Monash University • Clayton's School of Information Technology

CSE3313 Computer Graphics

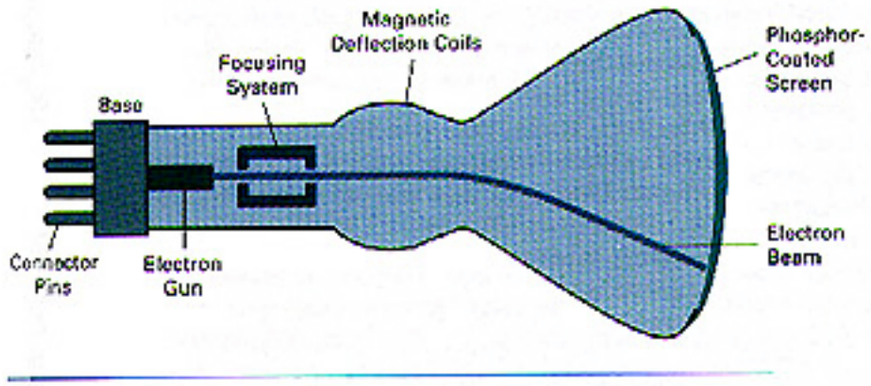
Lecture 2: Graphics Display Devices

Video Display Devices

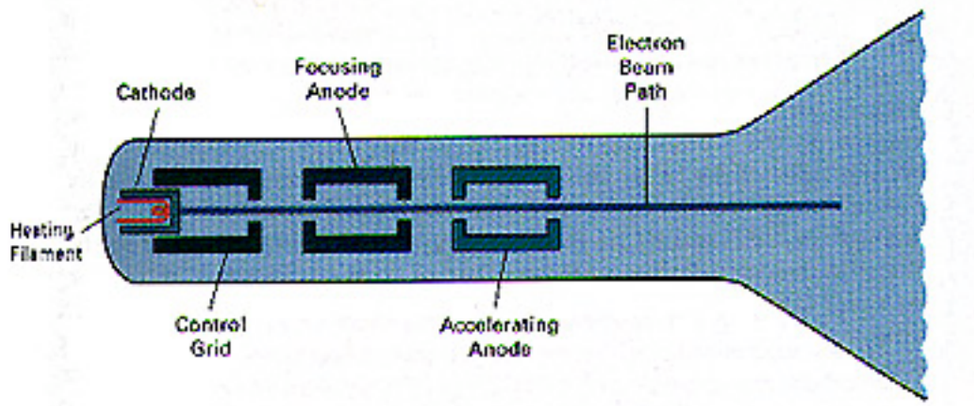
- CRT (Cathode Ray Tube)
- Electron beam through a vacuum tube.
- Beam is controlled magnetically.
- Electrons strike phosphors on screen, causing them to emit light.
- The intensity of the electron beam can be varied.
- Light from phosphors fade. Phosphor needs to be re-excited to maintain the picture.
- Screens need to be refreshed at least 25 times/sec of picture will flicker.
- Persistence of phosphor:
  - short persistence needed for animation (picture changes from frame to frame);
  - longer persistence, less need to refresh: ok for still image. applications.

Random Scan

- Also known as *vector*, *stroke-writing*
  - Draws picture using lines, 1 at a time;
  - Good for line drawing, poor for filling areas;
  - high resolution is possible;
  - largely replaced by raster scan devices.
- SGA, Flash: web standards for vector graphics.



Basic design of a magnetic-deflection CRT.

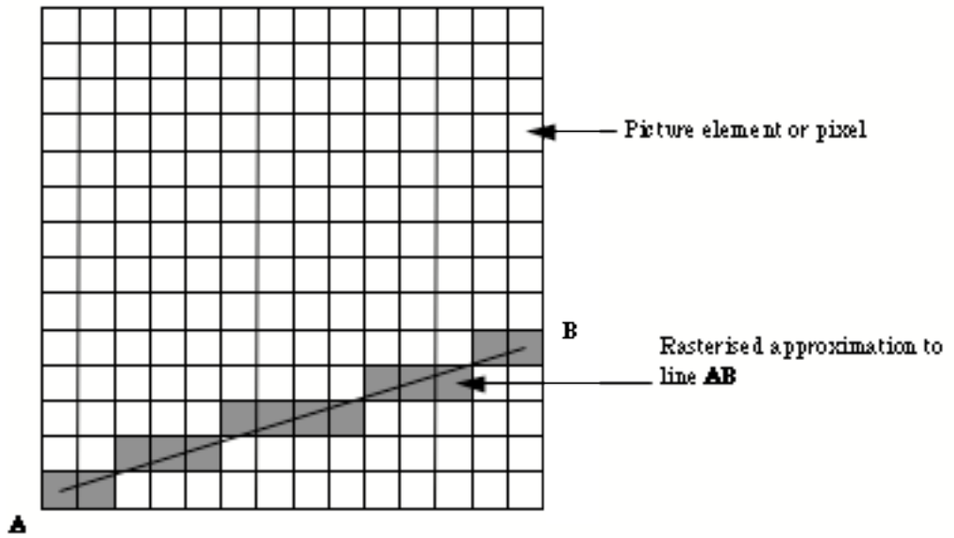


Operation of an electron gun with an accelerating anode.

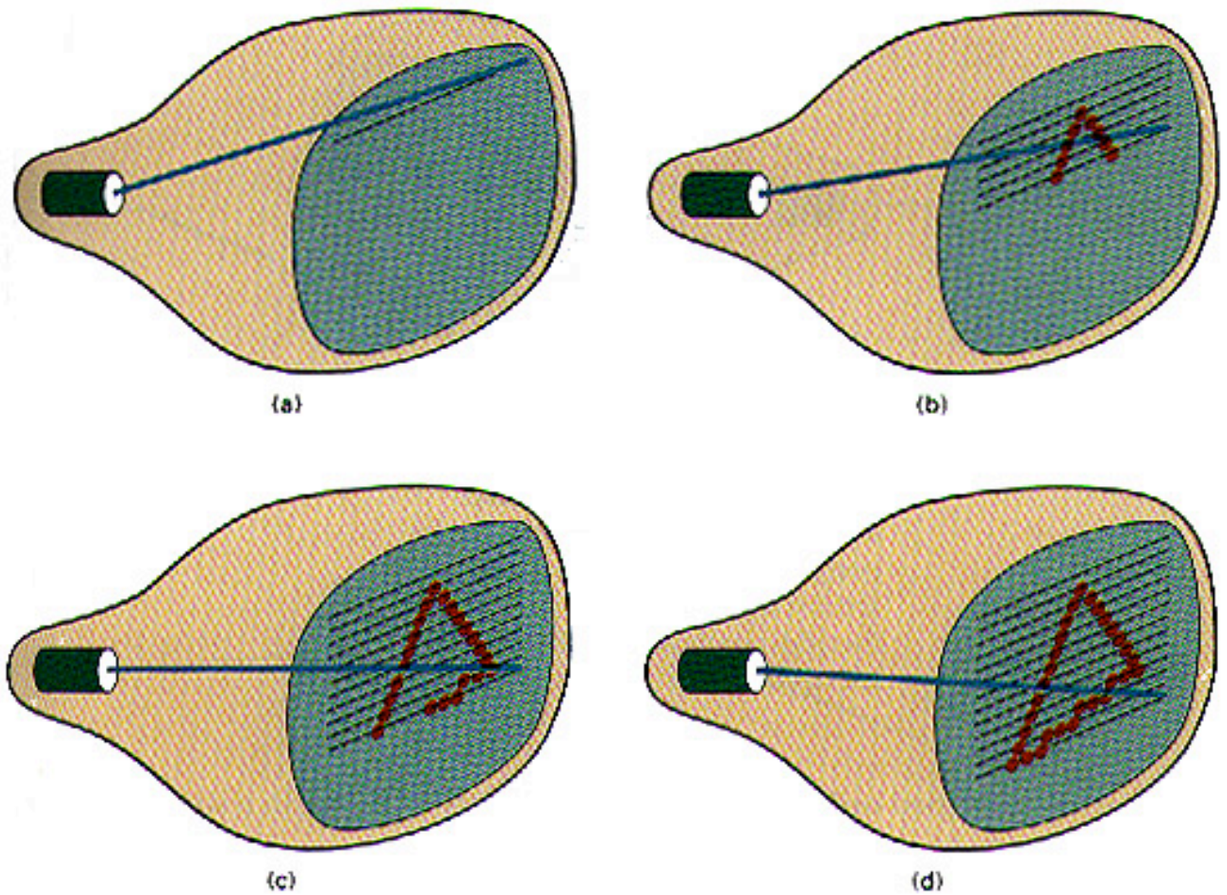
Raster Scan

- Draws the complete screen every refresh cycle;
- needs to remember what beam intensity is required for each pixel;
- simplest case: 0 = off, 1 = on, i.e. 0 = black, 1 = white (*binary display, bitmap*);

⇨ subject to aliasing artifacts due to finite number of pixels (resolution) and finite size of each pixel, which is of constant colour over its area.



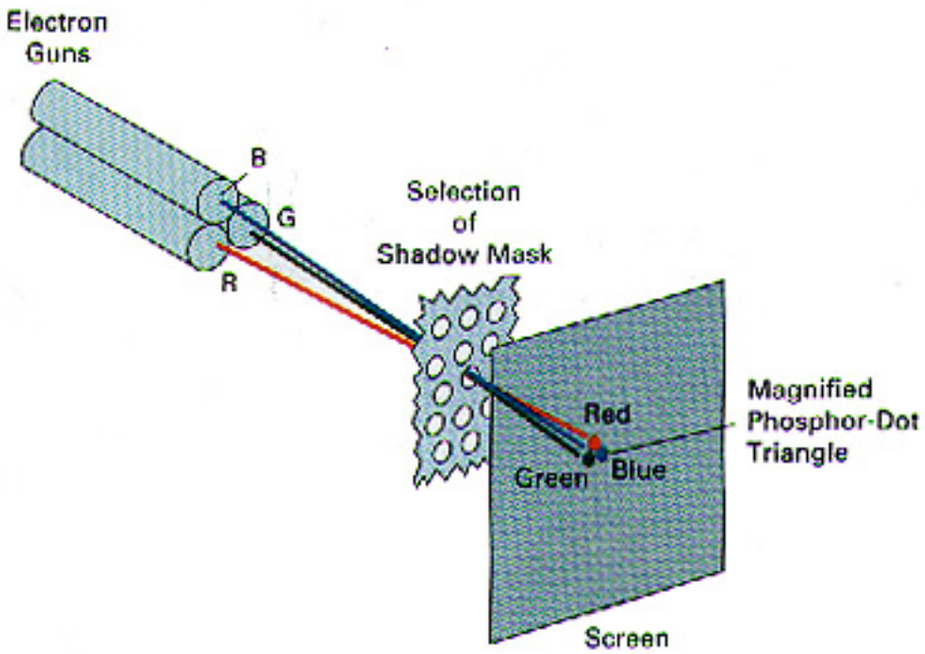
Raster Scan CRT



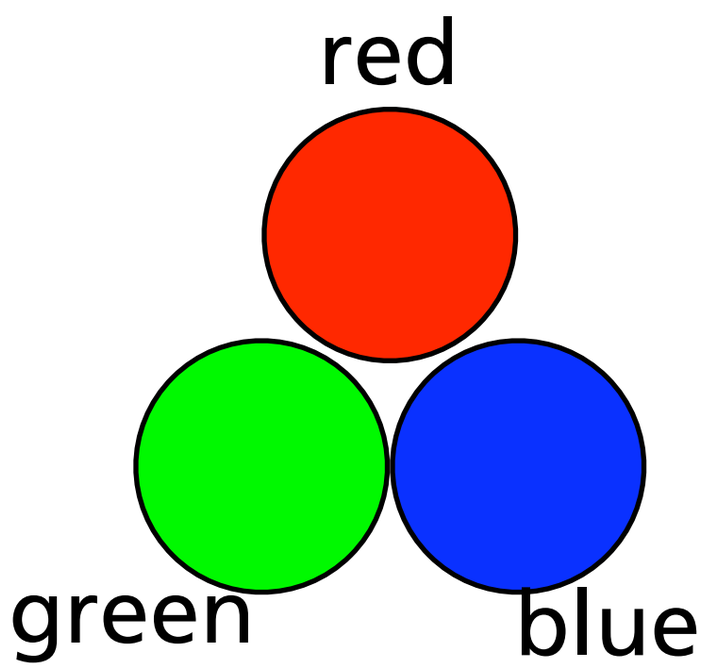
A raster-scan system displays an object as a set of discrete points across each scan line.

Colour Displays

- With colour CRTs there are three electron beams:
  RED, GREEN and BLUE.
  - We need to store intensities for each beam at each pixel.
  - The three *tri-stimulus* values are perceived as a single colour.

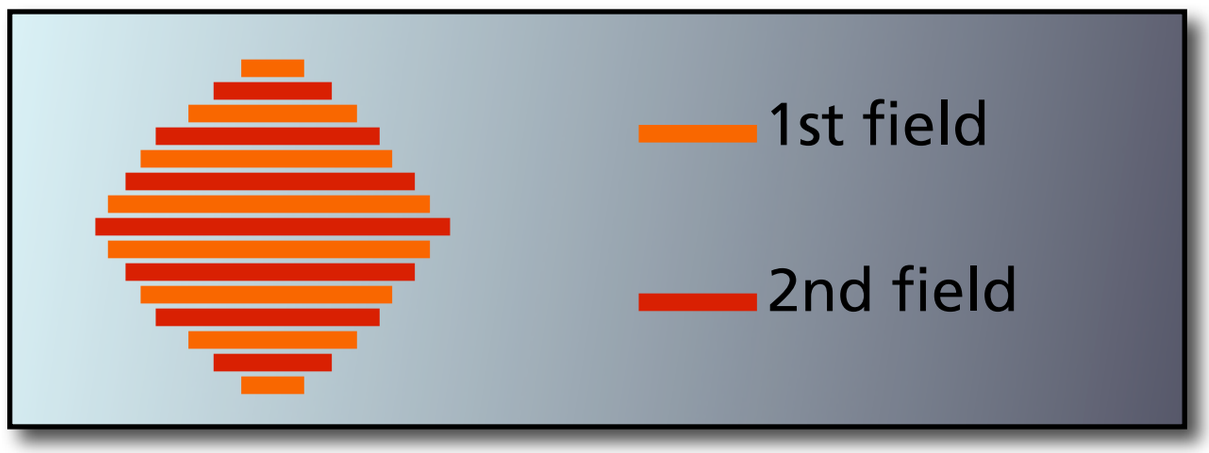


Operation of a delta-delta, shadow-mask CRT. Three electron guns, aligned with the triangular color-dot patterns on the screen, are directed to each dot triangle by a shadow mask.



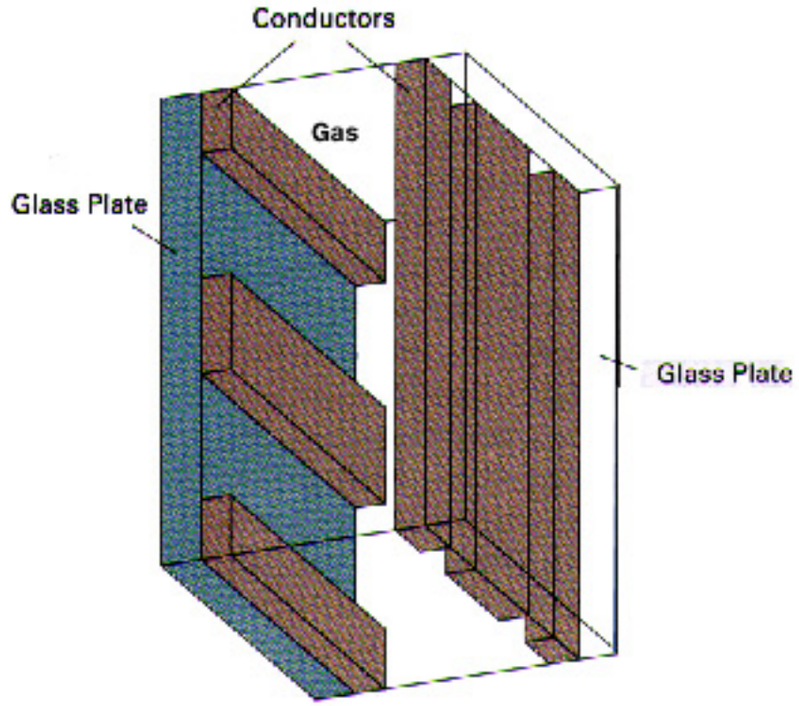
Interlaced Displays

- *Interlaced* display — every second line is refreshed every alternate pass.
- Each pass is referred to as a *field*. E.g. 30 frames per second (fps) interlaced:
  - 1/2 screen lines displayed in 1/60th of a second,
  - other half displayed in 1/60th of a second.



Other display devices: Plasma

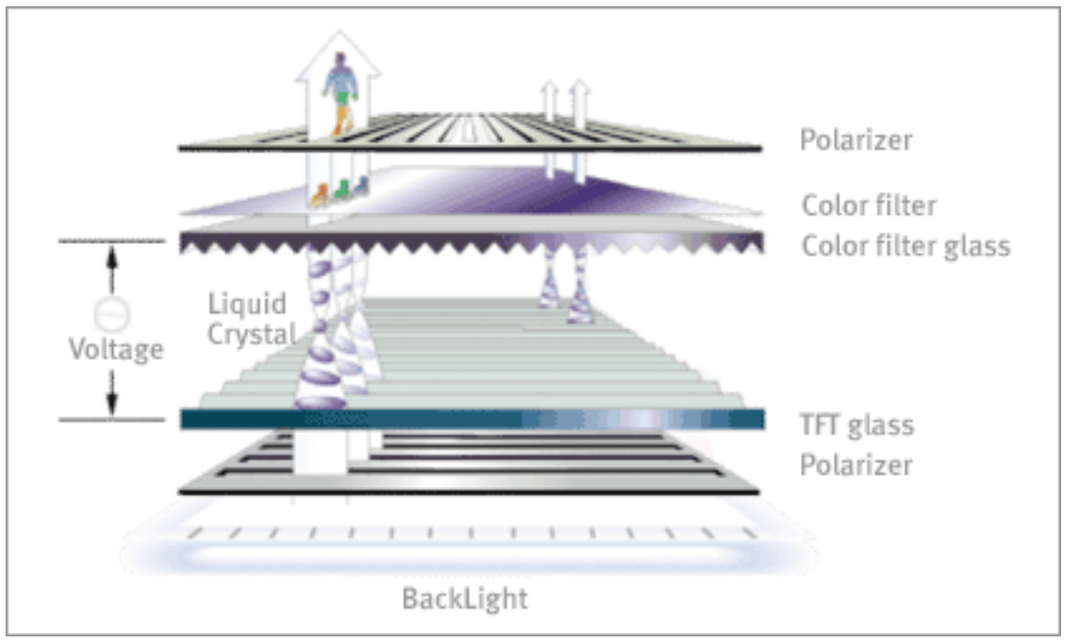
- Flat panel displays: 2 types — emissive and non-emissive.
- Plasma displays (gas discharge):
  - The region between two glass plates is filled with gas.
  - One plate has horizontal conducting
  - Pixels are addressed by applying voltage to horizontal and vertical conductors simultaneously, causing gas to break down into plasma.



Basic design of a plasma-panel display device.

Liquid Crystal Displays

- Liquid Crystal Displays (LCD)
  - used in portable systems such as laptop computers and PDAs.
  - Replacing most CRT display devices.
- Special compounds have a crystalline arrangement of molecules, yet flow like a liquid.
- Displays use nematic liquid-crystal compounds that tend to keep the long axes of the rod-shaped molecules aligned.
- Polarised glass plates with transparent conductors control twisting of the liquid crystal molecules and hence light reflection.

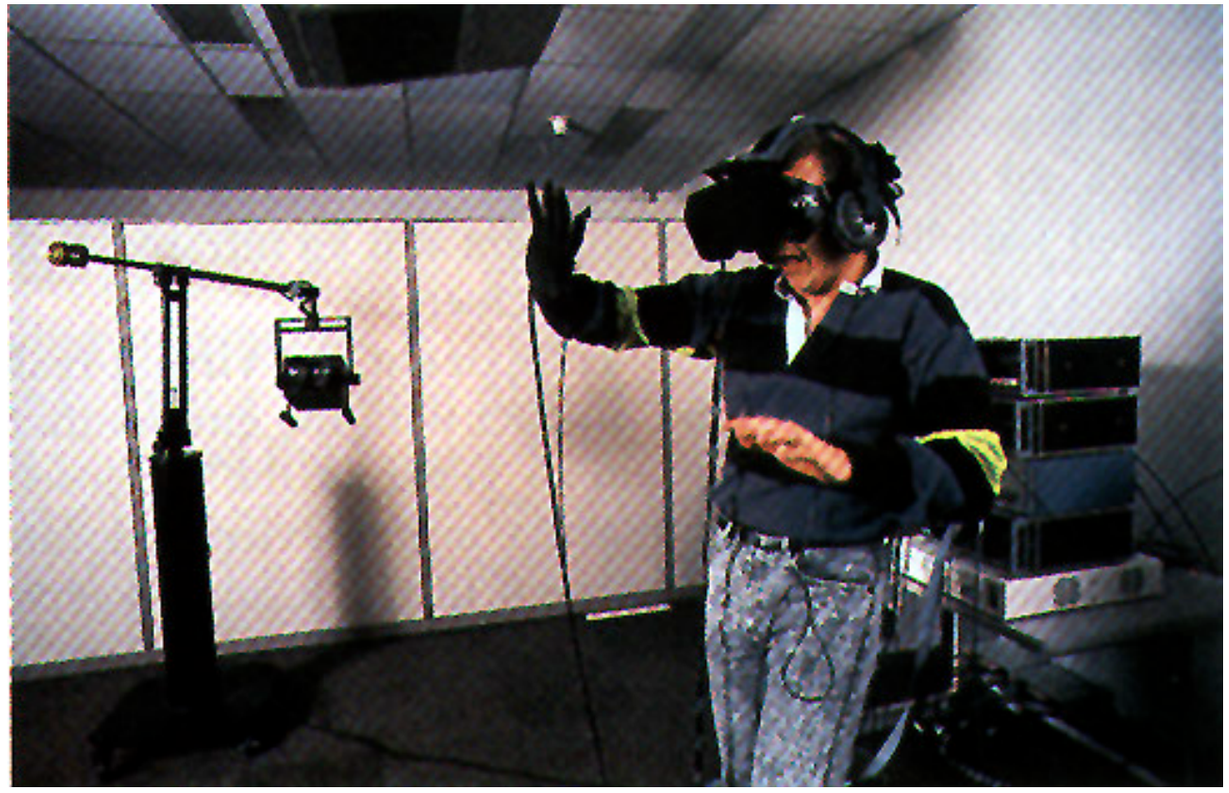


Liquid Crystal Displays (cont.)

- Drawbacks:
  - need to be lit from behind;
  - restricted viewing angle (overcome in newer displays);
  - Slow update ("submarining").
- *Passive matrix* — the voltage to two intersecting conductors to turn a pixel on;
- *Active matrix* — thin film transistor (TFT) placed at each pixel location to prevent voltage leaking out of the liquid crystal cells.
- Resolutions over 2000 x 2000 possible — expensive but becoming affordable.
- Flat panel displays usually connected via a digital interface (DVI), whereas CRTs predominantly analogue.

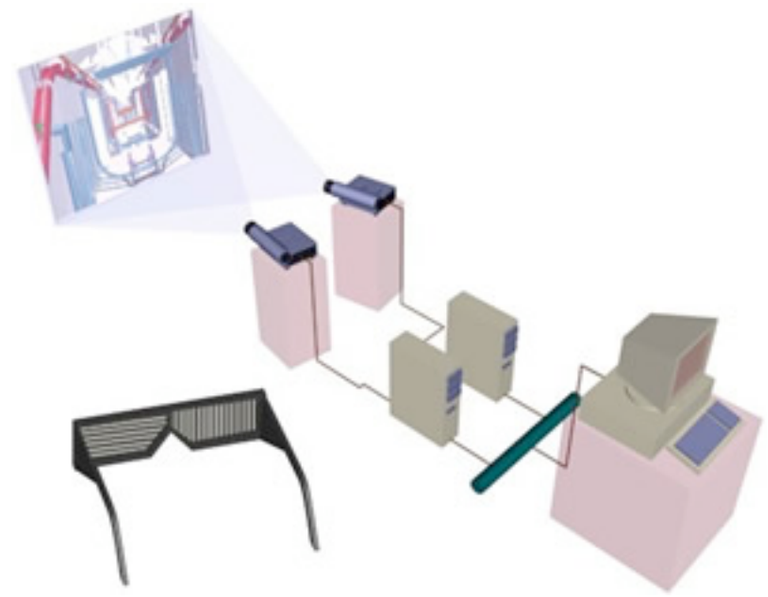
Stereoscopic Displays

- *stereoscopic displays* present a simultaneous left and right eye view.
- *Head Mounted Display* (HMD) — 2 small displays with close focus lenses attached to a helmet worn on the head.
- Interlaced stereoscopic display, viewed using glasses with synchronised liquid crystal shutters (*"active stereo"*); One field is presented to the left eye. The alternate field is then shown to the right eye.



Stereoscopic Displays (cont.)

- Twin-projection display (*"passive stereo"*) — requires two projectors with polarising filters and a special screen. Users wear glasses with polarising filters. Good for large number of users.



Stereo Example: the CAVE

- Users surrounded by a cube with 3–6 interlaced stereo projectors.
- Completely immersive, but expensive!
- Up to 10-12 users can be accommodated in the CAVE at one time.