Overview of Graphics Systems

- video display devices
- raster-scan systems
- graphics monitors and workstations
- input devices
- hard-copy devices

Video Display Devices (1)
- cathode-ray tube (CRT)
  - refresh CRT (raster-scan display, random-scan display)
  - direct-view storage tubes
- refresh CRT
  - electrons hit phosphor-coated screen
  - permanent glowing through refreshing
  - phosphor persistence
  - resolution, e.g., 1280x1024, aspect ratio
  - screen diagonal size, e.g., 21 inches

Video Display Devices (2)
- raster-scan displays
  - television technology
  - object represented as set of discrete points
  - screen point: pixel or pel
  - refresh buffer, frame buffer
    - bitmap or pixmap
    - 3Mbytes for 1024x1024x24
  - refresh rate (60 - 120 Hz)
  - horizontal, vertical retrace
  - interlacing
Video Display Devices (3)
- Color CRT Monitors
  - phosphors emit different-colored light
  - beam-penetration (for random-scan monitors)
  - shadow-mask
    - three different phosphors: R,G,B
    - delta-delta or in-line arrangement
    - additive color-mix, RGB-model
    - 24 bits color information (16 million colors), true-color system

RGB Shadow Mask Technology
- Electron Beam Systems
- Shadow Mask
- glass plate with phosphor dots

Video Display Devices (4)
- Flat-Panel Displays
  - reduced volume, weight, power requirement
  - emissive displays (plasma panel, LEDs)
  - nonemissive displays (LCD)
  - LCDs (liquid-crystal displays)
    - polarized light is (non)passing through liquid crystal material
    - refresh buffer, 60Hz refresh rate
    - passive-matrix, active-matrix

LCD Monitor
- LCD (Liquid Crystal Display)
  - advantages
    - flat
    - light-weight
    - radiation free
  - disadvantages
    - low contrast
    - low brightness
    - solutions:
      - "supertwist"
      - backlight
    - high persistence

Color LCD Monitor
- How pixels are controlled in an LCD Color Display

Plasma-Panel Display
- glowing gas between 2 glass panels
  - advantages: flat, high brightness, good image
  - disadvantages: heavy, expensive, instable
LED monitors

- LEDs (Light Emitting Diodes) are arranged in matrix form, each one can be controlled separately.

- advantages: flat, light-weight, robust, bright
- disadvantages: high energy consumption, expensive, reduced color gamut

3D Display Techniques

- Three-Dimensional Viewing Devices
  - vibrating flexible mirror
  - stereoscopic and virtual-reality systems
  - shutter glasses (+ tracking)
  - headset with tracking
  - other VR devices
  - holograms
  - NC-mills + soft material
  - stereolithographic apparatus (SLA)

Vibrating Mirror Display

- virtual images
- vibrating mirror
- screen
- eye
Overview of Graphics Systems

Vibrating Mirror Display

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Virtual Reality Devices

*Virtual reality* = stimulation of the human senses to *simulate a fictional environment* (reality) plus the possibilities to interact with this world

- eyes: private eye, head mounted displays (HMD)
- ears: headphones, 3D audio synthesis
- tactile sense: force feedback stylus or glove

Head Mounted Display (HMD)

- 2 small screens display images for both eyes:
  - high immersion degree
  - head movement controls virtual camera
  - artificial image only
  - limited field-of-view
  - rather expensive
  - cybersickness

Shutter Glasses

- ultrasound tracking device used with stereoscopic glasses to track head position
Interactive Walkthrough

Data Glove

Virtual Windtunnel

Workbench

Very large Viewing Screens

CAVE

Data glove as interaction device

HMD in combination with data glove

very large screen area

full immersion with 3D-projection (with glasses)
Motion platforms

Smell Device
experimental laboratory development

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Stereolithographic Apparatus (SLA)
- UV-laser gun
- polymerized plastic (solid)
- liquid plastic
- is dipped in layer by layer

SLA examples

Raster-Scan Systems (1)
- video controller controls display device
  - refresh operations
  - double buffering
  - areas of screen enlarged, reduced, moved
  - look-up table
  - mix of frame-buffer image and another image
Raster-Scan: Video Controller

Raster-Scan Syst.: Frame Buffer

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Raster-Scan: Display Processor

Raster-Scan Systems (2)

- display processor performs
  - raster graphics operations (instead of CPU)
  - scan conversion
  - line styles
  - raster ops
  - interface with input device (e.g., mouse)

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Input Devices (1)

- keyboard
- mouse (relative positioning)
- trackball (absolute positioning)
- spaceball (6 DOF)
- joysticks (stick for cursor steering)
- data glove (grasp virtual objects)

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**Input Devices: Keyboards**

- ergonomically designed keyboard with removable palm rests

**Input Devices: Joysticks**

- Spaceball

**Input Devices: Gamepads & Co**

- digitizer
  - drawing, painting, selecting coordinate positions
  - scanning 2D, 3D objects
  - graphics tablet
    - 2D coordinates
    - hand cursor or stylus
  - 3D digitizers, motion capture
  - electromagnetic, acoustic systems

**Input Devices: Tablets**

- desktop tablet with a 16-button hand cursor
- large tablet with hand cursor

- (gebrauchte Tastatur)
Input Devices: Tablets
- desktop tablet with stylus
- artist's digitizer system with cordless stylus

Input Devices: 3D Digitizers
- manual digitizer with stylus
- laser light stripe scanner, < 1 sec, 400x400 reconstruction by triangulation

Input Devices (3)
- image scanners
- touch panels (optical, electrical, acoustical)
- light pens
- voice systems
- others ...

Input Devices: Scanners
- flatbed scanner
- drum scanner
- floor-model scanner
- hand scanner

Input Devices: Touch Screens
- plasma panels with touch screens

Input Devices: Light Pen
- recognizes cathod ray to calculate position
Overview of Graphics Systems

**Input Devices: Haptic Devices**

**Hard-Copy Devices**
- paper output, slides, transparencies, videos
- quality depends on dot size, dots/inch
- CMY color model (cyan, magenta, yellow)
- printers:
  - impact devices (line, dot-matrix)
  - non impact devices (laser, ink-jet, electrothermal, thermotransfer, thermosublimation)
- pen plotters

**Hard-Copy Devices: Dot Matrix Printer**
- varying density of dot patterns
- produces light and dark areas

**Hard-Copy Devices: Laser Printers**

**Hard-Copy Devices: Ink Jet Plotter**

**Hard-Copy Devices: Pen Plotter**
Hard-Copy Devices: Pen Plotter