of BRDF model and its parameters is important.

We would like to have a BRDF model that works for "common" surfaces such as metal and plastic, and has the following characteristics:

1. **Plausible:** as defined by Lewis [5], this refers to the BRDF obeying energy conservation and reciprocity.
2. **Anisotropy:** the material should model simple anisotropy such as seen on brushed metals.
3. **Intuitive parameters:** for material such as plastics there should be parameters such as R_d for the substrate and R_s for the normal specular reflectance as well as two roughness parameters n_u and n_v.
4. **Fresnel behavior:** specularity should increase as the incident angle goes down.
5. **Non-Lambertian diffuse term:** The material should allow for a diffuse term, but the component should be non-Lambertian to assure energy conservation in the presence of Fresnel behavior.
6. **Monte Carlo friendliness:** there should be some reasonable probability density function that allows straightforward Monte Carlo sample generation for the BRDF.

Neumann et al's metallic model [6] captures items 1, 3, 4, and 6. Schlick's model [8] captures items. Ward's model [10] captures items 2, and 3. It only violates 1 for energy conservation at grazing angles. It also approximates Monte Carlo friendliness by giving a sample generation method but does not specify what the underlying density function is.

Our goal is to find a BRDF with all the properties outlined. Our basic strategy is to make a Fresnel-weighted Phong-style cosine lobe model that is anisotropic. This strategy borrows pieces from Ward's model [10] and from Neumann and Neumann's model [6]. In addition, we add some correction terms that are crucial to keep the directional hemispherical reflection near the desired level. For the diffuse term we use