CSCI 420 Computer Graphics
Lecture 2

Introduction to OpenGL

OpenGL API
Core and Compatibility Profiles
Colors
[Angel Ch. 2]

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What is OpenGL

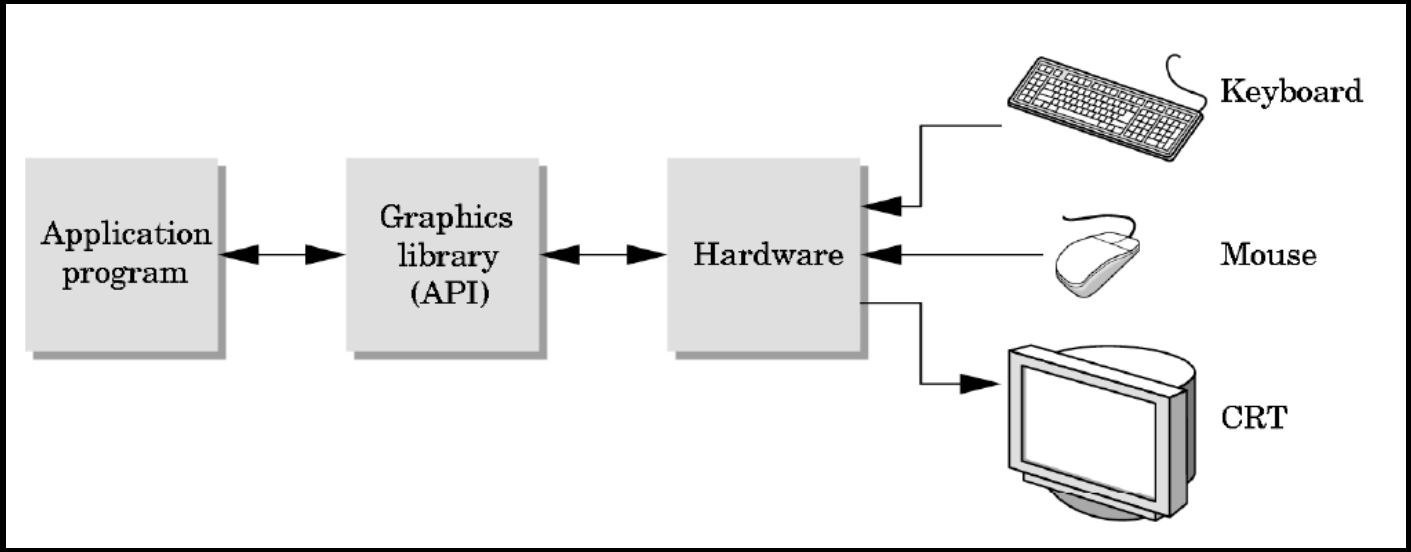
- A low-level graphics library (API) for 2D and 3D interactive graphics.
- Descendent of GL (from SGI)
- First version in 1992; now: 4.6 (released July 2017)
- Managed by Khronos Group (non-profit consortium)
- API is governed by Architecture Review Board (part of Khronos)

Where is OpenGL used

- CAD
- Virtual reality
- Scientific visualization
- Flight simulation
- Video games

Graphics library (API)

- Intermediary between applications and graphics hardware



- Other popular APIs:
  Direct3D (Microsoft)
  OpenGL ES (embedded devices)
  X3D (successor of VRML)
  Vulkan (more low-level than OpenGL)

OpenGL is cross-platform

- Same code works with little/no modifications
- Windows: default implementation ships with OS
  Improved OpenGL: Nvidia or AMD drivers
- Linux: Mesa, a freeware implementation
  Improved OpenGL: Nvidia or AMD drivers
- Mac: ships with the OS. Apple announced deprecation in 2018, but OpenGL continues to work.

Choice of Programming Language

- OpenGL lives close to the hardware
- OpenGL is not object-oriented
- OpenGL is not a functional language (as in, ML)
- Use C to expose and exploit low-level details
- Use C++, Java, ... for toolkits
- Support for C in assignments

OpenGL is cross-platform

Include file (OpenGL Compatibility Profile) :

```
#if defined(WIN32) || defined(linux)
  #include <GL/gl.h>
  #include <GL/glu.h>
  #include <GL/glut.h>
#elif defined(__APPLE__)
  #include <OpenGL/gl.h>
  #include <OpenGL/glu.h>
  #include <GLUT/glut.h>
#endif
```

OpenGL is cross-platform

Include file (OpenGL Core Profile) :

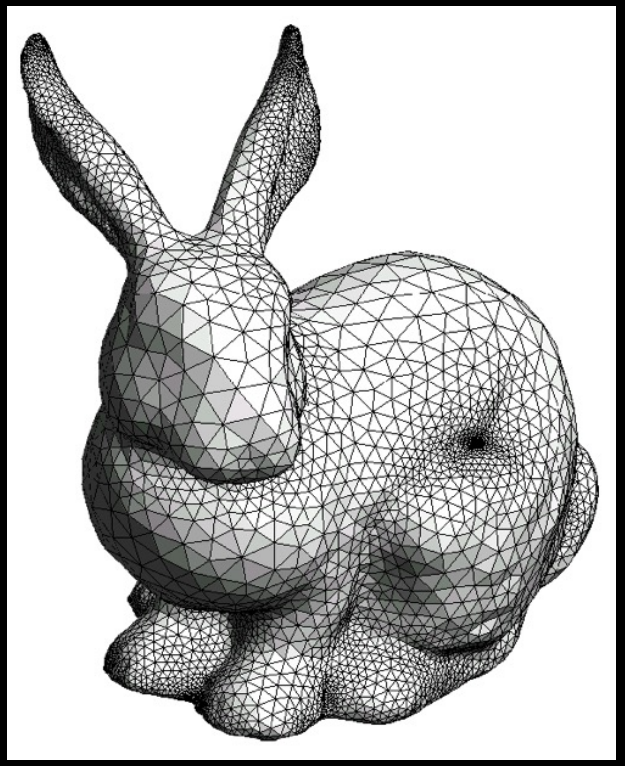
```
#if defined(WIN32) || defined(linux)
  #include <GL/glew.h>
  #include <GL/glut.h>
#elif defined(__APPLE__)
  #include <OpenGL/gl3.h>
  #include <OpenGL/gl3ext.h>
  #include <GLUT/glut.h>
#endif
```

How does OpenGL work

From the programmer's point of view:

1. Specify geometric objects

2. Describe object properties
   - Color
   - How objects reflect light

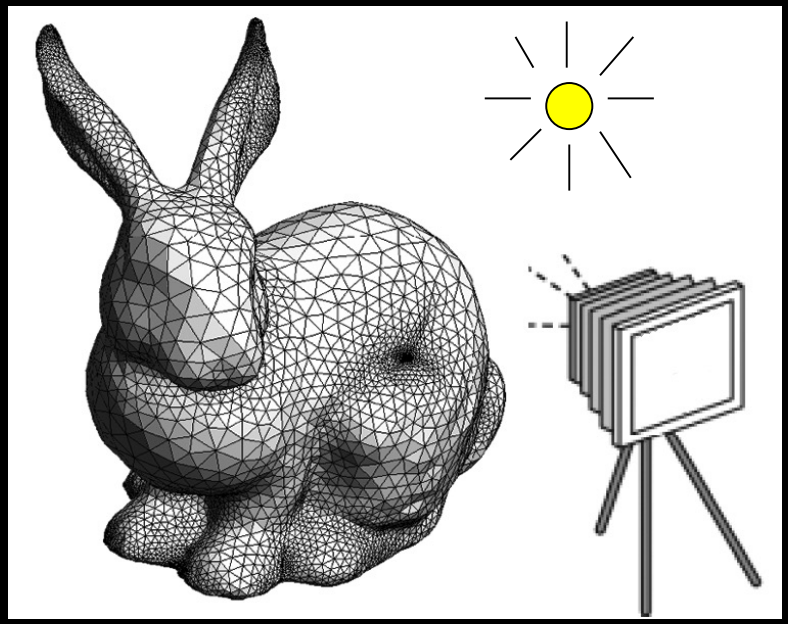


How does OpenGL work (continued)

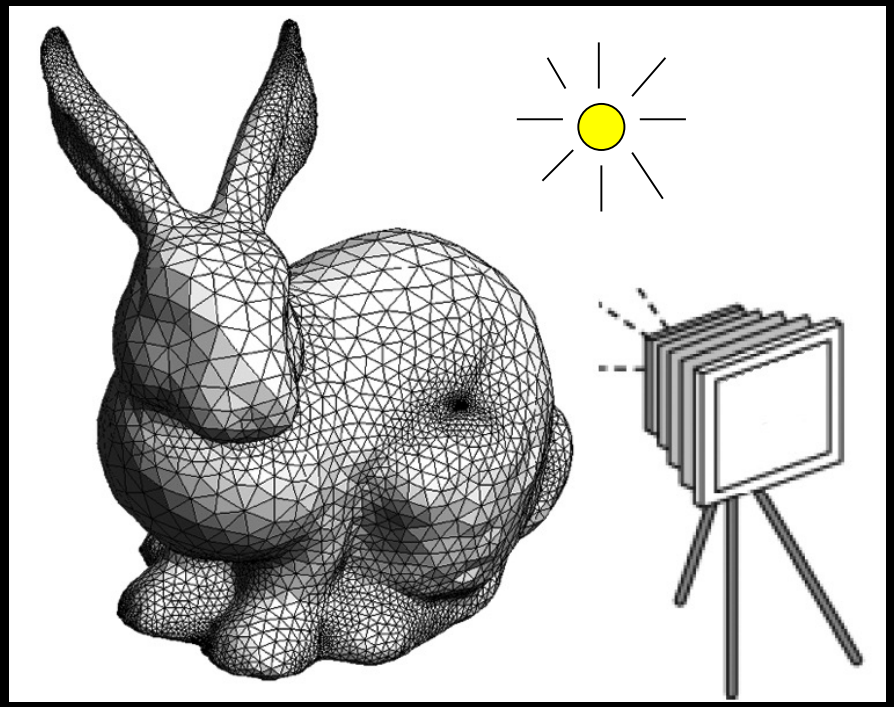
3. Define how objects should be viewed
   - where is the camera
   - what type of camera

4. Specify light sources
   - where, what kind

5. Move camera or objects around for animation



The result



the result

OpenGL is a state machine

State variables: vertex buffers, camera settings, textures, background color, hidden surface removal settings, the current shader program...

These variables (the *state*) then apply to every subsequent drawing command.

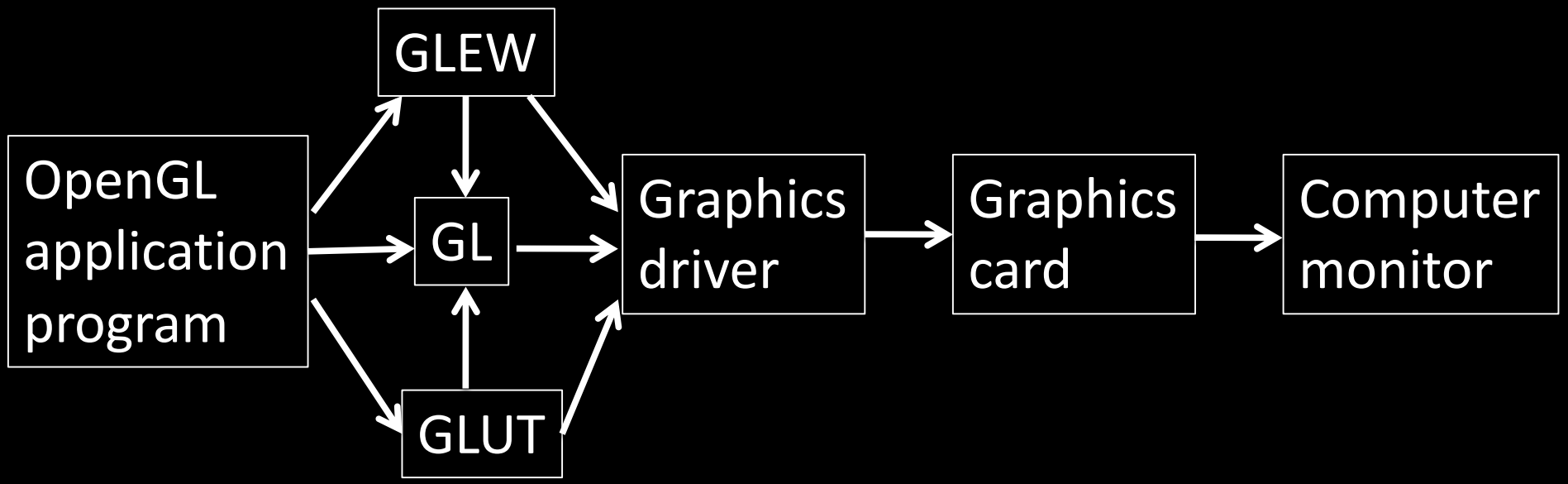
They persist until set to new values by the programmer.

Attributes:
color, shading and reflection properties

- Set before primitives are drawn
- Remain in effect until changed !

OpenGL Library Organization

- **GL** (Graphics Library): core graphics capabilities
- **GLUT** (OpenGL Utility Toolkit): input and windowing
- **GLEW** (Extension Wrangler): removes OS dependencies
- **GLU** (OpenGL Utility Library; compatibility profile only): utilities on top of GL



Core vs Compatibility Profile

- Core Profile:
  - “Modern” OpenGL
  - Introduced in OpenGL 3.2 (August 2009)
  - Optimized in modern graphics drivers
  - Shader-based
  - Used in our homeworks
- Compatibility Profile:
  - “Classic” OpenGL
  - Supports the “old” (pre-3.2) OpenGL API
  - Fixed-function (non-shader) pipeline
  - Not as optimized as Core Profile

Mixing core and compatibility profiles

- Windows, Linux:
  Can mix core and compatibility profile OpenGL commands
  ➔ can lead to confusion
  (is the specific OpenGL command optimized?)
  ➔ advantage: more flexible (can re-use old code)

- Mac:
  Can only choose one profile (in each application)

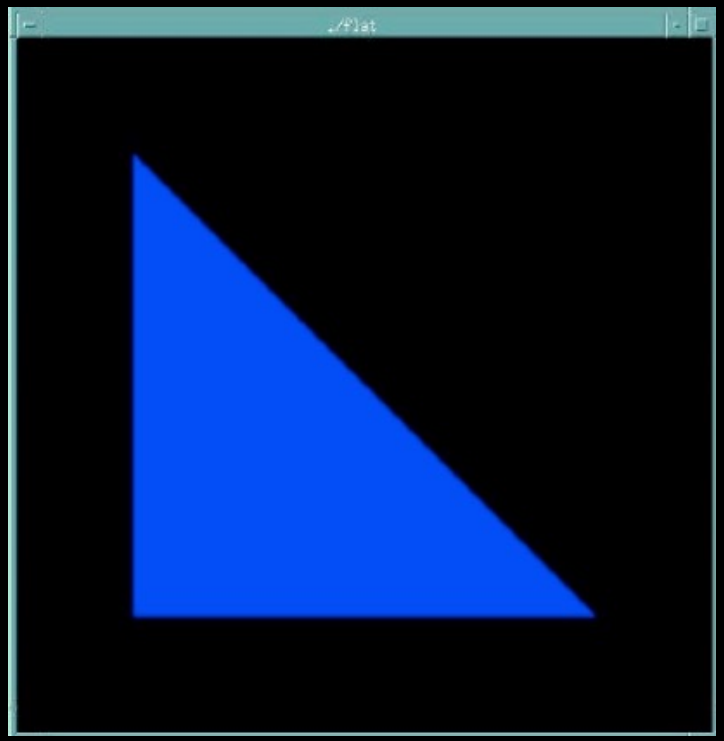
Flat vs Smooth Shading

Flat Shading

Smooth Shading

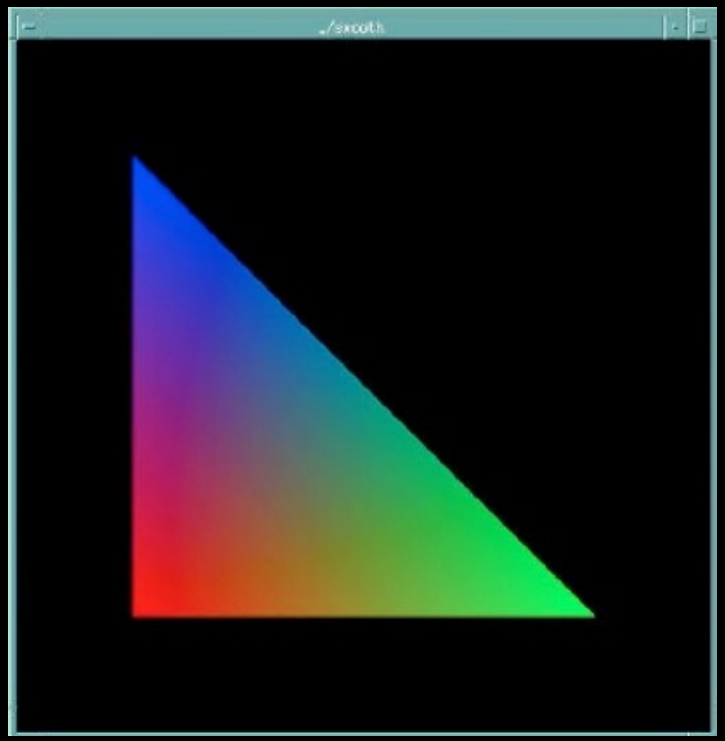
Flat vs Smooth Shading

color of last vertex



Compatibility profile:
glShadeModel(GL_FLAT)

each vertex separate color
smoothly interpolated

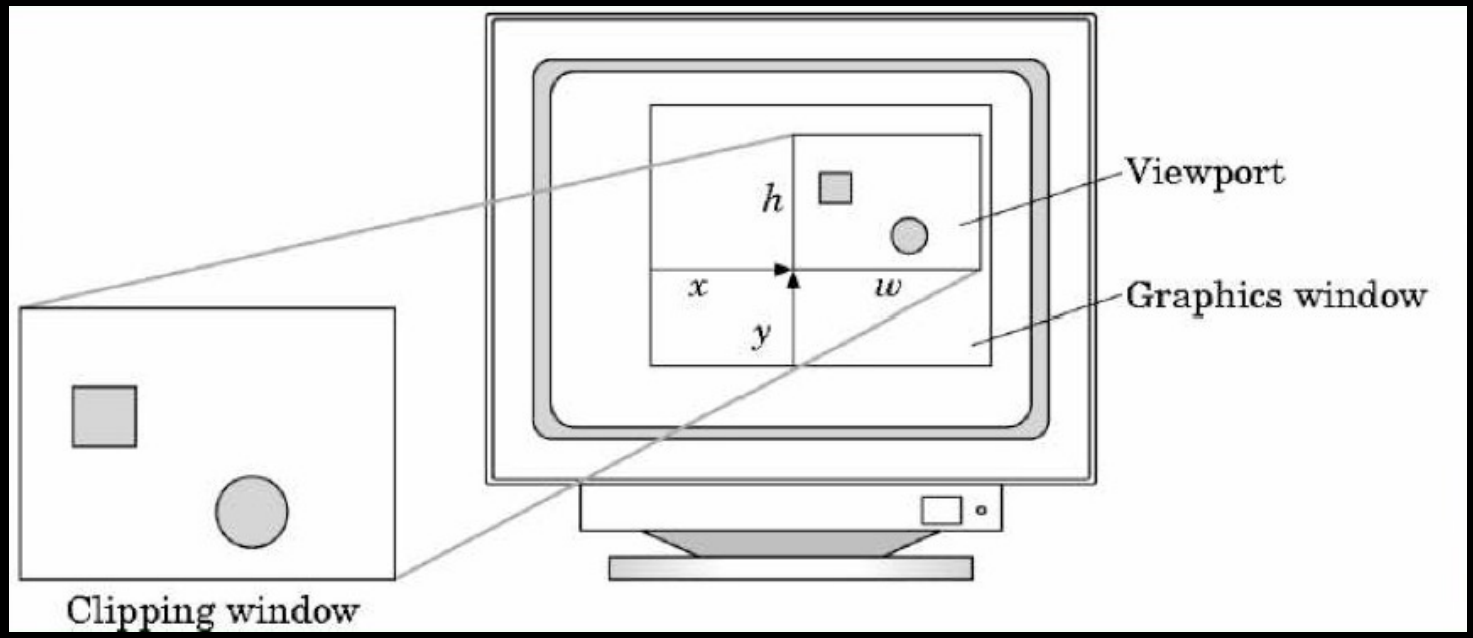


Compatibility profile:
glShadeModel(GL_SMOOTH)

Core profile: use interpolation qualifiers in the fragment shader

Viewport

- Determines clipping in window coordinates
- glViewport(x, y, w, h) (usually in reshape function)



Summary

1. OpenGL API
2. Core and compatibility profiles
3. Colors
4. Flat and smooth shading