

*Groupware and Collaborative Interaction*  
**Collaborative Virtual Environments**

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# Outline

Virtual Reality

Collaboration in Virtual Reality

Awareness

Communication

Collaborative Interaction

Navigation

Co-manipulation

# Outline

## Virtual Reality

### Collaboration in Virtual Reality

Awareness

Communication

Collaborative Interaction

Navigation

Co-manipulation

# Virtual Reality

## Virtual environment (VE)

3D virtual world

Simulated by computers



## Interaction in real time

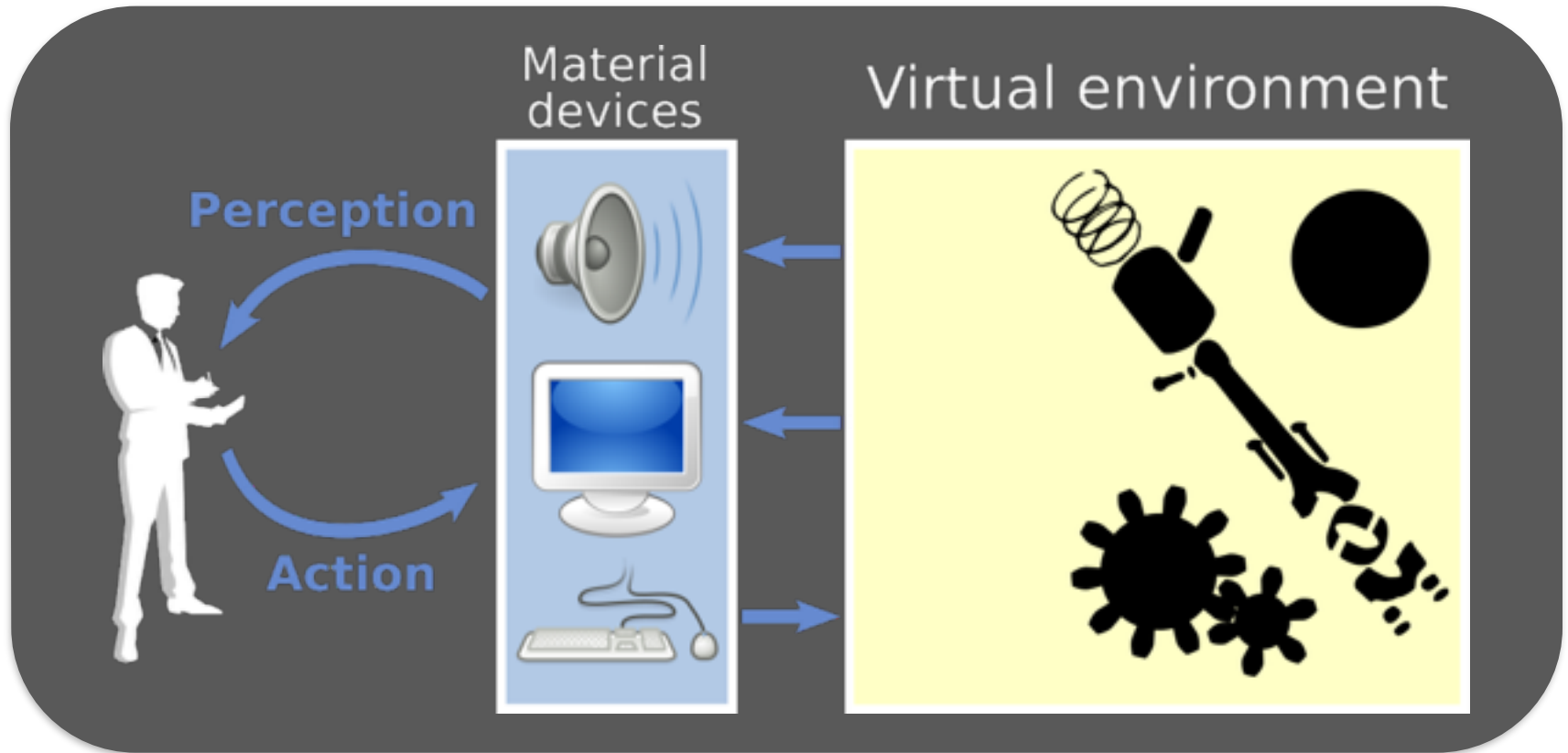
Trough various material devices

## Immersion

Multi-sensorial perception of the VE

# Virtual Reality

## Action/perception loop



# Interaction

3 kinds of interaction techniques [Hand, 1997]

Object manipulation (interaction)

Viewpoint manipulation (navigation)

Application Control

[Bowman et al., 2004]

Bowman D. A., Kruijff E., LaViola J. J. et Poupyrev I. (2004).  
3D User Interfaces : Theory and Practice. Addison Wesley.

# Navigation

Move the viewpoint + Modify the scale [Hand, 1997]

Manipulate its own viewpoint

or

Manipulate the viewpoint of the others

Include path finding [Bowman et al., 2004]

# Navigation

## Classical techniques

### Egocentric

Walking metaphor

Flying metaphor

Driving metaphor



### Exocentric

Navidget [Hachet et al., 2008]

Grabbing the air  
[Mapes et Moshell, 1995]

Video



[Hachet et al., 2008]

# Navigation

## Classical techniques : assisted navigation

### Select the destination

Pointing

World In Miniature (WIM)  
[Stoakley et al., 1995]

List of defined path



[Stoakley et al., 1995]

### Move to destination

Teleportation [Ruddle et al., 2000]

Interpolation [Mackinlay et al., 1990]

“Guided visit” metaphor [Elmqvist et al., 2007]

Video

# Navigation

## Multi-scale techniques

### Manuel scale modification

An additional DoF

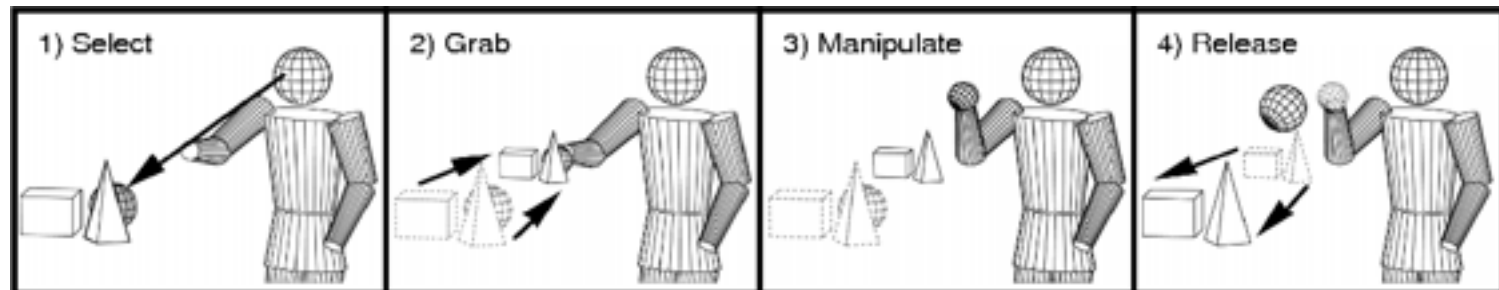
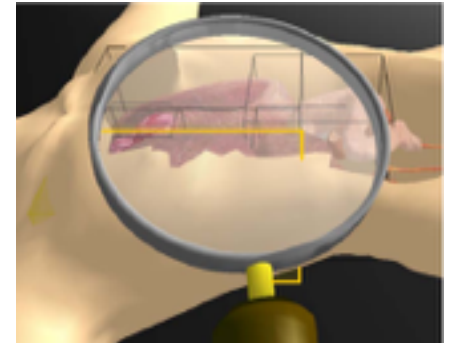
Head-butt Zoom [Mine et al., 1997]



### Automatic scale modification

Bounding Boxes [Kopper et al., 2006]

Scaled-world grab [Mine et al., 1997]



# Object Manipulation

Egocentric

vs

Exocentric

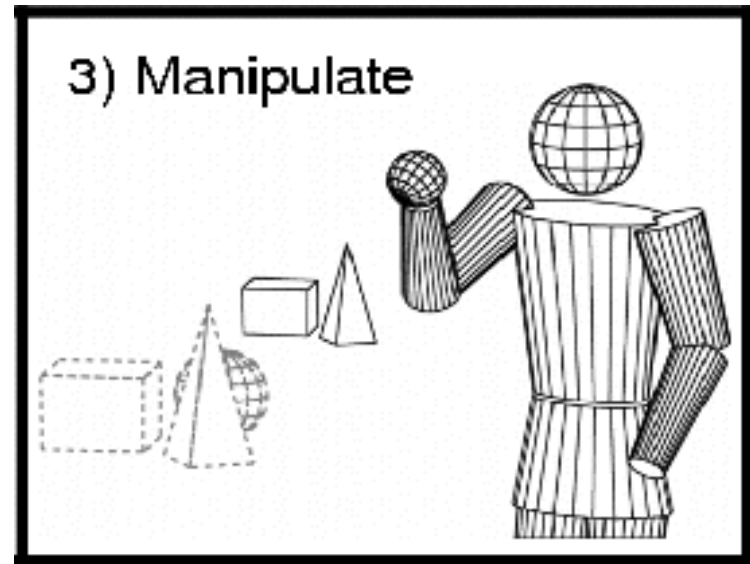
Scaled-world grab

WIM

2 main tasks

Selection

Manipulation



# Object Manipulation

## Virtual Hand [Jacoby et al., 1994]

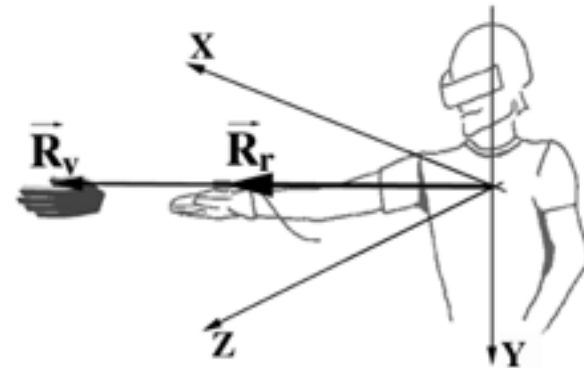
Select and manipulate by touching

## “Go-Go” metaphor

### [Poupyrev et al., 1996]

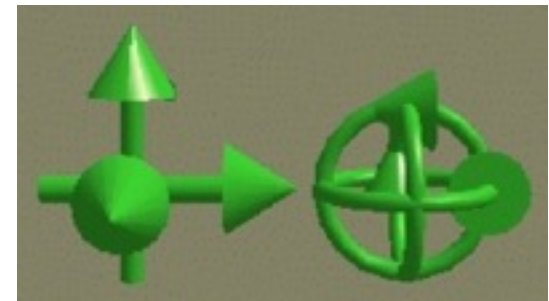
Extend the virtual hand

Move exponentially



## 3D cursor [Zhai et al., 1994]

Position or speed control



# Object Manipulation

Virtual Ray [Mine, 1995]  
Mimic a laser pointer

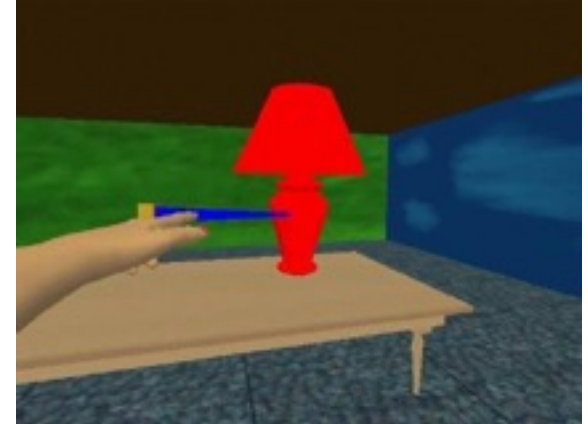
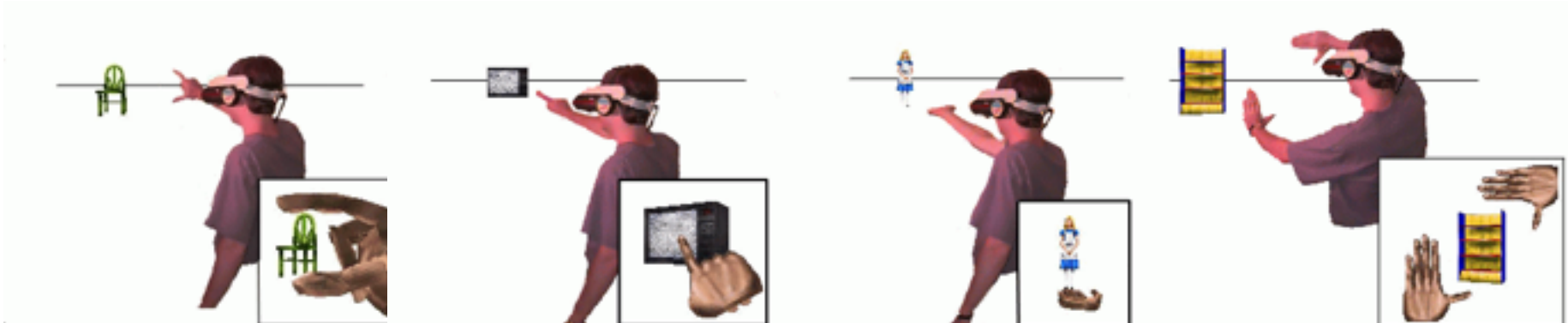


Image plan Interaction [Pierce et al., 1997]  
Select by pointing with one part of the body

Video



# Object Manipulation

Selection/manipulation techniques not always suitable for manipulation

Ex: virtual ray for rotations

Combining several interaction tools

HOMER [Bowman et Hodges, 1997]

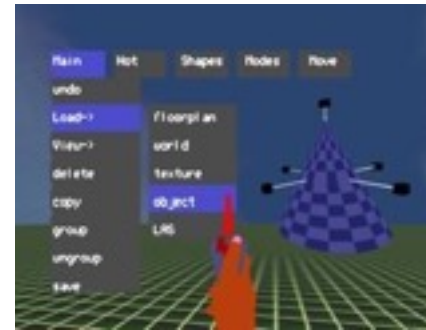
Move the manipulated object close to the user

Attached the interaction tools to the objects

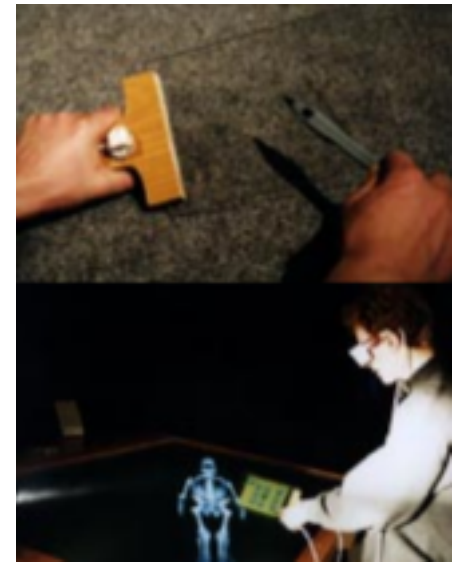
# Application Control

## Control

- Application (exit, pause,...)
- Rendering parameters
- Tools/actions selection



[CDS - Bowman et al., 1991]



[Coquillart et al., 1999]

## Techniques used

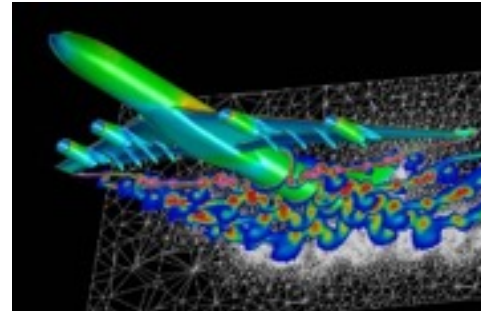
- 2D menus
- 3D menus
- Control on a tablet/smartphone



[CHIMP - Mine et al., 1997]

# Applications of Virtual Reality

Scientific data analysis



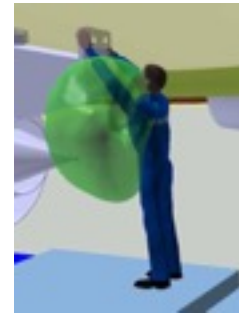
Industrial applications

Design, conception

Fabrication process



Training, education



Phobia therapy, rehabilitation



Entertainments

Video games

Virtual visits of museums

Social communication (telepresence)



# Outline

Virtual Reality

**Collaboration in Virtual Reality**

Awareness

Communication

Collaborative Interaction

Navigation

Co-manipulation

# Collaboration in Virtual Reality



Several users work/play together in a VE

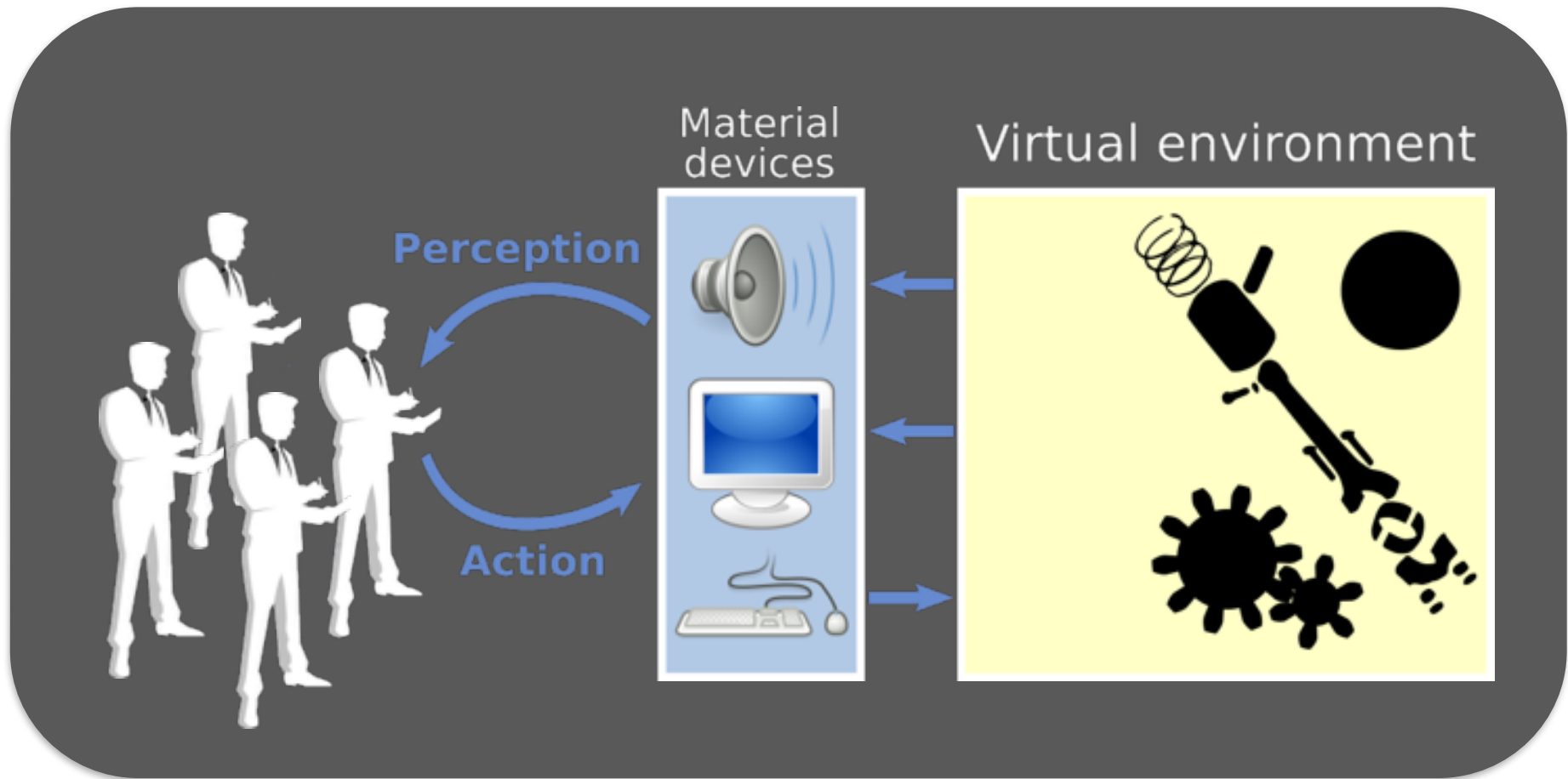
- Co-expertise of 3D data

- Complex manipulation (real or virtual)

- Training

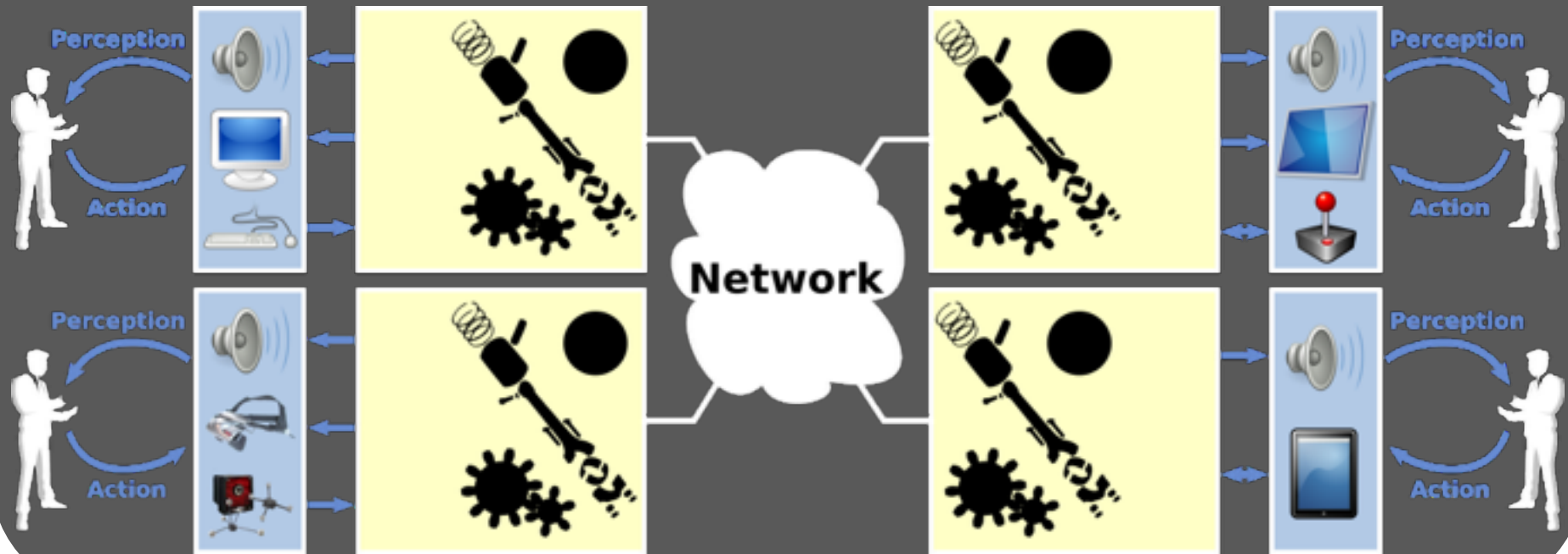
- Social presence (telepresence)

# Co-located collaboration



# Remote Collaboration

## Distributed virtual environment



# Outline

Virtual Reality

Collaboration in Virtual Reality

**Awareness**

Communication

Collaborative Interaction

Navigation

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# Awareness

## Perception of the other users

Where are they?

What are they doing?

What are they looking?

Are they looking at me?

What could they do ?

Can they see me?

Could they see what I am showing to them?

Could they do what I am asking them to do?

# Awareness

## Improve the mutual understanding

Just next to me... But where are you?

Just in front of me ... But where are you looking at?

Etc.

## Multi-sensorial restitution

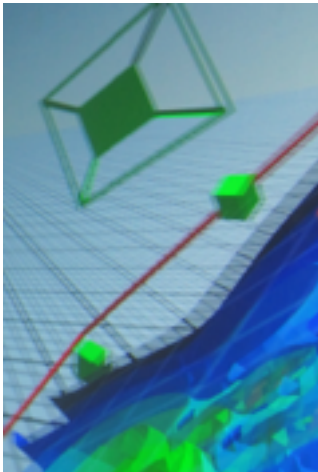
Visual awareness

Audio awareness

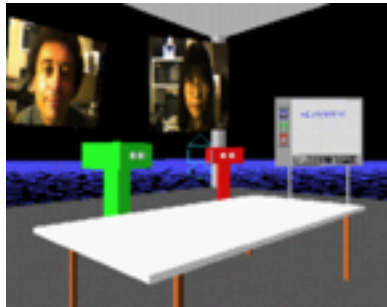
Haptic awareness

# Visual Awareness

Avatar: representation of users in the VE



[Fleury et al., 2012]



[DIVE, 1991]



[CALVIN, 1996]



[Fleury et al., 2008]



[Second Life, 2005]



[Fleury et al., 2013]



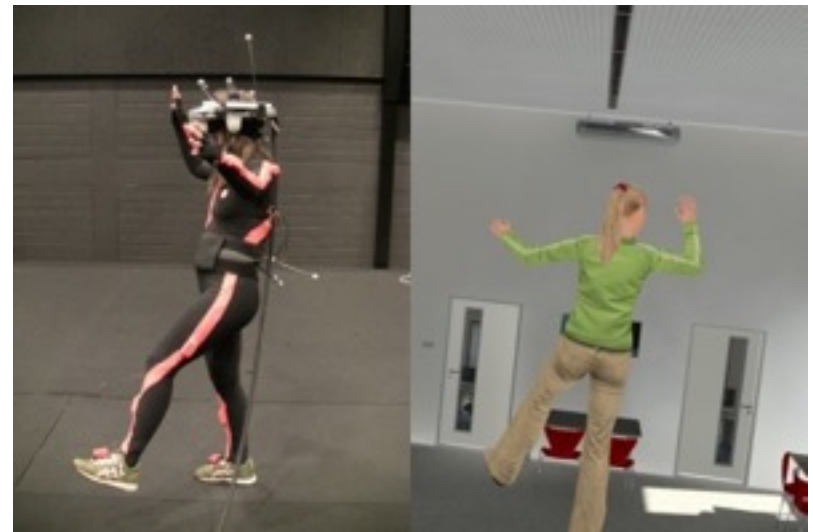
[Beeler et al., 2010]

# Visual Awareness

## Animation of the avatars



Kinect Avatar

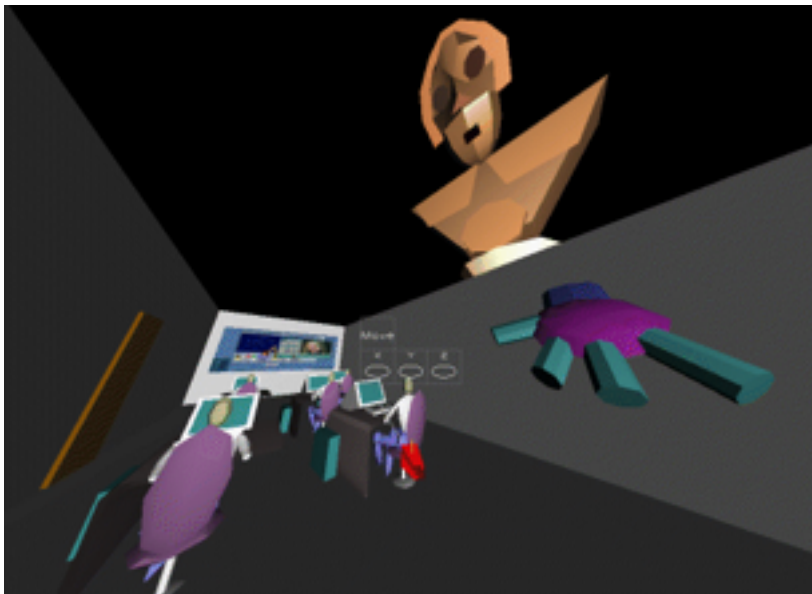


Body tracking

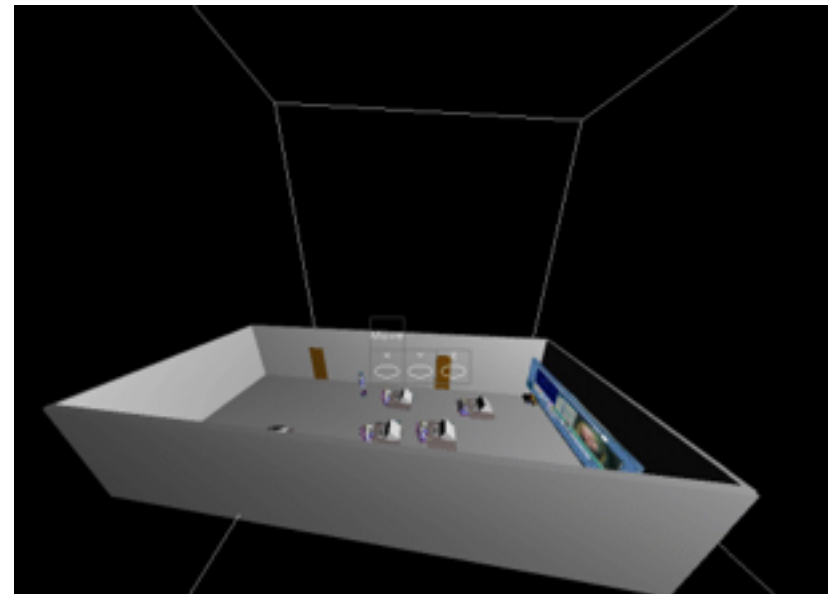
Video

# Visual Awareness

Use of a WIM [CALVIN, 1996]



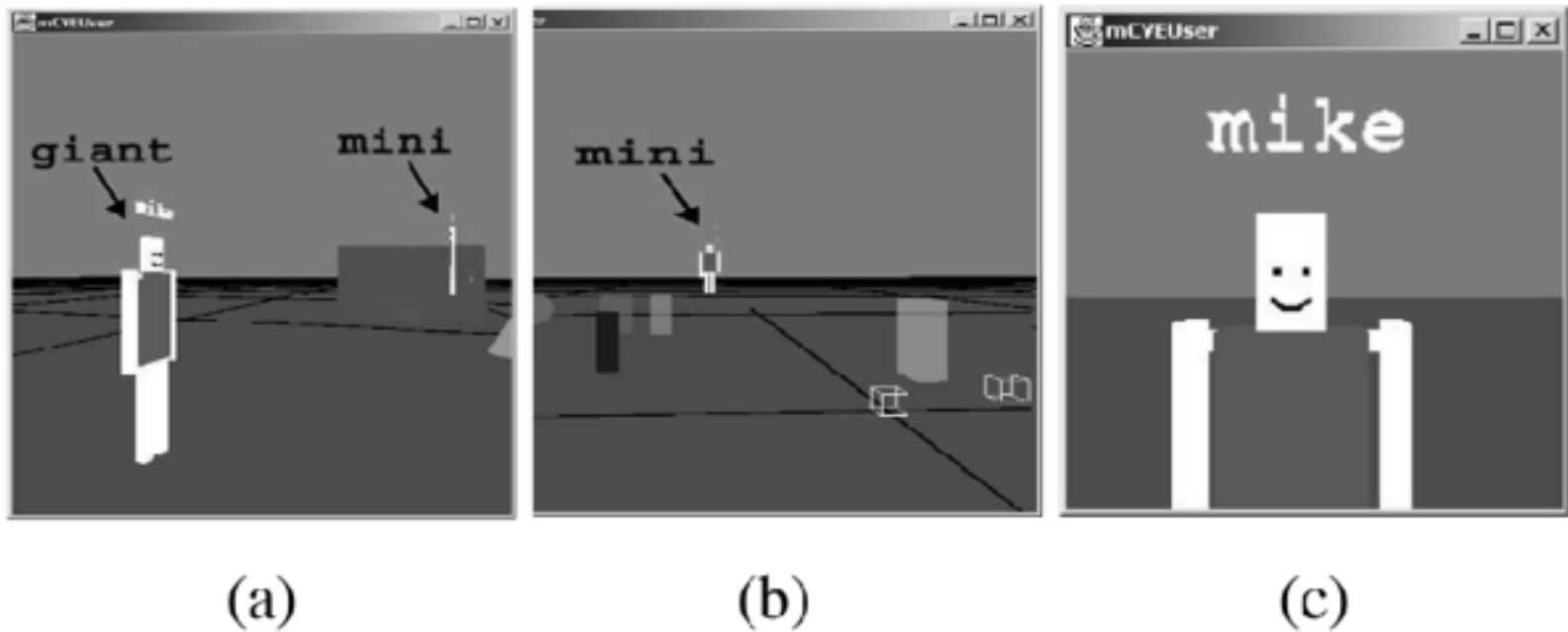
Mortal's view



Deity's view

# Virtual Awareness

## Multi-scale collaborative virtual environment



[Zhang et Furnas, 2002]

# Audio Awareness

Spatialized voice restitution

Remote users' noises

Give a lot of information

Where they are

What they are doing

Add some sounds to describe the actions

Need to be spatialized sounds

# Haptic Awareness

## Force feedback of the others

### Direct

Touch the others through haptic devices

Virtual handshake

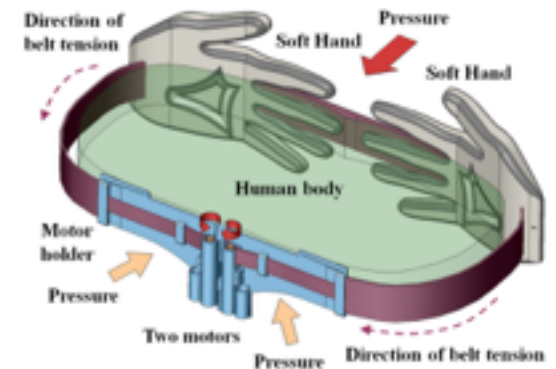
affective haptic

Can be asymmetrical

### Indirect

Manipulate an object together

Feel the force apply by the other on the object



# Awareness Model

## Spatial Model of Interaction [Benford et al., 1994]

Compute which users can interact with others

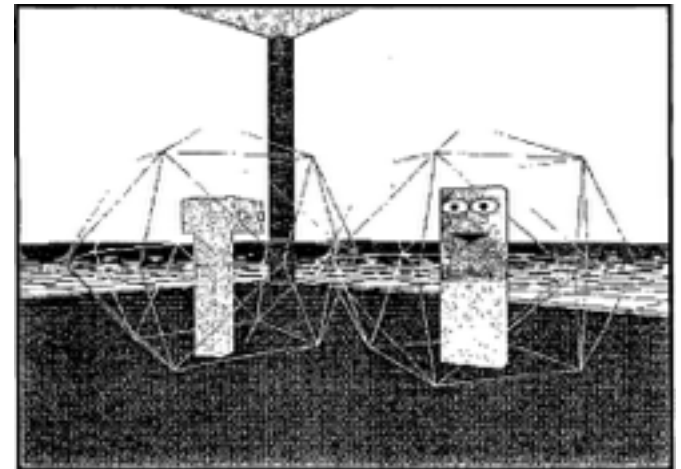
### Medium

A typical communication medium  
Ex: audio, visual, haptic, etc.

### Aura

Sub-space bounding the presence  
in a particular **Medium**

Interaction is possible between  
two users with colliding **Aura**



[Benford et al., 1994]

# Awareness Model

## Spatial Model of Interaction [Benford et al., 1994]

**Aura** determines potential interactions  
(on a technical point of view)

Users are responsible for controlling interactions

Measure of awareness between two users

Asymmetrical

Dependent of the **Medium**  
(i.e. different for each **Medium**)

Introduction of the **Focus** and **Nimbus**

# Awareness Model

## Spatial Model of Interaction [Benford et al., 1994]

### Focus

Area where a user perceives the others

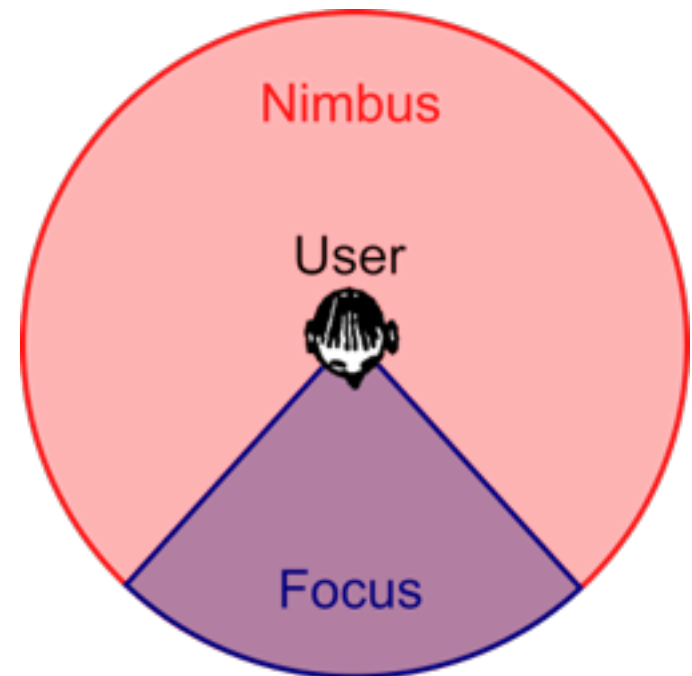
For each particular **Medium**

### Nimbus

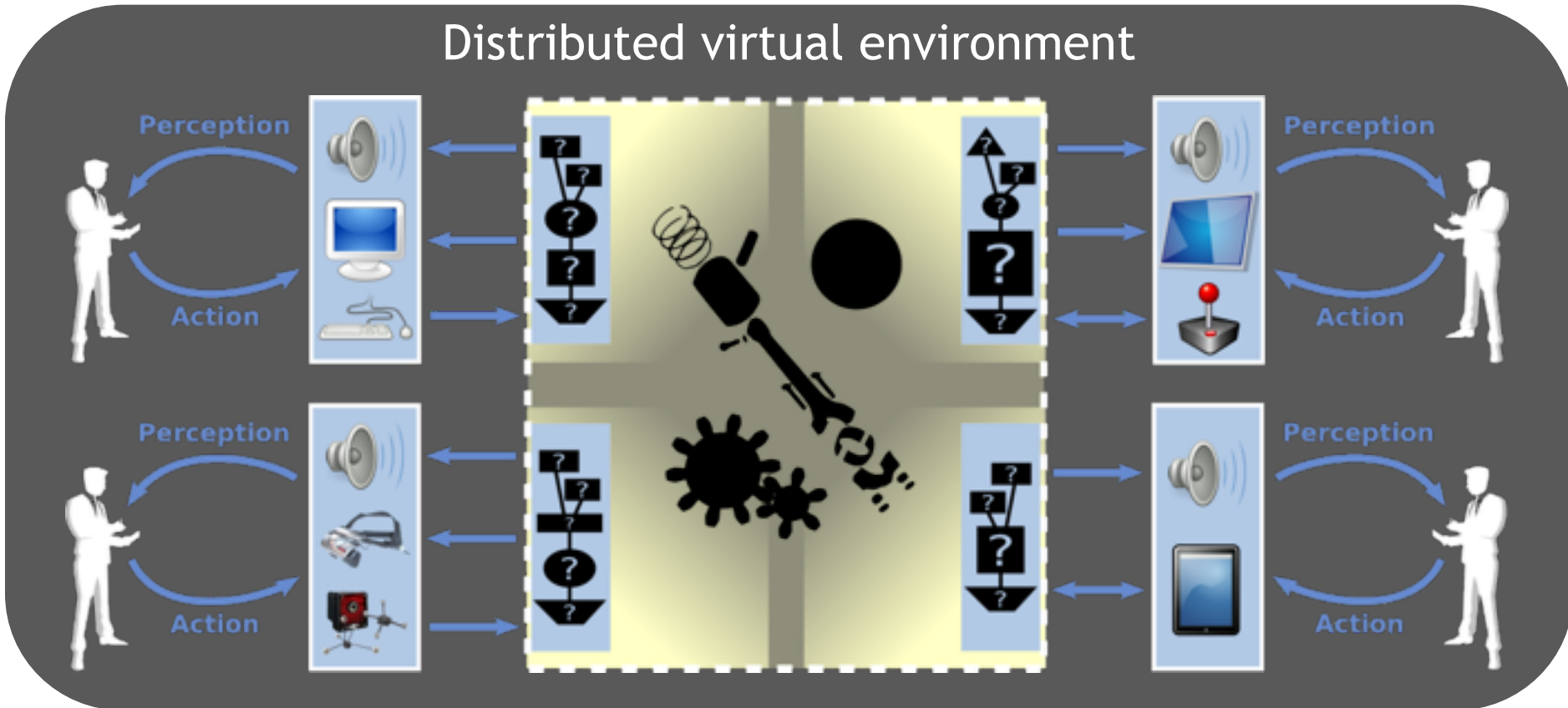
Area where the others can perceive a particular user

For each particular **Medium**

Different from the **focus**



# Activities/Capabilities Perception



⇒ How can users understand what the others are doing?

⇒ How can they understand what the others can do?

# Interaction Workspaces

## 3D space in the real world

Associated to a particular material device

Perceive or interact with the virtual world

Ex: visual, audio, haptic, physical displacement, etc.

## Why integrating these interaction workspaces?

Each user can have different interaction workspaces

Take into account workspaces for users' interaction

Adapt the interaction techniques

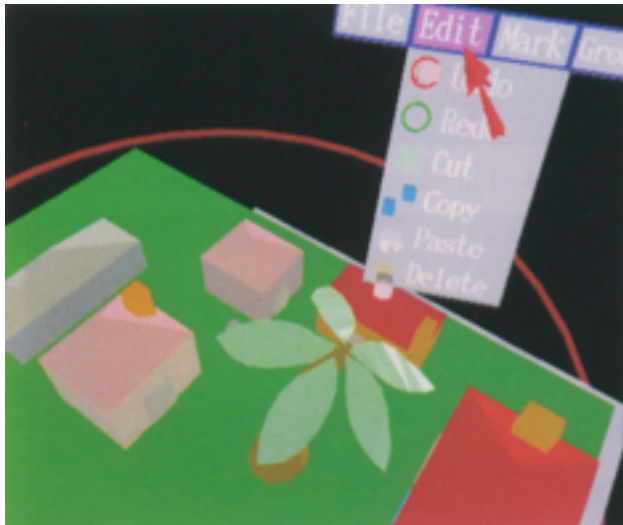
Capabilities perception

# Examples of Interaction Workspaces

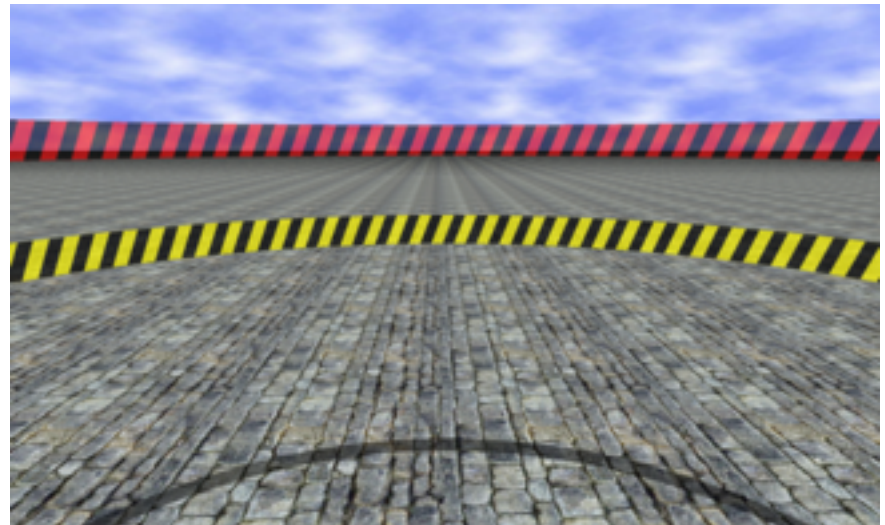
User's physical displacement workspace

Magic Carpet in 3DM [Butterworth et al. 92]

Magic Barrier Tape [Cirio et al. 09]



*Magic Carpet*

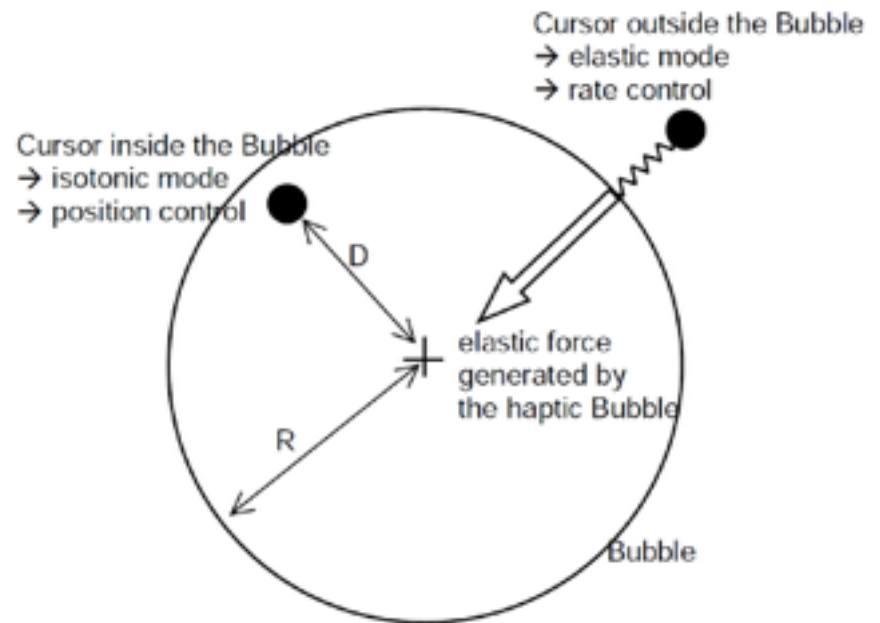
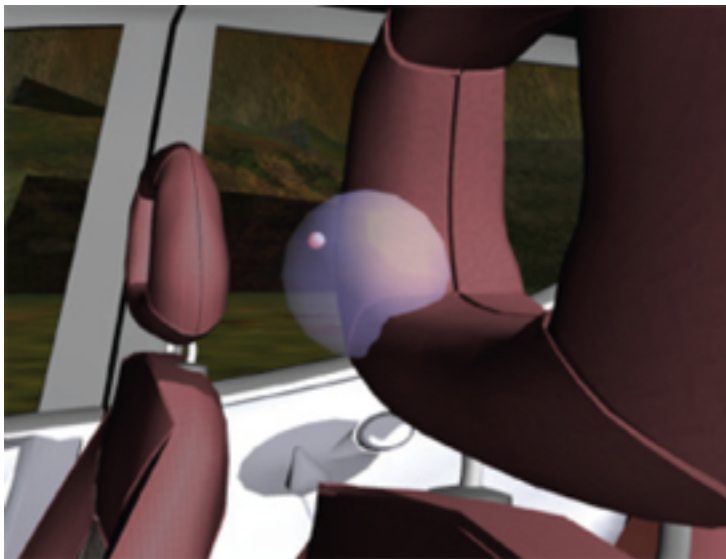


*Magic Barrier Tape*

# Examples of Interaction Workspaces

## Haptic interaction workspace

Bubble technique [Dominjon et al. 05]



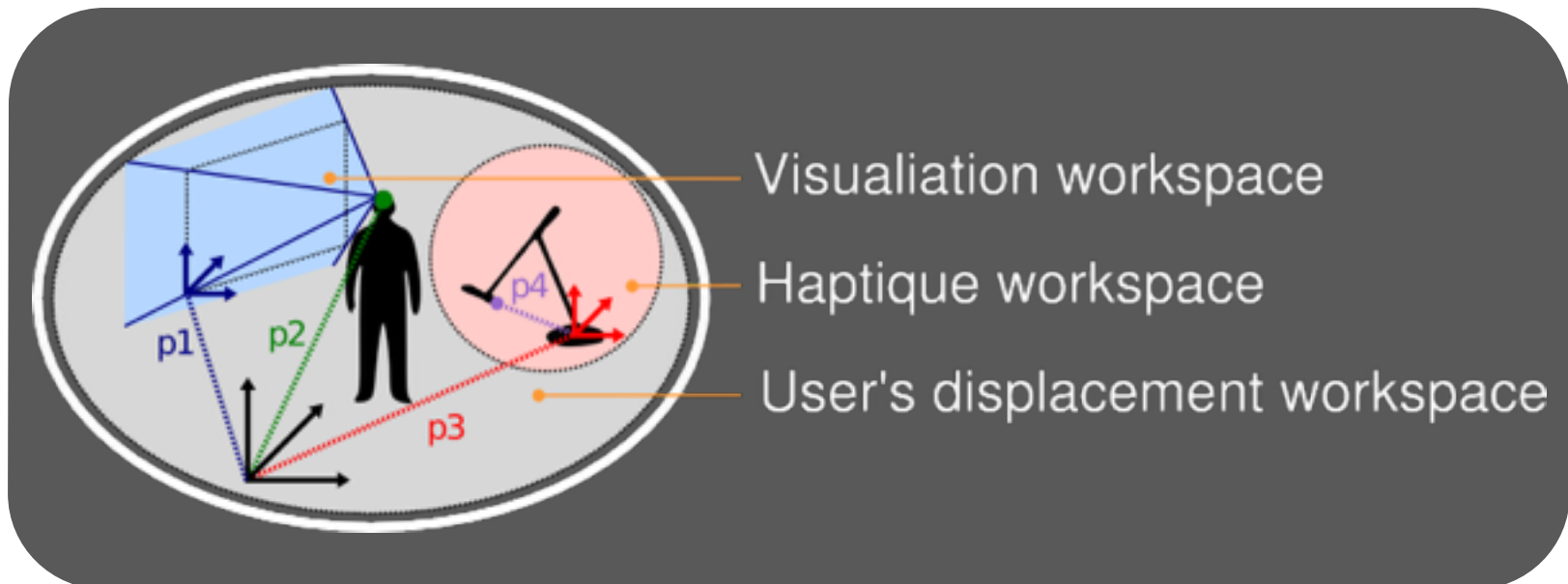
# Immersive Interactive Virtual Cabin

[Fleury et al., 2011]

Organizes and integrates interaction workspaces

Users can carry them on the VE

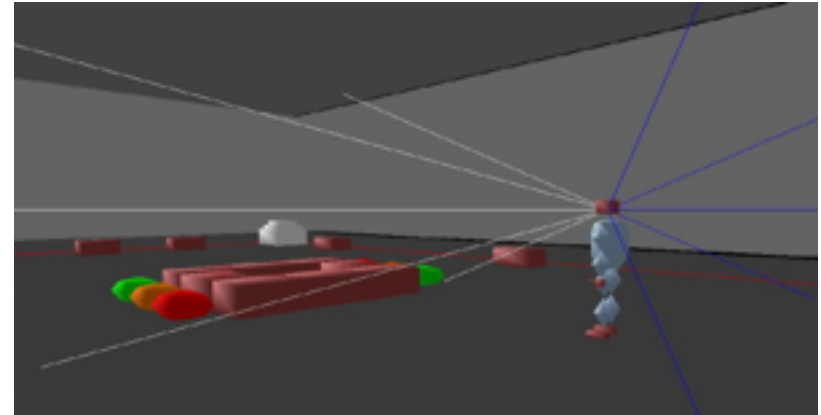
Based on a structured hierarchy



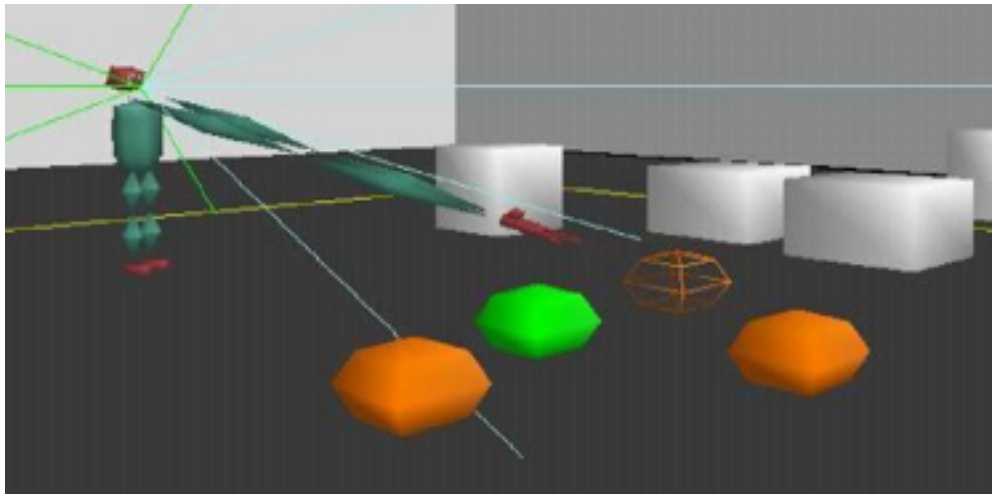
# Activities Perception

[Fraser et al., 1999]

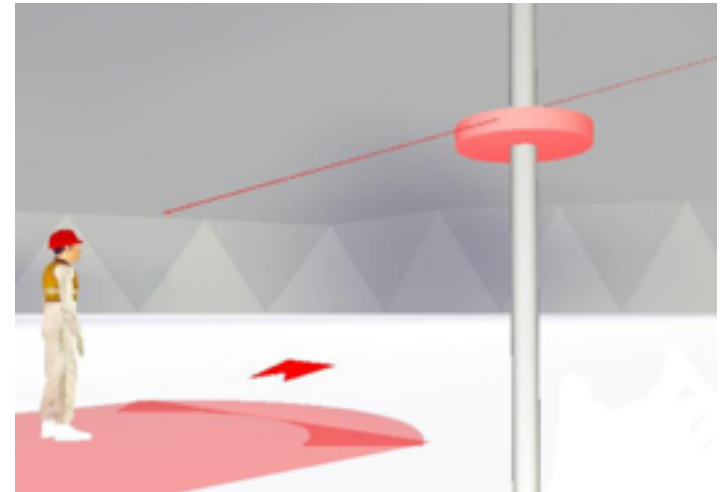
What is the user seeing?



What is the user doing?



[Fraser et al., 1999]



[Duval et al., 2008]

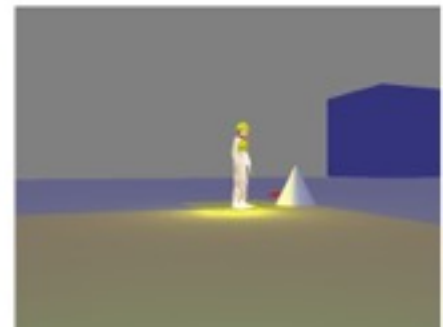
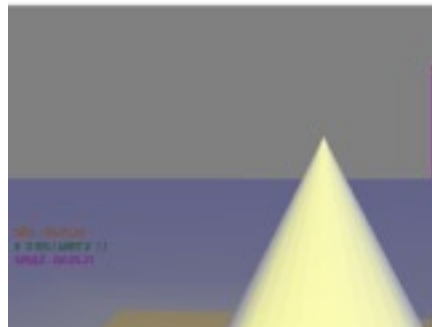
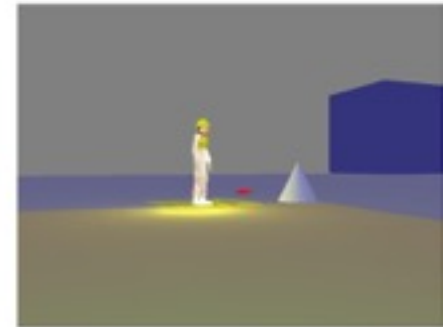
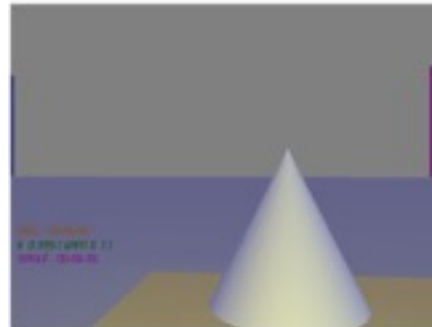
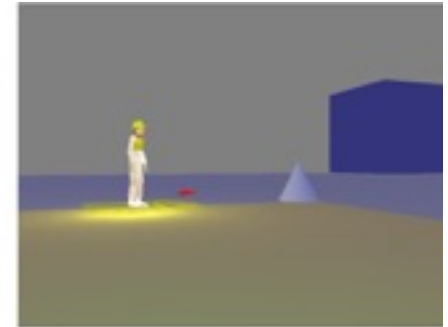
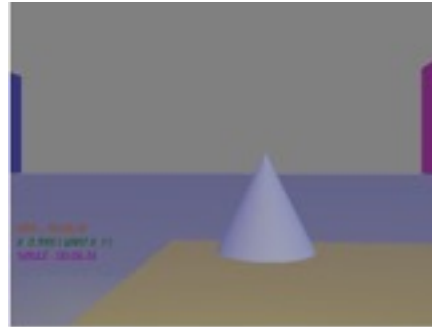
# Capabilities Perception

Example for the user himself:  
user's displacement workspace



# Capabilities Perception

Example for another user:  
interaction workspace



# Outline

Virtual Reality

Collaboration in Virtual Reality

Awareness

**Communication**

Collaborative Interaction

Navigation

Co-manipulation

# Voice communication

Essential for collaborative application

Compensate a bad perception of the VE  
[Hindmarsh et al., 1998]

Share different point of view

However:



Voice communication induces also discontinuity in interaction

[Bowers et al., 1996]

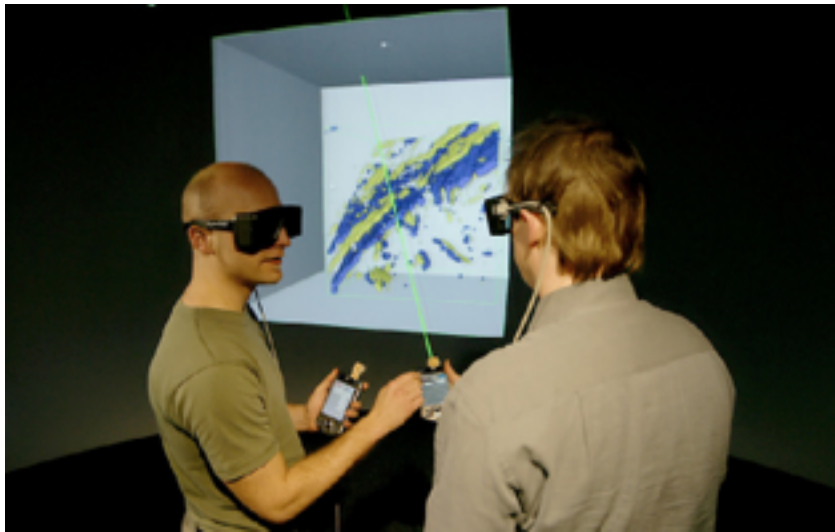
⇒ Users need specific tools for communication

# Tools for communication

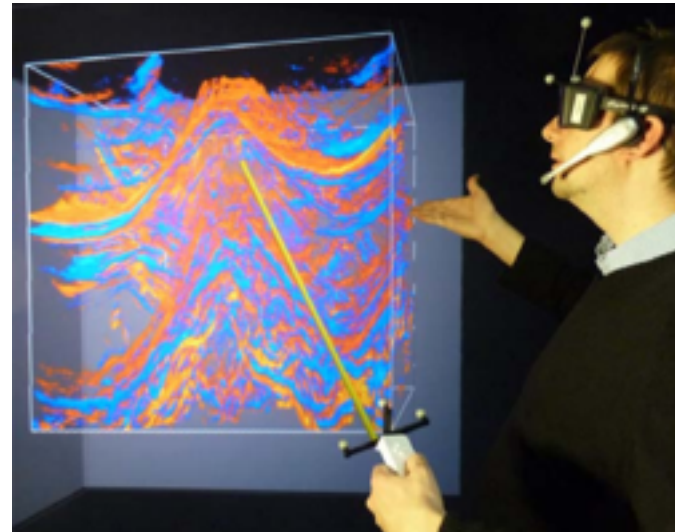
## Virtual Ray

Laser pointer metaphor

Easy and intuitive manipulation



[Simon, 2005]



[Schild et al., 2009]

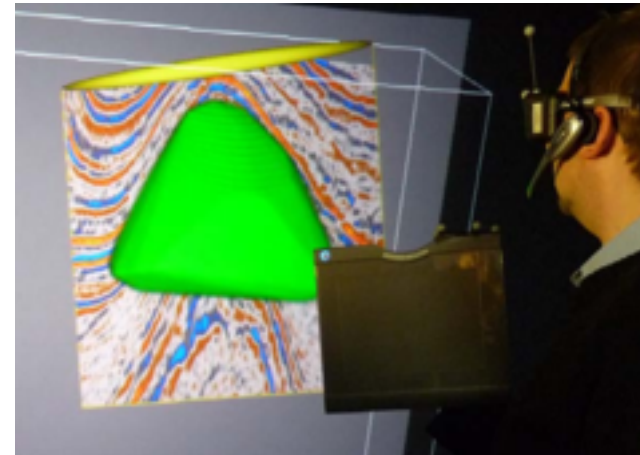
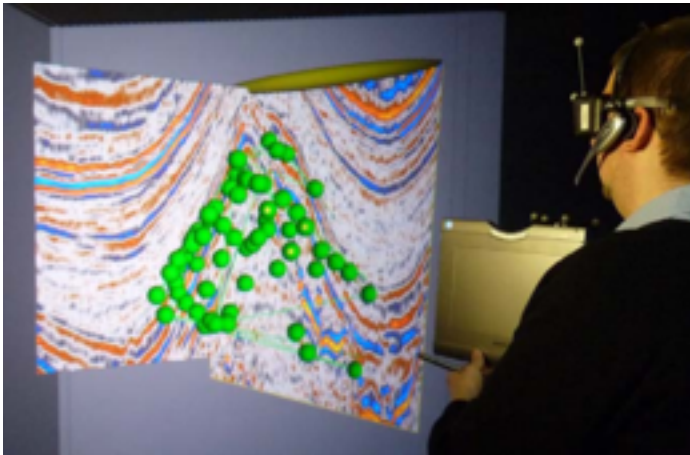
# Tools for communication

## Annotations

Sketching, text, audio, videos

Especially relevant for scientific data analysis

Synchronous and asynchronous collaboration



[Schild et al., 2009]

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# Collaborative Navigation

## Collaborative virtual environment

WYSINWIS (What Your See Is Not What I see)

Each user can have its own viewpoint

But, sometime users need:

To share the same viewpoint

To meet somewhere in the VE

To guide others in the VE

To follow each other

# Collaborative Navigation

## 3 main modes of collaborative navigation

Share the same point of view

One user drives, the other follows

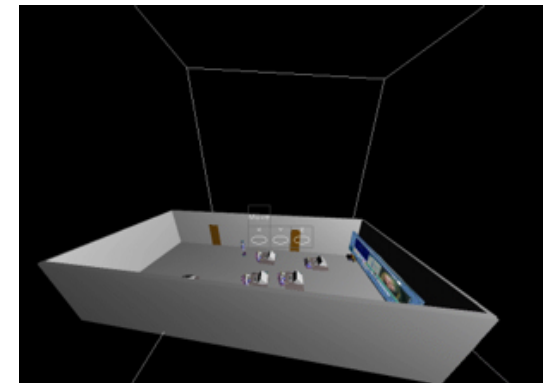
One move and the other follows with an offset

One user drives, the other can modify his offset

## World in Miniature

Guide the others through the WIM

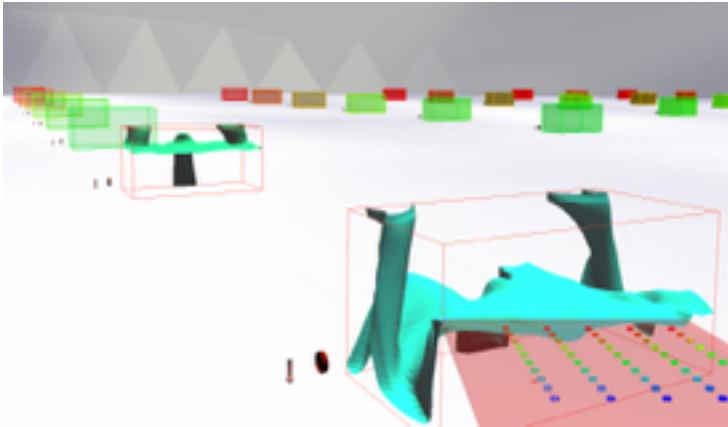
Move the others through the WIM



[CALVIN, 1996]

# Viewpoints sharing

[Duval et al., 2008]



Context: scientific data analysis

Users can:

- Save interesting viewpoints

- Select on particular viewpoint

- Travel cross of the saved viewpoints of a particular user





# Group Navigation

[Dodds et Ruddle, 2008]

Users are part of a predefined group

Each user can travel independently

Functionalities help to travel with the group

To follow the first member of the group

To come back at the middle of the group  
(mean of member positions)



# Guidance techniques

[Nguyen et al., 2013]



Context: collaborative navigation in a building

User 1 is in an immersive room

Find several targets in the building

User 2 is in front a desktop workstation

Guide the other user using a WIM

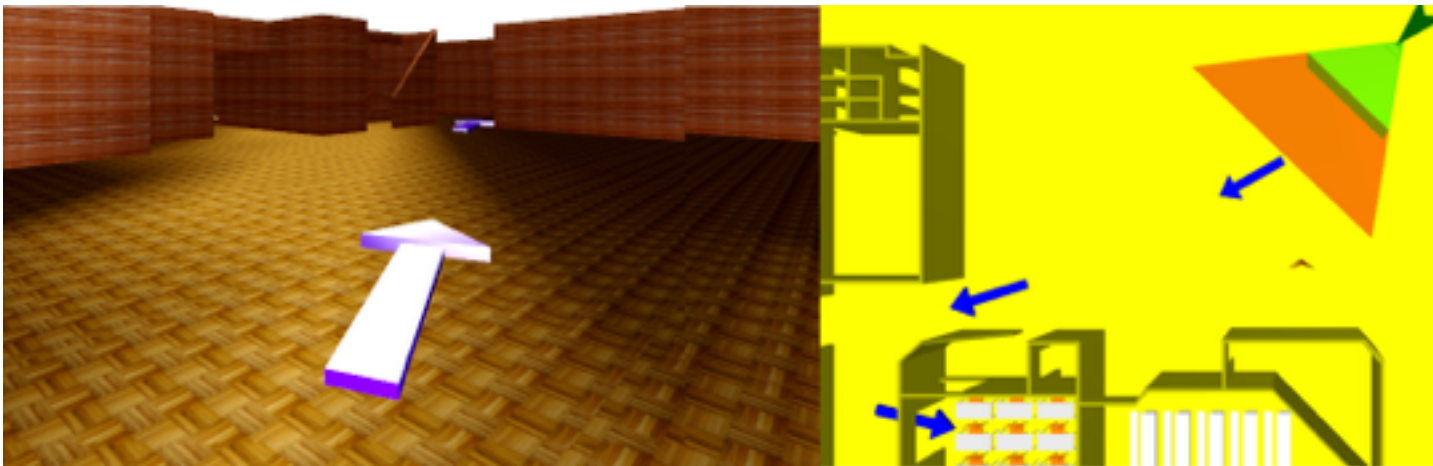
Not verbal communication

# Guidance techniques

[Nguyen et al., 2013]

## Technique 1:

Draw arrows in the virtual environment

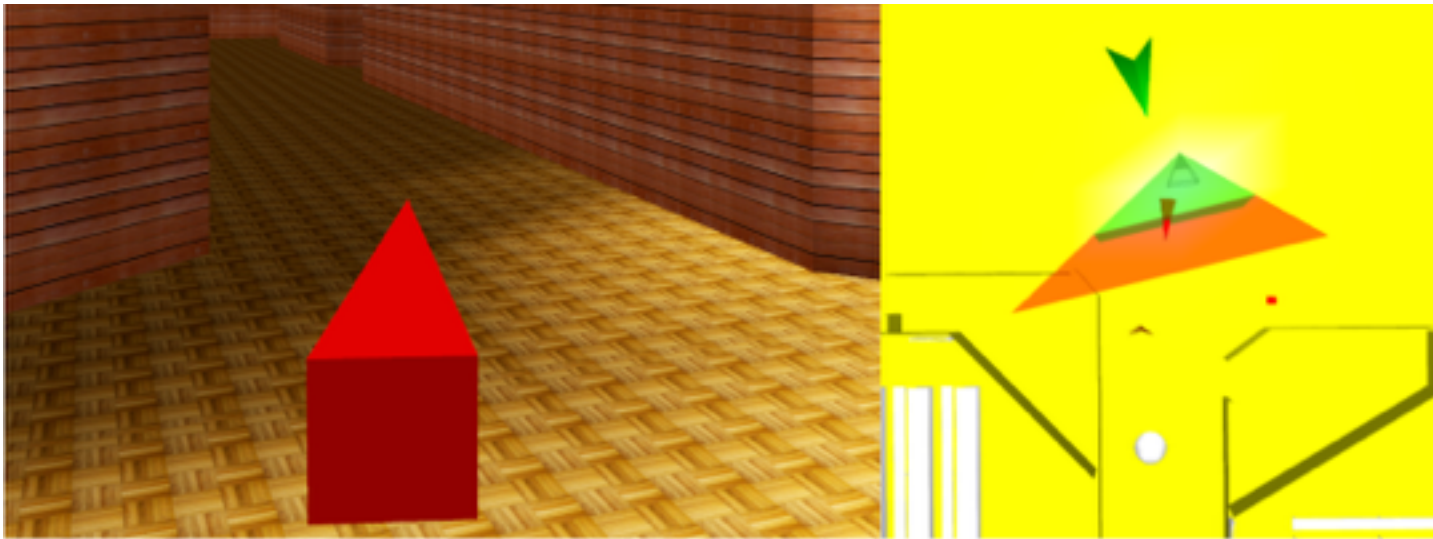


# Guidance techniques

[Nguyen et al., 2013]

## Technique 2:

Orient an arrow attached to the user (like a compass)

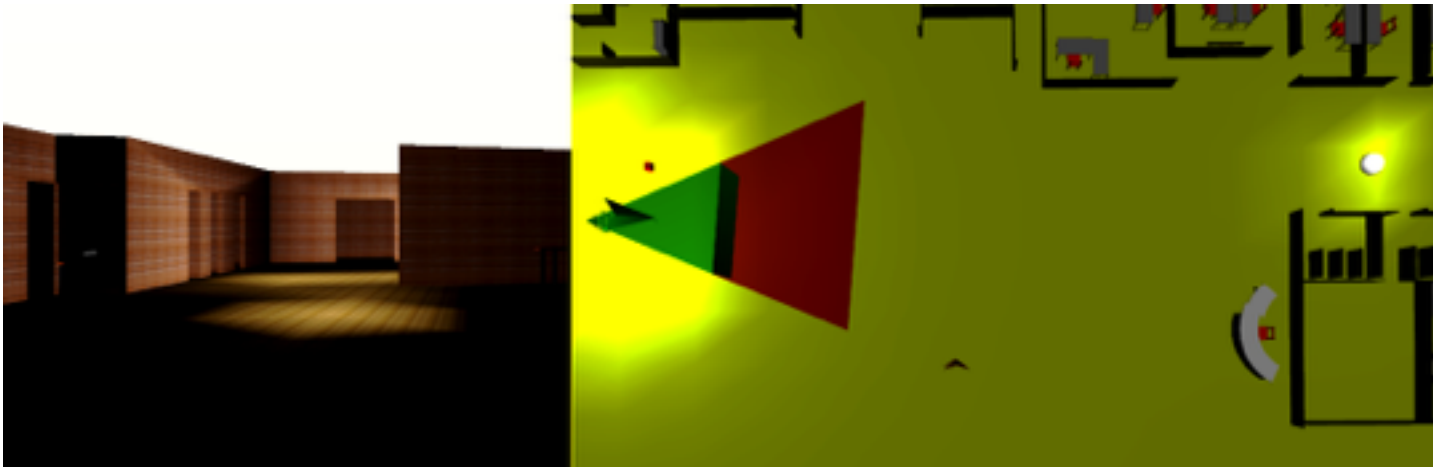


# Guidance techniques

[Nguyen et al., 2013]

## Technique 3:

Align the path in the virtual environment



Video

# Outline

Virtual Reality

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Awareness

Communication

**Collaborative Interaction**

Navigation

**Co-manipulation**

# Co-manipulation

Several users manipulate a same virtual object

Achieve a hard manipulation task in VE

Mimic the same task than in the real world (training)

2 solutions

Users manipulate different DoF of an object

Users can manipulate the same DoF of an object

DoF: Degree of Freedom

Usually 6 DoF (3 translations, 3 rotations) + the scale

Some other parameters (color, shape, etc.)

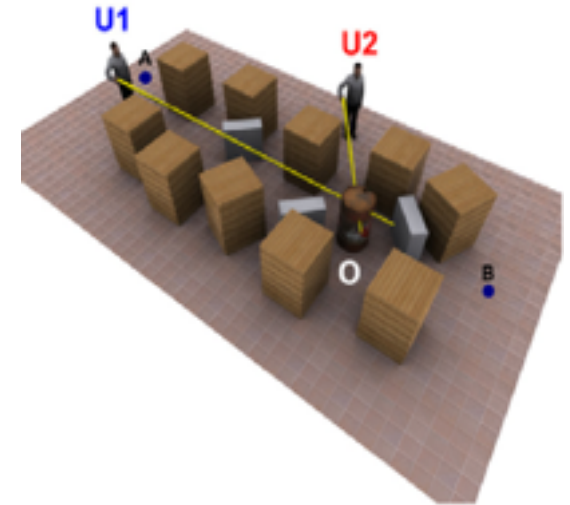
# Manipulate different DoF

Users use the same tools

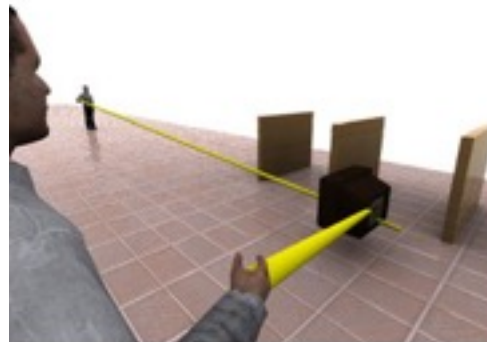
Ex: two virtual rays [Pinho et al., 2008]

Help with obstacles

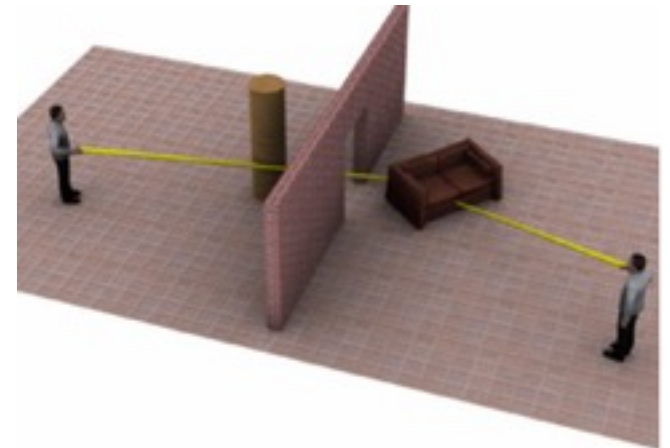
Help when the depth is hard to perceive



User U1's view



User U2's view



# Manipulate different DoF

Users use different tools

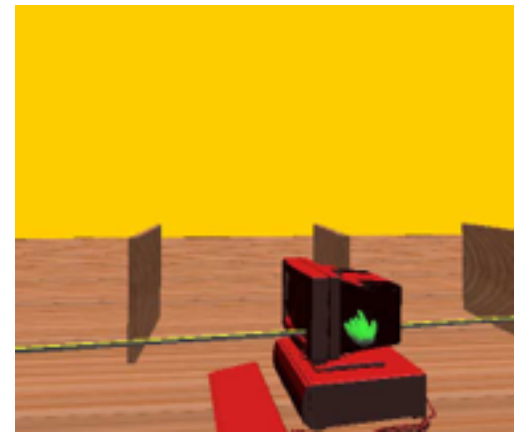
Ex: a virtual ray and a virtual hand

Virtual ray manages positions

Virtual hand manages rotations

User studies show [Pinho et al., 2002]

Faster, easier and more precise  
than single user manipulations



[Pinho et al., 2002]

# Manipulate the same DoF

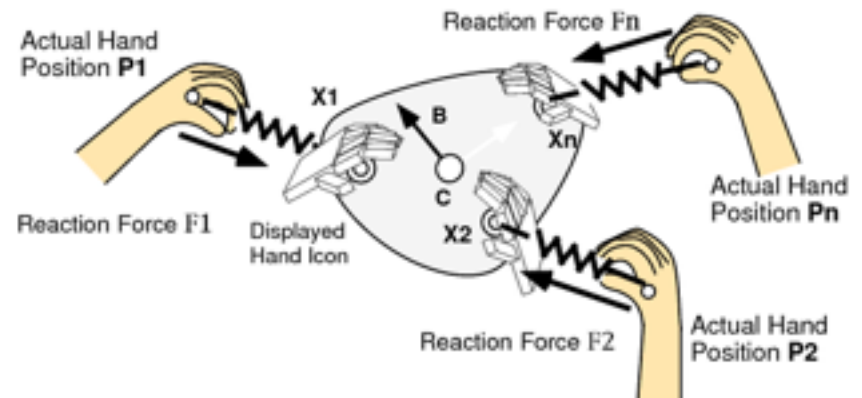
Manipulate together positions and orientations

Compute the mean of each user's actions

Use a physical engine [Noma et Miyasato, 1997]

Positions and orientations are the results of all the forces applied by the users

Add springs between users' hands and the object to avoid instability



# Manipulate the same DoF

Holding together a virtual object

Need at least 3 control points

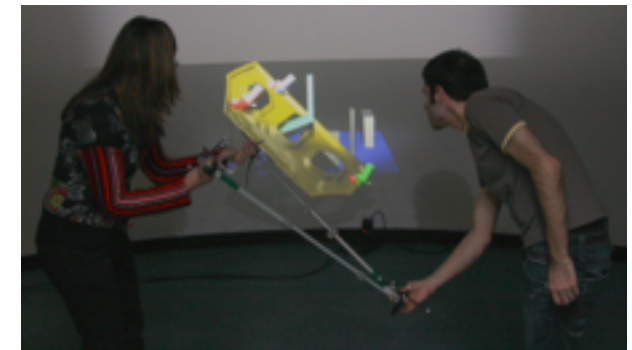
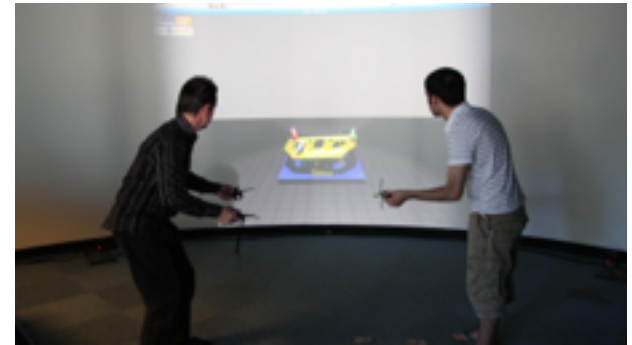
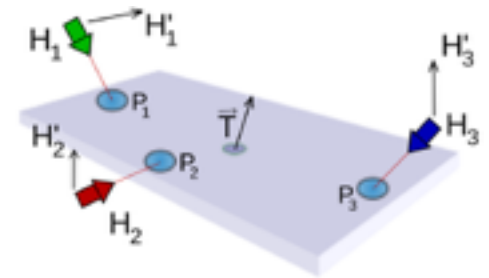
3 hand manipulation technique  
[Aguerreche et al., 2009]

One user has 2 control points

The other has 1 control point

Co-located or remote collab.  
[Fleury et al., 2012]

Implemented with a prop  
(Reconfigurable tangible device)  
[Aguerreche et al., 2010]



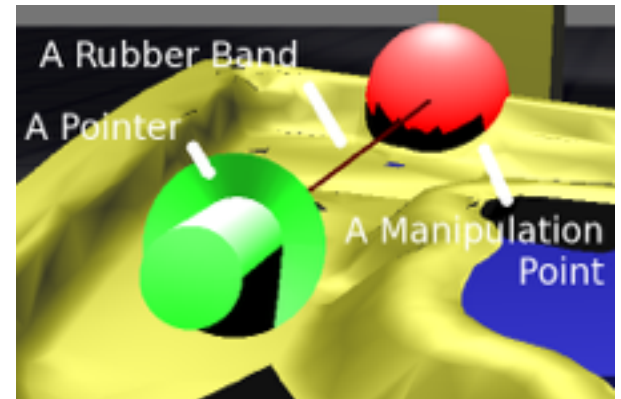
# Manipulate the same DoF

Provide feedback to users about their actions

Force feedback with haptic devices

Springs or rubber bands

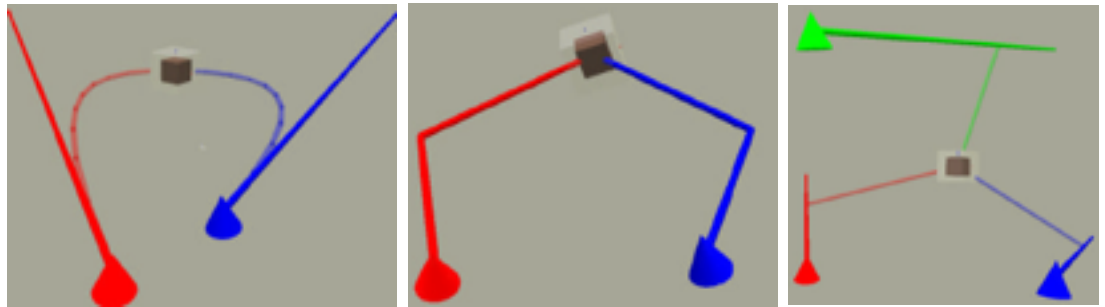
Curve virtual ray



[Aguerreche et al., 2009]



[Riege et al., 2006]



[Duval et Fenals, 2002]

# Conclusion

## Collaborative Virtual Environment (CVE)

Several solutions to represent users in a CVE

From realistic to simplified solutions

Activities/Capabilities perception

Usually voice communication

But not so much tools to improve the communication

Techniques for collaborative interaction

Navigation together or help the other to navigate

Move virtual objects together

# Conclusion

## Collaborative Virtual Environment (CVE)

Feedback of what the others are doing is very important  
Especially for co-manipulation

## Applications of CVE

Co-expertise, collaborative review or design

Training (learn a collaborative task or learn with a remote teacher)

Entertainment (video games, artistic performance, etc.)

Social presence (telepresence)