Title: Efficient and Expressive Microfacet Models

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Abstract: In realistic appearance modeling, rough surfaces that have microscopic details are described using so-called *microfacet models*. These include analytical models that statistically define a physically-based microsurface. Such models are extensively used in practice because they are inexpensive to compute and offer considerable flexibility in terms of appearance control. Also, small but visible surface features can easily be added to them through the use of a normal map. However, there are still areas in which this general type of model can be improved: important features like anisotropy control sometimes lack analytic solutions, and the efficient rendering of normal maps requires accurate and general filtering algorithms.

We advance the state of the art with regard to such models in these areas: we derive analytic anisotropic models, reformulate the filtering problem and propose an efficient filtering algorithm based on a novel filtering data structure.

Specifically, we derive a general result in microfacet theory: given an arbitrary microsurface defined via standard microfacet statistics, we show how to construct the statistics of its linearly transformed counterparts. This leads to a simple closed-form expression for anisotropic variations of a given surface that generalizes previous work by supporting all microfacet distributions and all invertible tangential linear transformations. As a consequence, our approach allows transferring macrosurface deformations to the microsurface, so as to render its corresponding complex anisotropic appearance.

Furthermore, we analyze the filtering of the combined effect of a microfacet BRDF and a normal map. We show that the filtering problem can be expressed as an *Integral Histogram (IH)* evaluation. Due to the high memory usage of IHs, we develop the *Inverse Bin Map (IBM)*: a form of an IH that is very compact and fast to build. Based on the IBM, we present a highly memory-efficient technique for filtering normal maps that is targeted at the accurate rendering of glints, but in contrast with previous approaches also offers roughness control.

Keywords: computer graphics, realistic rendering, appearance modeling, microfacet theory, anisotropy, glints, normal map filtering