Virtual Reality

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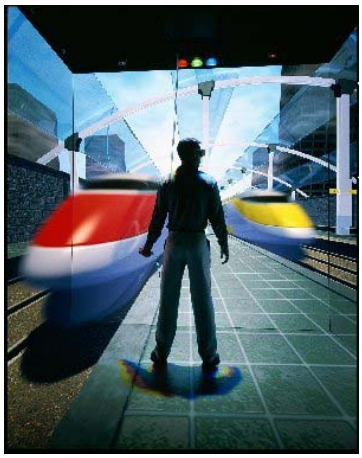
VIRTUAL REALITY

✓ VR goes beyond the flat monitor that you simply look at, and tries to **immerse** you in a **three dimensional** visual world. The things you see appear to be in the room with you. VR is a term conied by Jaron Lanier in the 70'

✓ There are a number of techniques for acheiving this, each with its own tradeoff between degree of immersion, senses envolved beyond sight, computational requirements, physical contraints, and others.



VIRTUAL REALITY

Some basic characteristics of VR are:

- ❑ Navigation
- ❑ Interaction
- ❑ Immersion
- ❑ Presence

1965 Ivan Stutherland's paper The ultimate display
one day computer will provide windows to virtual worlds
We also use the term *Virtual / Synthetic Environments* (VE)

VIRTUAL REALITY

✓ *Navigation* imply the ability to move around and explore features of a 3D scene.

✓ *Interaction* implies the ability to select and move objects in a scene.

✓ *Immersion* is achieved by using stereoscopic vision.

✓ Immersion increase the sensation of *presence* within the virtual world (first-person view)

→ To achieve these issue *real-time graphics* is fondamental.

VIRTUAL REALITY

High-speed rendering is vital to a successful VR system: if there is any delay in producing the images seen by the user, the illusion of immersion and presence are quickly lost. To uptade a VE at 25 Hz only 40 ms are available to create each image

VE modeled with care
High performace computing

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VIRTUAL REALITY: WHY?

- Education
- Training (surgery,
- Virtual Prototypes
- Spatial Visualization
- Heritage (virtual archaelogy..
- Scientific Visualization
- Urban Planning
- Environmental Impact
- Art , entertainment …

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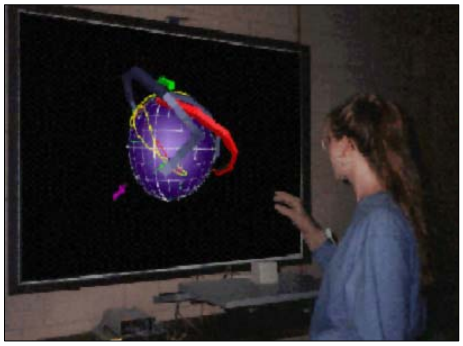
VIRTUAL REALITY: EDUCATION

✓ VR enables to discover the world through a *sense and motion learning process*, more natural for human beings than the symbolic-reconstructive way (ie. writing).

✓ If you can see things and experiment with objects you can learn in an easier and more intuitive way.

✓ The use of 3D graphics seems to be a powerful tool for visualizing and understanding complex and/or abstract information.



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VIRTUAL REALITY: TRAINING

VR is already being used in to teach people how to use expensive equipment, or when the cost of a mistake in Real Reality is very high.

- **aircraft simulators to train pilots**
- **military flight simulators**
- **medicine (virtual surgery)**
- **virtual therapy (phobias)**

A Boeing 737-800 fullflight simulator for Lufthansa.

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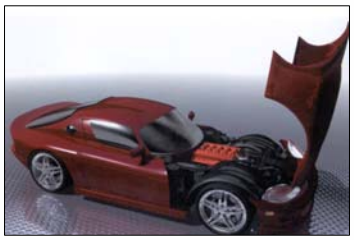
VIRTUAL REALITY: PROTOTYPES

- ✓ Reduce the need for physical prototype.
- ✓ Improve product ergonomics and functionality.
- ✓ Provide manufacturing with early access to product details.
- ✓ Collaborative design.
- ✓ Increase understanding of complex 3D assemblies starting from CAD systems
- ✓ Provide an effective way to present product configuration and aesthetics.
- ✓ Crash test



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VIRTUAL REALITY: SPATIAL VISUALISATION

- ✓ VR provides intuitive ways for exploring 3D environments.
- ✓ Can solve problems as factory construction or reorganization:
  - overall efficiency
  - machine accessibility
  - health and safety
  - services
  - others …

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VIRTUAL REALITY: HERITAGE

Virtual Reality applied to Cultural Heritage allows:

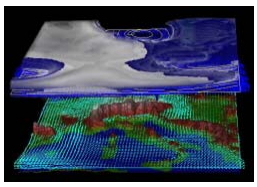
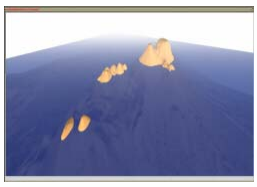
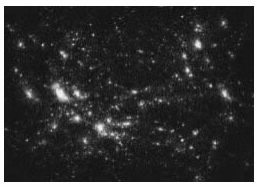
- ✓ public access to "monuments" that can not be normally accessed or that risk to be damaged;
- ✓ the reconstruction of objects and "scenarios" that do not exist anymore;
- ✓ a fruition without "frontiers" - taking "objects" to users and creating imaginary collections of disperse "objects";
- ✓ a vision with no space and time constrictions.

VIRTUAL REALITY: SCIENTIFIC VISUALISATION

The greatest impact virtual reality will have on science is how it will change our way of thinking.

Virtual reality encourages viewers to be participants immersed in the data rather than passive observers watching from a distance.

By thinking of some scientific problems as environments for the first time, new insights will be gained.

VIRTUAL REALITY: ENTERTAINMENT

Real-time computer graphics plays a central role in computer games and entertainment.

You can be in a computer game with computer generated players and/or other real players.

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VIRTUAL REALITY

Some Basics

1. **Stereo Viewing**
   - Shutter Glasses
   - HMD
2. **Input devices**
   - Hand Tracking
3. **Output devices**
   - Force Feedback
4. **Displays**
   - Projection Walls
   - Projection Tables
   - Full Immersion

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VIRTUAL REALITY: STEREO VIEWING

✓ An important aspect of VR is that things are presented in **three dimensions**.

✓ Humans see the world around them in 3D using **stereoscopic vision**.

✓ In stereoscopic 3D perception, we use the fact that we have **two eyes** that are set **some distance** apart from each other.

✓ Because the two images are taken from two different positions in space, the brain uses this differences to create a single image that contains **depth information**.

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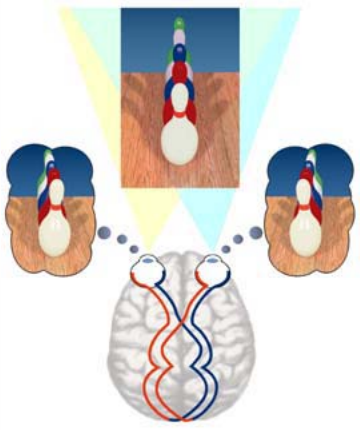
VIRTUAL REALITY: STEREO VIEWING



✓ We perceive the end result as objects at specific locations in the space around us.

✓ One way to make a 3D graphics display is to render two images from slightly different eye points and present them separately to each eye:

- **Shutter Glasses**
- **Head Mounted Display**

-First problem interocular distance changes from person-to person (6, 5 cm typical value)

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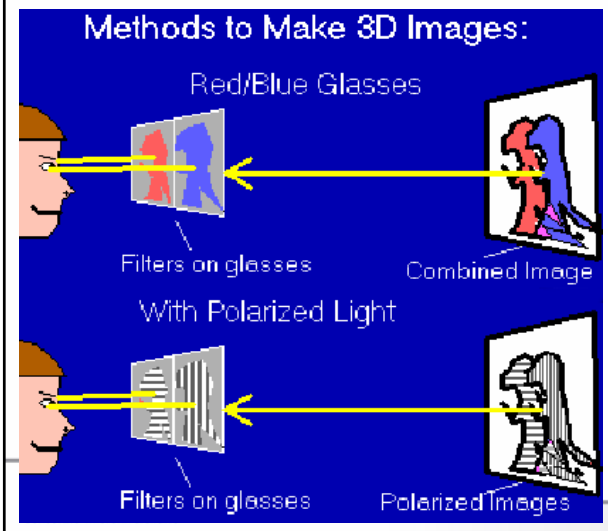
VIRTUAL REALITY: STEREO VIEWING



VIRTUAL REALITY: SHUTTER GLASSES

Shutter glasses allow displaying stereo computer images using the existing monitor.The display alternates rapidly between the left and right eye images.

Each eye only saw the image intended for it by opening a shutter in front of the eye when its image is being displayed.

The shutters would have to be synchronized to the display.

Shutter glasses typically use electronic shutters made with liquid crystals.

VIRTUAL REALITY: HEAD MOUNTED DISPLAY

Another way to present a separate image to each eye is to use a separate monitor for each eye

This can be done by mounting small monitors in some sort of head gear.

This setup is usually referred to as a head mounted display (**HMD**).

Virtual Retina Display

Head Mounted Display

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VIRTUAL REALITY: INPUT DEVICES

Motion sensors can be used to track the position and orientation of fingers. So, just like a mouse or joystick, fingers actions can be used to control a program.

This might take the form of pushing virtual menu buttons, or maybe grabbing an object and **moving it around with hands**.

Hands and fingers position and orientation can be achieved by wearing a **special glove** that has a position sensor on it and can sense the angles of fingers joints …

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VIRTUAL REALITY

It's difficult to find a range of technology that will mimic the senses of sight, sound, touch and balance, but the aim of VR is not to replicate our experience of the real world, but to make things as realistic and useful as possible. VEs must be

easy to use

accommodate a wide variety of human sizes

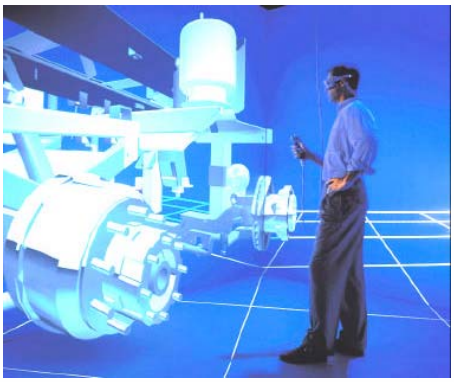
not cause fatigue

not induce nausea

not require long periods of adaptations

There is no need for sophistication if there is no real value added!

VIRTUAL REALITY: INPUT DEVICES

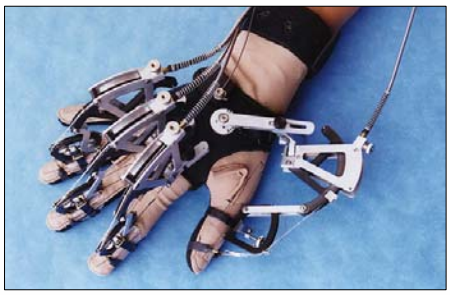


Immersive tracking systems

VIRTUAL REALITY: OUTPUT DEVICES

• The devices that return force information to a VR user are known as **haptic devices** as they provide some form of sensory **feedback** through the tactile senses. Thus it is possible to touch, weigh and grasp virtual objects.

• The cables and pulleys on the outside of the glove are used to "push back" at the user under computer control.



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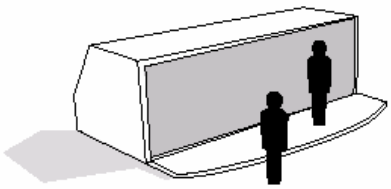
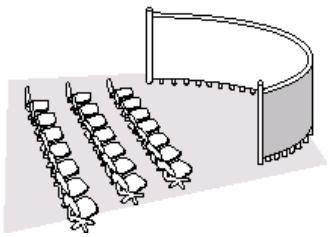
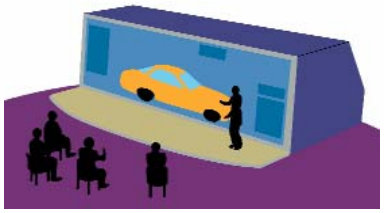
PROJECTION WALLS

Projection Walls







- Group (large) viewing
- medium immersion

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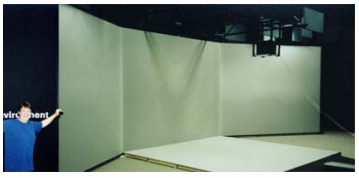
PROJECTION WALLS

Cylindrical screen

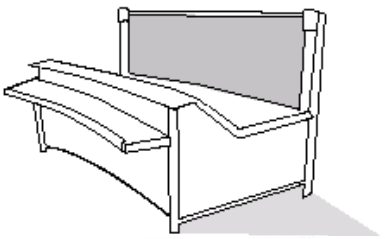
Flat screen

Virtual Theatre at CINECA



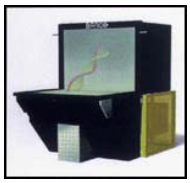
Reconfiguring geometry wall

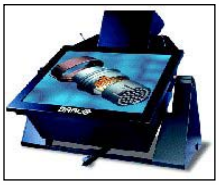
PROJECTION TABLES



- Single (Small group) viewing
- medium immersion

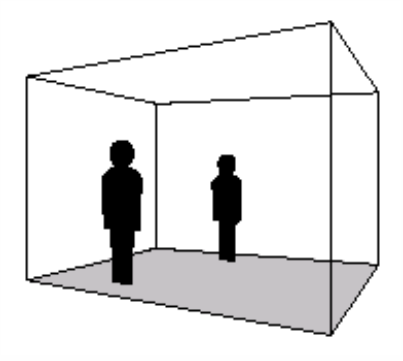
PROJECTION TABLES





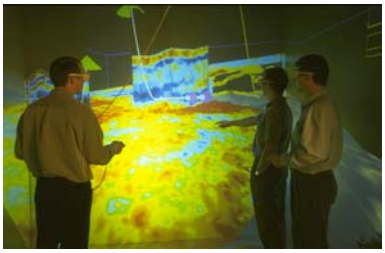
With tracking systems

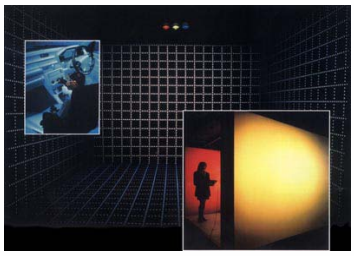

ROOMS – CAVE SYSTEMS



- Single (Small group) viewing
- Full immersion

ROOMS





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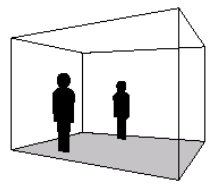
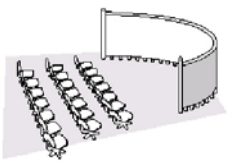
COSTS





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DESKTOP PROJECTION SYSTEMS

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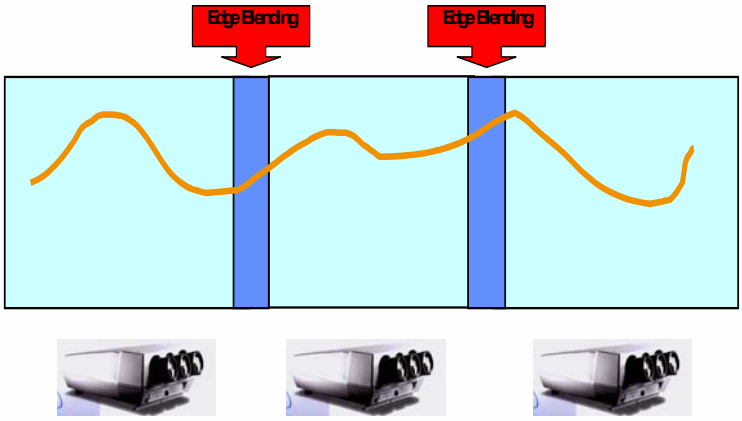
VIRTUAL REALITY: EDGE BLENDING



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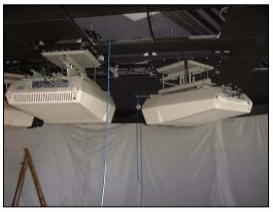
VIRTUAL THEATRE AT CINECA

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BOOKS

- Foley, vanDam, Feiner, Hughes *Computer Graphics*
- Alan Watt *3D Computer Graphics*
- Olin Lathrop *The Way Computer Graphics Works*
- John Vince *Essential Virtual Reality Fast*

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