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Paper Summary

**Redefining A in RGBA: Towards a Standard for Graphical 3D Printing**

In this paper, the writers try to redefine a new way of encoding 3D printing data to incorporate translucence. Currently, there is no good way to store this type of information alongside the RGB values free from specific 3D printing hardware. This isn't great, as if you wanted to transfer different models between different printers the translucence might not transfer properly. This is especially relevant now that we have multi-material printers. There are many specified 3D file formats out there, some which have a translucency attribute, but never actually establish a standard for the value.

The authors propose a new way of calculating the A coefficient in RGBA files. This new way will allow the files to also be scaled properly and keep the correct translucence properties (which correlate with the thickness and size of the objects). The calculations for the A value originate from the bidirectional surface scattering reflectance distribution function (BSSRDF), which accounts for the absorption of light when it hits a substance and the scattering of light beneath the surface, most of which reflects back out of the surface of the object. This is mainly made up of *lateral (subsurface) light transport* and *vertical light transport.* Lateral light is the light that scatters internally and reflects back at the viewer, while the vertical light is the light emerging from the back of the object, and scattering and shining through to the side of the viewer. The information from the BSSRDF function bases the calculations for their coefficients associated with their A value.

The premise of their calculations is based on *reference materials,* which are values calculated independent of the wavelengths (or colors) from the objects. This allows the A value to be device independent. Essentially, A is made up of two smaller coefficients - $\alpha$, the absorption coefficient, and *s,* the scattering coefficient. This is from the *mean free path* of a photon, which is the average distance a light particle travels before an event occurs (it scatters, or it's absorbed).

$$mean\,free\,path\ =\ 1/(\alpha\ +\ s)\ =\ 1/\eta$$

They formulated calculating A based off of these two coefficients to be so:

$$A(\alpha, s)\ =\ \phi(\hat{A}(\eta(\alpha, s)))\ =\ \phi(1\ -\ e^{-c\eta(\alpha,s)})$$

This allows the object to be fully transparent when $\eta$ = 0, and fully opaque when $\eta = \infty$. The constant c is inspired by Lambert's law, dealing with losing more light the farther the light travels.

Measuring $\alpha$ and s values from physical substances is a bit difficult. The authors calculate the edge-loss difference from shining a light through the object, measuring the diameter of the light entering the object (the incident light), and the diameter of the light exiting from the object (the detected radiance) as well as the difference in intensity. From this, you can compare it to the values from a completely translucent object (they use air). They then take the minimum values from the equation formed to give you an A value.

This model allows easy adjustment to the print size. Because we have the mean free path of the light particles (we can calculate it from A's coefficients), we can then scale that by the scale factor of the model. Scale the size of the object by k, then the number of scattering events will scale by k.

Their new model helps create a pathway for having a standard file format among different pieces of 3D printing hardware, as well as contributing a possible consistent format for simulating the prints graphically before printing.