

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**



5

## 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".



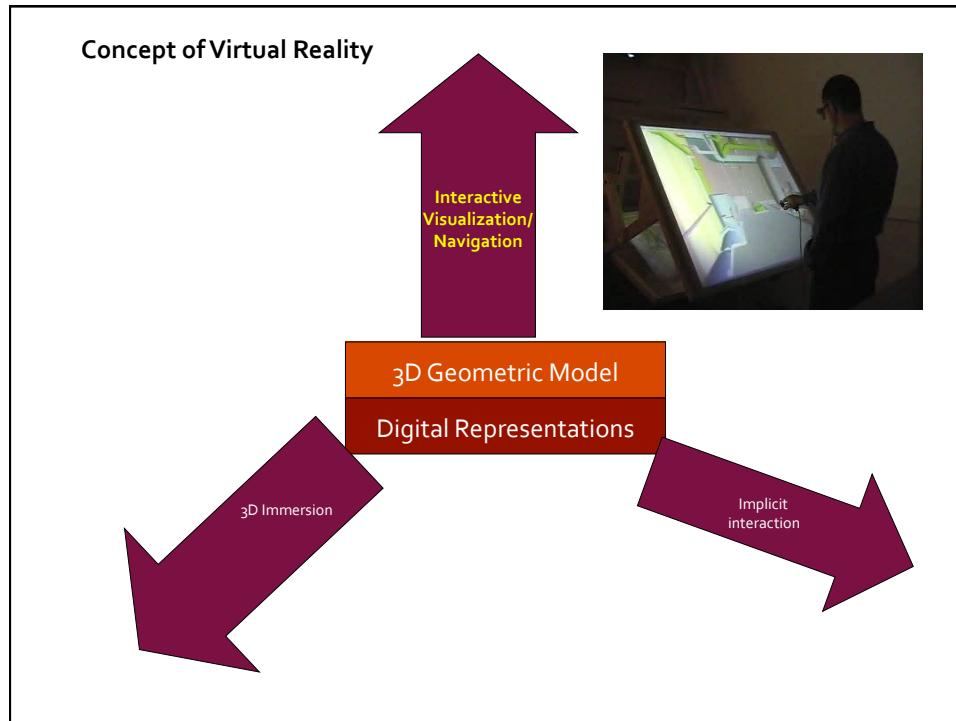
6

## Virtual Reality

### ■ Fonamental elements:

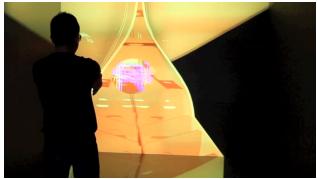
- *Digital 3D model*
- **Interactive Visualization/Navigation**
- **Implicit Interaction**
- **3D sensional immersion**



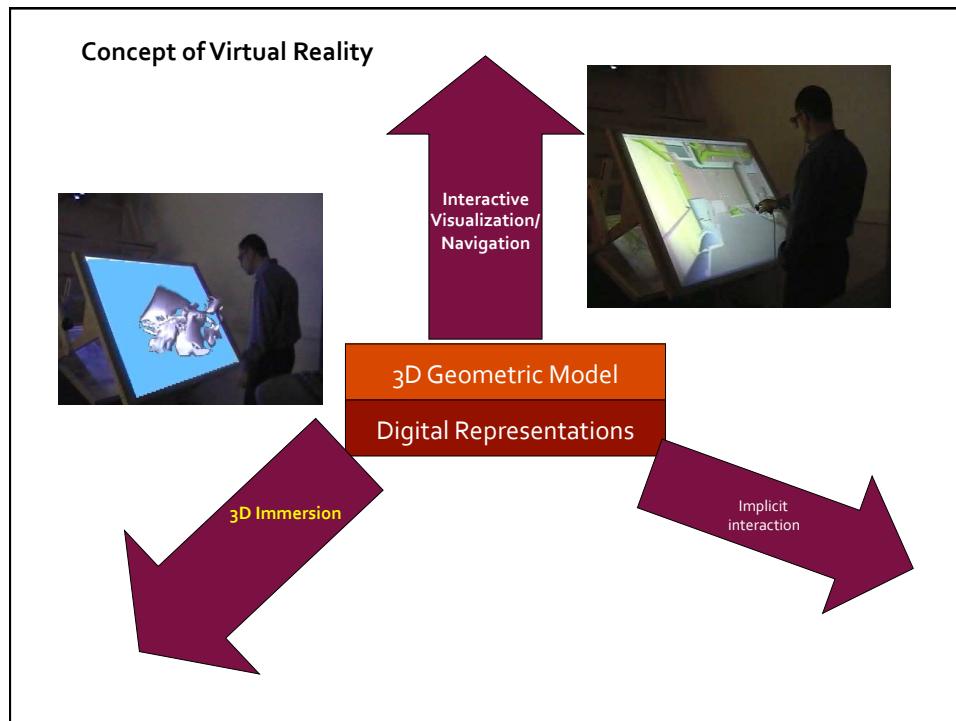


8

## The Virtual Reality

<ul style="list-style-type: none"> <li>• Interactive Visualization →</li> <li>• Implicit interaction</li> <li>• Immersion</li> </ul> 	<p><i>Reproduces a virtual world which only exists as a digital model inside the computer</i></p> <ul style="list-style-type: none"> <li>• Interactive simulation vs animation           <ul style="list-style-type: none"> <li>• passivity, previously decided</li> <li>• improvisation, <b>active, real time response</b></li> </ul> </li> <li>• 3D geometric and appearance representation</li> <li>• Realistic visualization algorithms</li> <li>• Memory management algorithms</li> <li>• Multiresolution models</li> <li>• “Zoom” capacity</li> <li>• Visibility pre-process</li> </ul>
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**The Virtual Reality**

1.0

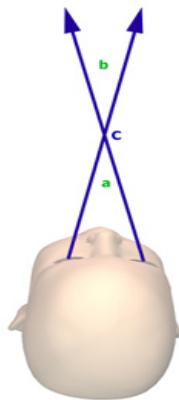
- Interactive Visualization
- Implicit interaction
- **Immersion** 

*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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## 1.1 Retinal disparity



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## 1.2 Retinal disparity

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



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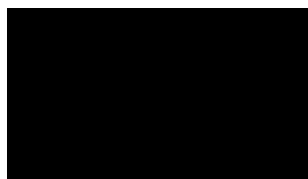
## Fusion and stereopsis

- 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**.



## 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...



20

## Realitat Virtual: Haptic Devices

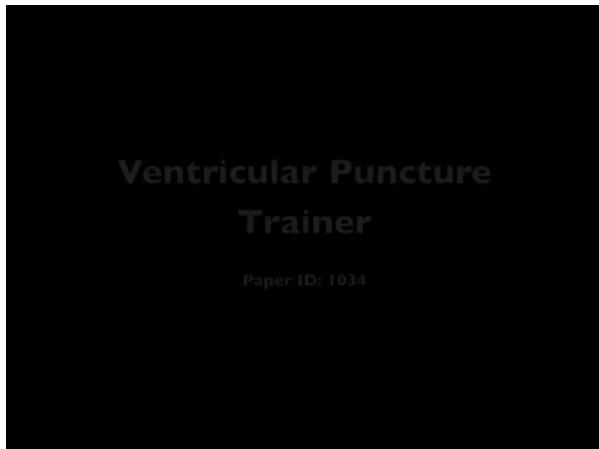


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21

## Realitat Virtual



Ventricular Puncture  
Trainer  
Paper ID: 1034

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## Virtual Reality: Haptic devices



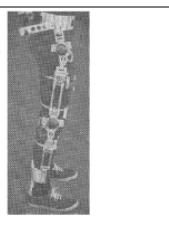




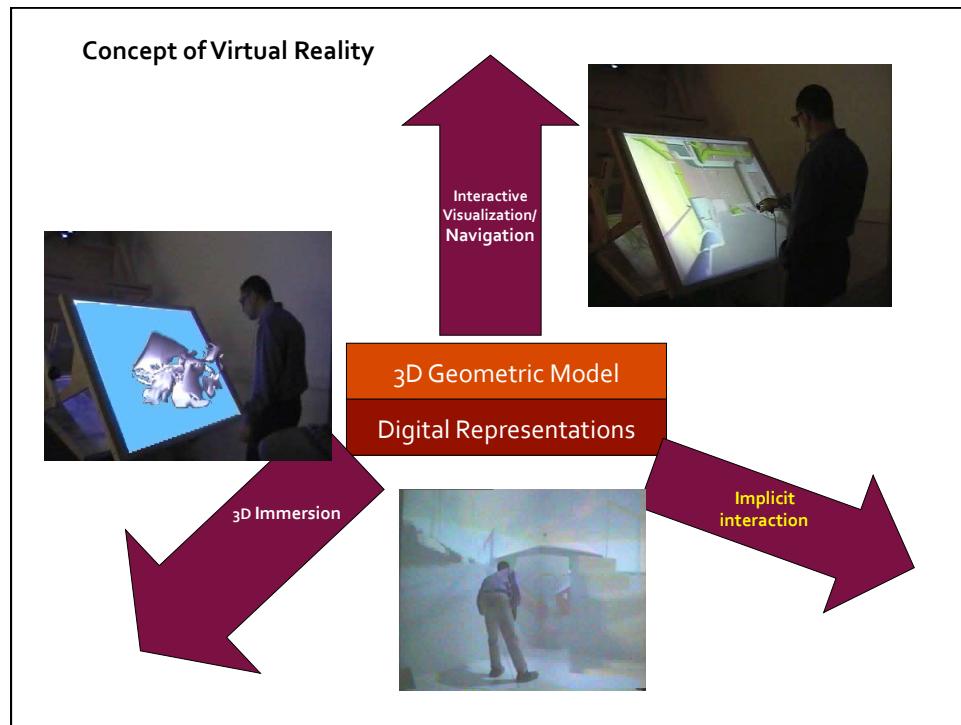
**rehabilitation**

Hogan & Krebs, MIT Biomechanics Lab: controllable brakets aids paraplegics in walking

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

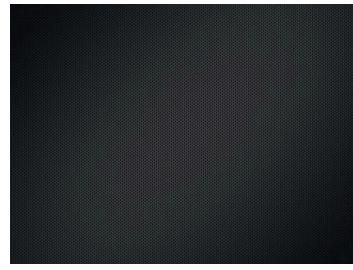



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## The Virtual Reality

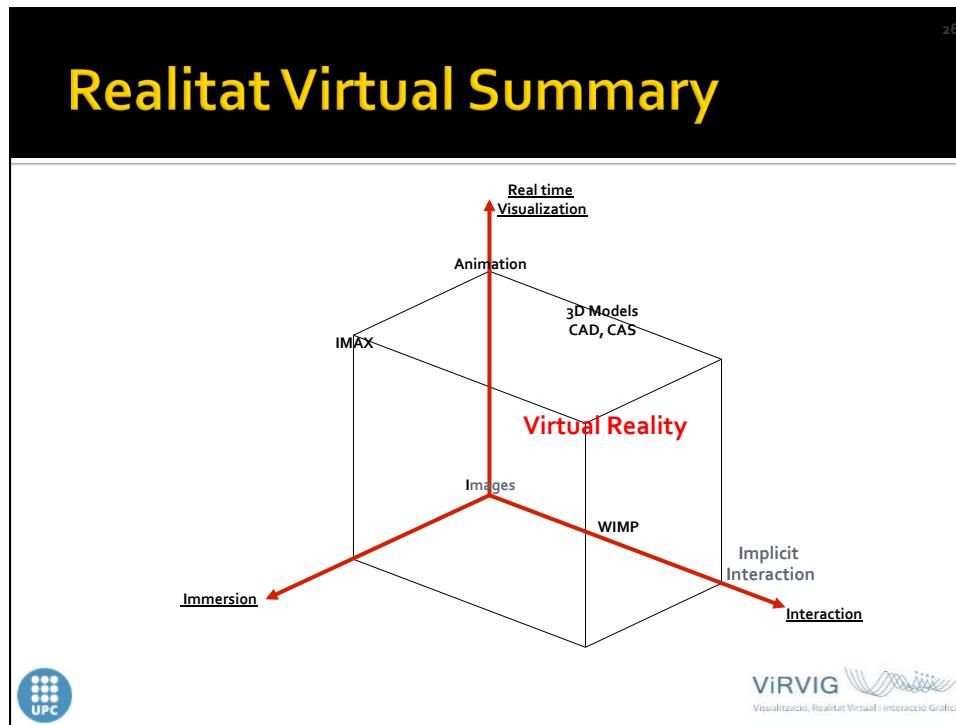
- Interactive Visualization
- **Implicit interaction** 
- Immersion



*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**

   
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27

# Continguts

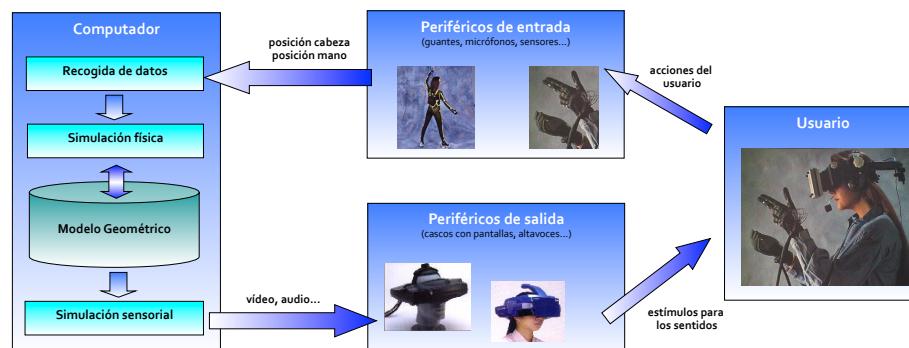
- Virtual Reality
  - General Concepts
  - VR Systems
  - Stereo Synthesis
  - Interaction
- Augmented Reality



28

## Architecture of the Virtual Reality systems

- Actualization frequency
- Latency time



29

## Virtual Reality Systems

- Immersive



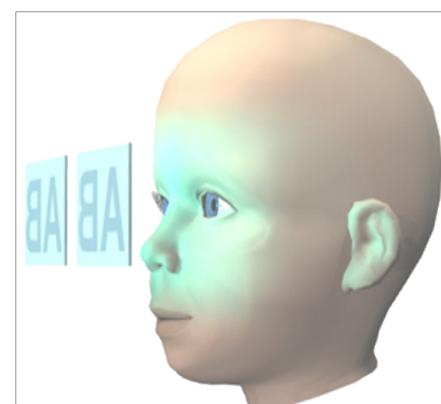
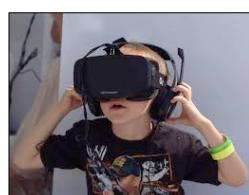
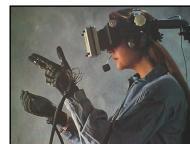
- Semi- Immersive



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30

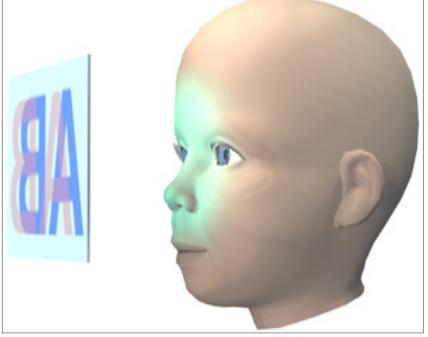
## VR: Immersive systems



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31

## VR: Semi-immersive systems

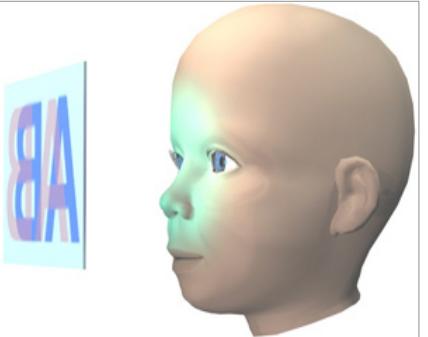
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32

## 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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33

# Continguts

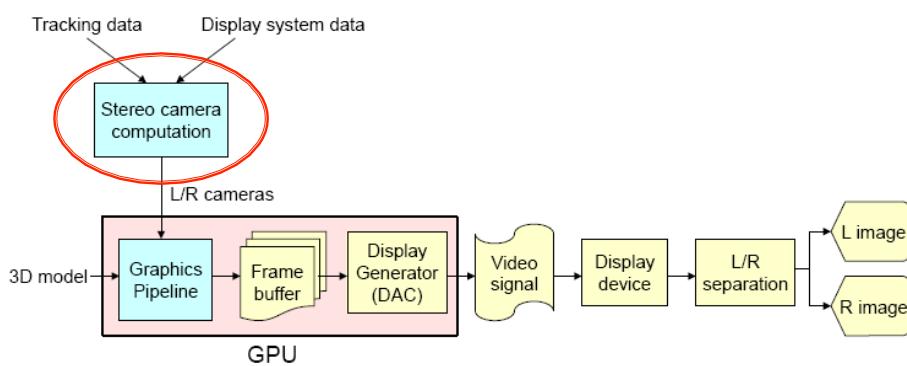
- **Virtual Reality**
  - General Concepts
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  - **Stereo Synthesis**
  - Interaction
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34

# VR: Synthesis of stereo images

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



35

## 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:

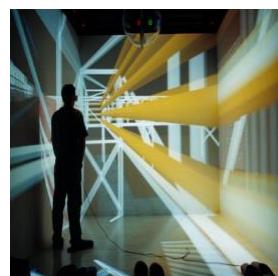
- view frustum geometry
- `frustum (left, right, bottom, top, near, far);`



36

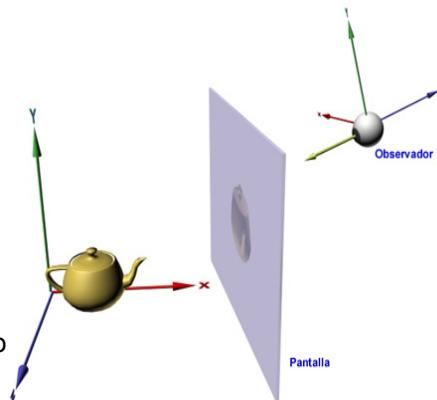
## VR System Configurations

- 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.



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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



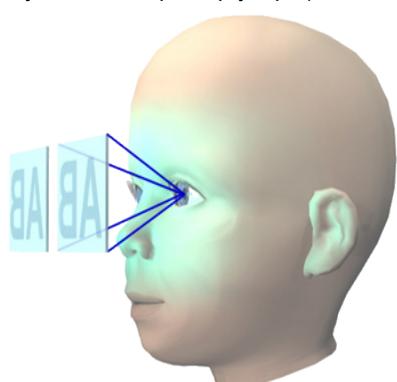
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39

## 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);

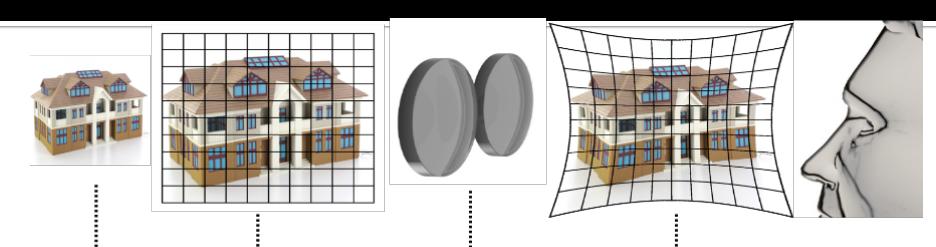
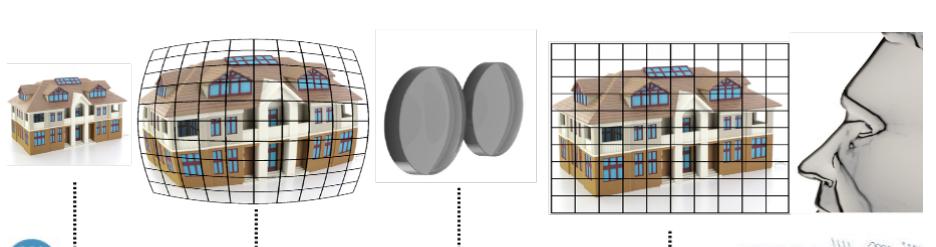
// Projection Matrix
PM = frustum (left, right, bottom, top, near, far);
sendProjectionMatrix (PM);
```



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39

40

## Distortion

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41

## Distortion

The images are distorted and appear as missshapen 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.

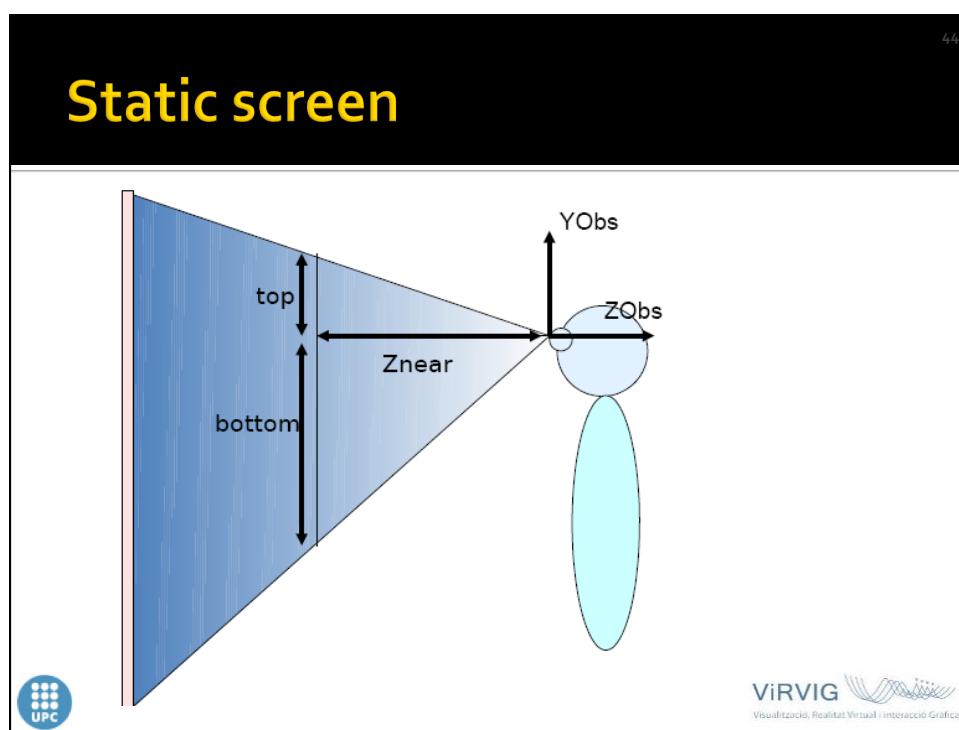
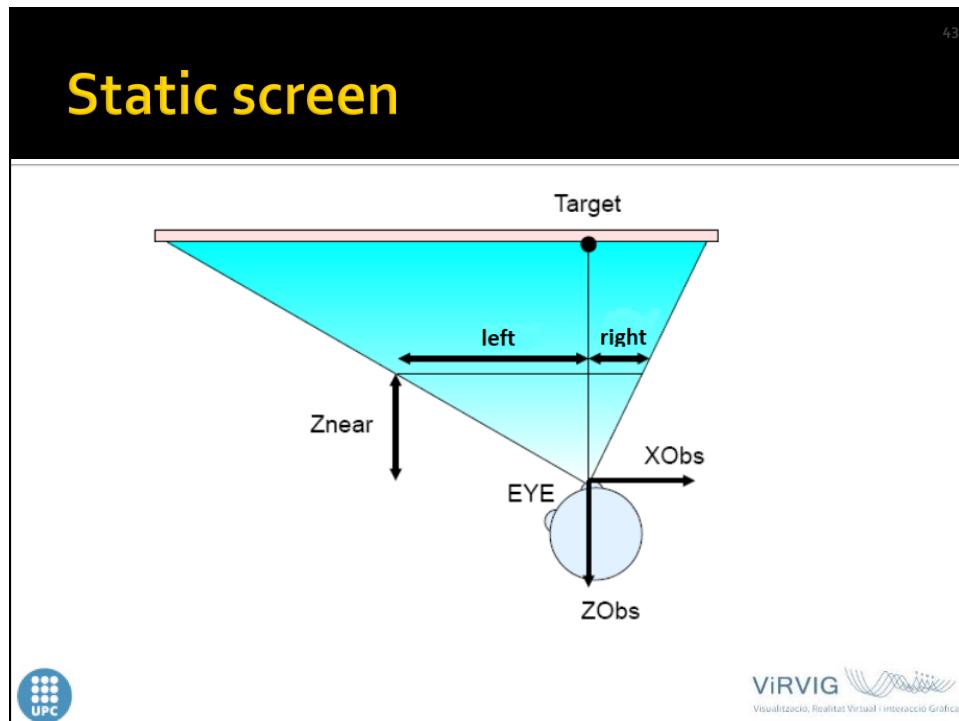
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42

## 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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## 45 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);
```



## 46 Continguts

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



47

## 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



48

## 3D selection

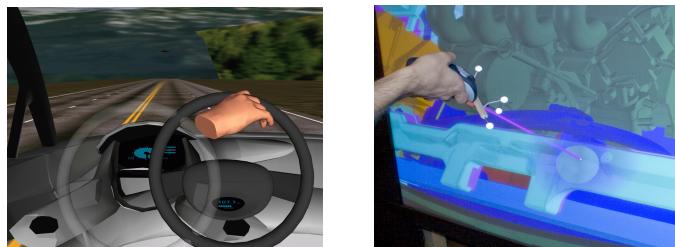
- 3D interfaces can make several tasks easier than classical 2D systems
  - Even better than reality?
- **3D selection:** selection task in a 3D immersive environment



50

## 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



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51

## 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

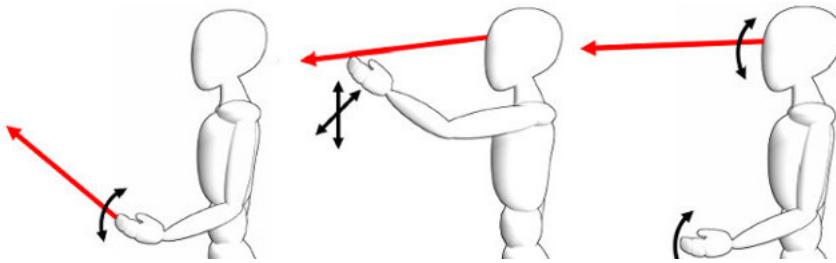


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## VR Interaction & 3D selection

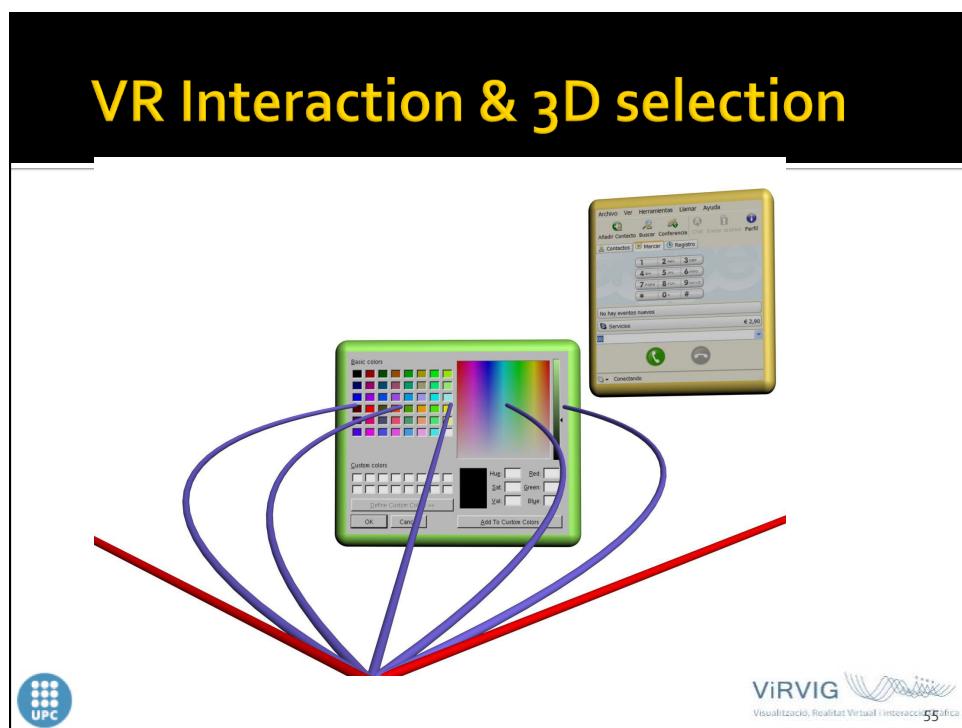
- Ray-based techniques:



## 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 & 3D selection



### Dynamic Scaling (DS)

Objects near the selection ray are dynamically scaled



## 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.



59

## 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.



60

## VR & Interaction: Navigation

Some Techniques:



61

## VR & Interaction: Navigation

Some Techniques:



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62



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63

## 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



64

## Realitat Virtual

- Presència



65

## Continguts

- Realitat Virtual
- Augmented Reality



66

## 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.



67

## 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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68

## Augmented Reality

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Shawn's Bar & Grill  
est. 1980  
325 Haven St.  
Monday-Sunday 11:00 AM - 10:00 PM  
Closed Sunday 2:00 PM

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## AR applications

- Archeology
- Entertainment



- Engineering design
- Consumer design



Try the Ray-Ban Virtual Mirror



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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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71

## 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).



72

## Augmented Reality

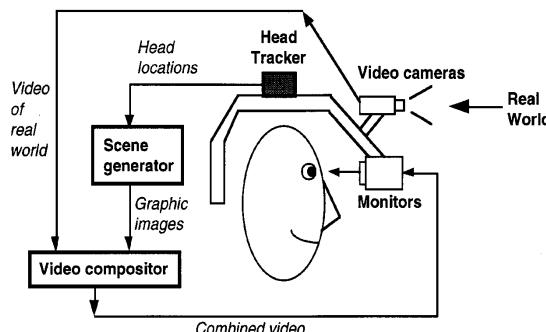
- There are basically three ways to visually present an augmented reality.
  - **Video see-through:** the virtual environment is replaced by a video feed of reality and the AR is overlaid upon the digitised images
  - **Optical see-through:** Leaves the real-world perception alone but displays only the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



73

## Video see-through HMDs

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

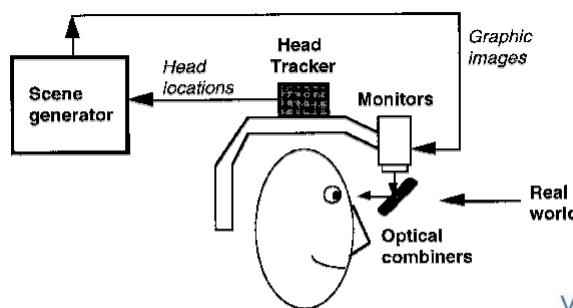


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74

## 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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## Optical see-through HMDs



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76

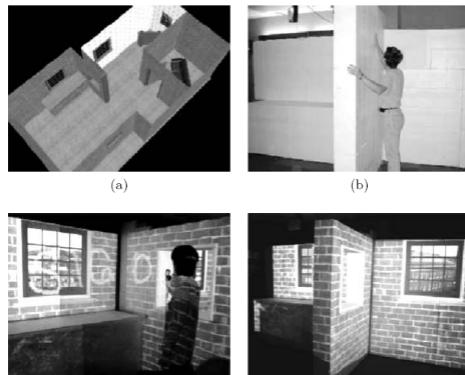
## Augmented Reality



77

## Projection-based spatial displays

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



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77

## Augmented Reality

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

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79

## 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.



80

## RA: Videos

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



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