Today's Outline

- OpenGL introduction
  - OpenGL primitives
  - Demos / code
- Rasterization rules
- The OpenGL graphics pipeline
- Graphics hardware

Goal: Understand the graphics pipeline and how to create pictures using OpenGL

Colored pixels on screen

shapes, lines, points, images, text
Demonstrations

(Understand example programs)

Framebuffer and Viewport

Display: 1280 x 1024

Window: 512 x 512

Viewport: 256 x 256

All coordinates are integers; they refer to pixels in the framebuffer
Viewport and Coordinate Systems

Viewport: 512 x 512

(-1.0,-1.0) to (1.0,1.0)

The coordinates on the edges are floating point and they create a user-defined coordinate system. For now it is 2D, but eventually it will be 3D.

Two Interpretations of Window

Window on the Display (Virtual Framebuffer)

http://www.imaginativeinteriors.co.uk/trompe.shtml

Window into a Virtual World
Pixel Coordinates

Viewport/Window edges at integers

Pixels inside window

OpenGL: Pixel centers correspond to non-integer coordinates
Rasterization Rules: Area Primitives

Output fragment if pixel center is *inside* area

Need rules for breaking ties (only left and bottom)

Fragments vs. Pixels

Combine fragment color with pixel color and store in framebuffer

"Fragments" are the output of the rasterizer
"Pixels" are what are stored in the framebuffer
The pixel in the framebuffer is updated by combining it with the fragment
Rasterization Rules: Lines

Output fragment if line intersects diamond

Need rules for breaking ties (only left and bottom)

OpenGL Shape Primitives

CS148 Lecture 2
Pat Hanrahan, Fall 2009
OpenGL Drawing Primitives

Geometric Shapes

Bitmaps

Images

OpenGL Architecture
Simplified Pipeline

- OpenGL commands
- Vertices
- Per-vertex ops
- Transformed vertices
- Rasterizer
- Texturing
- Fragments
- Per-fragment ops
- Shaded fragments
- Frame buffer ops
- Pixels

Modern PC

3.0 Ghz Intel Core2 Duo
- Core 1
- Core 2
- 4MB L2 Cache

1GB main memory (DDR2)

NVIDIA GeForce 8800 GTX (575 MHz)
- (16 cores)

512MB video Memory (GDDR3)

NVIDIA 8800GTX

System board (Intel D975)

PCIe Bus (max 4 GB/sec)

84 GB/sec
Game Machines – Xbox 360

3.2 Ghz PowerPC CPU
Core 1, Core 2, Core 3
L2 Cache

500 Mhz ATI GPU
48 3D Cores
Frame buffer
Video out

512 MB memory

controllers/ethernet/audio/DVD/etc.

Display (TV)

Game Machines – PS3

3.2 Ghz Cell
PPC Core
L2 Cache

550 Mhz NVIDIA RSX GPU
Multiple 3D cores
Video out

256 MB video Memory (GDDR3)

256 MB Memory (XDR)

controllers/ethernet/audio/DVD/etc.

Display (TV)
Modern Hardware Pipeline

OpenGL commands

Cmd

Rasterizer

Programmable processing cores
(runs vertex and fragment programs)

Frame buffer ops

Texturing

Frame buffer

Memory

Textures

Summary

Graphics state stores attributes

Graphics commands output primitives
  Shapes (points, lines, triangles, quads, etc.)
  Bitmaps (fonts)
  Images

Different coordinate systems
  User coordinates
  Pixel coordinates

Graphics system produces fragments from primitives

Demos: use simple GL commands and use GLUT for windowing/interaction