5. Graphics Programming

Optional reading

- Angel, sections 1.6-1.8, chapter 2
- Foley et al., section 5.4,
- Woo et al., chapters 1, 2, 8

Specifying a view in 2D

How do you specify a view of a 2D picture?

Most graphics systems let you specify:

- the part of a picture to display (the window)
- the place to display that picture on the screen (the viewport)

Specifying a view in 2D, cont.

Typically, the picture is defined in any convenient coordinate system, called world coordinates.

The viewport is generally specified in coordinates in \([0,1] \times [0,1]\) - called normalized device coordinates.

Ultimately, these coordinates are mapped to integer pixel coordinates - also known as device coordinates or screen coordinates.

- glViewport( x, y, w, h );
The 3D synthetic camera model

The synthetic camera model is a paradigm for creating images of 3D geometry.

It involves two components, specified independently:
- objects (a.k.a. geometry)
- viewer (a.k.a. camera)

Imaging with the synthetic camera

The image is rendered onto an image plane or projection plane (usually in front of the camera).

Projectors emanate from the center of projection (COP) at the center of the lens (or pinhole).

The image of an object point $P$ is at the intersection of the projector through $P$ and the image plane.

Clipping

We think of the image plane as having a finite (rectangular) extent.

Objects are clipped to a clipping rectangle or clipping window.

Graphics APIs

An application programmer’s interface (API) provides an interface between the application code and the hardware.

Most popular graphics APIs (OpenGL, DirectX, PHIGS, GKS-3D) are based on the synthetic camera model.

Have functions to specify:
- objects
- viewer
- light sources
- material properties
OpenGL objects

Most APIs support several different geometric primitives.

OpenGL provides:

- points (GL_POINTS)
- line segments (GL_LINES)
- polylines (GL_LINE_STRIP)
- unfilled polygons (GL_LINE_LOOP)
- filled polygons (GL_POLYGON)
- triangles (GL_TRIANGLES)
- quadrilaterals (GL_QUADS)
- strips (GL_TRIANGLE_STRIP, GL_QUAD_STRIP)
- fans (GL_TRIANGLE_FAN)

It also lets you read and write pixels in the framebuffer.

Specifying a viewer

Camera specification requires four kinds of parameters:

- **Position**: the COP.
- **Orientation**: rotations about axes with origin at the COP.
- **Focal length**: determines the size of the image on the film plane, or the **field of view**.
- **Film plane**: its width and height, and possibly orientation.

Specifying lights and materials

Light sources usually defined by:

- location
- strength
- color
- directionality

Materials usually defined by:

- various shading parameters
- texture maps

OpenGL rendering styles

OpenGL supports a variety of rendering styles:

- **Wireframe**
  - with depth-cueing
  - with antialiasing
- **Visible polygons**
  - with flat shading
  - with smooth (Gouraud) shading
  - with texture maps and shadows
  - with motion blur
  - with atmospheric effects
The geometric pipeline

Many commercial graphics workstations use a pipeline architecture, implemented in hardware, for processing geometry.

Works well because:

- Lots of data that is processed similarly
- Well-decomposed computation

Q: What's the downside of large pipelines?

The graphics pipeline

The pipeline metaphor can be extended to encompass just about everything we do in 3D graphics:

- animation
- modeling
- transformation
- clipping
- lighting and shading
- hidden surface
- projecting
- rasterizing
- compositing
- post-processing

Summary

Here's what you should take home from this lecture:

- All the boldfaced terms.
- The basic idea of the synthetic camera model and how its basic components are specified.
- The basic concept of the geometry and graphics pipelines.