Florida Tech

CSE 5255

INTRODUCTION TO COMPUTER GRAPHICS CLASS NOTES

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The Graphics Pipeline

- The graphics pipeline
  - specifies a series of steps needed to display data on an output device
  - the step vary depending on the needs of the application
    - realistic
    - fast
    - aesthetic
    - informatic
- To *draw* a collection of objects:
  - Define the objects
  - Map (place) objects in a single coordinate system
  - View from some position
  - Light and shade the visible surfaces
  - Map the *view volume* to portion of display sruface

- The basic steps:
  - Generate, edit or modify a model of the scene
  - Traverse the model
    - "Walk" the data structure if model is *retained*
    - "Execute" the procedures if model is *immediate*
  - Transform the objects to be displayed into world coordinates
  - Establish the view
  - Determine visible surfaces and shading
  - Clip the scene
  - Scan convert the objects into pixels
  - Display (scanout) the framebuffer
- The Graphics Pipeline
  - Modeling Objects (primitives — polygons)
  - Mapping modeling coordinates to world coordinates (scale, translate, rotate)
  - Mapping world coordinates to viewing coordinates (translate, rotate)
  - Mapping viewing coordinates to normalized coordinates (project, scale, translate)
  - Projecting normalized (3D) coordinates to 2D

- Mapping to hardware device coordinates
- Other operations — clip, determine visible objects, render, scan convert, etc.
- Clipping, visible object detection, lighting, etc., can be performed in one of many coordinate systems (depending on the algorithms and hardware used)

- Scan Conversion Algorithms
  - Draw lines, circles, curves, surfaces, etc.
    - Digitial Differential Analyzer (DDA)
    - Bresenham's algorithms
  - Polygon filling — flood/boundary fills and scanline fills
- Clipping
  - Cohen-Sutherland line clipping
  - Liang-Barsky line clipping
  - Sutherland-Hodgman polygon clipping
  - Weiler-Atherton polygon clipping
  - Blinn's efficient clipping

Overview of Topics

- Illimination Models
  - Ambient light
  - Diffuse reflection
  - Specular reflection
- Shading Models
  - Constant shading
  - Gouraud shading
  - Phong shading
- Color Models — CIE, RGB, CMY, HVS

- Input and Output
  - Physical display devices — printers, plotters, monitors, video, etc.
  - Output resolution, memory requirements, bandwidth
  - Raster scan versus vector (random, calligraphic) displays
  - Physical input devices — keyboard, mouse, tablet, etc.
  - Input modes – request, sample, and event
  - Logical input devices — locator, stroke, text, valuator, choice, pick
- Graphics packages
  - Control states and state tables
  - Coordinate transformations
  - The view orientation map and the view representation map
  - Output primitives and attributes
  - Input primitives
  - Workstations (output, input, outin)
  - Internal Storage — segments, structures
  - External Storage — metafiles, archives
  - Retained versus immediate modes

Uses of Computer Graphics

- Graphical User Interfaces – increase the communication bandwidth between humans and machines
- Office automation and electronic publishing
- Industrial Design – development of products (CAD)
- Scientific Visualization – "see" the results of simulations and theories
- Commercial Art – animated television commercials, feature films
- Fine Art – a new medium ripe for exploration
- Other Uses?

Physical Output devices:

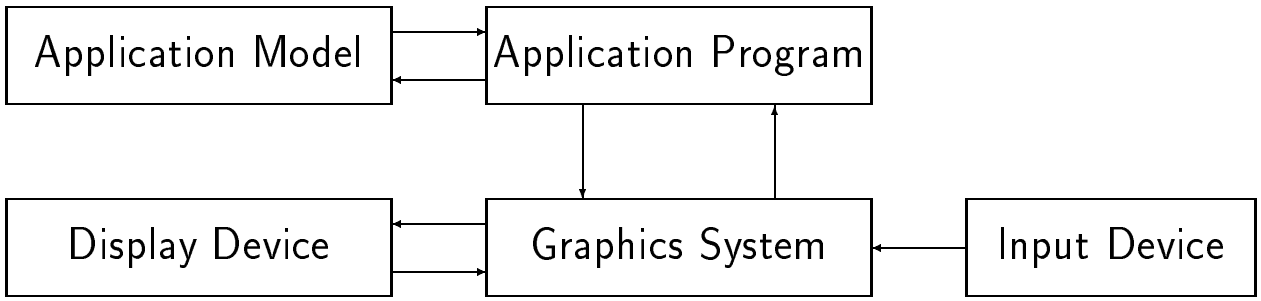
- Text CRT (Cathode Ray Tube) – can display letters, numbers, punctuation, usually only in monochrome (black and white, black and green, black and amber). Characters fixed in memory call *character ROM*.
- Color Raster CRT – High resolution with shaded and colored images. Images dynamically stored in a piece of memory called a *frame buffer*.
- Calligraphic (vector) CRT – Draws high precision lines, sometimes in color. Usually can draw faster than a color raster CRT. Useful for previewing animation, integrated circuit design, air traffic control. A program for drawing the lines is stored in a *display buffer*.
- Printer – like a text CRT, but for *hardcopy* (not softcopy).
- Film (video) recorder – like a color raster CRT.
- Plotter – like a calligraphic CRT.
- Head mounted displays – virtual realities.

Physical Input devices:

- Keyboard – good for entering alphanumeric data.
- Mechanical and optical Mice – good for choosing, positioning, drawing.
- Data tablet – used to trace objects with a stylus. With a puck you can choose and position objects as well as draw.
- Track balls and joysticks.
- Touch screens.
- Space tracker – a *source* and *sensor* that can pick, move, or copy objects in 3-dimensional space.
- Hand tracker – a glove with sensors.
- Image digitizers – a television camera that converts an image into a digital signal.
- Voice input systems.
- Some input devices return *absolute positions* from a fixed origin (e.g. data tablet with stylus or puck).
- Some input devices return *relative positions* from where it positioned last (e.g. a mouse).

Application Modeling

- All data, objects, and relationships among them relevant to display and interaction of the application program
- Examples — circuits, aircrafts, population, econometric, weather modeling
- Application database (application model)
  - Description of *primitives* (points, lines, polygons, polyhedra, parametric surfaces) define the *shape*
  - Object *attributes* (line style, color, texture) describes the "look" of the primitives
  - *Connectivity* relations and *positioning* data describe how components fit together
- Geometry spectrum — layout of physical objects to description of concepts without geometry (eg. statistics)
- Textual, numeric data (equations, formulas, etc.) and procedures often included in the models



History of Computer Graphics

- 1950 – Simple picture: SAGE and Whirlwind
- 1963 – Sketchpad: Ivan E. Sutherland (Interactive graphics)
- Mid 60's – MIT, General Motors, Bell Labs, Lockheed, NASA
- Late 60's – "Cheap" displays from Tektronics, Evans and Sutherland start a dynasty at Utah
- Late 70's – Evans & Sutherland (flight simulators)
- Early 70's – Alan Kay at Xerox
- 1974 – Economic threshold crossed, cheap memory, cheap displays
- Late 70's – Economic raster graphics

History of Computer Graphics

- Early 80's – Microprocessor graphics
- Early 80's – VRAM (from Texas Instruments)
- Mid 80's – Project Athena, X at MIT
- Mid to late 80's – Graphics workstations (Silicon Graphics, Ardent, Stellar)
- Mid to Late 80's – Photorealism (ray tracing and radiosity)
- Early 90's – Interactive 3D systems

- 1950's – Use of matrices and homogeneous coordinates
- 1960's – Interactive techniques for wire frame images
- 1965 – Bresenham's line and circle algorithms
- Late 60's and early 70's – hidden object removal and rendering algorithms
- 1974 – Call for a portable, device-independent graphics standard
- 1979 – Core finalized by SIGGRAPH – *de facto* 3D standard
- Early 80's – Ray tracing algorithms
- 1984 – PostScript – a page description language
- Mid 80's Radiosity, other photorealistic techniques, animation
- 1986 – GKS becomes 1st international standard
- 1986 – The X window system
- 1988 – PHIGS approved – 3D structure hierarchy
- 1988 – PHIGS+ proposed – rendering, lighting models, advanced primitives, etc.

The Future?

- Multiprocessor graphics workstations
- Virtual reality
- Multi-media
- Gigabit networks and mobile computers
- 3 dimensional holographic images
- Flat panel displays
- HDTV computers with international cable connections

Problems

1. What are some of the major topics we will discuss in this course?
2. Describe the major steps in the graphics pipeline.
3. Where is computer graphics used (useful)?
4. What types output devices are used in computer graphics?
5. What logical input devices are used in computer graphics?
6. What is the difference between a logical device and a physical device?
7. What is the difference between absolute and relative coordinates?
8. Who are some of the founders of the field of computer graphics?
9. What is X?
10. What is PHIGS?
11. What is Motif?
12. What is GKS?
13. What is PostScript?
14. Who is Ivan Sutherland?
15. Who is Alan Kay?
16. The phrase "look and feel" is used to describe graphical user interfaces. Itemize the major components — such as icons, windows, scroll bars, menus — of the look of the graphics interface of your favorite word-processor. List the kinds of graphics capabilities these "widgets" require.
17. Aliasing is a serious problem for raster scan displays. Discuss situations where there artifacts matter and those in which they do not. How could you minimize the effects of jaggies?