Professors d'IDI - UPC

Interacció i Disseny d'Interfícies

Continguts

- **Virtual Reality**
- Augmented Reality

Augmented vs Virtual Reality

Augmented Reality

- System augments the real world scene
- User maintains a sense of presence in real world
- Needs a mechanism to combine virtual and real worlds

Virtual Reality

- Totally immersive environment
- Visual senses are under control of system (sometimes aural and proprioceptive senses too)

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Continguts

- **Virtual Reality**
  - **General Concepts**
  - VR Systems
  - Stereo Synthesis
  - Interaction
- Augmented Reality

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Realitat Virtual

- Definició A. Rowell:
  - "La Realitat Virtual és una simulació interactiva per computador des del punt de vista del participant, en la qual se substitueix o s'augmenta la informació sensorial que rep".

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Virtual Reality

- Fundamental elements:
  - ***Digital 3D model***
  - **Interactive Visualization/Navigation**
  - **Implicit Interaction**
  - **3D sensorial immersion**

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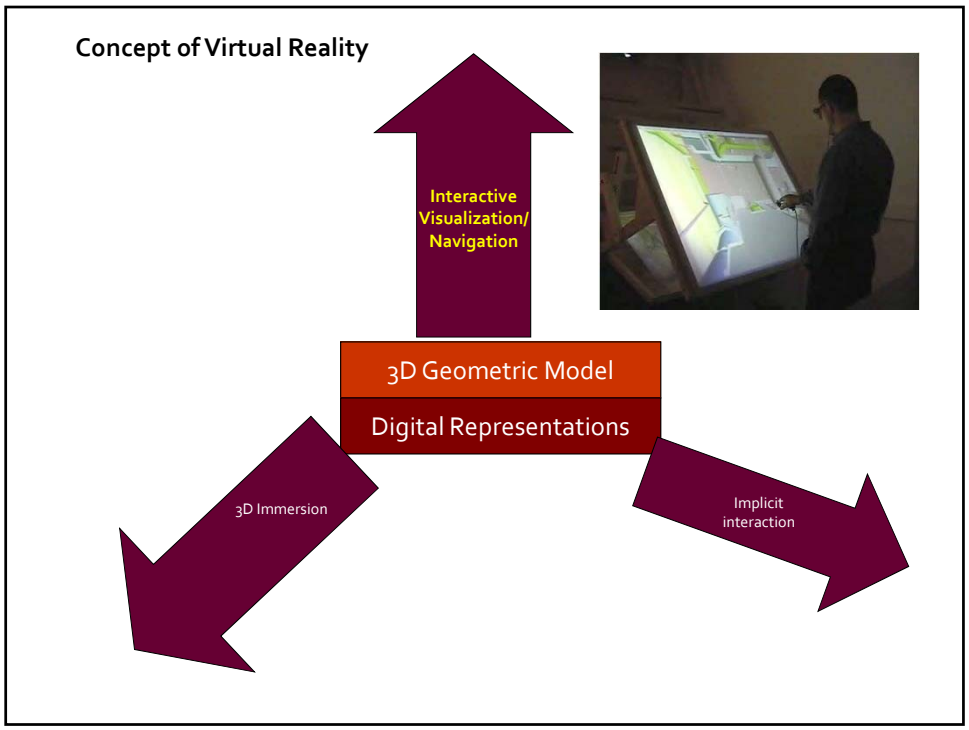
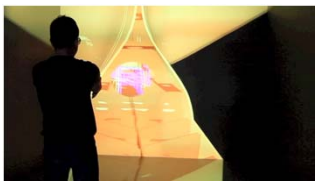
Concept of Virtual Reality



The Virtual Reality

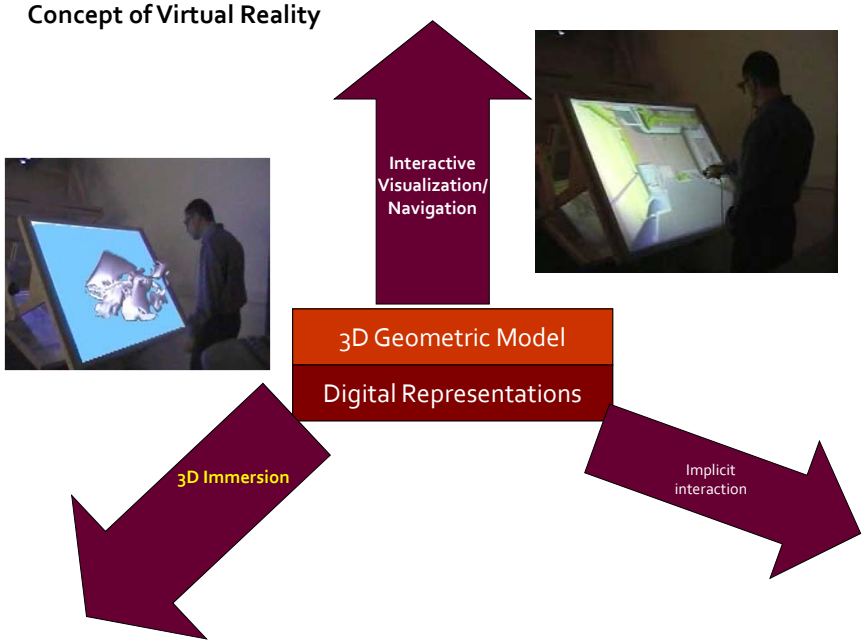
- **Interactive Visualization**
- Implicit interaction
- Immersion



Reproduces a virtual world which only exists as a digital model inside the computer

- **Interactive simulation vs animation**
  - passivity, previously decided
  - improvisation**, active, real time response**
- **3D geometric** and appearance representation
- Realistic visualization algorithms
- Memory management algorithms
- Multiresolution models
- "Zoom" capacity
- Visibility pre-process

Concept of Virtual Reality



The Virtual Reality

- Interactive Visualization
- Implicit interaction
- **Immersion**

Disconnecting senses from the real world, and connecting them to the virtual environment

- **Visual immersion**: objects exist independently of the visualization device
  - **Stereoscopic vision**. Presence feeling into the space
- Acoustics immersion
- Touch immersion
- Movement immersion: acceleration
- Smelling, tasting…

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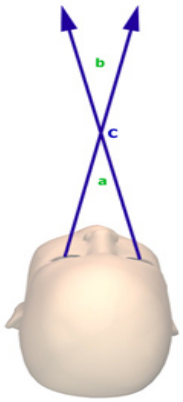
Retinal disparity



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Retinal disparity

Difference in the L/R images of an object due to the eyes' horizontal separation

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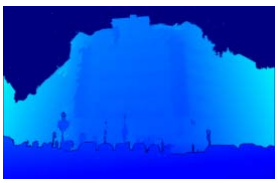
Fusion and stereopsis

- The human brain is able to **combine two images with disparity into a single image with depth**.
- This ability is called **fusion** and the resulting sense is called **stereopsis**.





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The Virtual Reality

- Interactive Visualization
- Implicit interaction
- **Immersion**

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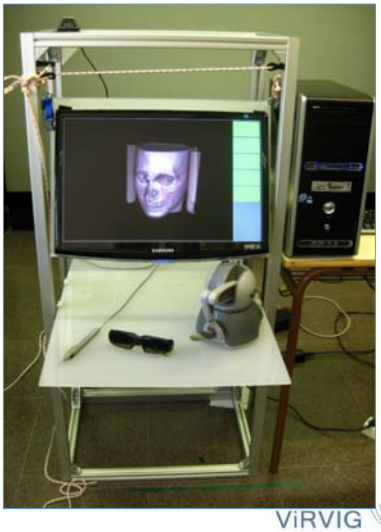
Realitat Virtual: Haptic Devices



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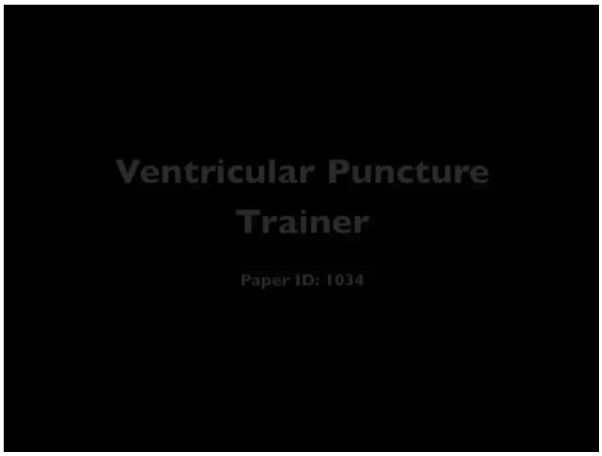
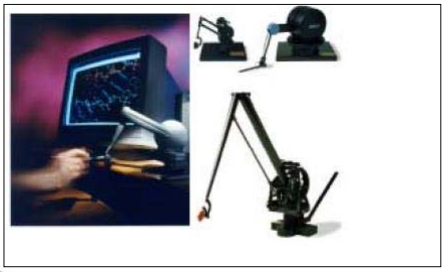
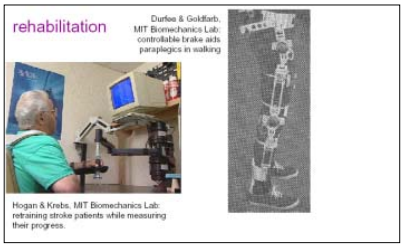
Realitat Virtual



Virtual Reality: Haptic devices





Concept of Virtual Reality

Interactive Visualization/ Navigation

3D Geometric Model

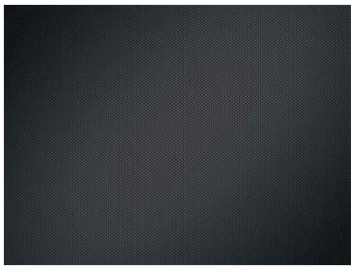
Digital Representations

3D Immersion

Implicit interaction

The Virtual Reality

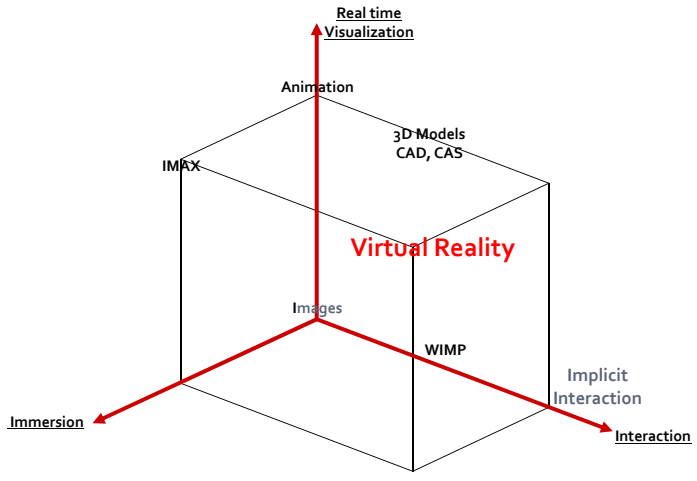
- Interactive Visualization
- **Implicit interaction**
- Immersion



*The system decides what the user wants from his **natural movements***

- Gestures, head movements vs interaction with the mouse
- Interaction, selection: movements of grab with hand or finger, etc.
- Transparency of the devices and the computer
- Perception of the direct interaction with objects
- **Window to the model vs immersion to the virtual environment**

Realitat Virtual Summary



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Continguts

- **Virtual Reality**
  - General Concepts
  - **VR Systems**
  - Stereo Synthesis
  - Interaction
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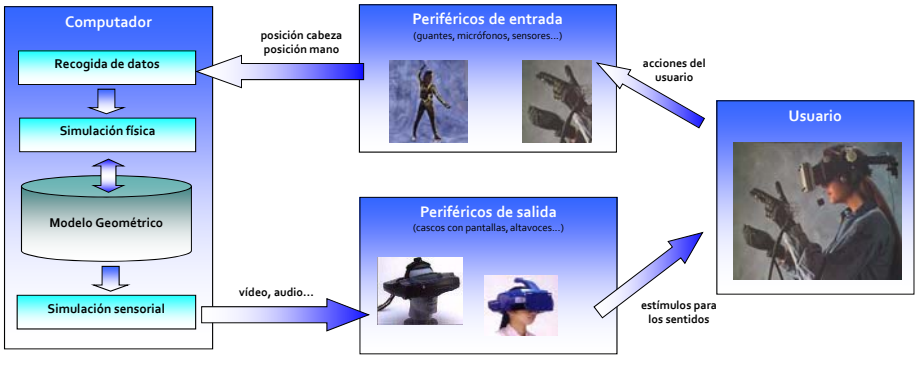
Architecture of the Virtual Reality systems

- Actualization frequency
- Latency time



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Virtual Reality Systems

- Immersive

- Semi- Immersive

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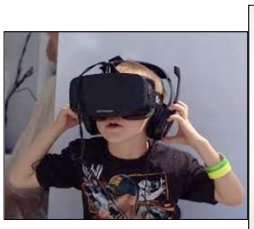
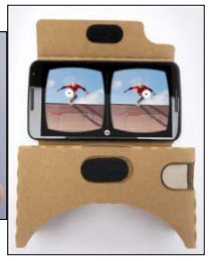
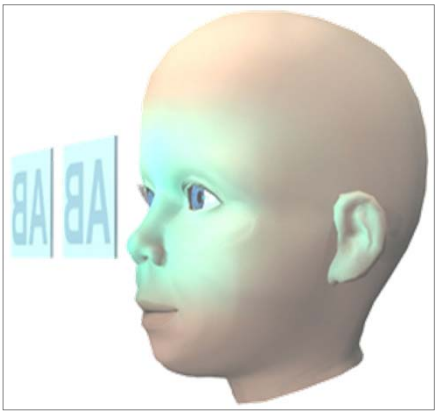
VR: Immersive systems







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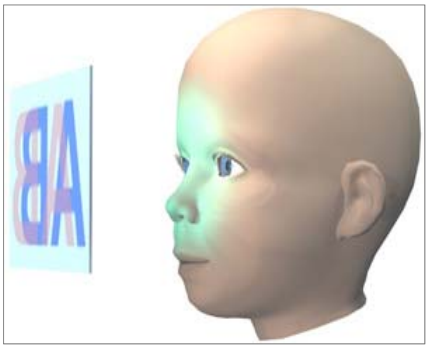
VR: Semi-immersive systems



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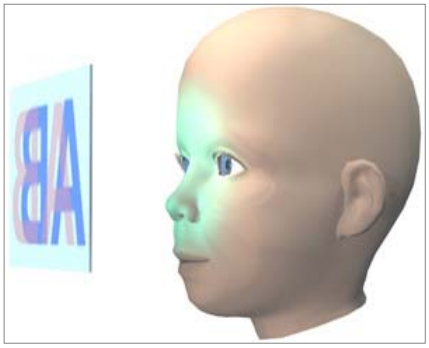
VR: Semi-immersive systems

- Both eyes can see the screen
- Requires some **image separation technique** (eg. polarization glasses, anaglyph…)
- Used in most projection-based equipment (CAVEs…)



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Continguts

- **Virtual Reality**
  - General Concepts
  - VR Systems
  - **Stereo Synthesis**
  - Interaction
- Augmented Reality

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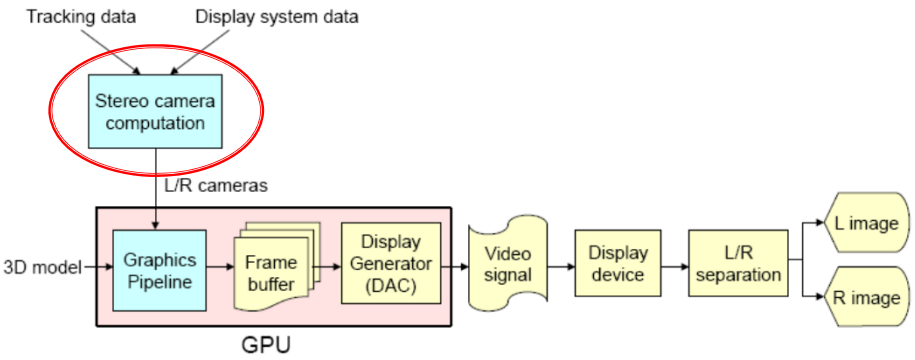
VR: Synthesis of stereo images

- Input: 3D model, tracking data, display system data
- Output: images with retinal disparity



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VR: Stereo camera computation

Output: **Left** and **Right** cameras:

- Position and orientation parameters:
  - Eye (OBS), target (VRP), up (VUV)
    - ➢ lookAt (eye.x, eye.y, eye.z, target.x, target.y, target.z, up.x, up.y, up.z);
- Intrinsic parameters:
  - view frustum geometry
    - ➢ frustum (left, right, bottom, top, near, far);

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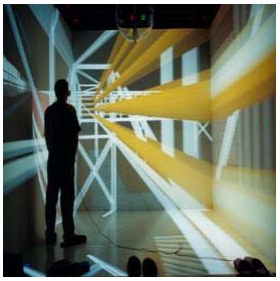
VR System Configurations

- Static screen + head-tracking (projection-based)
- Dynamic screen + head-tracking (HMDs)



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VR: Stereo camera computation

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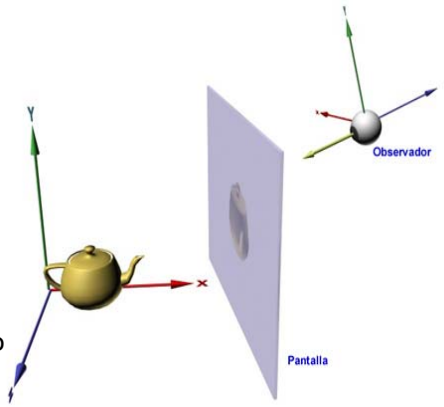
- The scene should be centered in the viewing path from user to screen
- The virtual camera must be computed taking into account:
  - Screen geometry (size, position, orientation)
  - The eye position with respect to the screen.



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Dynamic screen: Stereo Camera Computation

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- Used in HMDs
- The screens follow the head movements, so they are fixed with respect to the eyes.
- Parameters:
  - Head orientation
  - Head position (optional)
  - HMD frustum

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Dynamic screen: Stereo Camera Computation

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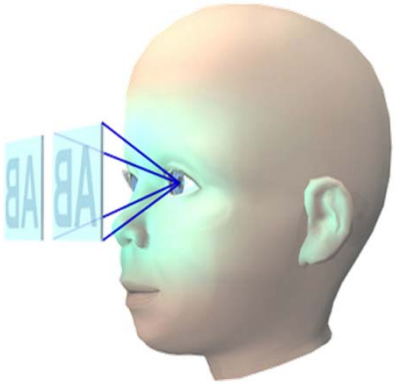
```
// View Matrix
VM = lookAt (eye.x, eye.y, eye.z, center.x, center.y, center.z, up.x, up.y, up.z);
sendViewMatrix (VM);
// Projection Matrix
PM = frustum (left, right, bottom, top, near, far);
sendProjectionMatrix (PM);
```



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Distortion

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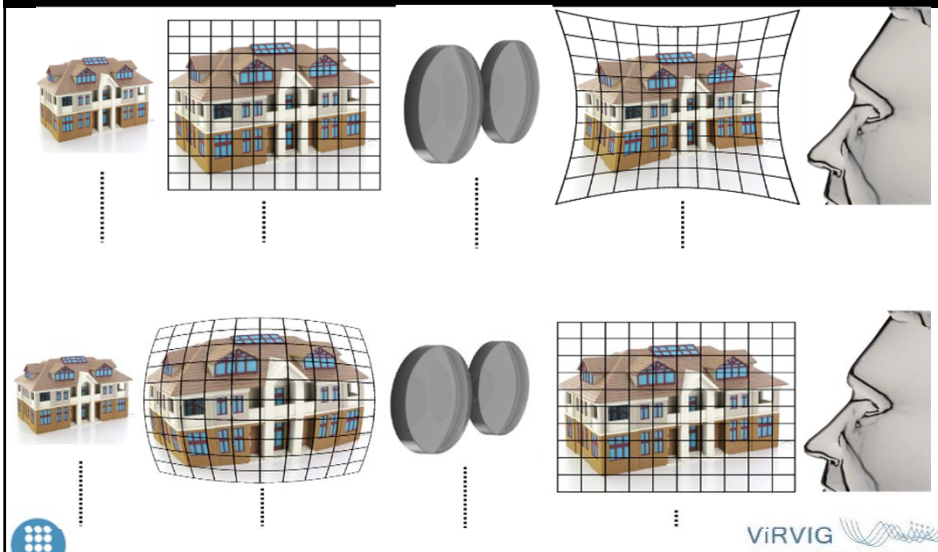

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Distortion

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Static screen: Stereo Camera Computation

- This is the configuration of projection-based systems (CAVEs, Videowalls, workbenches…)
- Parameters:
  - Tracking data: L/R eye position
    - Two position trackers (3DOF each)
    - One 6DOF tracker (head, glasses,…)
  - Display system data
    - Screen geometry

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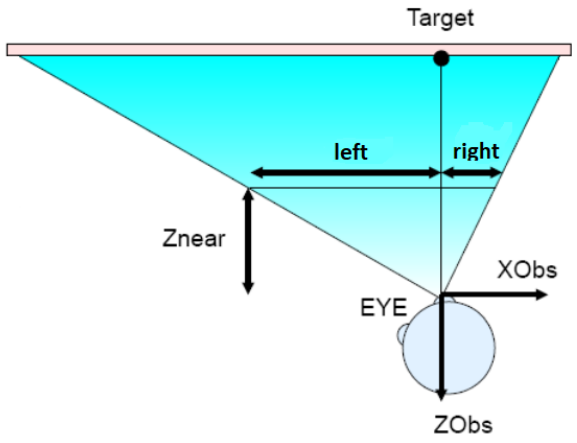
Static screen



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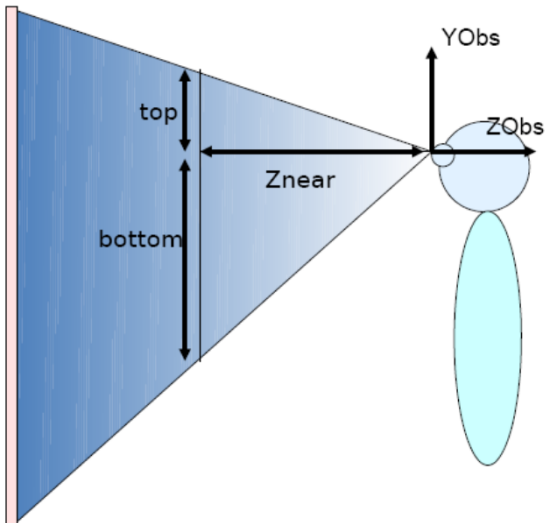
Static screen



Static screen: Stereo Camera Computation

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Continguts

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  - **Interaction**
- Augmented Reality

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VR Interaction

- Definitions
  - **3D interaction**
    - HC Interaction where user's tasks are carried out in a 3D spatial context
    - Using 3D or 2D input devices with direct mappings to 3D
  - **3D user interface**
    - A User Interface that involves 3D interaction.
  - **3D interaction technique**
    - Technique designed for solving a task
      - Involves the use of hardware and software

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3D selection

- 3D interfaces can make several tasks easier than classical 2D systems
  - Even better than reality?
- **3D selection:** selection task in a 3D immersive environment

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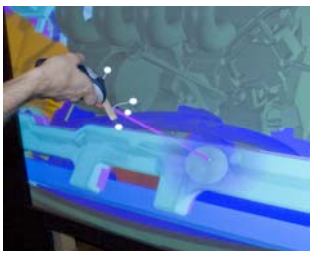
VR Interaction & 3D selection

- Hand extension techniques or 3D point cursors
  - A 3D point in space is represented as a mapping of the user's hand position.
- Ray-based techniques
  - Use the hand position and some element to indicate orientation
  - A ray is generated a ray in space and is used as a pointer
    - Also called aperture-based selection techniques or ray cursors

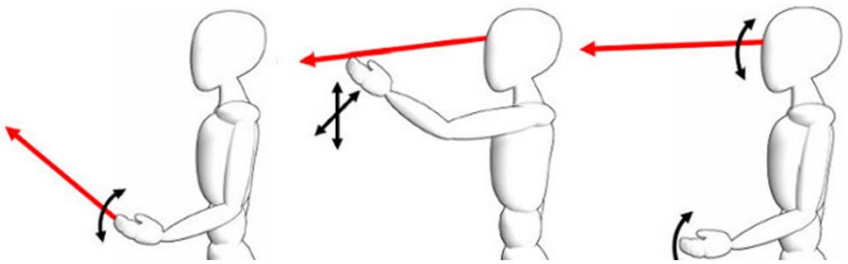


VR Interaction & 3D selection

- Hand extension:
  - May require ample movements due to the direct mapping with 3D world
  - Sometimes elements are difficult to reach
  - May be more intuitive if virtual world represents some real world

VR Interaction & 3D selection

- Ray-based techniques:



VR Interaction & 3D selection

- Ray-based techniques:
  - Hand position + wrist orientation
  - Head position and hand direction
- Problems:
  - Visible objects may be occluded to the ray
    - Difficult to reach
    - Selection of objects needs to visit all of them
  - Region selection not easy
- Some solutions
  - Sticky targets, enlarging objects, flatten regions…

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VR & Interaction: Navigation

Types of travel tasks according to user's goal:

- Exploration
  - No explicit goal.
  - Typically used at the beginning of the interaction with a VE.
- Search
  - The user knows the final location.
  - Naive search: the user doesn't know where the target is or how to get there.
  - Primer search: the user has knowledge about target location.

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VR & Interaction: Navigation

How interaction techniques should be for:

- Exploration
  - The user must be able to change the target at any moment (continuous control of the viewpoint).
  - Little cognitive load → user can focus on information gathering.
- Search
  - Techniques can be goal-oriented (e.g. specify the final location on a map) provided that the target is explicitly represented in the map.

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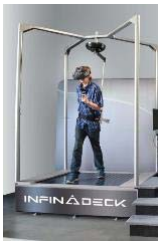
VR & Interaction: Navigation

Some Techniques:



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VR & Interaction: Navigation

Some Techniques:

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Realitat Virtual Summary (2)

- 3D **no** és Realitat Virtual:
  - RV implica 3D
  - 3D no implica RV
- Realitat Virtual no implica presència:
  - Presència: Sensació **d'estar allà**
    - El participant "oblida" que la simulació la veu utilitzant tecnologia

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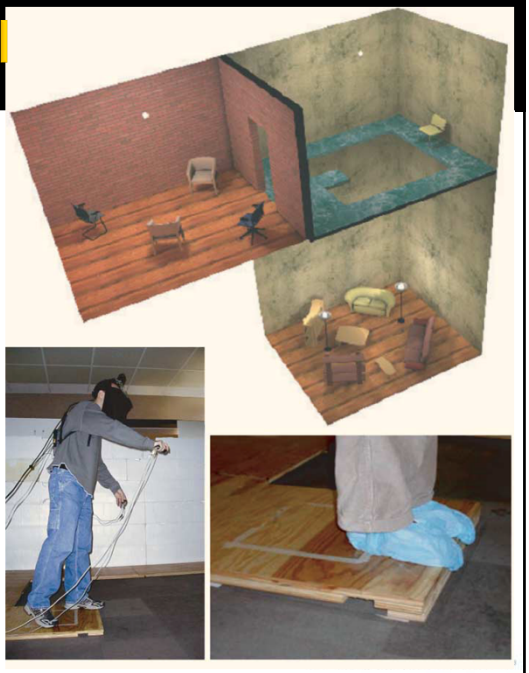
Realitat Virtual

- Presència



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Continguts

- Realitat Virtual
- **Augmented Reality**

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Introduction to AR

- Augmented Reality is a combination of a **real scene** viewed by a user and a synthetic **virtual scene** that augments the scene with additional information.
- AR environments differ from VEs in that we have access to both real and virtual objects at the same time.

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Goal of AR

- Goal: enhance user **performance** and **perception** of the world.
- Challenge: keep users from **perceiving the difference** between the real world and the virtual augmentation of it.

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Augmented Reality

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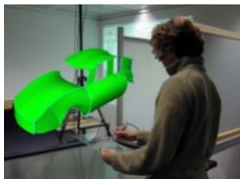
AR applications

- Archeology
- Entertainment

- Engineering design
- Consumer design



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Augmented vs Virtual Reality

Augmented Reality

- System augments the real world scene
- User maintains a sense of presence in real world
- Needs a mechanism to combine virtual and real worlds

Virtual Reality

- Totally immersive environment
- Visual senses are under control of system (sometimes aural and proprioceptive senses too)

Augmented Reality

- The importance of object registration:
  - The computer generated virtual objects must be **accurately registered** with the real world in all dimensions.
  - Errors in this registration will prevent the user from seeing the real and virtual images as fused.
  - The **correct registration** must be maintained while the user moves about within the real environment.
  - Discrepancies or changes in the apparent registration will range from distracting (difficult to work with), to physically disturbing (unusable system).

Augmented Reality

- There are basically three ways to visually present an augmented reality.
  - **Video see-through:** the virtual environment is replaced by a video feed of reality and the AR is overlaid upon the digitised images
  - **Optical see-through:** Leaves the real-world perception alone but displays only the AR overlay by means of transparent mirrors and lenses.
  - **AR projection** onto real objects.

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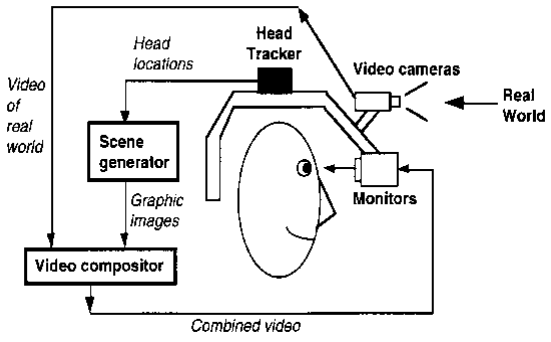
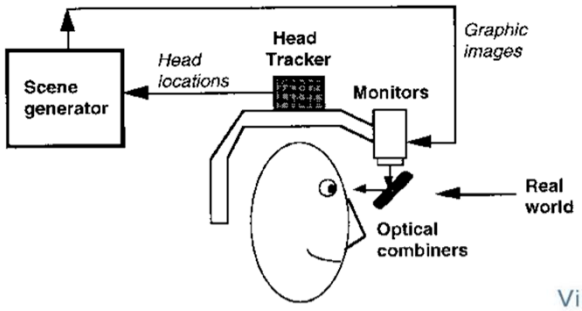
Video see-through HMDs

- Video see-through
  - Use closed-view HMDs.
  - Combine real-time video from head-mounted cameras with virtual imagery.



Optical see-through HMDs

- The user sees the real world **directly**
- Make use of optical combiners:
  - Half-silvered mirrors (partially transparent, partially reflective)
  - Transparent LCD



Optical see-through HMDs

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Augmented Reality

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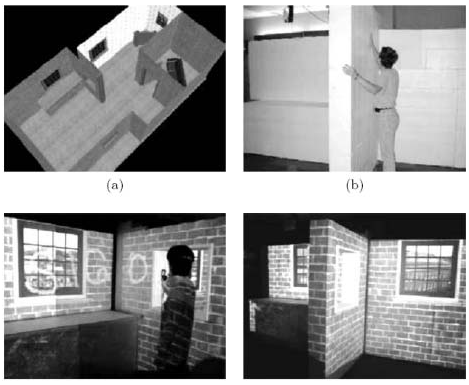
Projection-based spatial displays

- Images are projected directly into physical objects.
- Single static, single steerable or multiple projectors.



(a) (b)

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Augmented Reality

- Projective displays. Advantages:
  - They do not require special eye-wear
    - Eye accomodation not required
  - They can cover large surfaces for a wide field-of-view

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Augmented Reality

- Projective displays. Disadvantages:
  - Projectors need to be calibrated each time the environment or the distance to the projection surface changes (crucial in mobile setups).
    - Fortunately, calibration may be automated
  - Limited to indoor use only due to low brightness and contrast of the projected images.
  - Occlusion or mediation of objects is also quite poor.

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RA: Videos

- Robust high speed feature tracking:
  ./RobustHighSpeedTracking_PC_v2.avi
- http://www.telegraph.co.uk/news/newstopics/howaboutthat/10712923/New-Augmented-Reality-technology-stuns-shoppers.html

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