Introduction to Computer Graphics

- **What is Computer Graphics ?**

  - The art and science of generating <u>realistic</u> synthetic images

  - Requires a good background in physics (optics), mathematics (linear algebra and geometry), and algorithm design and analysis

- **Main idea**

  - By simulating a virtual camera looking at virtual object models

    * Generate geometric models of objects (e.g., chairs, tables, etc.)
    * Position the virtual camera and specify illumination model
    * Simulate the optics of image formation (i.e., projection)
    * Display the resulting image on the screen

- **Computer Graphics is related to Image Processing and Computer Vision**

Computer Graphics

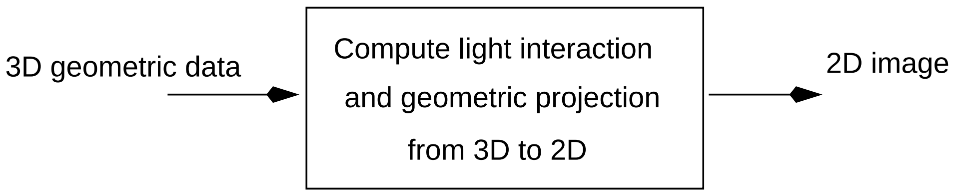
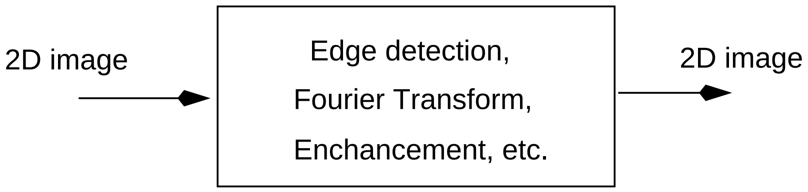
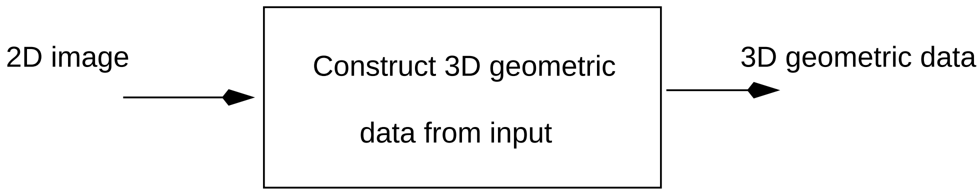


Image Processing



Computer Vision



- **Current application areas**

  - Graphical user interfaces (e.g., MS Windows)
  - Computer aided design (CAD) in manufacturing
  - Education and training (e.g., bar charts, line graphs, flight simulators)
  - Multimedia systems (WWW)
  - Visualization (e.g., scientific data, medical data, etc.)
  - Special effects in movies and commercials

- **History of Computer Graphics**

  - Prior to 1980's, computer graphics was a small and highly specialized area

  - Early applications, like flight simulators, required custom hardware and software and were quite expensive

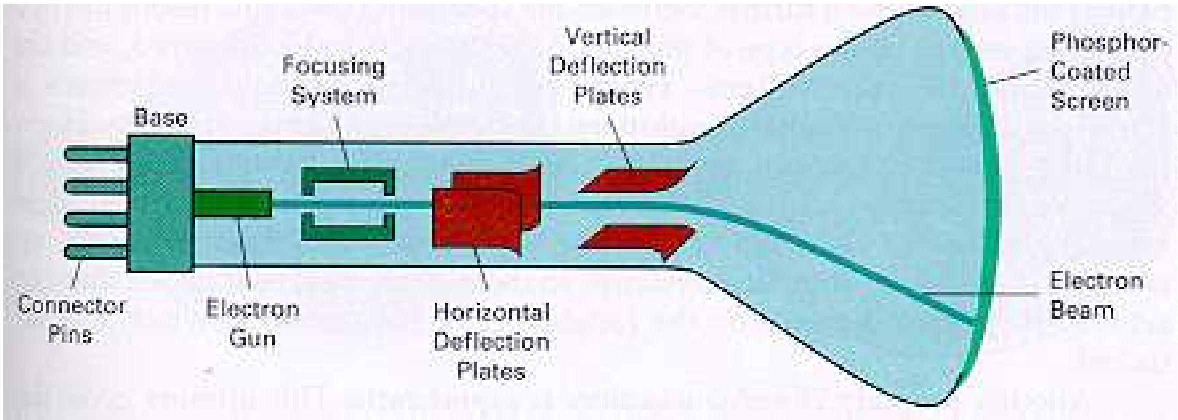
  - With the advent of inexpensive computer hardware, interactive computer graphics was born !!

- **Output technology**

  - Vector displays

  - Raster displays

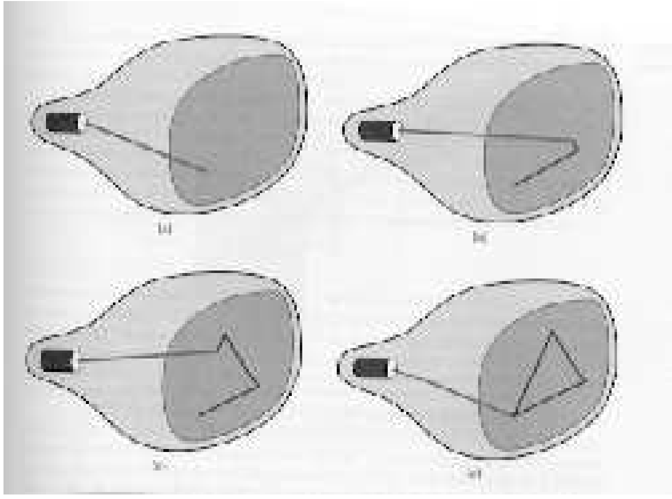
  - Both types of displays are based on the standard cathod-ray tube (CRT) design



- **Vector displays**

  - Appropriate for line drawings (wireframe models of objects used in the early days) but cannot display realistic shaded scenes

  - The beam of the CRT is directed from end point to end point of different lines (similar to the way pen plotters operate)



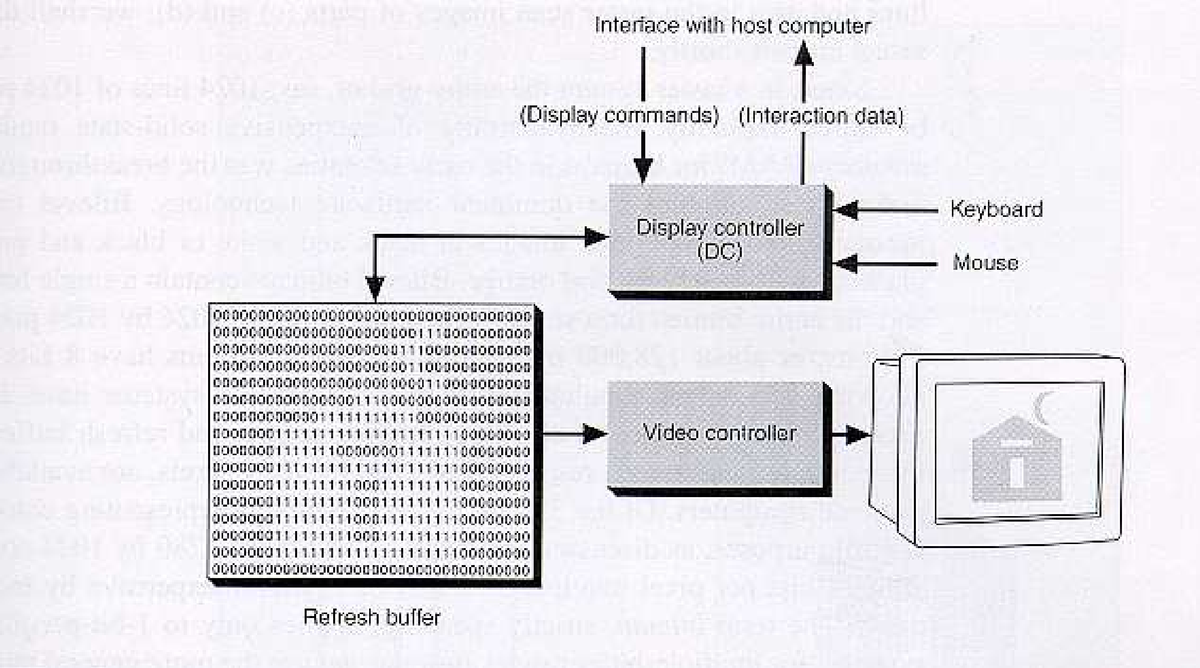
  - Lines are drawn in a random order (random scan)

  - Image definition is stored as a set of line-drawing commands in an area of memory <u>(refresh display file)</u>

- **Raster displays** (based on television technology)

  - Well suited for realistic images containing subtle shading and color patterns

  - Image is represented as a <u>bitmap</u> (1 bit/pixel) or as a <u>pixmap</u> (8 or 24 bits/pixel)

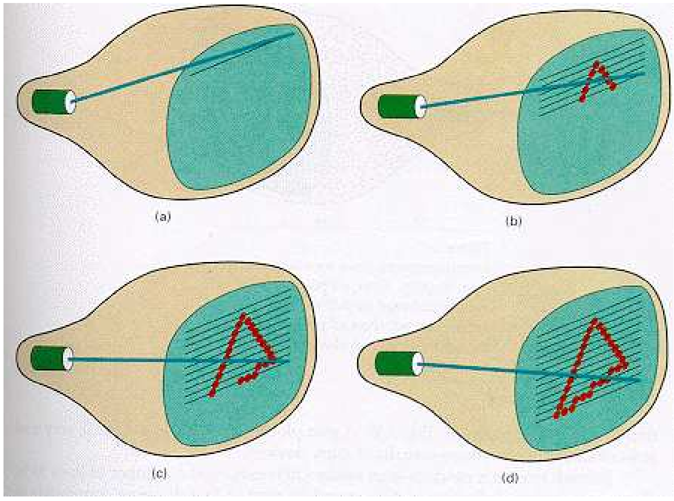


- Image description is stored in a memory area called refresh buffer or frame buffer

- The video controller sweeps the beam across the screen, one row at a time, from top to bottom and back to the top again

- The intensity of the beam in the CRT is set to the value stored in the frame buffer for each pixel

- Refreshing is carried out at the rate of 60 to 80 frames/second



- **Interlacing**

  - Each frame is displayed in two passes

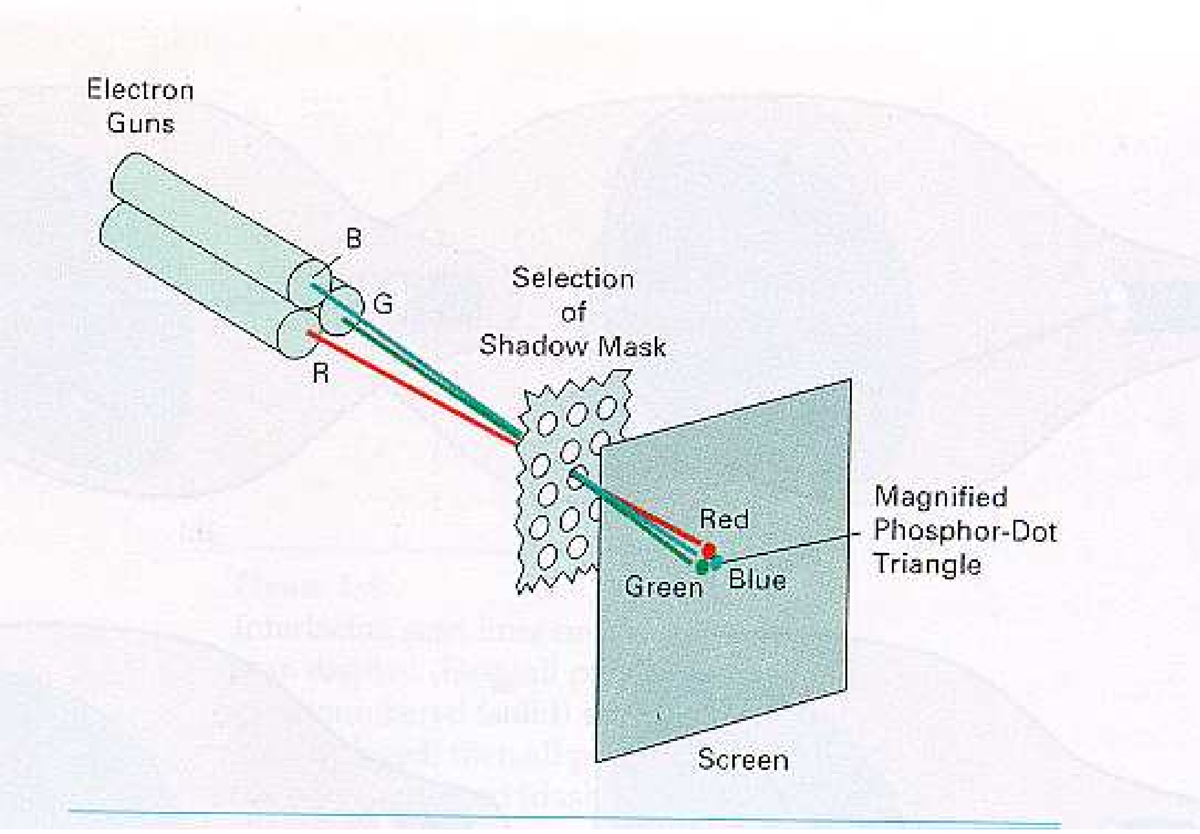
    * first pass: even numbered lines are displayed
    * second pass: odd numbered lines are displayed

  - Interlacing allows us to see the entire image in one half the time it would have taken to sweep accross all the lines

  - It is used with slower refreshing rates to make flickering less noticable

- **Color systems**

  - Three beams are controlled (red, green, blue) and the intensity of each color is stored in the frame buffer



- Screen resolution ranges from 480 x 640 to 1024 x 1024

- For a 1024 x 1024 screen

  * 1 bit/pixel needs a frame buffer of size 130K (depth=1)
  * 8 bits/pixel (256 colors) needs a frame buffer of size 1MB (depth=8)
  * 24 bits/pixel (16 million colors) needs a frame buffer of size 3MB (depth=24)

- **Advantages over vector graphic systems**

  - Low cost

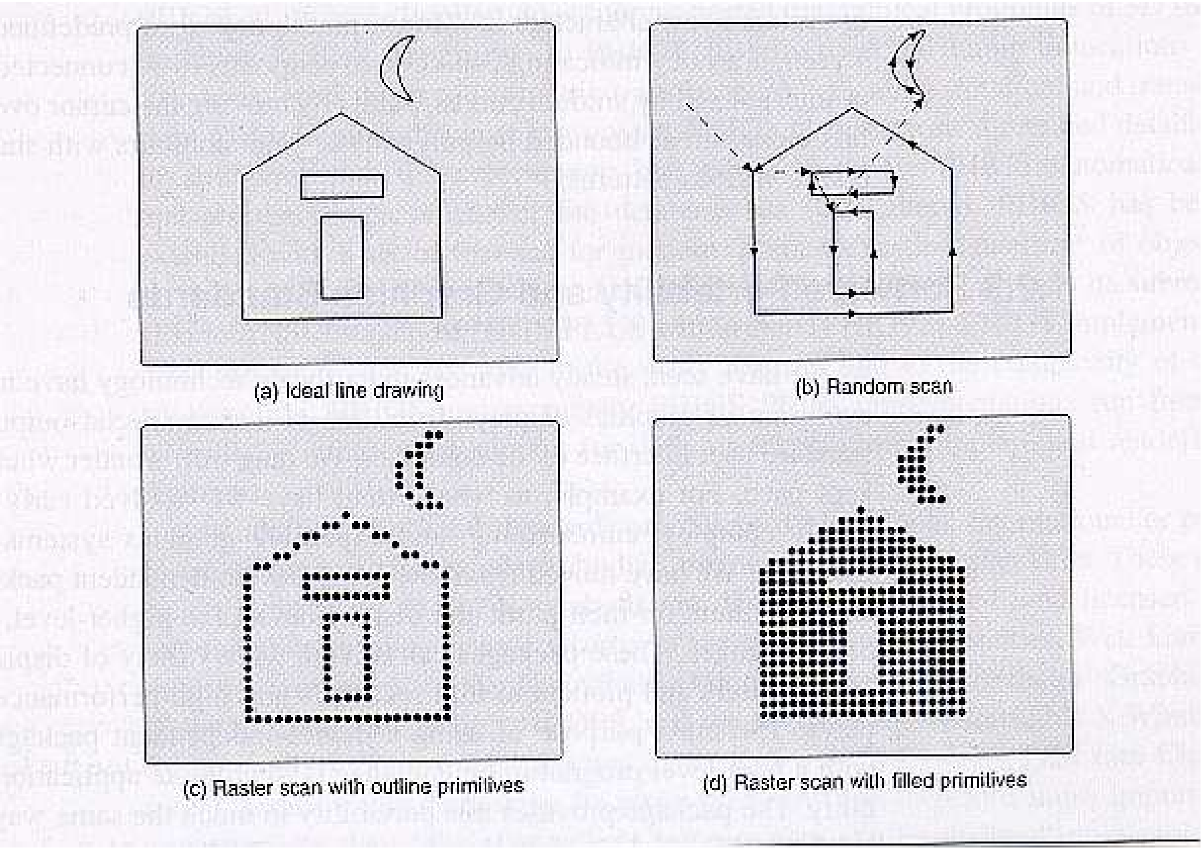
  - Filled areas are displayed with solid colors

- **Disadvantages over vector graphic systems**

  - Discrete nature of image produces jagged lines (aliasing)

  - Scan conversion is needed

  - Vector displays produce smooth lines because they have better resolution due to the fact that images are represented as a set of line drawing instructions



(a) Ideal line drawing (b) Random scan

(c) Raster scan with outline primitives (d) Raster scan with filled primitives

- **Input technology**

  - Wide range of input devices have been invented

    * basic: keyboard, mouse, light pen, joystic, trackball, etc.
    * advanced: data glove, 3D tracking equipment (virtual reality)

- **Graphics software**

  - It used to be low-level, hardware dependent, making it difficult to support applications on different platforms

  - These days, there are high-level, hardware independent graphics routines that make porting different applications on different machines a straightforward task

  - CGS (3D Core Graphics System, 1977)

  - GKS, GKS 3D (Graphical Kernel System, 1988)

  - X-windows (MIT, 1987)

  - PHIGS (1988)

- OpenGL (Open Graphics Library, SGI 1993)
- VRML (Virtual Reality Modelling Language)

- **Conceptual framework for interactive computer graphics**