

Rendering Systems

Introduction

A6983-1
Computational Design
Practices
Columbia GSAPP
Fall 2025
300 Buell North

Lecture
Tuesday, 7–9pm

Instructor
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Rendering Systems proposes that the computational image is a window into a simulated and systematized representation of reality. To create a rendering is, in effect, to create and frame a model of the entire world, from a single grain of sand to the most complicated urban environment.

Before rendering a new world, we must understand how to capture images in our current one. Over the course of the semester, we will study the fundamentals of light, physics, and perception. We will also situate the rendering in a history of media and medium specificity that overlaps with photography and drawing.

This course places a special emphasis on procedural modeling, procedural texturing, and procedural animation as techniques which serve the dual purpose of allowing for more efficient image making and deepening the image maker's stake in the systems which underpin the final image.

All topics will remain broadly applicable to multiple 3D software engines (in fact, it is a pedagogical aim to demystify the trope of rendering engine comparisons). The class will use Blender, a free and open source application that combines a professional physically-based pathtracing renderer, a realtime (viewport) rendering engine, a powerful suite of procedural modeling tools, and a rich ecosystem of community tutorials, tools, and plug-ins. No previous experience with Blender is required, but some previous modeling experience in a CAD environment such as Rhino is useful.

Course Structure

The course will meet weekly on Tuesday nights at 7pm for a lecture covering a key aspect of computational rendering. The lecture will introduce and explain topics in a generalized manner with commonalities across many rendering engines, programs, and software packages. After class, students will be expected to apply their learnings in Blender, by following 30-45 min of instructional screencasts and additional optional tutorial material.

There will be 3 regular assignments (due the night before class, at 11:59pm) and a final project, to be presented at the final review.

Assignments

Assignment I (due Sep 29)

Tell a story or show a unique vantage point with an intentionally-placed perspectival camera view. Describe how the framing, composition, and camera movement affect the viewer's experience of the image.

Assignment II (due Oct 13)

Find, study, and share a precedent black & white tone drawing, painting, or photo and create a rendering of a model that recreates a particular shadow or lighting effect from the precedent

Assignment III (due Nov 10)

Create a composite image that combines two or more render layers in a novel way.

Final Project (due Nov 24)

Develop an image series that explores the inner workings of a slice, section, segment, or layer of an existing architectural or urban site. Students will use novel rendering techniques, special material, lighting, and optical effects, and a variety of procedural experimentation tools to probe their model from new vantage points and show something through rendering which couldn't otherwise be seen. Students will depict their model as a sequence of images that show a dynamic system in motion.

Course Schedule

Sep 2

Introduction

Introduction to course & syllabus; discussion of Blender and rendering engines; introduction to path tracing, rendering systems, and view passes; introduce final project and show previous work

Sep 9

RGB XYZ

Introduction to 3D graphics; points, polygons, NURBs; normals; coordinate systems, precision; UV coordinates, shaders; geometry attributes

Sep 16

The Technical Camera

Primer on perspective rendering; the mechanics of the technical image; focal length; depth of field; exposure; composition; rendering as photography

Sep 23

Bouncing Light I

A primer on lighting for photography; reading images to understand lighting; exposure; area, point, and hemisphere lights; atmospheric and environmental lighting; shadows; tonemapping

Sep 30

Bouncing Light II

Atmospheric and environmental lighting; architectural lighting; tonemapping

Oct 7

Material Physics

Physically-based materials; BRDF surfaces; reflection, diffusion, transparency, fresnel; microsurfaces

Oct 14	<u>Material Computation</u> Image textures vs. procedural materials; node-based materials; material libraries
Oct 21	<u>Deconstructing the Image</u> Image as data; render passes; post-processing; compositing
Oct 28	<u>Abundance & Environments</u> Procedural systems; instancing & scattering methods; vegetation; organic systems; photoscanned assets; terrain generation; ecologies and biomes
Nov 4	<u>Election Holiday</u> <i>No class</i>
Nov 11	<u>In-Class Assignment 2 Review</u> <i>No lecture</i>
Nov 18	<u>Motion Systems</u> Keyframing motion; generating motion; designing systems of motion; motion graphics; rendering sequences; baking animation data
Nov 25	<u>Final Review</u> <i>No lecture</i>
Requirements	Students are expected to attend every lecture. If you are unable to attend a class meeting, please contact the instructor as soon as possible. This course is graded on the following scale: HP (high pass), P (pass), LP (low pass), or F (fail). Grades will be based on the following factors: 10% attendance, 20% class participation and discussion, 30% assignments, and 40% final project.
Academic Integrity	The intellectual venture in which we are all engaged requires of faculty and students alike the highest level of personal and academic integrity. As members of an academic community, each one of us bears the responsibility to participate in scholarly discourse and research in a manner characterized by intellectual honesty and scholarly integrity. Scholarship, by its very nature, is an iterative process, with ideas and insights building one upon the other. Collaborative scholarship requires the study of other scholars' work, the free discussion of

such work, and the explicit acknowledgement of those ideas in any work that inform our own. This exchange of ideas relies upon a mutual trust that sources, opinions, facts, and insights will be properly noted and carefully credited.

In practical terms, this means that, as students, you must be responsible for the full citations of others' ideas in all of your research papers and projects; you must be scrupulously honest when taking your examinations; you must always submit your own work and not that of another student, scholar, or internet agent.

Any breach of this intellectual responsibility is a breach of faith with the rest of our academic community. It undermines our shared intellectual culture, and it cannot be tolerated. Students failing to meet these responsibilities should anticipate being asked to leave Columbia.

For more information on academic integrity at Columbia, students may refer to the Columbia University Undergraduate Guide to Academic Integrity as well as the GSAPP Honor System and Plagiarism Policy.

Generative AI Use

Certain assignments and/or specific tasks in this course *may* permit the use of generative AI tools, but only when explicitly allowed. For all other assignments, AI use is not allowed.

When approved, any such use must be appropriately acknowledged and cited.

If you find yourself uncertain about the appropriate ways and circumstances to employ it, please feel free to seek guidance from your instructor. Please be aware that each student is responsible for assessing the validity and applicability of any submitted AI output, and violations of this policy will be considered academic misconduct.

Bibliography

Lucia Allais, "Rendering: On Experience and Experiments," *Design Technics: Archaeologies of Architectural Practice* (2020)
Andrew Atwood, "Rendering Air: On Representation of Particles in the Sky"
James Bridle, "The Render Ghosts," *Reading Design* (2019)
Roberto Casati and Patrick Cavanagh, *The Visual World of Shadows* (2019)
Bartosz Ciechanowski, "Lights and Shadows" (2020)
Matthew Fuller and Eyal Weizman, *Investigative Aesthetics: Conflicts and Commons in the Politics of Truth* (2021)
Jacob Gaboury, *Image Objects: An Archaeology of Computer Graphics* (2021)
Will Harrison, "Another Bullshit Night in Slop City," *The Baffler* (2025)
Sam Jacob, "Rendering: The Cave of the Digital," *e-flux* (2018)
Theodore Kim, "The Racist Legacy of Computer-Generated Humans," *Scientific American* (2020)
John May, "Everything Is Already an Image" *Log 40* (2017)
Marcel Minnaert, *Light and Color in the Outdoors* (1993)
Evan Narcisse, "The Natural: The Trouble Portraying Blackness in Video Games," *Kotaku* (2017)
Amelyn Ng, "7D Vision," *e-flux* (2020)
Matt Pharr, Wenzel Jakob and Greg Humphreys, *Physically Based Rendering, Fourth Edition* (2023)

Jeff Russell, "Basic Theory of Physically-Based Rendering,"
Marmoset blog (2020)
Hito Steyerl, "Mean Images," *New Left Review* 140/141 (2023)
Jesús Vassallo, "Seamless: Digital Collage and Dirty Realism in
Architecture," *Log* 39 (2017)
Alan Warburton, *Z* (2012)
Alan Warburton, *RGBFAQ* (2020)