MAT 594G - Introduction to Realistic Image Synthesis

Media Arts and Technology Program
University of California, Santa Barbara

Course Description

Photo-realistic, synthetic images have become ubiquitous in films, television, print, and digital media. A wide variety of algorithms are used to generate these images, and many of them are custom-designed to capture very specific visual phenomena. We will survey these techniques in this course from a phenomenological perspective. Starting from specific visual phenomena that we would like to capture, e.g. the appearance of human skin, brushed metal, or shafts of light piercing a through a cloud, we will examine how existing algorithms synthesize these phenomena effectively and efficiently.

Prerequisite(s):

This course will assume no prior experience in computer graphics. But, as it is focused on image synthesis, it will cover more advanced material than what is usually presented in a general computer graphics class. Students should be comfortable reading C/C++, and writing programs in some high-level language. Examples will be distributed in C/C++, but students are free to complete the assignments in the programming language of their choice.

Instructor:

Theodore Kim, kim@mat.ucsb.edu

Lecture:

Tuesdays and Thursdays, 10 AM to 12 PM
Location TBD

Grading Scheme:

- Readings and Homework assignments 75%

  Initially, homework will consist of writing the basic features for a ray tracer. In later assignments, students will have the option of either implementing more sophisticated features, or using an existing implementation to create non-trivial visual results.
- Term project 25%

  Students will choose from one of two options for the term project. Either implement some significant rendering feature from the literature,or generate an animation using an existing renderer that demonstrates significant temporal phenomena. Examples of such phenomena include motion blur and temporally-aware tone mapping.

Textbooks:

Required:

Physically Based Rendering: From Theory to Implementation, Pharr and Humphreys, 2nd Edition, Morgan Kaufmann, 2010.

Recommended:

Fundamentals of Computer Graphics, Shirley and Marschner, 3rd Edition, AK Peters, 2009.

Realistic Image Synthesis Using Photon Mapping, Jensen, AK Peters, 2001.

Realistic Ray Tracing, Shirley and Morley, 2nd Edition, AK Peters, 2003.

Course Outline:

- **Week 1:** Rendering plastic surfaces

  Basic ray tracing and the Phong shading model.

- **Week 2:** Rendering metal surfaces

  The Bi-Directional Reflectance Distribution Function (BRDF) and the Cook-Torrance model.

- **Week 3:** Soft shadows and glossy surfaces

  Point vs. area light sources and importance sampling.

- **Week 4:** Motion blur and depth of field

  Distribution ray tracing and Monte Carlo integration.

- **Week 5:** Acceleration structures

  Capturing all the previously mentioned visual phenomena simultaneously can involve shooting over a billion rays per pixel. How do we make this faster?

- **Week 6:** Color bleeding

  Diffuse inter-reflection, the radiosity method and the rendering equation. Irradiance caching and irradiance gradients.

- **Week 7:** Focused beams of light, 'God-rays'

  Caustics and photon mapping.

- **Week 8:** Skin, jade and wax

  The Bi-direction Subsurface Scattering Distribution Function (BSSRDF) and the dipole approximation.

- **Week 9:** Using real-world illumination, and the human visual system

  Environment lighting, perceptual considerations, and tone mapping.

- **Week 10:** Final project presentations

- **Additional topics:** Time permitting, some of the following topics may also be covered:

  - Hair rendering
  - Participating media: clouds, smoke and fog
  - Cloth rendering: The Oren-Nayar model
  - Fire and explosions: Blackbody radiation
  - Rendering a CD: diffraction effects