Skyglow

Towards a Night-time Illumination Model for Urban Environments

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Introduction

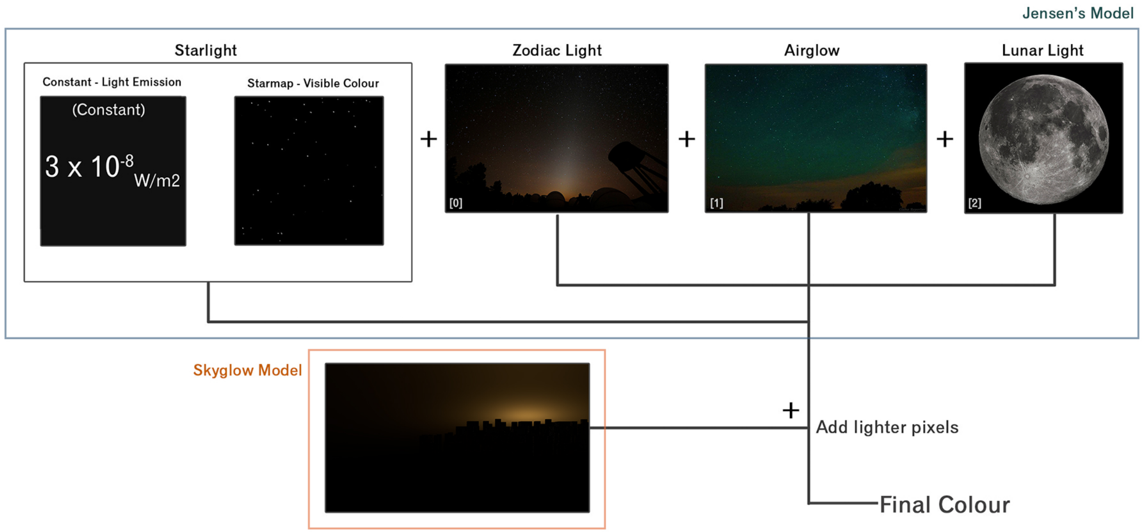
For night-time scenes in computer graphics there exist few consistent models or implementations for sky illumination, and those that do exist lack the feature of light pollution from artificial light sources. We present initial results for a physically-based night sky model including this "skyglow". Our model extends the existing models with the aforementioned "skyglow" from artificial light sources, using a technique derived from equations developed in the field of astronomy and adapted for a computer graphics context. Our current model has been implemented for Pixar's RenderMan renderer and also been trialled with ShaderToy.

Night Sky Rendering State Of The Art

Common methods for Atmospheric Rendering are:

- Nishita et al. [NSTN93]
- Preetham et al. [PSS99], which expands on the former

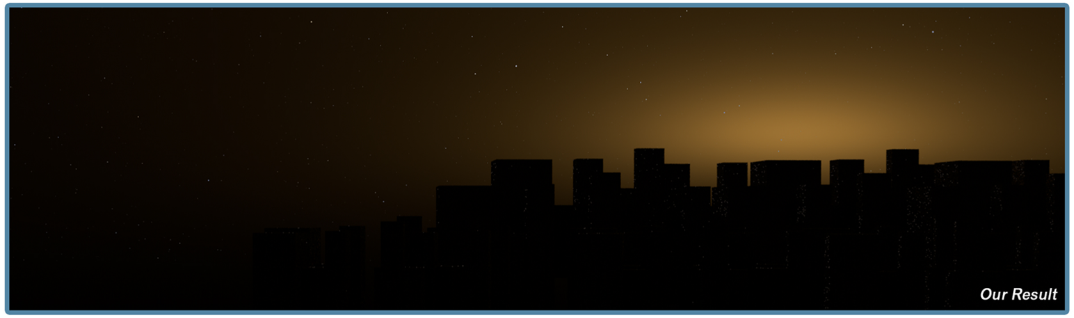
These describe techniques for atmospheric scattering, the phase functions for different types of atmospheric particles and suitable ray-marching integration methods. Jensen et al. [JDD*01] used these as a basis for their night sky illumination model, which calculates the contributions of the different types of natural light sources (starlight, airglow, lunar light and zodiacal light) that result in the colour of the night sky, blended with a procedurally generated starmap of visible stellar objects.



What Is Skyglow?

Skyglow is the effect of artificial light spill, i.e. light pollution, from urban areas reflecting from atmospheric particles. This lightening up of the night sky above built-up areas due to artificial light sources is a noticeable omission in CG night-time illumination models. In the visual effects industry to achieve this effect, either photographic background images that include skyglow are used, or the skyglow effect is painted in by artists.

In the field of astronomy, where light pollution is a problem for those observing the night sky, models for predicting skyglow from artificial light sources have been developed to allow astronomers aid astronomers in the selection of observation sites. Both Garstang [Gar86] and Yocke et al. [YHH86] describe analytical methods for modelling skyglow. A comprehensive survey and review of different light pollution models was presented by Garstang [Gar91].



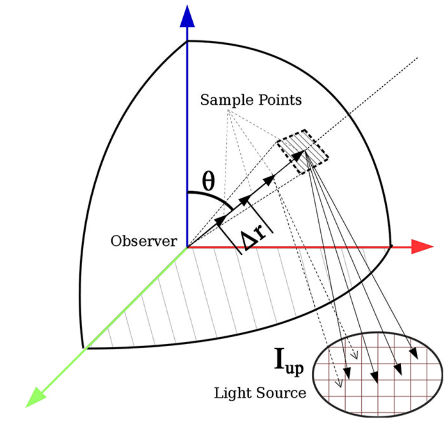
Towards a Night Sky Model including Skyglow

We have implemented our model using RenderMan RIS, adding skyglow to the night sky. We represent the urban area from which light pollution emits as a disk [Gar86] from which light samples for each sub-ray sample are taken using disk point picking [Wei]. We employ the atmospheric ray-marching equation proposed by Yocke et al. [YHH86] – using optimisations similar to those described by Nishita et al. [NSTN93] – to determine the skyglow component of our illumination model.

$$I(\lambda)_{r+\Delta r} \simeq \frac{\phi(\lambda,\theta)}{4\pi} b_{scat}(\lambda) F_s(\lambda)\Delta r \; - \langle b\rangle_{ext}(\lambda) I_r(\lambda)\Delta r + I_r$$

Where I is the spectral irradiance, λ is the wavelength of light, r is the distance along the ray, Δr is the distance between sub-ray samples, φ(λ,θ) is the phase function defining the distribution of photons scattered by particles of a given wavelength with the scattering coefficient $b_{scat}(\lambda)$ and the integration function for the extinction coefficient $\langle b\rangle_{ext}(\lambda)$, and $F_s(\lambda)$ is the flux from the source in $Wm^{-2}\mu m^{-1}$ for a given wavelength.

For every sample along the ray there are multiple light source samples and the sum of these, multiplied by Δr is the resulting skyglow component, which is used as the intensity value of the skyglow colour. We then add the skyglow component to the night sky resulting from the method by Jensen et al. [JDD*01]



Conclusion

We have presented an initial model for night sky rendering that includes skyglow from light pollution, which is still work in progress So far we only calculate the intensity and distribution of skyglow, using an estimate of its colour, which we hope to improve through adding a more accurate method for obtaining the colour of the skyglow. To provide a more complete model, this work could be combined with calculations of light-spill from buildings as presented by Munoz-Pandielle et al. [MAP13], as this is one of the primary causes of skyglow.

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