CSC 292
COMPUTER GRAPHICS

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Computer Graphics: Scope

Broad sense: Any computer-driven display of visual information.

For example:

- Text
- Line drawings
- Graphs, Charts, Schematics
- (Realistic) Pictures
- Pretty designs

Various tools to work with:

- Color, Shading, Texture
- Variation in time (movies)
- Human 3D perceptual abilities
- Interactivity

Application Areas

- User Interfaces: windowing systems, desktops, point and click interaction etc.
- (Interactive) plotting: 2D and 3D graphical representations of numerical data in science, engineering and business.
- Office automation: Word processing, desktop publishing, spreadsheets etc.
- Soft-copy publication and publicity: e.g. the Web
- Computer aided design: VLSI, planes trains and automobiles, buildings, bridges, communication networks, optical systems, nuclear reactors etc.
- Displaying and interpreting results of scientific simulation: physics, chemistry, geology, biology, climatology, cardiology, and any other "ology" you can think of.

- Visualizing 3D databases: medical tomography, engineering tomography, geological structure, etc.
- Entertainment: computer and arcade games, cartoons, special effects, whole movies, virtual environment and interactive games.
- Interactive training: Flight simulators, surgical simulators, immersive war games and practice scenarios.
- Process control: factories, power plants, networks, military command and control.
- Telepresence and augmented perception: Surgery, dangerous environments.
- Art and commerce: snazzy TV ads, virtual real-estate walkthroughs, fun visuals.
- Cartography: Maps for civilian and military use, navigation boxes.

Brief History

Development mostly driven by the cost of various hardware

- 1950s: Crude plotting on teletypes, line printers, CRT-to-camera copy, simple CRT and light-pen displays.
- 1960s: First interactive systems (Southerland's Sketchpad), early CAD/CAM, batch processing, vector displays, mouse (1968), high cost (many $100K).
- 1970s: Raster displays (TV technology), cheaper memory, early graphics standards (e.g. Core), cost starts to come down.

- 1980s: Cheap microprocessors, personal computers invented and explode (XEROX Star, Apple Mac, IBM PC), windowing systems, commodity 2D hardware/software, Improved and extended standards (GKS, PHIGS), extensive development of 3D technology at high-end.
- 1990s: Processor performance continues to explode; prices for memory, disks, display devices drop dramatically; commodity 3D hardware and software; realistic 3D animation becomes commercially viable; interactive, 3D, virtual environments developed

Display (Output) Technology

Can be divided into hard-copy or electronic displays, and vector or raster technology

- Hard-copy devices
  - vector technologies: pen plotters
  - raster technologies: CRT-camera, dot matrix, ink jet, dye sublimation, laser electrostatic, etc.
- Electronic displays
  - vector technologies: swept, direct view storage
  - raster technologies: CRT, LCD, plasma, EL, light valve, etc.

Vector Displays

- 60s through mid-80s. Practically obsolete now.
- Consists of a *buffer memory* containing endpoints of vectors (and characters) to be drawn, and a *display processor* that interprets the buffer and sends end points to a *vector generator* that drives the electron beam across the screen
- Random scan device, needed refresh rate of >30 Hz to avoid flicker.
- Direct-view storage tube (Tektronix 4010) eliminated refresh cycle and made interactive graphics affordable.

Raster Displays

- Became affordable in mid-70s, based on television technology.
- Represents image as an array called a *raster* of (colored) dots called *pixels* that are refreshed row by row. Each row is called a *raster line*.
- Consists of a buffer memory containing (codes describing) the dot colors, hardware that drives one or three electron beams in a regular scan pattern, and a display proccesor that scans the buffer in synch with the beam and sets the beam intensities to produce the desired color.
- Cheaper RAM was breakthrough needed to make technology affordable.

Typical Raster Specifications (1996)

- Size: 1024 x 768 pixels (640 x 480 - 1600 x 1200)
- Refresh rate: 75 Hz. (60 - 160)
- Bits per pixel: 24 (1-96)
- Price: $1000 ($300 - $4000+)

Advantages of raster displays

- Lower cost
- Less complex driver electronics
- Ability to display area filled with color or patterns
- Refresh independent of number of objects

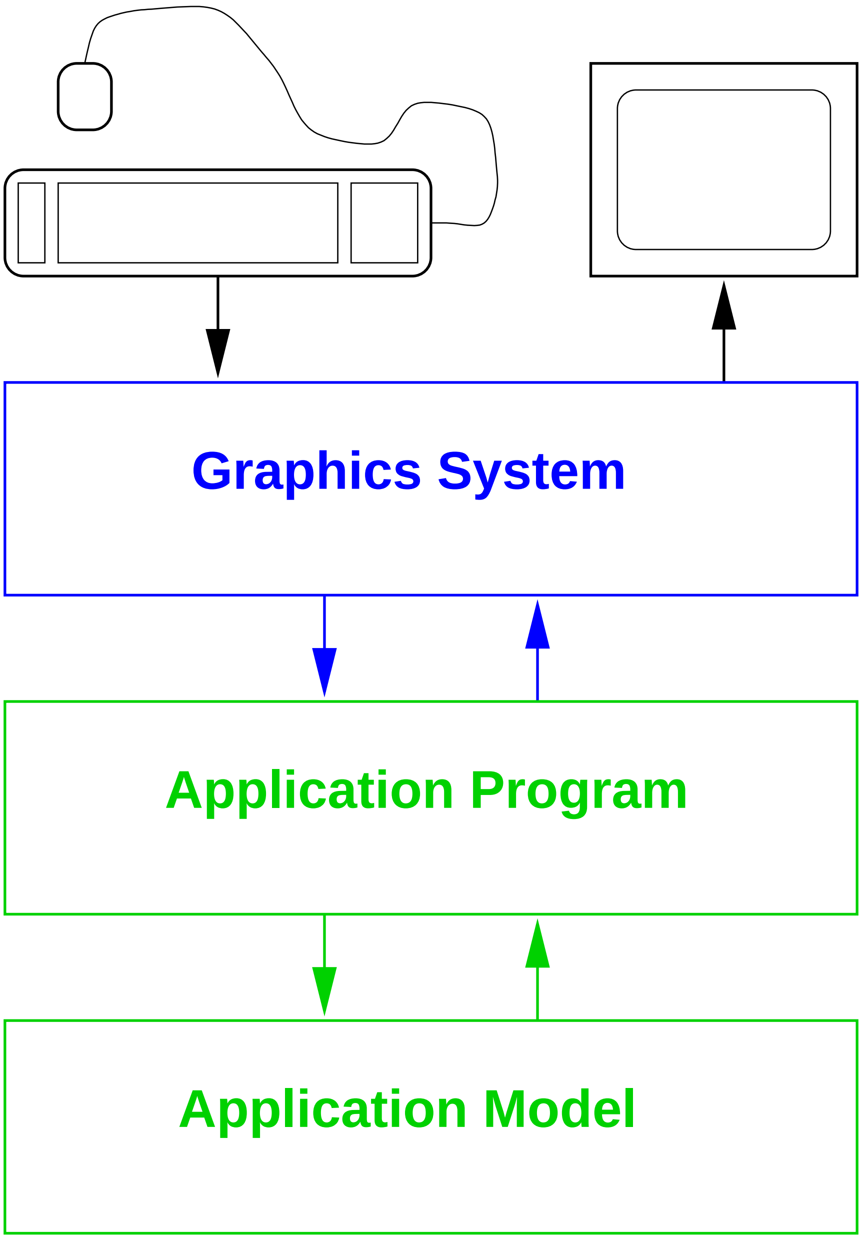
Disadvantages

- Need for *scan conversion*, e.g. lines to pixels. Software and hardware solutions.
- Slower real-time dynamics
- Problems with *aliasing*, aka "the jaggies". Lots and lots of work here.

Input Technology

- Light pen (obsolete)
- Mouse
- Touch screen
- Data tablet
- “Polhemus” sensor (6D mouse)
- Dataglove
- Haptic (force feedback) device (e.g. “Phantom”)
- Exoskeleton (force feedback possible)
- Audio (e.g. speech recognition)
- Visual (e.g. gesture recognition)

Framework for Interactive Graphics



Hardware

Systems Software

User Software

Input and display hardware:

- Takes user input and displays output.
- Hardware defined interface (sometimes partly soft).
- Fairly low-level language.

Graphics system:

- Stands between user and hardware.
- Provides higher-level, more usable interface.
- Provides Useful abstractions, objects.
- Provides hardware independence.
- Examples: SRGP, PHIGS, OpenGL.

Application Program:

- User software that creates and updates model.
- Modifies application model in response to user input.
- Ensures that changes to model are reflected in output.
- Uses system interface provided by graphics system.

Application Model:

- Basically, the computer's model of the world.
- Often uses primitives that correspond to common graphics system primitives.
- Not necessarily geometric (e.g. a spreadsheet)
- May be dynamic.