A Dual Funnel Approximation for the Appearance of Translucent Material

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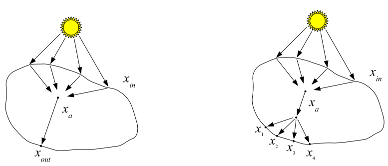
Abstract

The simulation of subsurface scattering of light is required for high-fidelity rendering of natural materials such as marble, jade, human skin and so on. In this work we extended the light model presented in [Banterle and Chalmers], that can handle subsurface scattering in real-time without constraints (deformable meshes and any kind of light are allowed). Our work is focused on the task of improving quality to try to match the appearance of the physically-based model [Jensen et al.].

1 The Algorithm

In this work, we extended the translucency model presented in [Banterle and Chalmers]. In this model the light is accumulated in a point near the surface x_a when it enters from an incoming point x_{in}. The light is then transmitted from x_a within the object according its index of refraction and it leaves the object from an outgoing point x_{out} (Figure 1.a). In order to achieve this the translucent object is rendered into a cube map (acquired from the faces of the objects bounding box) with only direct lighting. The irradiance of cubemap is then projected using spherical harmonics (SH), in order to accumulate light in x_a. Finally SH is evaluated using the refraction vector ($\vec{r}$) at the point to get the radiosity term ($B(\vec{r})$), and apply a function similar to the dipole approximation [Jensen et al.] to scale $B(\vec{r})$ to take into account the thickness (calculated using a shadow map) and the density of object. The main problem with this model is that it can handle very few kinds of paths, and a further drawback of this approach is that the final image is sharper then the dipole approximation. This problem can be solved by adding another funnel in the model, which does not accumulate light paths, but spreads them near to the outgoing point x_{out} (Figure 1.b). This softens the appearance of the resulting image. We implemented this second funnel by applying a Gaussian filter only to the subsurface scattering layer (A_0). First this layer is dilated in order to avoid errors during smoothing, then downsample it, and we apply in sequence two Gaussian filters (we get as result A_1 and A_2). We use a Gaussian with $\sigma = 2\sigma_s$, where σ_s is the reduced scattering coefficient of the material due to a direct correlation with the appearance softness and σ_s. Finally we blend these three layers using $color = \frac{A_0+2\sigma_s A_2+\sigma_s A_3}{1+3\sigma_s}$. This blending can achieve a soft appearance and keep some of the sharp features that are lost with application of the Gaussian filter. Finally we also solved in a efficient way the *shift problem* observed in [Banterle and Chalmers]. Instead of using a ray-box intersection per shader (which is computationally expensive), we correct $\vec{r}$ for calculating $B(\vec{r})$ using a parallax vector that achieves the same result.

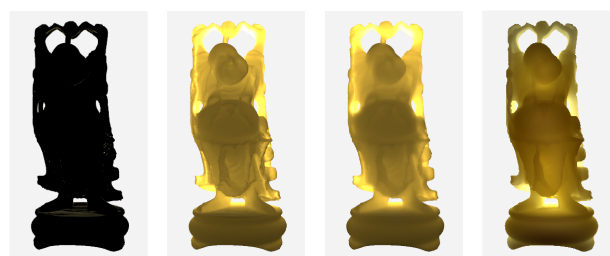


(a) (b)

Figure 1: Comparison between the new model and the old one: a) the old model in which there is only one funnel that accumulate irradiance in x_a. b) the new model we can model more paths, thanks to a second funnel that scatters paths when they reach the surface.

2 Results

We implemented the proposed technique on a GPU, using DirectX9c. For all the results, we used an Intel Pentium4 3.2 GHz PC, equipped with 2GB RAM and a NVIDIA GeForce6600 graphics board. The rendering viewport was 512x512 in window mode, and we chose a resolution of 64x64 for the faces of cubemap (Figure 2).



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

Figure 2: Results using Stanford's Happy Buddha (69K triangles version): a) without subsurface scattering b) with subsurface scattering using the algorithm presented in [Banterle and Chalmers] (67fps) c) uur new algorithm with two funnels (58fps) d) ground thruth using Precomputed Radiance Transfer.

3 Conclusion and Future Work

We extended the fast Funnel Approximation for translucency material and achieved a softer appearance equivalent to scattering properties. Also we sped-up the *shift problem* using parallax. In this work we also tried to extend this model to heterogeneous materials using multiple accumulation and one spread funnel, but we achieved very low frame rates. So we can conclude that the technique is not practical for heterogeneous materials, because it was designed for having a good balance between quality of the appearance and speed.

4 Acknowledgments

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References

BANTERLE, F., AND CHALMERS, A. A fast translucency appearance model for real-time applications. In *Proc. of SCCG '06*.

JENSEN, H. W., MARSCHNER, S. R., LEVOY, M., AND HANRAHAN, P. A practical model for subsurface light transport. In *Prof. of SIGGRAPH '01*.

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