

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)

# Continguts

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

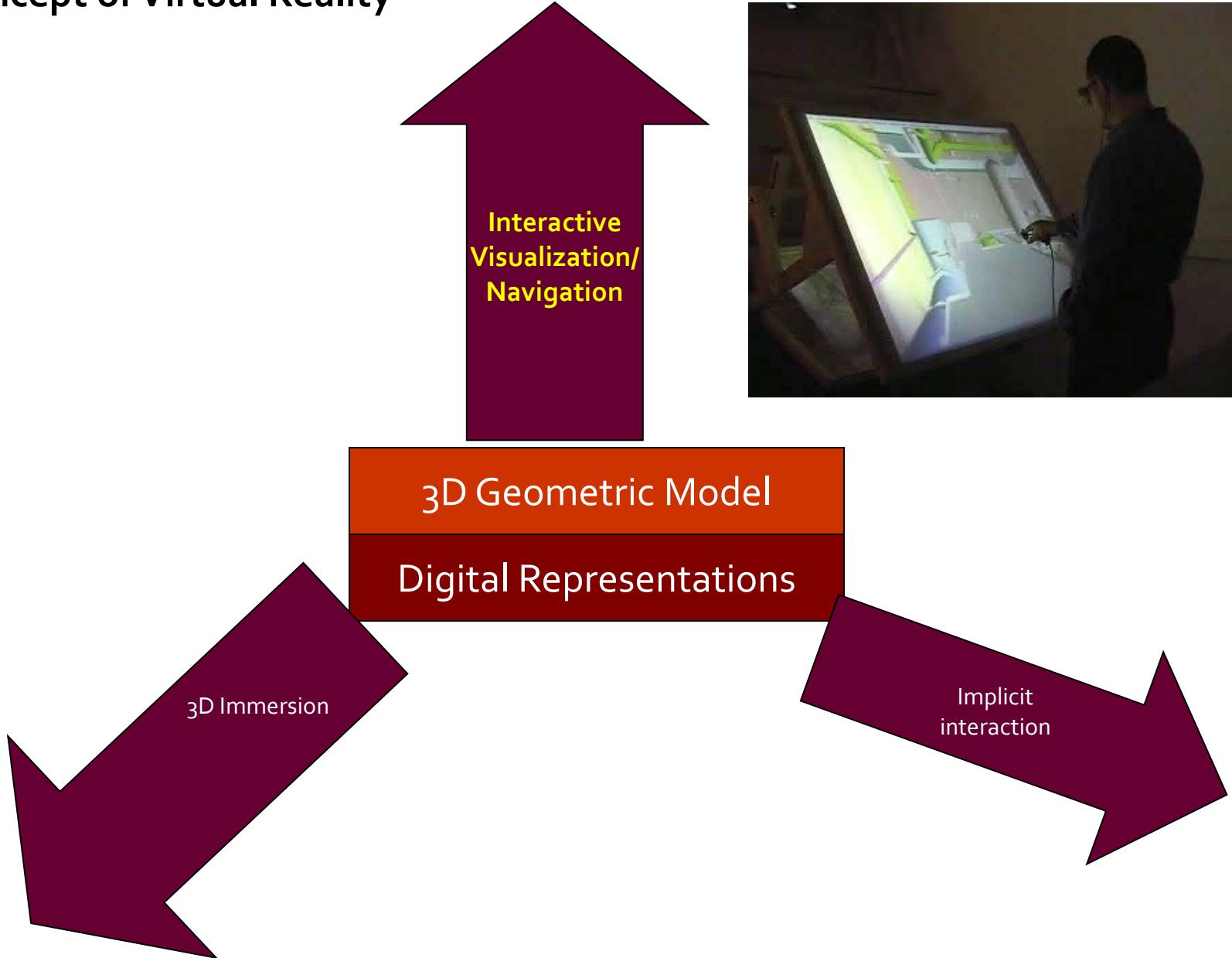
# Realitat Virtual

- 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".

# Virtual Reality

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

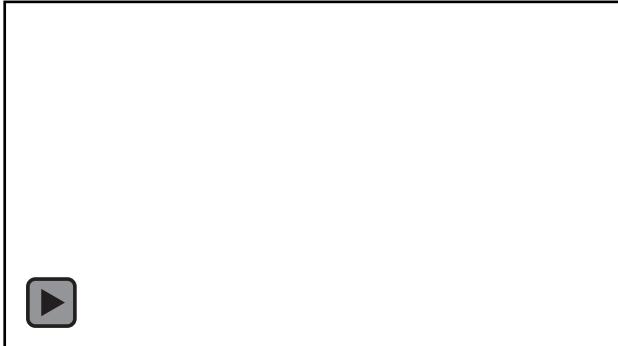
# Concept of Virtual Reality



# The Virtual Reality

- **Interactive Visualization** 

- Implicit interaction
- Immersion



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

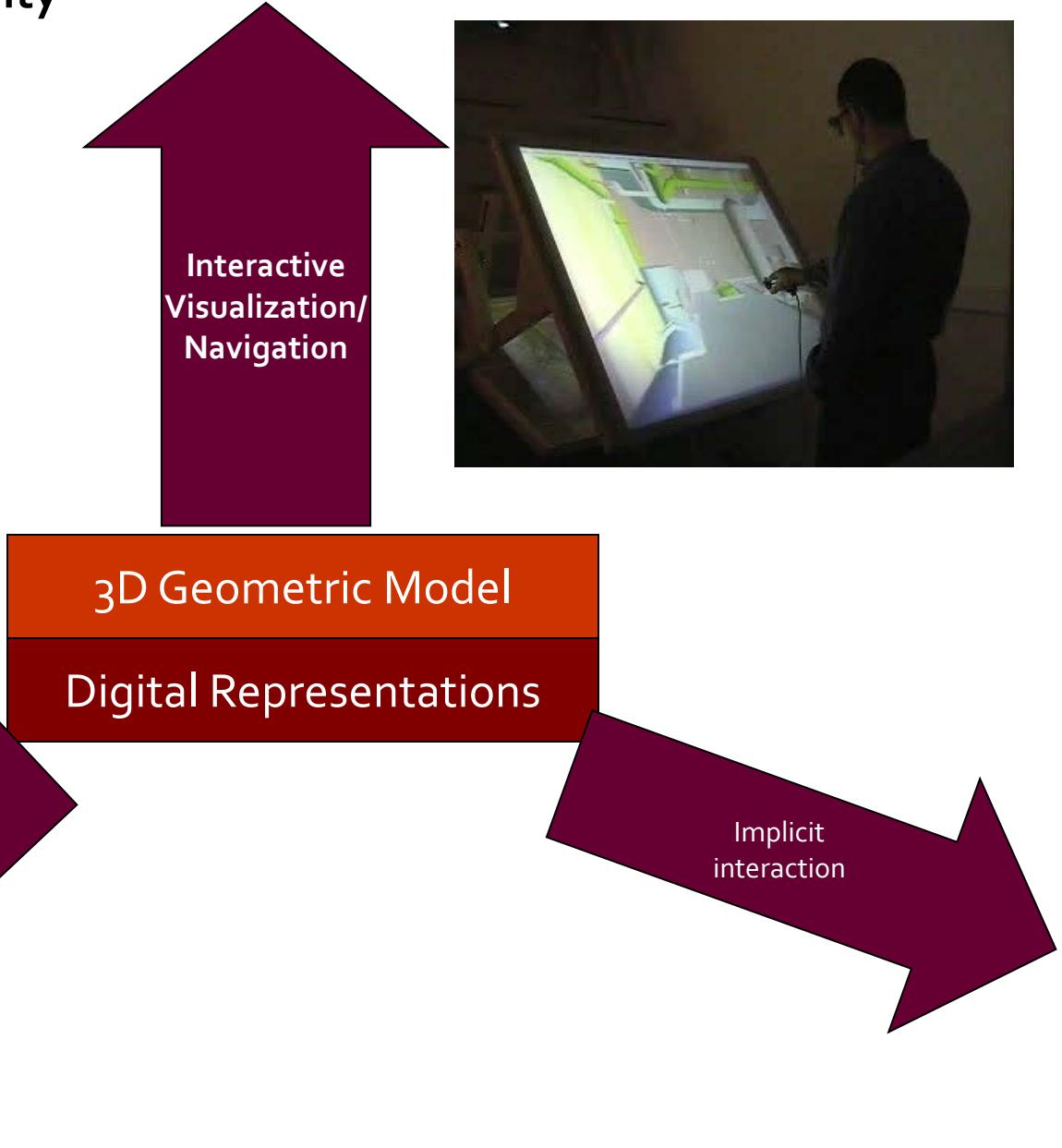
- **Interactive simulation vs animation**

- 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

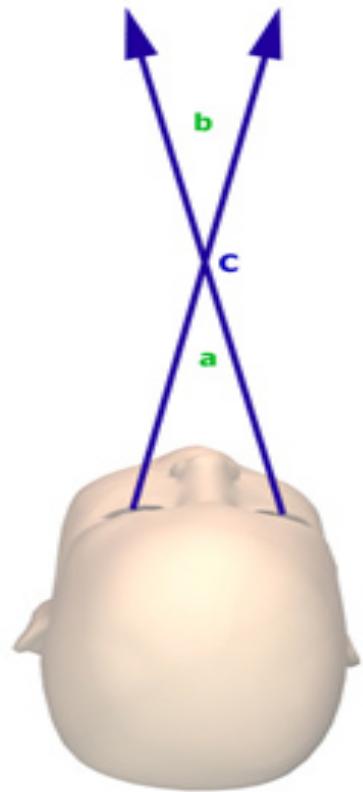


*Disconnecting senses from the real world, and connecting them to the virtual environment*

- **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...

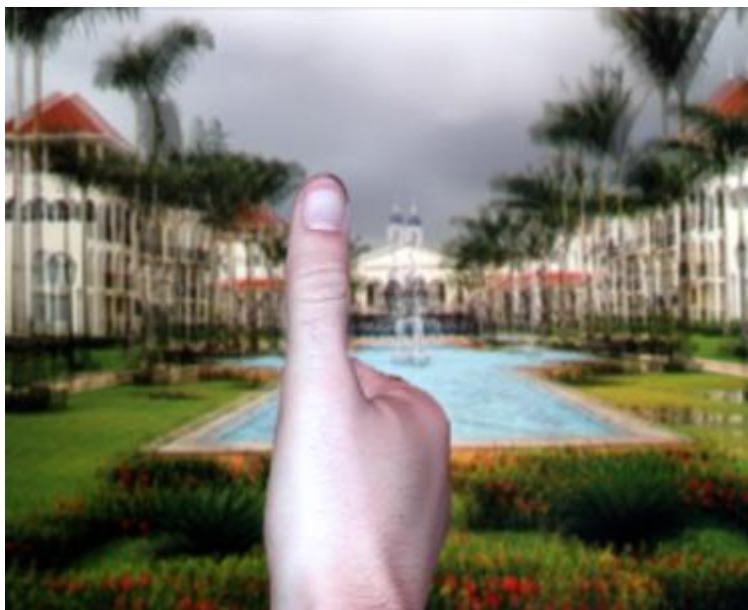


# Retinal disparity



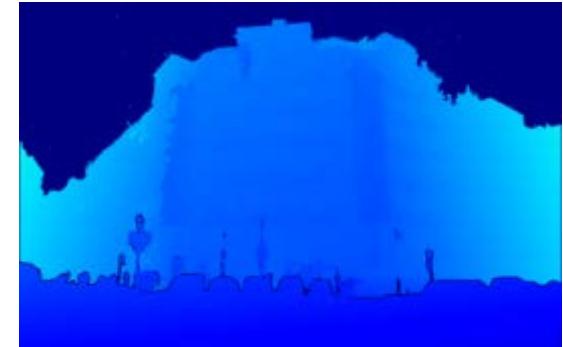
# Retinal disparity

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



# 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**.



# The Virtual Reality

- Interactive Visualization
- Implicit interaction
- Immersion

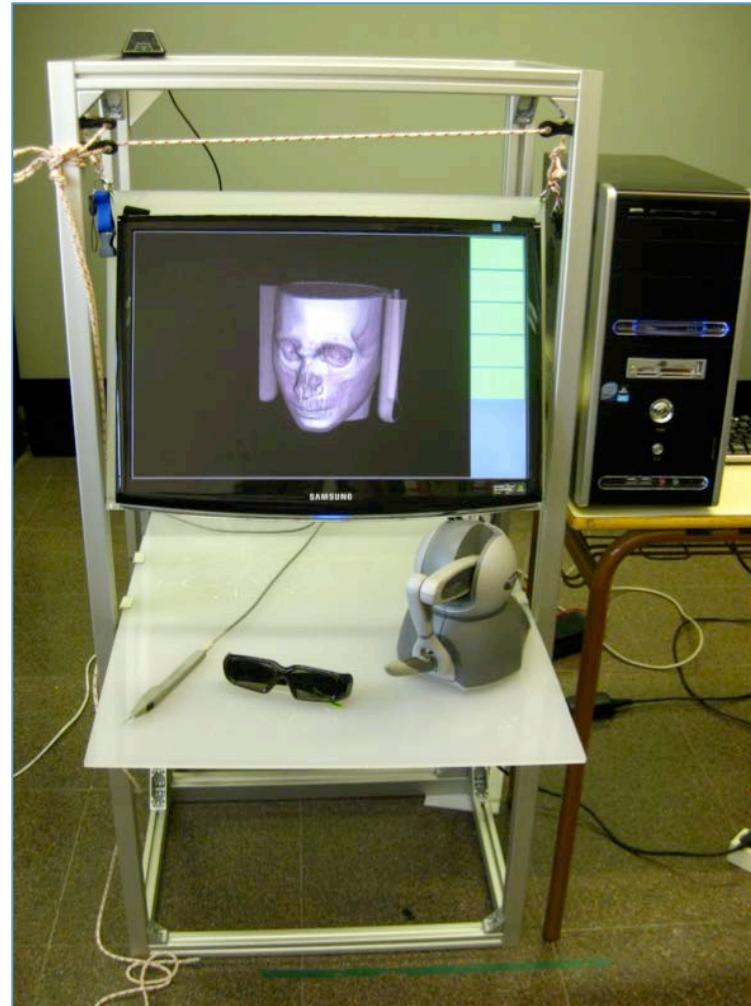


*Disconnecting senses from the real world, and connecting them to the virtual environment*

- **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...



# Realitat Virtual: Haptic Devices

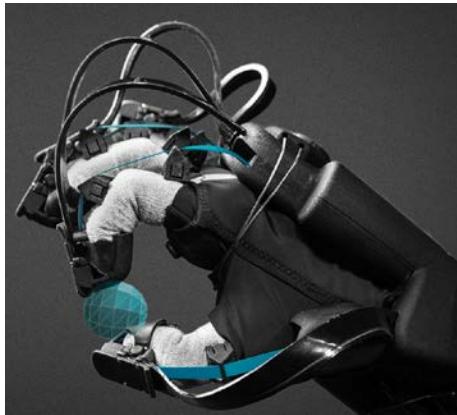


# Realitat Virtual

## Ventricular Puncture Trainer

Paper ID: 1034

# Virtual Reality: Haptic devices



## rehabilitation

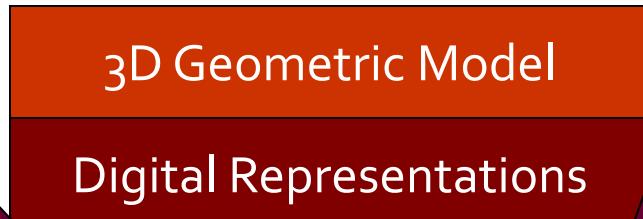
Durfee & Goldfarb,  
MIT Biomechanics Lab:  
controllable brake aids  
paraplegics in walking



Hogan & Krebs, MIT Biomechanics Lab:  
retraining stroke patients while measuring  
their progress.



# Concept of Virtual Reality



# The Virtual Reality

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

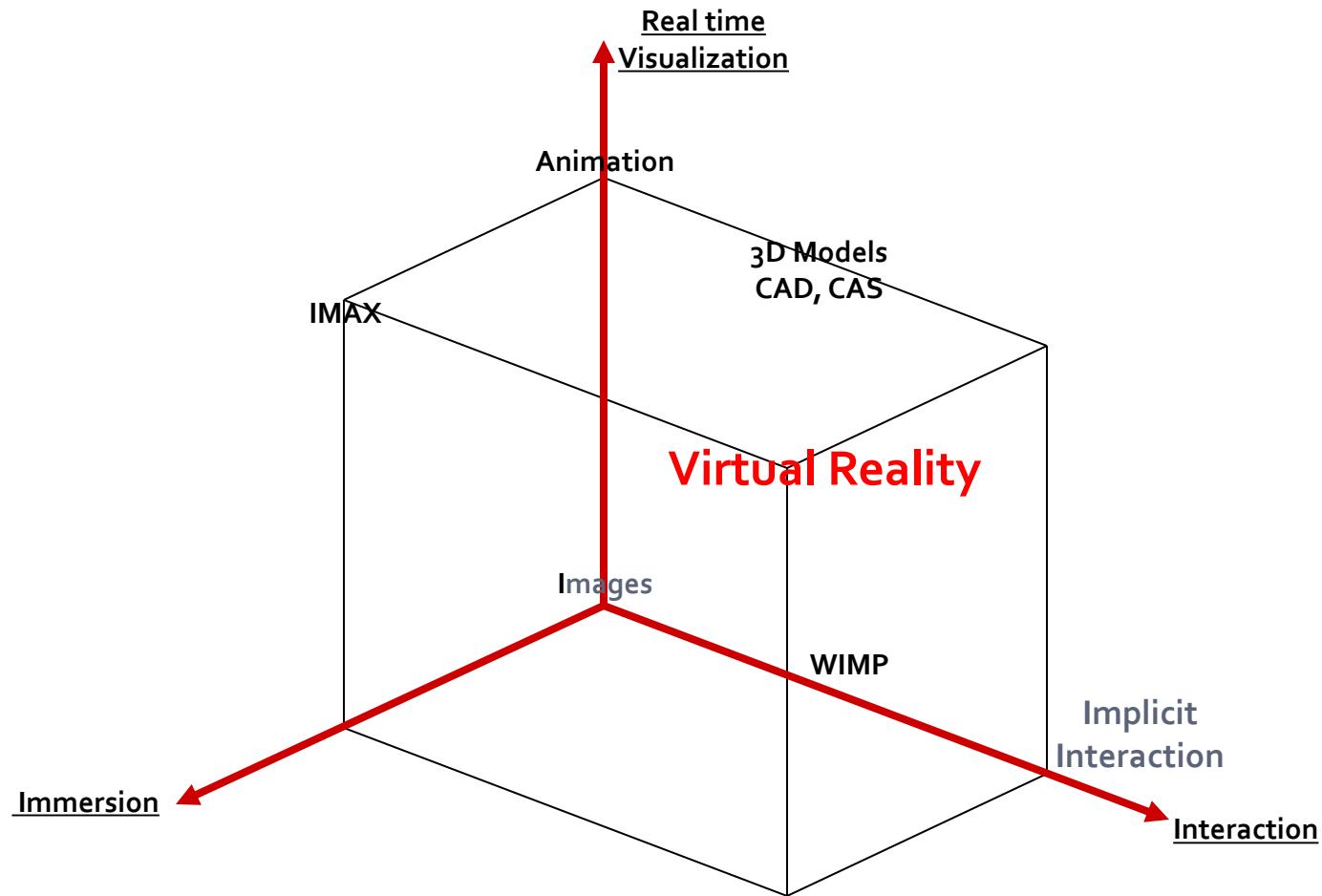


*The system decides what the user wants from his **natural movements***

- 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

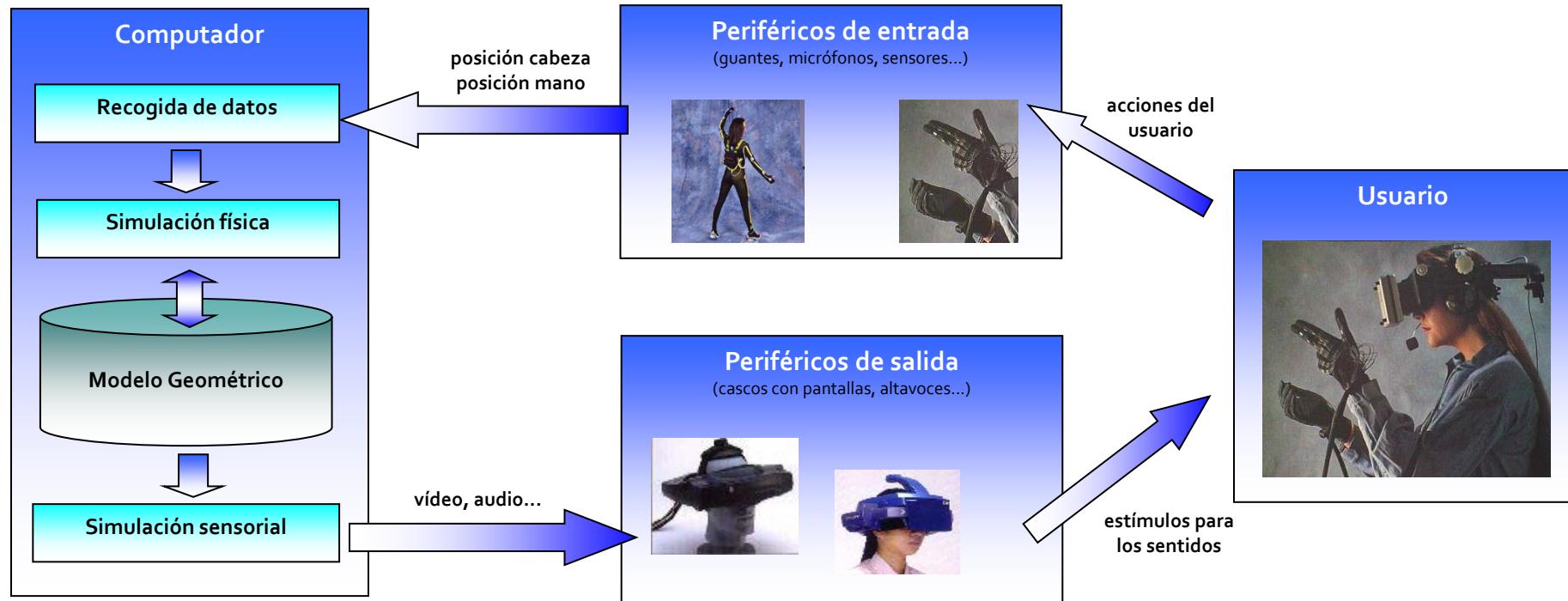


# Continguts

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

# Architecture of the Virtual Reality systems

- Actualization frequency
- Latency time



# Virtual Reality Systems

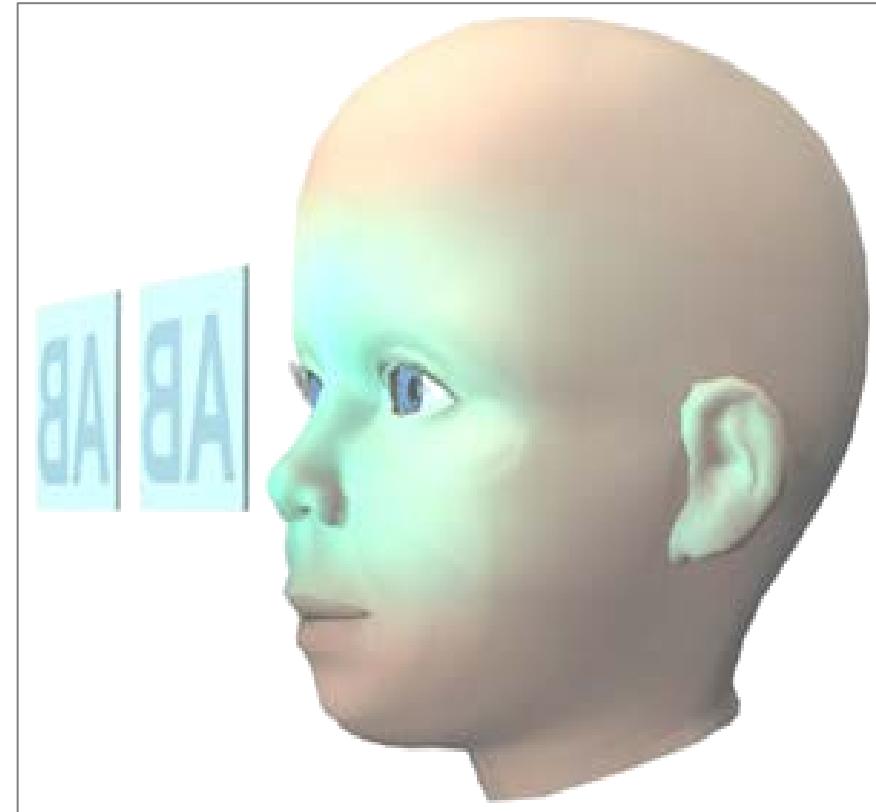
- Immersive



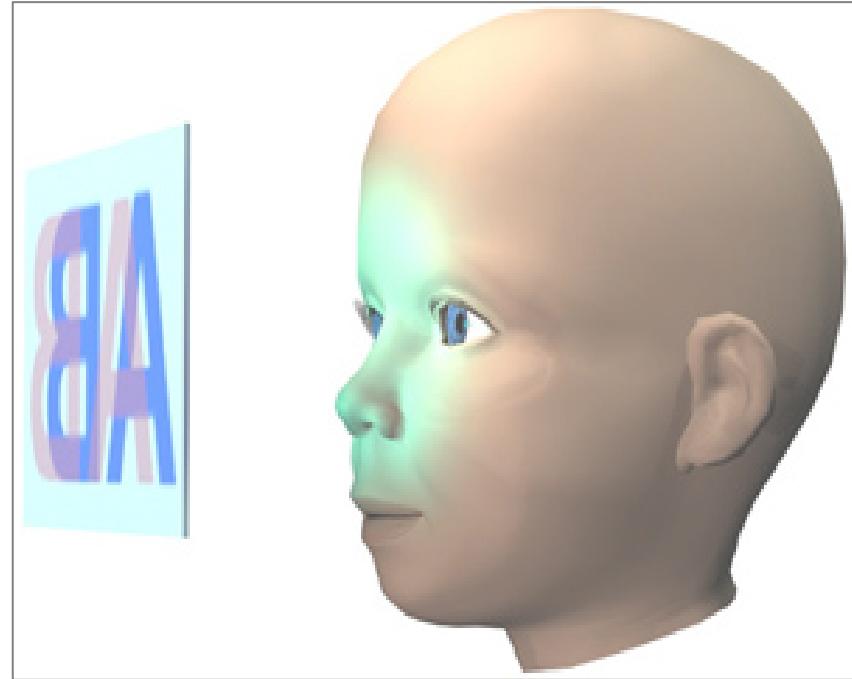
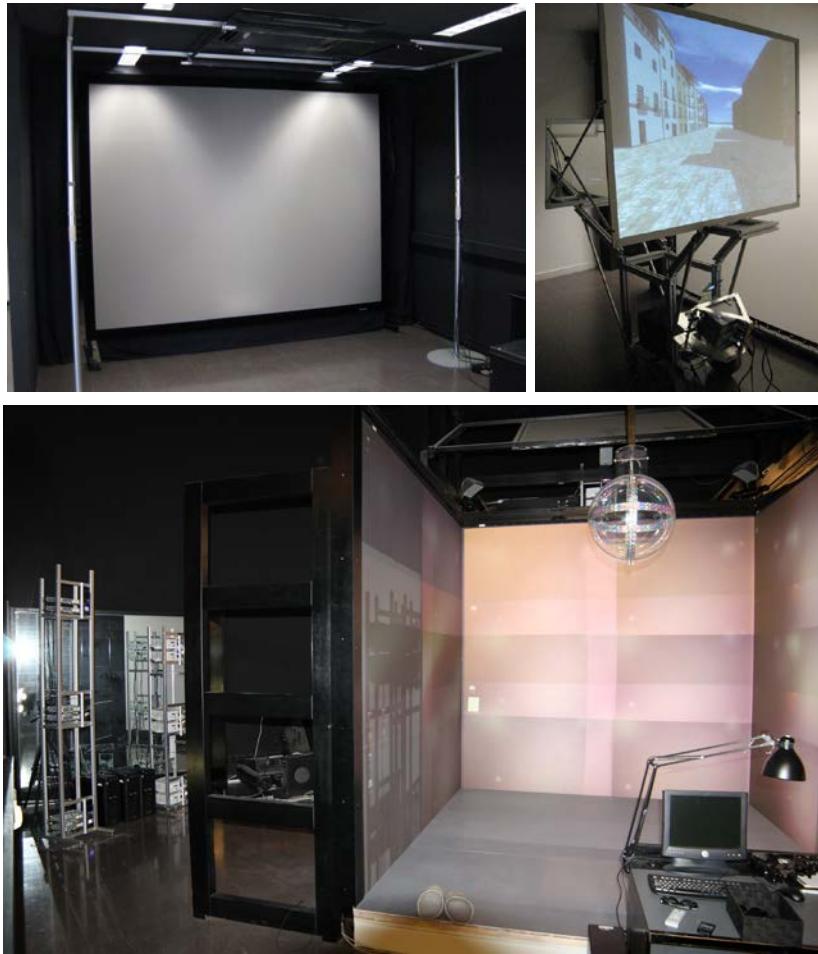
- Semi- Immersive



# VR: Immersive systems

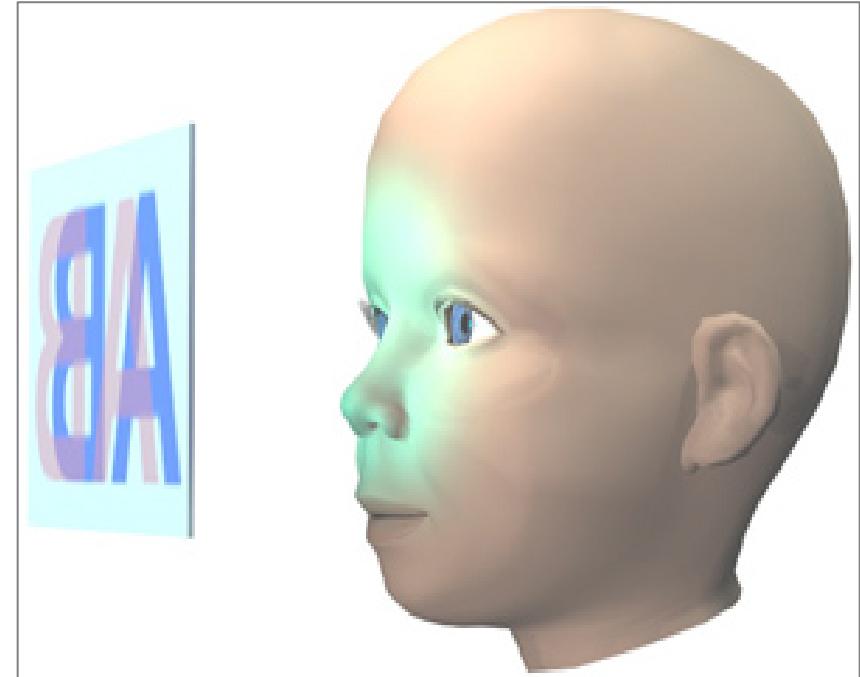
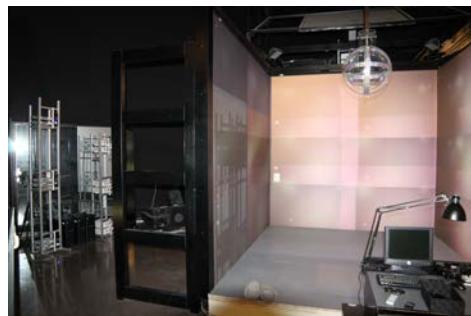


# VR: Semi-immersive systems



# 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...)

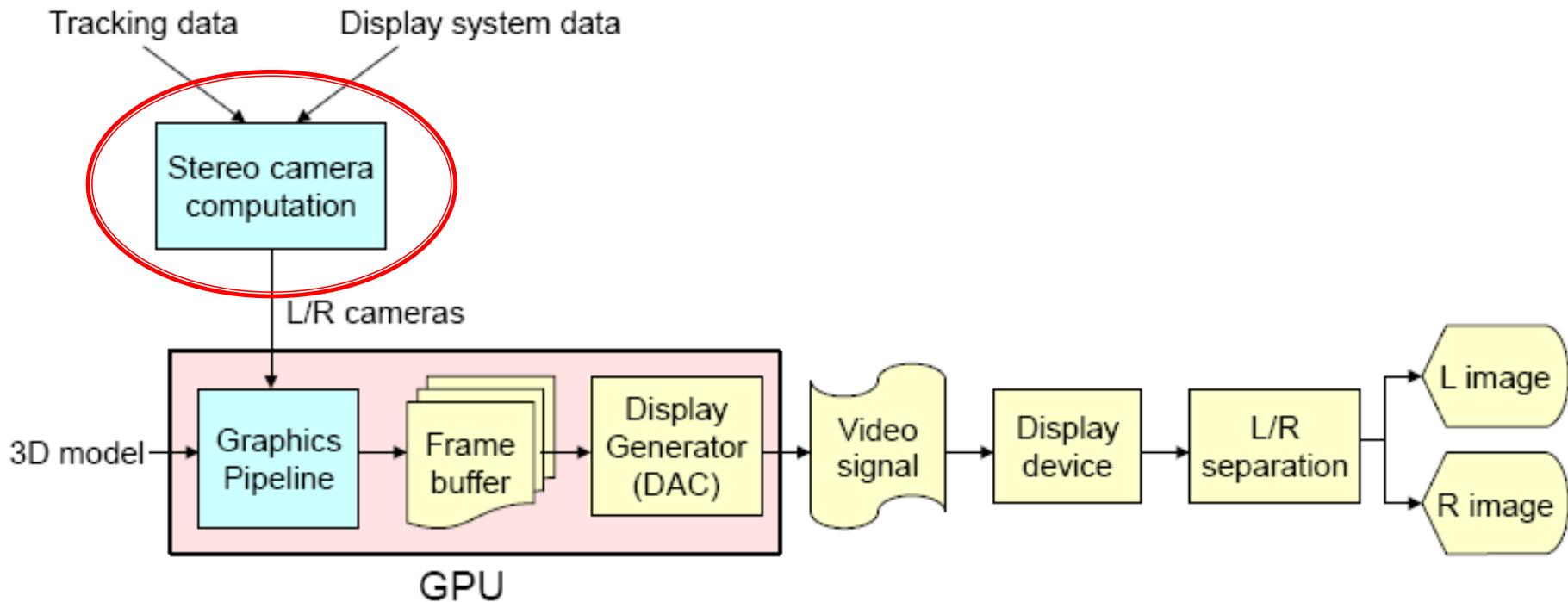


# Continguts

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

# VR: Synthesis of stereo images

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



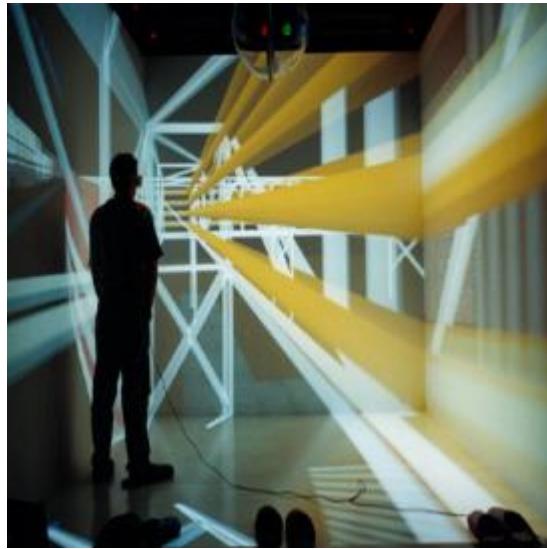
# VR: Stereo camera computation

## 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);`

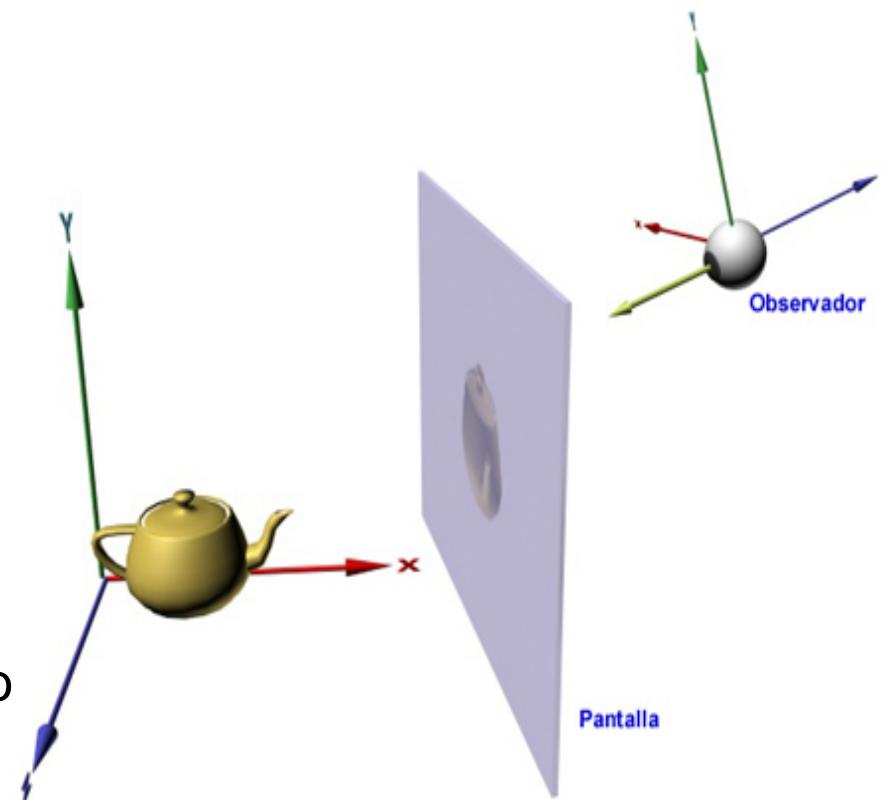
# VR System Configurations

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



# 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.



# 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



# Dynamic screen: Stereo Camera Computation

// View Matrix

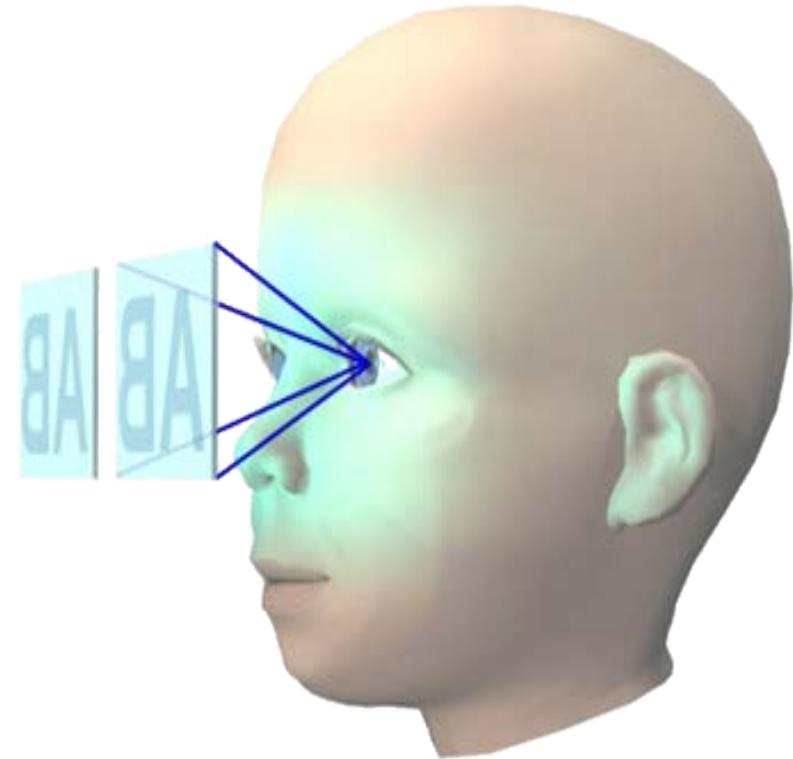
VM = lookAt (eye.x, eye.y, eye.z, center.x, center.y, center.z, up.x, up.y, up.z);

sendViewMatrix (VM);

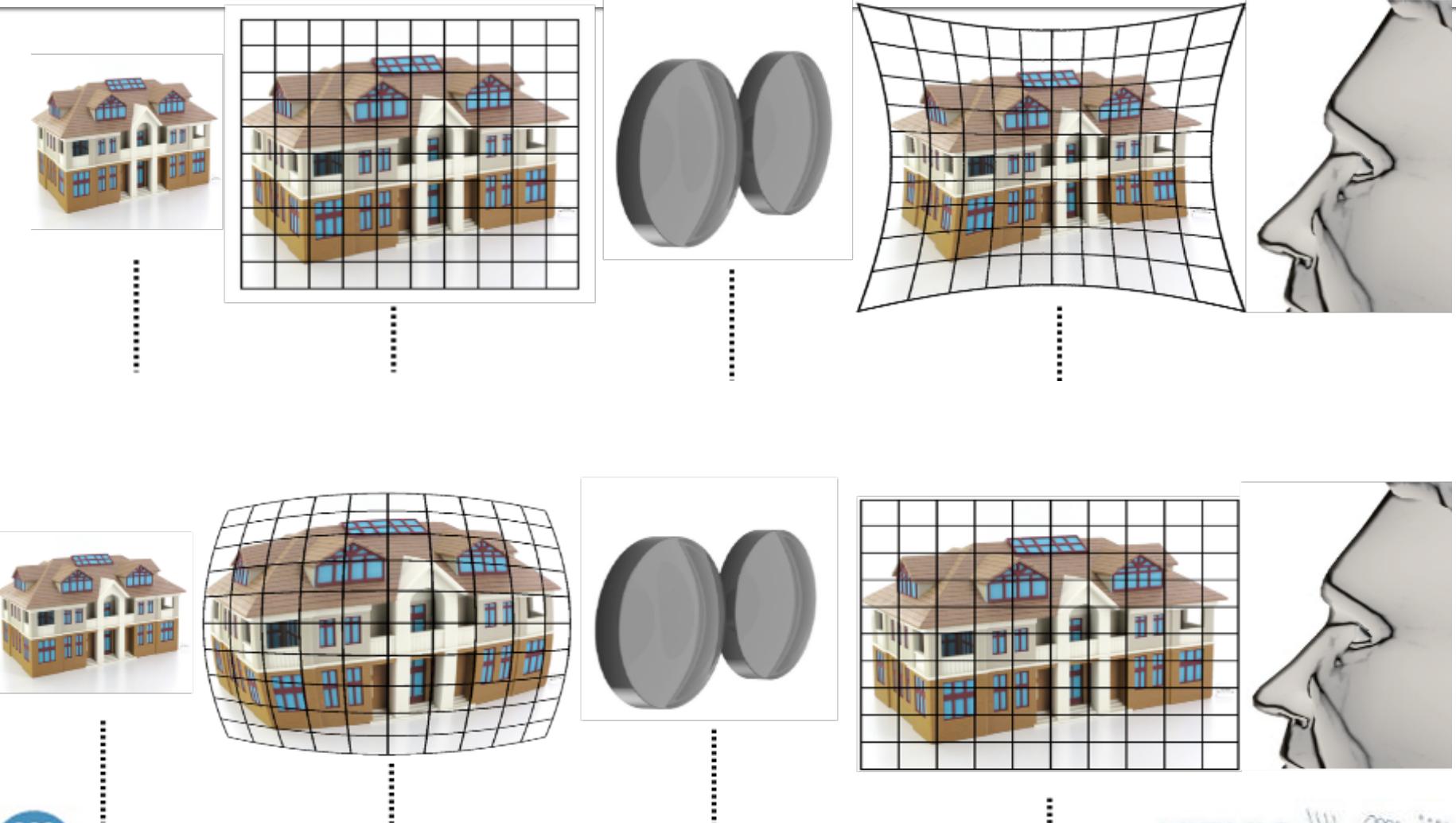
// Projection Matrix

PM = frustum (left, right, bottom, top, near, far);

sendProjectionMatrix (PM);



# Distortion



# Distortion

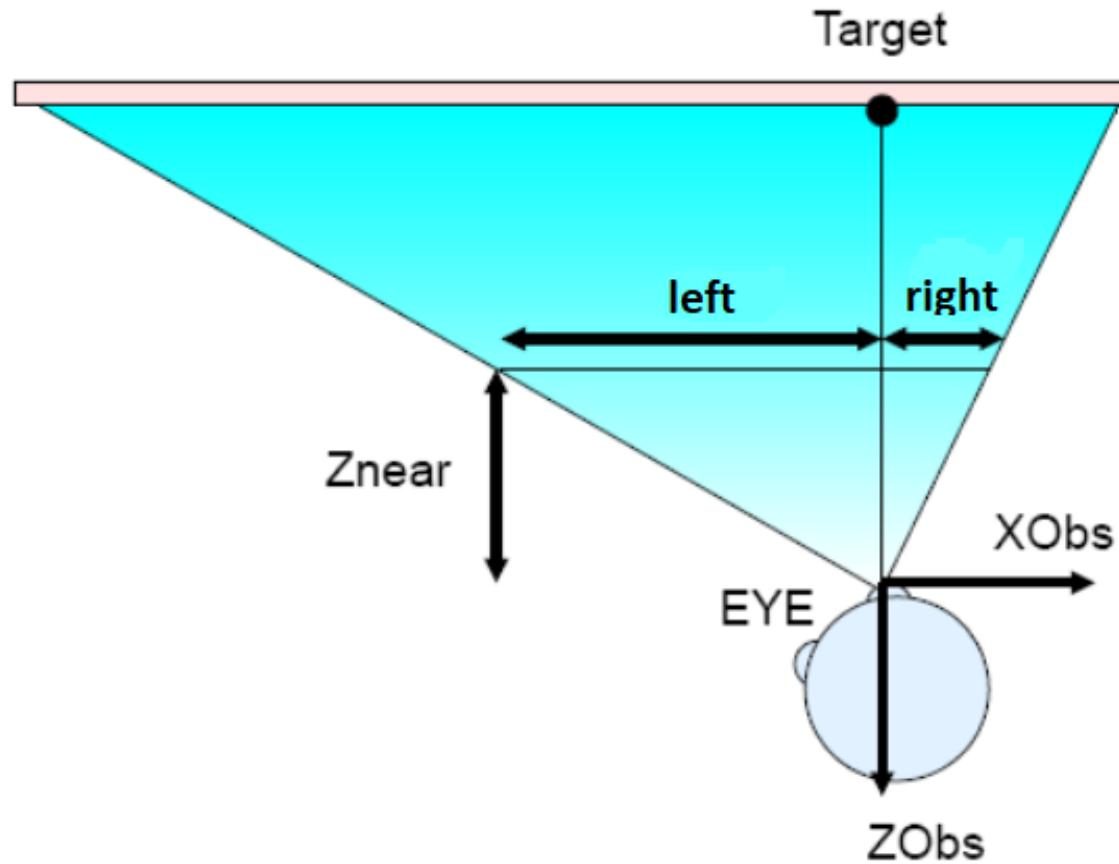


# Static screen: Stereo Camera Computation

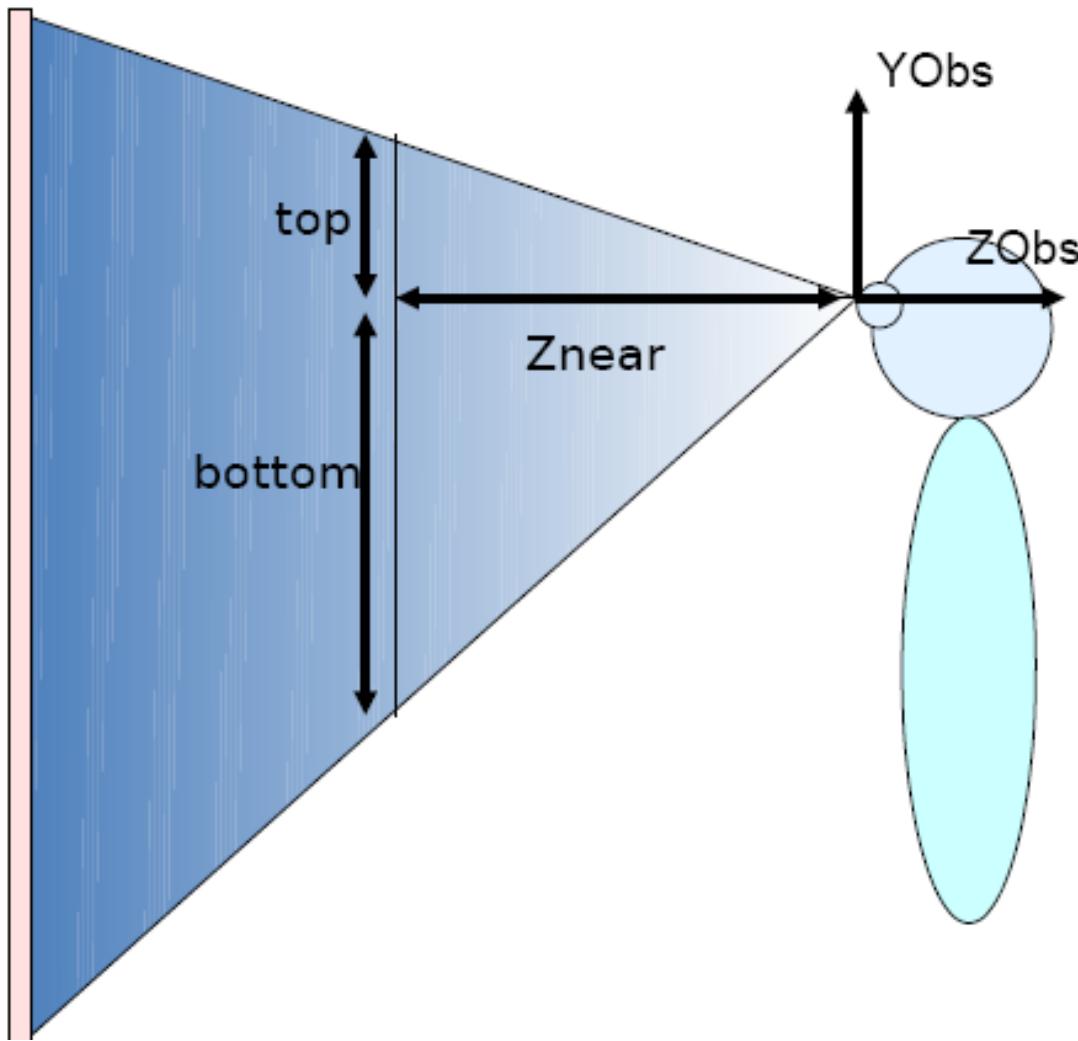
- This is the configuration of projection-based systems (CAVEs, Videowalls, workbenches...)
- Parameters:
  - Tracking data: L/R eye position
    - Two position trackers (3DOF each)
    - One 6DOF tracker (head, glasses,...)
  - Display system data
    - Screen geometry



# Static screen



# Static screen



# Static 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);
```

# Continguts

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

# 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**

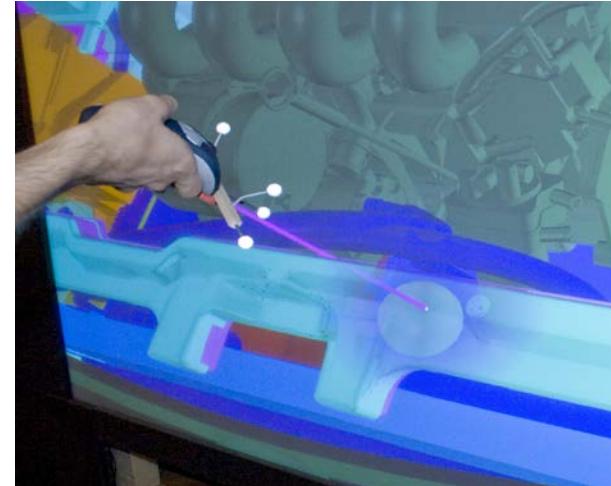
- Technique designed for solving a task
    - Involves the use of hardware and software

# VR Interaction

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

# 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

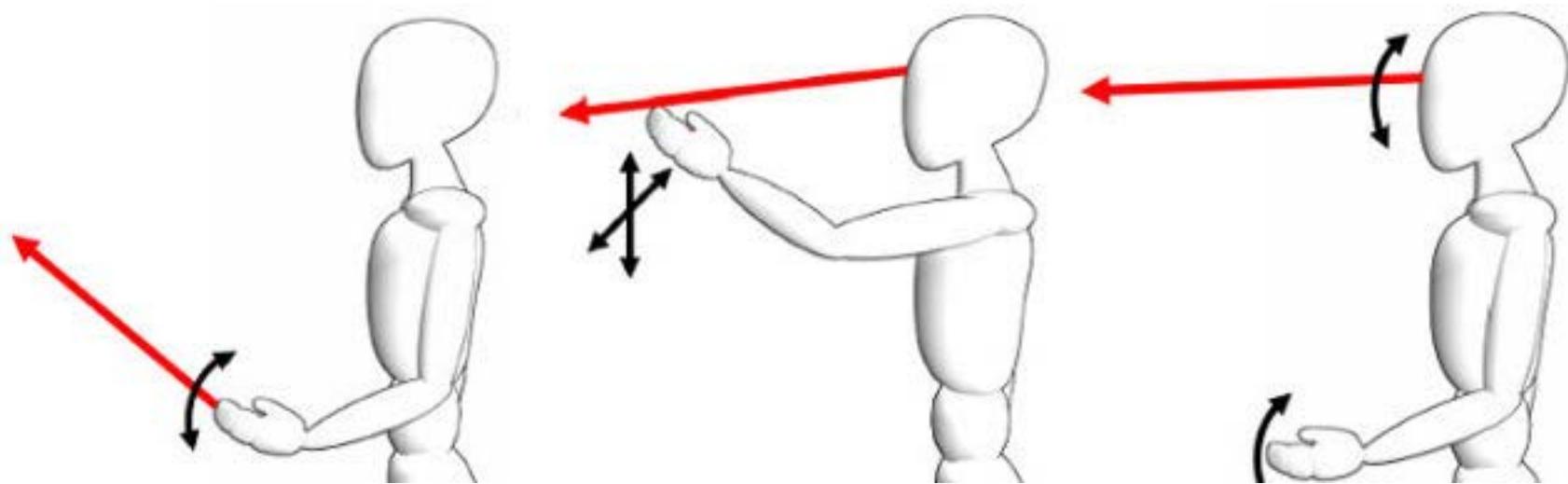
## ■ Hand extension:

- 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...

# 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.

# VR & Interaction: Navigation

How interaction techniques should be for:

- Exploration

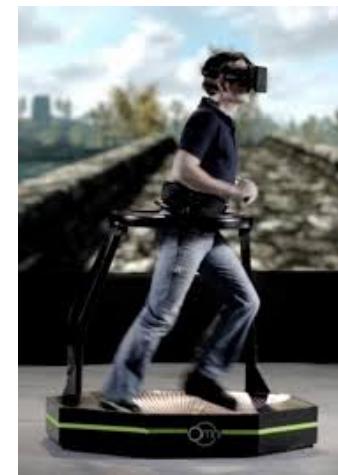
- The user must be able to change the target at any moment (continuous control of the viewpoint).
  - Little cognitive load → user can focus on information gathering.

- 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.

# VR & Interaction: Navigation

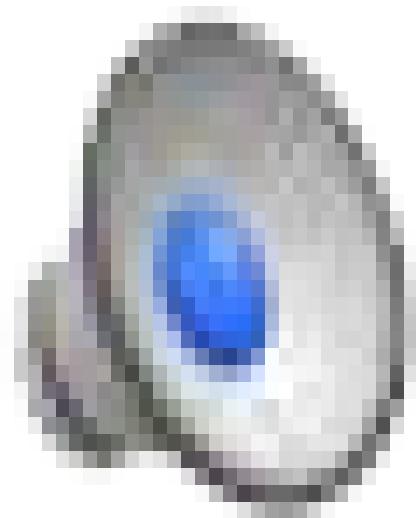
Some Techniques:



# VR & Interaction: Navigation

Some Techniques:





# Realitat Virtual Summary

- 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

# Realitat Virtual

- Presència

