Professors d'IDI - UPC

Interacció i Disseny d'Interfícies

Continguts

- **Realitat Virtual**
- 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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Realitat Virtual

- Elements bàsics que han d'estar presents en qualsevol sistema de realitat virtual:
  - **Simulació interactiva**
  - **Interacció implícita**
  - **Immersió sensorial**

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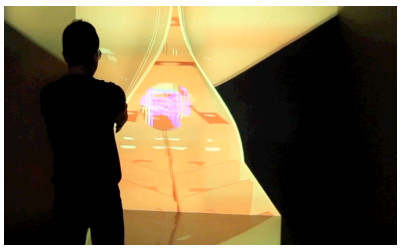
Concept of Virtual Reality

The Virtual Reality

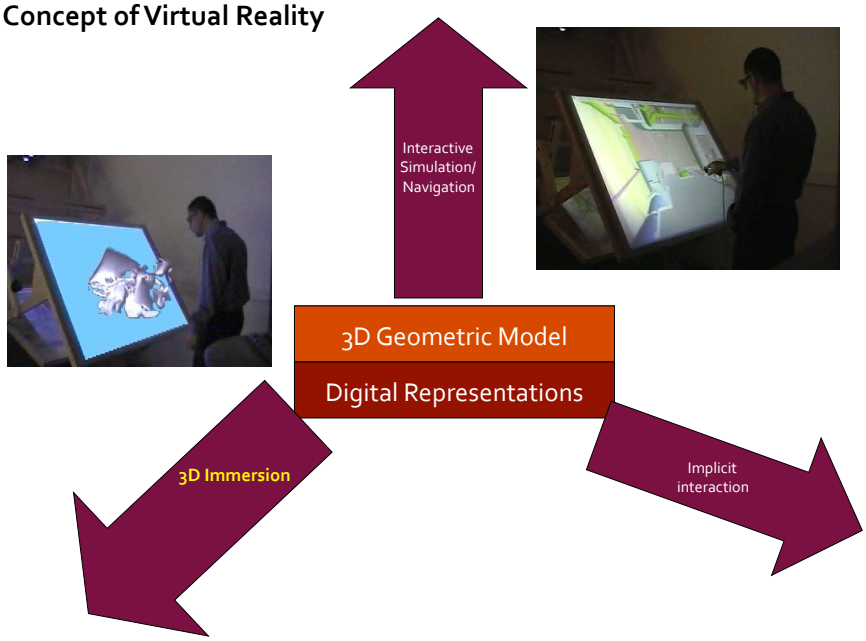
- **Interactive Simulation**
- Implicit interaction
- Immersion



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

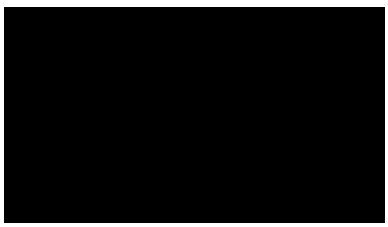
- Interactive simulation vs animation
  - passivity, previously decided
  - improvisation**, active, real time response**
- **3D geometric** and appearance representation
- Realistic visualization algorithms
- Memory management algorithms
- Multiresolution models
- "Zoom" capacity
- Visibility pre-process

Concept of Virtual Reality



The Virtual Reality

- Simulation
- 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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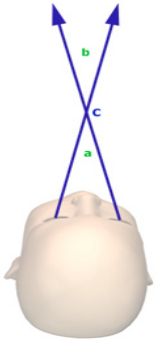
Retinal disparity



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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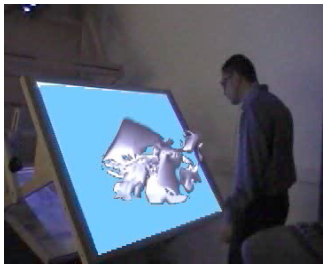
VR: Stereo Systems

- Immersive

- Semi- Immersive



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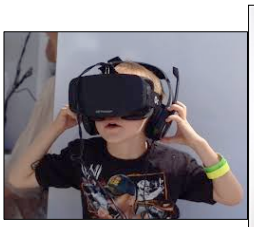
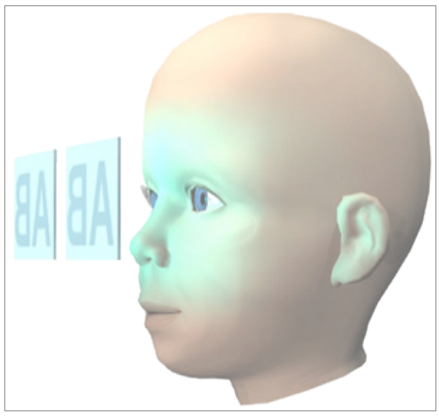
VR: Immersive systems





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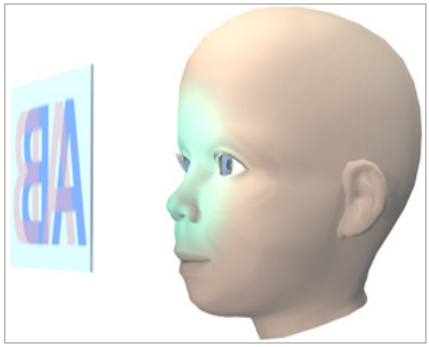
VR: Semi-immersive systems

- 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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The Virtual Reality

- Simulation
- 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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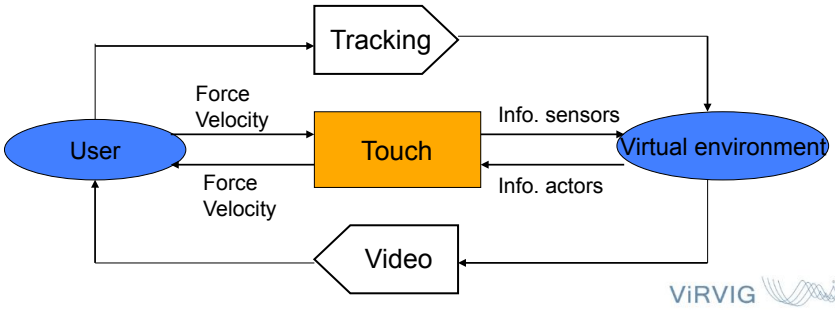
VR: Haptic systems

- The ***haptic feedback*** is related with the sense of *touching* (stimulus of contact) and the *propioceptive and cinestetic*
- The most important characteristic is the **bidireccionality**
- Require a **frequency of 1000 Hz** to simulate touch



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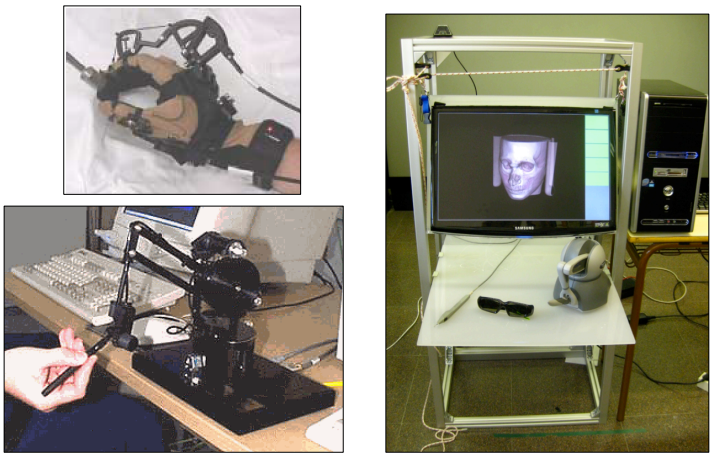
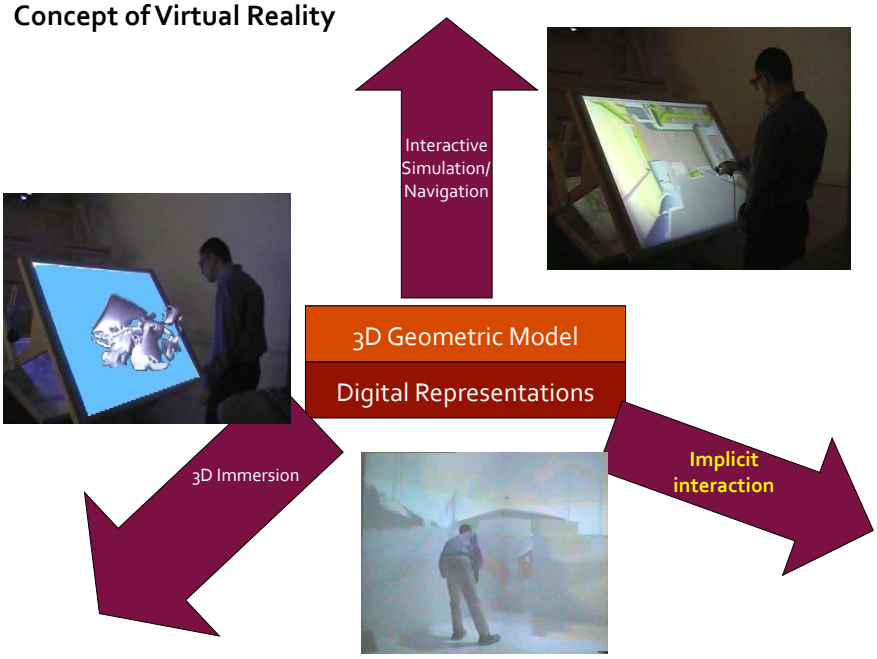
Realitat Virtual: Haptic Devices



Concept of Virtual Reality

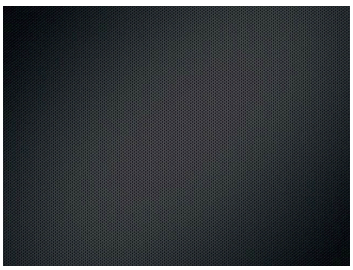


The Virtual Reality

- Simulation
- **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**



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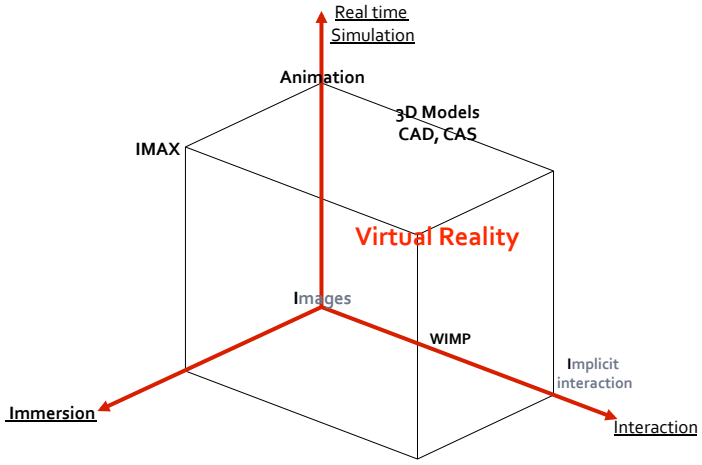
Realitat Virtual Summary (1)



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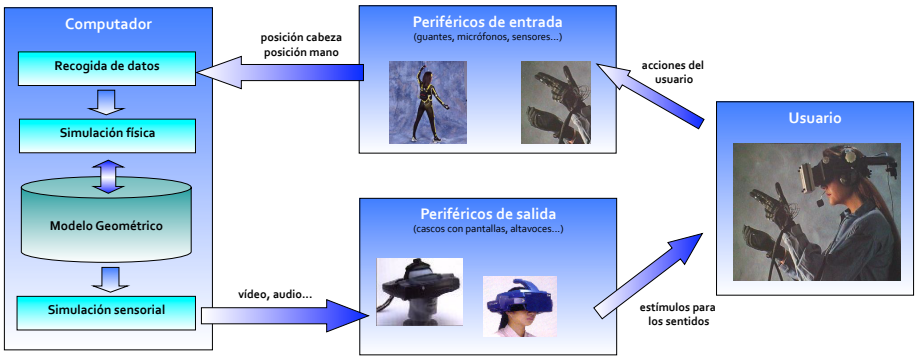
Architecture of the Virtual Reality systems

- Actualization frequency
- Latency time



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Realitat Virtual

- **Computador**
  - Realitza la simulació interactiva, basant-se en el model geomètric 3D i en el programari de recollida de dades, simulació física i simulació sensorial.
  - És el procés més crític en realitat virtual
- **Model geomètric 3D**
  - Permet fer els càlculs d'imatges, generació de so espacial, càlcul de col·lisions, etc.

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Realitat Virtual

- **Perifèrics de sortida (efectors)**
  - S'encarreguen de *traduir els senyals d'àudio, vídeo, etc. generats pel computador en estímuls pels òrgans dels sentits* (so, imatges, etc.).
    - **Visuals** (cascos estereoscòpics, pantalles...)
    - **Àudio** (sistemes de so, altaveus)
    - **Força i tacte** (dispositius tàctils)
    - **Equilibri** (plataformes mòbils).

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Realitat Virtual

- **Programari de tractament de dades d'entrada**
  - Llegeixen i processen la informació que proporcionen els sensors. Això inclou els controladors dels dispositius físics, i també els mòduls pel primer tractament de les dades subministrades.
- **Software de simulació física**
  - S'encarreguen de les modificacions pertinents en la representació digital de l'escena, a partir de les accions de l'usuari i de l'evolució interna del sistema.

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Realitat Virtual

- **Software de simulació sensorial**
  - S'encarreguen de calcular la representació digital de les imatges, sons, etc. que el maquinari s'encarregarà de traduir a senyals i finalment a estímuls pels sentits.
  - El més important és el de **simulació visual**
  - La **simulació auditiva** requereix tenir en compte les propietats acústiques les objectes. És tan complicada com la visual.
  - **Simulació tàctil**:
    - Sensació de tacte (sovint limitada a la mà),
    - Sensació de contacte (també limitada a la mà)
    - Realimentació de força (impedeixen o ofereixen resistència a fer moviments amb la mà en les col·lisions).
    - Detecció en temps real de les col·lisions

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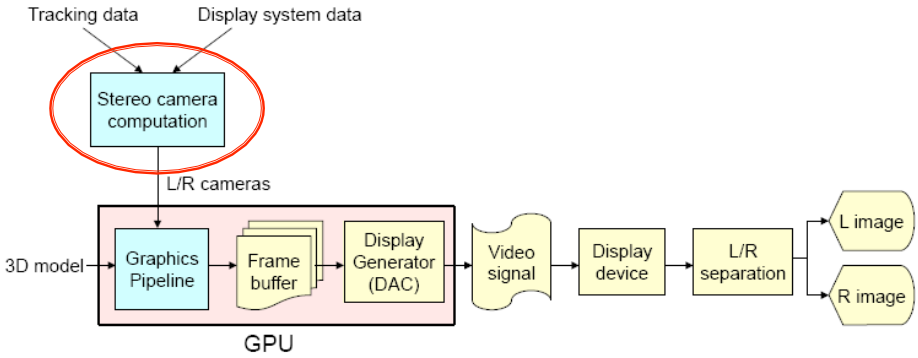
VR: Synthesis of stereo images

- 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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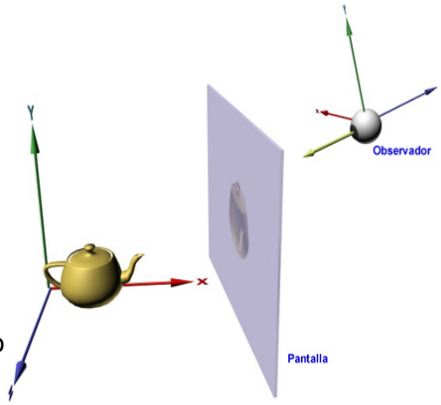
VR: Stereo camera computation

- 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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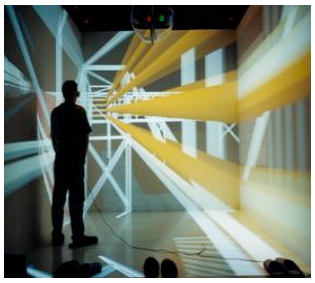
VR System Configurations

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



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Dynamic screen: Stereo Camera Computation

- 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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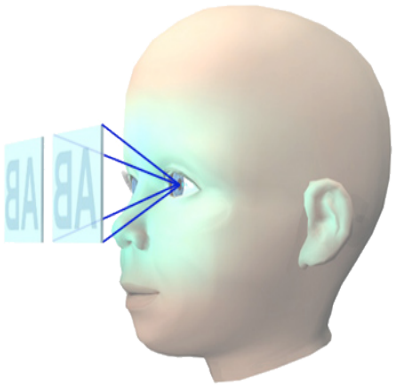
Dynamic screen: Stereo Camera Computation


```
// 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

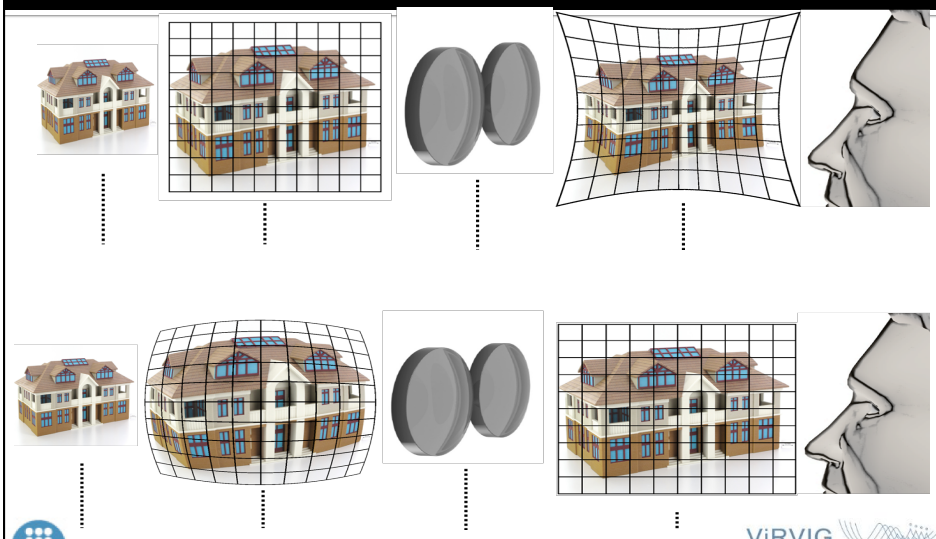
The images are distorted and appear as misshapen ovals.

More data is presented on the left of the image for the left eye.

There's an image per eye.

More data is presented on the right for the right eye.

Distortion



Dynamic screen: Stereo Camera Computation

- **View matrix:** standard view matrix with a per-eye offset to account for the different eye positions.
- **Projection matrix** (per-eye, provided by the SDK)
- A **texture** holds the **undistorted** view of the scene.
- A **distortion mechanism** for rendering the texture contents to the actual screen, appropriately distorted for the optics.

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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: 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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Static screen

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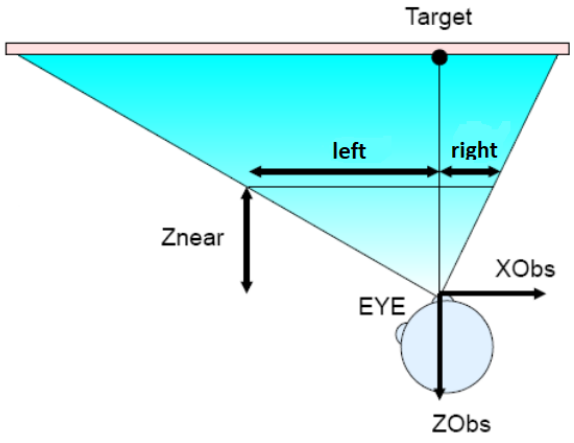

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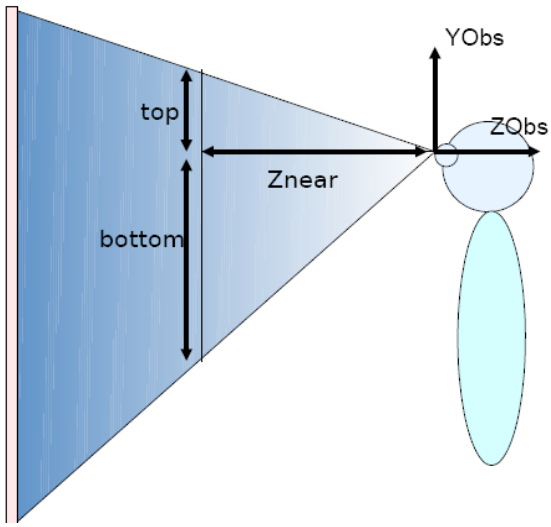
Static screen



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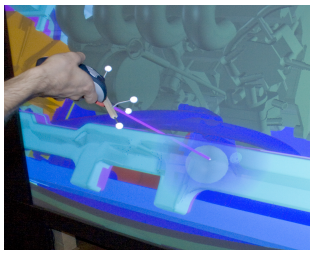
VR & Interaction: 3D selection

- 3D Selection techniques:
  - Hand extension, Ray-based tecniques



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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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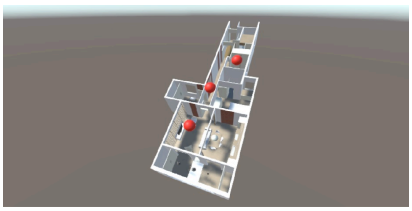
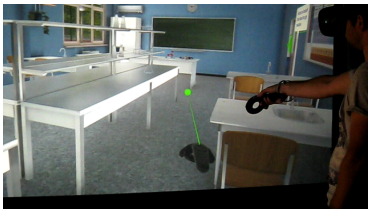
VR & Interaction: Navigation

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

VR

- Presència

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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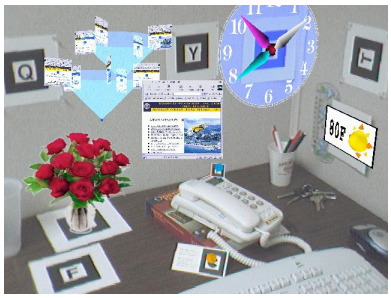
Goal of AR

- 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.



Augmented Reality

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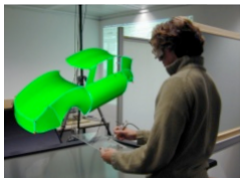
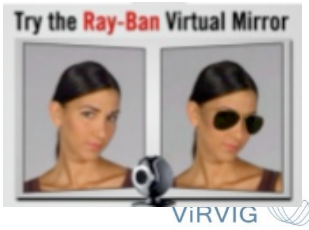
AR applications

- 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)

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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).

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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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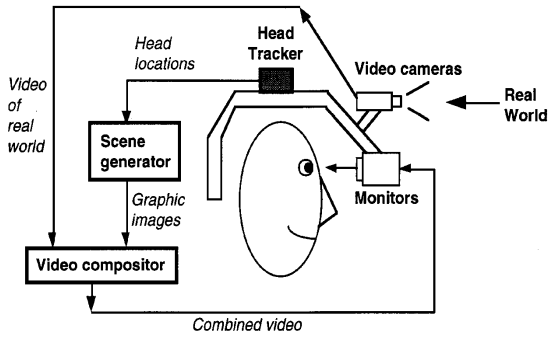
Video see-through HMDs

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



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Augmented Reality

- Video see-through. Advantages:
  - Cheap
  - Since reality is digitised, it is easier to mediate or remove objects from reality
    - Fiducial markers or placeholders with virtual objects
  - Brightness and contrast of virtual objects are matched easily with the real environment
  - Digitised images allow tracking of head movement for better registration.
    - It is possible to match perception delays of the real and virtual

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Augmented Reality

- Video see-through. Disadvantages:
  - Low resolution of reality
  - Limited field-of-view
  - User disorientation due to a parallax (eye-offset) due to the camera's positioning at a distance from the viewer's true eye location
    - Causes significant adjustment effort for the viewer
  - Focus distance of is fixed in most display types
    - Poor eye accommodation

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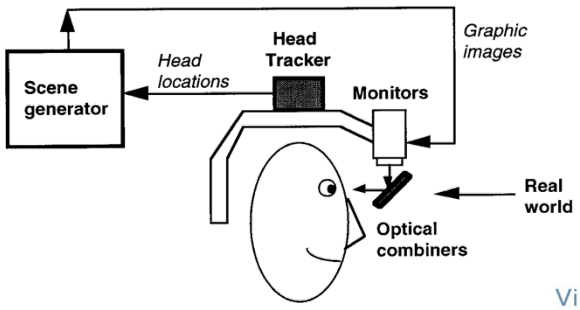
Optical see-through HMDs

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



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Augmented Reality

- Optical see-through. Advantages:
  - May be applied in head-worn displays, hand-held displays, and spatial setups where the AR overlay is mirrored either from a planar screen or through a curved screen.
  - Leave the real-world resolution intact
  - Cheap, safe, and parallax-free (no eye-offset due to camera positioning).
    - Users can still see when power fails
    - Ideal technique for military and medical purposes

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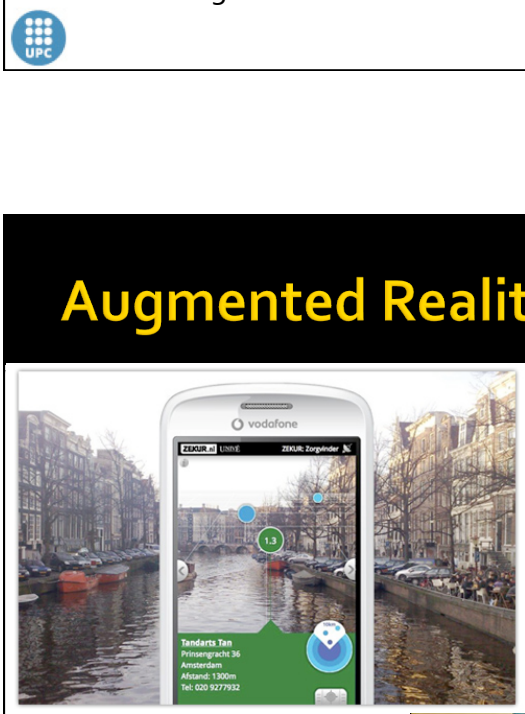
Augmented Reality

- Optical see-through. Disadvantages:
  - Other input devices such as cameras are required for interaction and registration.
  - Combining the virtual objects holographically through transparent mirrors and lenses reduces brightness and contrast of both the images and the real-world perception
  - Field-of-view is limited and may cause clipping of virtual images at the edges of the mirrors or lenses
  - Occlusion (or mediation) of real objects is difficult because their light is always combined with the virtual image



Optical see-through HMDs

Optical vs video see-through

Fixed focal length problem:
- **Video see-through**: real and virtual objects focused at the same distance.
- **Optical see-through:** real objects and virtual objects are sensed at different depths → the eyes are forced to either **continuously shift focus** between the different depth levels, or perceive one level as unsharp.

Calibration:
- **Video see-through**: graphics can be integrated on a pixel-precise basis.
- **Optical see-through:** require **difficult calibration** (user- and session-dependent) and precise head tracking to ensure a correct overlay.

Occlusion effects between real and virtual objects:
- **Video see-through:** well supported
- **Optical see-through**: **incapable of providing consistent occlusion effects**.

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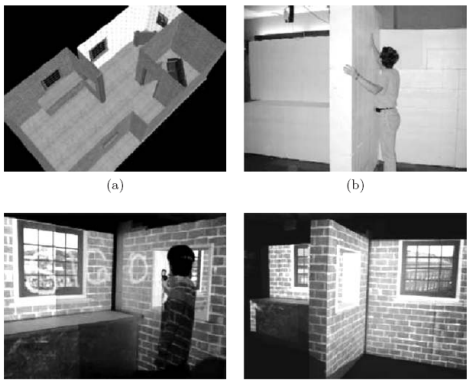
Projection-based spatial displays

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



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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

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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