osgHimmel

Photorealistic Rendering of Day and Night Sky Phenomena in Interactive 3D Geovirtual Environments

open source

System for Image-Synthesis of Skies

Applications such as video games and simulators (e.g., flight and vehicle simulators), as well as architectural and historical visualizations demanding spatiotemporal correctness, often benefit from appropriate environment rendering and seamless transitions of day and night skies. With osgHimmel we present a system that features texture-based, and simulation-based approaches for interactive, photorealistic image-synthesis of dynamic skies.

Figure 1: Composed extracts of simulated backdrops of our dynamic day-night transition.

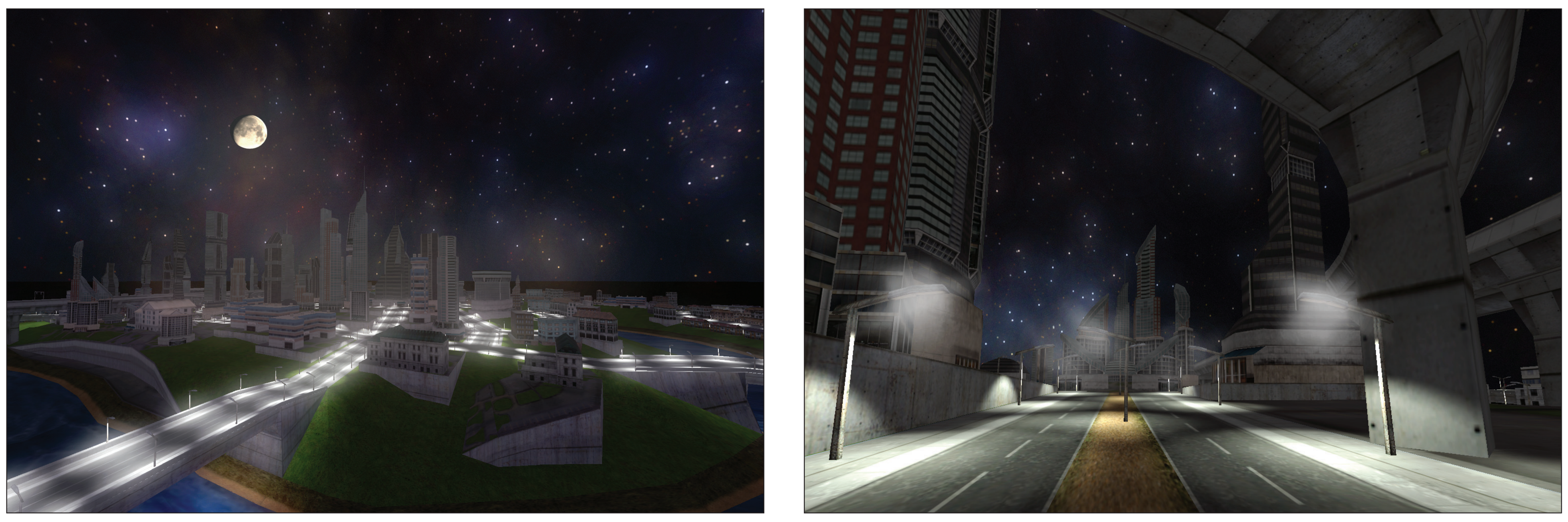

Figure 2: Two renderings within an imaginary, virtual 3D city model and our simulated night sky applied. The sky features correct lunar illumination, orientation and positioning, as well as accurate stars. It provides various parameters for adjustments towards arbitrary needs and deviations from simulation.

Traditional and Astrophysical Rendering

The texture-based, traditional approach targets the imitation of any environment with hardly any creative limitations:

- Minimal performance impact: textured screen-aligned-quad.
- Support for most common projections: polar-, shere-, paraboloid-, and cube-mapping (with optimized texel density).
- Time controlled texture transitions allowing for day-night-cycles or weather changes.
- Improved dynamic, e.g., through rotation around the zenith.
- Collection of diverse imagery for timed texture-transitions.

The simulation-based, astrophysical approach, in contrast, is based on astronomical algorithms and astrophysical observations:

- Rendering within a single pass supporting interactive day-night cycles with low performance impact.
- Skies seen from low altitudes on earth, in respect to geolocation, date, and time.
- Composition of atmosphere with sun, multiple cloud-layers, moon, bright stars, and Milky Way, into a holistic sky.
- Believable atmosphere through Mie- and Rayleigh scattering, refraction, and blue hour approximation.
- Rendering of a 3d moon, correctly lit and shaded, with support for dynamic lunar eclipses.
- Rendering of thousands of individually stars also indicating the Milky Way.

Both approaches are optimized for rendering dynamic day-night cycles within a single rendering pass and without subsequent processing.

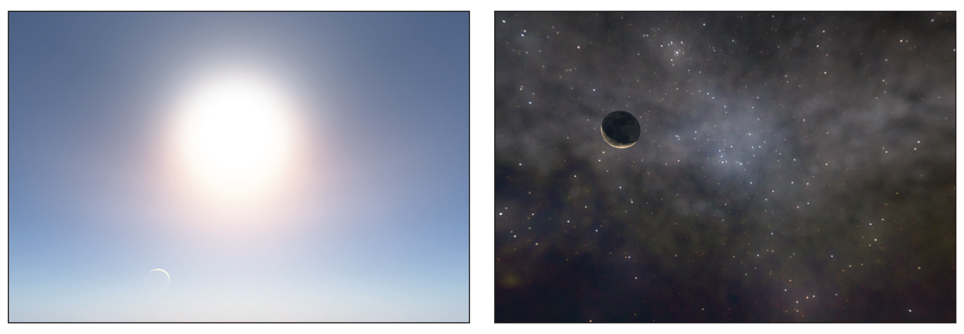

Figure 3: Simulated atmosphere with sun and moon (both enlarged) after sunrise (left). Night sky with the moon and Orion's Belt in the center (right). GPU generated, viewpoint-aligned billboards are used to render stars with approximated color, brightness, and scintillations. Note the faint Milky Way, the moon's earthshine masking the background, and the atmospherical scattering attenuating the stars.

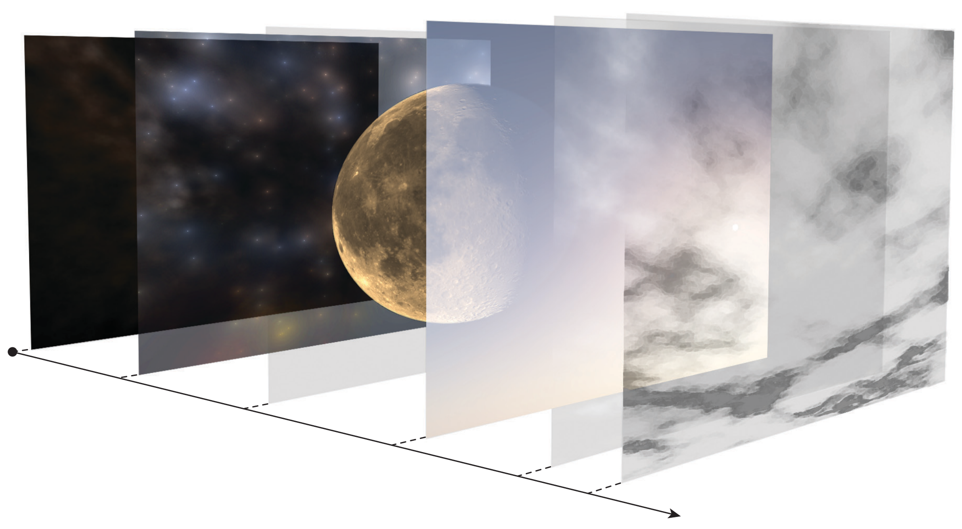

Figure 4: Layered, sequential composition of all phenomena.

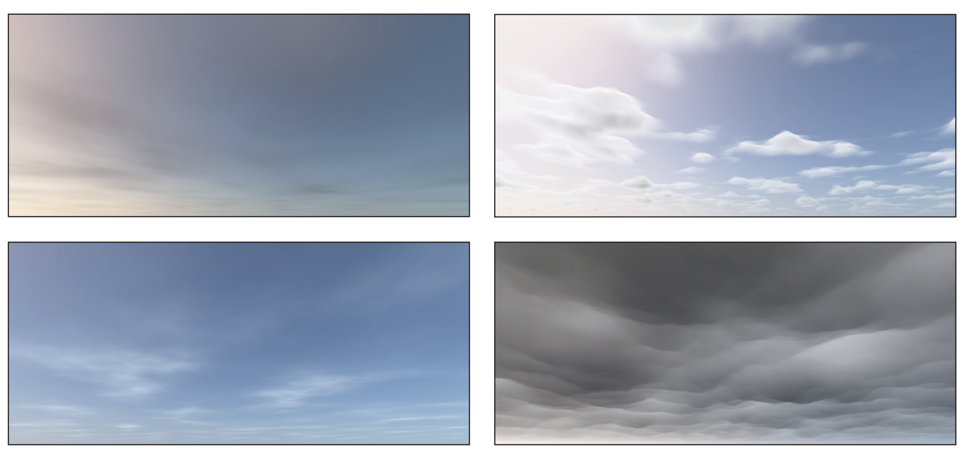

Figure 5: Examples of different clouds at various altitudes and density levels rendered with our system. High, two-dimensional clouds (left column) and lower-lying, three-dimensional clouds (right column) allowing for approximation of cirrus clouds, dark rain clouds, or complete cloud cover.

Figure 6: Simulated skies under various cloud layers and different atmosphere properties, at different times of the day. From top to bottom: early morning with high humidity, afternoon with dark clouds, sunset with colored clouds, and finally, a cloudy night at full moon.

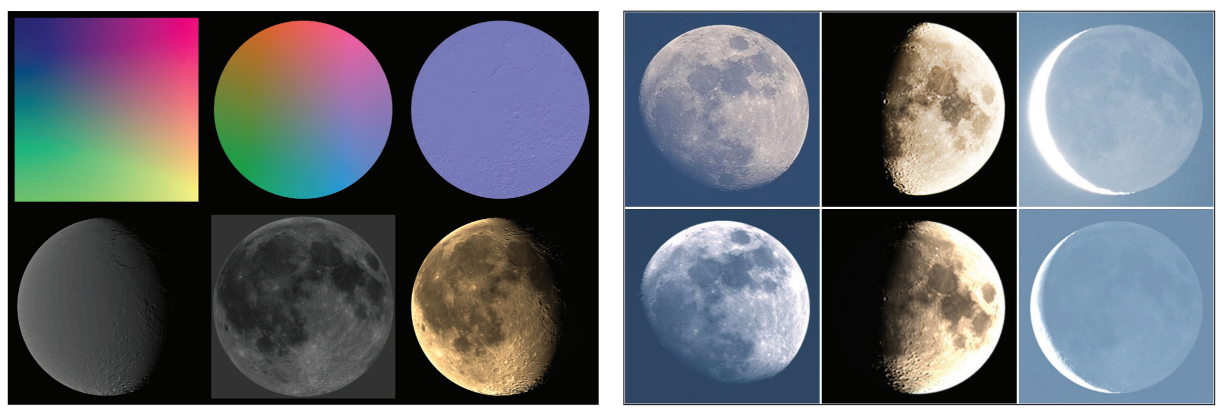

Figure 7: The moon is modeled entirely on the GPU as a viewpoint oriented billboard: a quad, projected onto a unit-sphere's tangent plane, oriented with respect to the world's up direction. On that we simulate the virtual moon-sphere (left). Various photos of the moon in the top right and our renderings in the bottom right row, at corresponding day, time, and location (right)

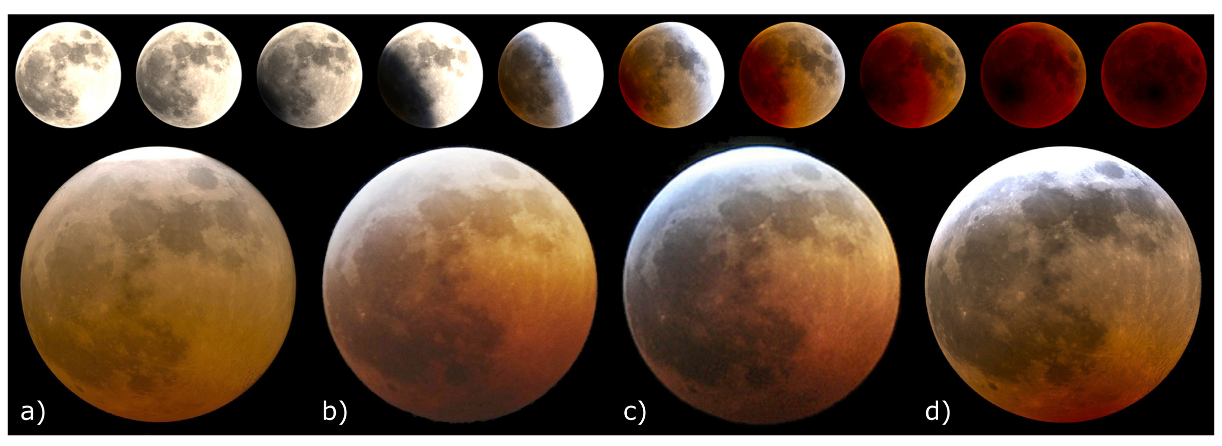

Figure 8: Renderings of the June 15th 2011 total lunar eclipse, as seen from Mangalore, India, using our technique. The images correlate to universal time in 15 minute intervals, beginning at 18:00 UTC on the left (top row). A comparison of a rendering of the December 21, 2010 lunar eclipse viewed from New York about 7:40 UTC, between a) Yapo and Cutler 2009, two photographs b) and c), and using the method presented in this work d).

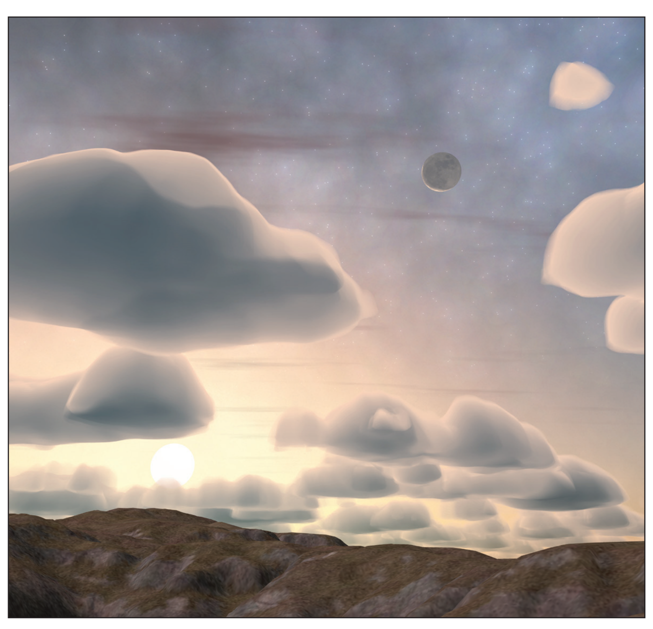

Figure 9: Virtual terrain combined with a sky at day-time, rendered using our system. It contains two cloud layers at 1km (with scattering) and 7km, the moon and the sun (both enlarged), as well as faint star lights.

Challenges and Future Work

The methods provide astrophysical pleasing skies and are well suited for on the fly computations of backgrounds and cubemaps, often required for real-time reflections, global illumination, or various post-processing. Among other issues, blending based on an apparent control magnitude or radiance, modeled for all individual phenomena would be most valuable. This however, requires a uniform integration of all phenomena within a single model. Finally, we would like to address proper, astrophysical pleasing synthesis of solar eclipses.

osgHimmel is and built upon OpenSceneGraph published as an open-source library. It features a yet unprecedented high level of detail and diversity.

Müller, Daniel, Engel, Juri, & Döllner, Jürgen (2012). Single-pass rendering of day and night sky phenomena. Proceedings of the Vision, Modeling, and Visualization Conference 2012.

Müller, Daniel (2012). Photorealistisches Rendering atmosphärischer Effekte in geovirtuellen 3D-Umgebungen in Echtzeit. Unpublished master's thesis for master's degree, Hasso-Plattner-Institut, Universität Potsdam

Source Code, Examples, and Videos: http://osghimmel.googlecode.com

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