Computer Graphics

Lecture 1

By

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Based on Computer Graphics By Hearn & Baker

What is Computer Graphics?

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

Application of Computer Graphics

1. **Computer-Aided Design for engineering and architectural systems**
   - Objects maybe displayed in a wireframe outline form.
   - Multi-window environment is also favored for producing various zooming scales and views.
   - Animations are useful for testing performance.

Application of Computer Graphics

2. Presentation Graphics

- To produce illustrations which summarize various kinds of data.
- Except 2D, 3D graphics are good tools for reporting more complex data.

Application of Computer Graphics

3. Computer Art

- Painting packages are available. With cordless, pressure-sensitive stylus, artists can produce electronic paintings which simulate different brush strokes, brush widths, and colors.
- Photorealistic techniques, morphing and animations are very useful in commercial art.
- For films, 24 frames per second are required. For video monitor, 30 frames per second are required.

Application of Computer Graphics

4. Entertainment

- Motion pictures, Music videos, and TV shows, Computer games

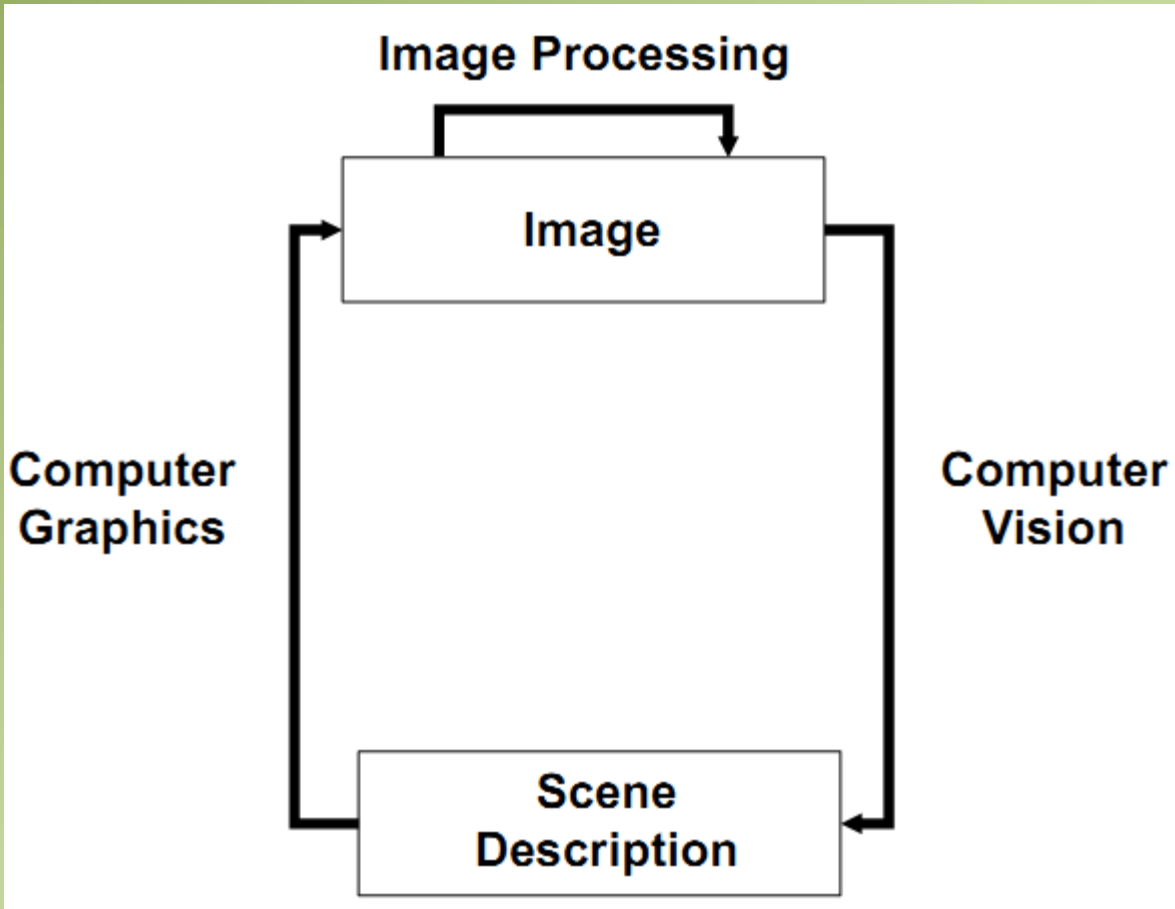
5. Education and Training

- Training with computer-generated models of specialized systems such as the training of ship captains and aircraft pilots.

Application of Computer Graphics

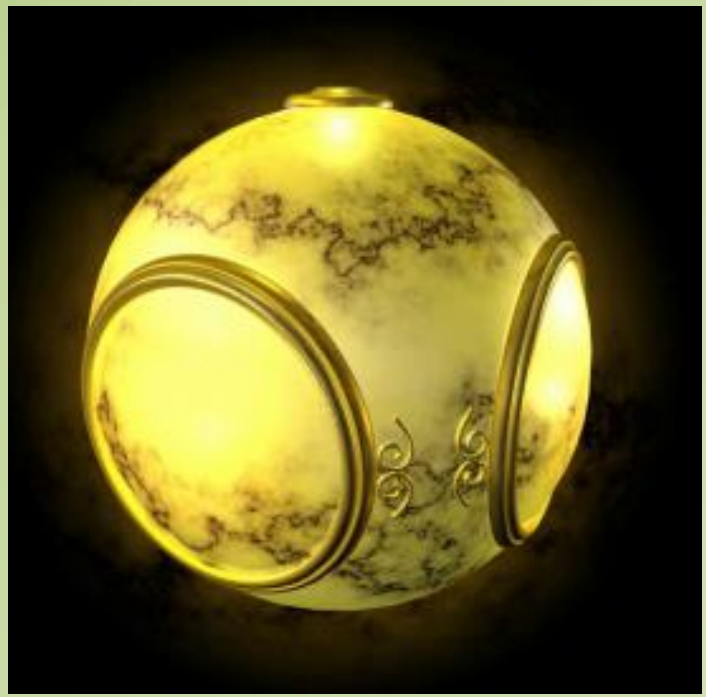
6. **Visualization**
   - For analyzing scientific, engineering, medical and business data or behavior.
   - Converting data to visual form can help to understand mass volume of data very efficiently.
7. **Image Processing**
   - Image processing is to apply techniques to modify or interpret existing pictures.
   - It is widely used in medical applications.
8. **Graphical User Interface**
   - Multiple window, icons, menus allow a computer setup to be utilized more efficiently.

Related Fields



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 cards for modeling and rendering

Basic Graphics System

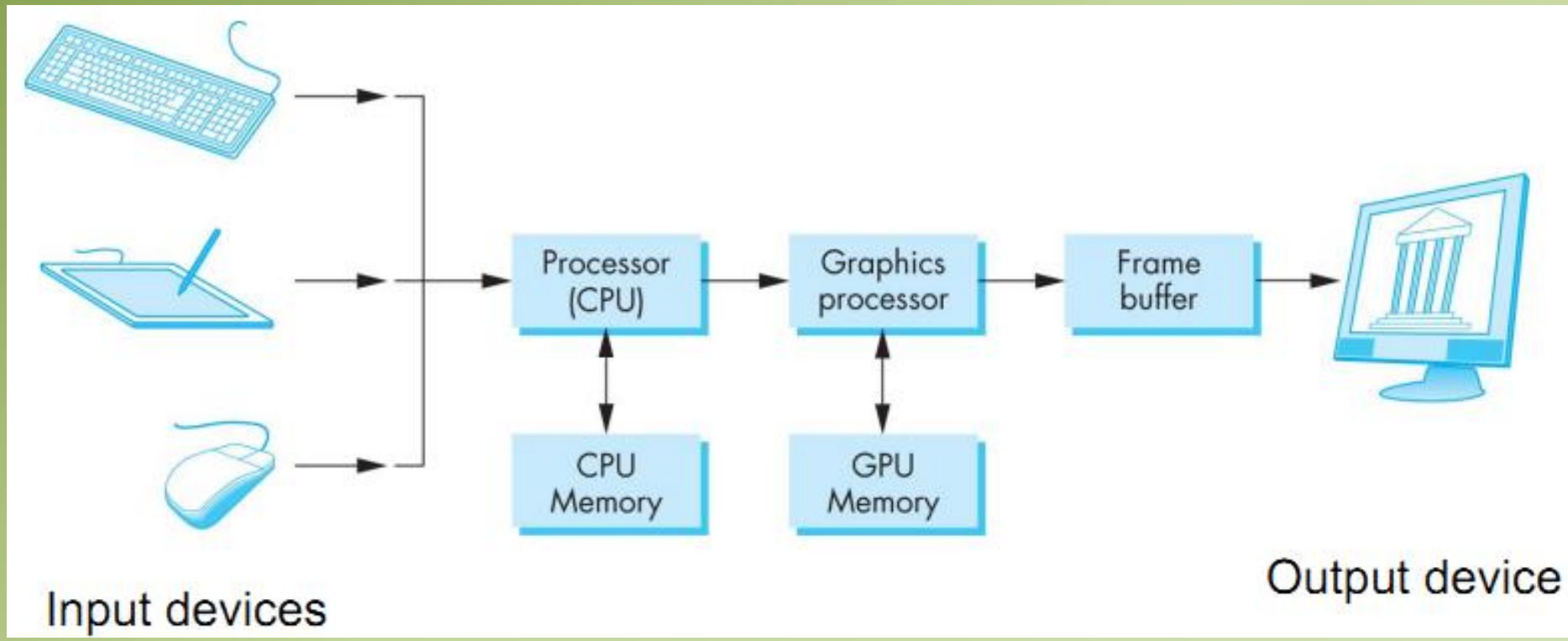


Image formed in frame buffer

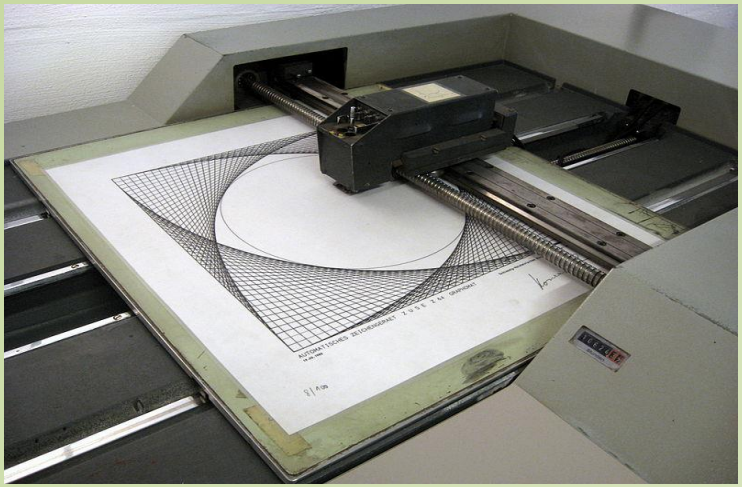
Computer Graphics History 1950 - 1960

- 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

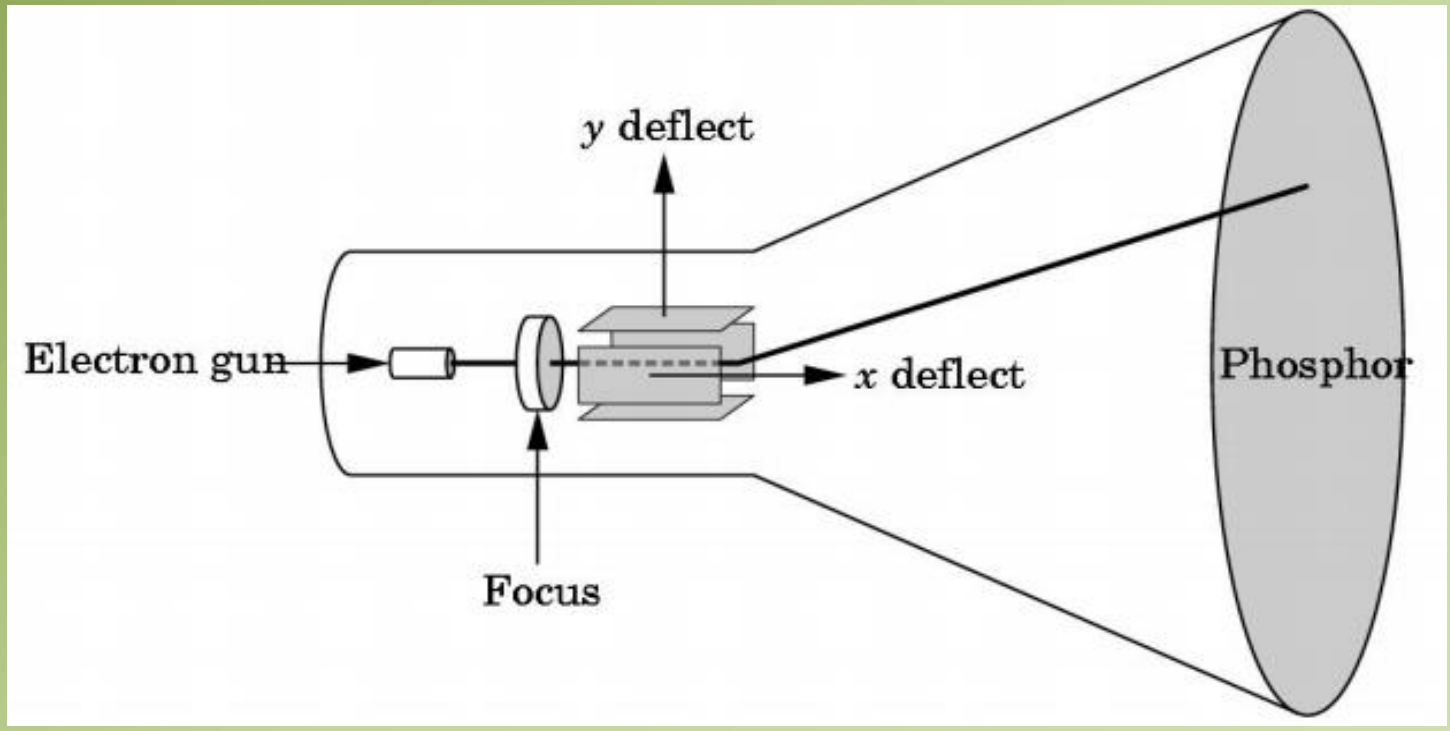
Computer Graphics History 1950 - 1960

Pen plotters

Pen plotters print by moving a pen or other instrument across the surface of a piece of paper. This means that plotters are vector graphics devices, rather than raster graphics as with other printers. Pen plotters can draw complex line art, including text, but do so slowly because of the mechanical movement of the pens. They are often incapable of efficiently creating a solid region of color, but can hatch an area by drawing a number of close, regular lines.

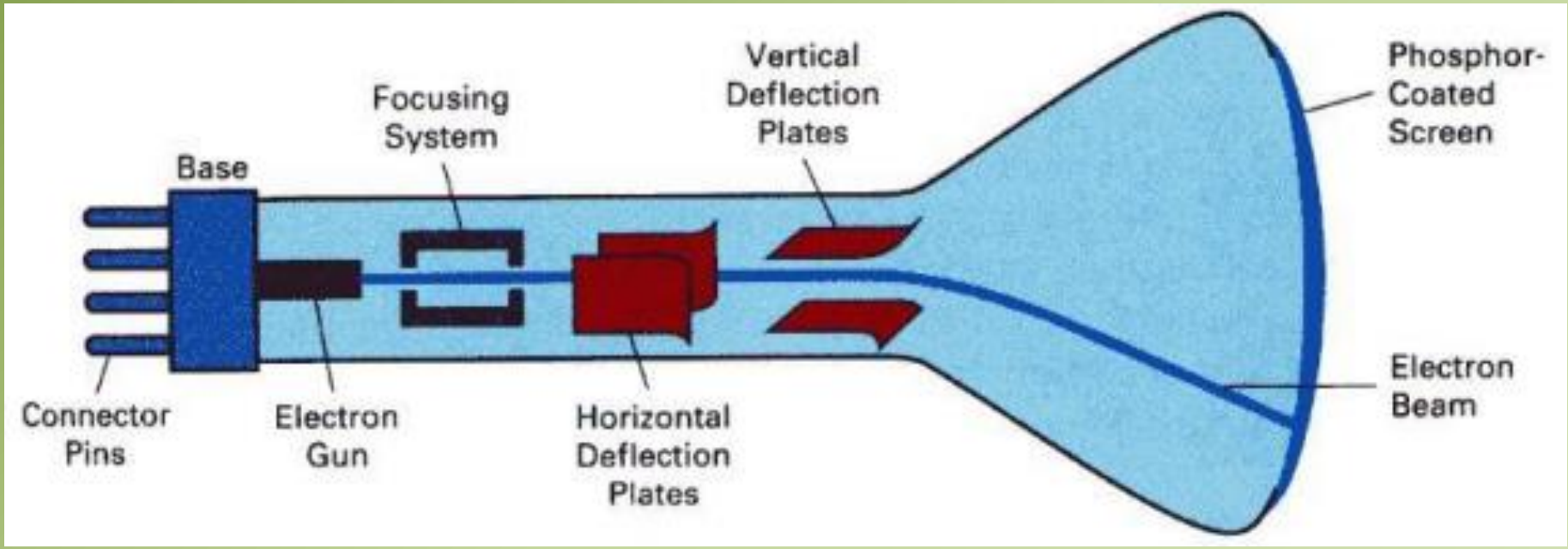


Cathode-Ray Tubes (CRT)



Can be used as a line-drawing device (vector graphics) or to display contents of frame buffer (raster graphics)

Cathode-Ray Tubes (CRT)

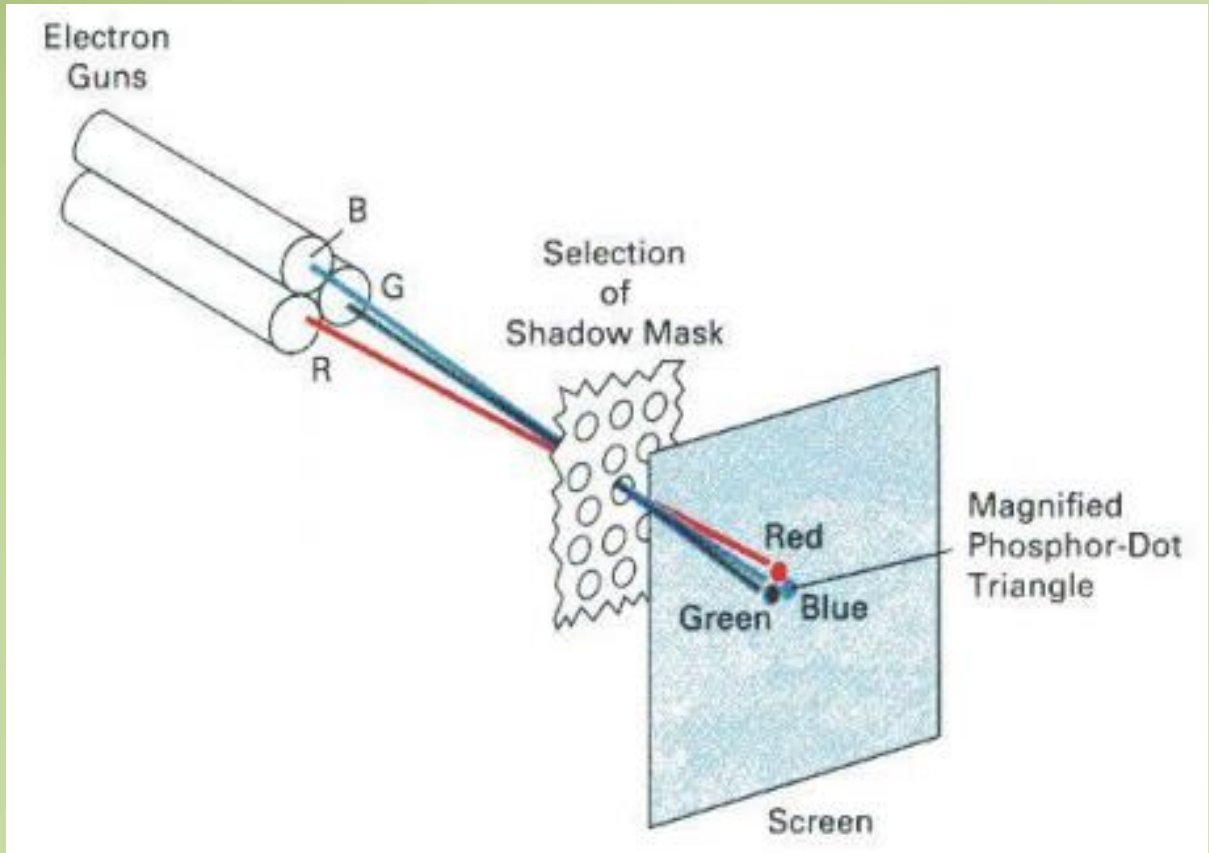


Cathode-Ray Tubes (CRT)

- An electron gun emits a beam of electrons, which passes through focusing and deflection systems and hits on the phosphor-coated screen.
- The number of points displayed on a CRT is referred to as **resolution** (eg. 1024x768).

Color Cathode-Ray Tubes

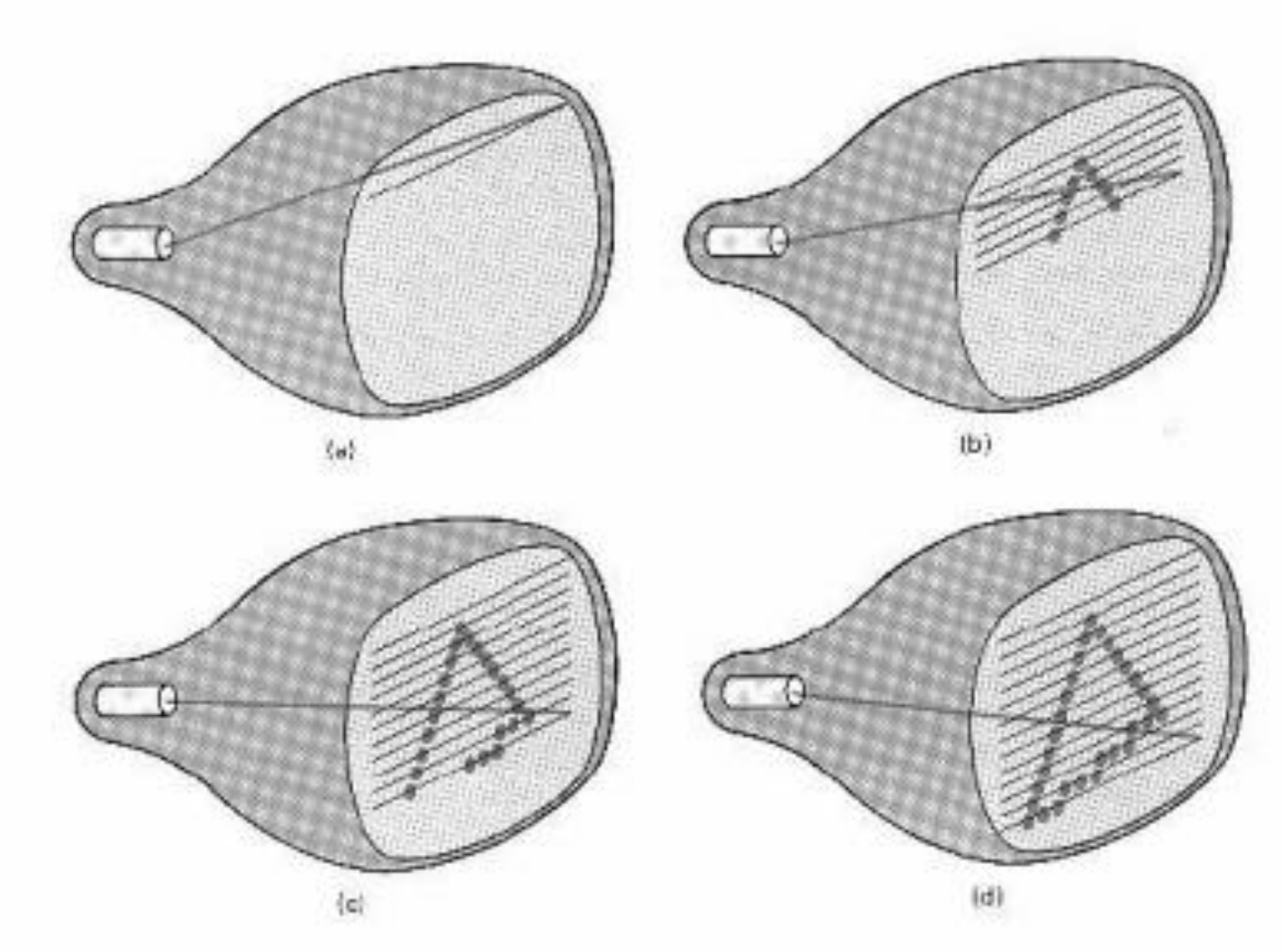
- Different phosphors emit small light spots of different colors, which can combine to form a range of colors.
- A common methodology for color CRT display is the Shadow-mask method.



Cathode-Ray Tubes (CRT)

- The light emitted by phosphor fades very rapidly, so it needs to redraw the picture repeatedly.
- There are 2 kinds of redrawing mechanisms: Raster-Scan and Random-Scan

Raster-Scan



Raster-Scan

- The electron beam is swept across the screen one row at a time from top to bottom.
- As it moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots. This scanning process is called **refreshing**.
- Each complete scanning of a screen is normally called **a frame**.
- The refreshing rate, called the **frame rate**, is normally 60 to 80 frames per second, or described as 60 Hz to 80 Hz.

Raster-Scan

- Picture definition is stored in a memory area called the **frame buffer**. This frame buffer stores the intensity values for all the screen points. Each screen point is called a **pixel** (picture element).
- On black and white systems, the frame buffer storing the values of the pixels is called a **bitmap**. Each entry in the bitmap is a 1-bit data which determine the on (1) and off (0) of the intensity of the pixel.

Raster-Scan

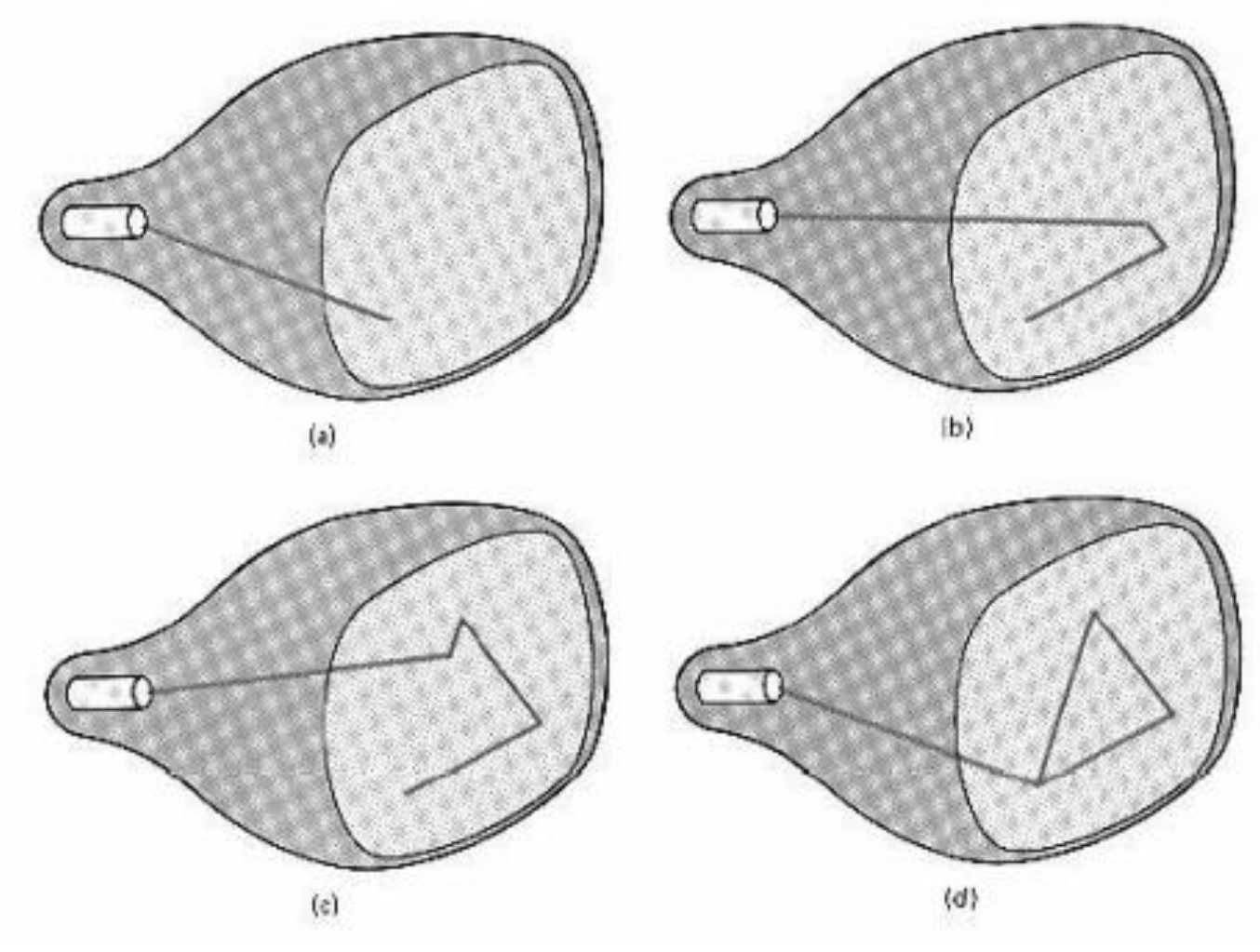
- On color systems, the frame buffer storing the values of the pixels is called a **pixmap** (Though nowadays many graphics libraries name it as bitmap too). Each entry in the pixmap occupies a number of bits to represent the color of the pixel.
- For a true color display, the number of bits for each entry is 24 (8 bits per red/green/blue channel, each channel $2^8 = 256$ levels of intensity value, ie. 256 voltage settings for each of the red/green/blue electron guns).

Raster-Scan

Another definition for **Bitmap**

- A graphics pattern such as an icon or a character may be needed frequently, or may need to be re-used.
- Generating the pattern every time when needed may waste a lot of processing time.
- A bitmap can be used to store a pattern and duplicate it to many places on the image or on the screen with simple copying operations.

Random-Scan (Vector Display)



Random-Scan (Vector Display)

- The CRT's electron beam is directed only to the parts of the screen where a picture is to be drawn. The picture definition is stored as a set of line-drawing commands in a refresh display file or a refresh buffer in memory.

- Random-scan generally have higher resolution than raster systems and can produce smooth line drawings, however it cannot display realistic shaded scenes.

Display Controller

- For a raster display device reads the frame buffer and generates the control signals for the screen, ie. the signals for horizontal scanning and vertical scanning.
- Most display controllers include a **color map** (or video look-up table).
- The major function of a color map is to provide a mapping between the input pixel value to the output color.

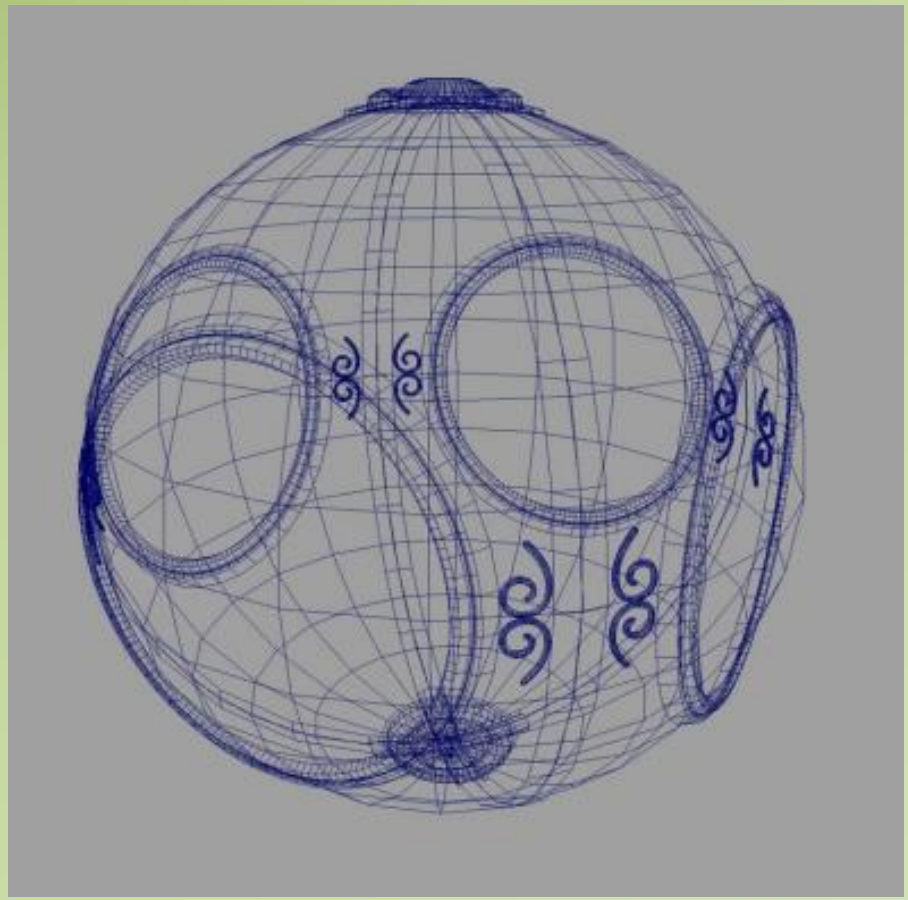
Anti-Aliasing

- On dealing with integer pixel positions, jagged or stair step appearances happen very usually. This distortion of information due to under sampling is called aliasing. A number of ant aliasing methods have been developed to compensate this problem.

- One way is to display objects at higher resolution. However there is a limit to how big we can make the frame buffer and still maintaining acceptable refresh rate.

Computer Graphics History 1960 - 1970

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



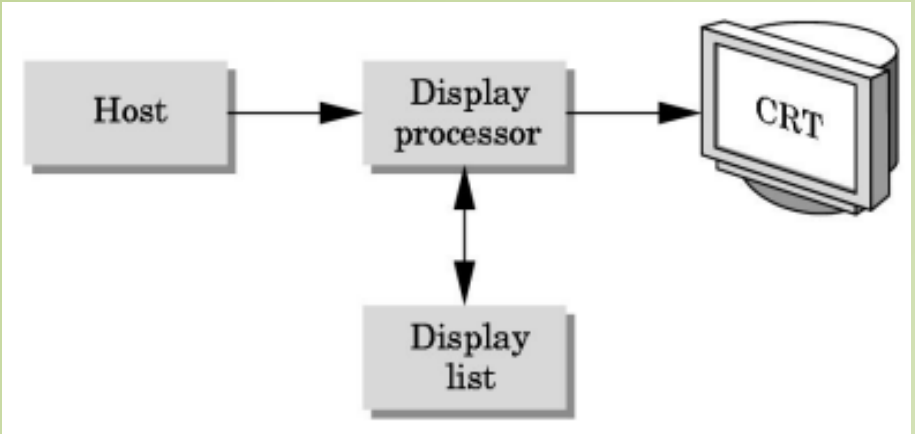
wireframe representation of sun object

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

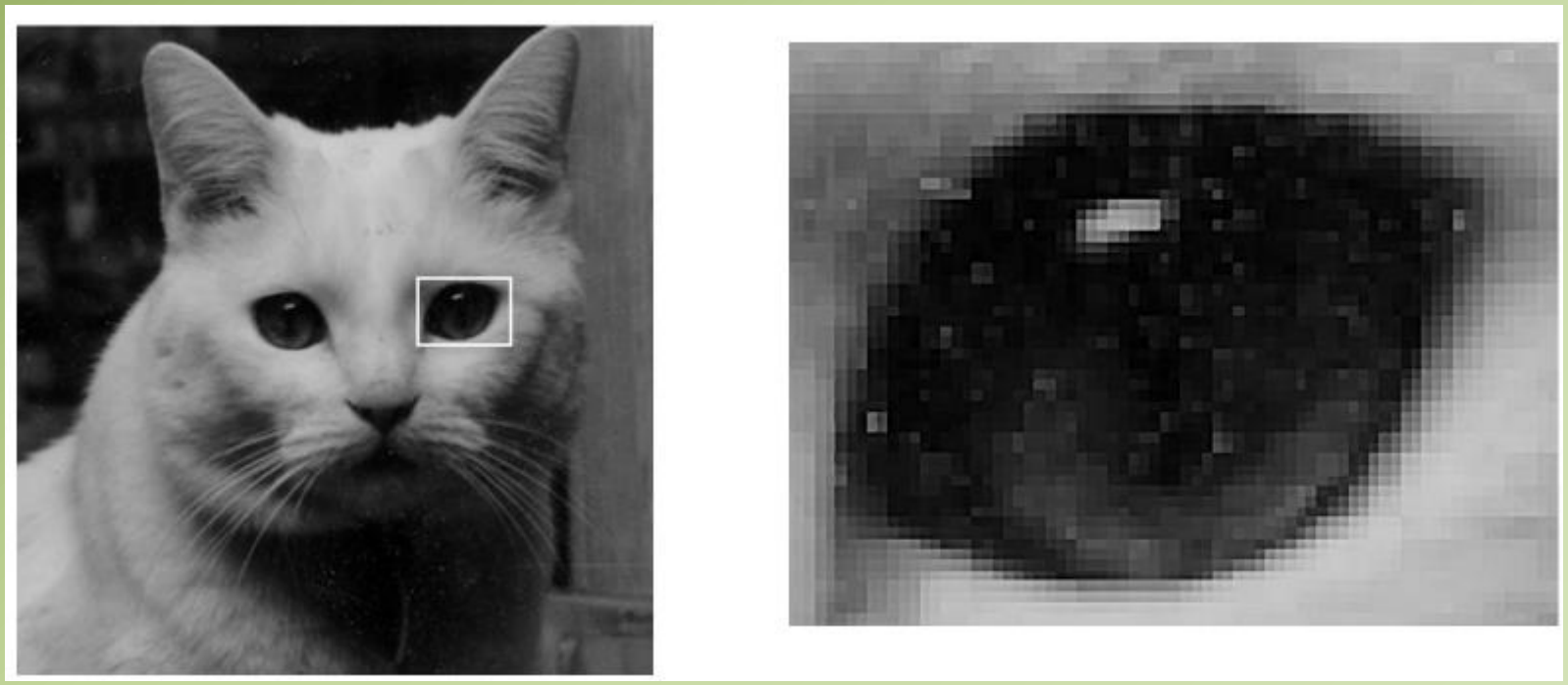


Computer Graphics History 1970 - 1980

- 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

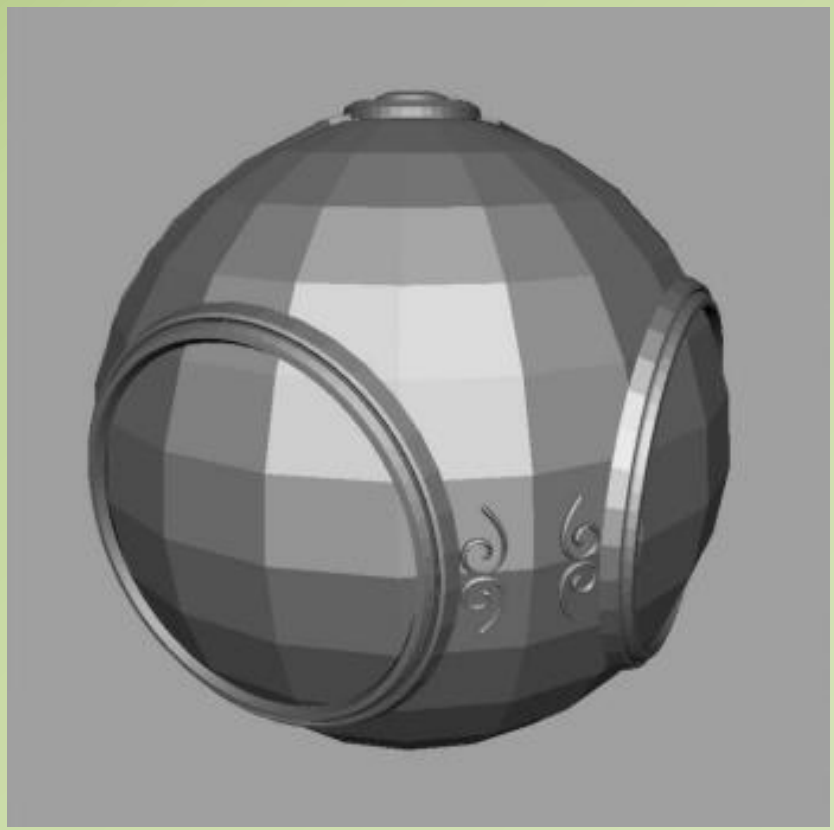
Raster Graphics

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



Raster Graphics

- Allow us to go from lines and wireframes to filled polygons

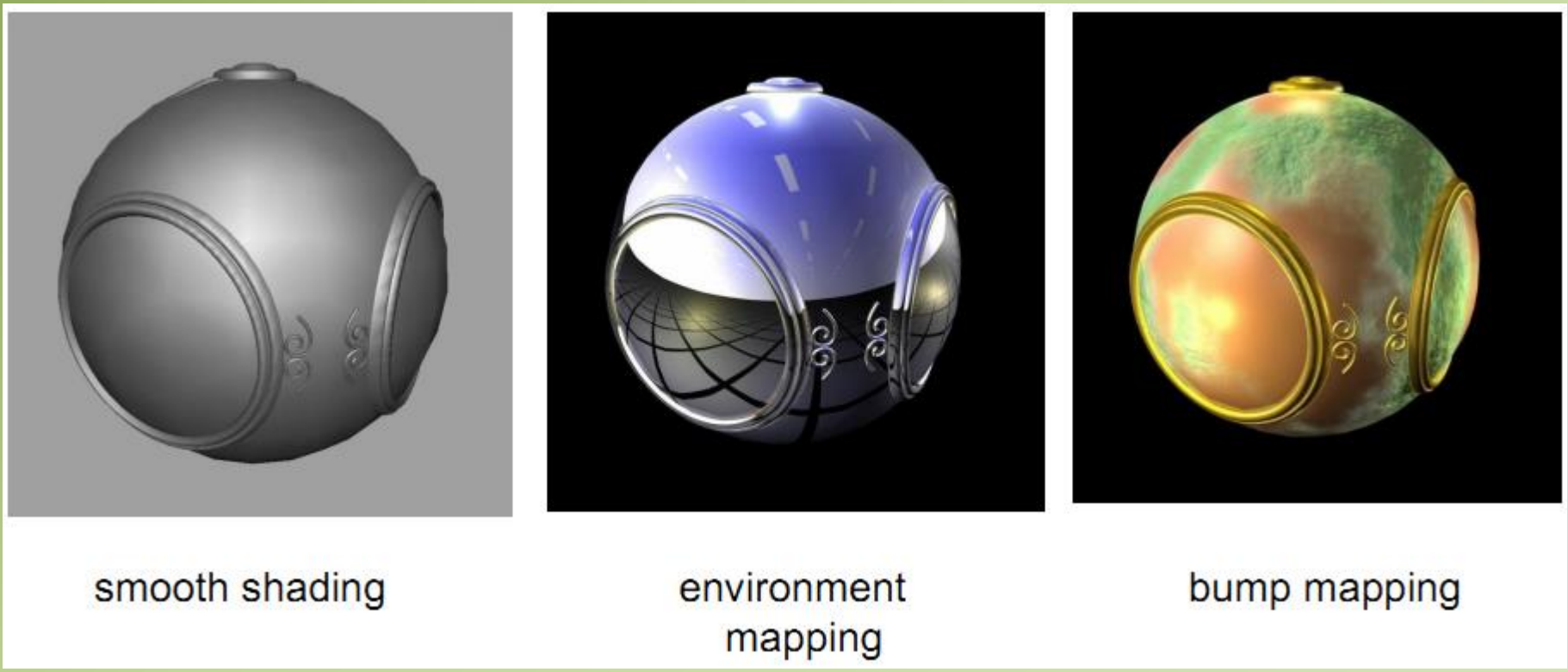


PCs and Workstations

- 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 History 1980 - 1990

- Realism comes to computer graphics



Computer Graphics History 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)

Computer Graphics History 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 History 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

Computer Graphics History 2010 - now

- Graphics is now ubiquitous
  - Cell phones and embedded systems
- OpenGL ES and WebGL
- Xbox, Playstation
  - Realistic rendering, animation
- Kinect sensor
  - Gesture recognition
- 3D scanning and printing
  - Editing tools for rapid prototyping 3D models

Thank you

- Updated on 29-9-2014