Introduction to OpenGL

(Slides courtesy of Tamar Shinar)

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

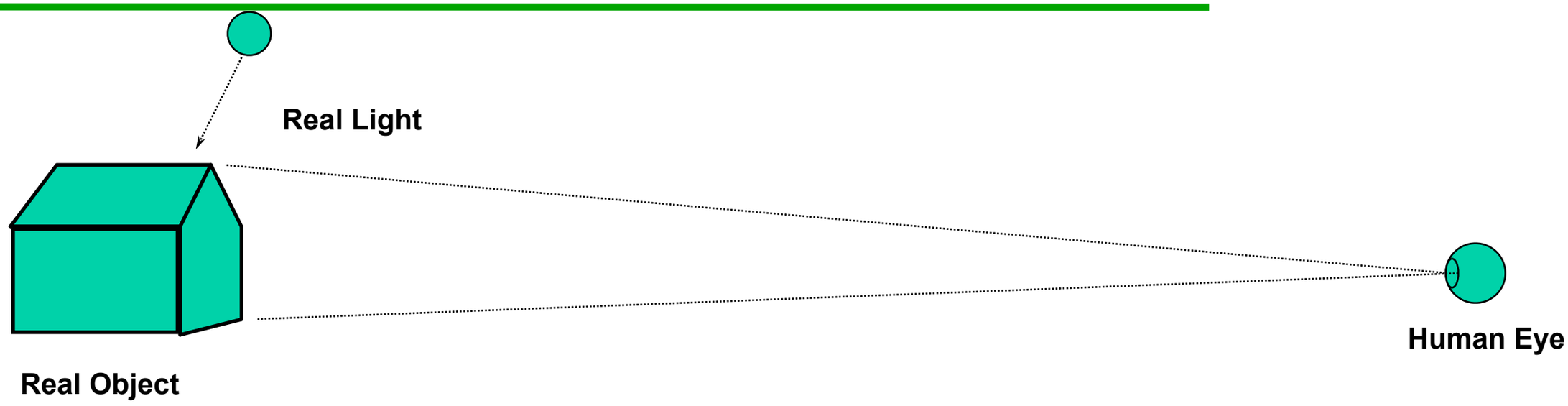
OpenGL

- 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

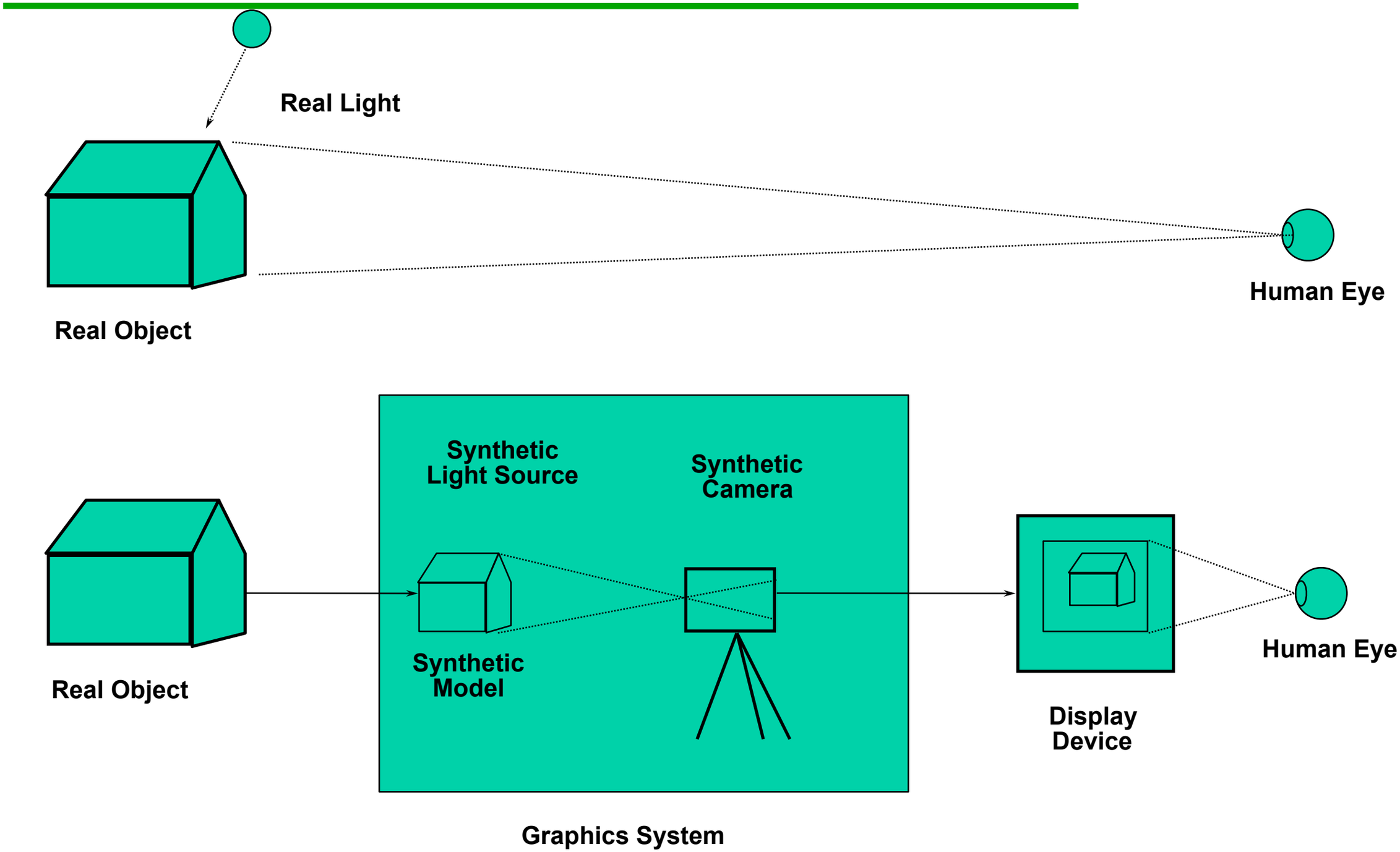
Introduction to OpenGL

- **Open G**raphics **L**ibrary, managed by Khronos Group
- A software interface to graphics hardware (GPU)
- 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

OpenGL: Conceptual Model

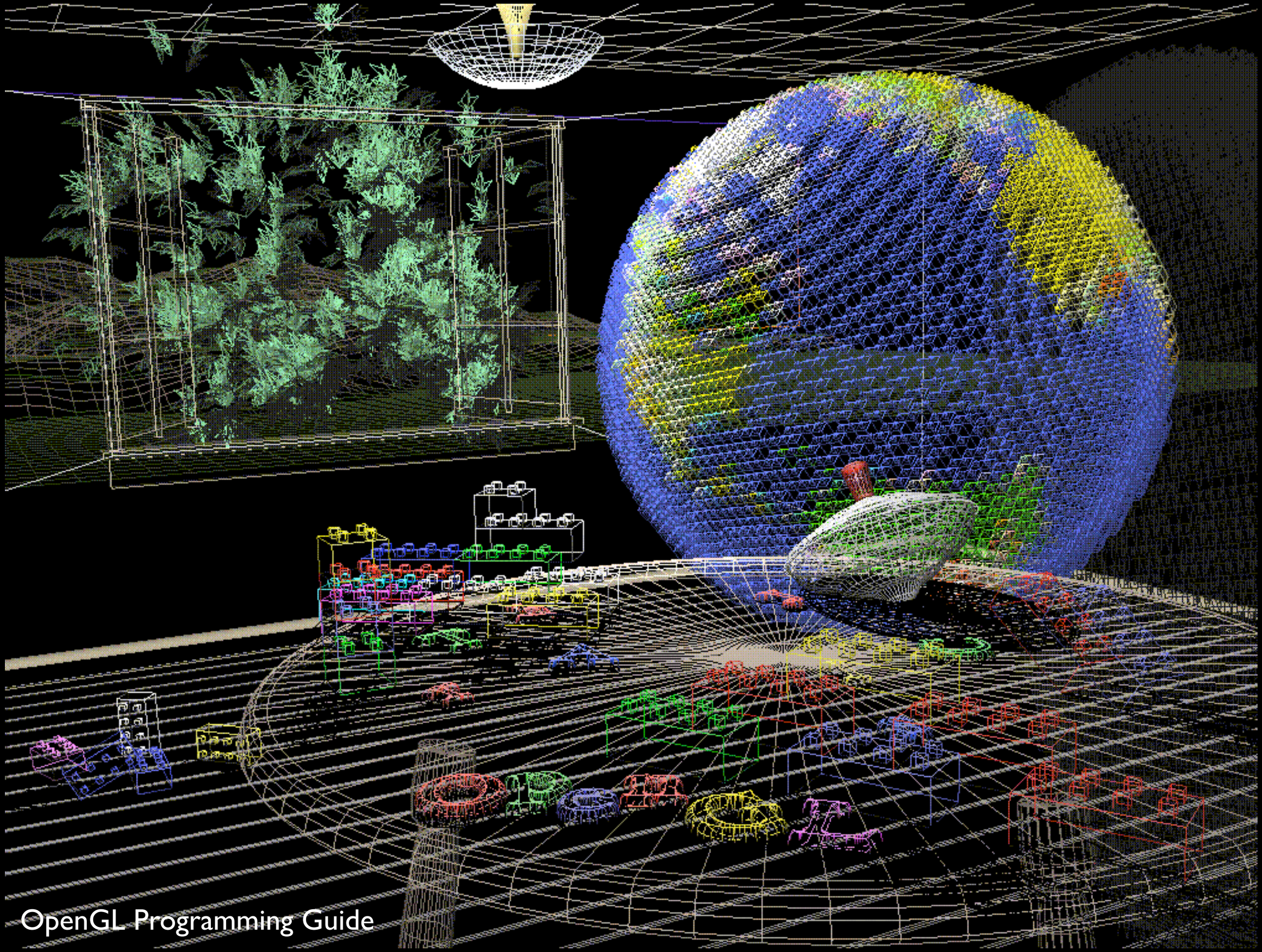


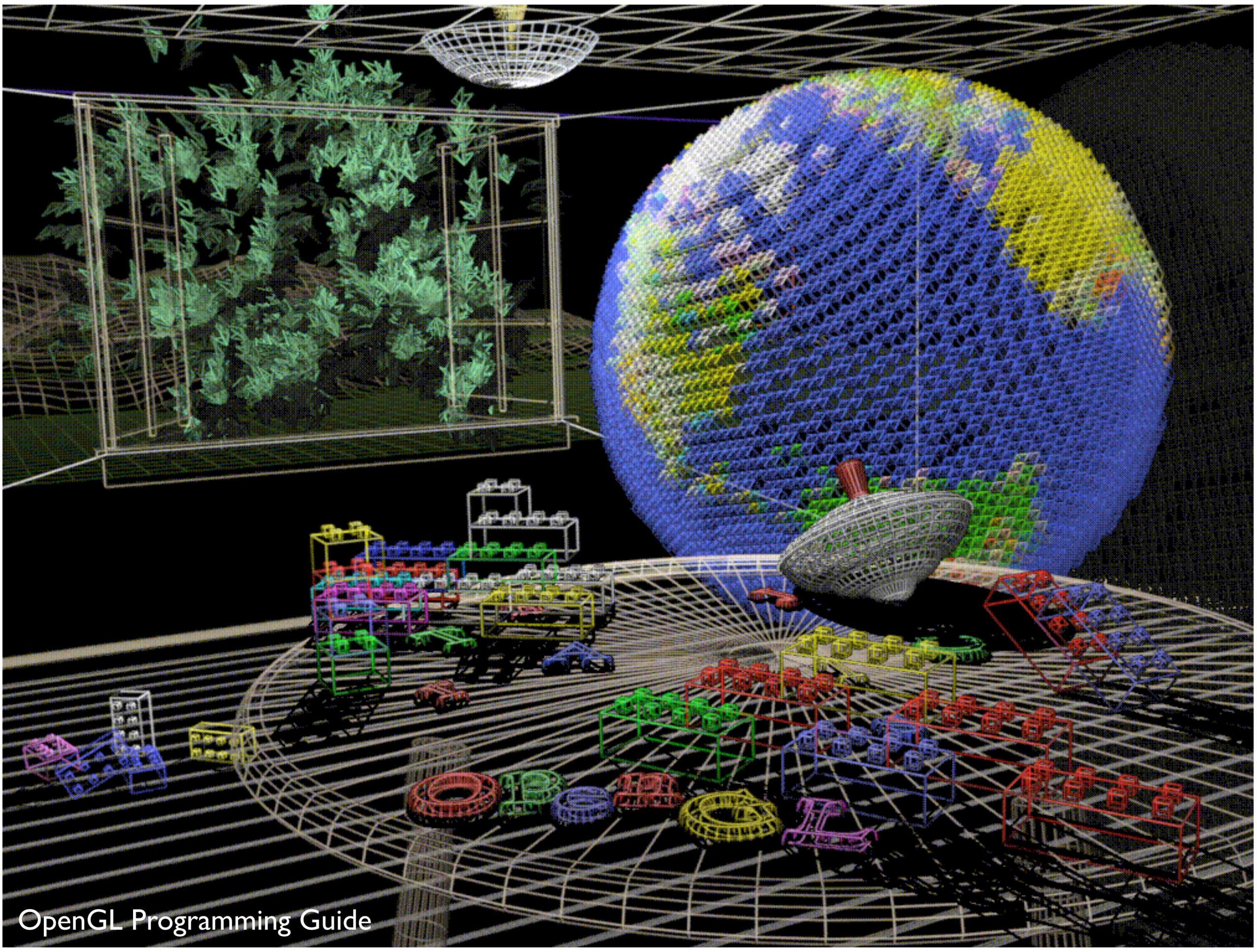
OpenGL: Conceptual Model



What can OpenGL do?

Examples from the OpenGL Programming Guide ("red book")


OpenGL Programming Guide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OpenGL Context

- contains all the information that will be used by OpenGL in executing a rendering command
- OpenGL functions operate on the “current” context
- local to an application
- application may have several OpenGL contexts

OpenGL State

- context contains "state" information
- 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 Rendering Pipeline

- sequence of steps taken when user issues a rendering command
- objects (appear to be) rendered in the exact order user provides

OpenGL Shaders

- Some stages of the rendering pipeline are programmable
  - programs are called “Shaders”
- Written in the OpenGL Shading Language

OpenGL command syntax

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

Simple OpenGL program

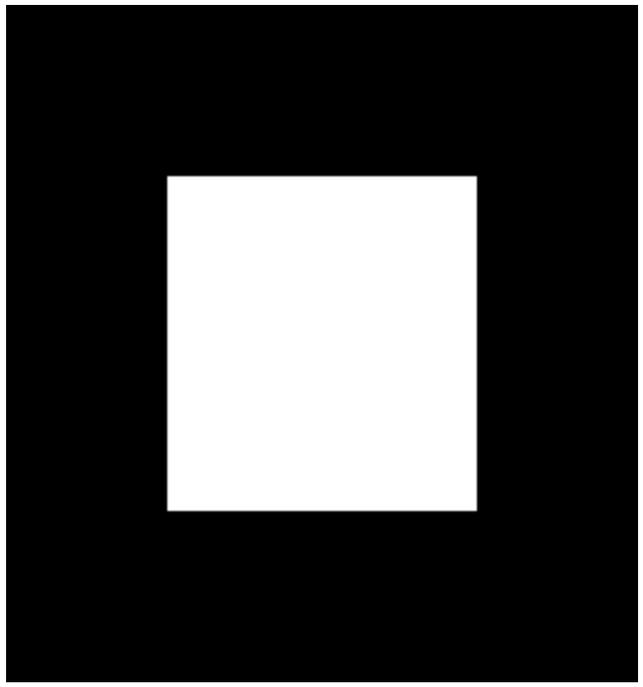
```
#include <whateverYouNeed.h>

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();
}
```

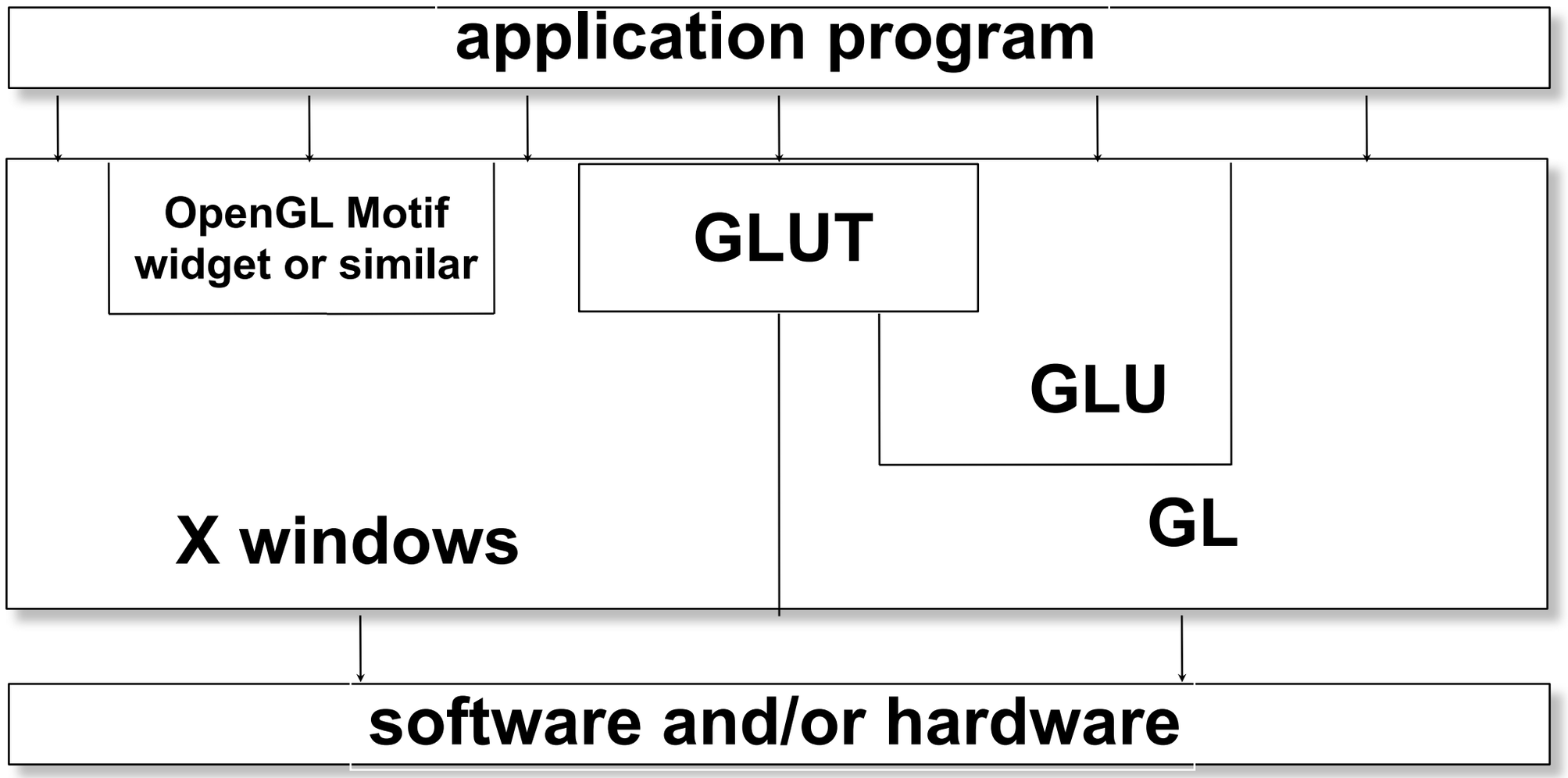


OpenGL Programming Guide, 7th Ed.

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 Toolkit -GLUT (glut.h)
  - Provides functionality such as:
    - Open a window
    - Get input from mouse and keyboard
    - Menus

Software Organization



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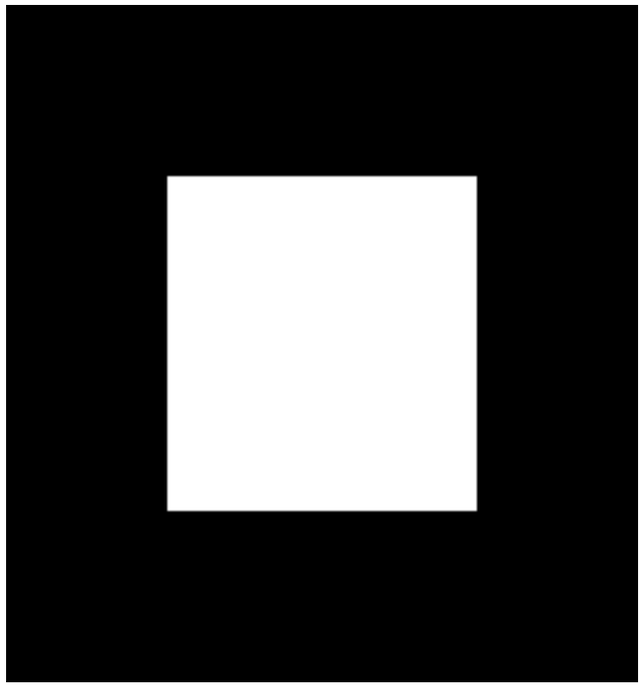

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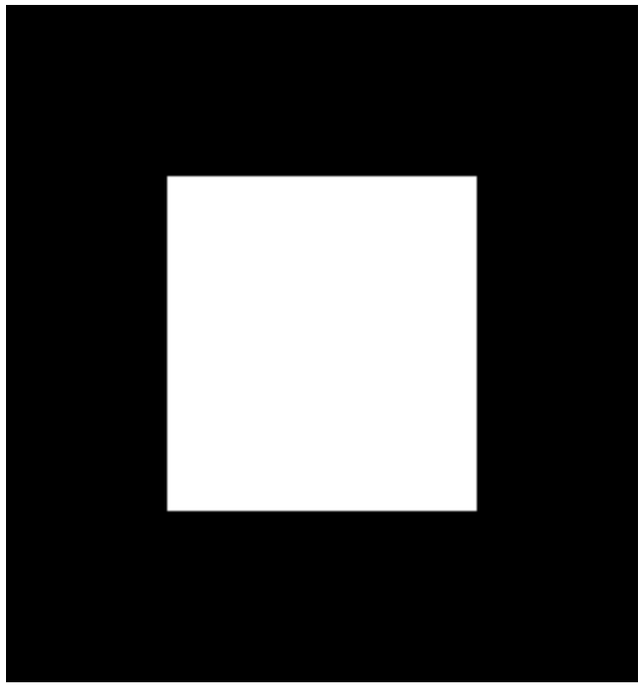
Simple OpenGL program

```
#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();
}
```



Choice of primitives

- Which primitives should an API contain?
  - small set - supported by hardware, *or*
  - lots of primitives - convenient for user

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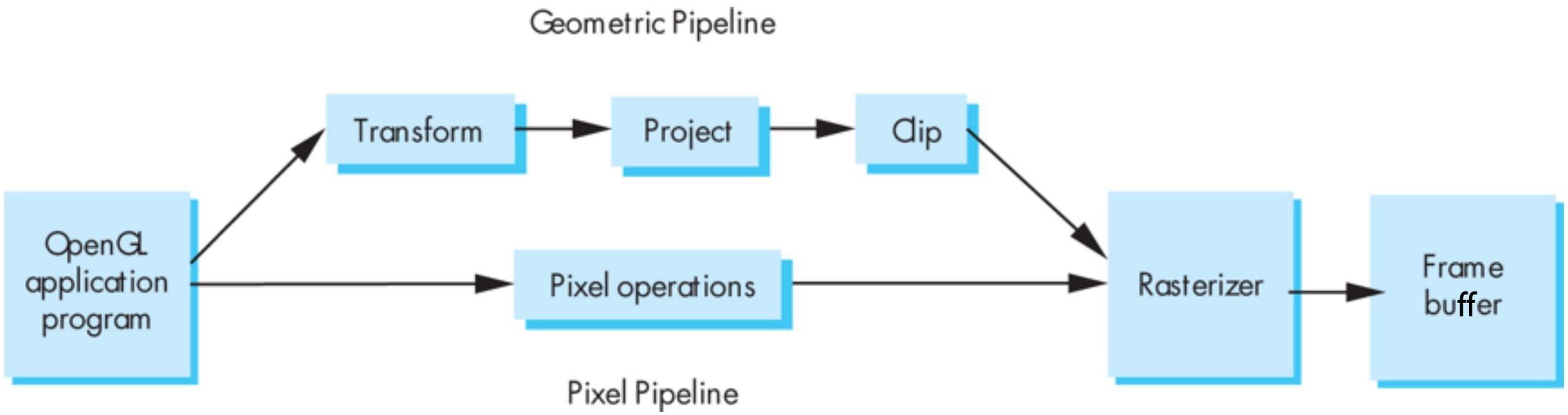
GPUs are optimized for
points, **lines**, and **triangles**

Two classes of primitives

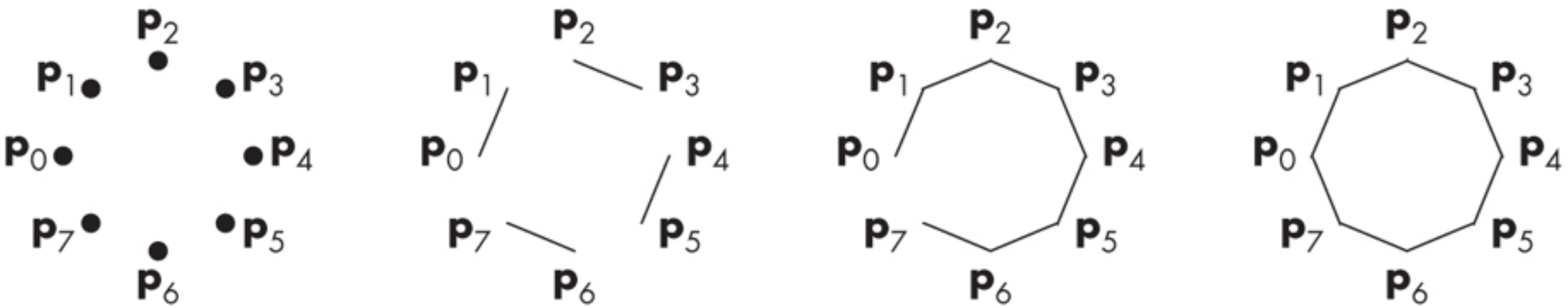


[Angel and Shreiner]

Geometric : points, lines, polygons

Image : arrays of pixels

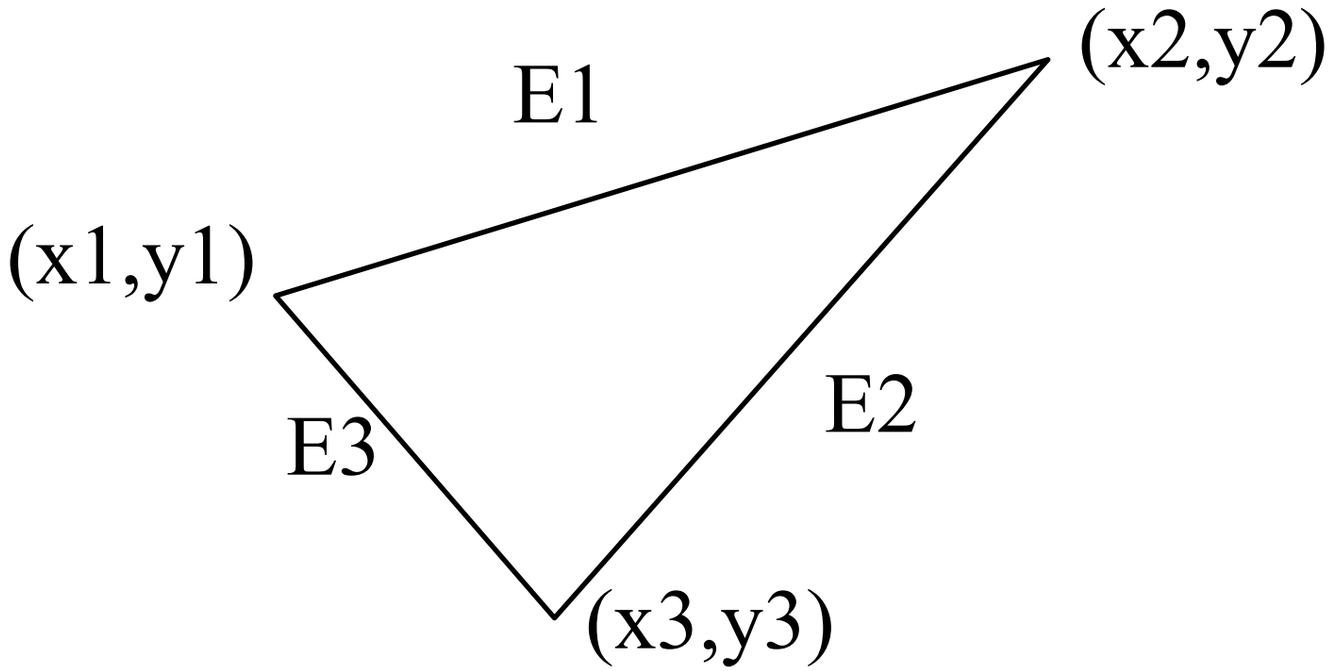
Point and line segment types



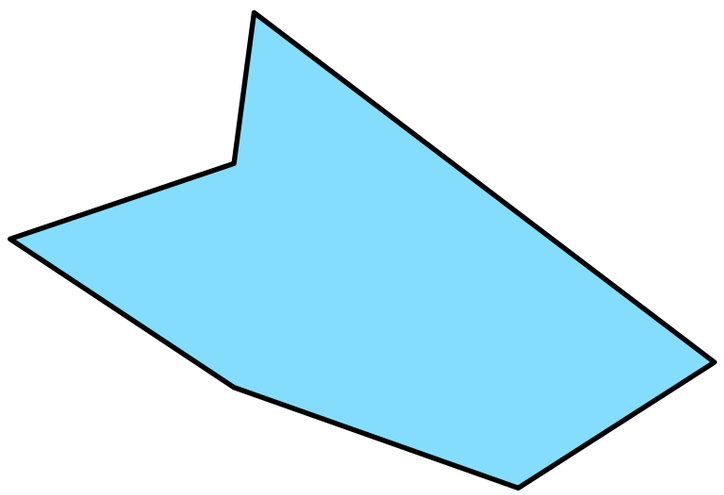
[Angel and Shreiner]

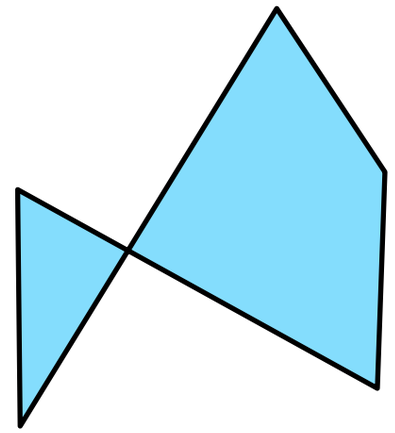
Polygons

- Multi-sided planar element composed of edges and vertices.
- Vertices (singular vertex) are represented by points
- Edges connect vertices as line segments



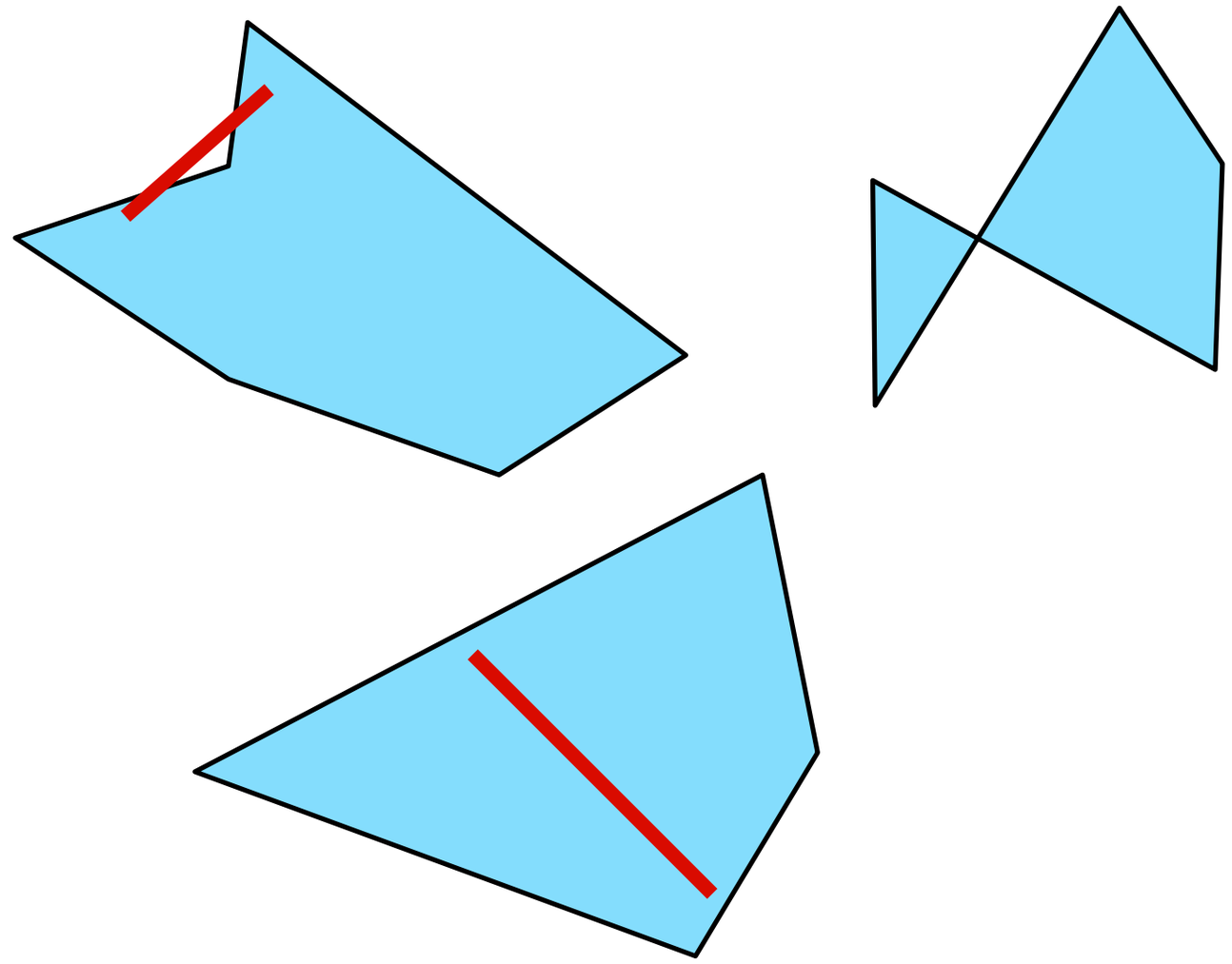
Valid polygons





- Simple
- Convex
- Flat

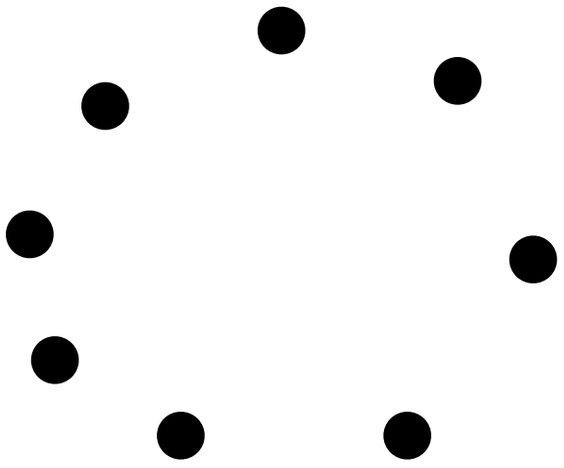
Valid polygons



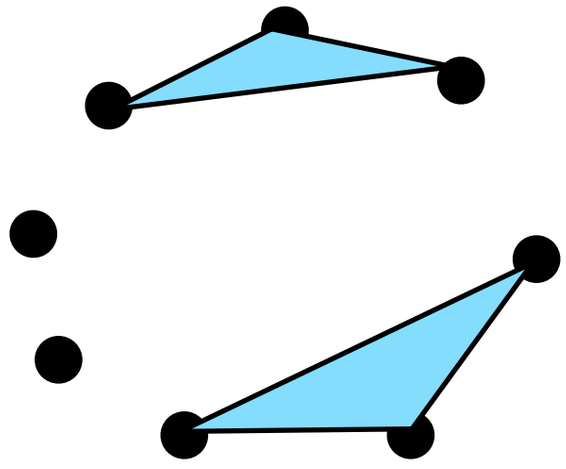
- Simple
- Convex
- Flat

OpenGL polygons

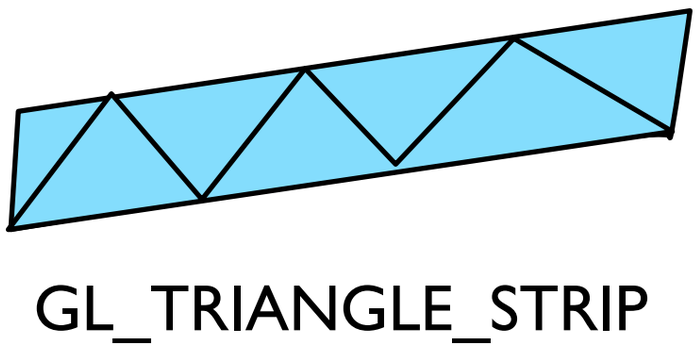
- Only triangles are supported (in latest versions)



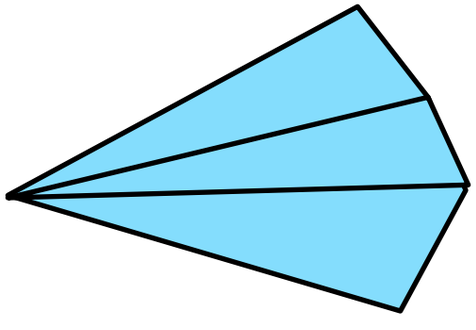
GL_POINTS



GL_TRIANGLES



GL_TRIANGLE_STRIP



GL_TRIANGLE_FAN

Other polygons