Introduction to Computer Graphics

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Objectives

- Broad introduction to Computer Graphics
  - Software
  - Hardware
  - Applications
- Top-down approach
- OpenGL

Text Book

- Ed Angel, Interactive Computer Graphics, A Top-down Approach with OpenGL (Third Edition)

- The lectures cover the material in Chapters 1-10

Prerequisites

- Good programming skills in C (or C++)
- Basic Data Structures
  - Linked lists
  - Arrays
- Geometry
- Simple Linear Algebra

Requirements

- 3 Assigned Projects
  - Simple
  - Interactive
  - 3D
- Term Project
  - You pick

Resources

- Can run OpenGL on any system
  - Windows
  - Linux
  - Mac
- CS lab
  - Linux/mesa
  - Scalable systems lab
    - Intellestations Gforce 3 and FX

References

- Other helpful references
  - OpenGL: A Primer, Ed Angel, Addison-Wesley, 2002
    - Designed for students who need more programming information
  - The OpenGL Programmer's Guide (the Redbook) and the OpenGL Reference Manual (The Blue book), Addison-Wesley,
    - **The definitive references**

Web Resources

- www.opengl.org
- www.cs.unm.edu/~angel

Outline: Part 1

- Part 1: Introduction
- Text: Chapter 1
- Lectures 1-3
  - What is Computer Graphics?
  - Applications Areas
  - History
  - Image formation
  - Basic Architecture

Outline: Part 2

- Part 2: Basic OpenGL
- Text: Chapters 2-3
- Lectures 4-9
  - Architecture
  - GLUT
  - Simple programs in two and three dimensions
  - Interaction

Outline: Part 3

- Part 3: Three-Dimensional Graphics
- Text: Chapters 4-6
- Lectures 10-20
  - Geometry
  - Transformations
  - Homogeneous Coordinates
  - Viewing
  - Shading

Outline: Part 4

- Part 4: Discrete Methods
- Text: Chapter 7
- Lectures 21-24
  - Buffers
  - Bitmaps and Pixel Maps
  - Texture Mapping
  - Compositing and Transparency

Outline: Part 5

- Part 5: Implementation
- Text: Chapter 8
- Lectures: 25-28
  - Approaches (object vs image space)
  - Implementing the pipeline
  - Clipping
  - Line drawing
  - Polygon Fill
  - Display issues (color)

Outline: Part 6

- Part 6: Hierarchy
- Text: Chapter 9
- Lectures: 29-31
  - Tree Structured Models
  - Traversal Methods
  - Scene Graphs

Outline: Part 7

- Part 7: Curves and Surfaces
- Text: Chapter 10
- Lectures: 32-36

What is Computer Graphics

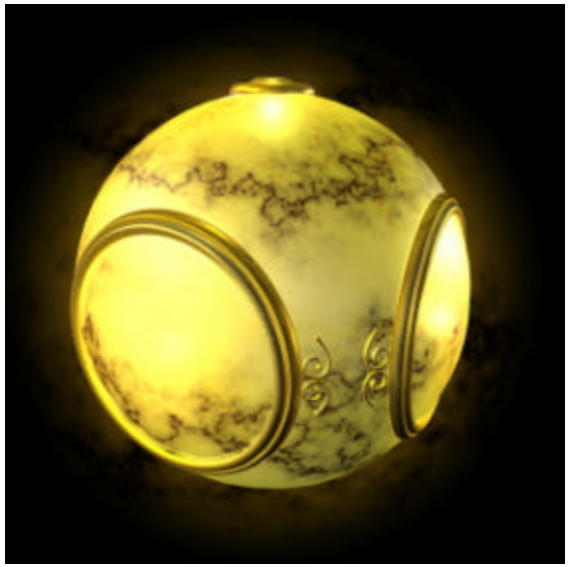
- Now we start to explore what computer graphics is about and survey some application areas
- But we start with a historical introduction

Computer Graphics

- *Computer graphics* deals with all aspects of creating images with a computer
  - Hardware
  - Software
  - Applications

Example

- Where did this image come from?

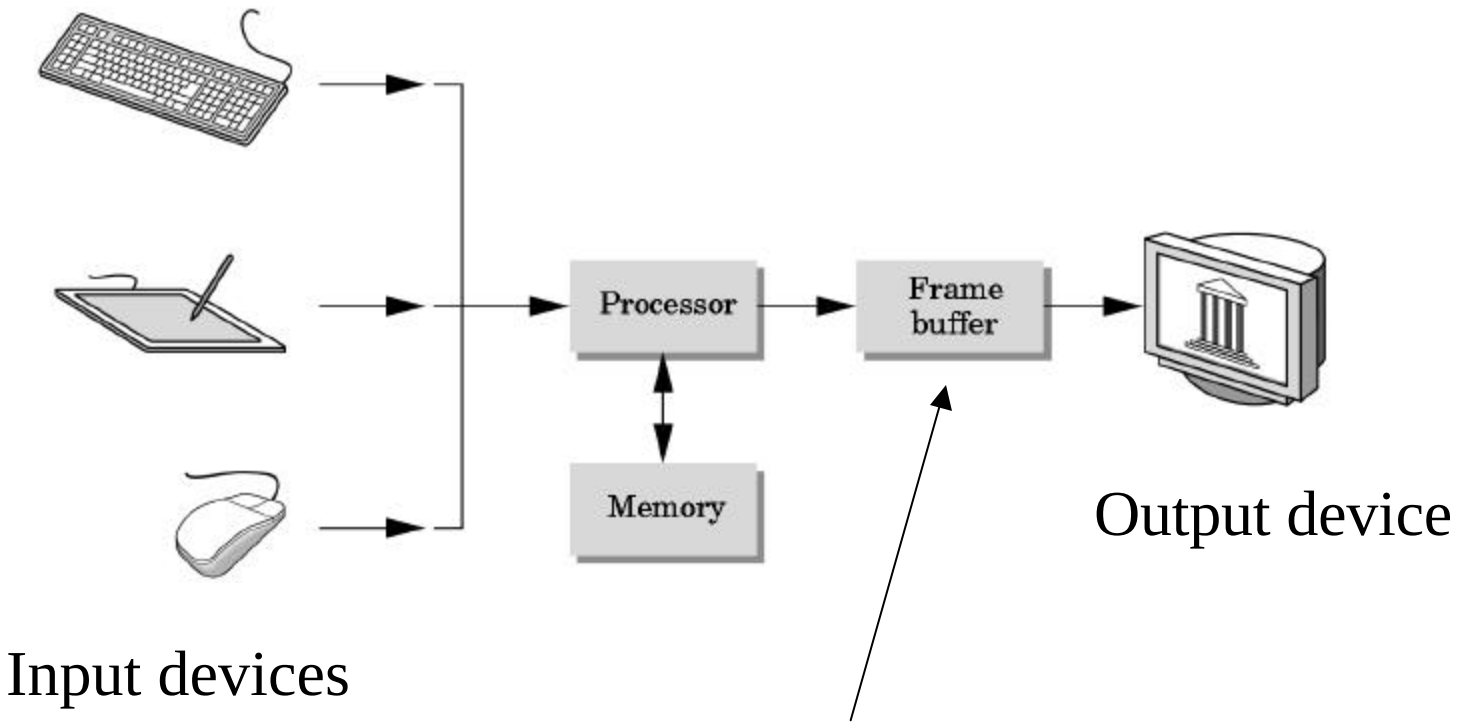


- What hardware/software did we need to produce it?

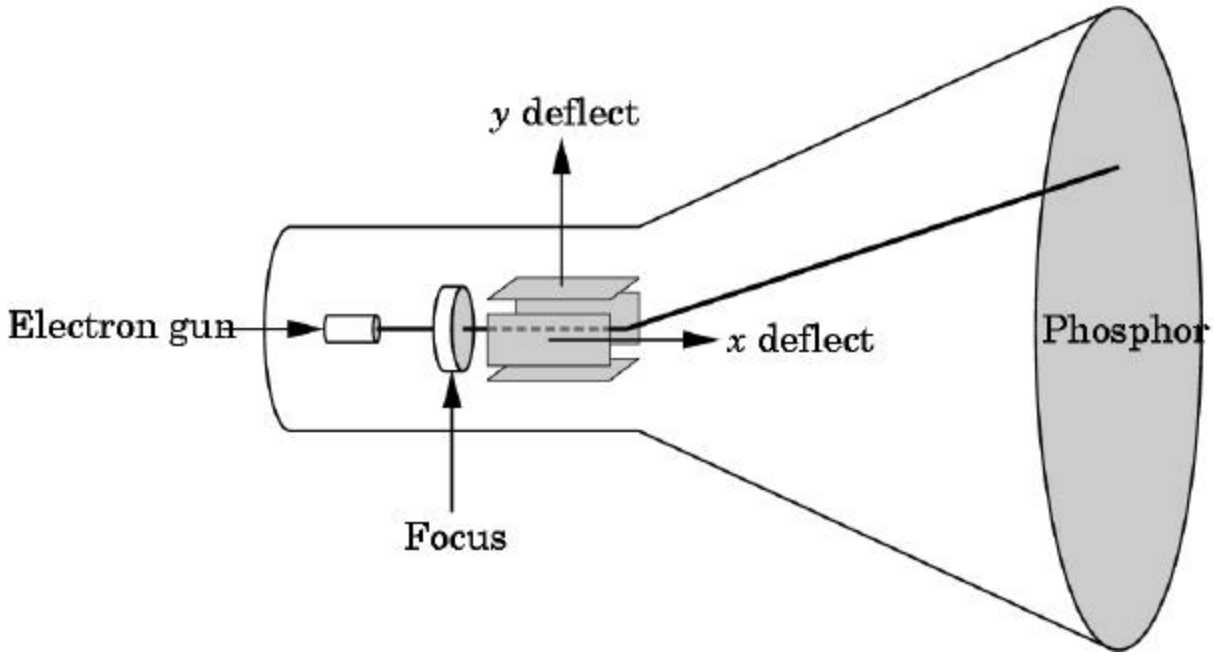
Preliminary Answer

- **Application**: The object is an artist's rendition of the sun for an animation to be shown in a domed environment (planetarium)
- **Software**: Maya for modeling and rendering but Maya is built on top of OpenGL
- **Hardware**: PC with graphics card for modeling and rendering

Basic Graphics System



CRT



Can be used either as a line-drawing device (calligraphic) or to display contents of frame buffer (raster mode)

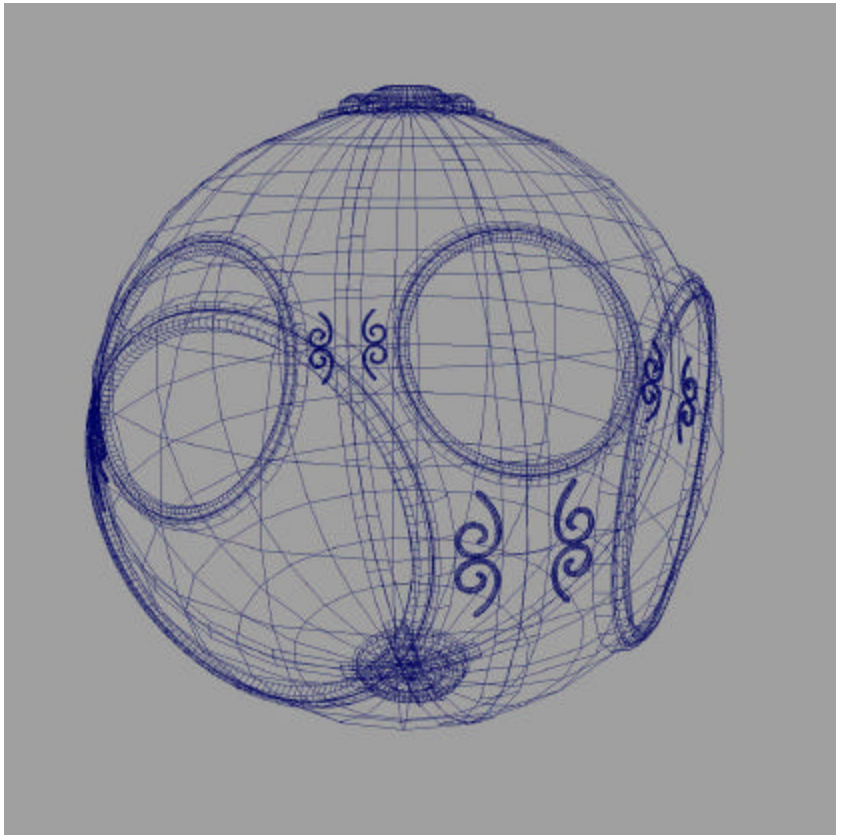
Computer Graphics: 1950-1960

- Computer graphics goes back to the earliest days of computing
  - Strip charts
  - Pen plotters
  - Simple displays using A/D converters to go from computer to calligraphic CRT
- Cost of refresh for CRT too high
  - Computers slow, expensive, unreliable

Computer Graphics: 1960-1970

- *Wireframe* graphics
  - Draw only lines
- Project Sketchpad
- Display Processors
- Storage tube

wireframe representation
of sun object

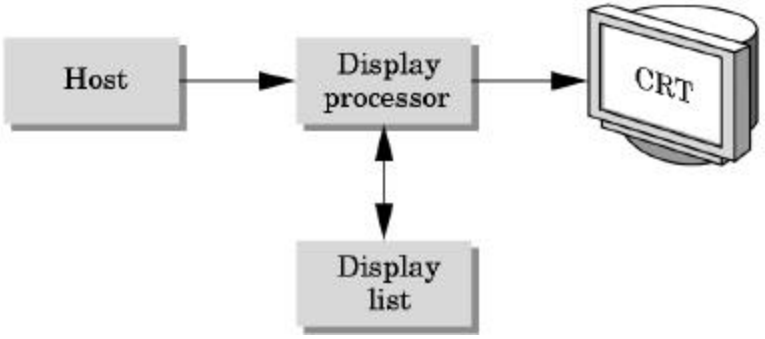


Project Sketchpad

- Ivan Sutherland's PhD thesis at MIT
  - Recognized the potential of man-machine interaction
  - Loop
    - Display something
    - User moves light pen
    - Computer generates new display
  - Sutherland also created many of the now common algorithms for computer graphics

Display Processor

- Rather than have host computer try to refresh display use a special purpose computer called a *display processor* (DPU)



- Graphics stored in display list (display file) on display processor
- Host *compiles* display list and sends to DPU

Direct View Storage Tube

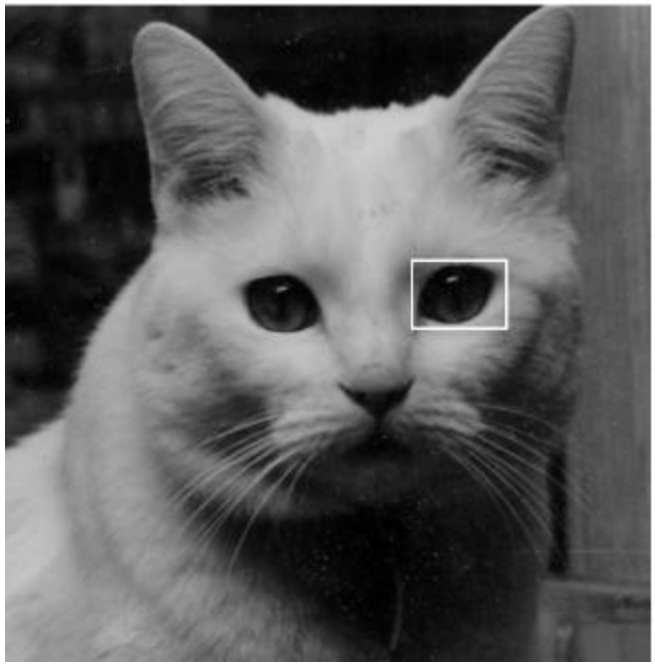
- Created by Tektronix
  - Did not require constant refresh
  - Standard interface to computers
    - Allowed for standard software
    - Plot3D in Fortran
  - Relatively inexpensive
    - Opened door to use of computer graphics for CAD community

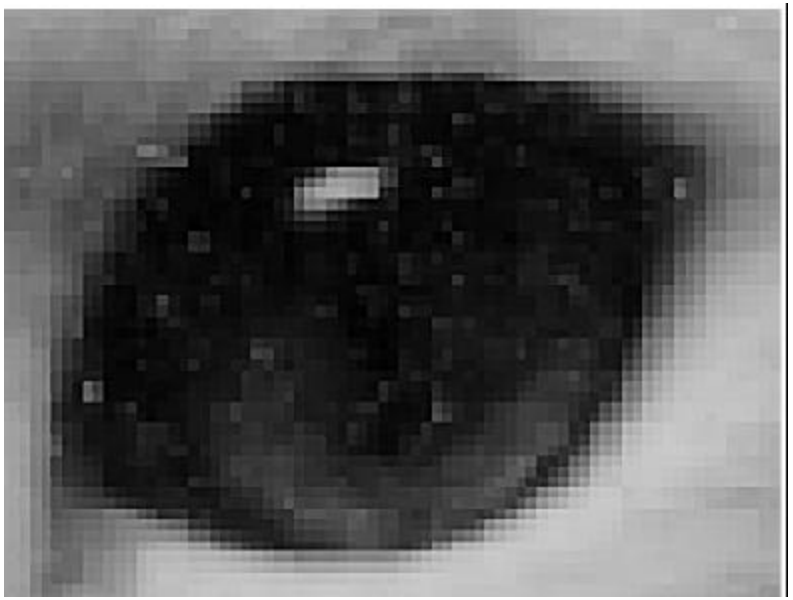
Computer Graphics: 1970-1980

- Raster Graphics
- Beginning of graphics standards
  - IFIPS
    - GKS: European effort
      - Becomes ISO 2D standard
    - Core: North American effort
      - 3D but fails to become ISO standard
- Workstations and PCs

Raster Graphics

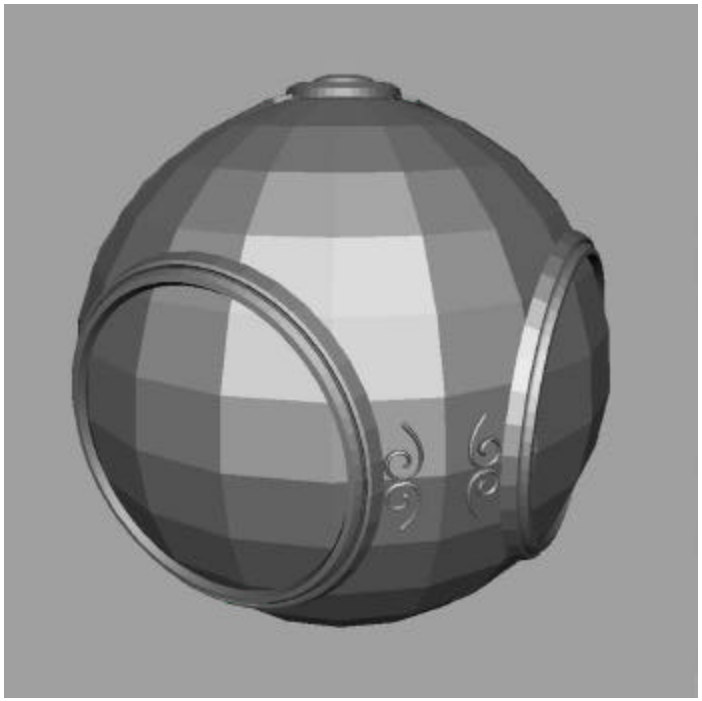
- Image produced as an array (the *raster*) of picture elements (*pixels*) in the *frame buffer*





Raster Graphics

- Allows us to go from lines and wire frame images to filled polygons

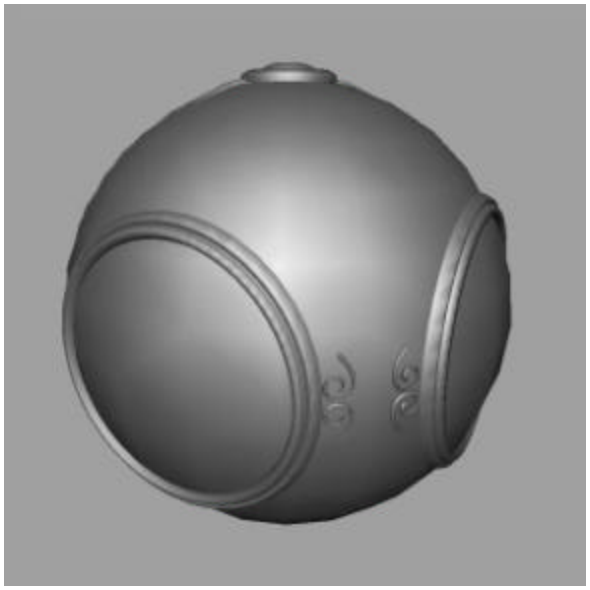


PCs and Workstations

- Although we no longer make the distinction between workstations and PCs, historically they evolved from different roots
  - Early workstations characterized by
    - Networked connection: client-server model
    - High-level of interactivity
  - Early PCs included frame buffer as part of user memory
    - Easy to change contents and create images

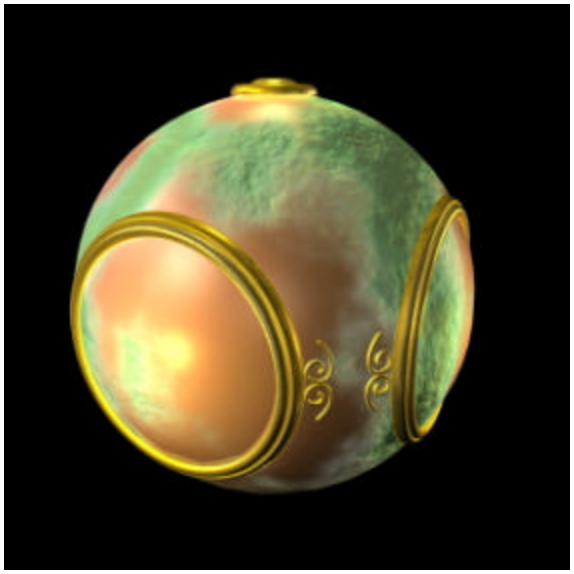
Computer Graphics: 1980-1990

Realism comes to computer graphics



smooth shading

environmental mapping



bump mapping

Computer Graphics: 1980-1990

- Special purpose hardware
  - Silicon Graphics geometry engine
    - VLSI implementation of graphics pipline
- Industry-based standards
  - PHIGS
  - RenderMan
- Networked graphics: X Window System
- Human-Computer Interface (HCI)

Computer Graphics: 1990-2000

- OpenGL API
- Completely computer-generated feature-length movies (Toy Story) are successful
- New hardware capabilities
  - Texture mapping
  - Blending
  - Accumulation, stencil buffers

Computer Graphics: 2000-

- Photorealism
- Graphics cards for PCs dominate market
  - Nvidia, ATI, 3DLabs
- Game boxes and game players determine direction of market
- Computer graphics routine in movie industry: Maya, Lightwave