### Input and Output Devices

#### Foley & Van Dam, Chapter 4

**Input Devices:**
- Alphanumeric input- (Keyboards)
- 2D Inputs - (Joystick, Mouse, Digitizer etc)
- 3D Inputs - (Glove, Space Ball)
- Image Inputs - (Camera, Scanner)

**Output Devices:**
- Display Devices - (CRTs, Monitors)
- Hard Copy Devices - (Printers, Plotters)

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#### CRT - Cathode Ray Tube

- Cathode (electron gun)
- Focusing yoke
- Shadow mask and phosphor coated screen
- Electron guns
- Phosphors on glass screen

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#### Vector vs. Raster Display

**Vector Display:**
- Only lines can be drawn
- Locations are converted to analog voltage applied to the deflection yoke
- Lines drawn by gradual change of voltage
- Also known as random scan
- Refresh time is scene dependent
- Old fashioned - very uncommon today

**Raster Display:**
- Discrete grid of elements (frame buffer’s pixels)
- Complex to draw “nice” lines
- Arbitrary shapes can be drawn
- Frame buffer is scanned, one line at a time
- Used almost everywhere.

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#### Terminology

**Pixel:** Picture element.
- Smallest accessible element in picture
- Assume rectangular or circular shape

**Aspect Ratio:** Ratio between physical dimensions of a pixel (not necessarily 1)

**Dynamic Range:** The ratio between the minimal (not zero!) and the maximal light intensity a display pixel can emit

**Resolution:** The number of distinguishable rows and columns in the device.
- Measured in:
  - Absolute values (1K x 1K) or,
  - Density values (300 dpi [=dots per inch])

**Screen Space:** A discrete Cartesian coordinate system of the screen pixels

**Object Space:** The Cartesian coordinate system of the universe, in which the objects (to be displayed) are embedded

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#### Hardcopy Devices

**Pen Plotter**

- ElectroMagnet
- Paper

**Dot Matrix Printer**

- Pin motion
- Ink covered tape
**Hardcopy Devices**

**Ink Jet Printer**
- Ink supply
- Filter
- unused ink returned to reservoir
- Electrode
- High voltage deflection plates
- Paper
- Drop generator

**Thermal-Bubble Ink Jet Printer**
- Resistor is heated and bubble nucleates.
- Bubble grows to maximum ink drop is ejected.
- Bubble collapses. Drop breaks off.
- System returns to initial state.

**Laser Printer**
- Laser gun
- Electric charger
- Drum
- Laser beam
- Toner
- Paper

**Color Laser Printer**
- Laser gun
- Electric charger
- Drum
- Laser beam
- Color inks / toners
- Paper

**Thermal Wax Printer**
- Color wax roll
- Printer head
- Paper

**Dye Sublimation Printer**
- Color plastic roll
- Thermal elements
- Plastic ink
- Paper

**Input Devices**

**Keyboard:**
- For alphanumeric input
- Provides relative movement information

**Joystick:**
- Usually two degrees of freedom
- Provides relative movement information

**Mouse/Trackball:**
- A two degrees of freedom device controlled by a rolling ball
- Provides relative movement information

**Digitizer/Tablet:**
- A two degrees of freedom device controlled by electro-magnetic or sound sensing
- Provides absolute position information

**Touch Screen:**
- A CRT screen that can sense pressure on its surface

**Light Pen:**
- A two degrees of freedom sensing device
- Synchronized with the CRT scan, it can locate a position on the screen

**Data Glove/Polhemus:**
- A modern attempt to provide the user with more degrees of freedom
- Common in Virtual Reality applications
- Polhemus can provide six degrees of freedom (rotation and translation)

**Head Mounted Display:**
- Although primary a display device, it can also track position and orientation like Polhemus

**Space Ball:**
- Six degrees of freedom sphere

**Video Camera:**
- Captures an array of image pixels

**Scanner:**
- Digitizes a hardcopy images
Data Gloves

Head Mounted Display

Space Ball

Three Pass Color Scanner

Single Pass Color Scanner

Single Pass Color Scanner
Low Cost Digital Camera

Virtual Ink Mimio

Logitech Digital Pen