# *VIRTUAL REALITY*
# *Introduction*

**Course 2024/2025**

# Organization

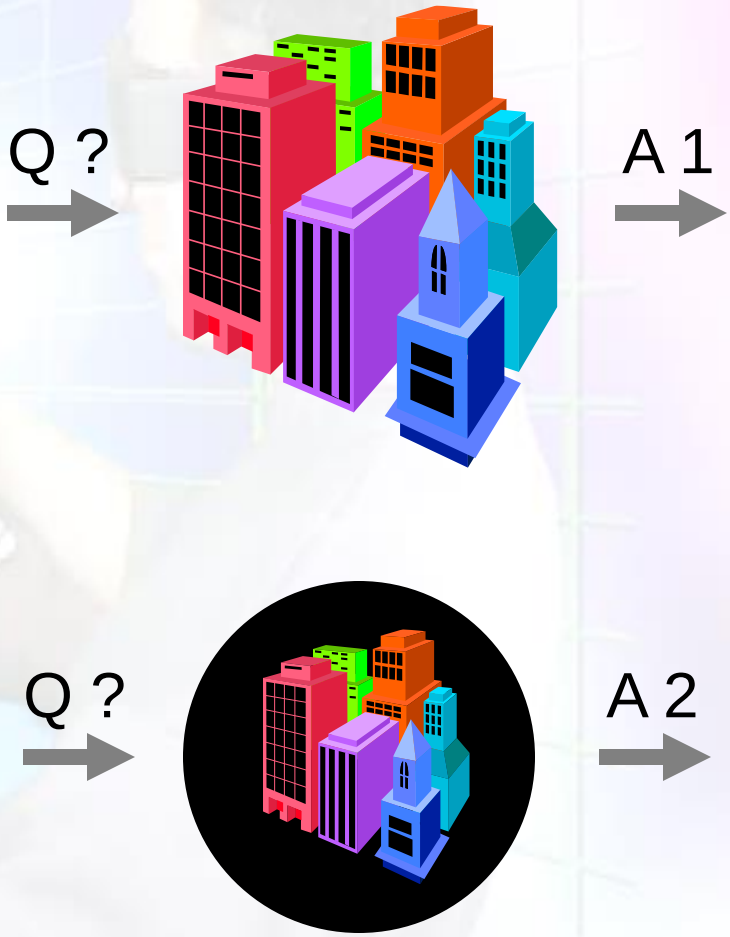
- Definition and basic concepts
- Architecture of a Virtual Reality system
- Projects of the VR Center of Barcelona

# Definition and basic concepts

- Reality and Models
- Historic evolution of models
- Virtual Reality definition
- Simulation, interaction, immersion
- Immersive and semi-immersive systems
- Virtual prototypes

# Reality and Models

- Necessity of Models
- Models and reality:
  - questions, queries
  - expected answers
  - depends on the complexity of the model
- Evolution:
  - Physic models
  - Analogical models
  - Digital models

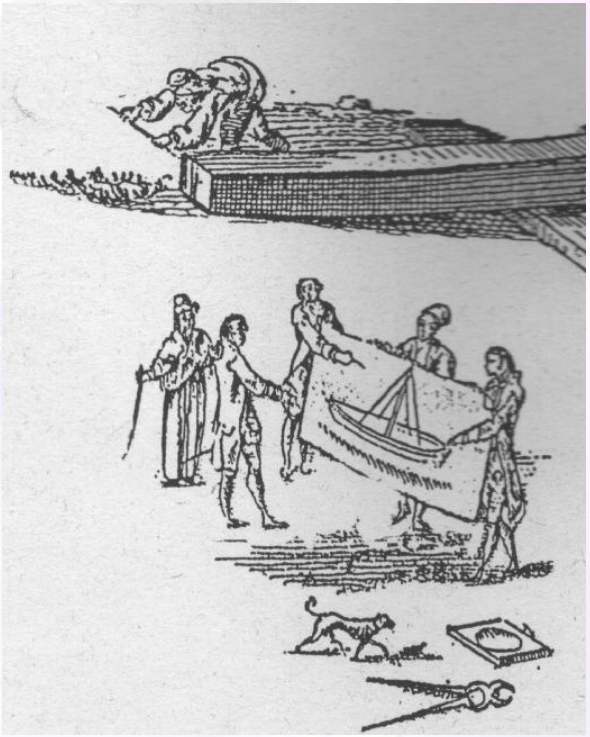


# Reality and Models

**Model:**

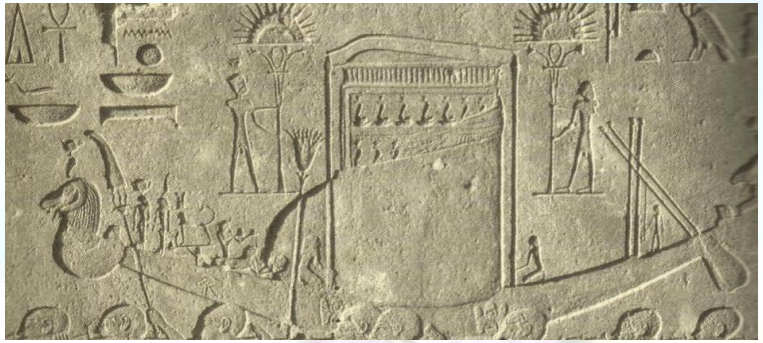
1. Simplified representation of the reality

2. Reproduction, in lab scale, of the behaviour of a physic system, to the study and design of systems presenting great difficulties for its experimentation



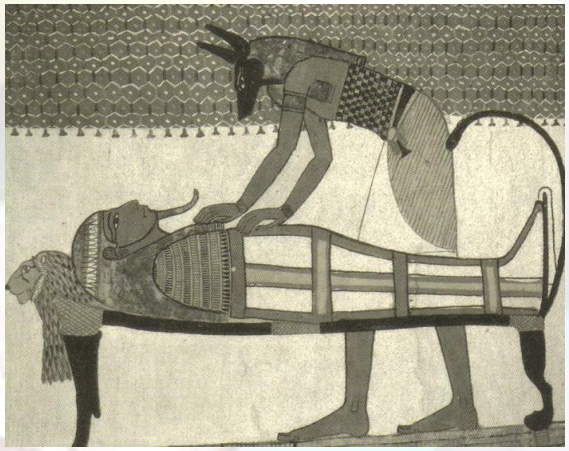
# Reality and Models

# Reality and Models



**Model:** simplified representation of the reality (design, experimentation, communication)

Annubis



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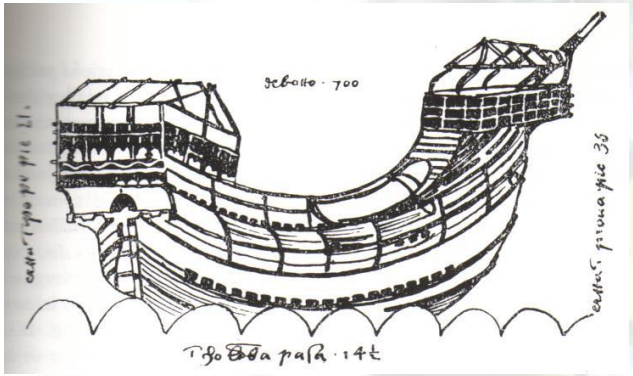
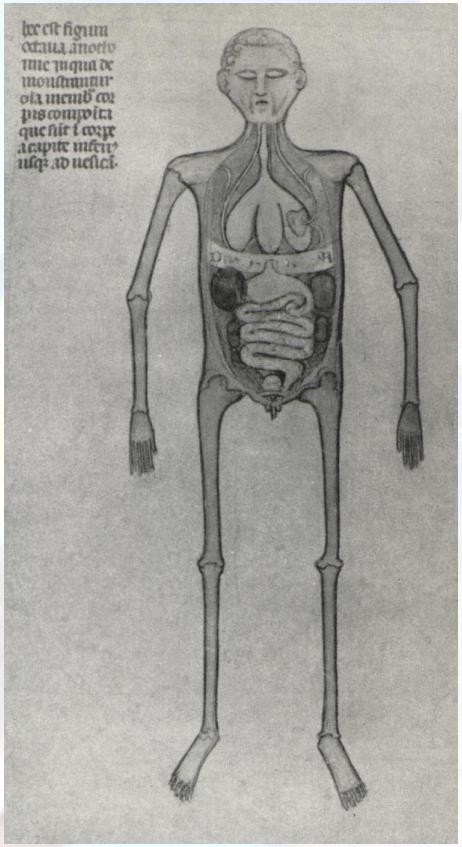
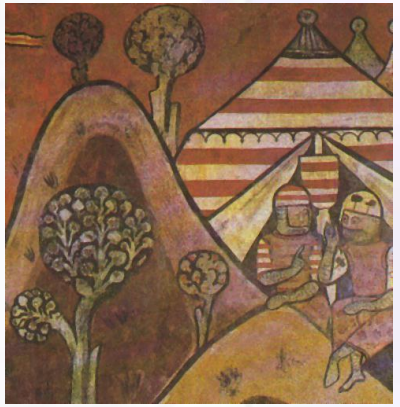




Guido's anatomy of Vigevano (1345)



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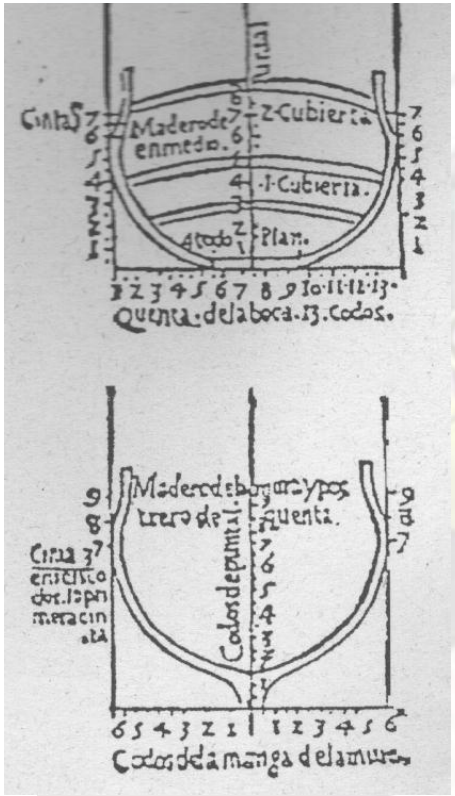
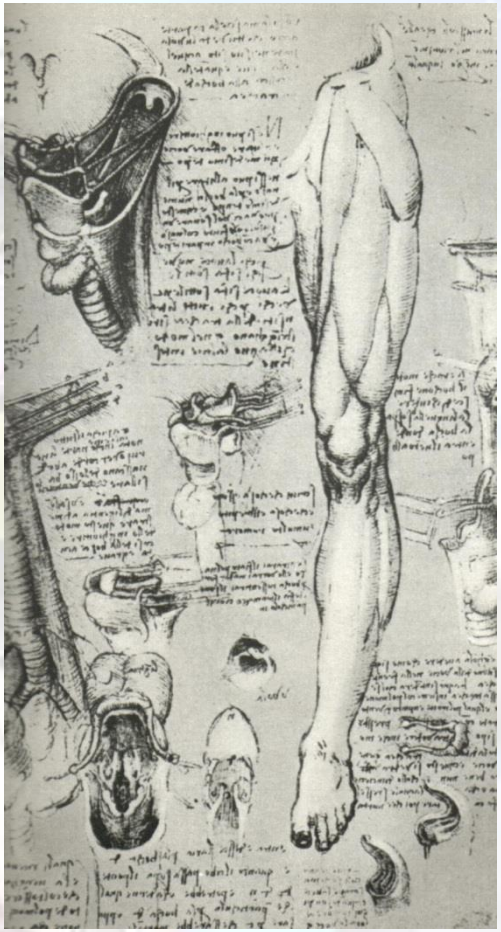
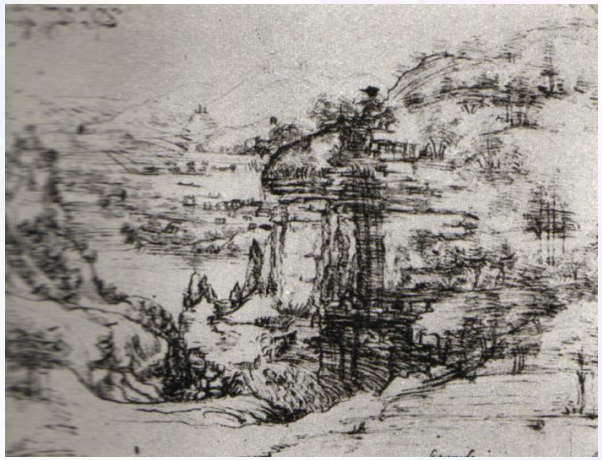
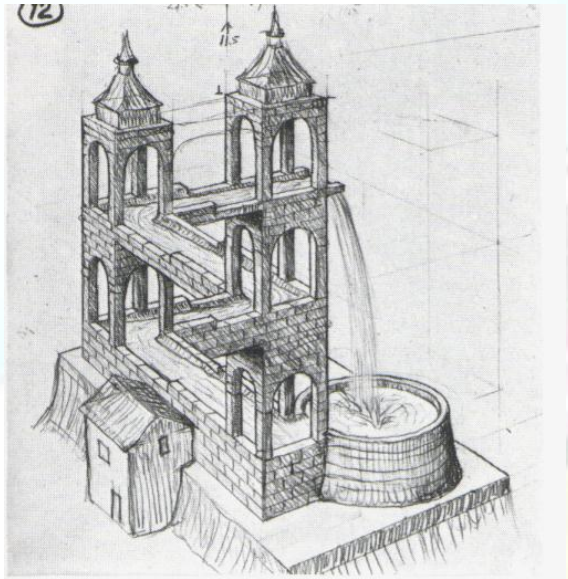


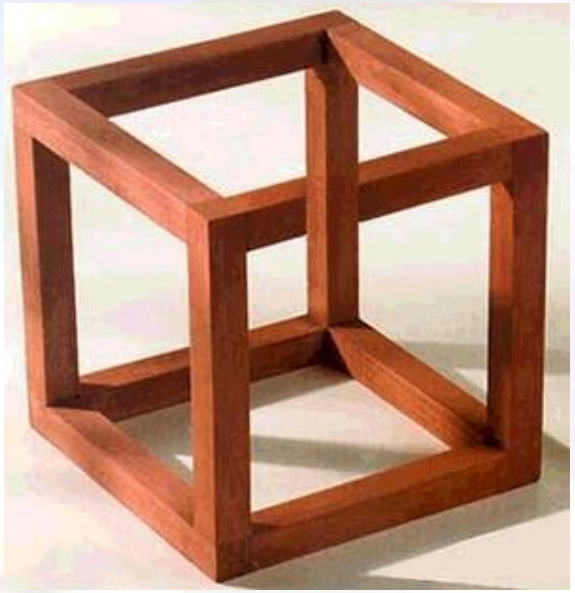



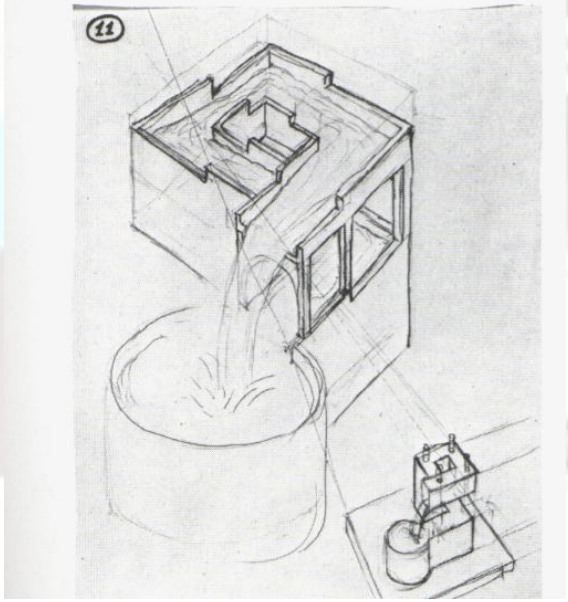
Leonardo da Vinci

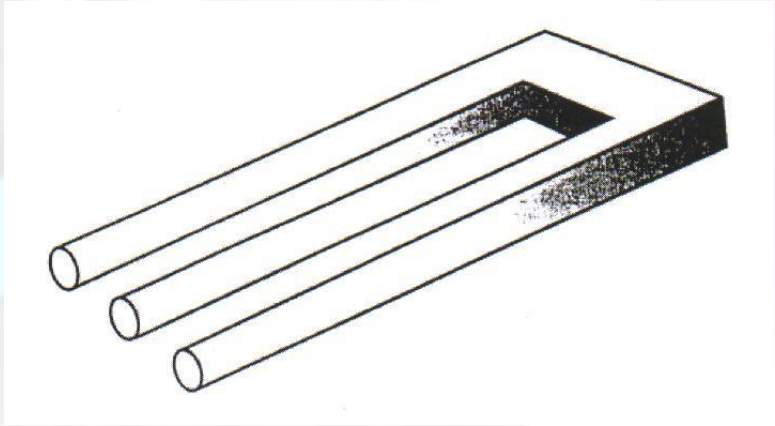


# Reality and Models





# Historic evolution

| | Digital Models | Memory, compute power, algorithms | Graphic cards | Interaction techniques |
|---|---|---|---|---|
| 70 | Geometry | Object models | ---- | Commands |
| 80 | Images<br>pixels | Small sets of objects | 2D | WIMP |
| >90 | Textures<br>Volume: voxels<br>Big models<br>3D textures<br>MPEG, etc | Big systems,<br>level of detail | 3D | Implicit<br>Direct interaction |

# The Virtual Reality

Definition given by A. Rowell:

“The Virtual Reality is the computer interactive simulation from the point of view of the participant, in which the sensory information he/she perceives is substituted or augmented".

- Interactive visualization
- Implicit interaction
- Immersion

# Concept of Virtual Reality

Interactive Visualization

3D Geometric Model

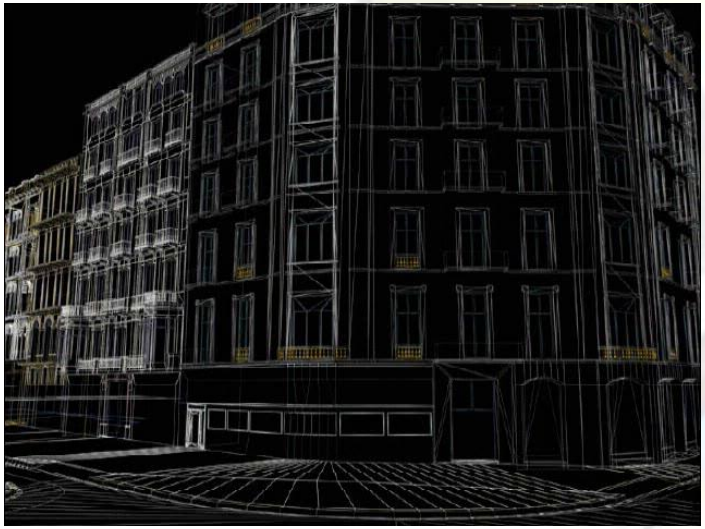
Digital Representations

3D Immersion

Implicit interaction

# 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, 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

Interactive Visualization

3D Geometric Model

Digital Representations

3D Immersion

Implicit interaction

# 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…

# Stereoscopy
## 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**.

# Concept of Virtual Reality

Interactive Visualization

3D Geometric Model

Digital Representations

3D Immersion

Implicit interaction

# The Virtual Reality

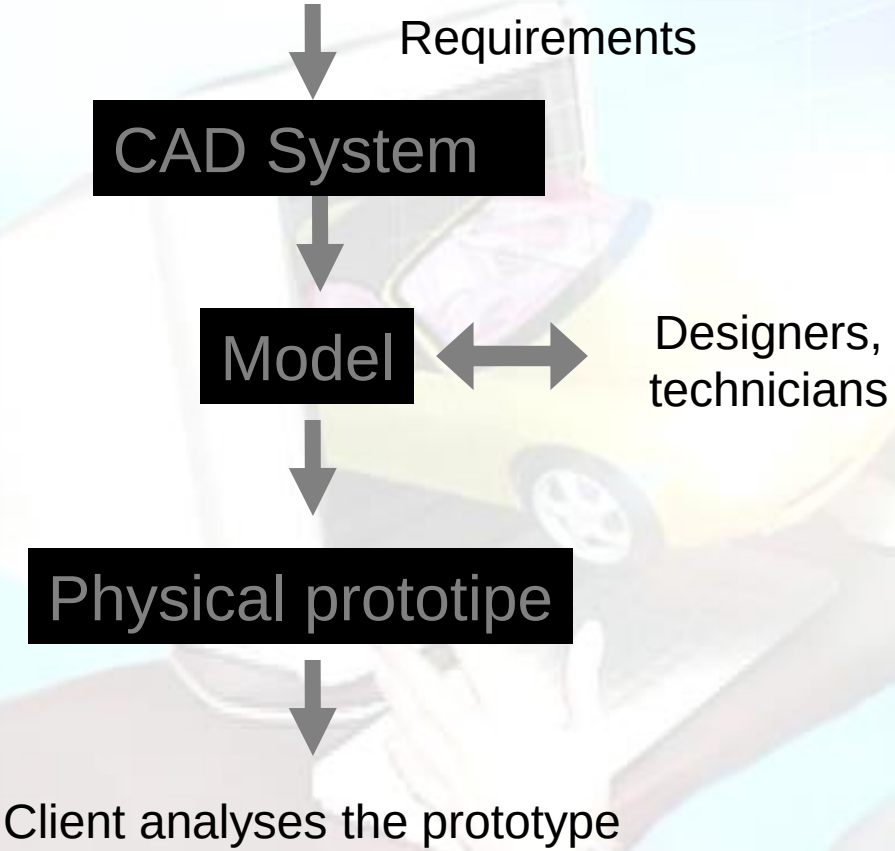
- Interactive visualization
- Implicit interaction
- Immersion

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

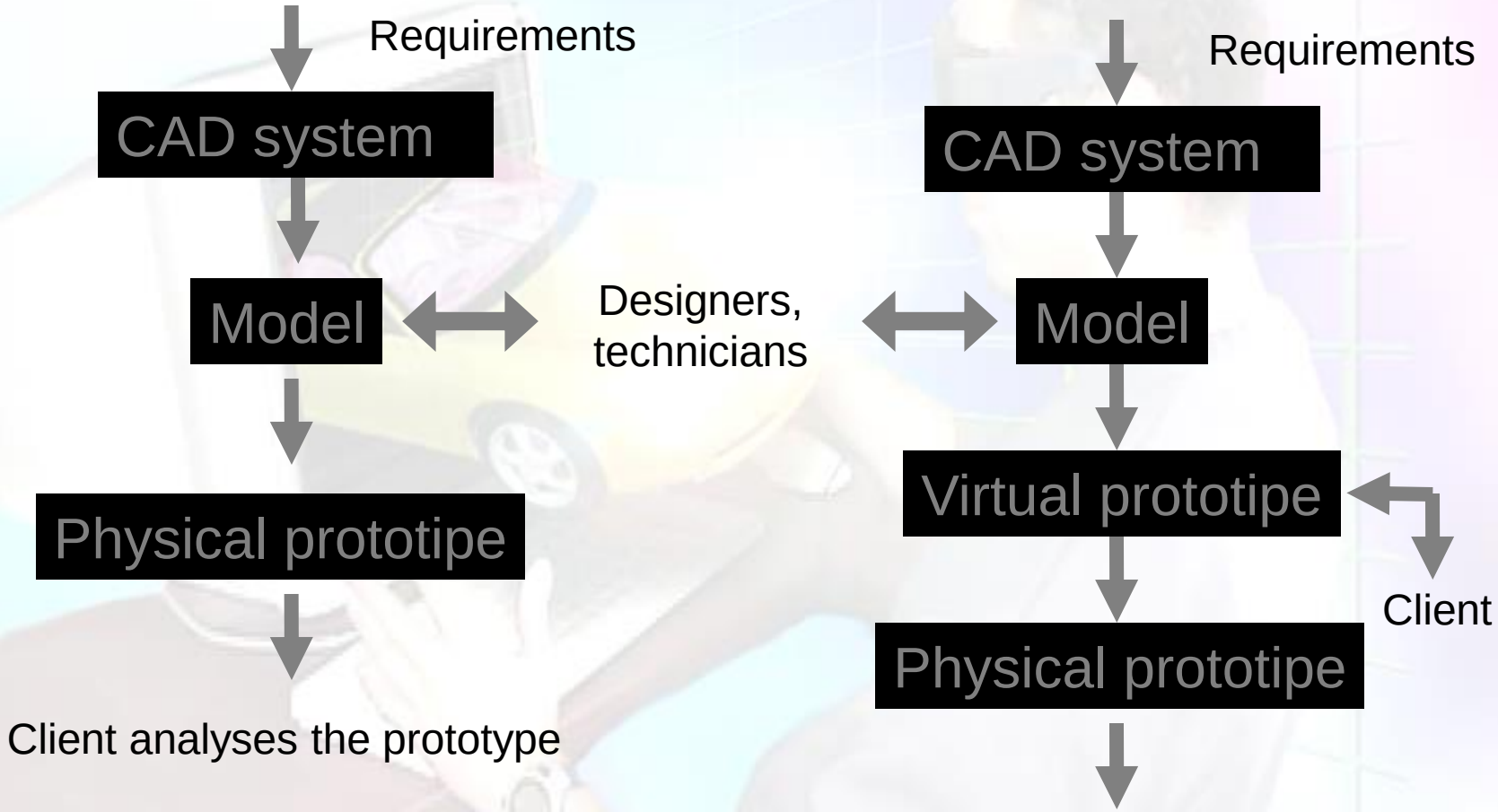
- Gestures, head movements vs interaction with the mouse

- 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**

# Example of VR: The virtual prototype




# Example of VR: The virtual prototype



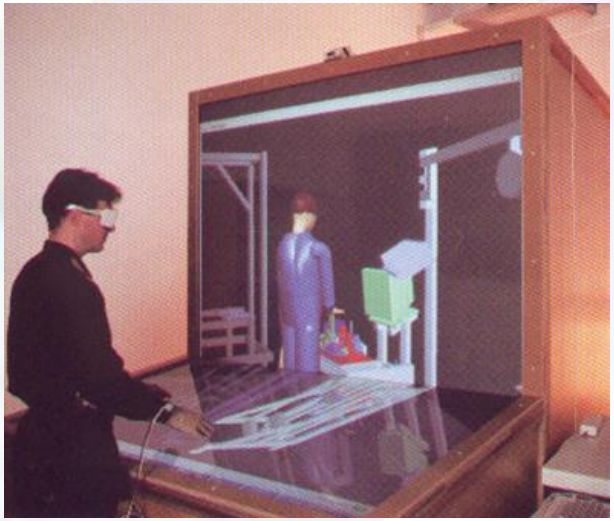
# Architecture of a VR System

- Actualization frequency
- Latency time

# Virtual Reality Systems

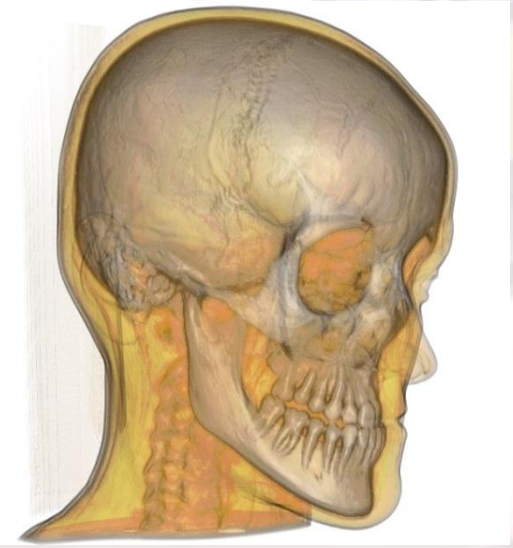
- Immersive systems

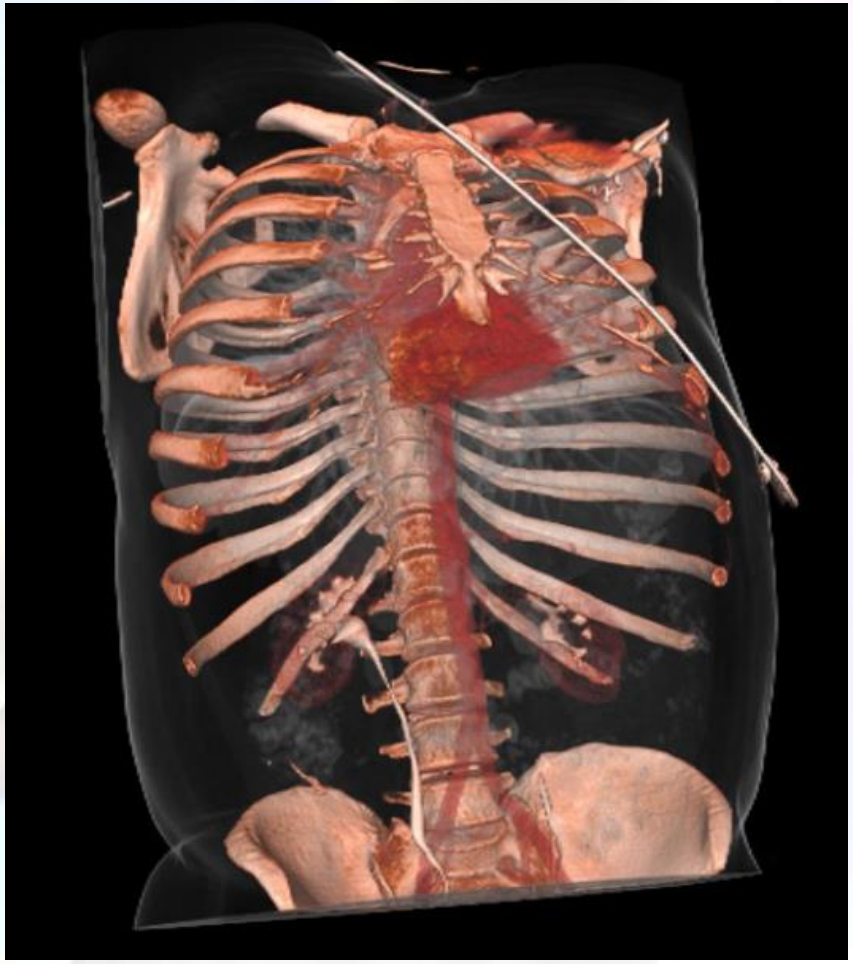
- Semi-immersive systems



# Applications

- Medicine



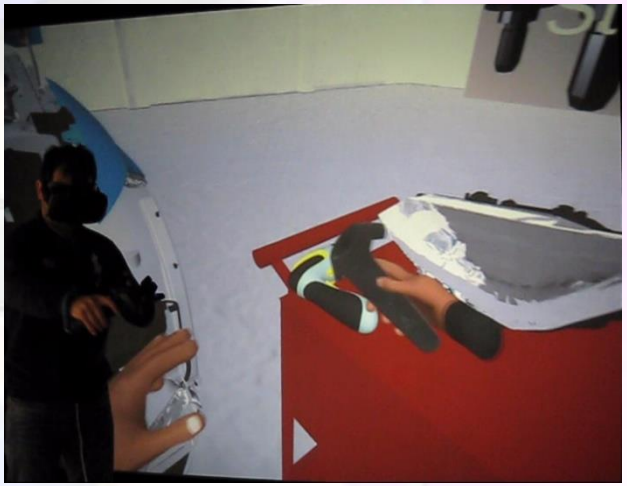


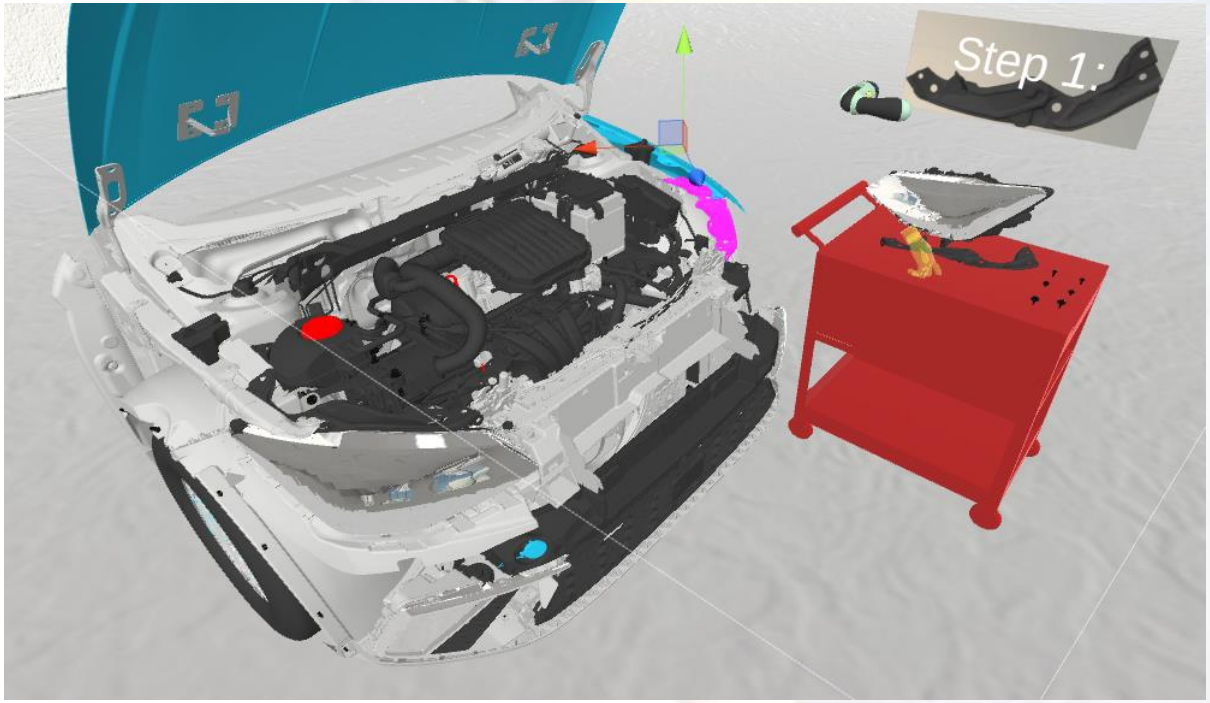
# Applications

- Medicine
- Architecture

# Applications

- Medicine
- Architecture
- Industrial engineering





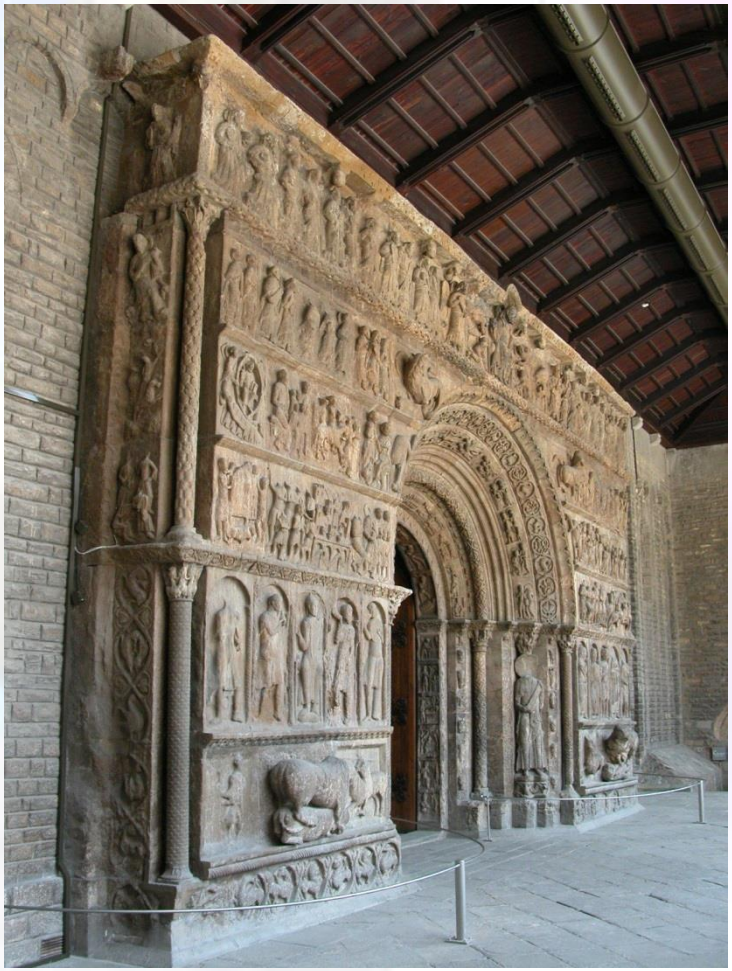
# Applications

- Medicine
- Architecture
- Industrial engineering
- Entertainment

The Climb

# Applications

- Medicine
- Architecture
- Industrial engineering
- Entertainment
- Cultural Heritage



# The Virtual Reality Center of BCN

Created through a contract between UPC and Gedas (10-6-99)

- Sited at the Parc Científic i Tecnològic de Barcelona
- The Hospital de la Vall d´Hebron came in as an associate

- Nowadays being part of the ViRVIG Research Center

**Objectives:**

- Research applied to fields like simulation, visualization, training, planning and prototyping in virtual environments

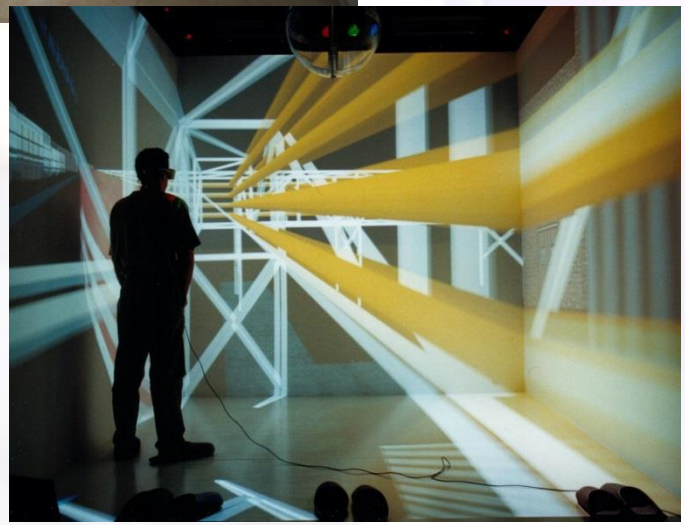
- Projects of R+D in collaboration with companies

- Teaching activities directed to the University and others

# The Virtual Reality Center of BCN

**Equipment:**

- Cave System
  - Cave of 4 walls
  - Cluster of PCs
- Presentations room
- Labs
  - HMDs
  - Low cost VR systems
  - VR projects
  - services



# CRV projects:
## Reconstruction of Cadiz, S XVII

**Objective**: Virtual walk through Cadiz, s. XVII-XVIII

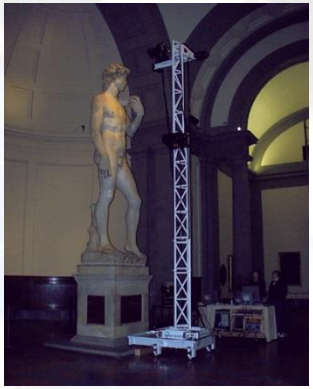
- modeling of buildings
- walk
- navigation
- immersion

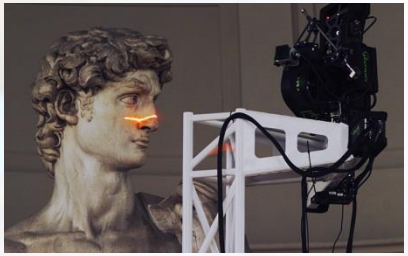
Carles III, 1777

# CRV projects:
## ViHAP 3D

Virtual Heritage: High Quality 3D Acquisition and Presentation

Objective: 3D scan, optimized representation, navigation in virtual museums



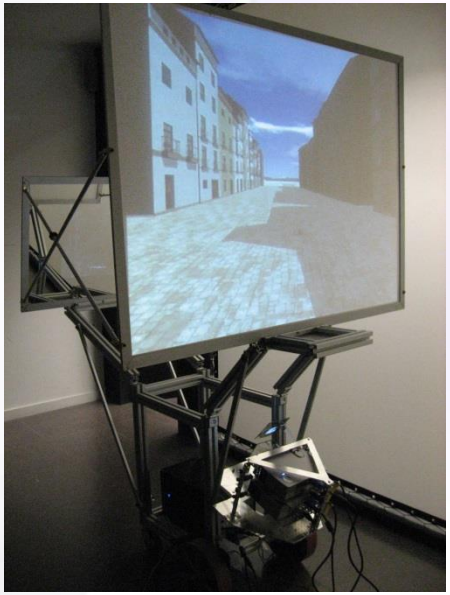


# CRV projects:
## Low Cost VR systems

Virtual Reality table

- Stereoscopic table
- Based in one PC
- Navigator (soft)
- Low cost projection system
- Tracking of the user
- Haptic interaction in a finger

VR portable system (virtual window)



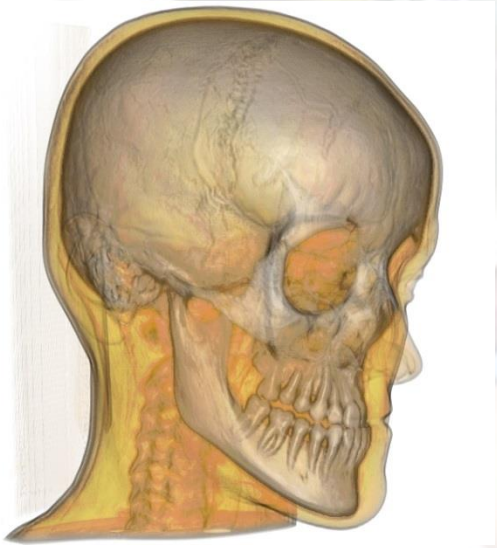
See through projection system

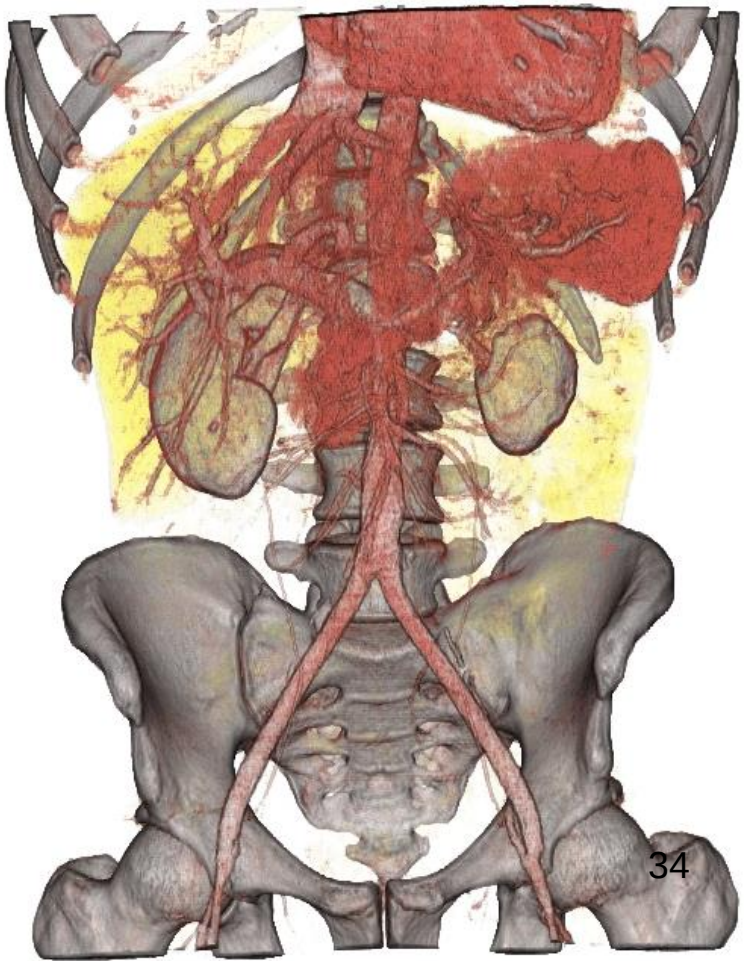
# CRV projects:
## Medicine

Generation, inspection and analysis of models
- From scanner images
- segmentation, voxelization
- generation of the surface model
- inspection on real time

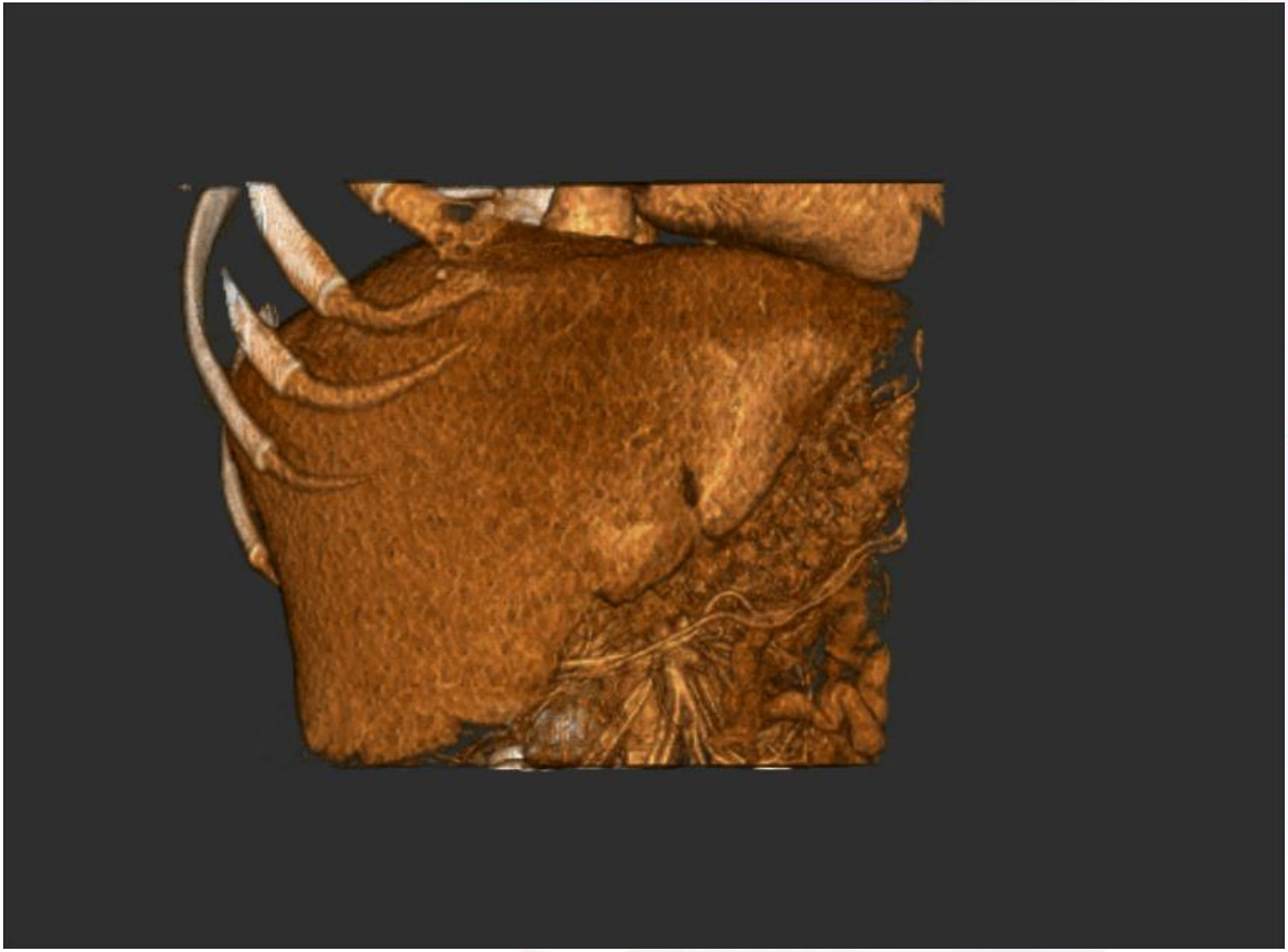
Visualization for planning of maxillary osteotomies

Visualization of several body parts (like liver) for surgery planning





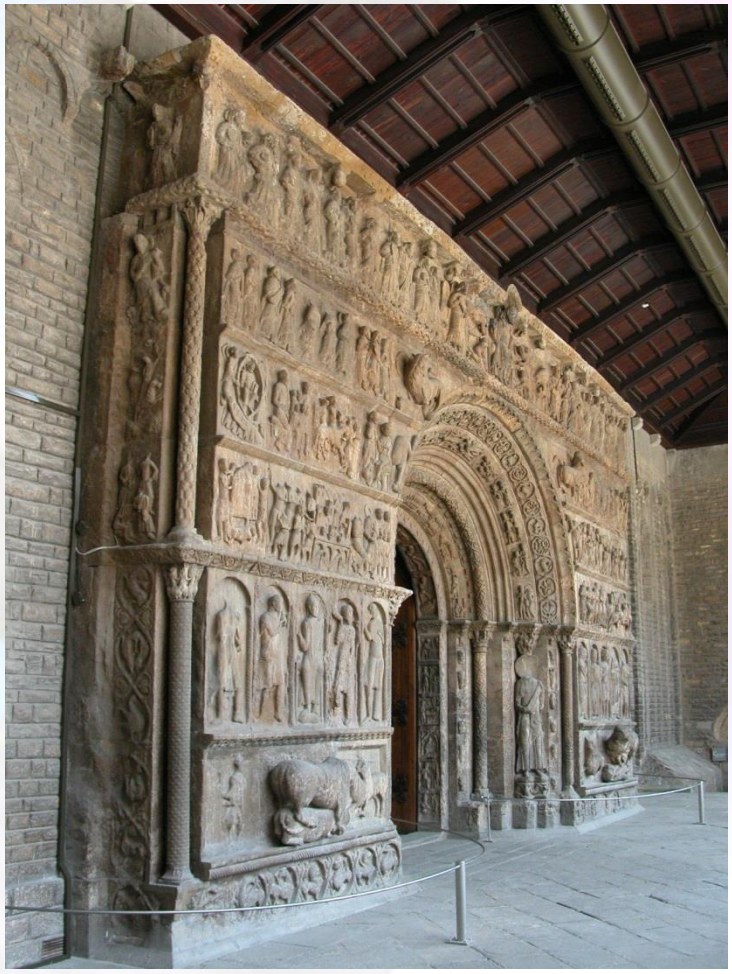
# Liver project



# CRV projects:
## Ripoll portal reconstruction

Virtual Heritage: High Quality 3D Acquisition of the Ripoll portal

Objective: 3D scan, high quality representation, museum interactive demonstration



# CRV projects:
## Architecture

Johan Cruyff Stadium

Sagrada Familia

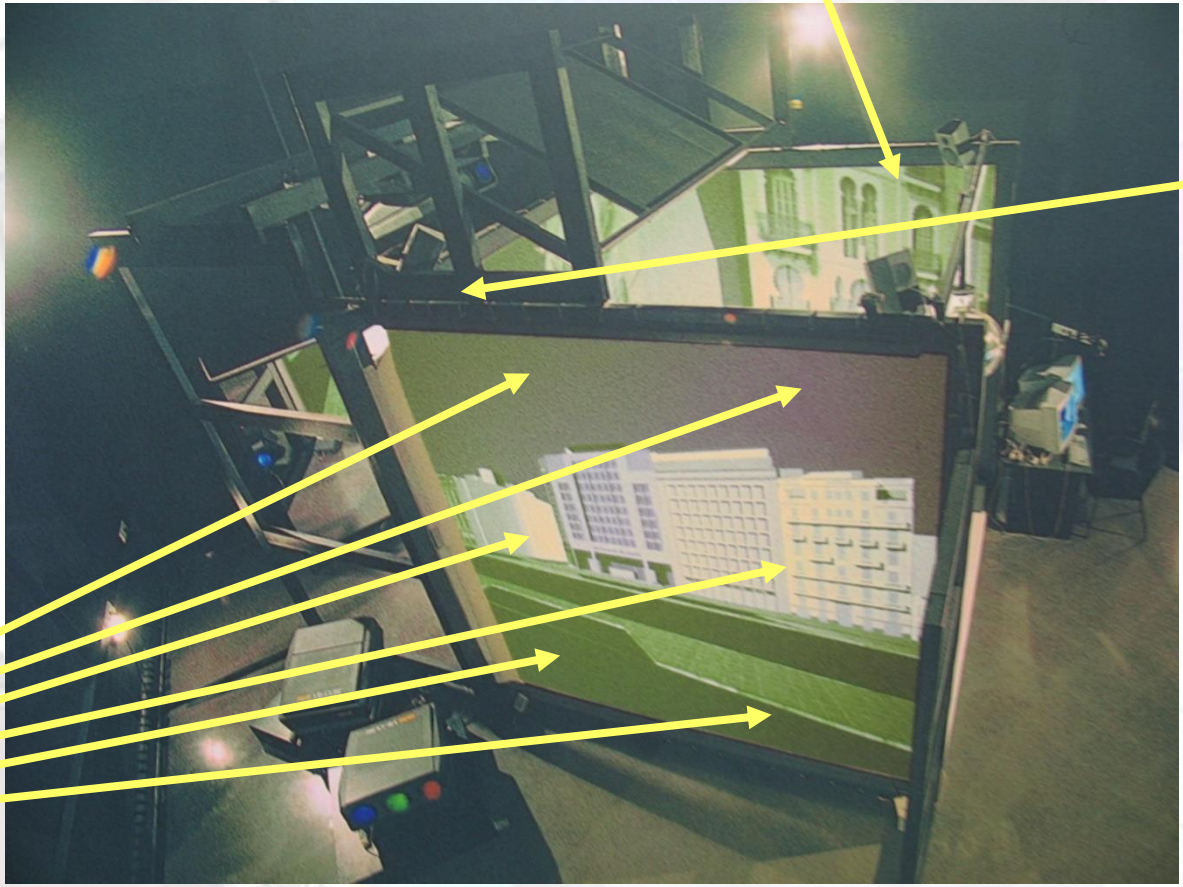
# Multi-projector CAVE System

Four Cameras
(auto-callibration)

Two
Kinects

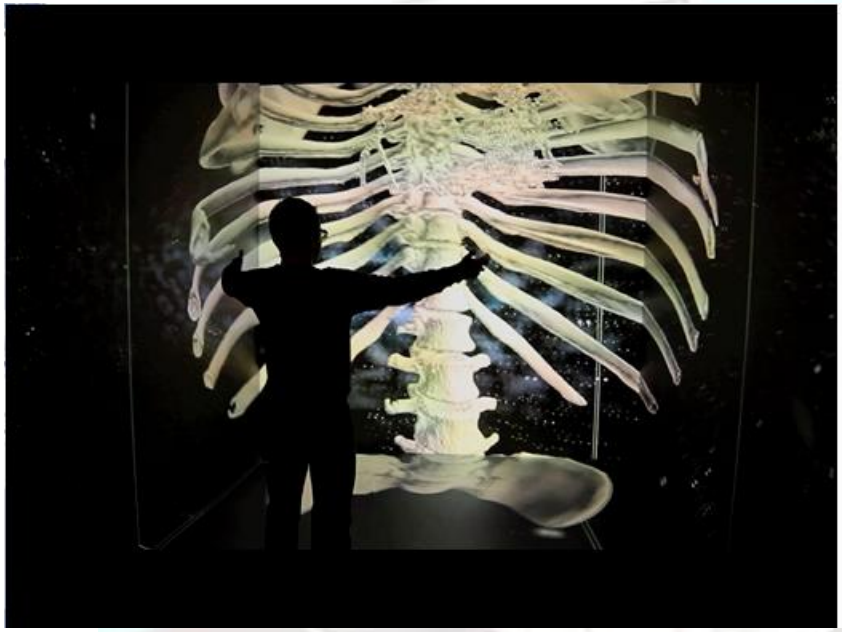
Three PCs
for wall

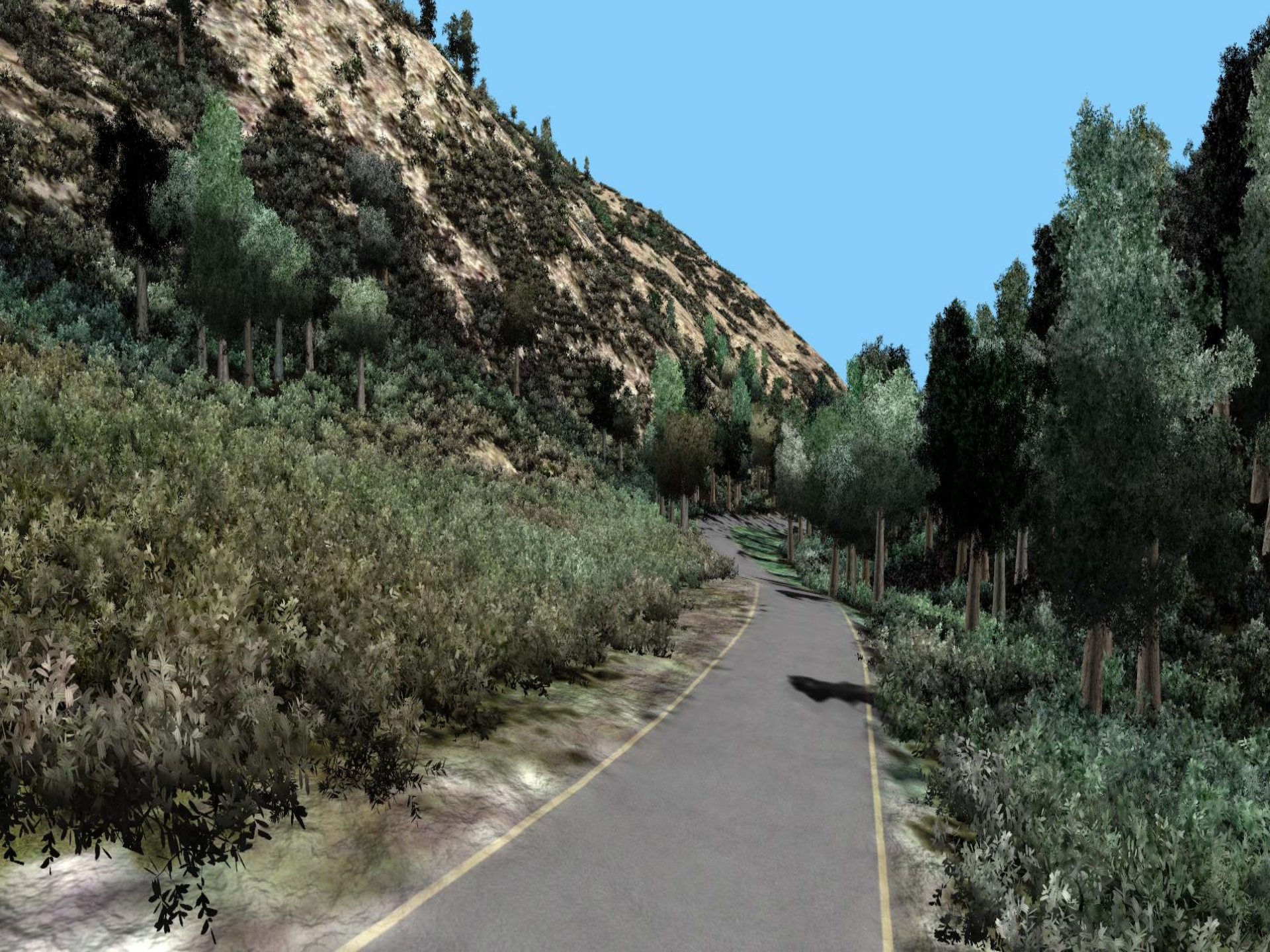
6 * 2
projectors



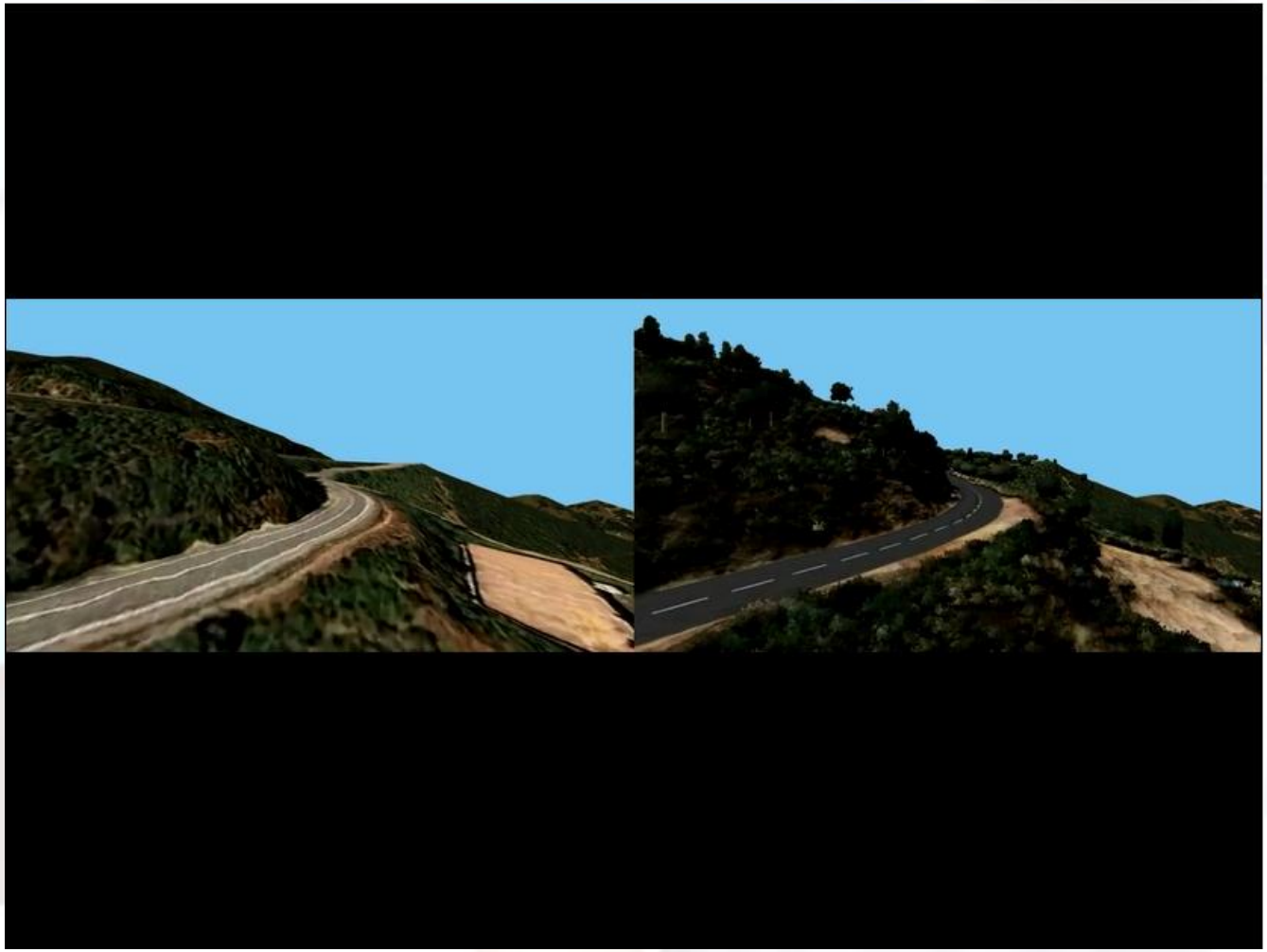
Total: 3*3+1+1+1 = 12 PCs, network-connected
3*6*2+2+2 = 38 DLP, 1024 x 768 projectors + 2 Full HD
4 cameras, Canon EOS 1100-D (18mm, 14mm)

# CRV projects:
## Implicit interaction using Kinect

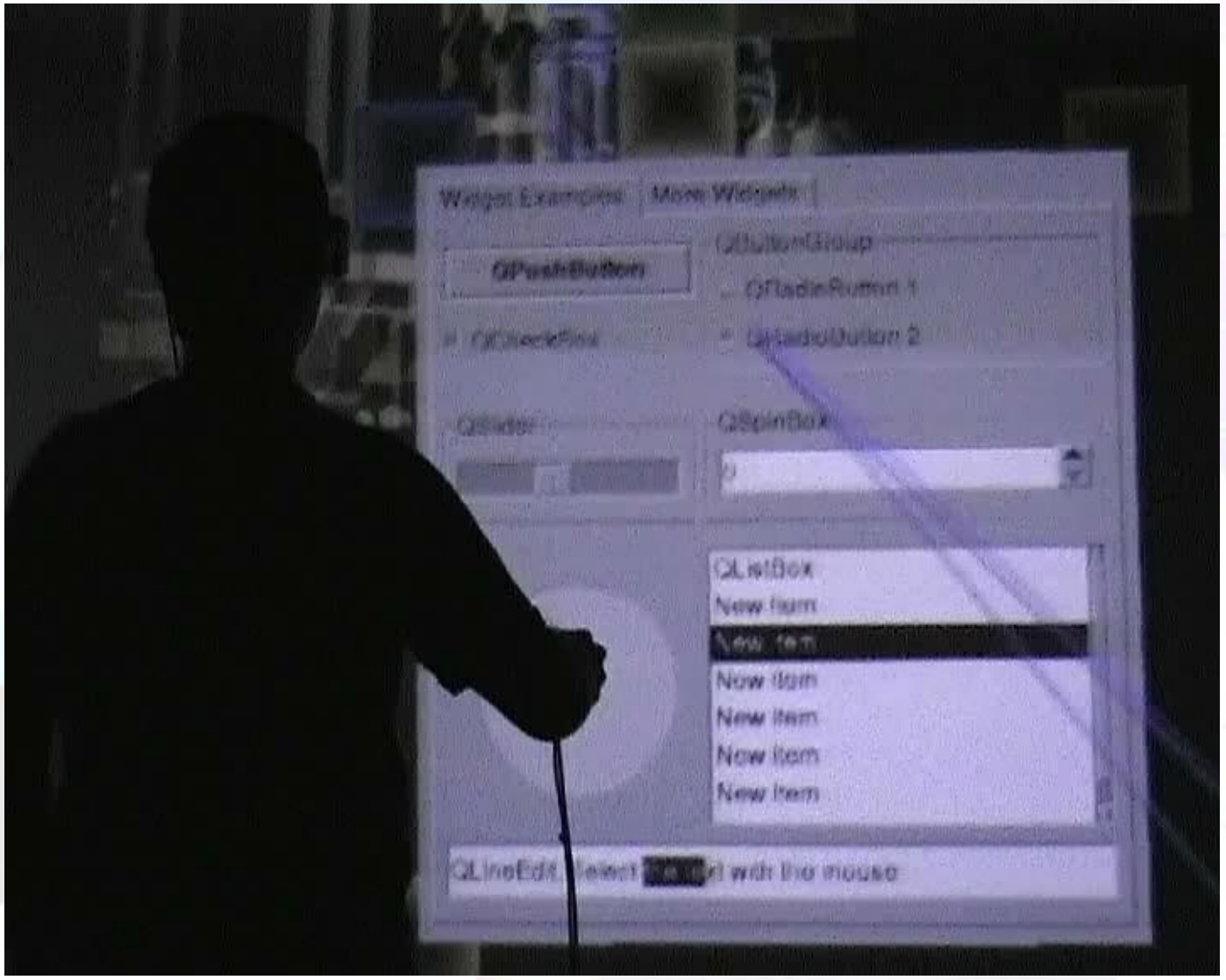




# Natural environment reconstruction



# 3D Interaction



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