Display Hardware

Outline
- Display technologies:
  - Cathode ray tube
  - Liquid crystal display
  - Plasma display panel
  - Digital light processing
  - Electronic paper
- Display environments:
  - Immersive display
  - Stereoscopic display
  - Autostereoscopic display

Cathode Ray Tube (CRT)
- Key components:
  - Electron gun
  - Deflection plates
  - Shadow mask
  - Screen
- Advantages:
  - Excellent image quality
  - Excellent viewing angles
  - Low price
- Disadvantages:
  - Bulky and heavy

Color CRT
- Based on the geometric position among:
  - Three electron guns
  - Metal shadow mask
  - Phosphors on CRT face
- Phosphor patterns:
  - Delta electron gun arrangement
  - In-line electron gun arrangement

Liquid Crystal Display (LCD)
- Key components:
  - Backlight
  - Polarizer
  - Liquid crystal
  - Polarizer
- Advantages:
  - Thin & light
- Disadvantages:
  - Slow response times
  - Limited viewing angles
  - Poor black levels

How Liquid Crystal Works
- Without voltage:
  - Liquid crystal molecules change the light's plane of vibration to match their own angle
- With voltage:
  - Liquid crystals are untwisted
  - Transmissive or reflective display:
    - Pixels do not lit from themselves
Plasma Display Panel (PDP)

- Key components:
  - Gas-filled cells
  - Phosphors
- Advantages:
  - Easy to make larger sizes
  - Cheaper than LCD
- Disadvantages:
  - Susceptible to burn-in
  - Heavier than LCD

How Plasma Display Works

- Same principle as the ordinary fluorescent lamp
- Electric current passes through gas-filled cells
- Ionized gas emits ultraviolet light
- Ultraviolet light stimulates phosphors

Digital Light Processing (DLP)

- Key components:
  - Light source
  - Color filter
  - Digital micromirror device (DMD)
  - Projection lens
- Advantages:
  - Smooth image
- Disadvantages:
  - Video noise
  - Possible rainbow effect

How Micromirror Works

- Based on controlling the angle of micromirrors
- On position reflects light to the lens
- Off position reflects light to absorb surface
- Grey level is created by the percent of time the mirror is in the on position during an image refresh cycle

Electronic Paper

- Key components:
  - Charged pigment particles
  - Electric field
- Advantages:
  - Requires no power to maintain a static image
  - Viewable in direct sunlight
- Disadvantages:
  - Very low refresh rate

How E-Paper Works

- Use electric field to control the positions of charged pigment particles
- Reflect ambient light & does not emit light
Display Environments

- **Desktop display:**
  - Monitors
  - Low cost, high resolution, but limited field of views
- **Immersive display:**
  - VisionDome
  - Fakespace Cave
  - IMAX
- **Stereoscopic display:**
  - 3D glasses
  - Head-mounted display
  - Autostereoscopic display:
    - Flat-panel auto-stereoscopy
    - Light field display

VisionDome

- Display a large image on a spherical screen
- **Advantages:**
  - High resolution
  - Large field of views
- **Disadvantages:**
  - Expensive
  - Best to view at a fixed position
  - Image distorted at other locations

Fakespace Cave

- Use multiple projectors to project images onto 3 walls & floor
- **Advantages:**
  - Immersive field of views
  - Allow viewer to move around and observe different perspectives
- **Disadvantages:**
  - Expensive
  - Need to track viewer’s location

3D Glasses

- Red/Cyan glasses:
  - For anaglyph images
  - Affect color perception
- Polarized glasses:
  - For polarization-multiplexed displays
  - Ghosting effects
- LCD shutter glasses:
  - For time-multiplexed displays
  - Require synchronization

Head-mounted Display

- Display stereoscopic images on 2 build-in screens
- **Advantages:**
  - Offer 3D effects
  - Full field of views
- **Disadvantages:**
  - Limited resolution
  - Need to track head direction
  - Weights on the head
  - For one person only

Flat-panel Autostereoscopy

- Lenticular lenses:
  - An array of magnifying lenses that magnify different pixels
- **Parallax barrier:**
  - A series of precision slits that block different pixels
- **Disadvantages:**
  - Must to view from a well defined spot
  - No motion parallax
  - Eye strain
Light Field Display

- Projecting high-speed video onto a spinning anisotropic mirror
  - The mirror reflects different images to different directions
- Advantages:
  - Omnidirectional viewing
  - Offer motion parallax & occlusion effects
- Disadvantages:
  - Grayscale images only