Simulating Nature

Day light sky color

It took me quite some time to implement, more or less successful, the sky color part of the Preetham et al. paper "Practical Analytic Model for Daylight". So i want to provide some stuff which might help others finding the information required to get at least something sky-like-looking together. All color conversion matrices and functions, sourcecode and other things are provided.

Overview

The **Practical Analytic Model for Daylight** suggests a simple model for parametric sky color computation and scattering. I just cover the sky color computation.

Chromaticity

To get the sky color we first compute the chromaticity(xy) and luminance(Y) at the zenith with the given sun position (theta,phi) and turbidity(T).

$$Mx_{zenith} = \begin{pmatrix} 0.00166 & -0.00375 & 0.00209 & 0 \\ -0.02903 & 0.06377 & -0.03203 & 0.00394 \\ 0.11693 & -0.21196 & 0.06052 & 0.25886 \end{pmatrix}$$

$$My_{zenith} = \begin{pmatrix} 0.00275 & -0.00610 & 0.00317 & 0 \\ -0.04214 & 0.08970 & -0.04153 & 0.00516 \\ 0.15346 & -0.26756 & 0.06670 & 0.26688 \end{pmatrix}$$

$$x_{zenith} = \begin{pmatrix} T^2 & T & 1 \end{pmatrix} \cdot Mx_{zenith} \cdot \begin{pmatrix} \theta_{sun}^3 \\ \theta_{sun}^2 \\ \theta_{sun} \\ 1 \end{pmatrix}$$

$$y_{zenith} = \begin{pmatrix} T^2 & T & 1 \end{pmatrix} \cdot My_{zenith} \cdot \begin{pmatrix} \theta_{sun}^3 \\ \theta_{sun}^2 \\ \theta_{sun} \\ 1 \end{pmatrix}$$

$$Y_{zenith} = (4.0453 \cdot T - 4.9710) \cdot tan\Big((\frac{4.0}{9.0} - \frac{T}{120}) \cdot (\pi - 2\theta_{sun})\Big) - 0.2155 \cdot T + 2.4192$$

Distribution

For the color distribution on the sky the paper suggested the Perez Model. The parameters A,B,C,D and E for x,y and Y are in the appendix (A2) of the paper.

$$distribution = \frac{\mathcal{F}_{perez_0}(A,B,C,D,E,\theta,\gamma)}{\mathcal{F}_{perez_1}(A,B,C,D,E,0,\theta_{sun})}$$

Getting the color

After the chromaticities and distributions for x,y and Y are computed we are almost done. Now we have to fit everything together to get a Yxy color value for sample point on the sky.

$$Y_{sky} = Y_{zenith} \cdot distribution_Y$$

$$x_{sky} = x_{zenith} \cdot distribution_x$$

$$y_{sky} = y_{zenith} \cdot distribution_y$$

Color Conversion

Once you have computed the chromaticities and the distribution(Perez Function) you get a color sample in **Yxy** Space. Now, unfortunately, we have our vertex colors in **RGB** space. So how to get there? Fist, we convert our **Yxy** into **CIE XYZ** tristimulus values.

$$\begin{aligned} \mathrm{X}_{XYZ} &= x_{Yxy} \cdot \frac{Y_{Yxy}}{y_{Yxy}} \\ \mathrm{Y}_{XYZ} &= Y_{Yxy} \\ \mathrm{Z}_{XYZ} &= (1 - x_{Yxy} - y_{Yxy}) \cdot \frac{Y_{Yxy}}{y_{Yxy}} \end{aligned}$$

Since the luminance Y we get, is pretty big, we have to scale it to get valid (in the range[0.0,1.0]) RGB later. Since i don't know how to do that a better way i just scale it exponentially. There are for sure better and more correct ways to do that.

$$\mathrm{Y}_{Yxy} = 1 - e^{-\frac{1.0}{25.0}} \cdot Y_{Yxy}$$

So we are still not at the end. The conversion matrix from CIE XYZ to RGB (D65 Whitepoint) looks like this.

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = \begin{pmatrix} 3.240479 & -1.53715 & -0.49853 \\ -0.969256 & 1.875991 & 0.041556 \\ 0.055648 & -0.204043 & 1.057311 \end{pmatrix} \cdot \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

Screenshots

Source Code

I stripped this code directly out of the OpenMountains CVS. It doesn't run without changes and the Skydome is written using the **OpenSceneGraph** library. The DaySky class which is responsible for the sky color computation doesn't rely on any other part of OpenMountains or OSG. The color conversion functions are included.

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