



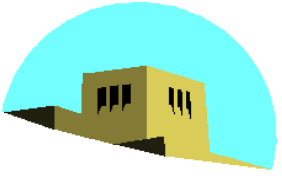
Introduction to Computer Graphics with WebGL

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What is Computer Graphics?

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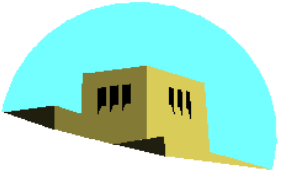
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Computer Graphics

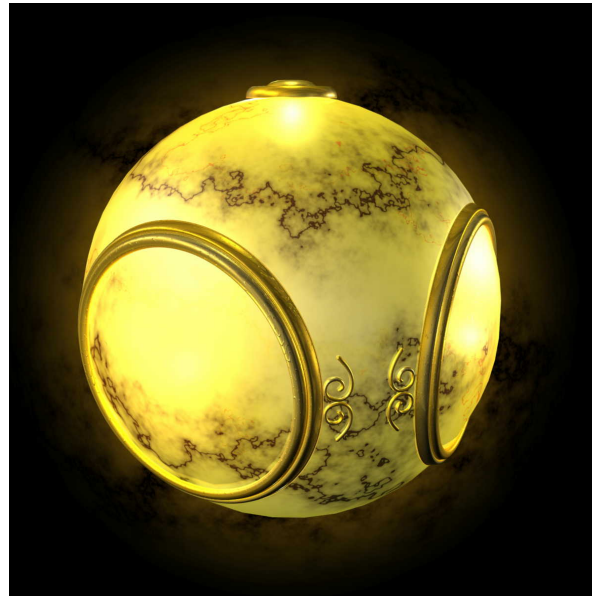
- *Computer graphics* deals with all aspects of creating images with a computer
 - Hardware
 - Software
 - Applications



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Example

- Where did this image come from?



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



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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



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Basic Graphics System

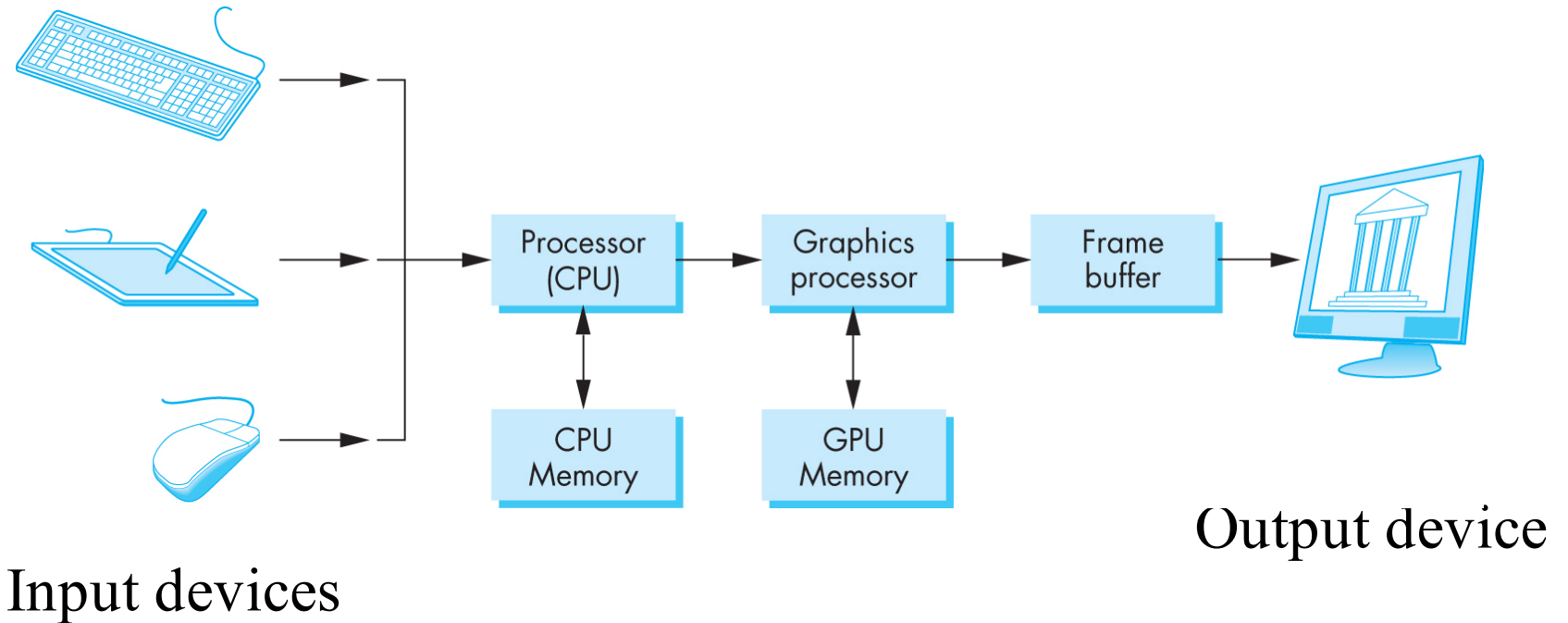


Image formed in frame buffer



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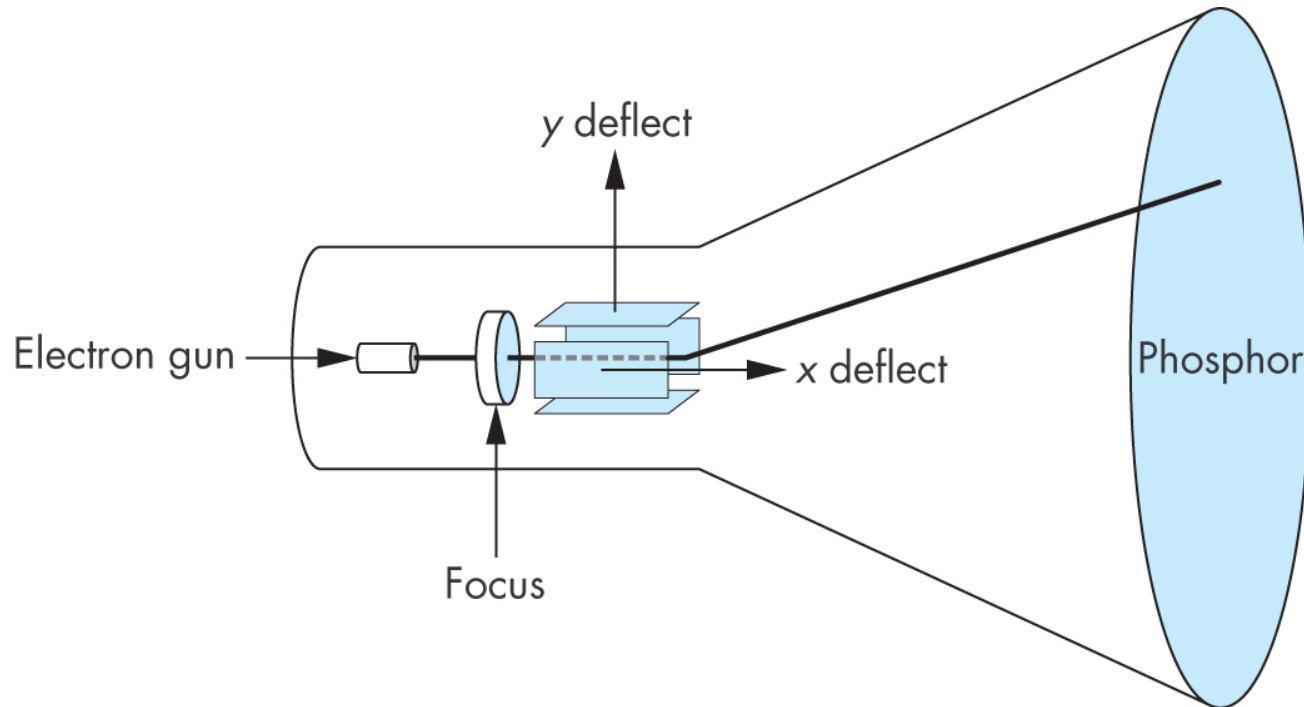
Computer Graphics: 1950-1960

- 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

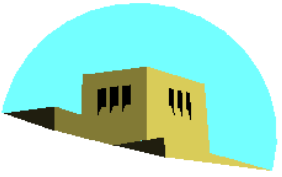


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Cathode Ray Tube (CRT)

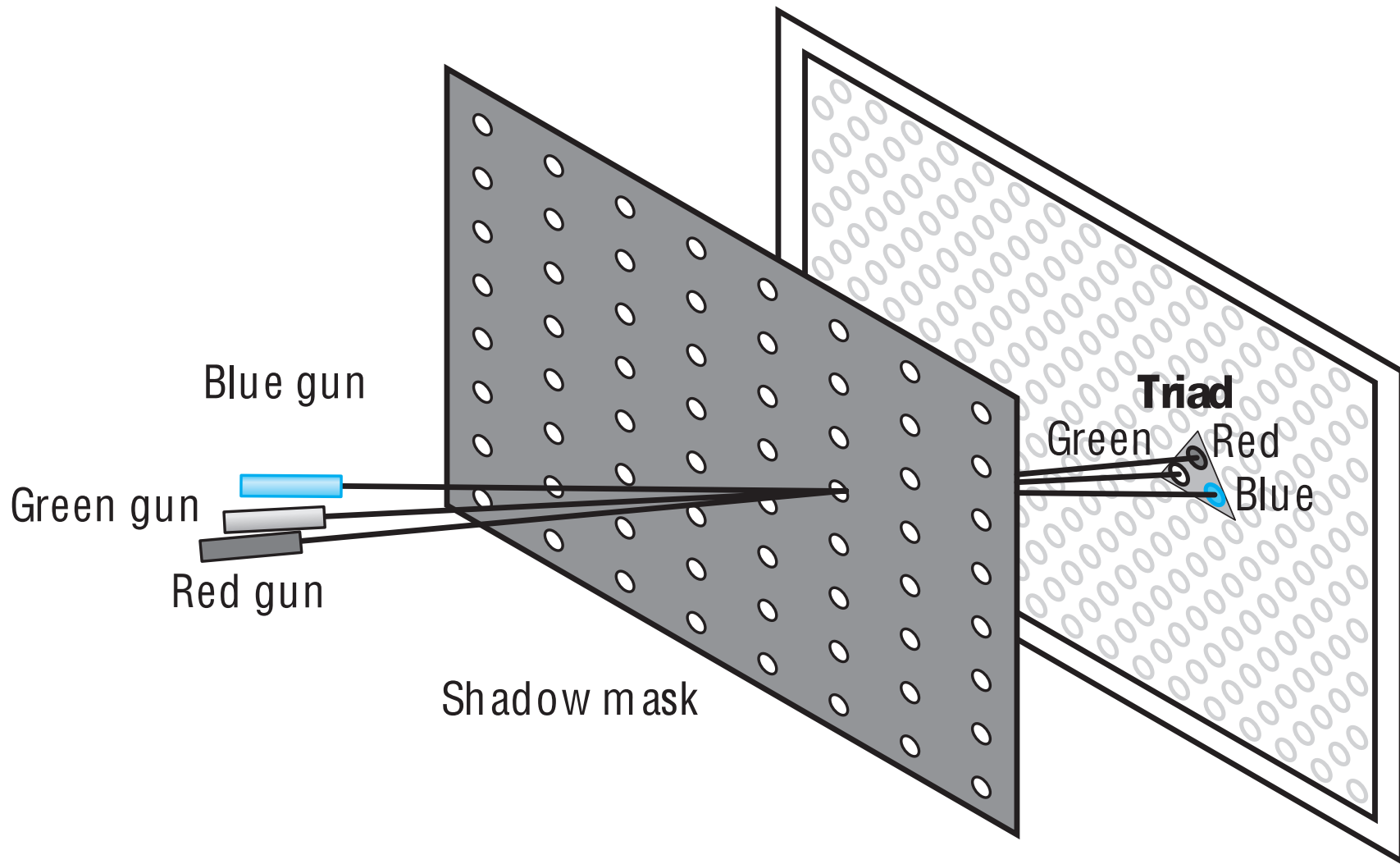


Can be used either as a line-drawing device (calligraphic) or to display contents of frame buffer (raster mode)



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Shadow Mask CRT



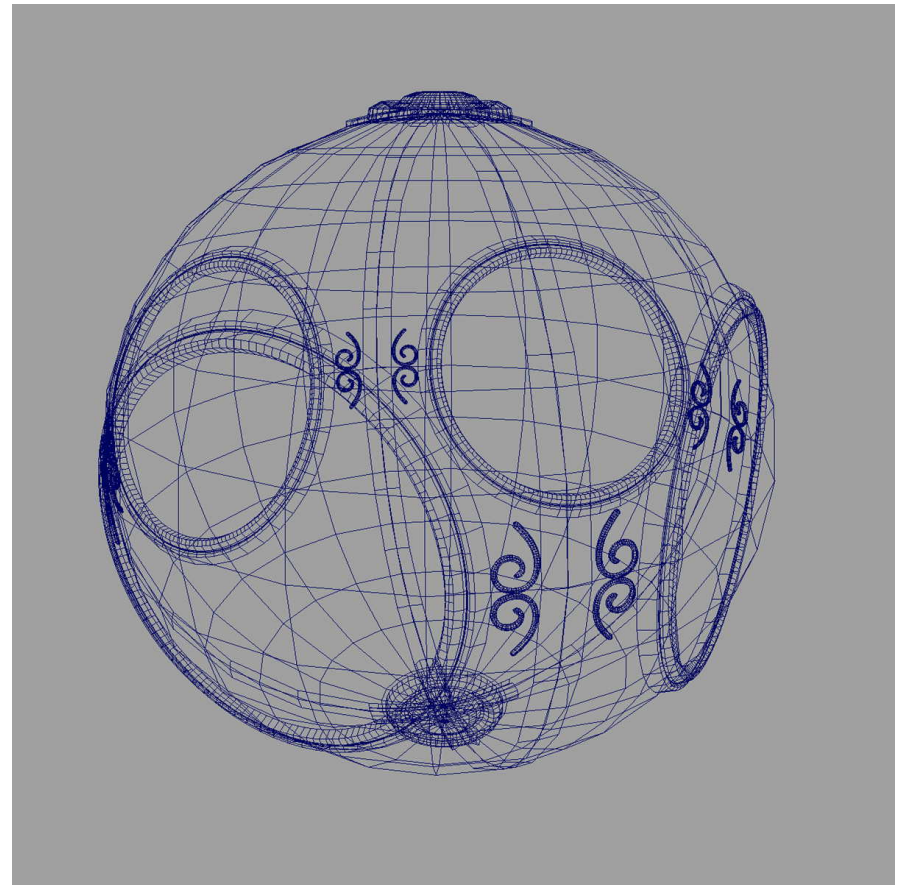


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Computer Graphics: 1960-1970

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

wireframe representation
of sun object





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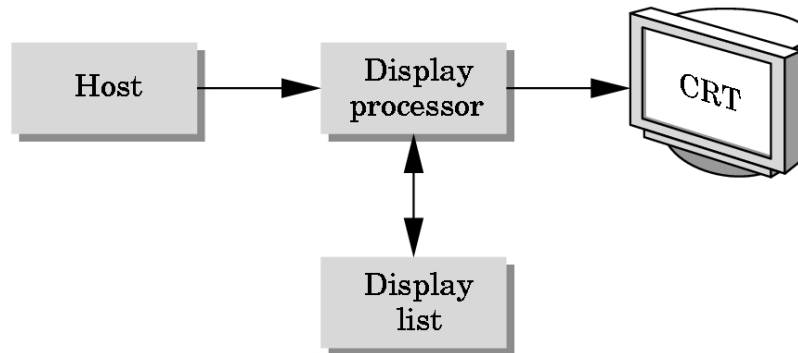
Sketchpad

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



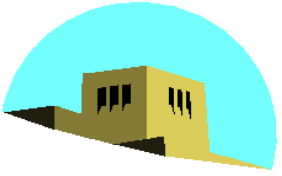
- Graphics stored in display list (display file) on display processor
- Host *compiles* display list and sends to DPU



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Computer Graphics: 1970-1980

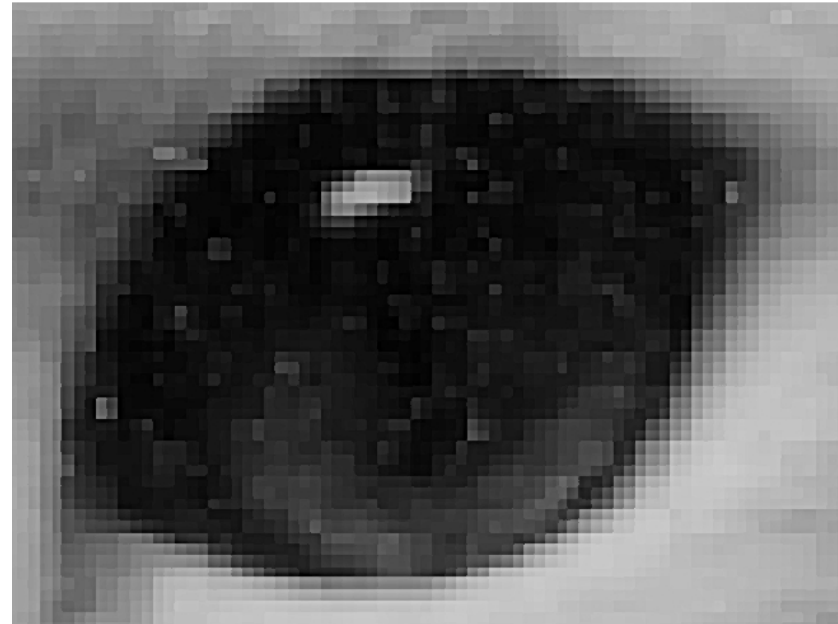
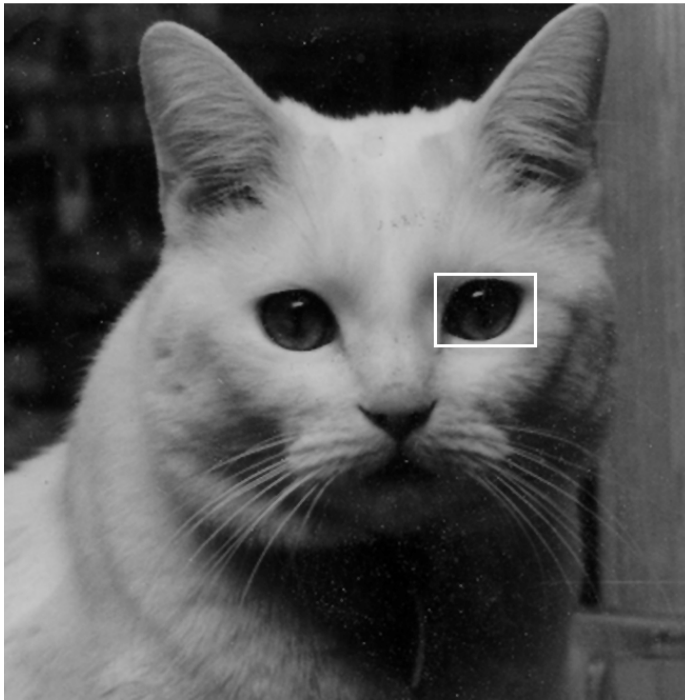
- Raster Graphics
- Beginning of graphics standards
 - IFIPS
 - GKS: European effort
 - Becomes ISO 2D standard
 - Core: North American effort
 - 3D but fails to become ISO standard
- Workstations and PCs

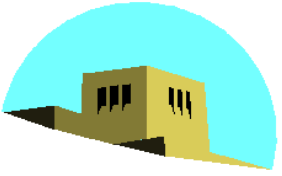


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Raster Graphics

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

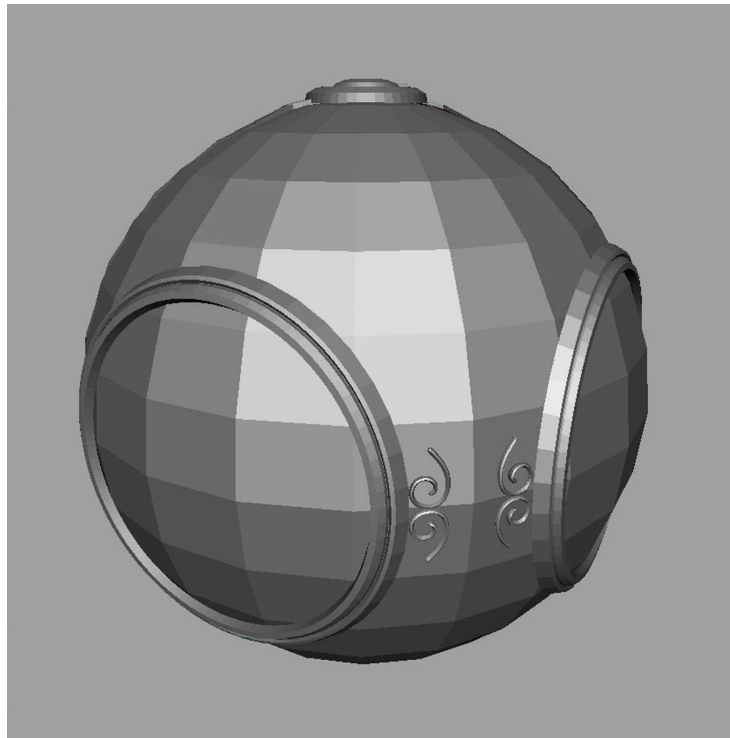




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Raster Graphics

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





PCs and Workstations

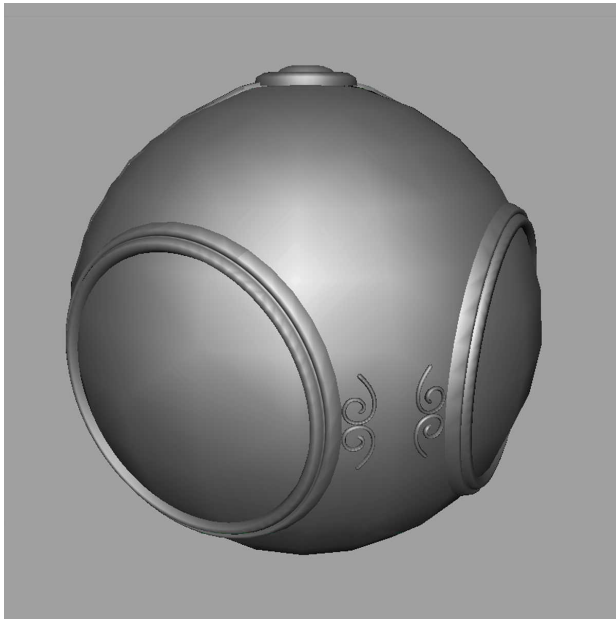
- Although we no longer make the distinction between workstations and PCs, historically they evolved from different roots
 - Early workstations characterized by
 - Networked connection: client-server model
 - High-level of interactivity
 - Early PCs included frame buffer as part of user memory
 - Easy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



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Computer Graphics: 1980-1990

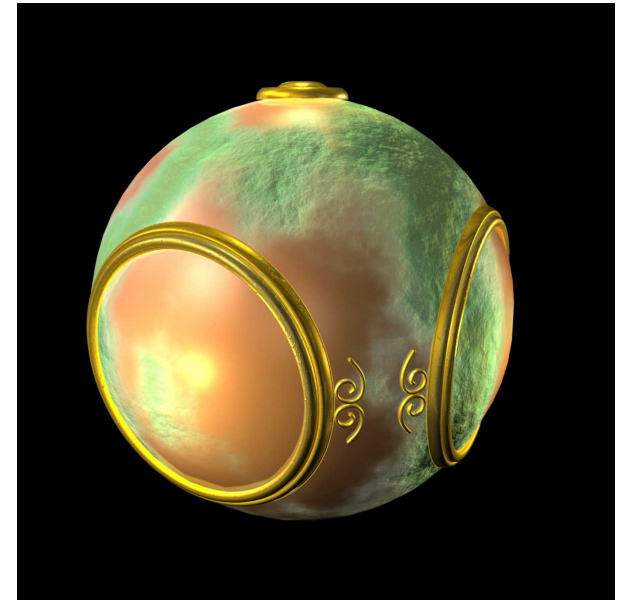
Realism comes to computer graphics



smooth shading



environment
mapping



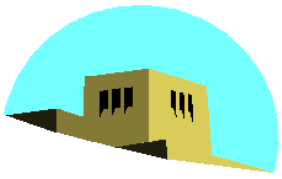
bump mapping



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Computer Graphics: 1980-1990

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



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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



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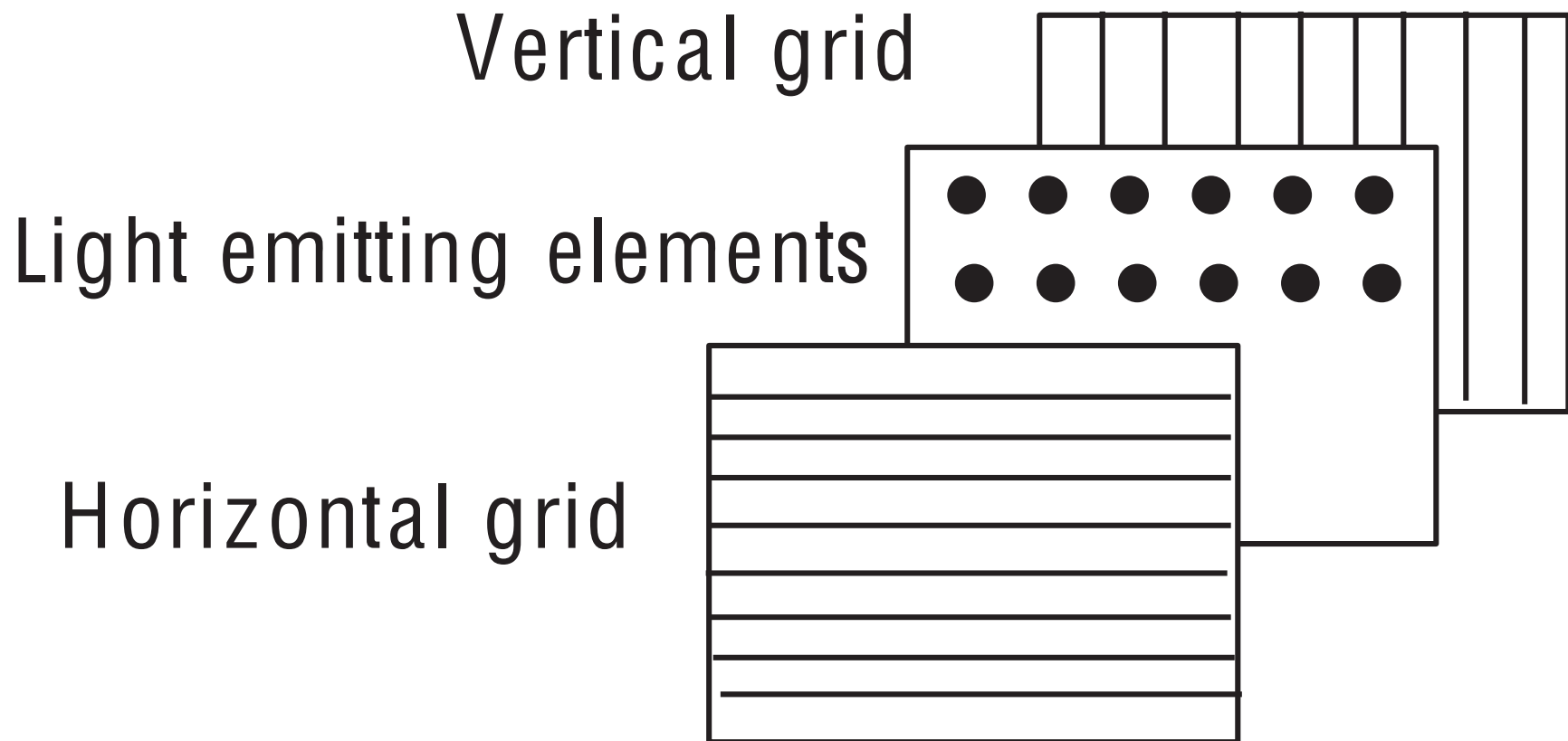
Computer Graphics: 2000-2010

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



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Generic Flat Panel Display





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Computer Graphics 2011-

- Graphics is now ubiquitous
 - Cell phones
 - Embedded
- OpenGL ES and WebGL
- Alternate and Enhanced Reality
- 3D Movies and TV