

## Groupware and Collaborative Interaction Collaborative Virtual Environments

M2R Interaction - Université Paris-Sud - Année 2013-2014  
Cédric Fleury (cedric.fleury@lri.fr)

### Outline

- Virtual Reality
- Collaboration in Virtual Reality
- Awareness
- Communication
- Collaborative Interaction
  - Navigation
  - Co-manipulation

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### Outline

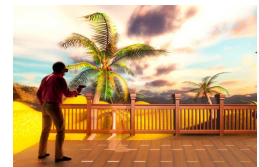
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### Virtual Reality

- Virtual environment (VE)
  - 3D virtual world
  - Simulated by computers
- Interaction in real time
  - Through various material devices
- Immersion
  - Multi-sensorial perception of the VE

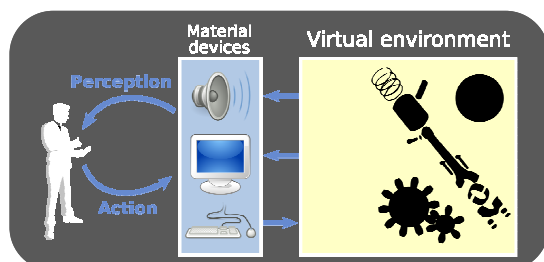


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### Virtual Reality

- Action/perception loop



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### 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.

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## Navigation

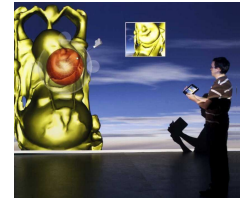
- Move the viewpoint + Modify the scale [Hand, 1997]
- Manipulate its own viewpoint  
or Manipulate the viewpoint of the others
- Include path finding [Bowman et al., 2004]

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## Navigation

- Classical techniques
  - Egocentric
    - Walking metaphor
    - Flying metaphor
    - Driving metaphor
  - Exocentric
    - Navidget [Hachet et al., 2008]
    - Grabbing the air [Mapes et Moshell, 1995]



[Hachet et al., 2008]

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## Navigation

- Classical techniques : assisted navigation
  - Select the destination
    - Pointing
    - World In Miniature (WIM) [Stoakley et al., 1995]
    - List of defined path
  - Move to destination
    - Teleportation [Ruddle et al., 2000]
    - Interpolation [Mackinlay et al., 1990]
    - “Guided visit” metaphor [Elmqvist et al., 2007]



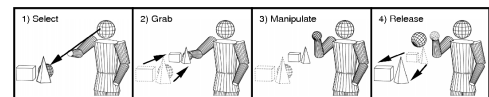
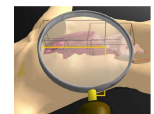
[Stoakley et al., 1995]

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## 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]

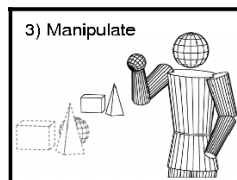


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## Object Manipulation

- Egocentric  
vs Exocentric
  - Scaled-world grab
  - WIM
- 2 main tasks
  - Selection
  - Manipulation



Video

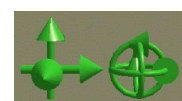
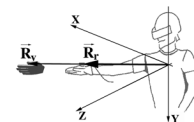
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## Object Manipulation

- 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

Video

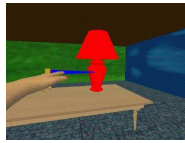


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## Object Manipulation

- Virtual Ray [Mine, 1995]
  - Mimic a laser pointer
- Image plan Interaction [Pierce et al., 1997]
  - Select by pointing with one part of the body



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## 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

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## 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]



[Coquillart et al., 1999]

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## 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)



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## Collaboration in Virtual Reality

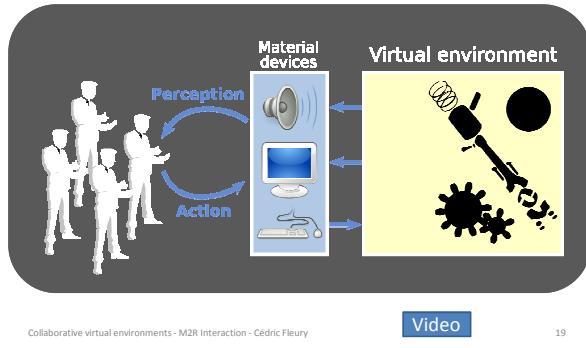


- Several users work/play together in a VE
  - Co-expertise of 3D data
  - Complex manipulation (real or virtual)
  - Training
  - Social presence (telepresence)

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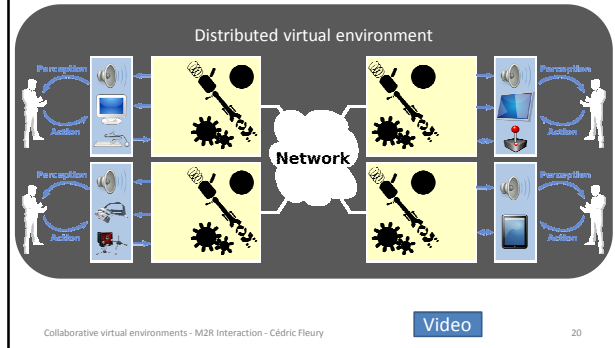
## Co-located collaboration



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## Remote Collaboration



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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?

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## Awareness

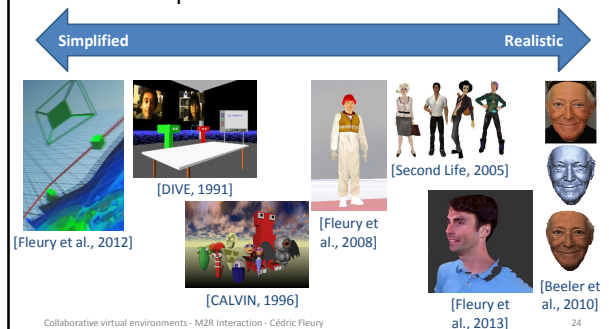
- Improve the mutual understanding
  - Just next to me... But where are you?
  - Just in front of me ... But where are you looking at?
  - Etc.
- Multi-sensorial restitution
  - Visual awareness
  - Audio awareness
  - Haptic awareness

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## Visual Awareness

- Avatar: representation of users in the VE



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## Visual Awareness

- Animation of the avatars



Kinect Avatar



Body tracking

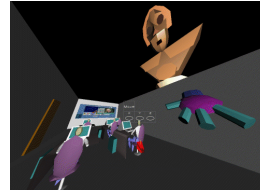
Video

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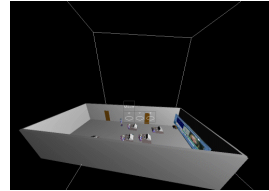
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## Visual Awareness

- Use of a WIM [CALVIN, 1996]



Mortal's view



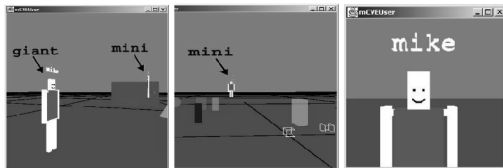
Deity's view

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## Virtual Awareness

- Multi-scale collaborative virtual environment



(a)

(b)

(c)

[Zhang et Furnas, 2002]

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## 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

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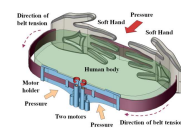
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## Haptic Awareness

- Force feedback of the others

### – Direct

- Touch the others through haptic devices
  - Virtual handshake
  - affective haptic
- Can be asymmetrical



### – Indirect

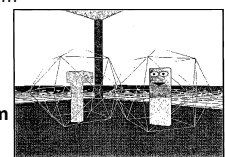
- Manipulate an object together
- Feel the force apply by the other on the object

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## Awareness Model

- Spatial Model of Interaction [Benford et al., 1994]
  - Compute which users can interact which 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]

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## Awareness Model

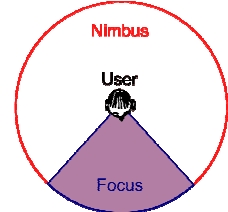
- **Spatial Model of Interaction** [Benford et al., 1994]
  - **Aura** determines potential interactions (on a technical point of view)
  - Users are responsible for controlling interactions
  - Measure of awareness between two users
    - Asymmetrical
    - Dependent of the **medium** (i.e. different for each **medium**)
  - Introduction of the **Focus** and **Nimbus**

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## Awareness Model

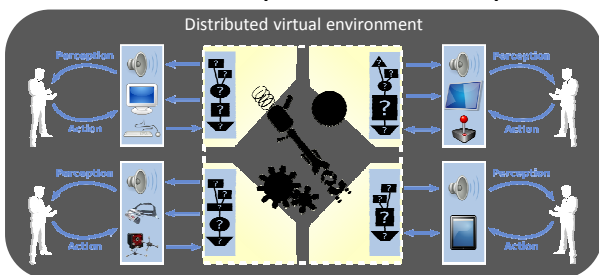
- **Spatial Model of Interaction** [Benford et al., 1994]
  - **Focus**
    - Area where a user perceive the others
    - For each particular **medium**
  - **Nimbus**
    - Area where the others can perceive a particular user
    - For each particular **medium**
    - Different from the **focus**



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## Activities/Capabilities Perception



- ⇒ How can users understand what the others are doing?
- ⇒ How can they understand what the others can do?

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## 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

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## 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



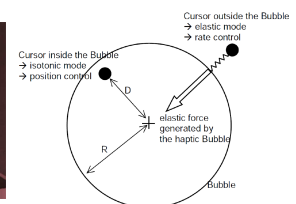
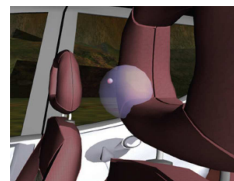
Magic Barrier Tape

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## Examples of Interaction Workspaces

- **Haptic interaction workspace**
  - Bubble technique [Dominjon et al. 05]



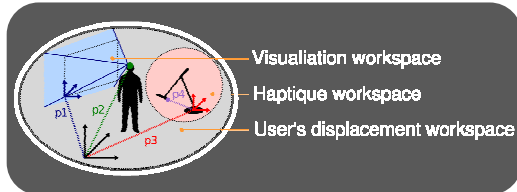
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## Immersive Interactive Virtual Cabin

[Fleury et al., 2011]

- Organizes and integrates interaction workspaces
  - Users can carry them on the VE
- Based on a structured hierarchy



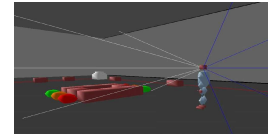
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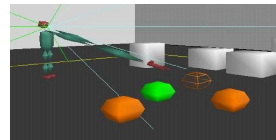
## Activities Perception

What is the user seeing?

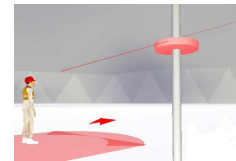
[Fraser et al., 1999]



What is the user doing?



[Fraser et al., 1999]



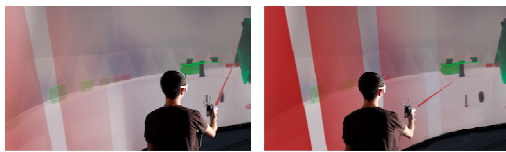
[Duval et al., 2008]

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## Capabilities Perception

- Example for the user himself:  
user's displacement workspace

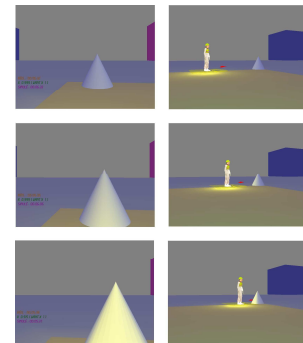


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## Capabilities Perception

- Example for  
another user:  
interaction  
workspace



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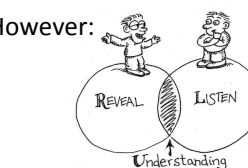
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## Voice communication

- Essential for collaborative application
  - Compensate a bad perception of the VE
- However:



Voice communication induces also discontinuity in interaction

[Bowers et al., 1996]

⇒ Users need specific tools for communication

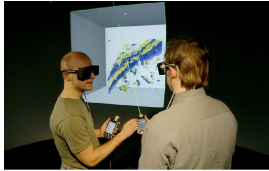
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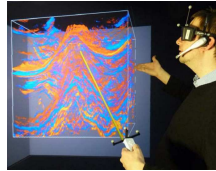


## Tools for communication

- Virtual Ray
  - Laser pointer metaphor
  - Easy and intuitive manipulation



[Simon, 2005]



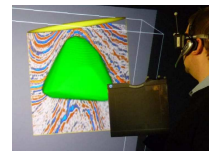
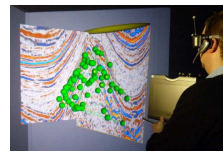
[Schild et al., 2009]

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## 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

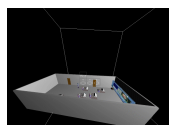
- Collaborative virtual environment
  - WYSINWIS (What Your See Is Not What I see)
    - Each user can have its own viewpoint
  - But, sometime users need:
    - To share the same viewpoint
    - To meet somewhere in the VE
    - To guide others in the VE
    - To follow each other

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## 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]

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## 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



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## 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)

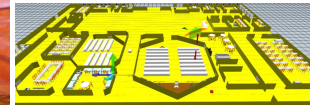


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## Guidance techniques

[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

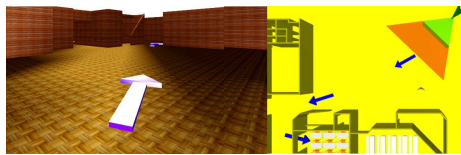
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## Guidance techniques

[Nguyen et al., 2013]

- Technique 1:
  - Draw arrows in the virtual environment



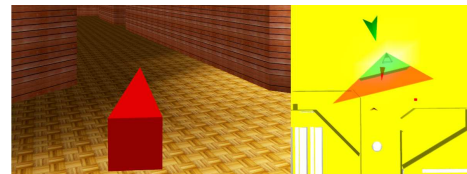
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## Guidance techniques

[Nguyen et al., 2013]

- Technique 2:
  - Orient an arrow attached to the user (like a compass)



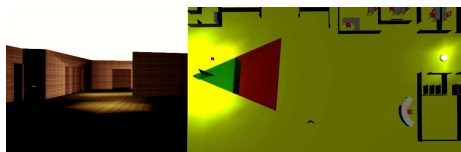
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## Guidance techniques

[Nguyen et al., 2013]

- Technique 3:
  - Align the path in the virtual environment



Video

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## Co-manipulation

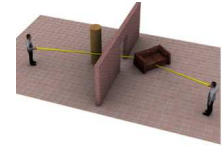
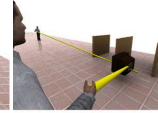
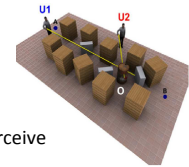
- Several users manipulate a same virtual object
  - Achieve a hard manipulation task in VE
  - Mimic the same task than in the real world (training)
- 2 solutions
  - Users manipulate different DoF of an object
  - Users can manipulate the same DoF of an object
- DoF: Degree of Freedom
  - Usually 6 DoF (3 translations, 3 rotations) + the scale
  - Some other parameters (color, shape, etc.)

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## 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

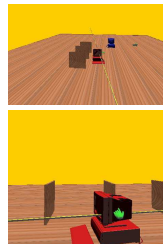


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## Manipulate different DoF

- 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



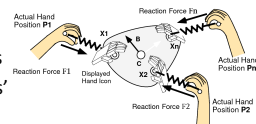
[Pinho et al., 2002]

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## 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

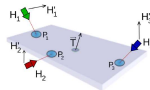


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## Manipulate the same DoF

- 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]

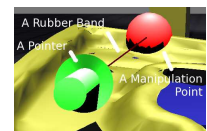


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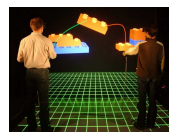
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## Manipulate the same DoF

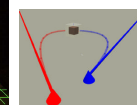
- Provide feedback to users about their actions
  - Force feedback with haptic devices
  - Springs or rubber bands
  - Curve virtual ray



[Aguerreche et al., 2009]



[Riege et al., 2006]



[Duval et Fenals, 2002]

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## 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

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## 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)

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