Collaborative Virtual Environments

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Outline

Introduction to Mixed Reality (MR)

Overview of Interaction in MR

Collaboration in MR

- Remote Collaboration
- Co-located Collaboration

Awareness and Communication

Collaborative Interaction

- Navigation
- Co-manipulation

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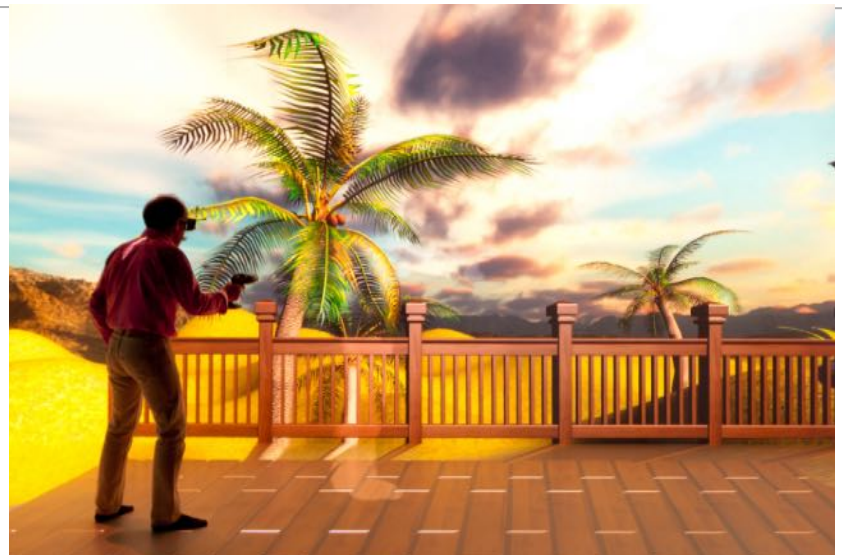
Virtual Reality



Virtual environment (VE)

- 3D virtual world
- Simulated by computers

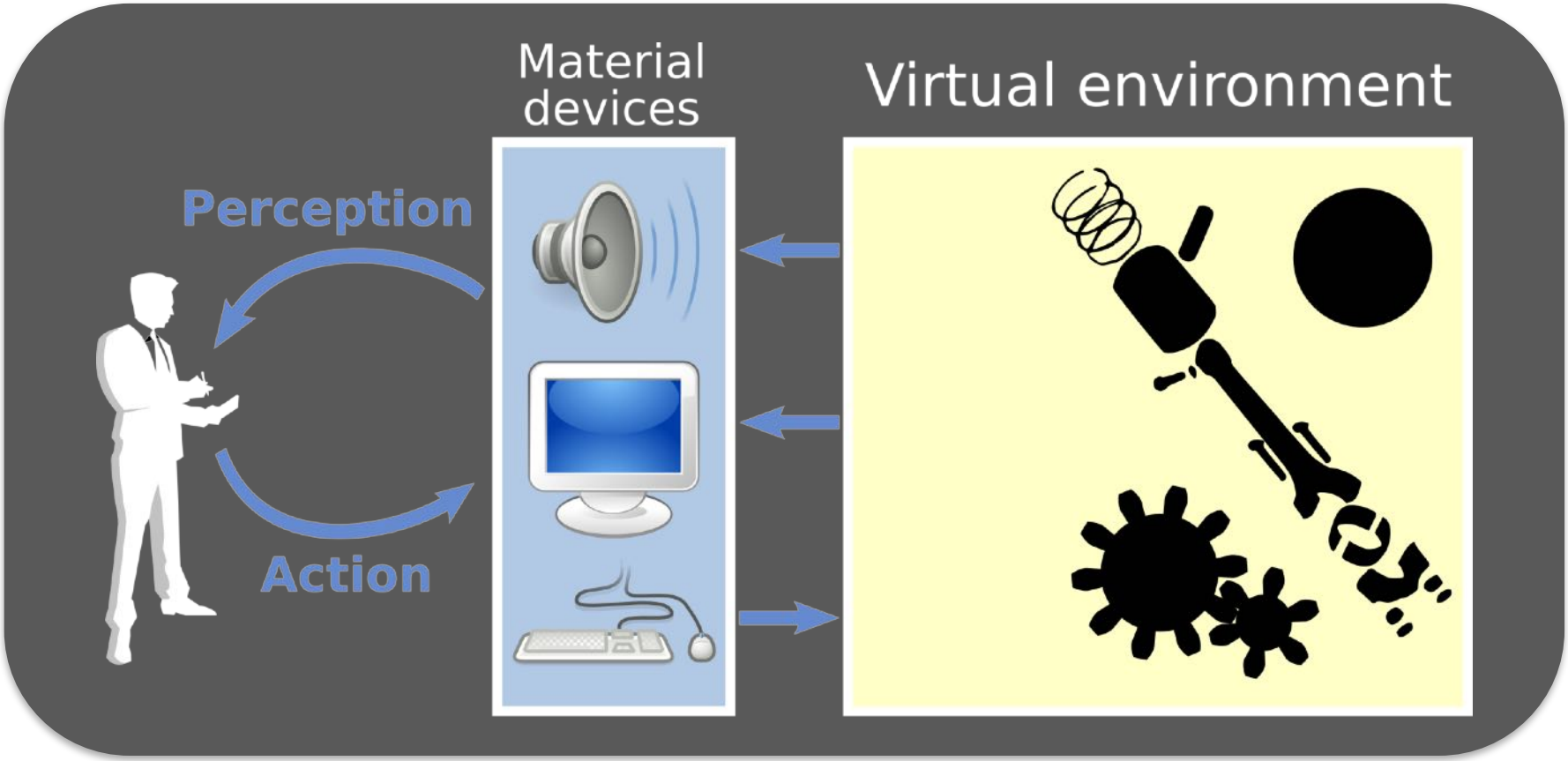
Interaction in real-time

- Through various material devices

Immersion

- Multi-sensorial perception of the VE

Action/perception loop

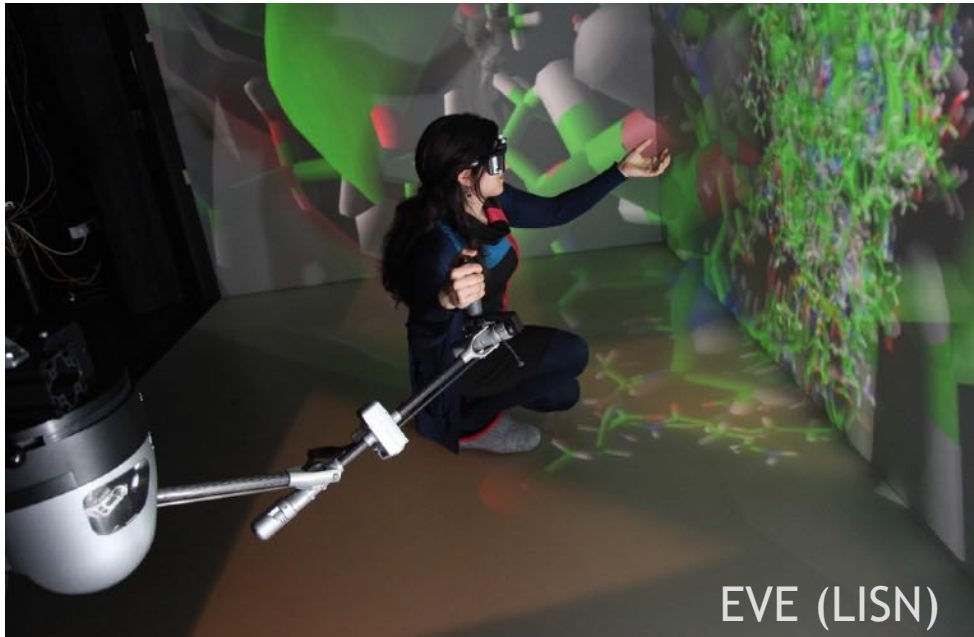


Immersive devices


Ivan Sutherland (1968)

HTC Vive


CAVE (Univ. Chicago)


EVE (LISN)

The power of immersion

Body perception

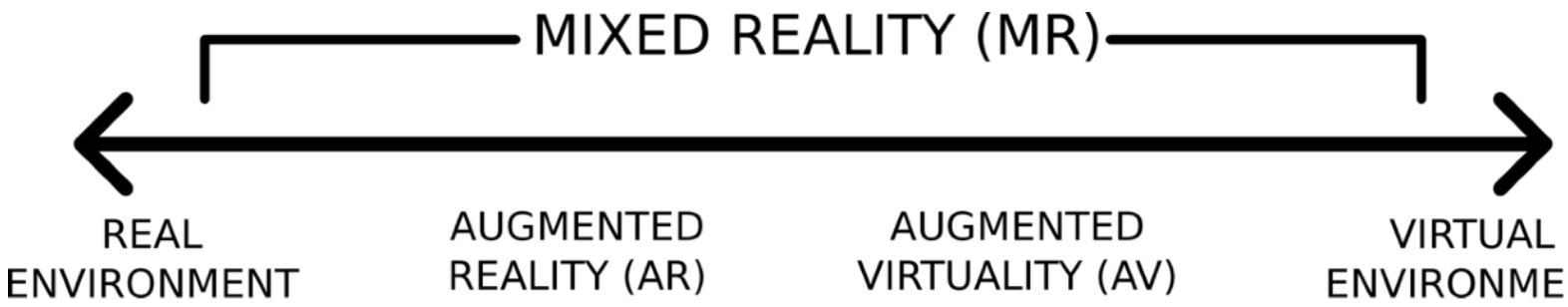
Cure phobia

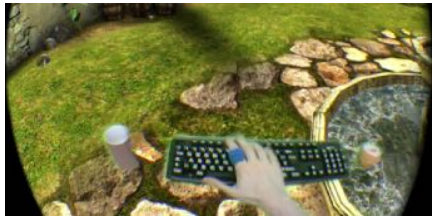
Augmented Reality

Real environment + Virtual environment

Add virtual information onto the real environment

Milgram Continuum





Virtual Reality

Applications of Mixed Reality

Scientific data analysis

Industrial applications

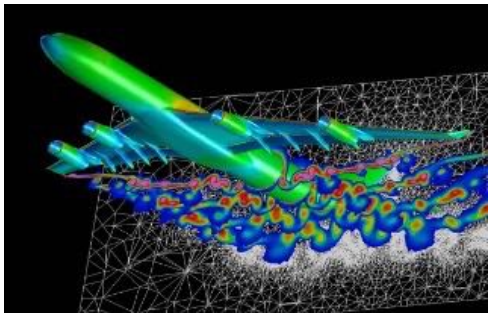
- Design, conception
- Fabrication

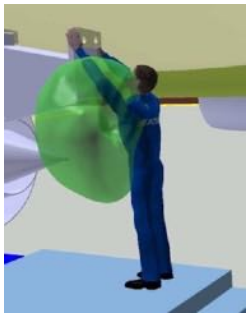
Training, education

Phobia therapy, rehabilitation

Entertainment

- Video games
- Virtual visits of museums
- Social communication (telepresence)





Outline

Interaction

3 kinds of interaction techniques [Hand, 1997]

- Viewpoint manipulation (navigation)
- Object manipulation (interaction)
- 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

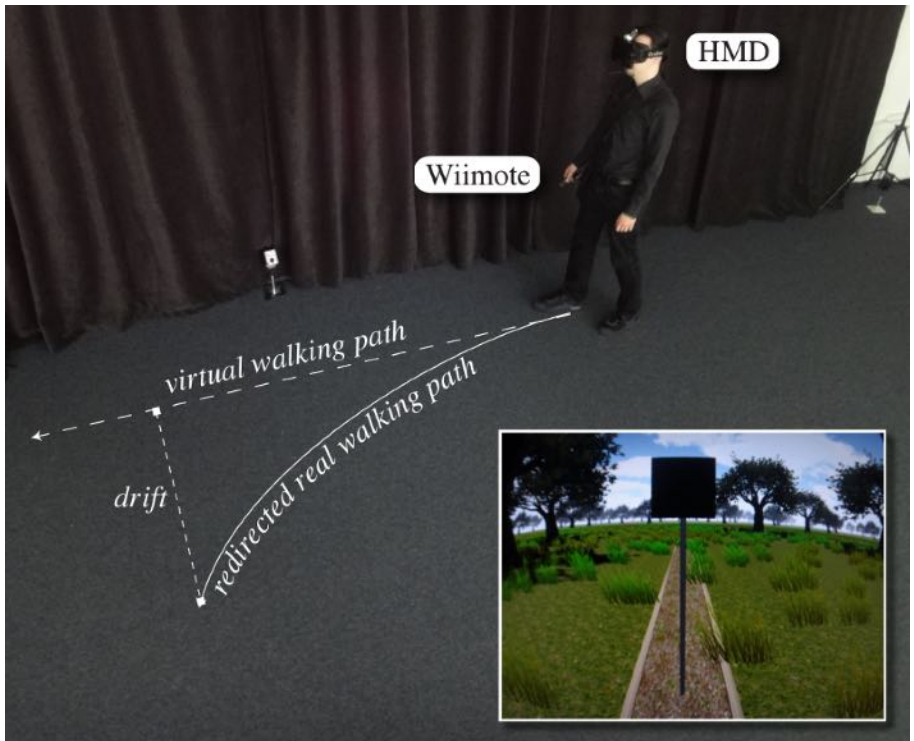
Manipulate the viewpoint of the others

Includes path finding [Bowman et al., 2004]

Navigation

Egocentric techniques

- Walking metaphor
- Flying metaphor
- Driving metaphor

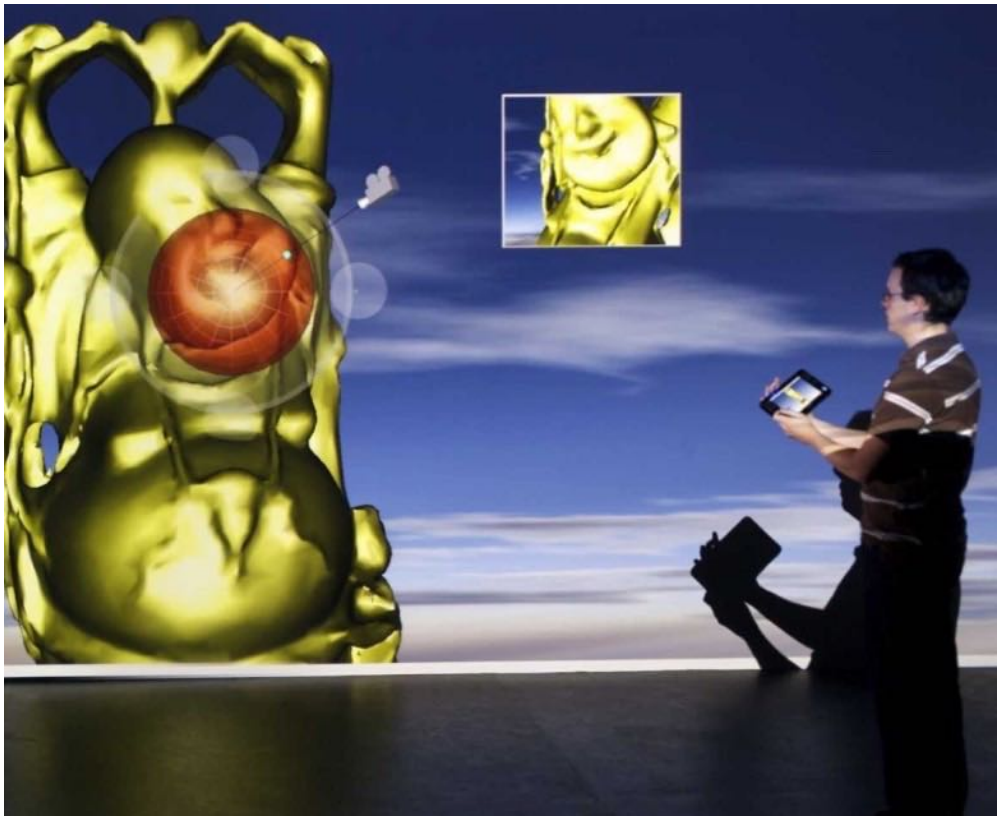


Navigation

Exocentric techniques

Navidget [Hachet et al., 2008]

Grabbing the air [Mapes et Moshell, 1995]



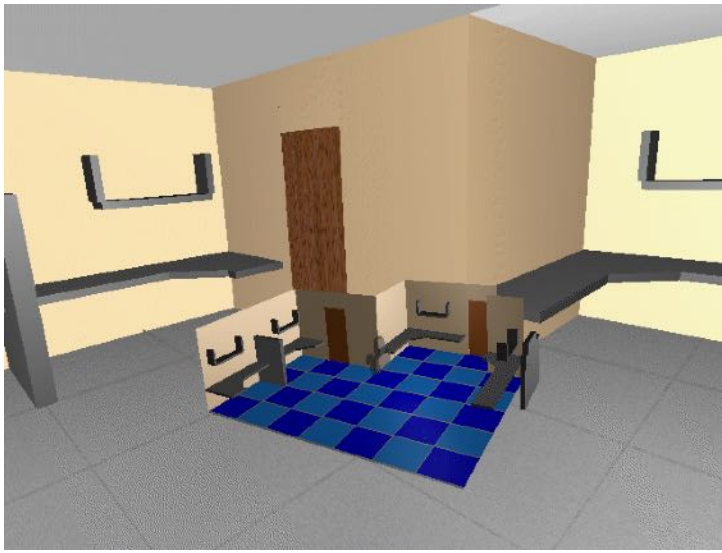
Navigation

Grabbing the air [Mapes et Moshell, 1995]

Navigation

Assisted navigation techniques

- Select the destination
  - Pointing
  - World In Miniature (WIM) [Stoakley et al., 1995]
  - List of (pre-)defined paths



[Stoakley et al., 1995]

- Move to destination
  - Teleportation [Ruddle et al., 2000]
  - Interpolation [Mackinlay et al., 1990]
  - “Guided visit” metaphor [Elmqvist et al., 2007]

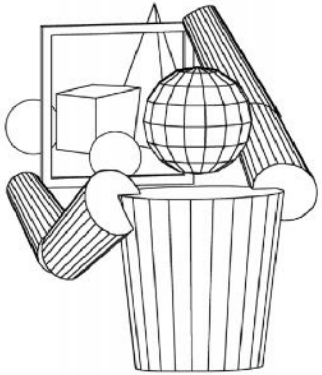
Navigation

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

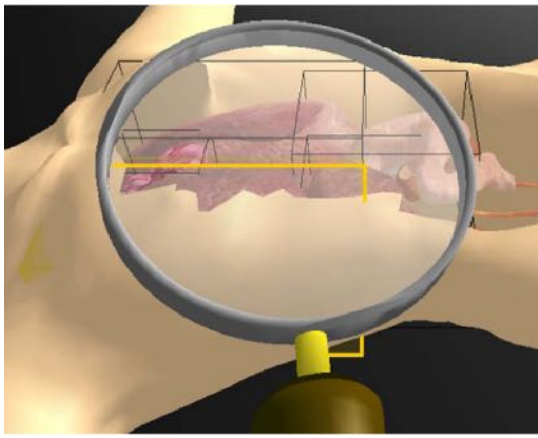
Navigation

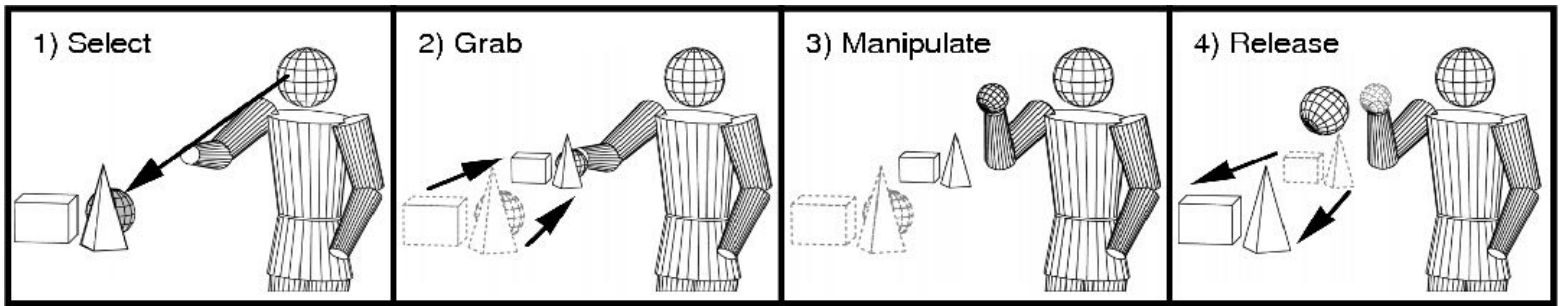
Multi-scale techniques

- Manual scale modification
  - Scale the world
  - Head-butt Zoom [Mine et al., 1997]



- Automatic scale modification
  - Bounding Boxes [Kopper et al., 2006]
  - Scaled-world grab [Mine et al., 1997]

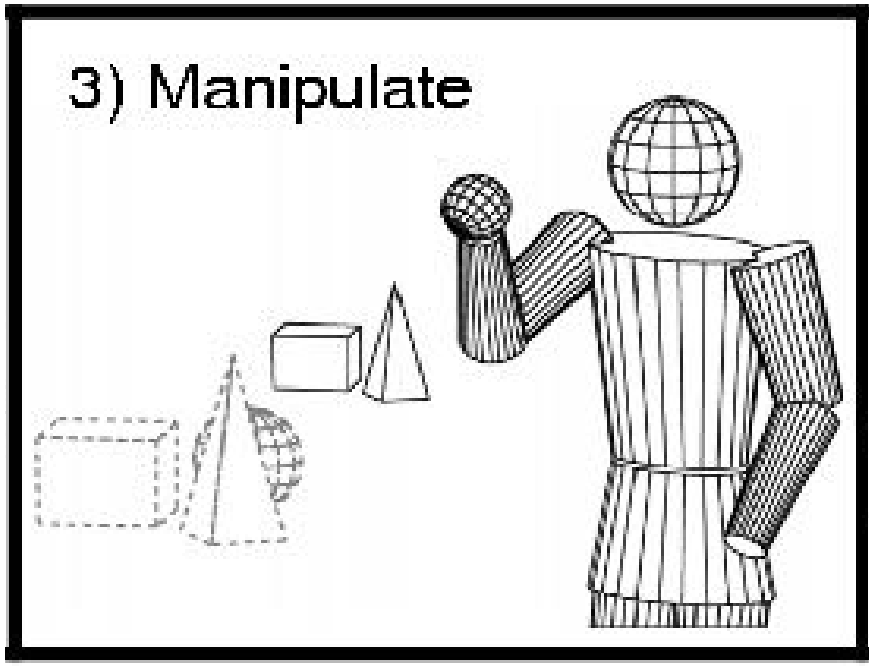




Object Manipulation

2 main tasks

- Selection
- Manipulation



Object Manipulation

Virtual Ray [Mine, 1995]

Mimics a laser pointer

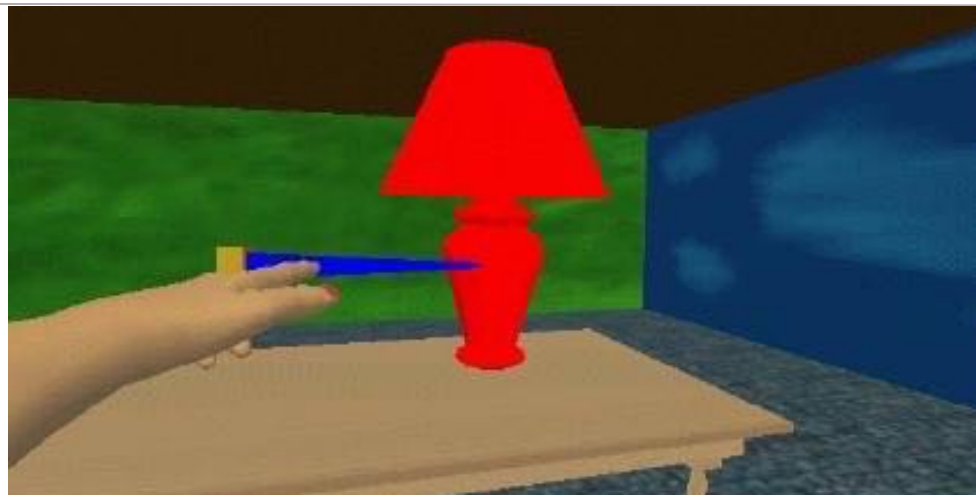
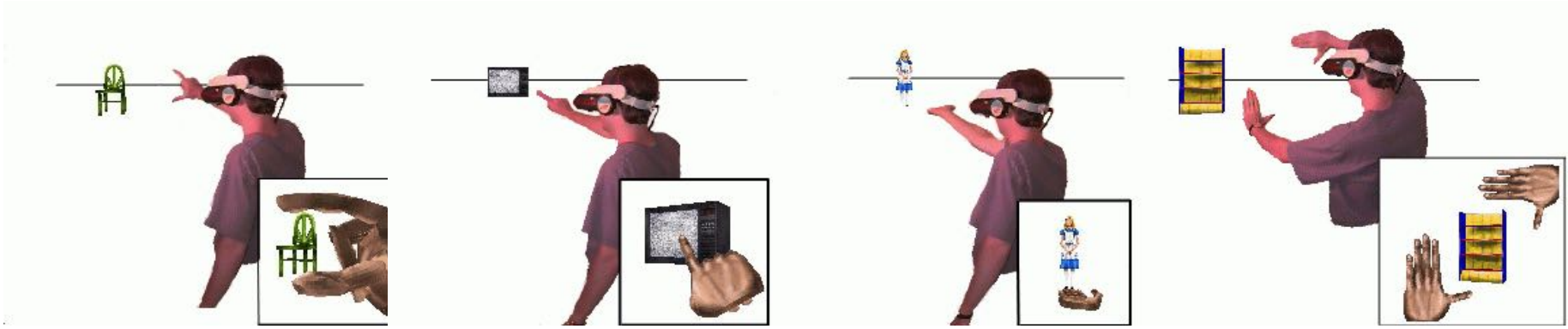


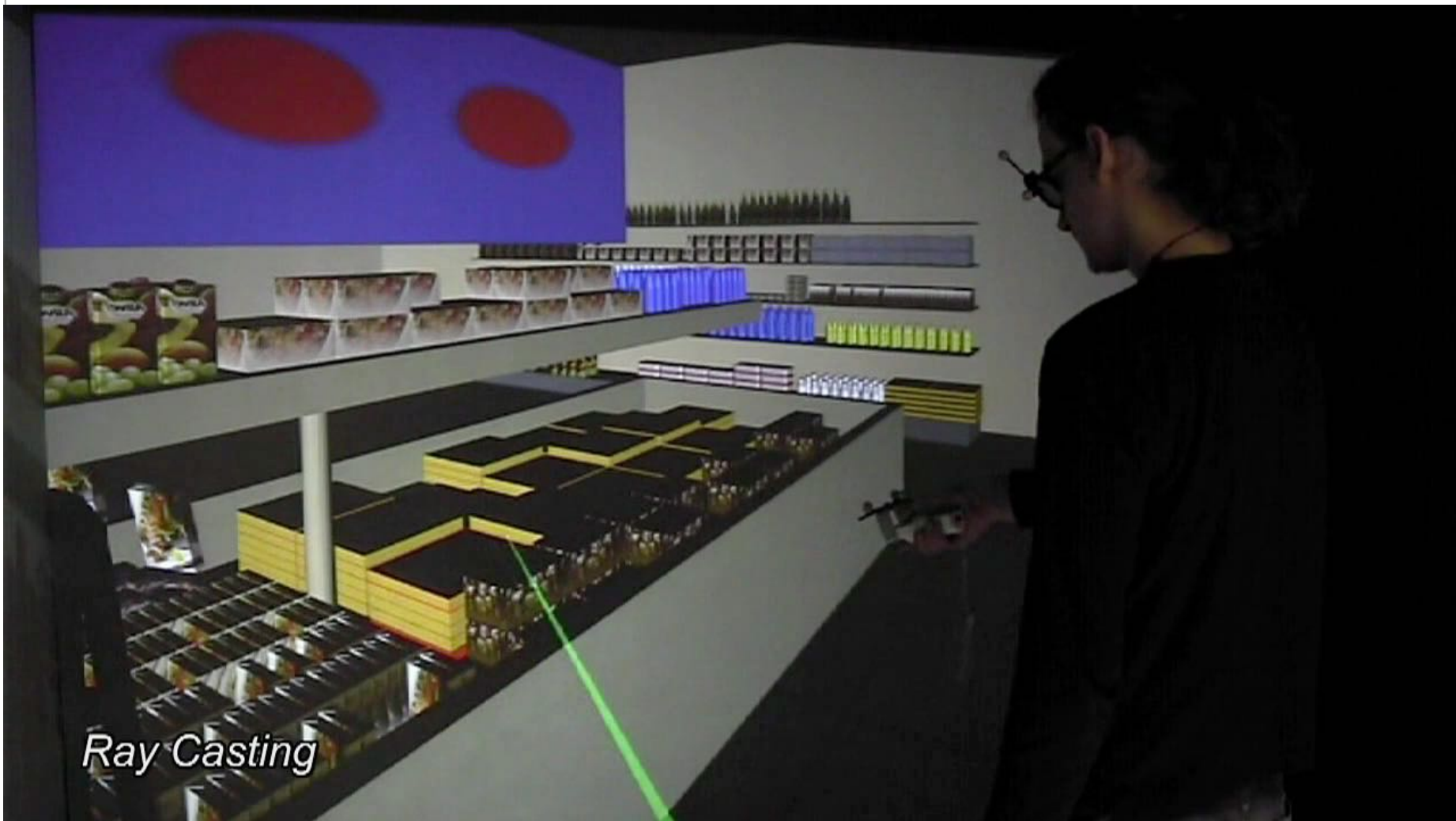
Image plan Interaction [Pierce et al., 1997]

Select by pointing with one part of the body



Object Manipulation

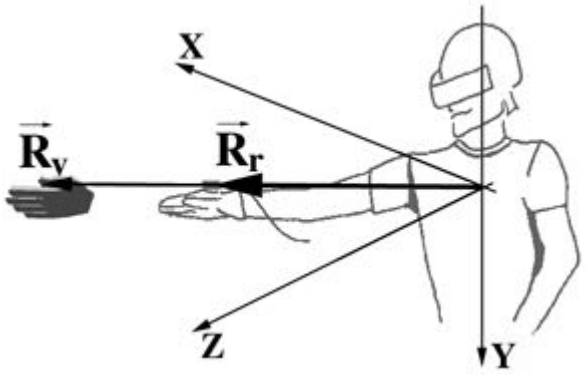
Virtual Ray [Mine, 1995]



Object Manipulation

Virtual Hand [Jacoby et al., 1994]

Select and manipulate by touching



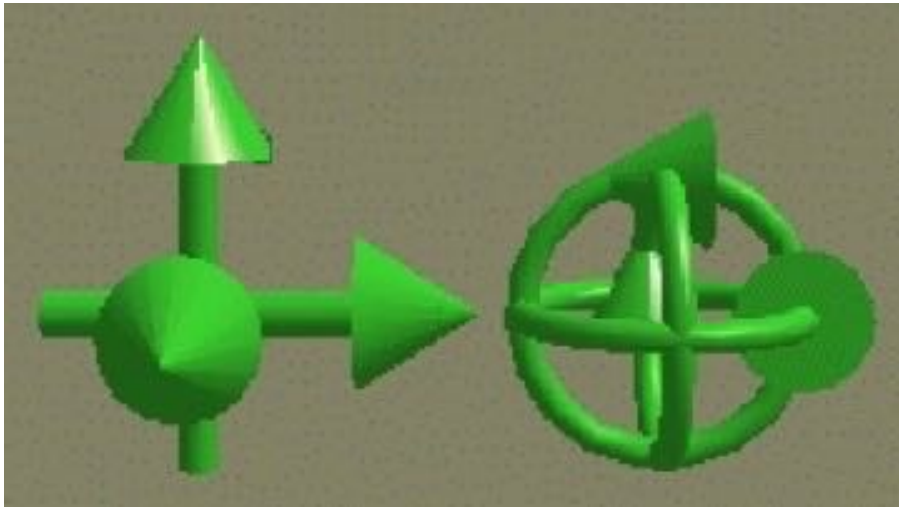
"Go-Go" metaphor
[Poupyrev et al., 1996]

Extend the virtual hand

Move exponentially

3D cursor [Zhai et al., 1994]

Position or speed control



Object Manipulation

Selection techniques not always suitable for manipulation

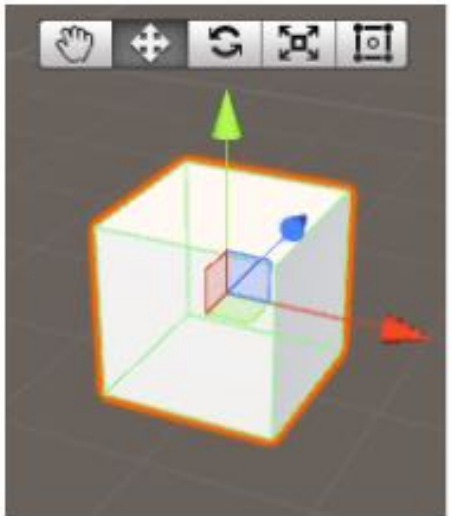
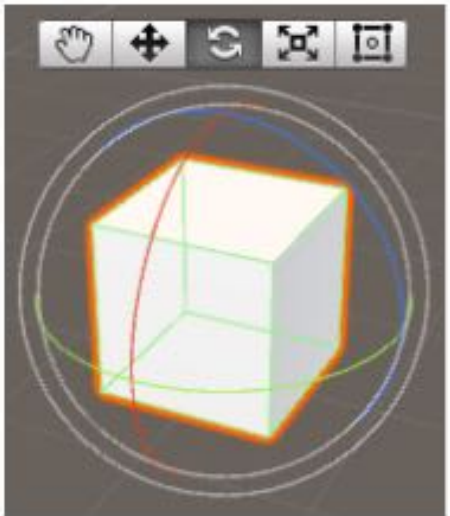
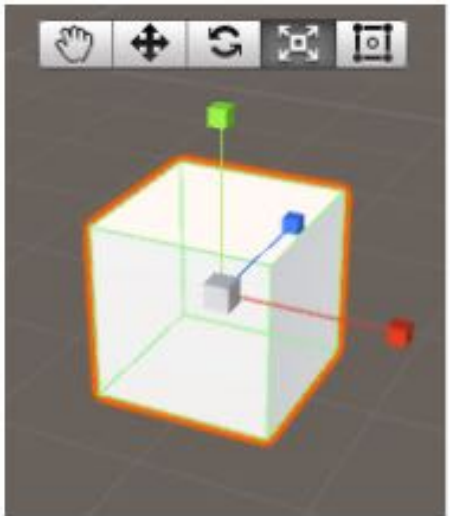
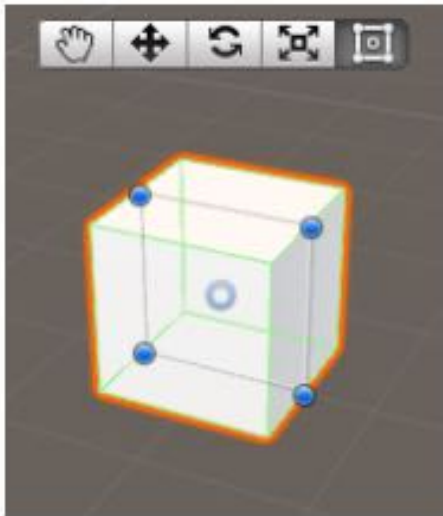
eg: virtual ray for rotations

Combining several interaction tools

extend hand reach HOMER [Bowman & Hodges, 1997]

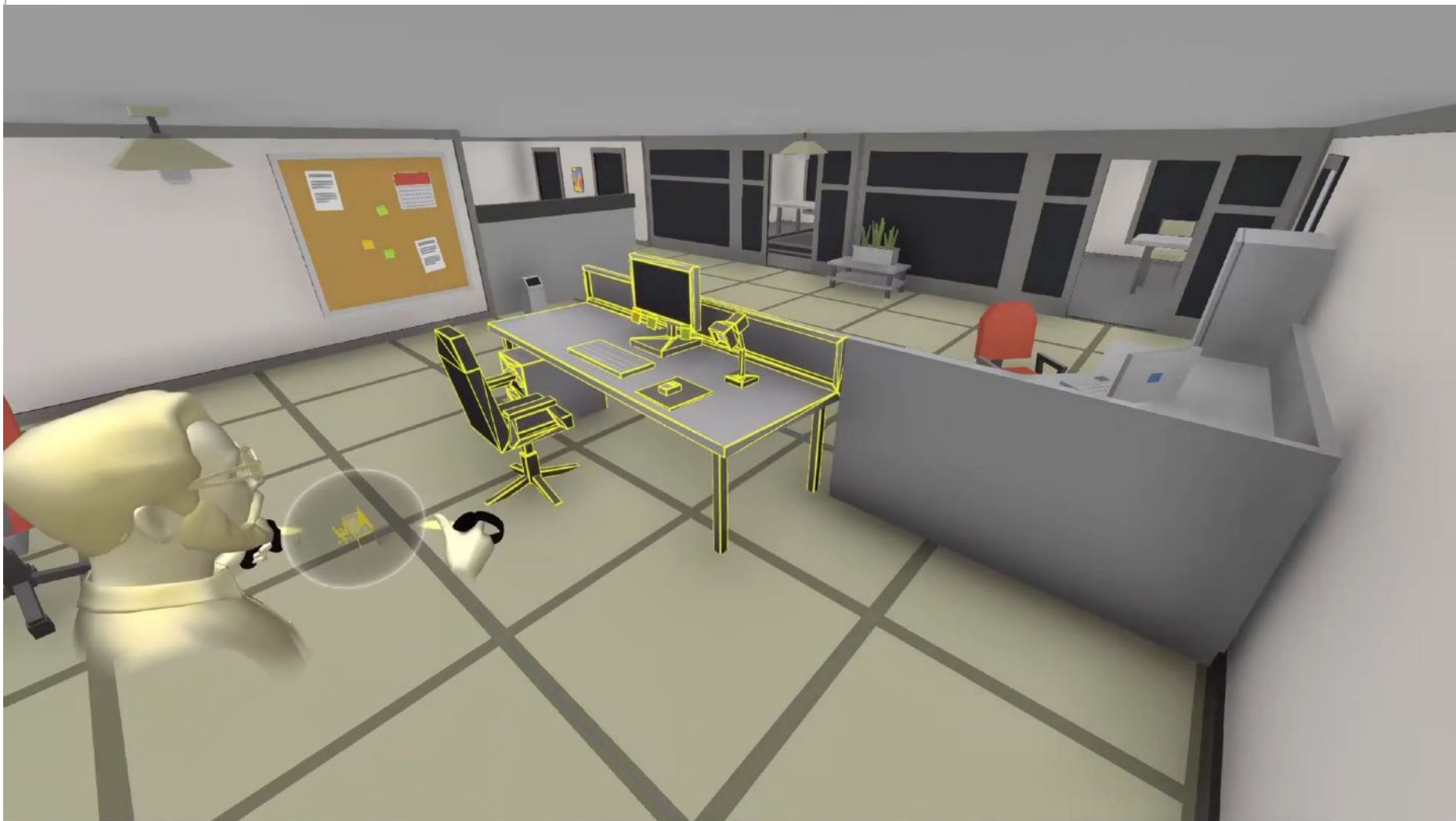
move the manipulated object close to the user

attached the interaction tools to the objects

Multi-object manipulation

Containers & controls in Spacetime [Xia et al., 2018]



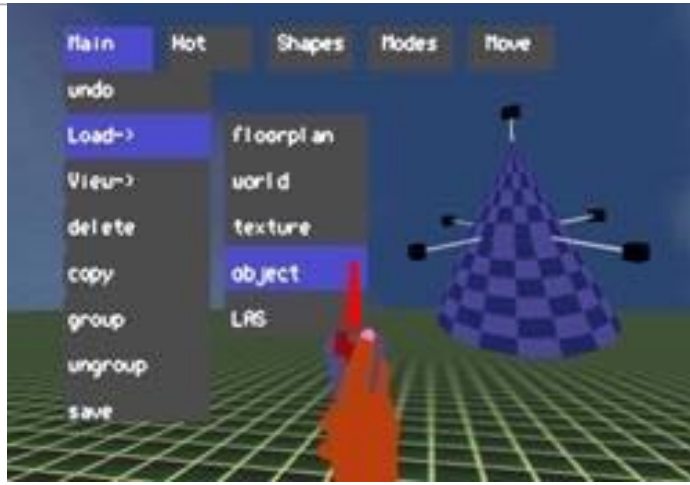
Application Control

Control

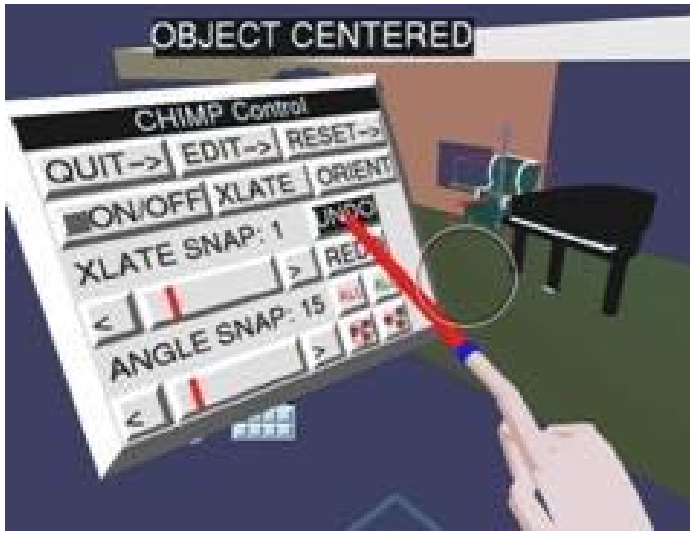
- Application (exit, pause,…)
- Rendering parameters
- Tools/actions selection

Techniques used

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



[CDS – Bowman et al., 1991]



[CHIMP – Mine et al., 1997]

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Awareness and Communication

Collaborative Interaction

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Collaboration in Mixed Reality

Several users work/play together in a VE

- Co-expertise of 3D data
- Complex manipulation (real or virtual)
- Training
- Social presence (telepresence)

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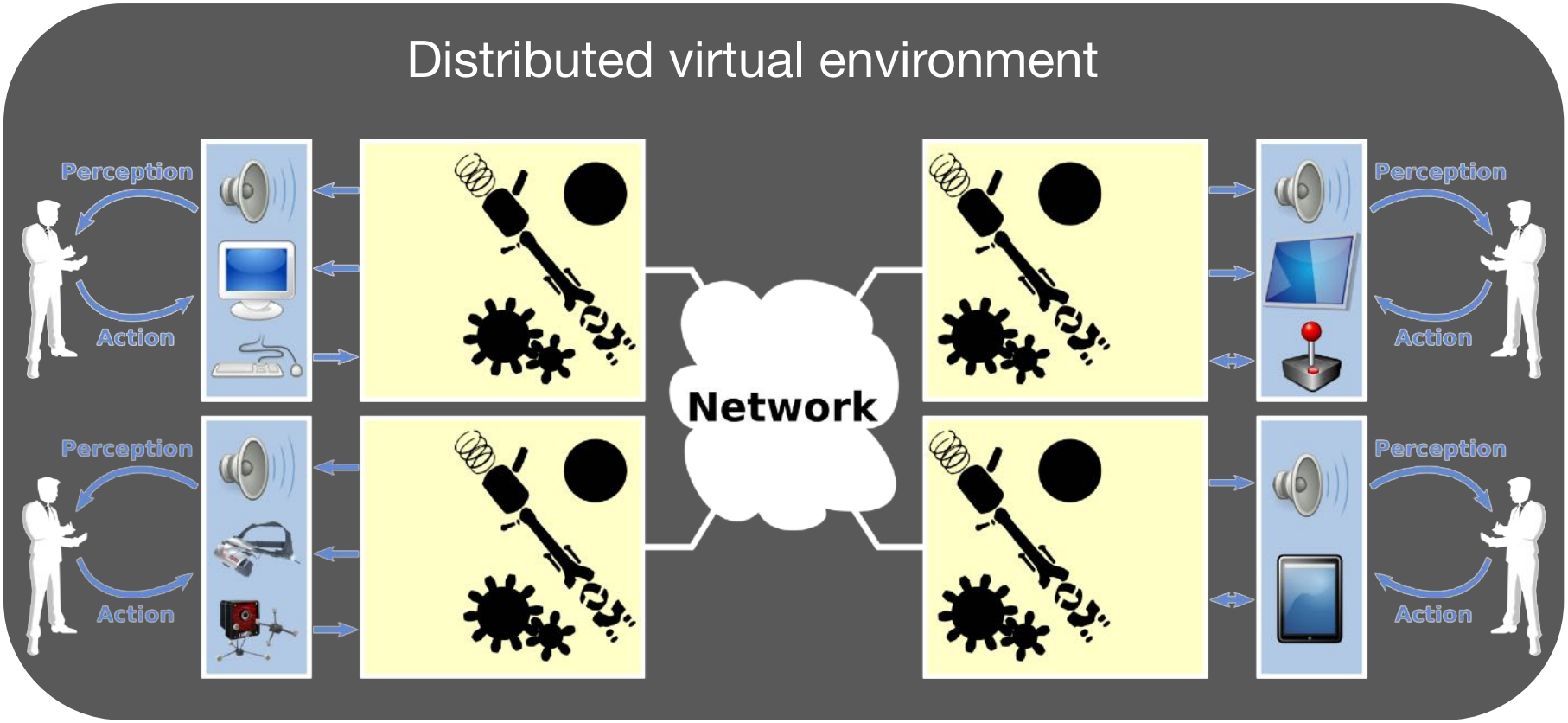
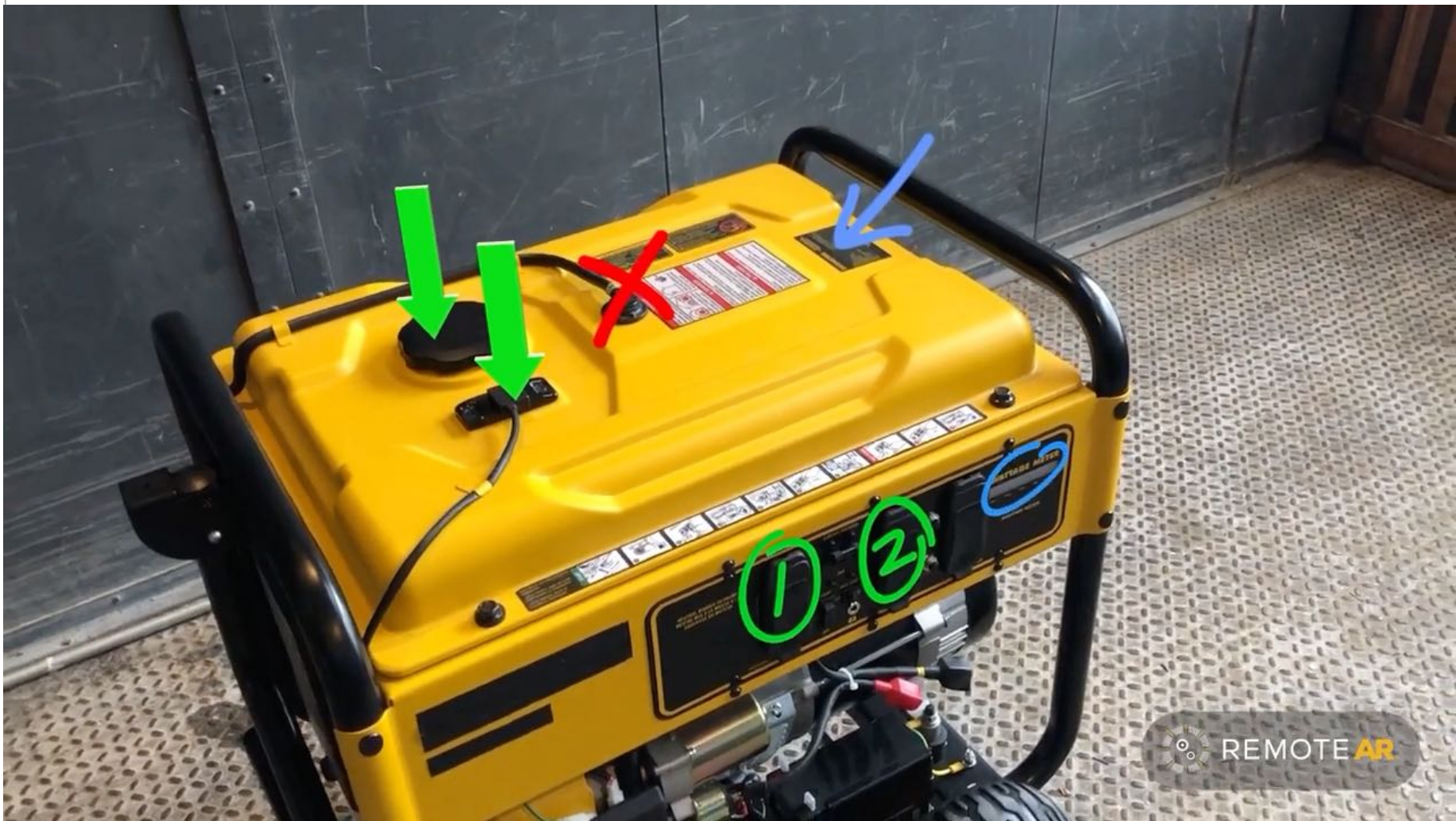
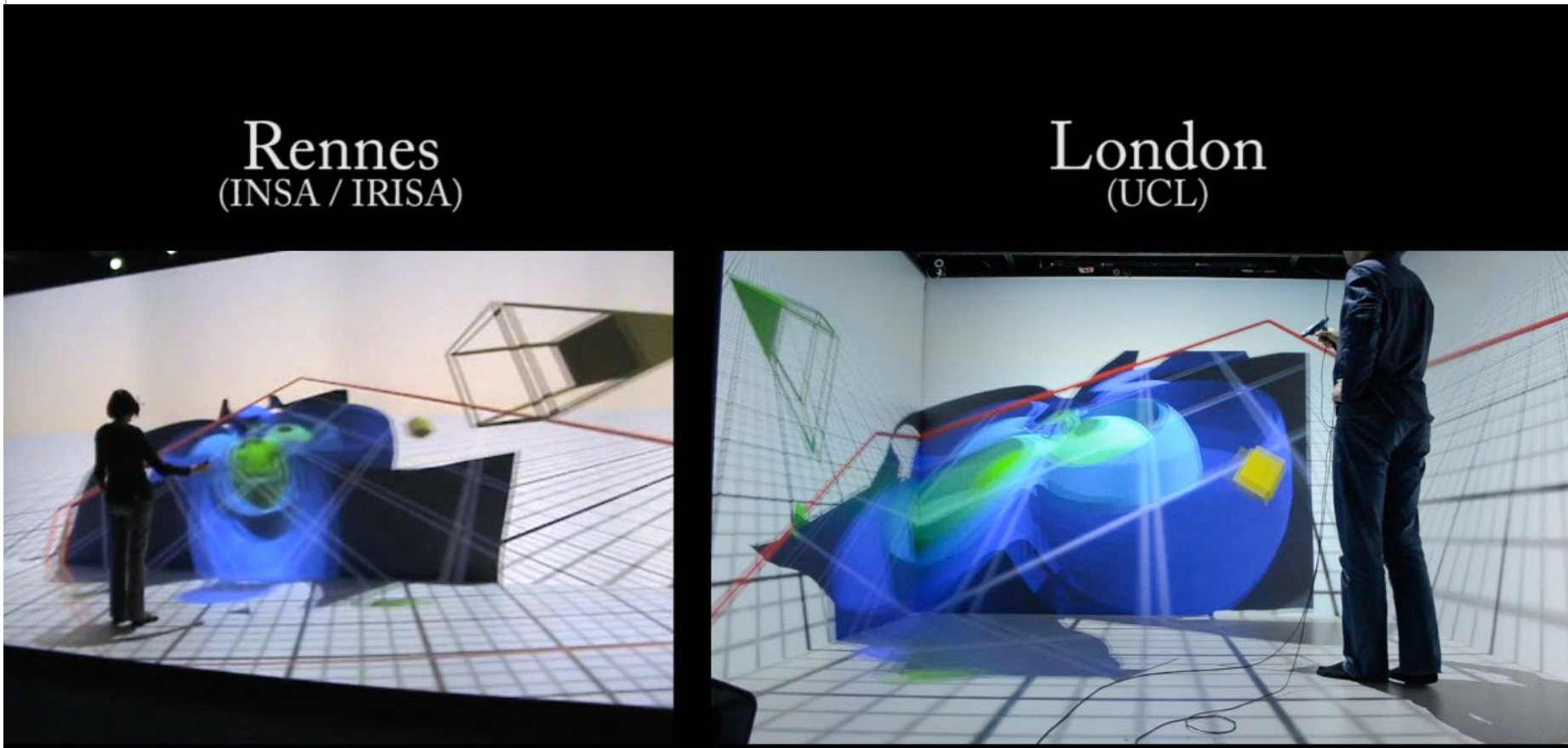
Remote Collaboration



Remote Collaboration in AR



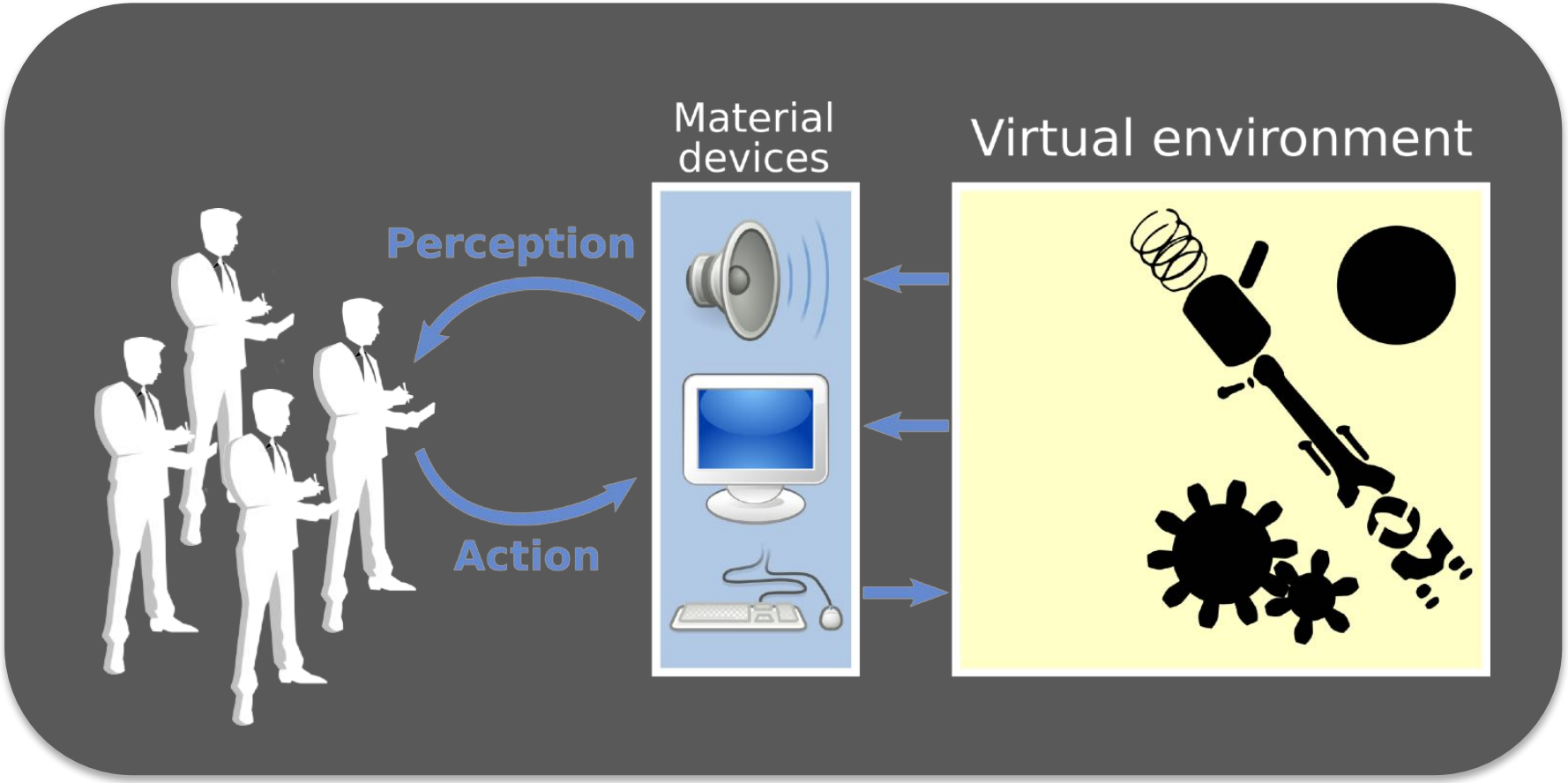
Remote Collaboration in VR



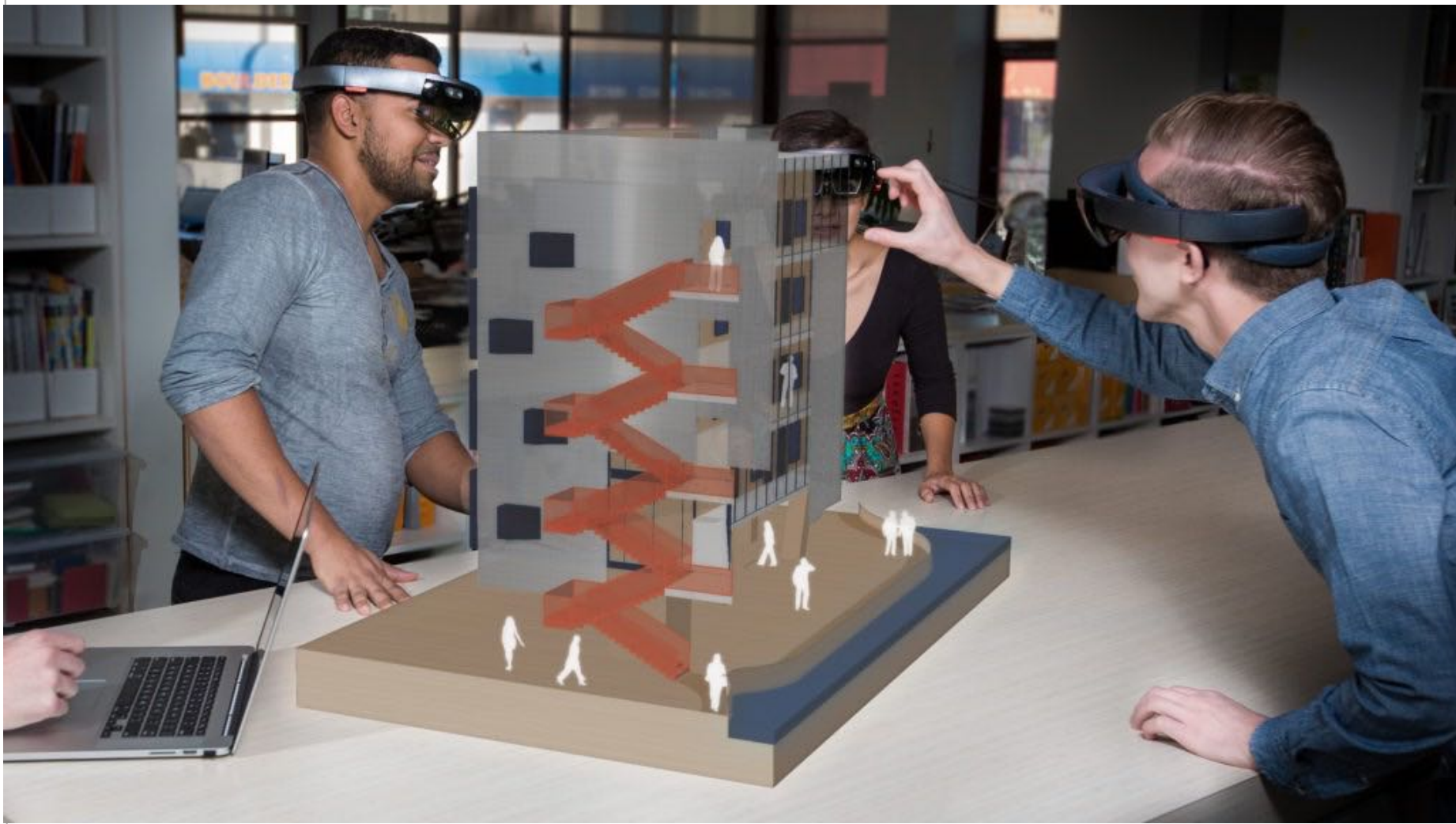
[Fleury et al., VRST 2012]

Outline

Co-located Collaboration

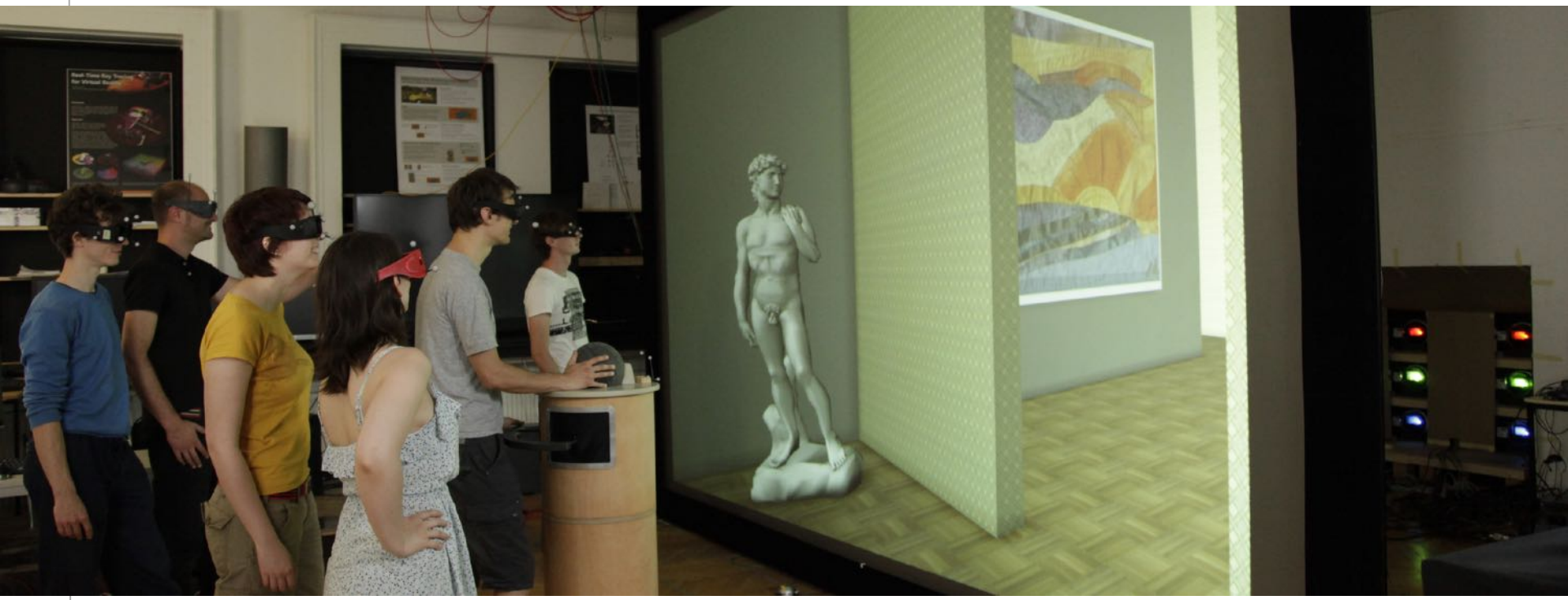


Co-located Collaboration in AR



Co-located Collaboration in VR

Integrate several users in a VE with the same devices



[Kulik et al., 2011]

Multi-stereoscopic display

Integrate several users in the same devices

[Kulik et al., 2011]

Co-located Collaboration in VR

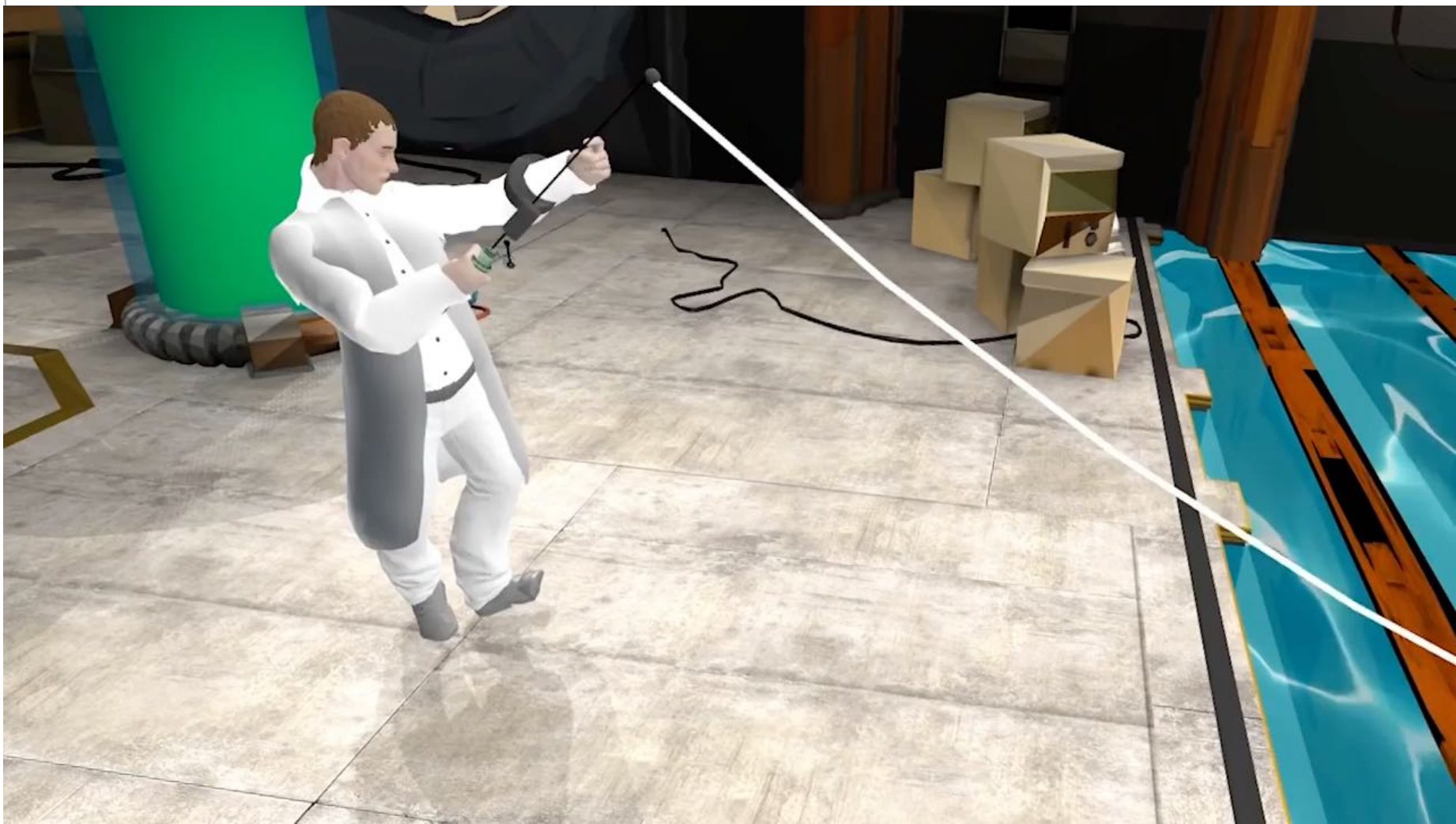
Users cannot see the other in the real world

Users can hear the other

Users can feel the haptic force of the other

Mutual human actuation

[Cheng et al., UIST 2017]



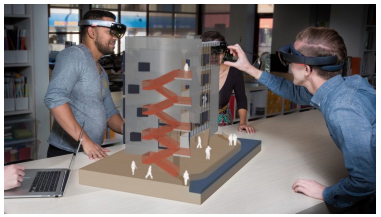
Co-located vs. Remote

Limits between co-located and remote collaboration

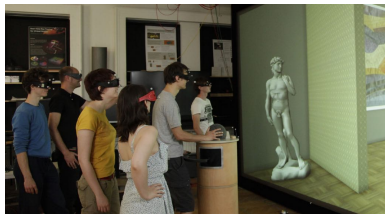
are not clearly defined

- 2 users with AR headsets in the same room?
- 2 users in a CAVE?
- 2 users with HMDs in the same room?
- 2 users with HMDs in a different room?
- 2 users with HMDs & headphones in the same room?

Collaboration in MR



Co-located

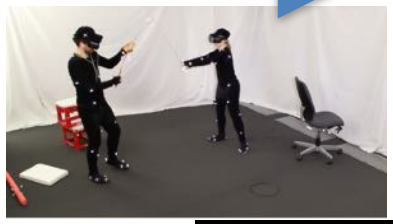


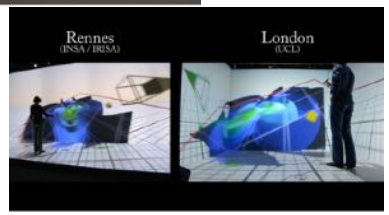
Social presence

Milgram Continuum

Real

Virtual





Remote

Outline

Awareness

Perception of the other users

- Where are they?
- What are they doing?
  - What are they looking at?
  - 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

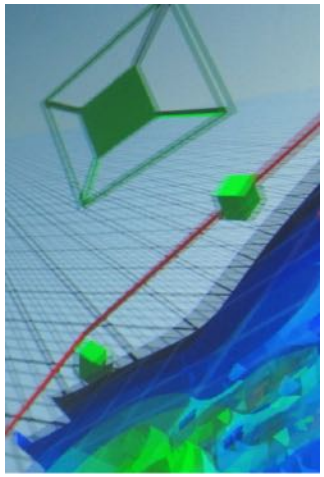
- Just next to me… But where are you?
- Just in front of me … But where are you looking at?
- Etc.

Multi-sensorial restitution

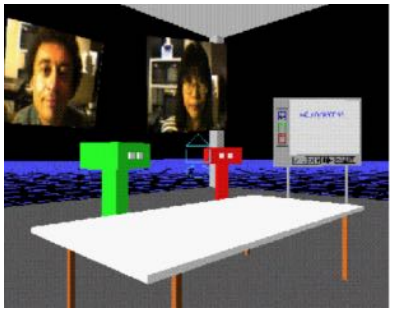
- Visual awareness
- Audio awareness
- Haptic awareness

Visual Awareness

Avatar: representation of users in the VE



[Fleury et al., 2012]



[DIVE, 1991]

CALVIN, 1996

Second Life, 2005

[Beeler et al., 2010]

Visual Awareness

Animation of the avatars

Kinect Avatar

Body tracking

Kinect Avatar

Embodiment and sense of presence

Self-image

Body swapping

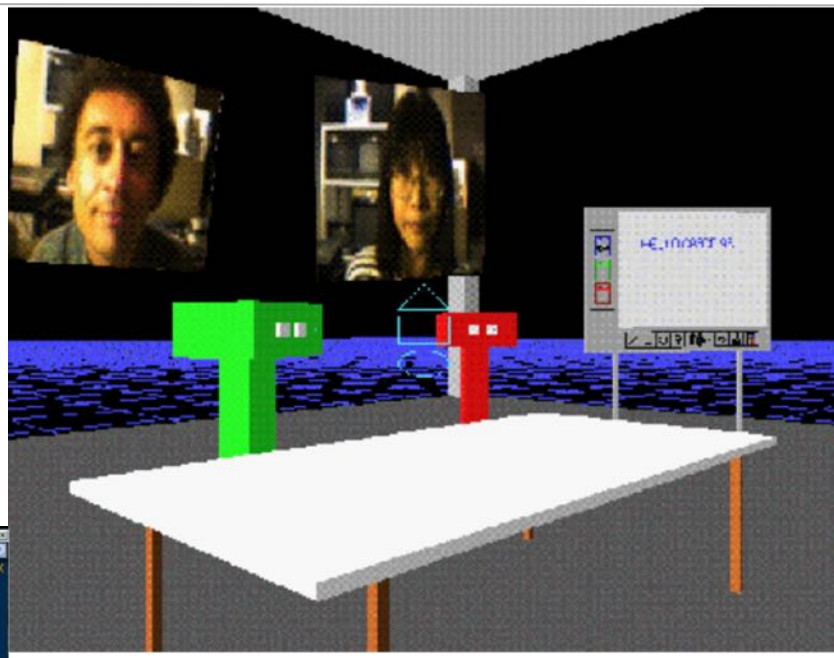
Milgram experiment

[Mel Slater]

Social Presence

Animated avatars

Collaborative interaction



DIVE (1991)

Second Life (2005)

Social Presence

Animated avatars, Collaborative interaction, Video facilites

[Facebook Social VR Demo - Oculus Connect 2016]

“The metaverse”


Horizon worlds

Mozilla hubs


Engage

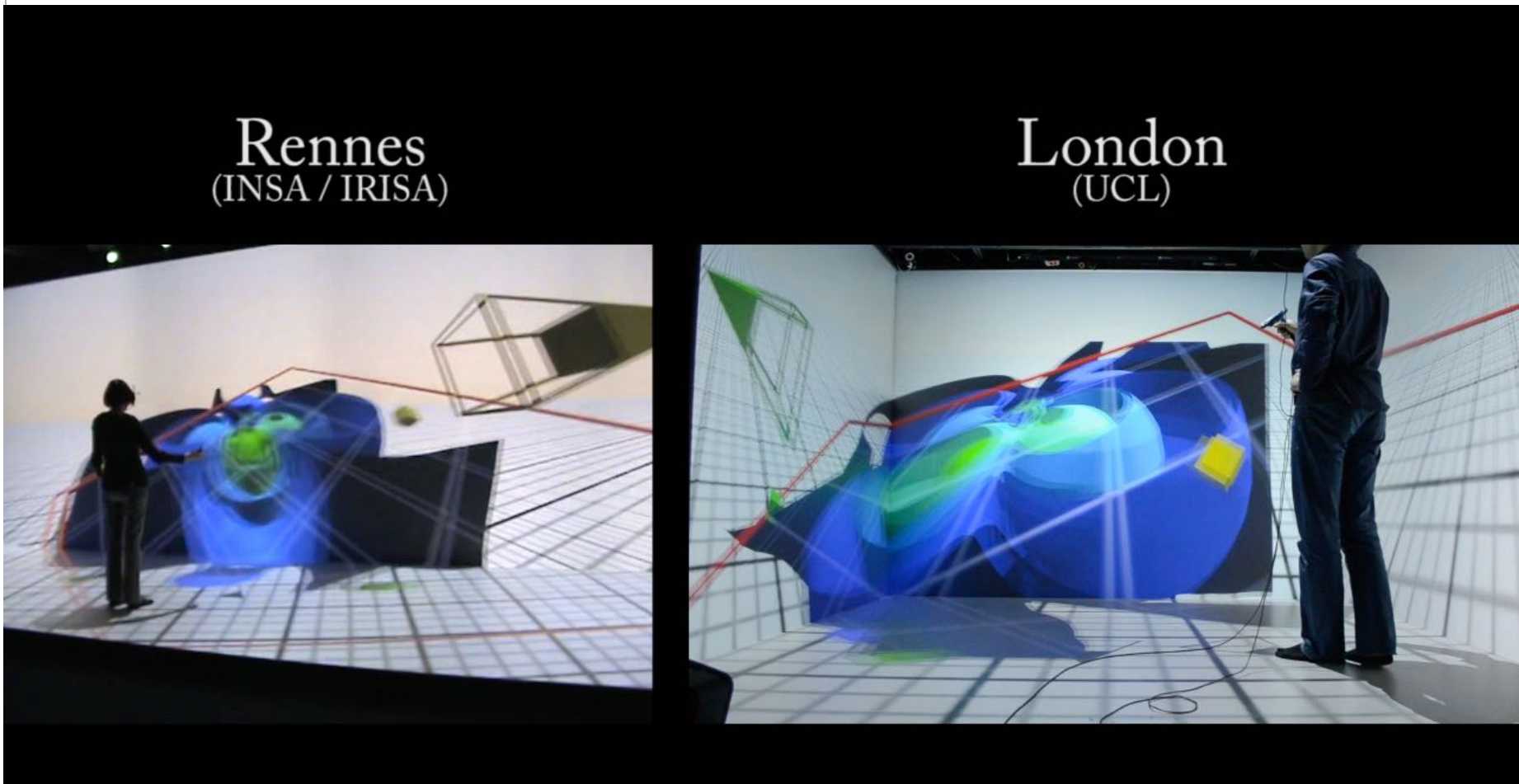
Ready player me

Social Presence

Simplified Avatars

Collaborative interaction

[Fleury et al., VRST 2012]



Social Presence

Real 3D video integration, Collaborative interaction,
Specific tools for collaboration [Beck et al., IEEE VR 2013]

Telepresence in virtual reality

Animated virtual characters

Real 3D video integration

Video facilities

Audio Awareness

Spatialized voice restitution

Remote users' noises

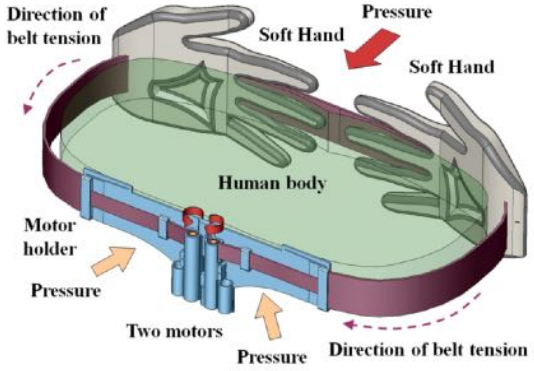
- Give a lot of information
  - Where they are
  - What they are doing
    - Add some sounds to describe the actions

- 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 applied by the other on the object

Awareness Model

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

Compute which users can interact with which others

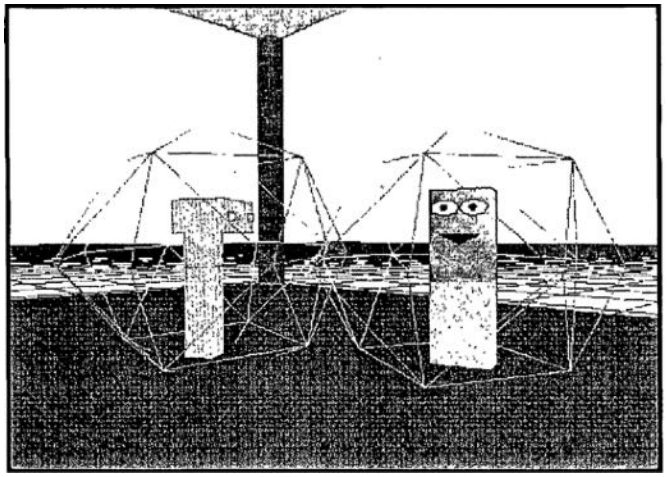
Measure of awareness between two users

Medium

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

Focus and **Nimbus**

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



[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

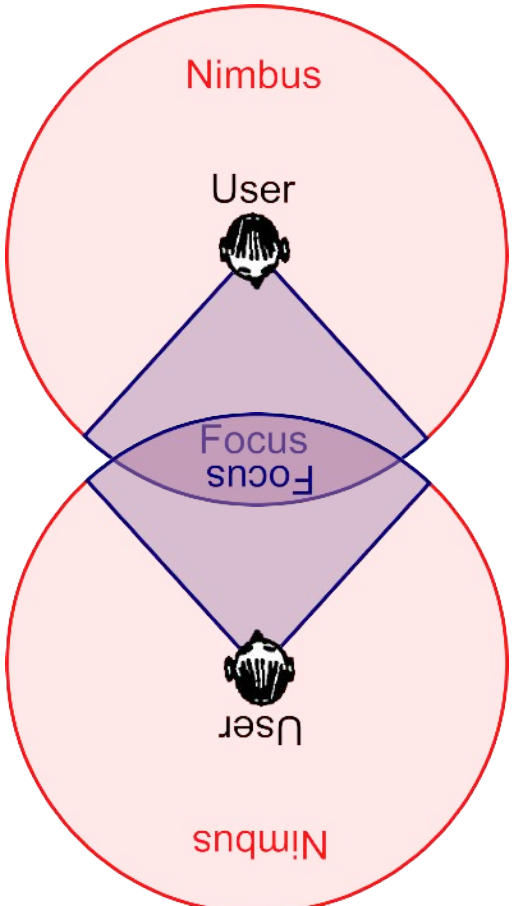
For each particular **Medium**

Nimbus

Area where the others can perceive a particular user

For each particular **Medium**

Different from the **focus**

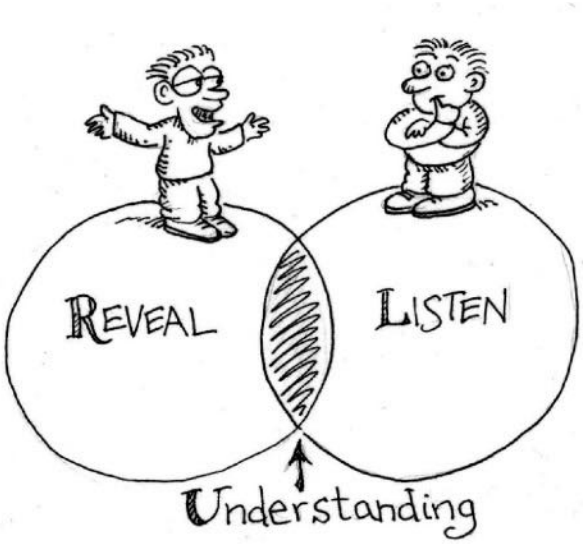


Voice communication

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

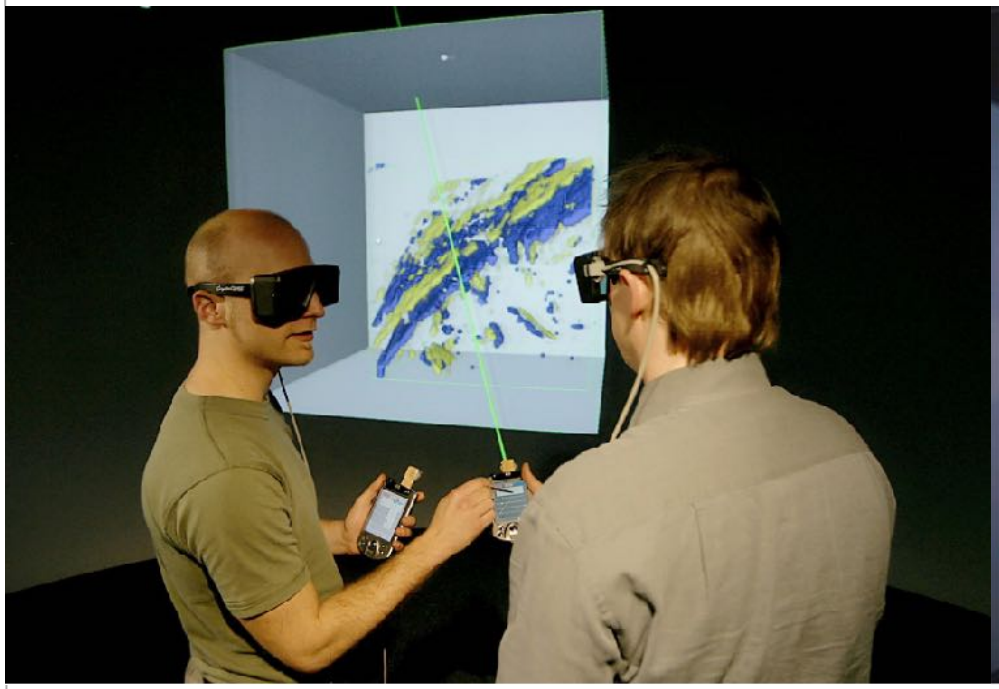
[Bowers et al., 1996]

⇒ Users need specific tools for communication

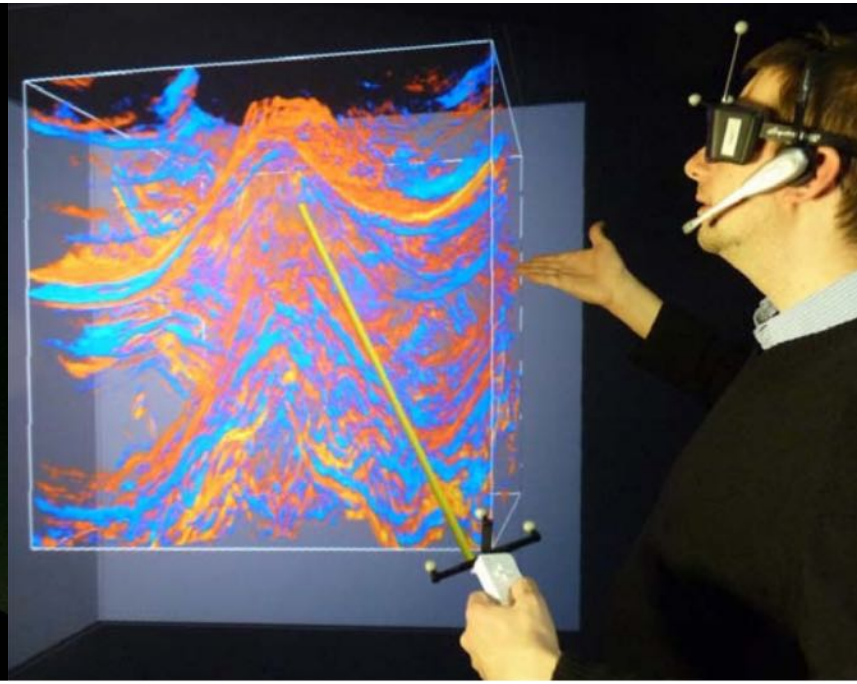
Tools for communication

Virtual Ray

- Laser pointer metaphor
- Easy and intuitive manipulation



[Simon, 2005]

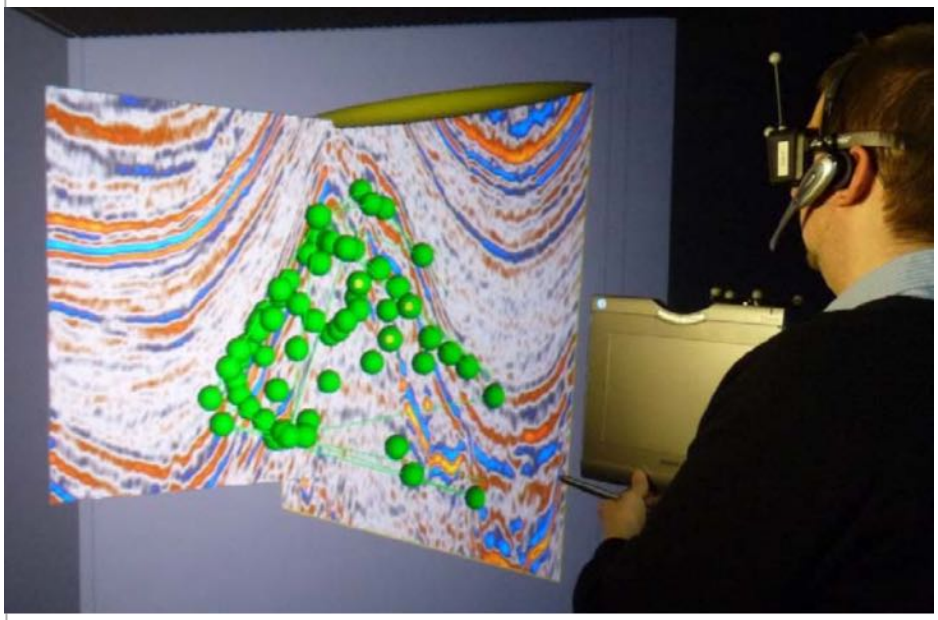


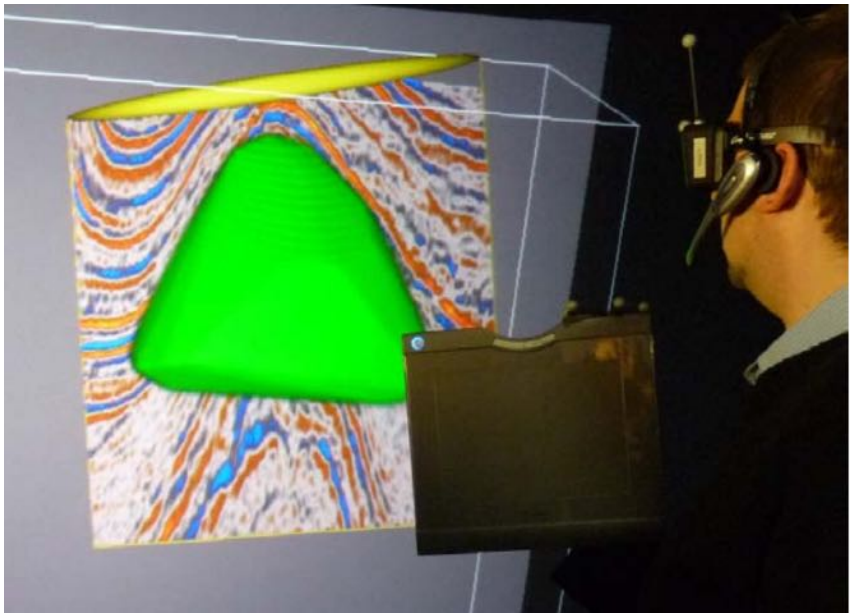
[Schild et al., 2009]

Tools for communication

Annotations

- Sketching, text, audio, videos
- Especially relevant for scientific data analysis
- Synchronous and asynchronous collaboration



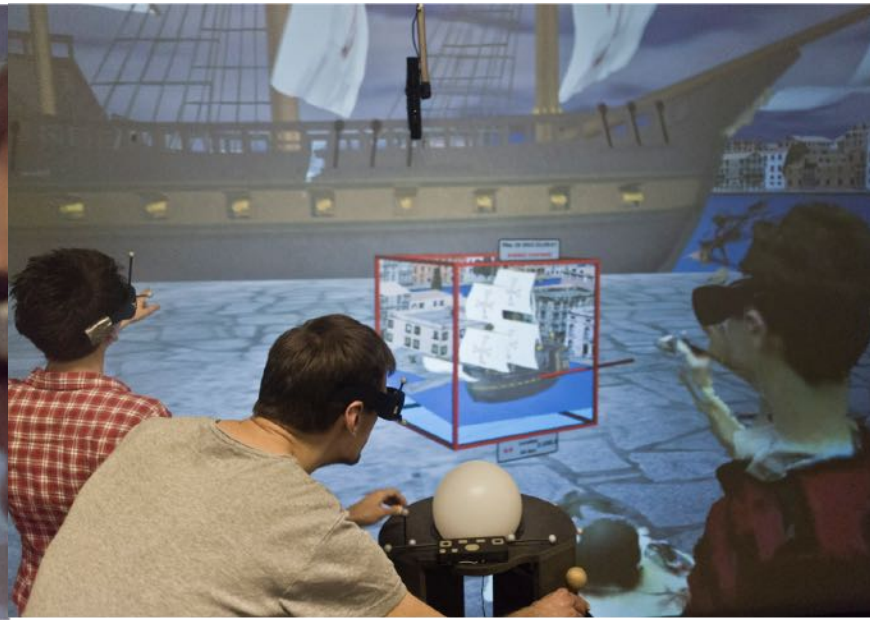


[Schild et al., 2009]

Tools for communication

Photoportals

- Shared 2D or 3D views
- Annotations
- Interaction with the shared views



Photoportals

[Kunert et al., CSCW 2014]

Photoportals: Shared References in Space and Time

André Kunert, Alexander Kulik, Stephan Beck, Bernd Fröhlich

Starring: Jan Beckmann, Anniek Vetter, André Kunert, Felix Trojan and Eik List
Voice: Ben Sassen
Production: Marcel Karnapke

3D model of Castle Vianden (Luxembourg)
Courtesy of ArcTron 3D GmbH (www.arctron.com)

Additional 3D Models from Blendswap Members:
Sizzler, Hjford, Michal David, Nicolas Damore, Ian57, Komtraya

CSCW 2014

Bauhaus-Universität Weimar
VR-Systems Group

Outline

Introduction to Mixed Reality (MR)

Overview of Interaction in MR

Collaboration in MR

- Remote Collaboration
- Co-located Collaboration

Awareness and Communication

Collaborative Interaction

- Navigation
- Co-manipulation

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

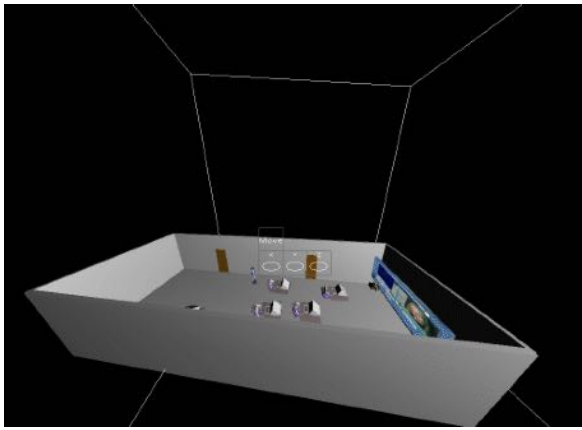
To guide others in the VE

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 moves 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

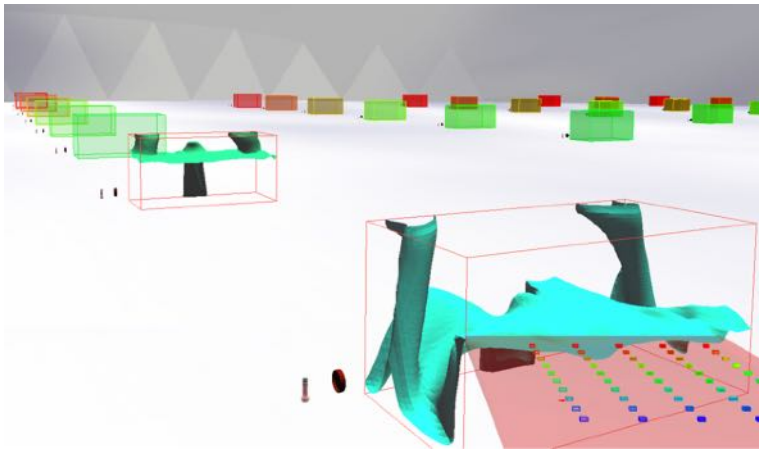


[CALVIN, 1996]

Viewpoints sharing

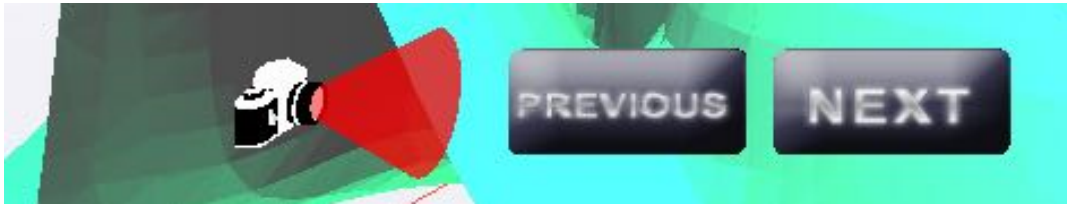
[Duval et al., 2008]

Context: scientific data analysis



Users can:

- Save interesting viewpoints
- Select on particular viewpoint
- Travel through the saved viewpoints of a particular user



Group Navigation

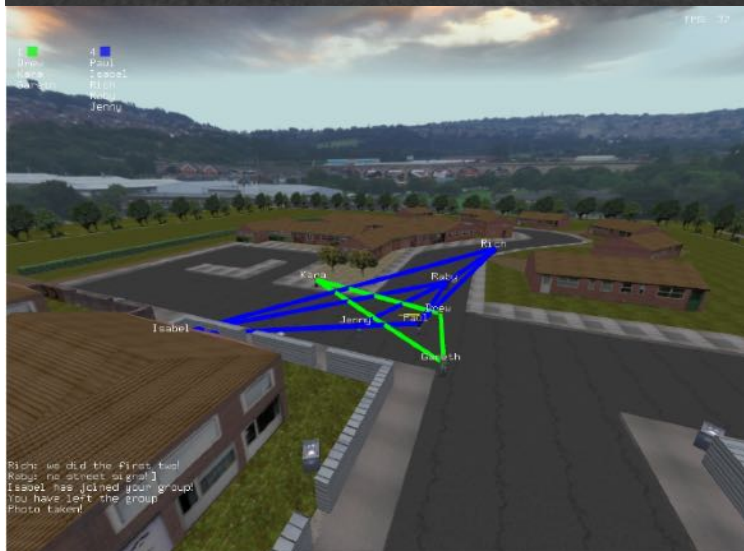
Each user can travel independently, … or

[Dodds & Ruddle, 2008]

Users can be part of a predefined group, and have functionalities that help them travel with the group

To follow the first member of the group

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



Collaborative teleportation

Spacetime

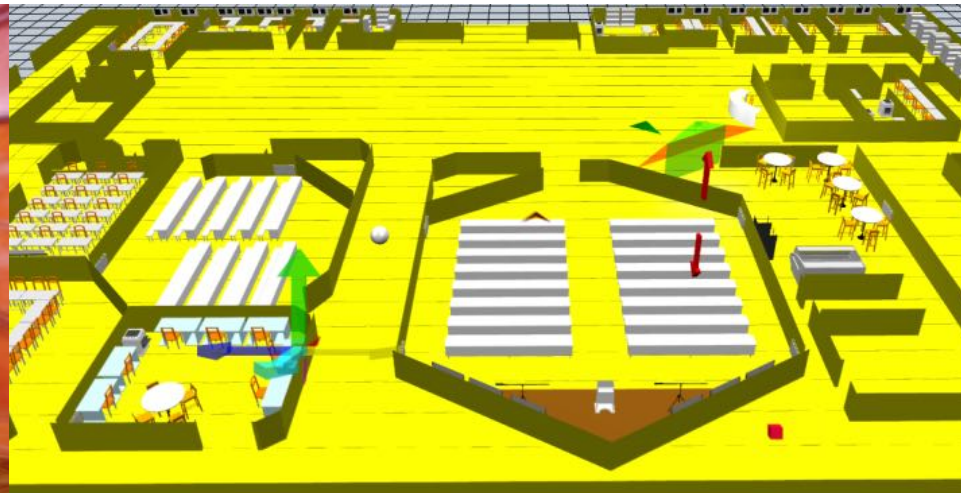
[Xia et al., 2018]

Guidance techniques

Context: collaborative navigation in a building

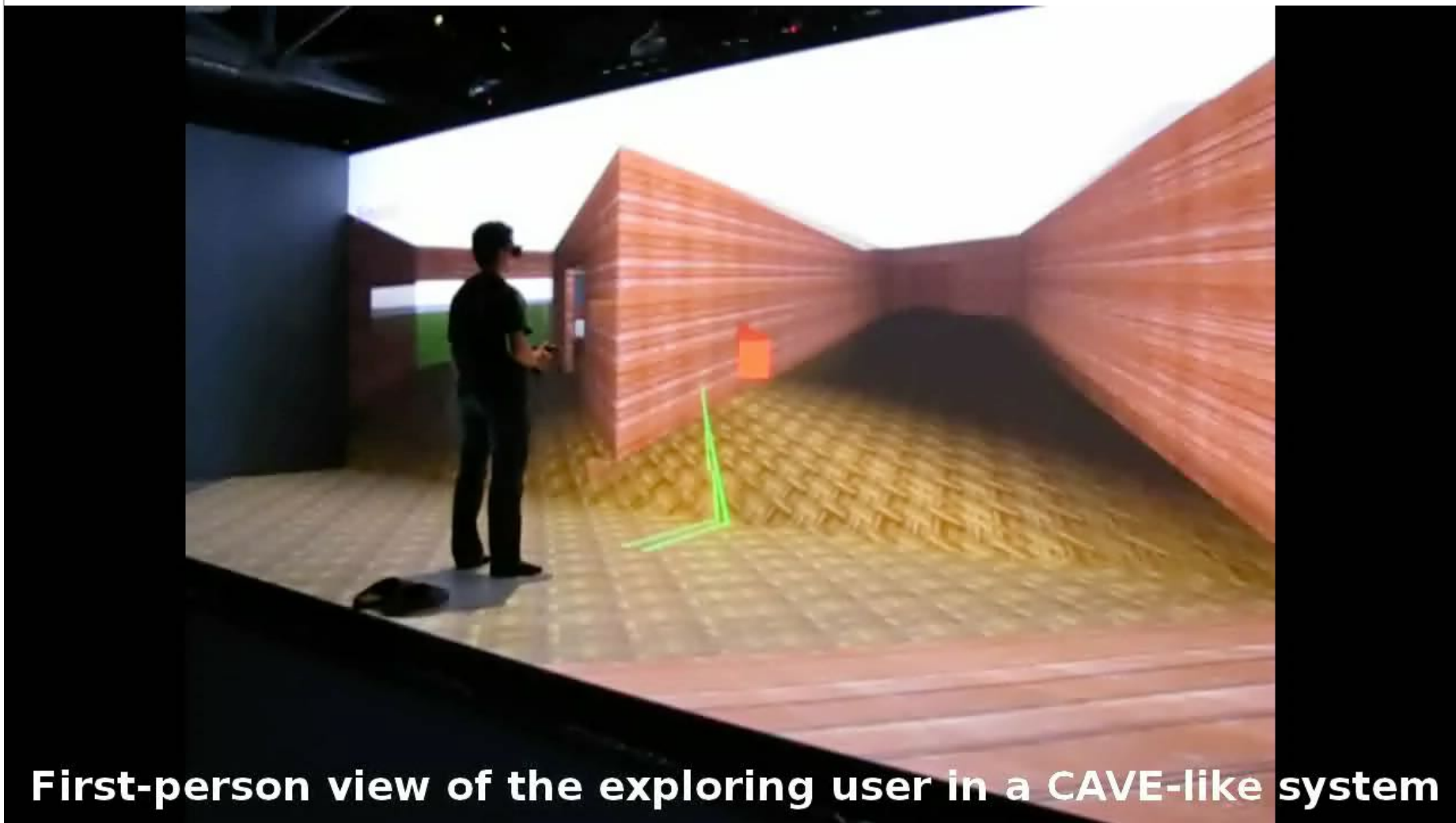
- User 1 is in an immersive room
  - Find several targets in the building
- User 2 is in front a desktop workstation
  - Guide the other user using a WIM
- Not verbal communication

[Nguyen et al., 2013]



Guidance techniques

[Nguyen et al., 2013]



First-person view of the exploring user in a CAVE-like system

Co-located Navigation

Integrate several users in the same environment

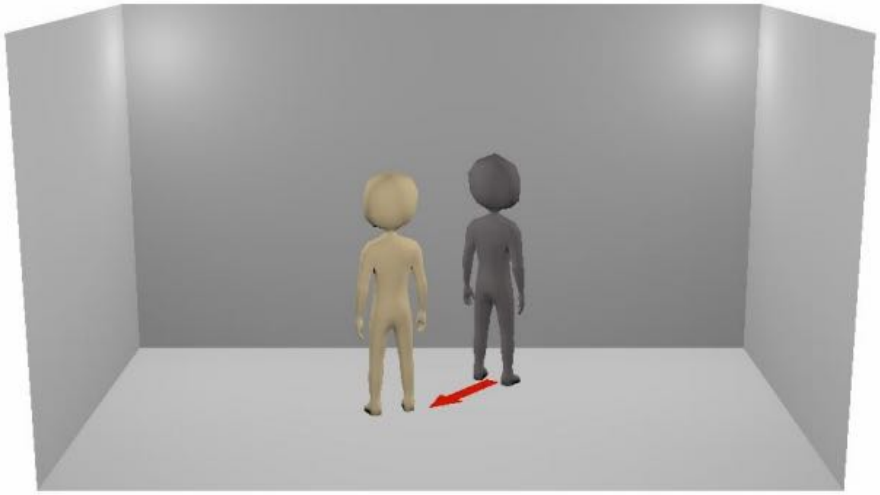
[Kulik et al., 2011]

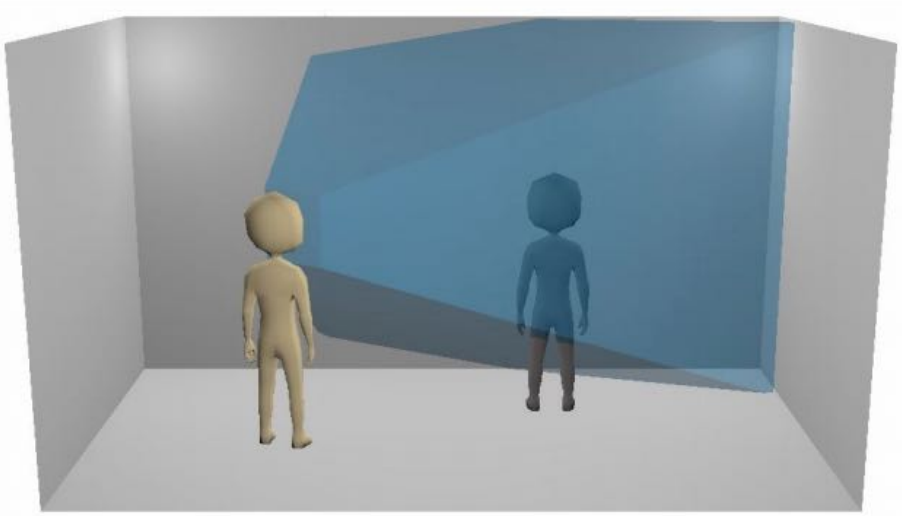
Co-habitation in a CAVE

[Chen et al., 2015]

Problems when several users are co-located in a CAVE

- Collisions
- Occlusion





Co-habitation in a CAVE

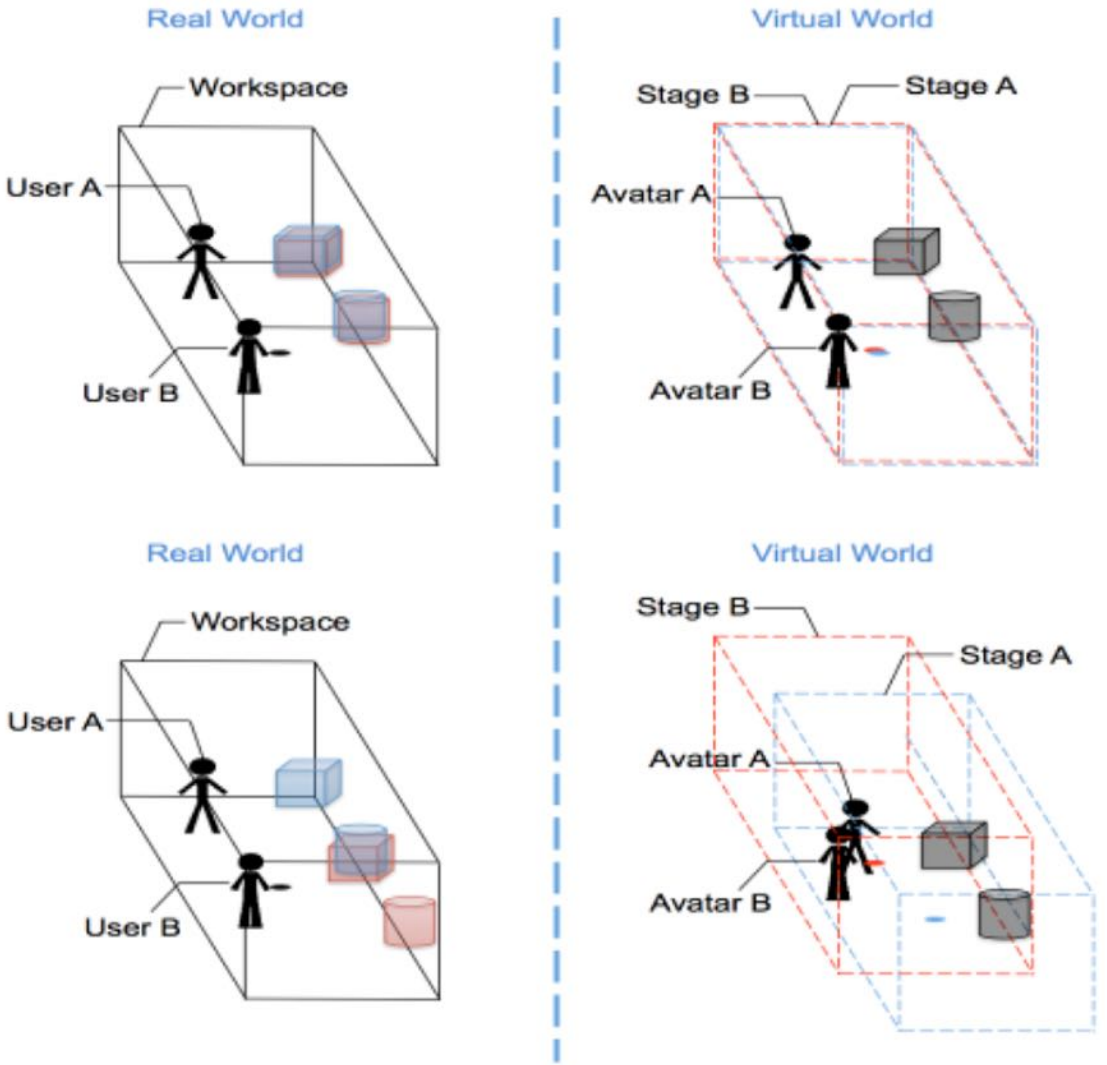
[Chen et al., 2015]

Problems when several users are co-located in a CAVE

Consistent

vs.

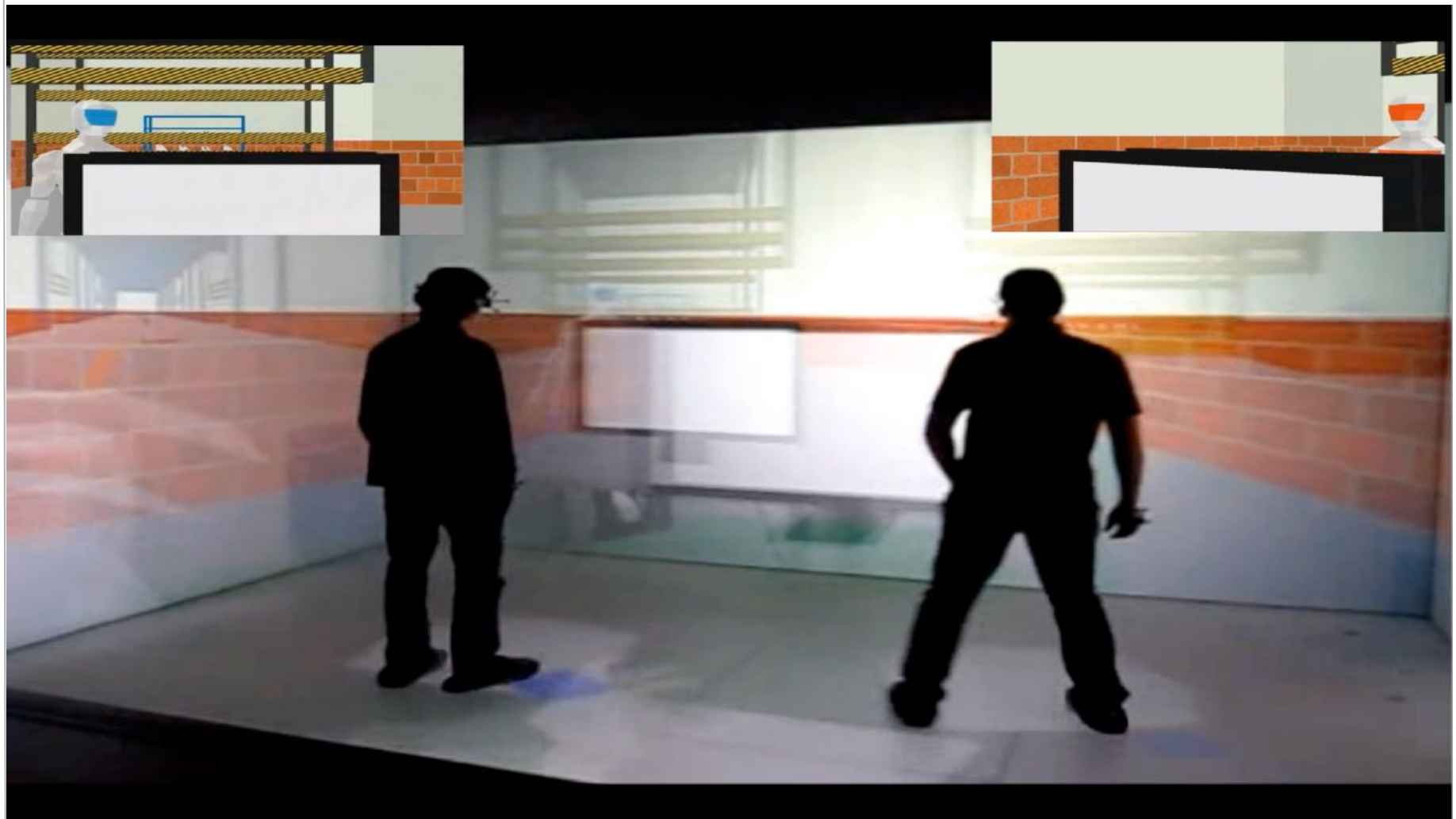
Inconsistent



Co-habitation in a CAVE

[Chen et al., 2015]

Problems arise when several users are co-located in a CAVE



Outline

Co-manipulation

Several users manipulate a same virtual object

- Edit a same virtual objet
- Achieve a hard manipulation task in VE
- Mimic the same task than in the real world (training)

Degree of Freedom (DoF)

- Usually 6 DoF (3 translations, 3 rotations) + the scale
- Some other parameters (color, shape, etc.)

3 solutions: users manipulate

- Copies of the object
- Different DoF of an object
- Same DoF of an object

Manipulate copies

Spacetime [Xia et al., 2018]

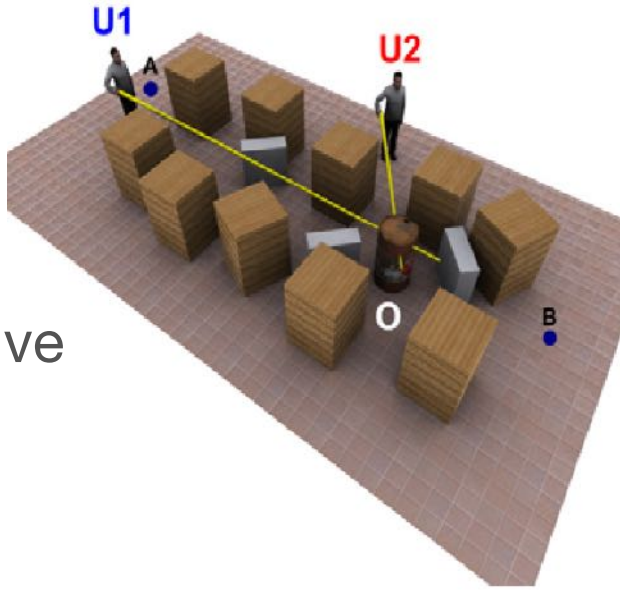
Manipulate different DoF

Users use the same tools

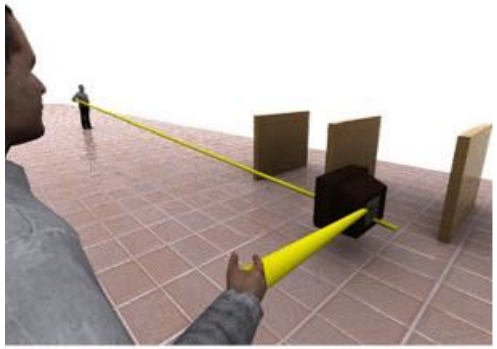
Ex: two virtual rays [Pinho et al., 2008]

Help with obstacles

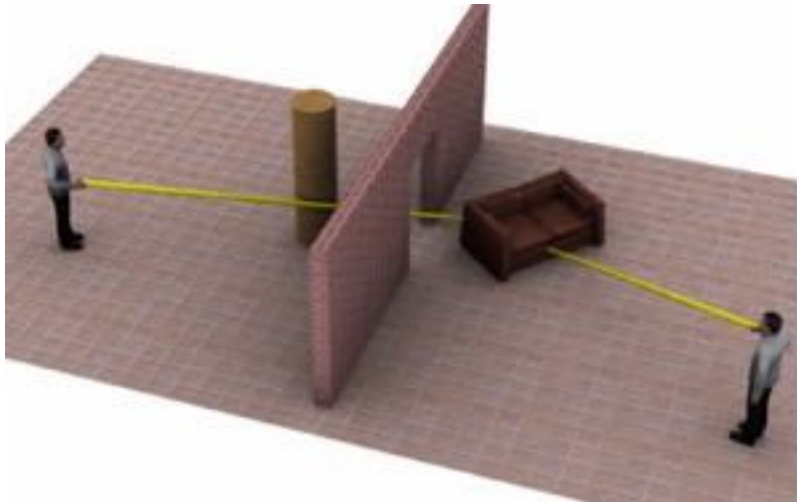
Help when the depth is hard to perceive



User U1's view



User U2's view



Manipulate different DoF

Users use different tools

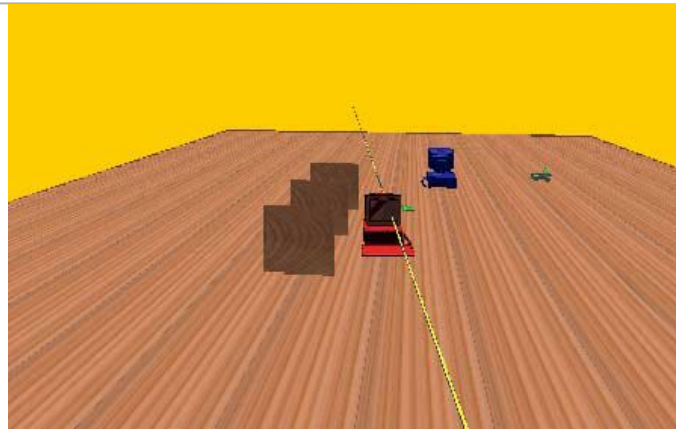
Ex: a virtual ray and a virtual hand

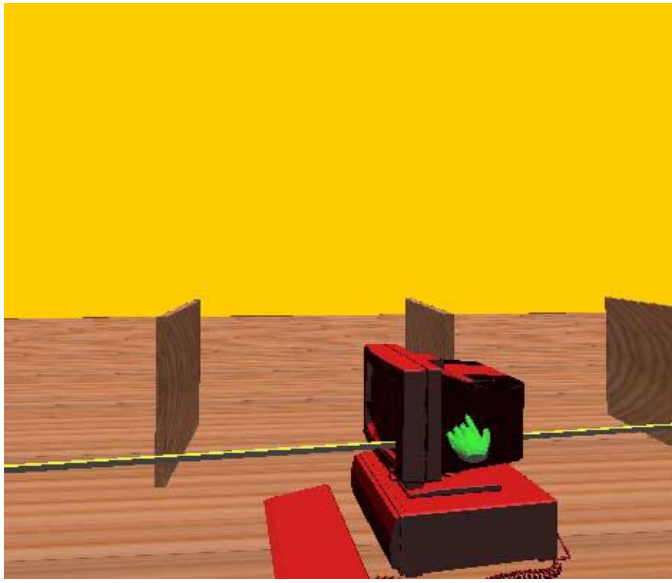
Virtual ray manages positions

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

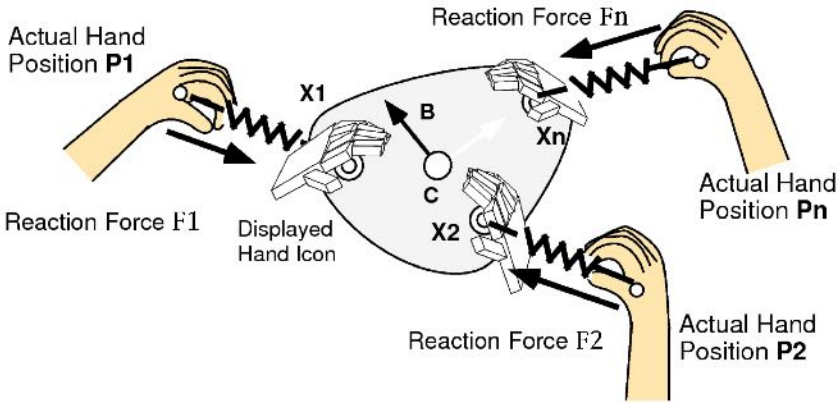
Manipulate together positions and orientations

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

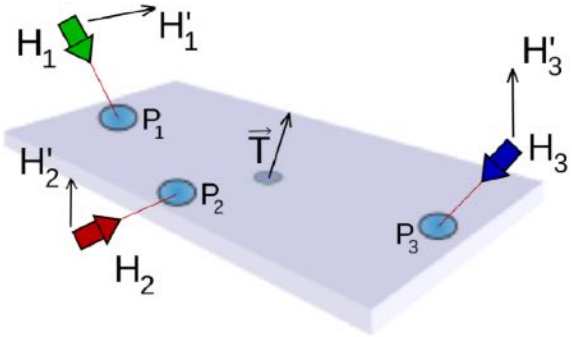
Add springs between users' hands and the object to avoid instability

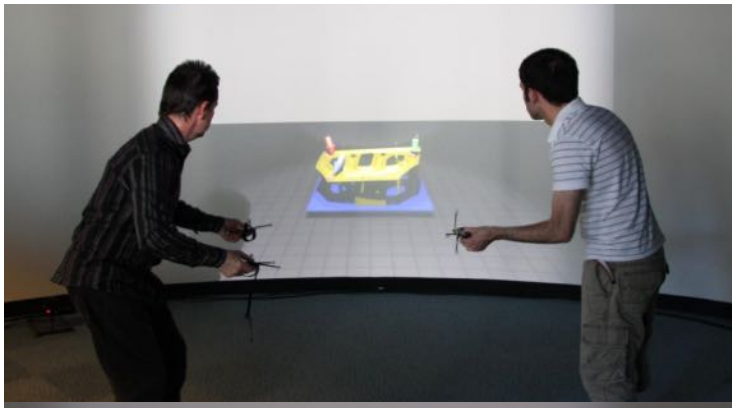


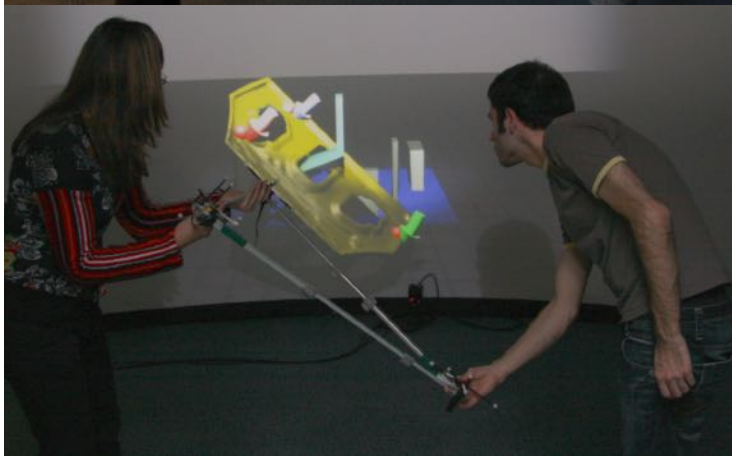
Manipulate the same DoF

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







Co-located manipulation

[Aguerreche et al., 2010]

Co-located manipulation

Even if users cannot see the others,

haptic feedback is still important

[Salzmann et al., 2009]

Conclusion

Conclusion

Co-located vs. Remote collaboration

- Social presence is a continuum

Several solutions to represent users in a CVE

- From realistic to simplified solutions
- Activities/Capabilities perception

Usually voice communication

- But still need visual tools to improve the communication

Wide range of collaborative interaction

- Navigation together or help the other to navigate
- Move virtual objects together

Conclusion

Feedback of the others are very important

- Especially for co-manipulation

Applications of CVE

- Co-expertise, collaborative review or design
- Training
  - Learn a collaborative task
  - Learn with a remote teacher
  - Learn with additional virtual content
- Entertainment (video games, artistic performance, etc.)
- Social presence (telepresence)