Computer Graphics 1
Instructor Information

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Books

- Required Textbook
  - Title: Computer Graphics with OpenGL 3/E
  - Authors: Donald Hearn and M. Pauline Baker
  - Publisher: Prentice Hall
  - Copyright: 2004
- Suggested References
  - OpenGL reference book
  - C or C++ reference book

Course Goals and Outcomes

- Goal: to provide a broad exposure to the computer graphics field in order to be prepared for follow-on study
- Outcomes
  - Appreciation of the history and evolution of computer graphics, both hardware and software.
  - Understand/implement 2D graphics and algorithms including: line drawing, polygon filling, clipping, and transformations.
  - Understand concepts of and techniques used in 3D computer graphics, including viewing transformations, hierarchical modeling, color, lighting and texture mapping.
  - Exposed to current computer graphics research areas.
  - Ability to use a current graphics API (OpenGL).
  - Introduced to algorithms and techniques fundamental to 3D computer graphics. Ability to reason about and apply these in new situations.

Graphics?

- What is graphics?
- How is it useful?

Where are computer graphics?

- Art, Entertainment, and Publishing
  - Movies, television, games, art, web, books, magazines

Where are computer graphics?

- Image Processing
  - Photo enhancement, image analysis, printing
Where are computer graphics?
- Process Control
  - Status displays

A day at Springfield Nuclear Power Plant

Where are Computer Graphics?
- Computer-aided Design
  - Architecture, circuit design

Cyan's world of Riven under construction

What isn’t computer graphics?
- Graphics is NOT image processing, but image processing can use techniques from graphics and vice versa

Mathematica displays a complex mathematical surface

Graphics Display Devices
- Hardware devices used to display computer graphics:
  - Line Drawing Devices
  - Vector Displays
  - Raster Displays
  - Flat Panel Displays
  - Hard-Copy Raster Devices

Line Drawing Devices and Vector Displays
- The classic line drawing device is the pen plotter.
  - Raise pen, move paper, drop pen, move paper, etc.
- Vector Displays
  - Internal circuitry sweeps an electronic beam from point to point across the face of a cathode ray tube, leaving a glowing trail.
Raster Displays

- Important component: frame buffer
  - Holds the image to be displayed
  - Each pixel is represented by data in the FB
  - Display refreshed (redrawn) line by line, top to bottom
    - May alternate rows (0, 2, 4, ..., 1, 3, 5, ...) to avoid flicker

Video Monitor

- Number of “planes” in FB determines the color depth
- Each pixel represented by one bit in each plane
  - Six planes → six bits per pixel
  - Bits are paired; pairs associated with colors (RGB)
  - Two bits per color → four voltage/brightness levels
  - Thus, 4x4x4 = 64 different color combinations

Display Characteristics

- Number of colors displayable is dependent on width (w) of whatever drives the color guns
  - E.g., 24-bit LUT → $2^w$ colors → 16,777,216 colors
- Number of colors displayable at one time depends upon depth of the FB in bits (b)
  - E.g., 8-bit FB → $2^b$ colors → 256 colors
  - Normally, $w > b$
Display Comparisons

Flat Panel Display

Active Matrix and Plasma Panels

- Active matrix panels
  - LCD panels with tiny transistors at each pixel.
  - Brightness is controlled by adjusting the liquid crystals proportional to the electric field.
  - The transistors provide memory that holds the crystals in their adjusted state
    - No need to constantly refresh the display.
- Plasma panels
  - Tiny neon bulbs at each pixel, controlled by an electric field.
  - Also provides memory.

Hard-Copy Raster Devices

- Various types of printed output
  - Film recorders
  - Laser printer
  - Inkjet plotter
- Printers accept print jobs in the format of a page description language
  - PostScript
  - PDF
  - TIFF, etc.
- PostScript is device-independent
  - Different printers produce same basic image (barring quality differences).

Graphics Input Devices

- Different devices send different types of input:
  - **String** - sequence of characters.
  - **Choice** - selection from a set of options.
  - **Valuator** - value within a range (e.g., 0.0-1.0).
  - **Locator** - position (usually in some coordinate system).
  - **Pick** - identifies a portion/segment of the image.
- Types of devices:
  - Keyboard
  - Mouse, joystick, trackball
  - Buttons
  - Tablet
  - Knobs

Remembering Math

- Basic math useful for graphics discussed
- Please see the tutorial off of the web site for practice
Elements in CGI

- The basic objects of pictures are **output primitives**
  - Polylines
  - Text
  - Filled regions
  - Raster images

Polylines

- A **polyline** is a connected sequence of straight lines
  - Example: sequence (2,4), (2,11), (6,14), (12,11), (12,4), etc.
  - Each pair of points defines a line segment
  - This is a *line drawing*

Polylines

- Terms: **Edge** – line segment in multi-line polyline
  - **Vertex** – endpoint of two edges
- Polylines can be open or closed
  - Open – first and last points are not connected by a line segment
  - Closed – forms a **polygon**

Text

- Two distinct display modes
  - **Text mode** – built in positioning
  - **Graphics mode** – Rich shapes and positioning

Text

- Can alter fonts (typefaces)
- Can represent characters as polylines or bitmaps
Filled Regions

- Commonly, polygons with a color, pattern or texture

Raster Images

- Array of small cells.
- Each cell represents a pixel.
  - Often called a pixel map, or bitmap

Raster Images

- Simplest form of a bitmap – two levels, one bit per pixel, or a pixel depth of 1.
- To generalize, a pixel depth of \( n \) has \( 2^n \) possible levels.

Raster Images

- Lines that are not horizontal or vertical suffer the jaggies when zoomed in on.
- Antialiasing is a technique used to minimize jaggies.