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A Spectral BSSRDF for Shading Human Skin

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Abstract

We present a novel spectral shading model for human skin. Our model accounts for both subsurface and surface scattering, and uses only four parameters to simulate the interaction of light with human skin. The four parameters control the amount of oil, melanin and hemoglobin in the skin, which makes it possible to match specific skin types. Using these parameters we generate custom wavelength dependent diffusion profiles for a two-layer skin model that account for subsurface scattering within the skin. These diffusion profiles are computed using convolved diffusion multipoles, enabling an accurate and rapid simulation of the subsurface scattering of light within skin. We combine the subsurface scattering simulation with a Torrance-Sparrow BRDF model to simulate the interaction of light with an oily layer at the surface of the skin. Our results demonstrate that this four parameter model makes it possible to simulate the range of natural appearance of human skin including African, Asian, and Caucasian skin types.

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

1 Introduction

Simulating the appearance of human skin is a challenging problem due to the complex structure of the skin. Furthermore, even small variations in color and shade significantly influence the perception of skin, as they convey information about a person's health, ethnicity, and physiological state. A physically accurate shading model that takes into account the full spectral interactions of light with tissue is essential for realistic renderings of human skin.

Light scattering in skin is dominated by subsurface scattering, which was first recognized in computer graphics by Hanrahan and Krueger [HK93]. They developed a BRDF model for skin that accounted for single scattering of light plus a diffuse term. Stam [Sta01] further enhanced this model by simulating multiple scattering of light. Marschner et al. [MWL*99] measured isotropic BRDFs of human skin and used these for rendering. These BRDF techniques, however, assume that light both enters and exits the skin at a single point, and they cannot simulate the softness and the color bleeding effects that are characteristic of translucent materials such as skin [JMLH01].

Debevec et al. [DHT*00] measured the reflectance field of human faces, allowing for rendering of skin under varying illumination conditions with excellent results. Jensen and Buhler [JB02], Hery [Her03] and Weyrich et al. [WMP*06] have investigated methods to measure the surface and subsurface properties of human faces. While these techniques can be used to reproduce measured data accurately, there is no clear way to modify model parameters arbitrarily to generate a desired appearance.

Tsumura et al. [TM99, TOS*03] developed an image-based technique to recover and subsequently model the concentrations of melanin and hemoglobin in skin. Their method makes the assumption that melanin and blood have completely independent effects on skin color, which has been shown to not be the case [SzZKB04]. Also, their technique is limited to specific camera-light combinations.

Jensen et al. [JMLH01] developed a BSSRDF model for simulating subsurface scattering within translucent materials, and showed how their model captures both the softness and the color bleeding characteristics of human skin. They also measured optical parameters for skin assuming that skin is a homogenenous semi-infinite medium. Donner and Jensen [DJ05] later developed a BSSRDF model for thin or layered materials. They demonstrated how their technique

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