A Physical Rendering Model for Human Teeth

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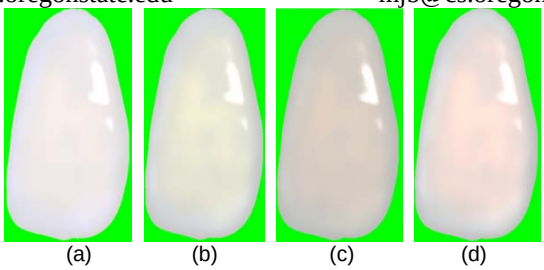

(a) (b) (c) (d)

Figures 1: *(a)-(d) show various shades exhibited by a central incisor for different optical properties. In younger people, teeth tend to be whiter (a): High scattering, Low absorption. With age, teeth tend to be yellowish due to wear and tear of enamel, exposing more dentin, and thus reducing scattering (d): Low scattering, High Absorption. Our model simulates these conditions.*

1 Abstract

This paper introduces a layered model for rendering human teeth, to be used in photorealistic rendering of humans for games and animations. While the lighting responses of teeth have been studied in the dental industry ([Joiner 2004], [Brodbelt et al 1981], [Zijp and ten Bosch 1993]) for the production of realistic-looking dentures, to our knowledge this is the first study of its type in computer graphics for the production of realistic renderings. Human teeth exhibit translucency and are characterized by complex light interaction. From a rendering perspective, we make use of a bank of sliders (Figure 2) to vary optical properties at runtime and achieve desired rendering effects, including aging effects as shown in Figure 1. We also make use of hand drawn distribution maps for different layers rather than texture maps to achieve diffuse coloring.

2 Description

Tooth enamel is predominantly made of a hydroxyapatite-like crystalline material in addition to other organic materials. Dentin is composed of tubules which extend from the dentin enamel junction (DEJ) to the pulp. Dentin concentration is less in DEJ also density of enamel decreases from the surface as we move inwards.

Our model is composed of two layers: The outer enamel (with a thin film of saliva on top) and inner dentin. We neglect the pulp layer and consider only crown section for our simulation. We use a multipole diffusion model to approximate diffuse color contribution and a Kelemen/Szirmay- Kalos model to obtain specular contribution for a fixed roughness and specular intensity factors.

We make use of a distribution map which can be characterized as a grey scale variation of density of layers. Diffuse color is computed by convolution of reflectance profiles with the distribution maps along with the total irradiance available for the diffusion process. Sliders (Figure 2) are used to vary optical properties of enamel and dentin such as scattering, absorption and asymmetry factors over red, green and blue wavelengths. We then combined this with sub-surface scattering (such has been recently used in skin rendering [Dreon et al 2007]) and Rayleigh Scattering (which accounts for a slight blue-ish hue on some teeth).

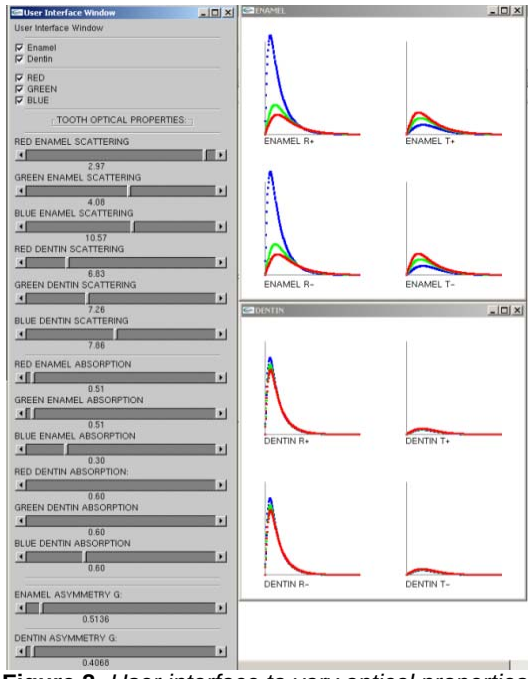

Figure 2: *User interface to vary optical properties*

3 References

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