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Department of Biomedical Engineering

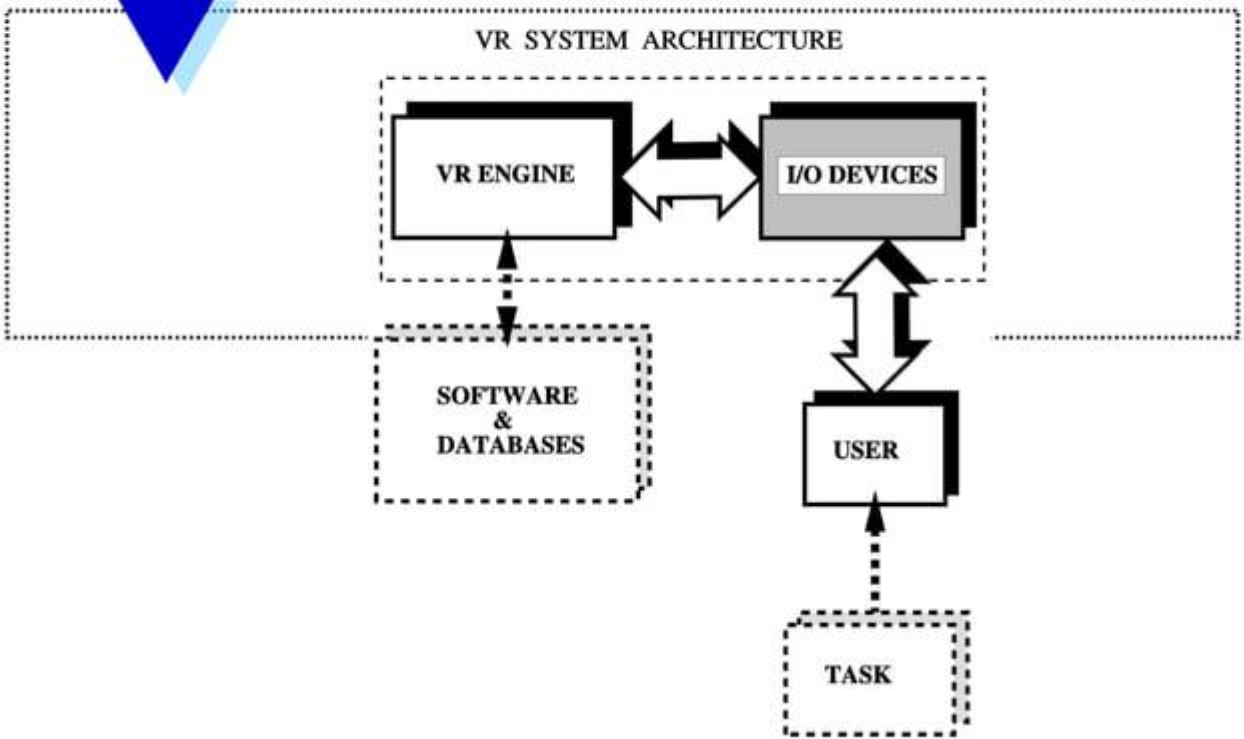
Course Name: 19BMT401 – Virtual Reality in Medicine

IV Year : VII Semester

Unit I –INTRODUCTION

Topic : Output Devices: Graphics displays-sound displays & Haptic feedback

Output Devices:
Graphics, 3-D Sound, Haptics and olfactory



The human senses need specialized interfaces

- ✓ Graphics displays for visual feedback;
- ✓ 3-D audio hardware for localized sound;
- ✓ Haptic interfaces for force and touch feedback;
- ✓ Interested in smell and not yet in taste feedback.

Definition:

A graphics display is a computer interface that presents synthetic world images to one or several users interacting with the virtual world.

Graphics Displays

- ✓ Human stereo viewing;
- ✓ Personal displays;
- ✓ Large volume displays:
  - –Active glasses
  - – Workbenches;
  - – Microsoft Surface
  - – Caves;
  - – Walls;

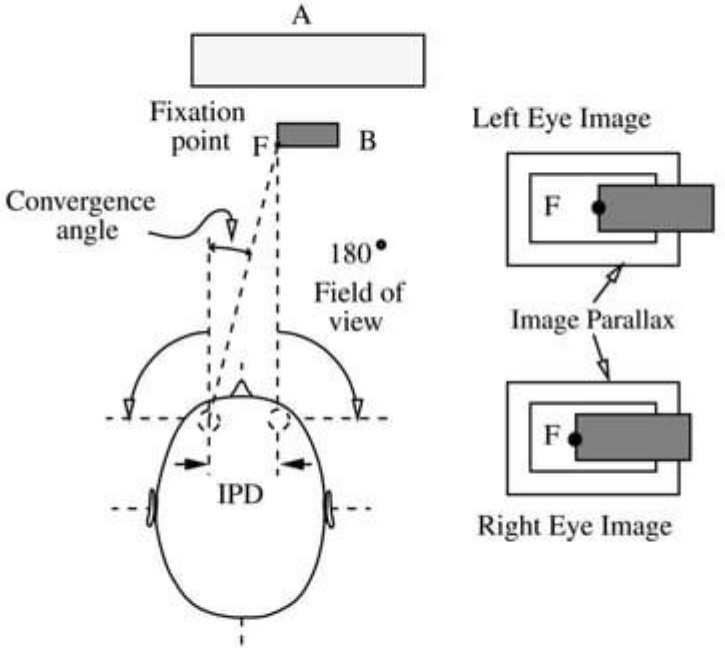
Human Visual System

- ✓ Vision is the dominant sensorial channel;
- ✓ Depth perception in mono images is based
  - on occlusion (one objects blocks another from view;
  - on shadows, textures and motion parallax (closer images appear to move more than distant ones)

Human Visual System-continued

- Depth perception in stereo is based on *seteropsis* when the brain registers and fuses two images;
- Image parallax means that the two eyes register different images (horizontal shift);
- The amount of shift depends on the "inter-pupillary distance" (IPD) (varies for each person in the range of 53-73 mm);
- Works in the near field (to a few meters from the eye)

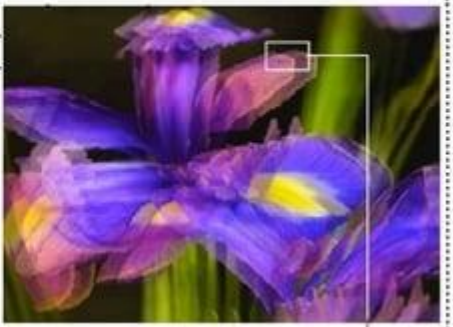
Output Devices



Output Devices (same principle used in new 3D HDTVs)

Left eye image

Right eye image



DLP® 3-D HDTV Input Format

Zoom View

Implications for Stereo Viewing devices

- ✓ Need to present *two images* of the same VR environment;
- ✓ The two images can be presented at the same time on *two* displays (HMD);
- ✓ The two images can also be presented time-sequenced on *one* display (active glasses);
- ✓ The two images can also be presented spatially-sequenced on *one* display (auto-stereoscopic displays).

Personal Displays

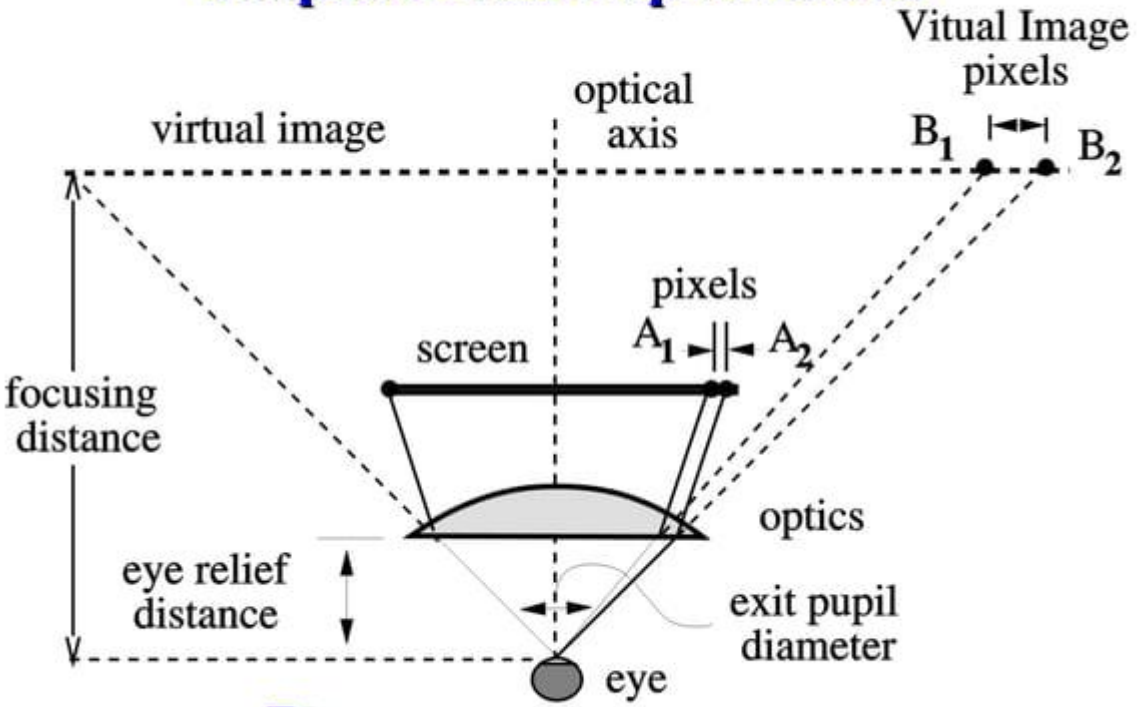
Definition:

A graphics display that outputs a virtual scene destined to be viewed by a single user. Such image may be monoscopic or stereoscopic, monocular (for a single eye) or binocular (displayed on both eyes).

Personal Displays

- ✓ Head Mounted Displays;
- ✓ 3-D Binoculars (hand supported);
- ✓ Booms (floor supported);
- ✓ Virtual windows (floor supported);
- ✓ Auto-stereoscopic displays (desk supported).

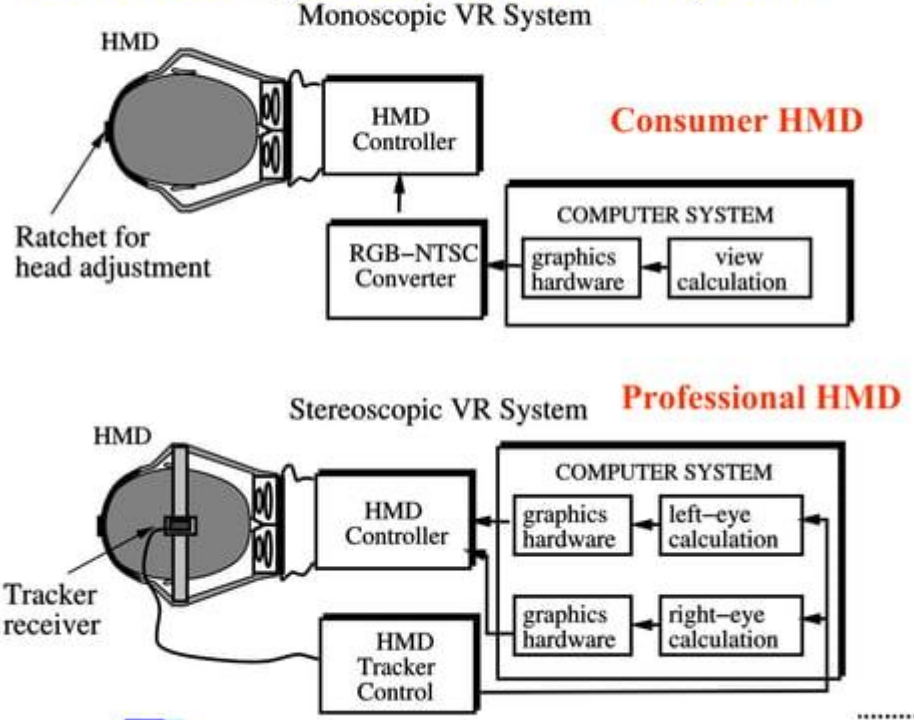
Simplified HMD optics model



HMD Characteristics

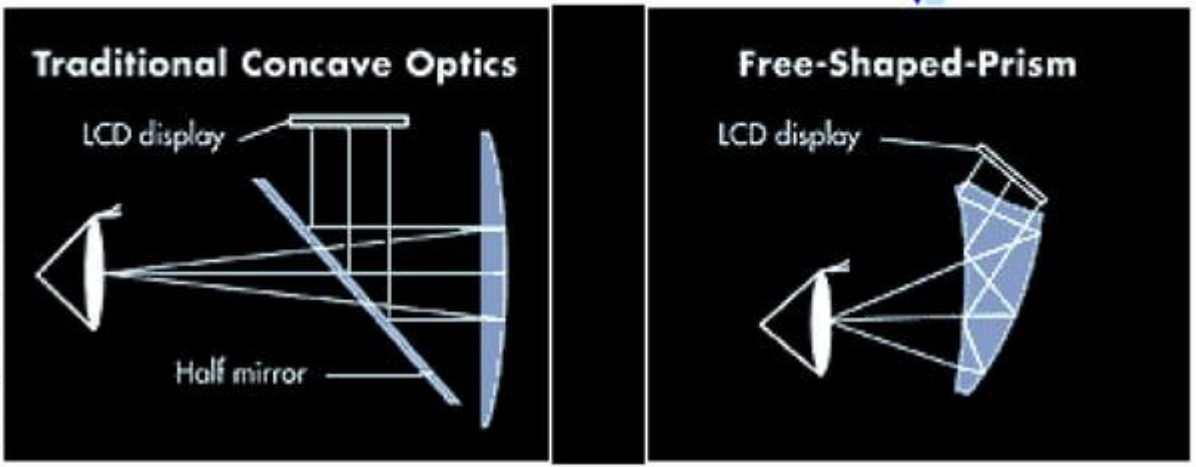
- ✓ Stereo or monoscopic
- ✓ Resolution;
- ✓ Field of view (horizontal);
- ✓ Field of view (vertical);
- ✓ Weight
- ✓ Price

HMD integration in a VR system



AMLCD display,
Resolution: 267x225
FOV: 30x23 degrees–
Equivalent to 62 in at 2 m
Weight: 100 grams
Can be worn over glasses

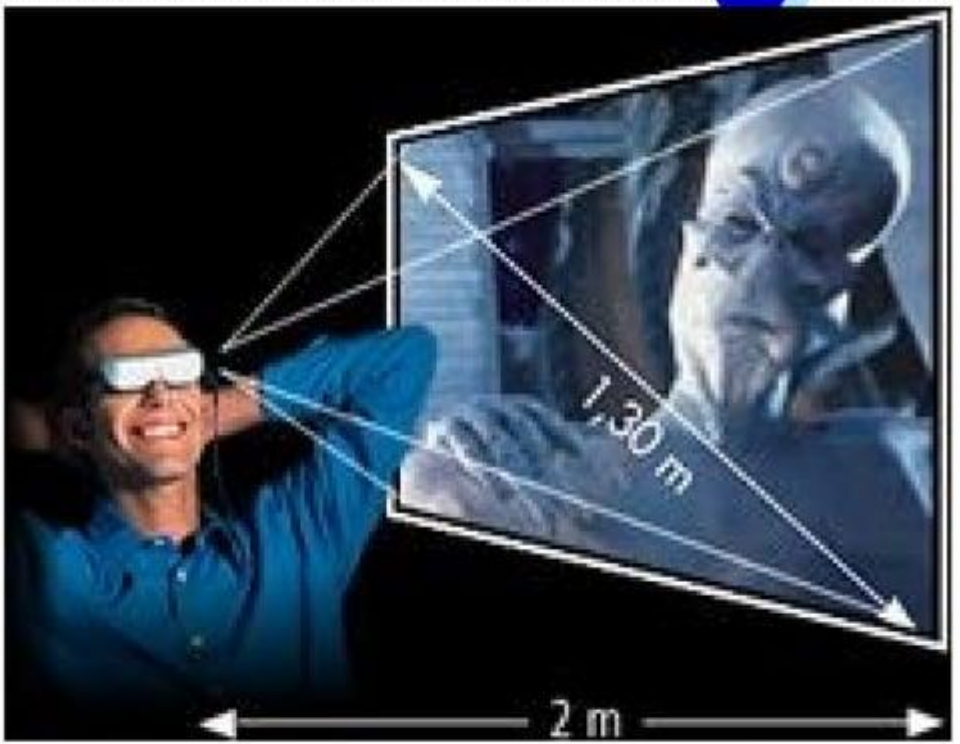
Olympus Eye Trek *Face* Mounted Display (FMD 200)



Olympus Eye Trek Head Mounted Display Optics

– uses free-form lens to compensate for aberrations;

- an eccentric optical system to reduce size (eliminate 45 degree mirror)



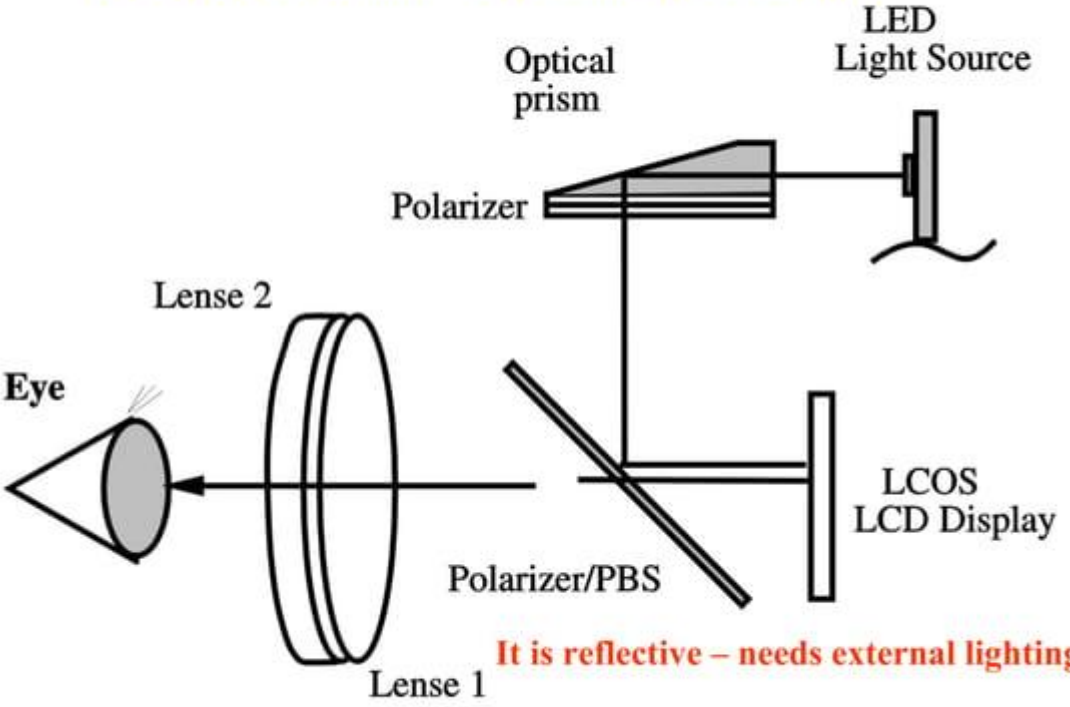
Olympus Eye Trek Face Mounted Display Optics

Daeyang "cy-visor" Face Mounted Display

LCOS display,
Resolution: 800x600
FOV: 60x43 degrees–
Weight: 160 grams
Can be worn over glasses

Liquid Crystal on Silicon display (LCOS)

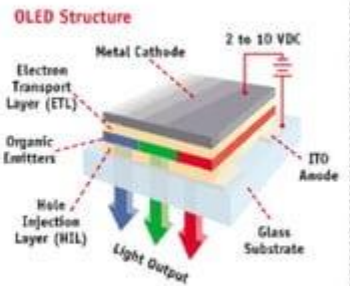
Daeyang "cy-visor" Face Mounted Display



Organic LEDs (OLED)

✓Active-matrix OLED display, each pixel can be addressed independently via the associated TFT's and capacitors in the electronic back plane. Each pixel element can be selected to stay "on" during the entire frame time. Since OLED is an emissive device, the display aperture factor is not critical.

✓ There are no intrinsic limitations to the pixel count, resolution, or size of an active-matrix OLED display, leaving the possibilities for commercial use open to our imagination. Also, because of the TFT's in the active-matrix design, a defective pixel produces only a dark effect, which is considered to be much less objectionable than a bright point defect, like found in LCD's.



Organic LEDs (OLED)

✓ Robust Design - OLED's are tough enough to use in portable devices

✓ Viewing Angles –up to 160 degrees screens provide a clear image, even in bright light.

High Resolution –Each pixel can be turned on or off independently to create multiple colors in a fluid and smooth edged display.

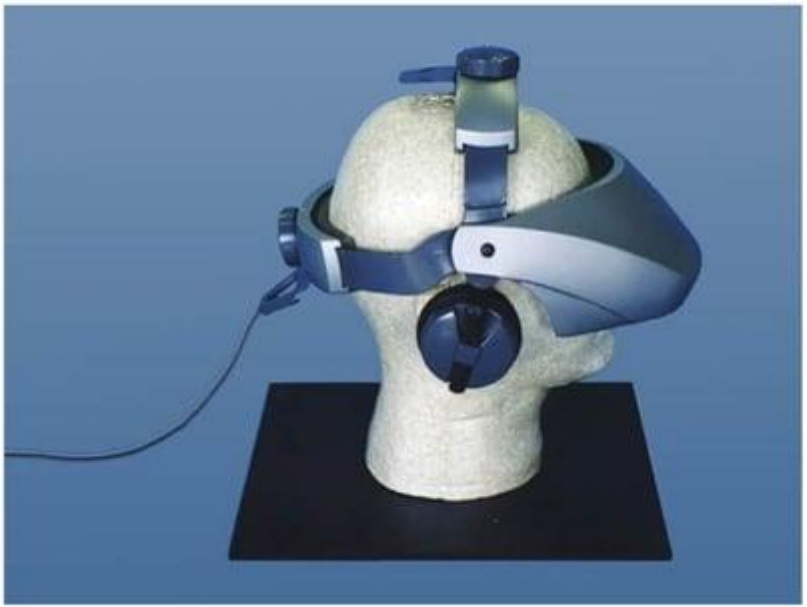
✓ "Electronic Paper" – OLED's are paper-thin. Due to the exclusion of certain hardware goods that normal LCD's require, OLED's are as thin as a dime.

✓ Production Advantages –20% to 50% cheaper than LCD processes.

Video Capabilities –handle streamlined video, which could revolutionize the PDA and cellular phone market.

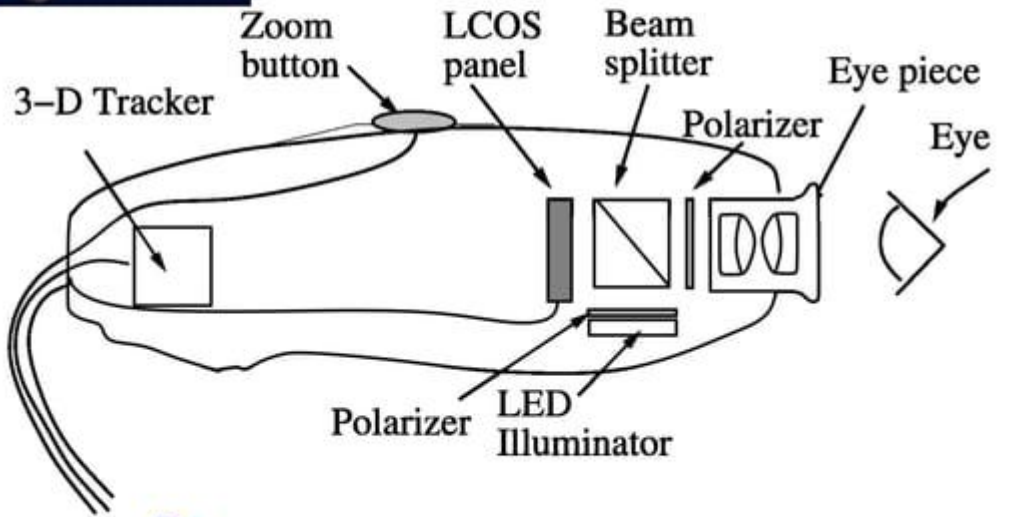
✓ Hardware Content – Lighter and faster than LCD's. out of plastic and bendable. do not need lamps, polarizers, or diffusers. Takes less power to run (2 to 10 volts).

5DT Head Mounted Display

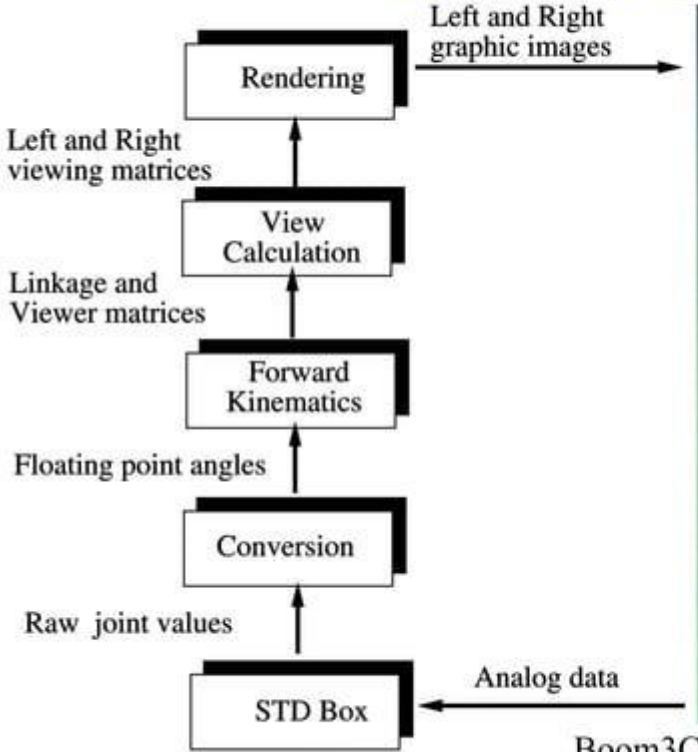


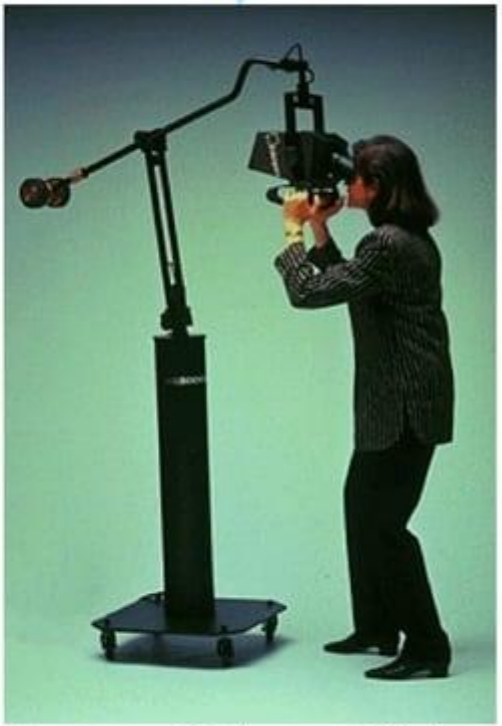
800x600 pixels
40° diagonal view
Organic LED
Frame sequential stereo
600 grams
$4k

Virtual Binoculars



Floor-supported displays





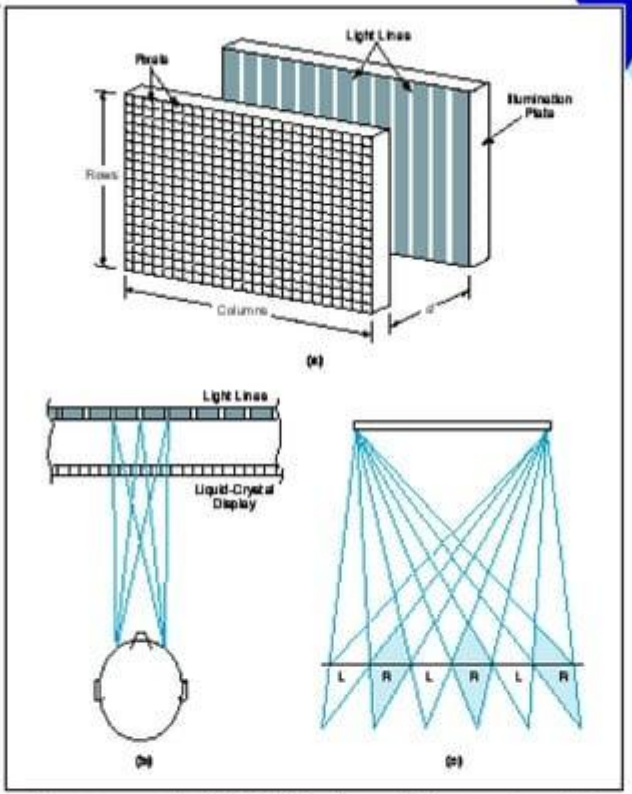
Boom3C (courtesy of Fakespace Labs.)

21" LCD display,
Resolution: SXGA (1600x1200)
Weight: Counter-Balanced;
No dead space but
High latencies due to Third-party tracker

Virtual Window 3-D Display (courtesy of Virtual Research Co.)

Auto-stereoscopic displays

- Do not require use of special glasses;
- *Passive* auto-stereoscopic displays do not track user's head and thus restrict user's position;
- *Active* auto-stereoscopic displays track the head motion and give more freedom of motion.



Passive Auto-stereoscopic 3-D Display (Dimension Technologies Co.)

20" LCD display,
Resolution:
1600x1200 (mono)
100° horizontal viewing
(1.5 to 6 feet)
Weight: 8.4 kg

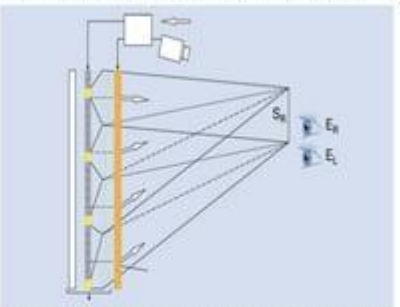
SynthaGram 204 (courtesy of StereoGraphics Co. - $3,000)

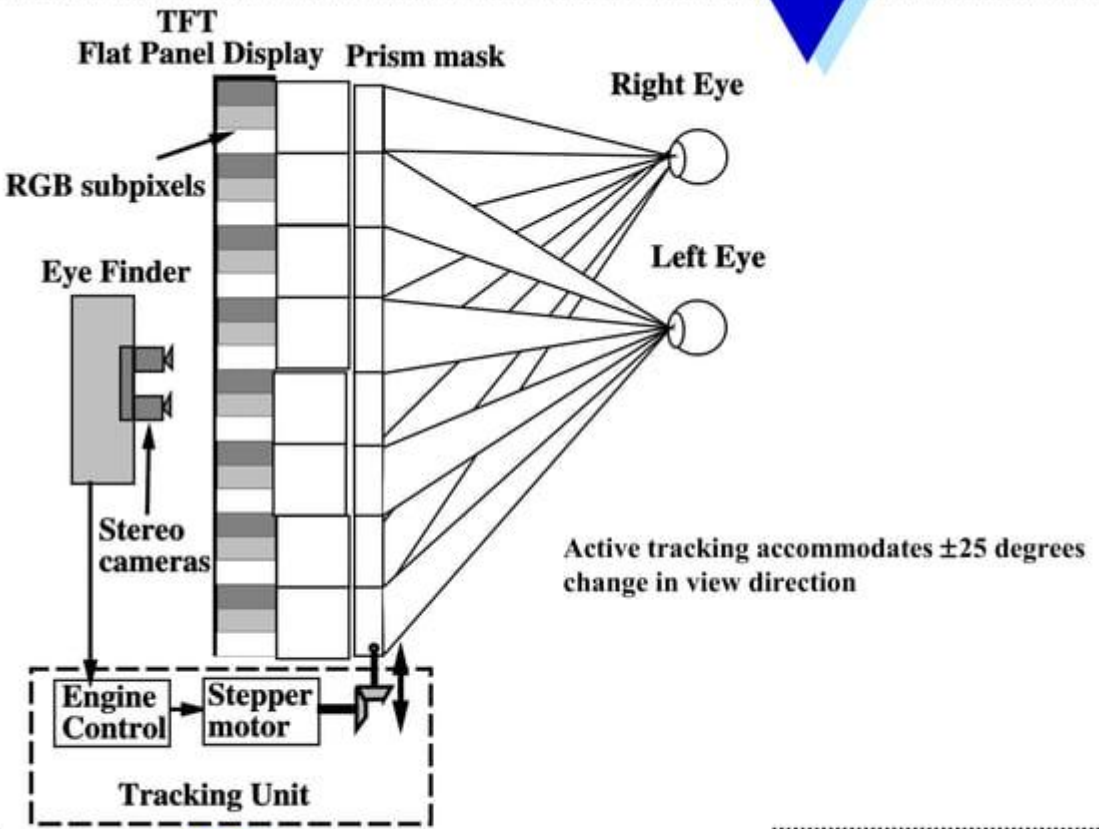
18" LCD display,
Resolution:
1280x1024 (mono)
640 x 1024 (stereo)
Weight: 17 kg

Active auto-stereoscopic 3-D Display (courtesy of Dresden 3D Co.)

Single-user Auto-stereoscopic display…

- The display redirects the appropriate frames to the right and left eye so that each eye can only see the relevant frame.
- The tracker locates each eye and sends the information to the control box.
- The control box then tells the LCD screen what pixels to display.
- Through the optics system in the screen, the image will get directed through the TFT directly to the appropriate eye.
- A split second later it would do the same to the other eye.
- Hence, creating a 3D image.

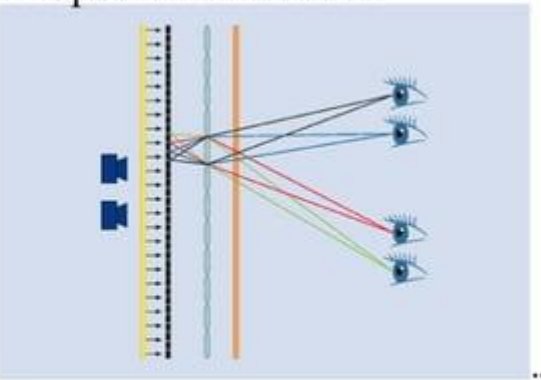



TFT
Flat Panel Display
Prism mask
Right Eye
RGB subpixels
Left Eye
Eye Finder
Stereo
cameras
Active tracking accommodates ±25 degrees
change in view direction
Engine
Control
Stepper
motor
Tracking Unit

Multi-user Auto-stereoscopic display…

- ✓ Multiple users can be tracked simultaneously and more pixels can be opened up at any given time allowing light beams to be directed simultaneously to more than one eye and more than one 3D user.
- ✓ Position finders already track pupils of multiple viewers with very small delay. Good resolution but still shows some flicker.
- ✓ OLED's becoming mainstream can help eliminate flicker

What needs to be done?
Better displays (100Hz…120Hz)
Complete the multi-user concept



Sharp autostereoscopic laptop

✓ Pentium 4, 15" diagonal display, 1024x768 resolution, 2D and 3 D mode, uses parallax barrier.

http://www.inition.co.uk/inition/product_stereovis_sharp_actius_rd3d.php

Autostereoscopic cell phones!

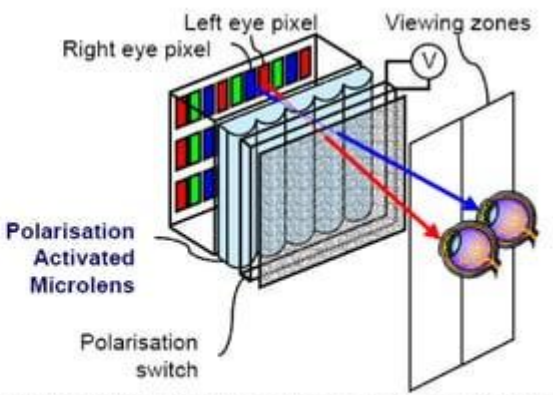
Ocuity (UK) and NEC make 2.5" diameter autostereoscopic cell phones. InTouch mobile handset (TTPCom)

2.1" Transflective 2D/3D TFT-LCD

132xRGBx176 pixel display

Automatic control of 2D to 3D switching function

Running TTPCom WGE 3D stereo game demonstration



Holographic displays

• The image source is based on standard flat panel technology of which the image is seen upon a nine optical layer glass panel. Objects will appear to float in space.

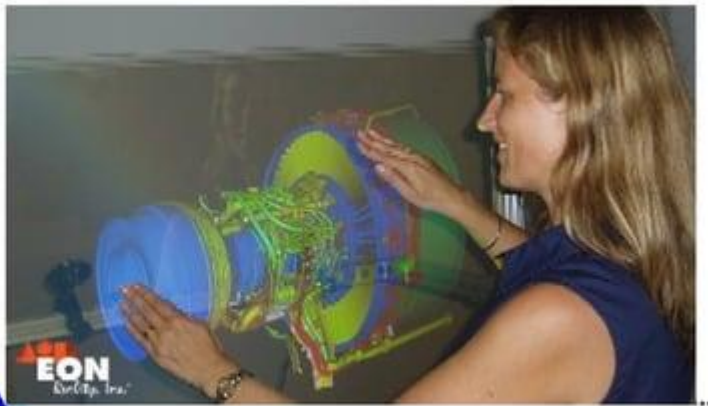
•For the maximum 3D effect, the background seen through the display should be several feet behind the display and dark in color.

http://www.eonreality.com/files/brochures/eon_icrystal_hd.pdf

Holographic displays – EON TouchLight

- Bare-hand 3D interaction virtual reality display system
- VR scene can be zoomed, panned and rotated with both hands
- Uses image processing techniques to combine the output of two video cameras placed behind a semi-transparent plane in front of the user. Incorporates IR cameras and image processing board

http://www.eonreality.com/files/brochures/eon_touchlight_hd.pdf



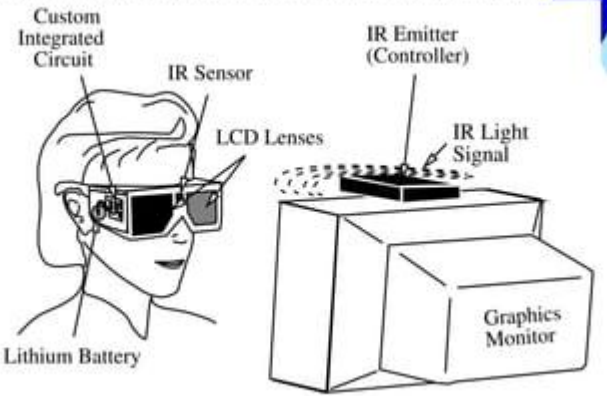
Large Volume Displays

- Allow several co-located users to view a monoscopic or stereoscopic view of the virtual world;
- Can be classified as *monitor*-based large volume displays or *projector*-based large volume displays.
- Allow more freedom of motion vs. personal displays.

Monitor-based Large Volume Displays

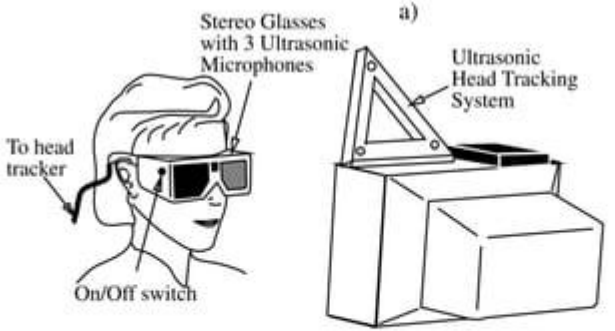
- ✓ Use active or passive glasses;
- ✓ Several users can look at a monitor;
- ✓ Can have a *single* monitor, or *multiple* side-by-side monitors;
- ✓ If side-by-side, image continuity becomes an issue.

Untracked and wireless



a)

Tracked and wireless



b)

Active glasses

Active glasses vs. FMDs

Some advantages:

- ✓ **no cables if head position is not tracked;**
- ✓ **light and ergonomic (can be used over vision glasses);**
- ✓ **work well with large volume displays.**
- ✓ **allows full screen resolution 1280x1024**

Some disadvantages:

- ✓ **lose 2/3 of image light intensity through LCD filtering;**
- ✓ **require special CRT "stereo ready" that has twice the hardware refresh rate (Hz) 120 Hz or more;**
- ✓ **require direct line of sight for IR controller;**
- ✓ **different viewing metaphor "through the window".**

Wall and Dome-type displays

- **Advantages:**
  - **Accommodate more users (tens to hundreds)**
  - **Give users more freedom of motion;**

- **Disadvantages:**
  - **Large cost (up to millions of dollars);**
  - **Even with multiple projectors, resolution is much lower than for CRTs (because the area is large).**
  - **Example PanoWall has 200,000 pixels/m^2 while a monitor has 18,200,000 pixels/m^2**
- **To have equal numbers of pixels/unit are – more projectors (military)**

Haptic Interfaces

Haptics…

- Comes from Greek *Hapthai* meaning the sense of touch;
- Groups touch feedback and force feedback

Touch Feedback

- ✓ Relies on sensors in and close to the skin;
- ✓ Conveys information on contact surface geometry, roughness, slippage, temperature;
- ✓ Does not actively resist user contact motion;
- ✓ Easier to implement than force feedback.

Force Feedback

- ✓ Relies on sensors on muscle tendons and bones/joints proprioception;
- ✓ Conveys information on contact surface compliance, object weight, inertia;
- ✓ Actively resist user contact motion;
- ✓ More difficult to implement than touch feedback (no commercial products until mid 90s).

Haptic Interfaces

Human touch sensing mechanism

- ✓ Most touch sensors are on the hand (much less density on other parts of the body);
- ✓ Four primary types of sensors:

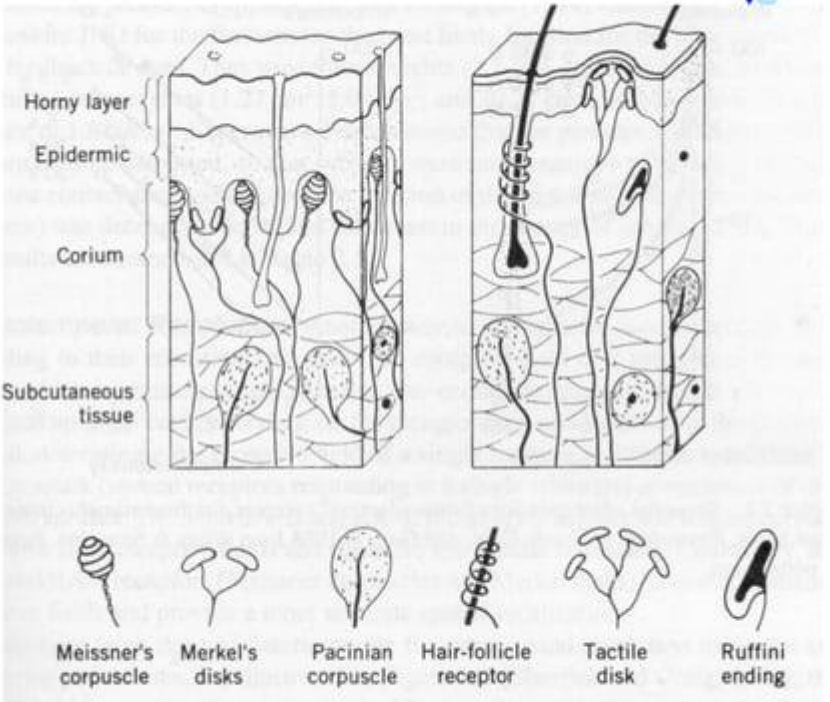
40 % are **Meissner**'s corpuscles – detect movement across the skin – velocity detectors

25% are **Merkel**'s disks – measure pressure and vibrations

13 % are **Pacinian** corpuscles – deeper in skin (dermis) – acceleration sensors. Most sensitive to vibrations of about 250 Hz

19% are **Rufini** corpuscles – detect skin shear and temperature changes

Haptic Interfaces



Skin touch sensors

Haptic Interfaces

Sensorial adaptation

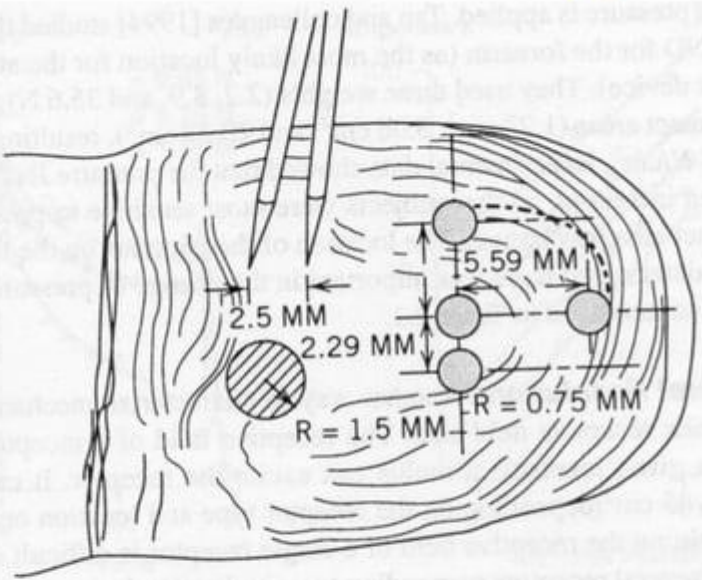
- ✓ Measure the decrease in electrical signals from the skin sensor over time, for a constant stimulus;
- ✓ If the sensor produces a constant electrical discharge for a constant mechanical stimulus – It is called "Slow Adapting" (SA);
- ✓ If the rate of electrical discharge drops rapidly over time for a constant stimulus – called "Rapidly Adapting" (RA)

Haptic Interfaces

Spatial resolution

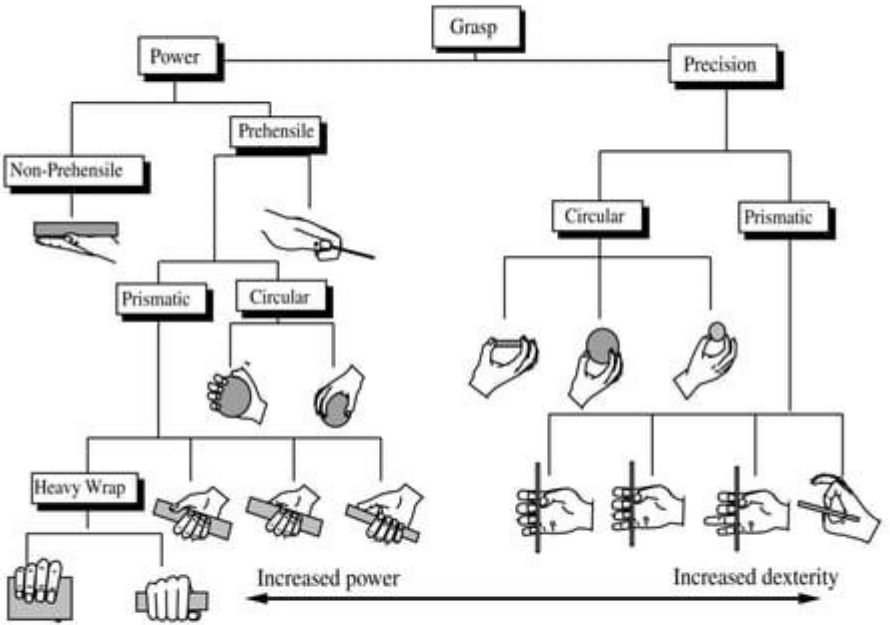
- ✓ Measure the receptive field size of a sensor;
- ✓ If the sensor has a large receptive field – it has low spatial resolution (Pacinian and Ruffini) SA-II, RA-II
- ✓ If the receptive field is small – has high spatial resolution (Meissner and Merkel) SA-I, RA-I

Haptic Interfaces



Two-point limen test: 2.5 mm fingertip, 11 mm for palm, 67 mm for thigh

Haptic Interfaces



Human grasping configurations

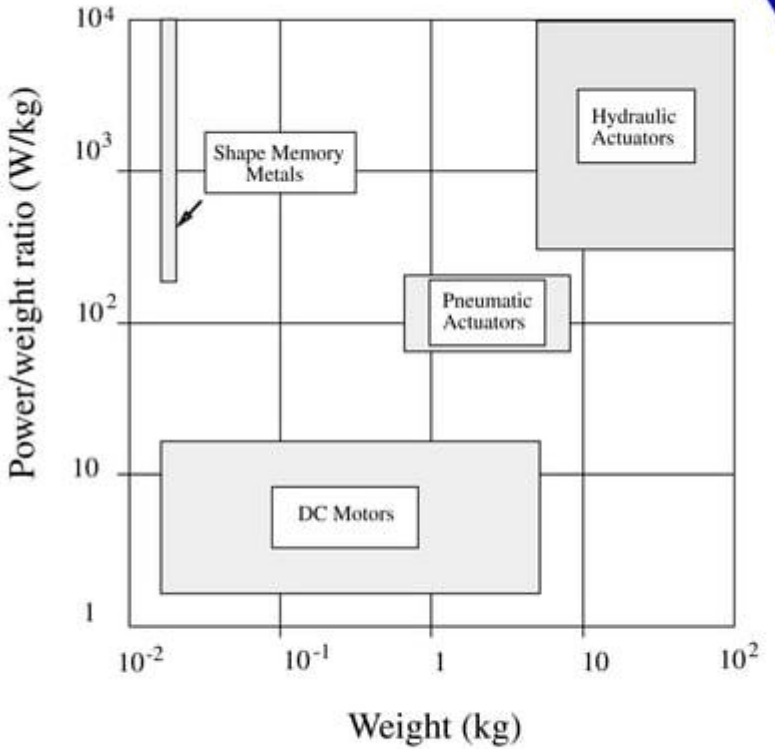
Haptic Interfaces

Haptic feedback actuators

- ✓ Need to maximize power/weight ratio;
- ✓ Need to have high power/volume ratio;
- ✓ Need to have high bandwidth;
- ✓ Need to have high dynamic range (fidelity);
- ✓ Need to be safe for the user

- None of the current actuator technology satisfies all these requirements

Haptic Interfaces

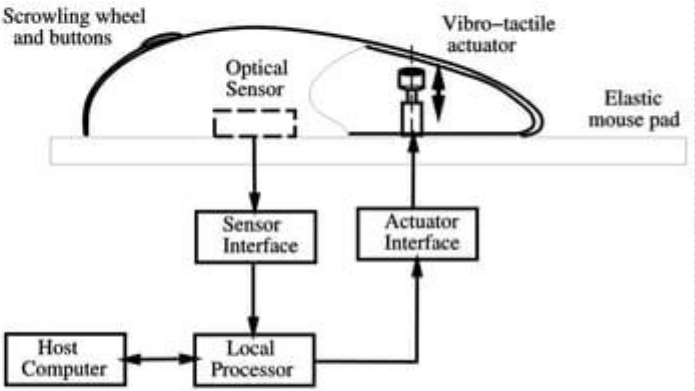


Actuator comparison based on P/W ratio

Touch Feedback Interfaces…

- ✓ Can be desk-top or wearable (gloves);
- ✓ touch feedback mouse;
- ✓ CyberTouch glove;
- ✓ Temperature feedback actuators;

Haptic Interfaces



The iFeel Mouse (0-125 Hz).

Haptic Interfaces

6 individually Controlled Vibrotactile actuators

0-125 Hz frequency
1.2 N amplitude at 125 Hz

CyberTouch Glove (Virtex)

Thank You