CS130 : Computer Graphics

Spring 2012

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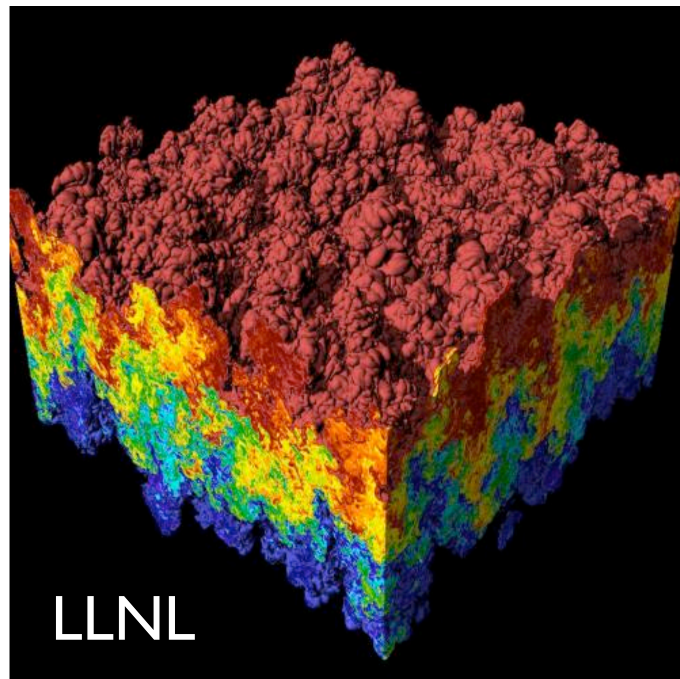
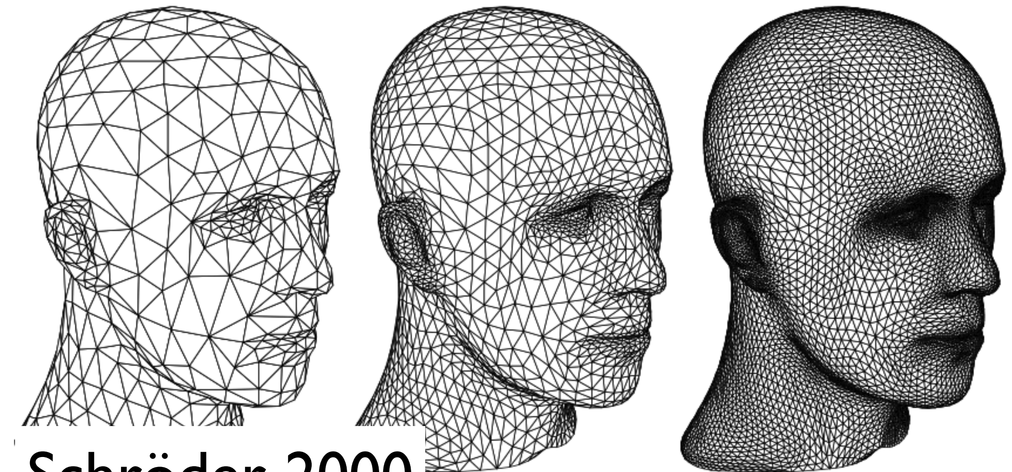
Computer Science & Engineering
UC Riverside

Welcome to CS130!

Talton et al., 2011



LLNL



Schröder, 2000

ILM

Henrik Wann Jensen

Hong et al. 2007

Pixar

Today’s agenda

- Course logistics
- Introduction: graphics areas and applications
- Introduction to OpenGL
- Math review

Course Overview

- Learn fundamental 3D graphics concepts
- Implement graphics algorithms
  - make the concepts concrete
  - expand your abilities and confidence for future work

Course Logistics

- Instructor: Tamar Shinar
- TA: Nam Nguyen
- Website: http://www.cs.ucr.edu/~nnguyen/cs130
- Lectures: MWF 8:10-9am
- Lab: M 2:10-5:00pm, WCH 127
- announcements (assignments, etc.) made in class and on course website

Course Logistics

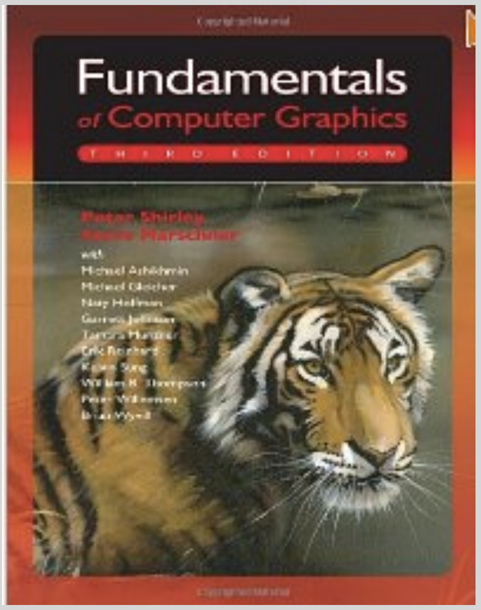
- Grading
  - 10% labs
  - 10% homework
  - 30% assignments (2 assignments, 15% each)
  - 50% tests (2 midterms, 1 final)
- Detailed schedule on class website

Course schedule

tentative; see course website for up-to-date schedule

Lecture	Date	Topic	Reading	Assigned	Due
1	4/2	Introduction	Chapters 1-2		
2	4/4	Graphics Pipeline	Chapter 3		
3	4/6	Graphics Pipeline			
Lab 1	4/2	Introduction to OpenGL			
4	4/9	2D lines and circles	Chapter 8.1.1		
5	4/11	Modeling and Rendering Curves	Chapter 15		
6	4/13	Modeling and Rendering Curves			
Lab 2	4/9	Line Rasterization			
7	4/16	Transformations	Chapters 5-6	Assignment 1	
8	4/18	Transformations (cont.)			
9	4/20	Transformations (cont.)			
Lab 3	4/16	Transformations			
10	4/23	Polygons	Chapters 2.7, 8.1.2		
11	4/25	Polygons (cont.) and Review			
-	4/27	Test 1			
Lab 4	4/23	Modeling with Maya			
12	4/30	Rotations	Chapter 17.2.2		
13	5/2	Rotations (cont.)			
14	5/4	Projections	Chapter 7		
Lab 5	4/30	SLERP			
15	5/7	Projection (cont.)			
16	5/9	Shading	Chapter 10		
17	5/11	Shading (cont.)			Assignment 1
Lab 6	5/7	Programmable Shading			

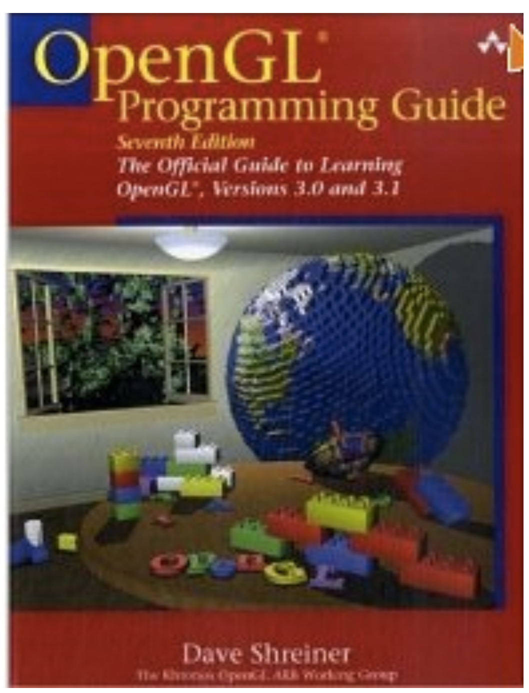
Textbook

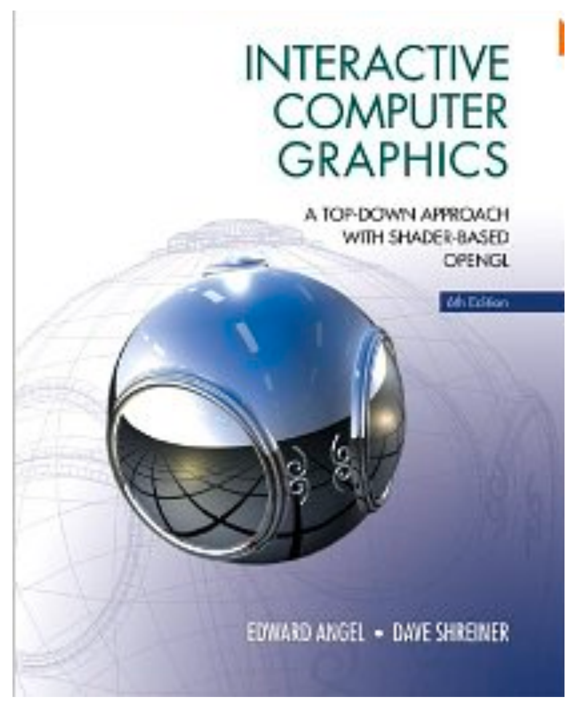


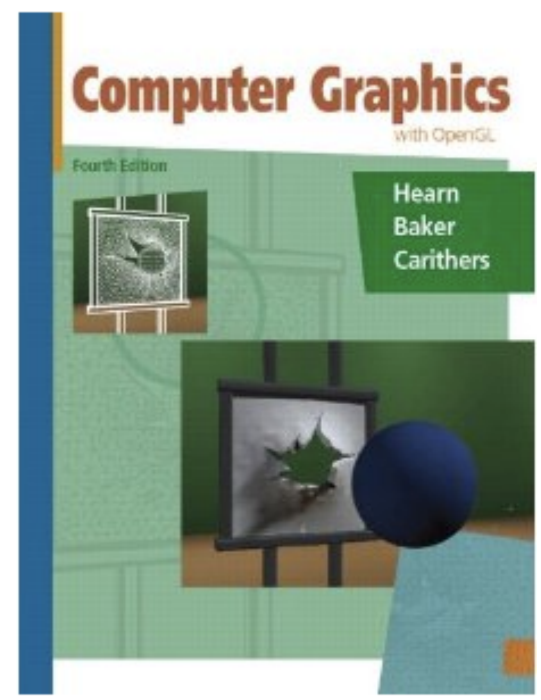
Fundamentals of Computer Graphics

Shirley and Marschner

Additional books







if you like using a book
- red book older version online:http://fly.cc.fer.hr/~unreal/theredbook/
And if you prefer -- all material is online in one form or another -- you don't have to buy a book but it can be useful for a coherent presentation

About your instructors

- B.S., University of Illinois in Urbana-Champaign, Mathematics, Computer Science, Art
- Ph.D., 2008, Stanford University on simulation methods for computer graphics
- Started at UCR in the fall
- Work in graphics simulation and biological simulation

http://www.cs.ucr.edu/~shinar

http://www.cs.ucr.edu/~nnguyen

Introduction

Graphics applications

- 2D drawing
- Drafting, CAD
- Geometric modeling
- Special effects
- Animation
- Virtual Reality
- Games
- Educational tools
- Surgical simulation
- Scientific and information visualization
- Fine art

Graphics areas

- **Modeling** - mathematical *representations* of physical objects and phenomena
- **Rendering** - creating a *shaded image* from 3D models
- **Animation** - creating motion through a sequence of images
- **Simulation** - physics-based models for modeling dynamic environments

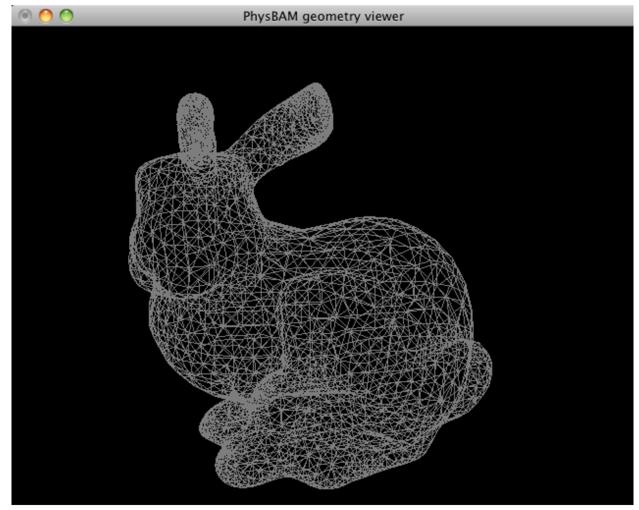
Think about which area interests you, dovetails with your present or future research, or that you want to learn more about

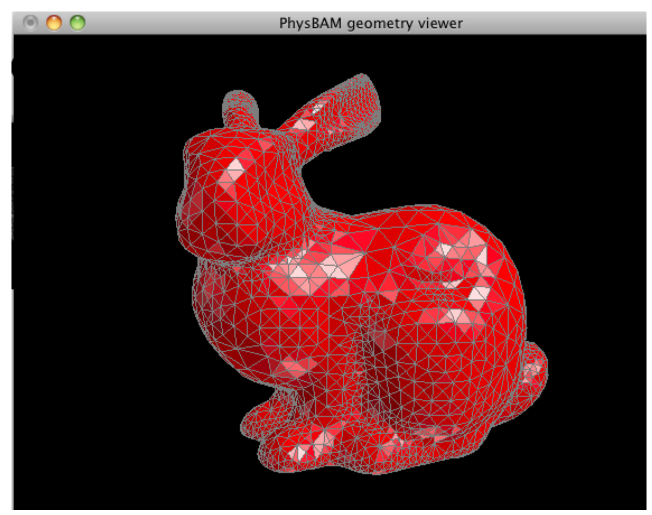
Modeling and **rendering** are separate stage

- first design and position objects -- **modeling**
- then add lights, materials properties, effects -- **rendering**

Modeling


Talton et al., 2011





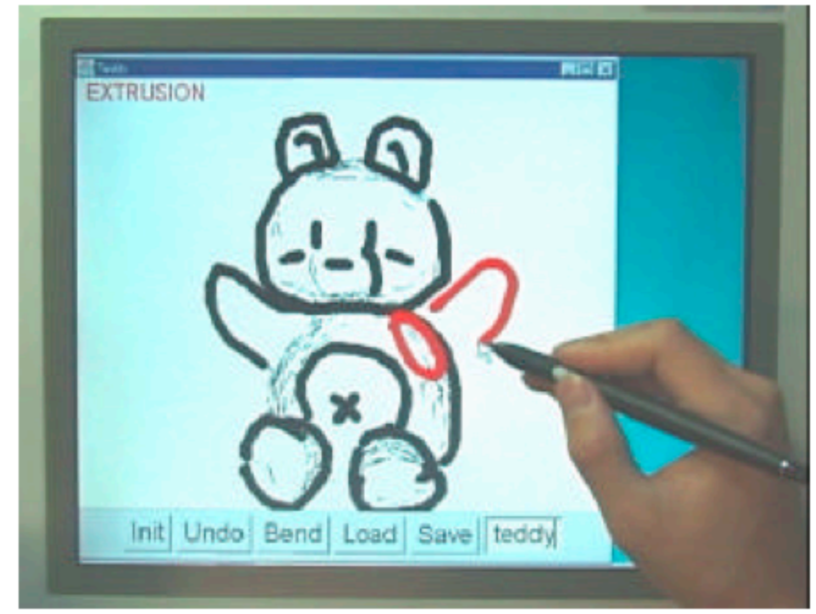
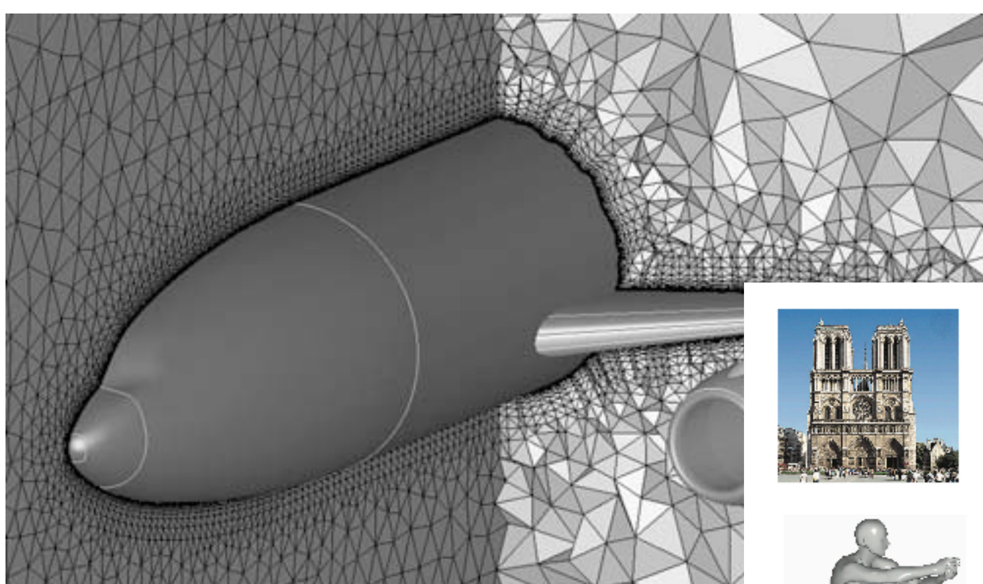
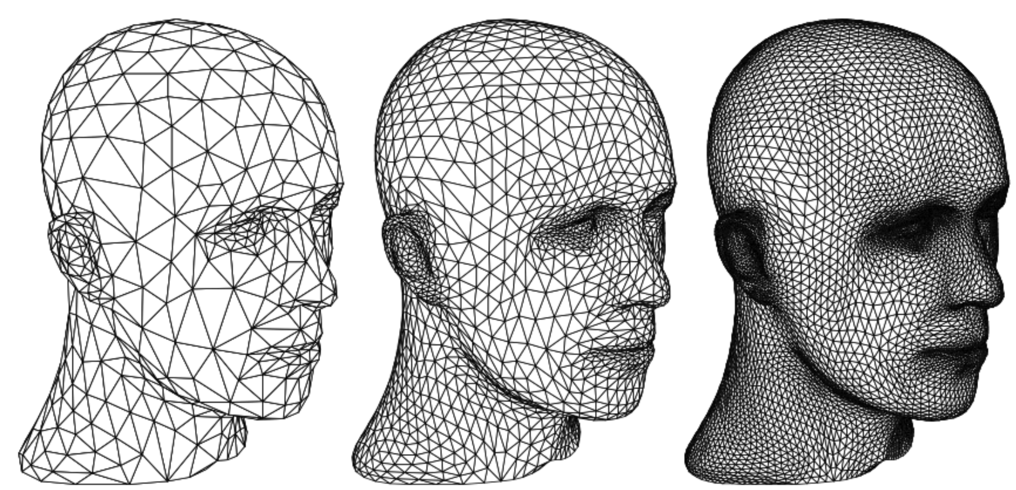


Figure1: Teddy in use on a display-integrated tablet.


Igarashi et al., 2007

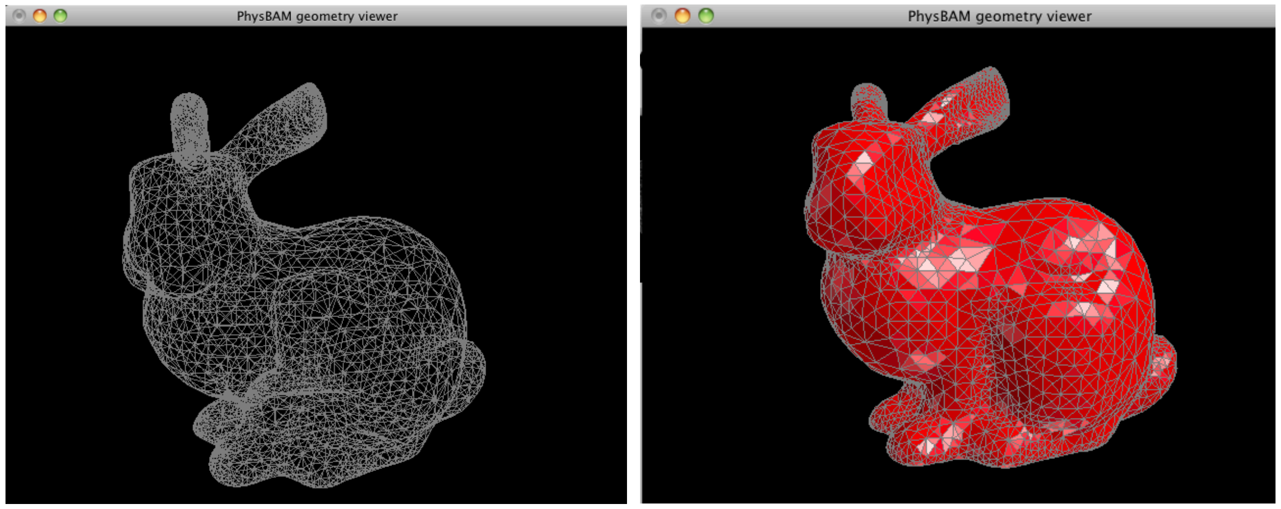

CFD Technologies


Bronstein et al., 2011


Schröder, 2000

- subdivision surface – Siggraph course notes 2000
- Teddy : sketch based interface for 3D modeling
- Talton et al. -- procedural modeling – for games, virtual worlds, design, etc.
  - combine machine learning and graphics
- Bronstein – reasoning about geometric models for search

Rendering

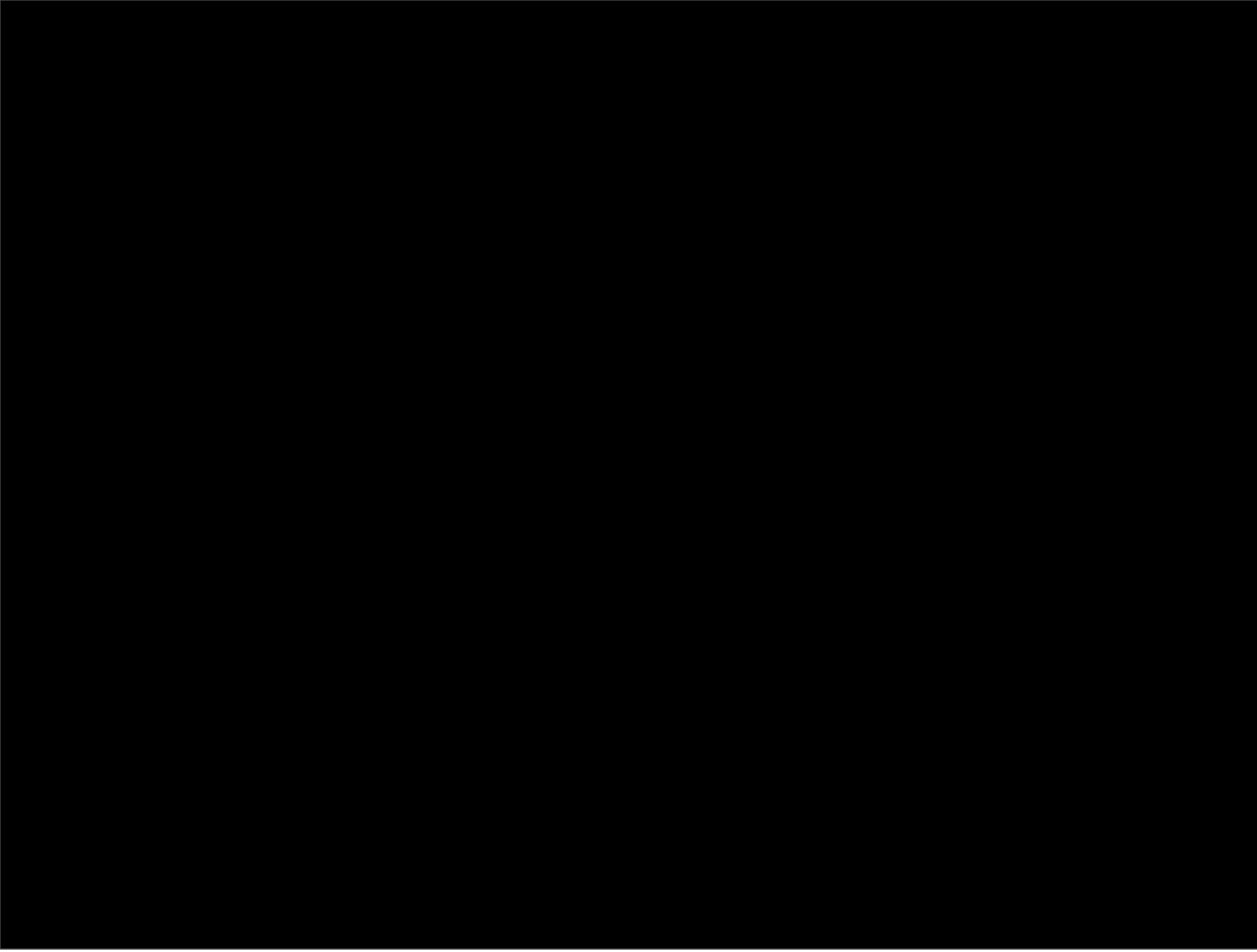



Hong et al. 2007

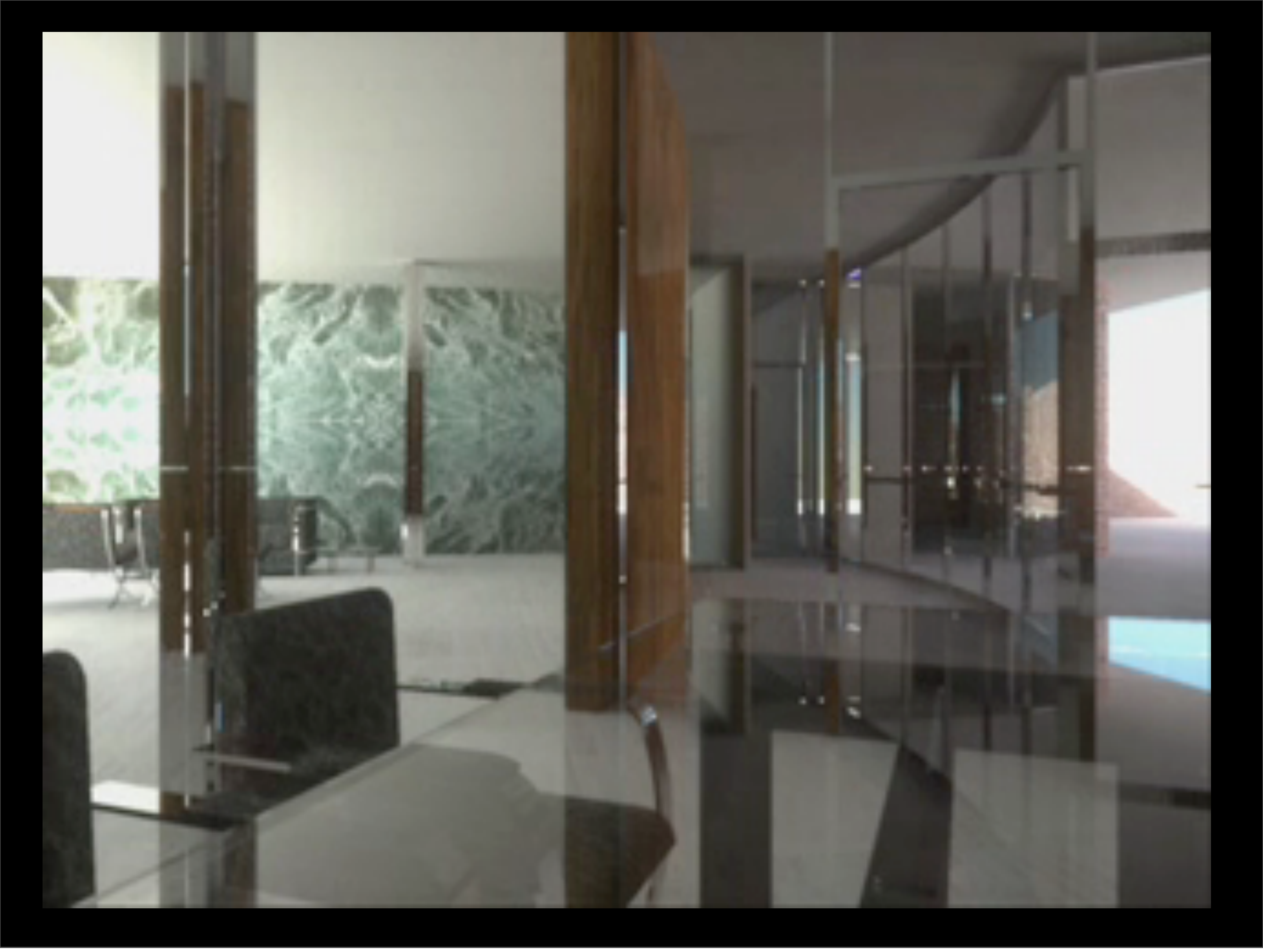

Henrik Wann Jensen


d'Eon and Irving, 2011

- opengl - 3D graphics (z-buffer) rendering
- **teapot - image-based lighting -** illuminated by a high dynamic range environment - metal, glass, diffuse, and glossy
- **subsurface scattering** - to capture translucent materials such as skin and marble
- rendering a emissive material such as fire - **participating medium** - scattering, absorption
- **local** vs **global** illumination



– direct vs. global illumination



- direct vs. global illumination

Animation

Sleeping Beauty, Disney, 1959

Adventures of Tintin, Weta 2011

Animation

Sleeping Beauty, Disney, 1959

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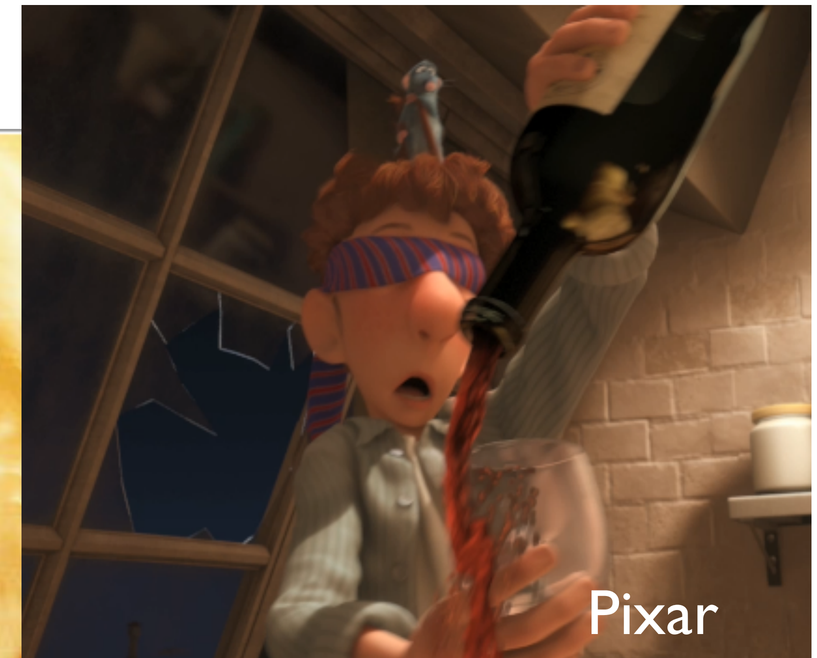
Simulation



Firestorm
Harry Potter and the Half Blood Prince
Industrial Light + Magic

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Harry Potter and the Half Blood Prince
Industrial Light + Magic

fluid simulation in Pixar's *Ratatouille*

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Introduction to OpenGL

Introduction to OpenGL

- **Open G**raphics **L**ibrary, managed by Khronos Group
- A software interface to graphics hardware
- Standard API with support for multiple languages and platforms, open source
- ~250 distinct commands
- Main competitor: Microsoft's Direct3D
- **http://www.opengl.org/wiki/Main_Page**

- used to produce interactive 3D graphics
- sits between programmer and 3D accelerators and hardware
- **standard** requires support for feature set for all implementations
- Both OpenGL and Direct3D support feature sets -- they take advantage of hardware acceleration or use software emulation when a feature is unavailable in hardware
- Direct3D is proprietary
- OpenGl and Direct3D both implemented in the display driver

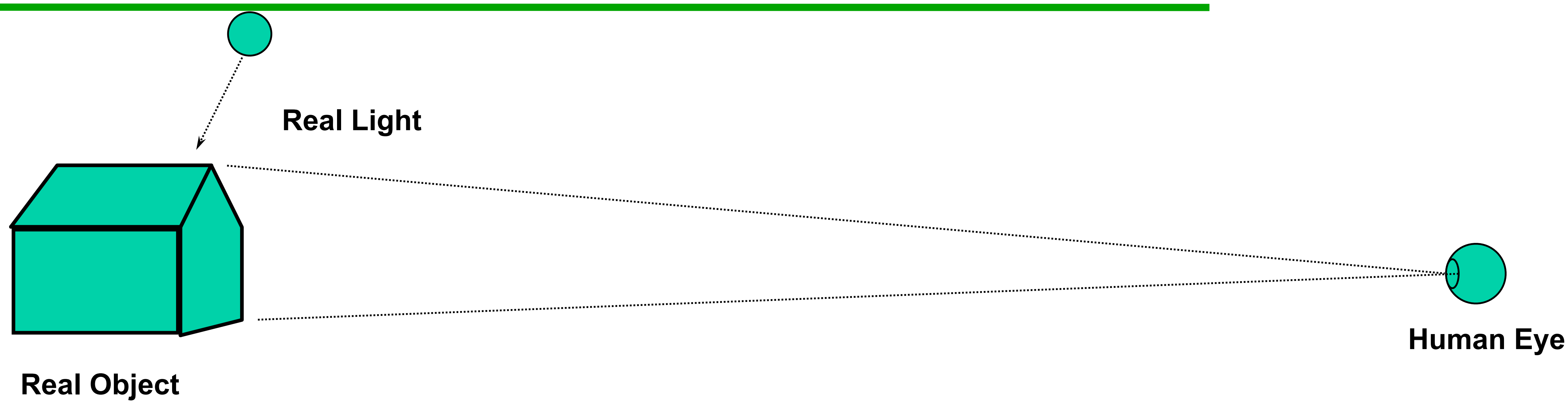
OpenGL - Software to Hardware

- Silicon Graphics (SGI) revolutionized the graphics workstation by putting graphics pipeline in hardware (1982)
- To use the system, application programmers used a library called GL
- With GL, it was relatively simple to program three dimensional interactive applications

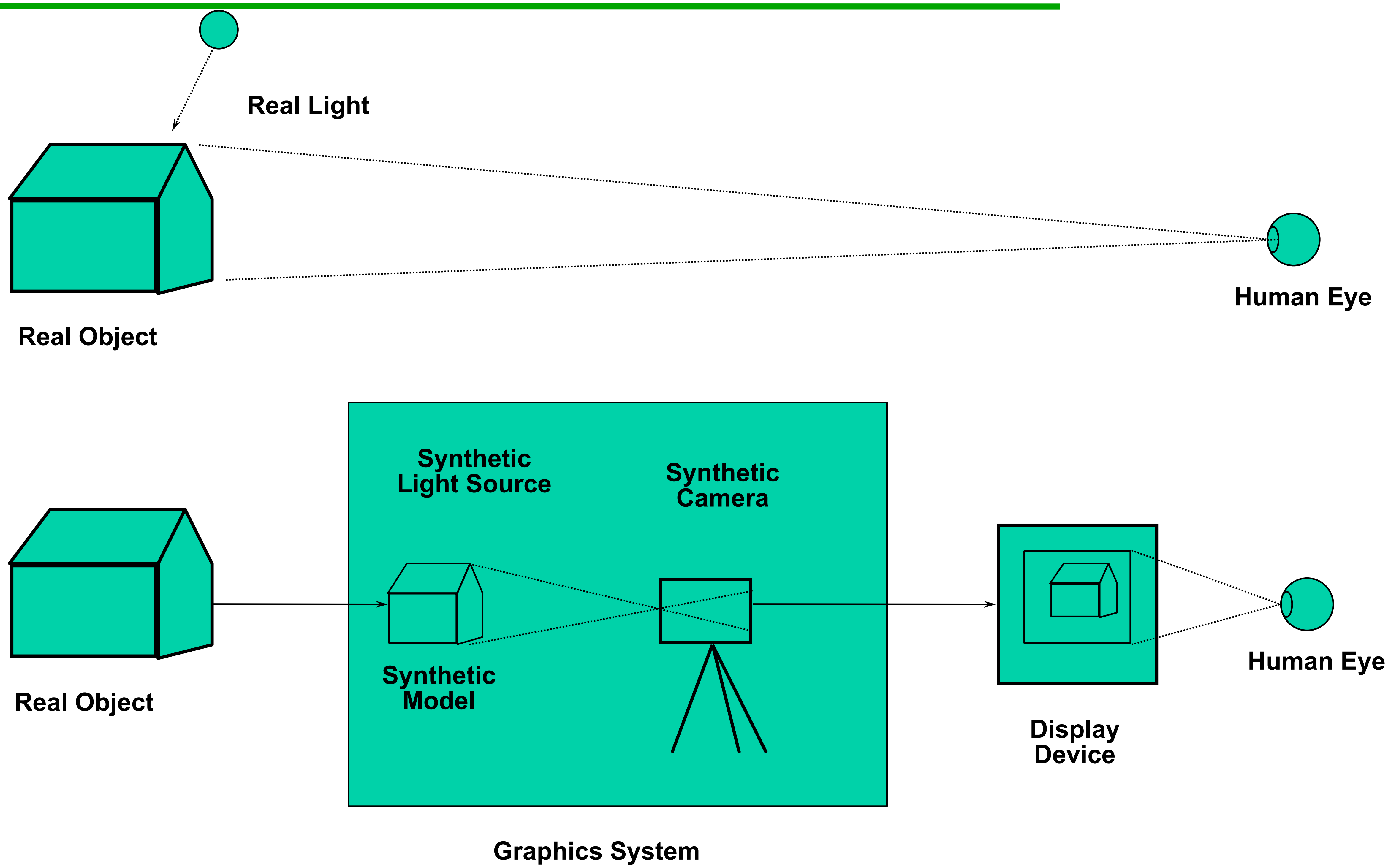
OpenGL

- The success of GL lead to OpenGL (1992), a platform-independent API that was
  - Easy to use
  - Close to the hardware - excellent performance
  - Focus on rendering
  - Omitted windowing and input to avoid window system dependencies

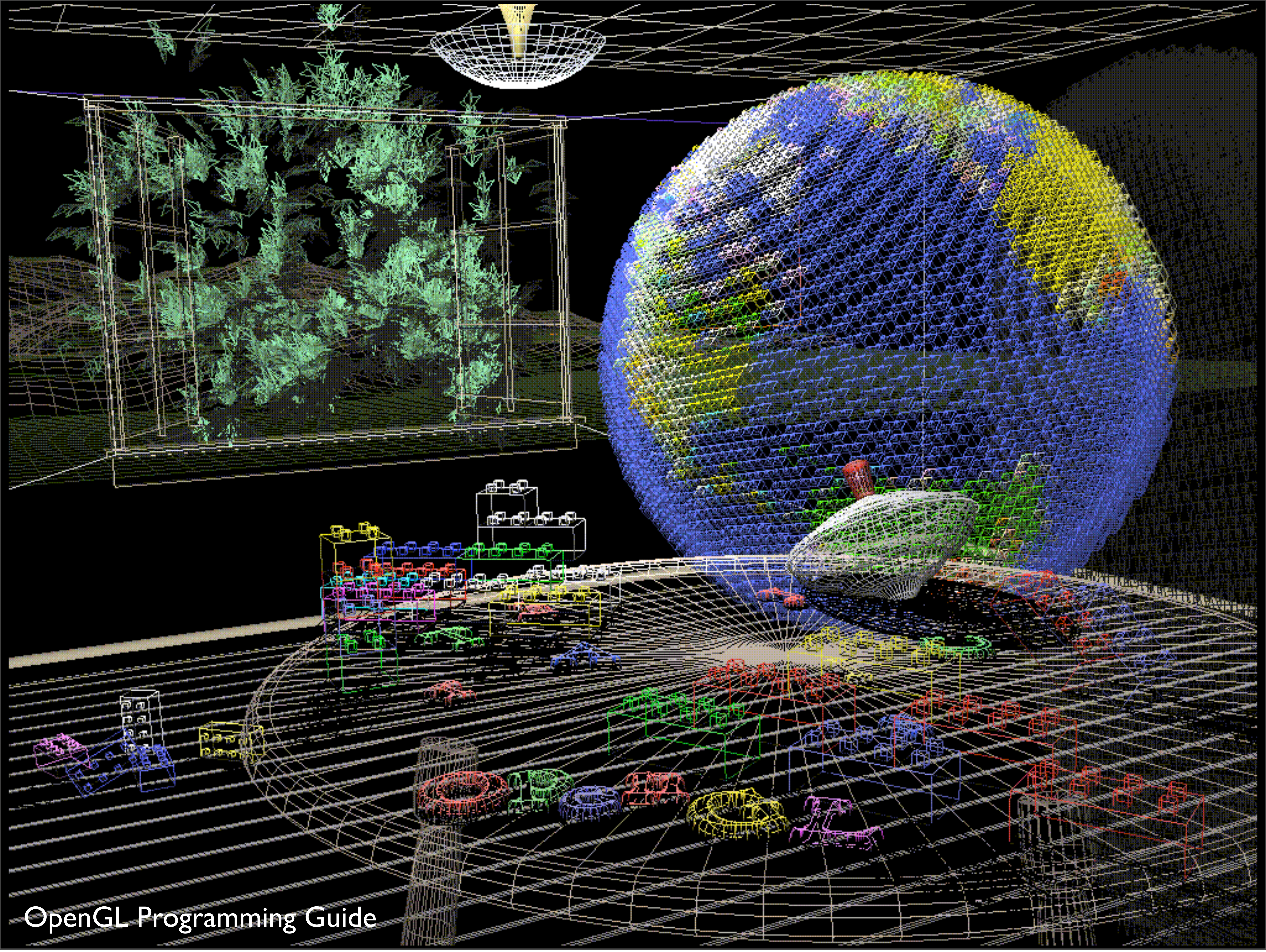
OpenGL: Conceptual Model



OpenGL: Conceptual Model



What can OpenGL do?
Examples from the
OpenGL Programming Guide (“red book”)



- **Wireframe** models
    - shows each object up of polygons
- the **lines are are the edges** and the **faces of the polygons make up the object surface**

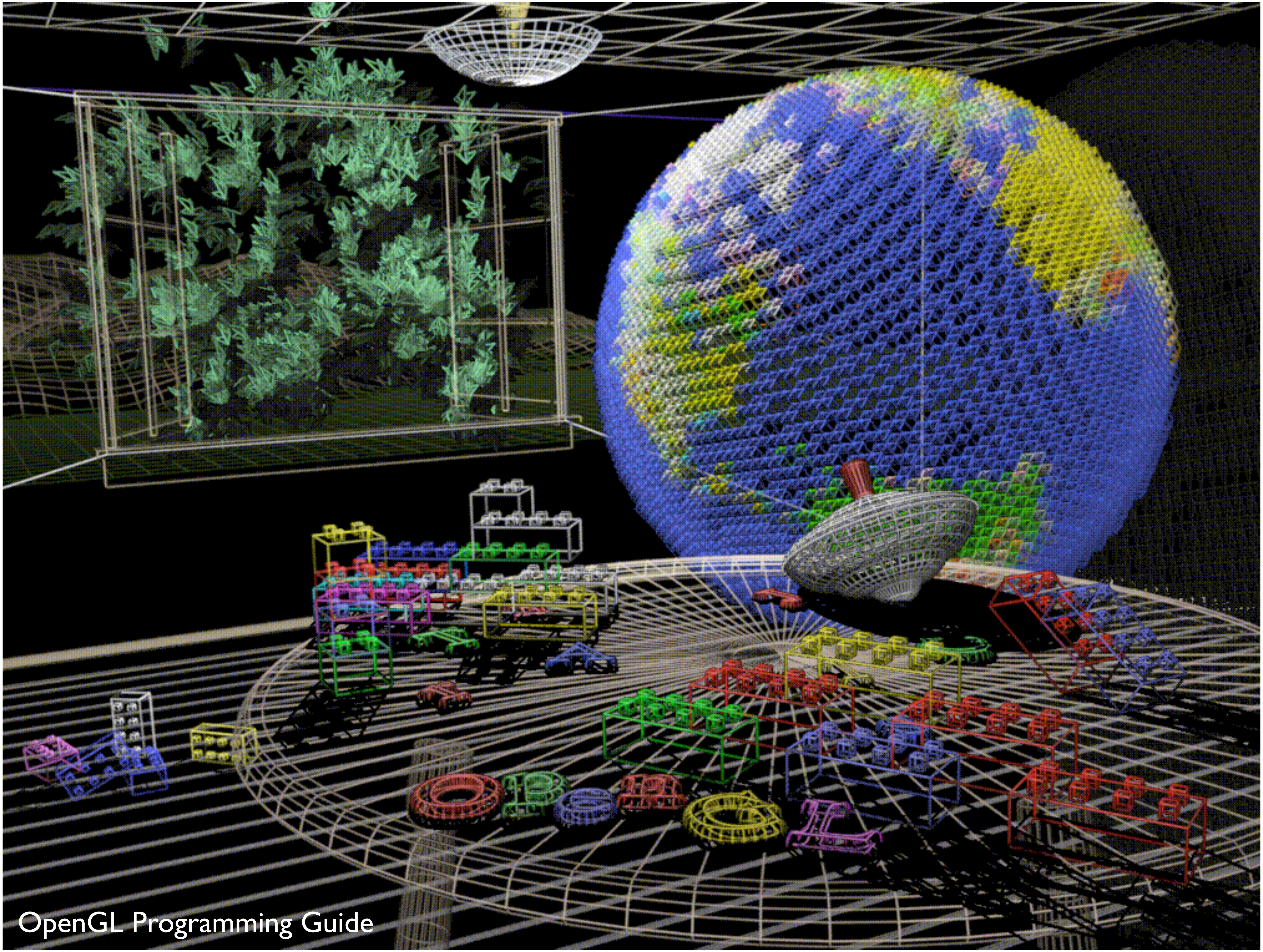


Plate 3. The same scene with **antialiased lines** that **smooth the jagged edge**s. See Chapter 7 .

when you approximate smooth edges using pixels, this leads to jagged lines
especially with near vertical and near horizontal lines

Plate 4. The scene drawn with **flat-shaded polygons** (a **single color for each filled polygon**). See Chapter 5 .

“unlit scene”

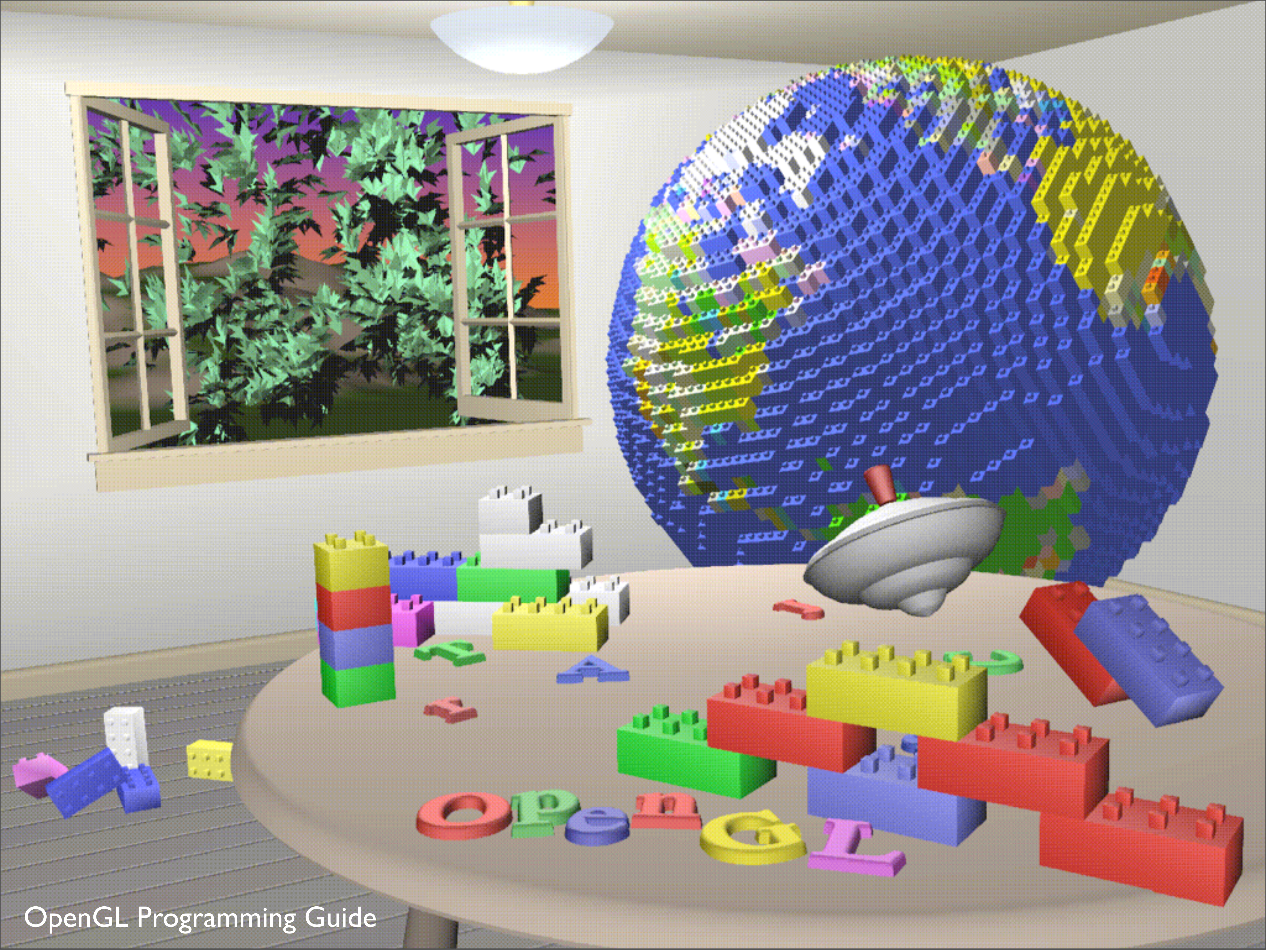


Plate 5. The scene rendered with **lighting** and **smooth-shaded polygons.** See Chapter 5 and Chapter 6 .

Plate 6. The scene with **texture maps and shadows added.** See Chapter 9 and Chapter 13 .

Plate 7. The scene drawn with one of the objects **motion-blurred**. The **accumulation buffer** is used **to compose the sequence of images** needed to blur the moving object. See Chapter 10 .

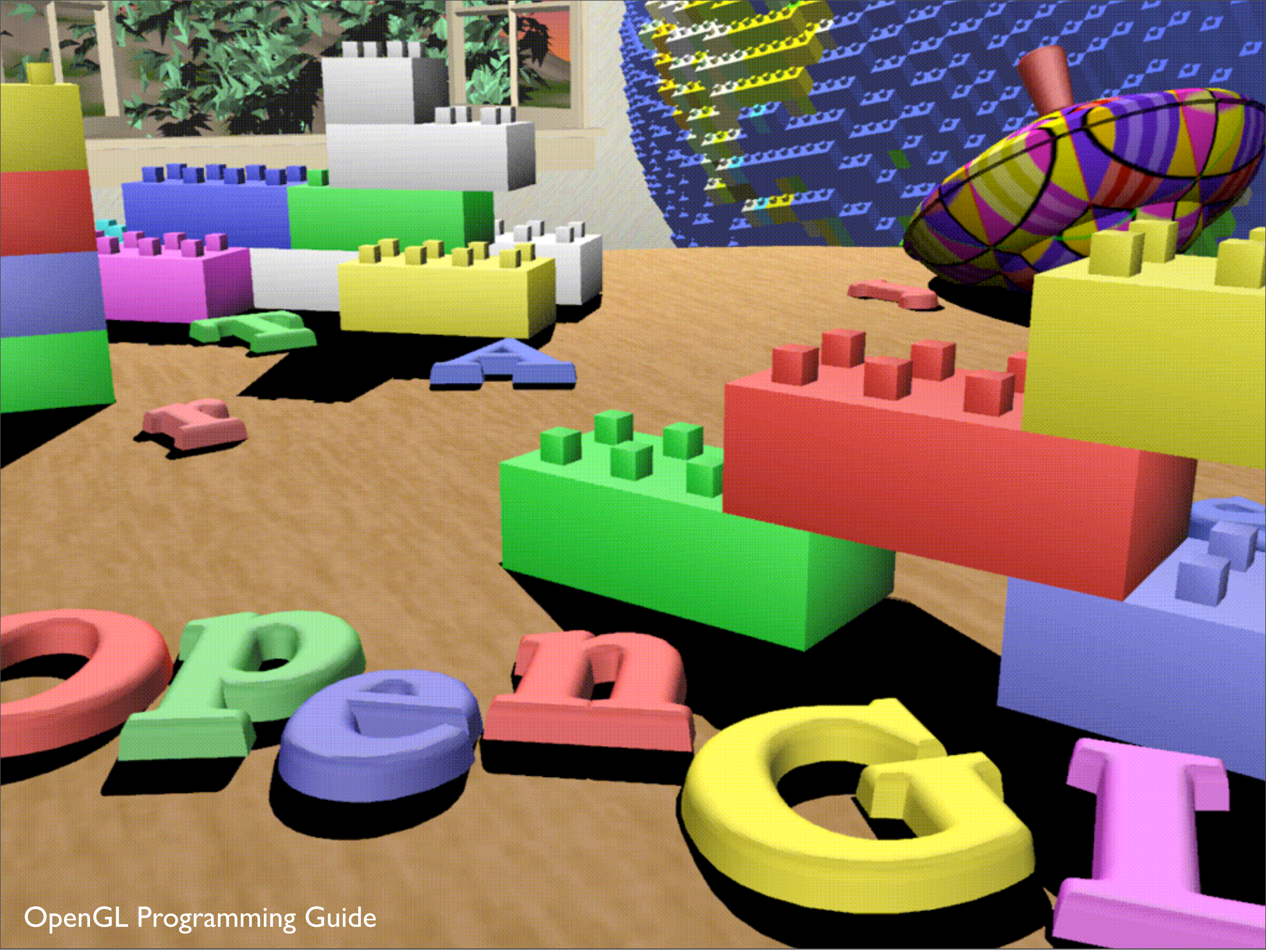


Plate 8. A close-up shot - the scene is **rendered from a new viewpoint.** See Chapter 3 .

OpenGL state machine

- put OpenGL into various states
  - e.g., current color, current viewing transformation
  - these remain in effect until changed
  - glEnable(), glDisable(), glGet(), glIsEnabled()
  - glPushAttrib(), glPopAttrib() to temporarily modify some state

OpenGL command syntax

- commands: **gl**ClearColor();
  - glVertex**3f**()
- constants: **GL**_COLOR_BUFFER_BIT
- types: GLfloat, GLdouble, GLshort, GLint,

Simple OpenGL program

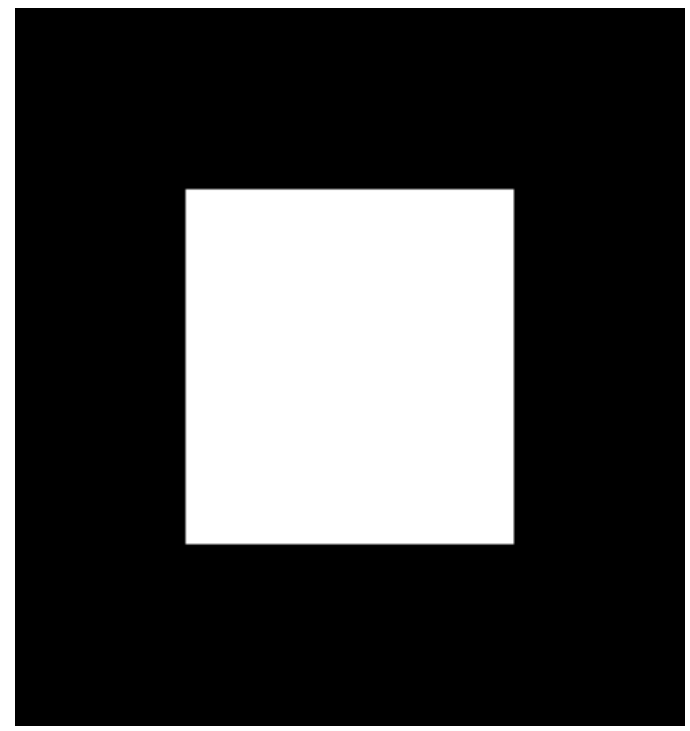
```
#include <whateverYouNeed.h>

main() {

   InitializeAWindowPlease();

   glClearColor(0.0, 0.0, 0.0, 0.0);
   glClear(GL_COLOR_BUFFER_BIT);
   glColor3f(1.0, 1.0, 1.0);
   glOrtho(0.0, 1.0, 0.0, 1.0, -1.0, 1.0);
   glBegin(GL_POLYGON);
      glVertex3f(0.25, 0.25, 0.0);
      glVertex3f(0.75, 0.25, 0.0);
      glVertex3f(0.75, 0.75, 0.0);
      glVertex3f(0.25, 0.75, 0.0);
   glEnd();
   glFlush();

   UpdateTheWindowAndCheckForEvents();
}
```



OpenGL Programming Guide, 7th Ed.

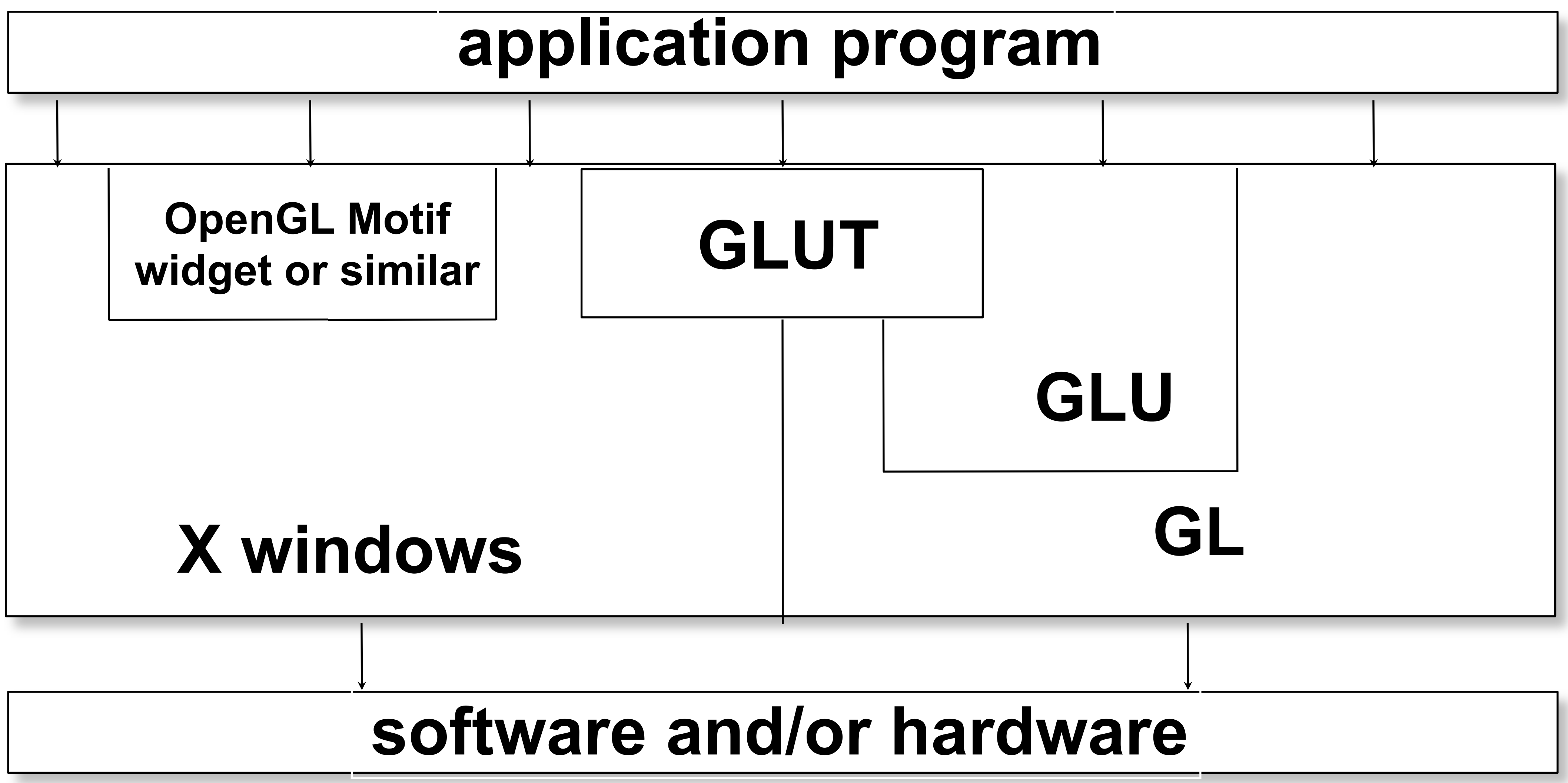
- blue are placeholders for windowing system commands
- clear color, actual clear
- Ortho – the coordinate system
- flush executes the commands

OpenGL Libraries

- OpenGL core library (gl.h)
  - OpenGL32 on Windows
  - GL on most unix/linux systems
- OpenGL Utility Library -GLU (glu.h)
  - avoids having to rewrite code
- OpenGL Utility Library -GLUT (glut.h)
  - Provides functionality such as:
    - Open a window
    - Get input from mouse and keyboard
    - Menus

- GL
  - no windowing commands
  - no commands for higher-level geometry - you build these using primitives (points, lines, polygons)
- GLU - standard in every implementation
- OpenGL Utility library provides modeling support

Software Organization



Simple OpenGL program

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main() {

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   glClearColor(0.0, 0.0, 0.0, 0.0);
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   glOrtho(0.0, 1.0, 0.0, 1.0, -1.0, 1.0);
   glBegin(GL_POLYGON);
      glVertex3f(0.25, 0.25, 0.0);
      glVertex3f(0.75, 0.25, 0.0);
      glVertex3f(0.75, 0.75, 0.0);
      glVertex3f(0.25, 0.75, 0.0);
   glEnd();
   glFlush();

   UpdateTheWindowAndCheckForEvents();
}
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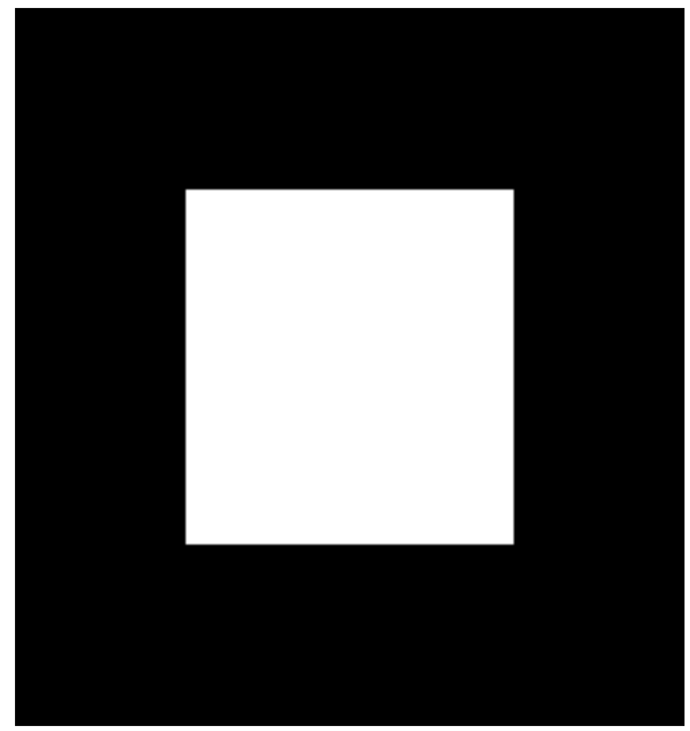


OpenGL Programming Guide, 7th Ed.

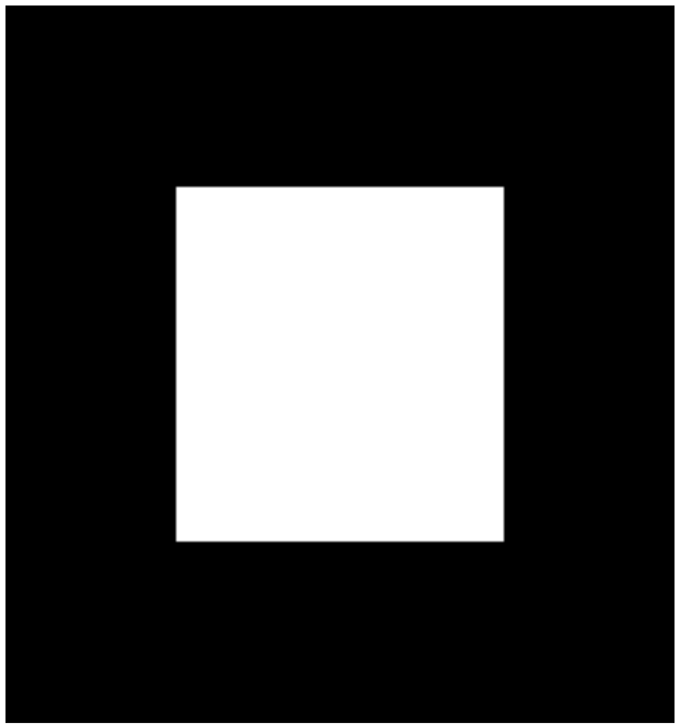
- blue are placeholders for windowing system commands
- can replace blue code with calls to **glut**

Simple OpenGL program

```
#include<GL/glut.h>

void init() {
   glClearColor(0.0, 0.0, 0.0, 0.0);
}

void display() {
   glClear(GL_COLOR_BUFFER_BIT);
   glColor3f(1.0, 1.0, 1.0);
   glOrtho(0.0, 1.0, 0.0, 1.0, -1.0, 1.0);
   glBegin(GL_POLYGON);
      glVertex3f(0.25, 0.25, 0.0);
      glVertex3f(0.75, 0.25, 0.0);
      glVertex3f(0.75, 0.75, 0.0);
      glVertex3f(0.25, 0.75, 0.0);
   glEnd();
   glFlush();
}
main() {
    glutInit(&argc, argv);
    glutInitDisplayMode (GLUT_SINGLE | GLUT_RGB);
    glutInitWindowSize (FB_WIDTH, FB_HEIGHT);
    glutCreateWindow ("Test OpenGL Program");
    init();
    glutDisplayFunc(display);
    glutMainLoop();
}
```



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