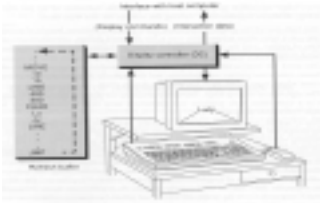
Development of Computer Graphics

- 1951
  - Whirlwind, Jay Forrester (MIT)
  - CRT displays
- mid 1950s
  - SAGE air defense system
  - command & control CRT, light pens
- late 1950s
  - Computer Art, James Whitney Sr.
  - Visual Feedback loops
- 1962
  - Sketchpad, Ivan Sutherland
  - data structures, light pen for drawing and choices

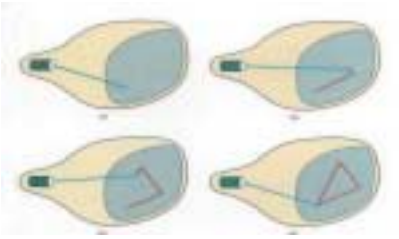
Development of Computer Graphics

- Early display devices (mid-60s):
- Vector, stroke, line drawing, calligraphic displays
- Architecture of Vector Display



Development of Computer Graphics

- Architecture of a vector display - random scan
  - vector generator converts digital coordinates to beam deflections



Development of Computer Graphics

- 1964
  - CAD and CAM
  - General Motors DAC, Itek Digitek for Lens Design
- 1964-1970s
  - Photorealism at University of Utah
  - Sutherland, Evans, Catmull, Blinn
- 1968
  - Evans & Sutherland
  - commercial company - flight simulators
  - 3D vector pipeline, matrix multiplier, clipping
- 1969
  - First SIGGRAPH

Development of Computer Graphics

- 1970
  - Pierre Bezier - Bezier curves

Development of Computer Graphics

- 1971:
  - Gouraud Shading

Development of Computer Graphics

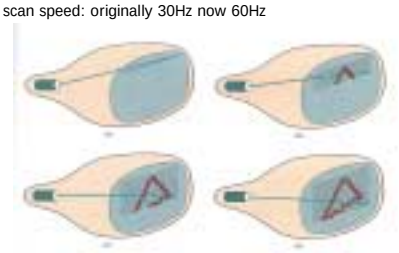
- 1974-1977
  - Catmull - Z-buffer
  - Bui-Toung Phong creates Phong Shading (Utah)
  - Martin Newell's teapot (Utah)
  - Computer graphics at NYIT - computer animation
  - Raster Graphics (Xerox PARC, Shoup)

Development of Computer Graphics

- Architecture of a raster display

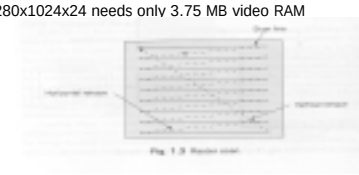
Development of Computer Graphics

- Architecture of a raster display - raster scan
  - beams (3 beams) intensity set to reflect pixel intensity
  - scan speed: originally 30Hz now 60Hz



Development of Computer Graphics

- Raster Scan
  - need to store whole image
  - 1024 x1024 x n - n bits per pixel
  - mono 1 bit, color 8 (256 color), 24 (16 million)
  - 32 to 96 bits used (*double buffering, z-buffering*)
  - 1280x1024x24 needs only 3.75 MB video RAM



Development of Computer Graphics

- Random Scan versus Raster Scan
  - note ragged lines

Development of Computer Graphics

- Random Scan versus Raster Scan
- Raster advantages:
  - low cost, superior fill ability, refresh rate independent of complexity, 70Hz sufficient to avoid flicker
- Raster disadvantages:
  - discrete nature of pixel representation, need for scan conversion in software or RIP chips
    - real-time dynamics more demanding
  - approximation of lines by sequence of pixels
    - *aliasing* - jaggies or staircasing
    - manifestation of sampling error in signal processing
    - need for *anti-aliasing*

Development of Computer Graphics

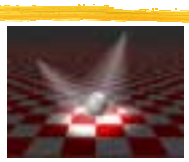
- 1976
  - Image and texture mapping (Blinn)
- 1977
  - 3D Core Graphics System,
  - first "standard" for device independent graphics package
  - allowed portable graphics programming
  - ACM SIGGRAPH committee including Foley, Van Dam, Feiner
  - baseline specification - many implementations

Development of Computer Graphics

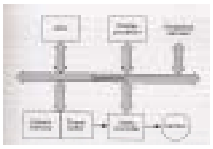
- 1982
  - Clarke, Geometry Engine
    - hardware support for transforms (matrix-vector multiplies), clipping (variant of Sutherland-Hodgman algorithm)
  - IRIS - Integrated Raster Imaging System, SGI
    - high-end workstation
    - hardware acceleration of graphics pipeline
- 1982
  - TRON - 'non-realism' and realtively low technical quality special effects
  - Star Trek - Genesis Effect ; Lucasfilm's computer graphics division (later split into Industrial Light and Magic, and Pixar)
    - used key technical effects (such as particle systems and caustics)

Development of Computer Graphics

- 1982
  - Ray Tracing, Turner Whitted
  - good at rendering reflections, refractions and shadows

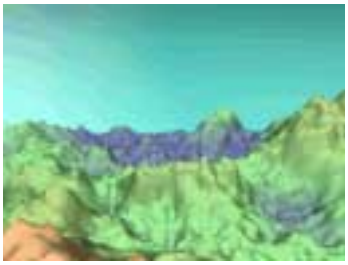


- 1983
  - VRAM, Video random access memory, Texas Instruments
    - can read out all pixels in one memory cycle



Development of Computer Graphics

- 1983
  - Fractals
  - Allowed generation of the key components of natural-looking landscapes



Development of Computer Graphics

- 1985
  - Radiosity, Don Greenberg (Cornell)
  - GKS, Graphical Kernel System
    - first ANSI standard
    - elaborated cleaned up version of CORE but only 2D
- 1986
  - Renderman - an extensible 'procedural language' for controlling the animation/rendering process
- 1988
  - GKS, Graphical Kernel System - 3D version

Development of Computer Graphics

- 1988
  - PHIGS, PHIGS+
  - Programmer's Hierarchical Interactive Graphics System
  - More complex than CORE

PHIGS v GKS

- GKS allowed grouping of primitives into “segments”
  - no nesting of segements
- PHIGS allowed nested hierarchical grouping of 3D primitives into “structures”
  - all primitives subject to geometric transformations
  - editable database of structures
  - auto-update of screen when database altered
- PHIGS+
  - extension for pseudo-realistic rendering on raster devices
- PHIGS, PHIGS+ large packages
  - run best with hardware support of transforamtions, clipping and rendering

Development of Computer Graphics

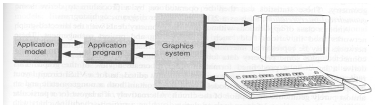
- 1993
  - OpenGL - Open Graphics Library
  - derived from SGI’s GL library
- 1993
  - Open Inventor, OO layer on OpenGL
- 1995
  - QuickDraw 3D, Apple
- 1995
  - Direct3D, Microsoft, game playing API

Development of Computer Graphics

- Input Devices
  - early light pens to modern mice
  - data tablet
  - touch sensitive screens
  - 3D input devices (spaceballs etc.)
  - button and dial boxes

Describing Scene to be viewed

- Application Program - creates application
- Application Model - independent of display system
  - program must extract geometry and convert to *primitives* of graphics system
  - primitives: points, lines, (rectangles, ellipses, text, polygons, polyhedra, spheres, curves, surfaces
  - application must convert geometry to primitives supported
  - *attributes* (line style, color, line width, fill style)



Graphics Systems

- Typically libraries: output subroutines
  - user programs in *logical display device* terms
  - graphics library converts to device dependent instructions
  - abstraction of display device
    - *locator* - mouse, tablet, joystick etc
    - *sample* - return from locator
    - *event* - generated by user input

Graphics Systems

- Interaction Handling - *event driven loop*
  - **while** (!quit) {
    - enable selection of commands/objects
    - wait for user selection
    - **switch** (selection) { process selection, updating model and screen as necessary}
  - }
- User interaction
  - change in screen appearance - does not involve update of model: application updates state and calls graphics package
  - change in model : must recalculate