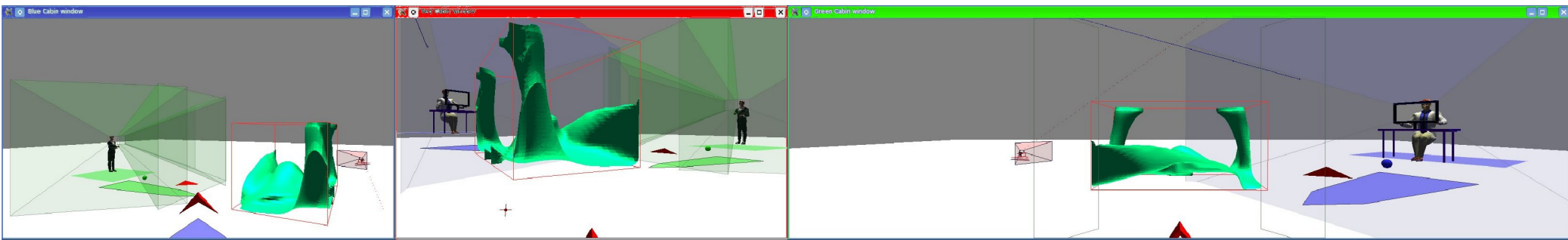


Embedding the Features of the Users' Physical Environments to Improve the Feeling of Presence in Collaborative Virtual Environments



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What is a CVE ?

- A 3D Collaborative Virtual Environment (3D CVE) is an interactive 3D virtual environment where several local or distant users can join to share a collaborative interaction experience



Exemple of CVE



What is the use for CVEs ?

- Collaborative 3D modeling or prototyping
- Virtual projects reviews
 - ✓ Automotive, plane, energy, petroleum industries, architecture
 - ✓ Collaboration between experts with different knowledge
- Distant demonstrations of complex manipulations on virtual mock-ups
- Virtual learning
 - ✓ A tutor with one or several students
 - ✓ Several students for really collaborative tasks

What is the problem with the design of CVEs ?

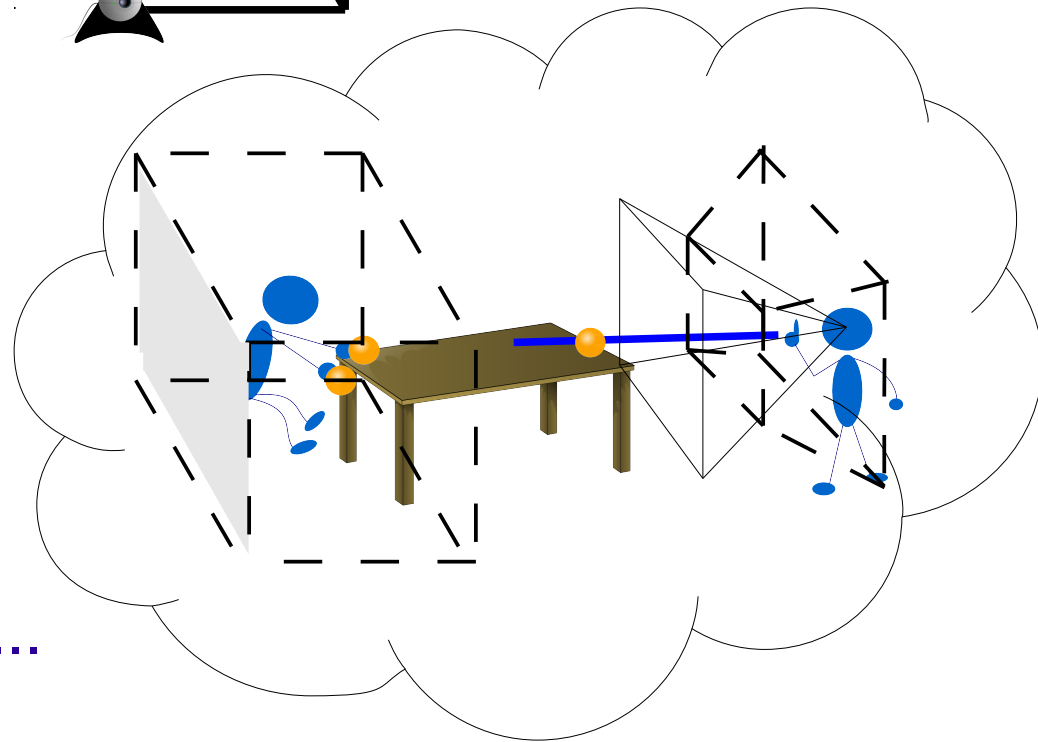
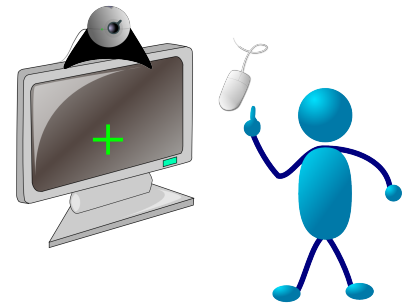
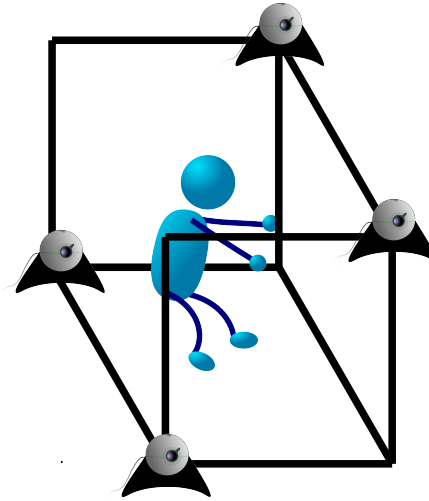
- Designing 3D CVE is a complex task
 - ✓ Address system, hardware and software issues
 - x Consistency maintenance of the shared data
 - Distribution, Synchronization
 - x Various 3D input and output devices
 - x Various 3D graphics APIs
 - ✓ Address collaborative issues
 - x 3D interaction and immersion issues
 - Description of the interactive content of the shared universe
 - Immersive 3D interaction metaphors
 - x Collaborative interaction metaphors
 - x Awareness of immersion, interaction, collaboration
- To meet all these requirements, merge knowledge about :
 - ✓ Networks, CSCW, VR, 3DUI, HCI, Software Engineering...

Designing a CVE : the functional features

➤ 2 distant users want to co-manipulate a virtual object

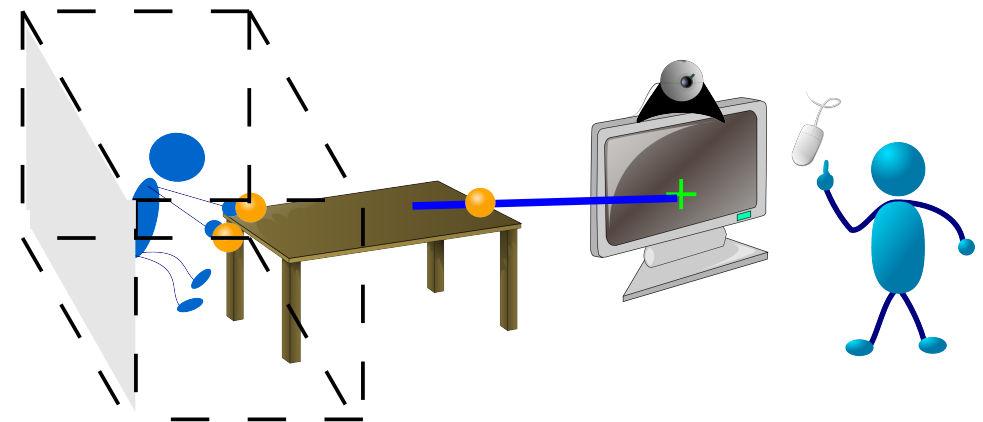
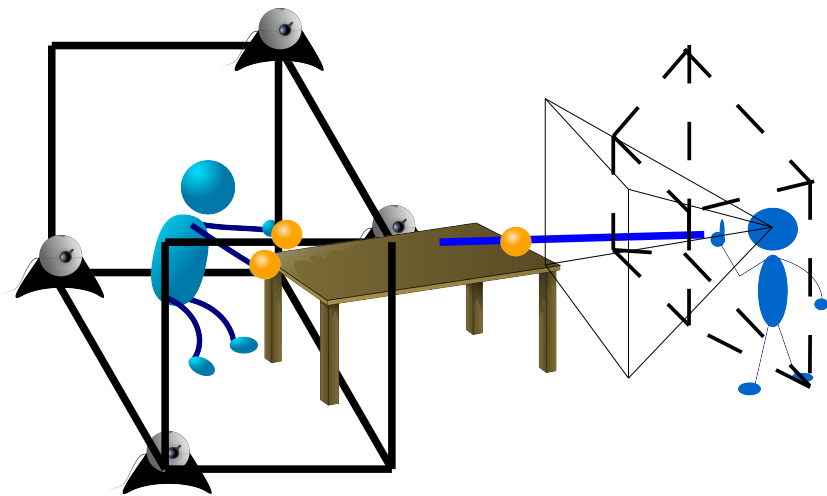
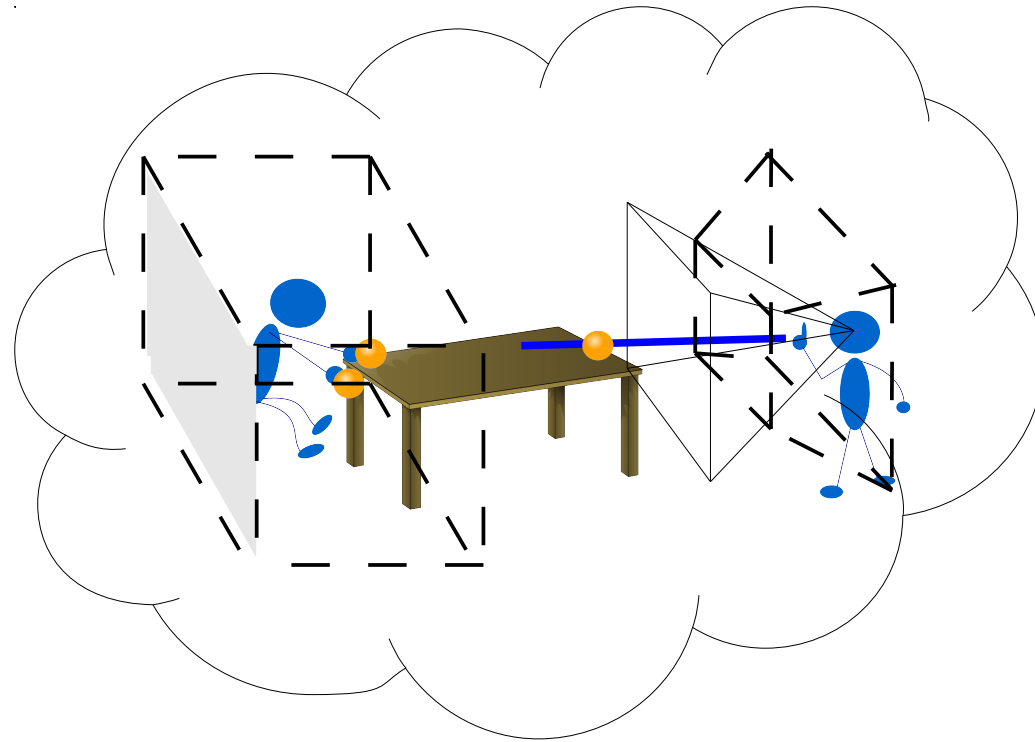
➤ The needs for the CVE

- ✓ Input device drivers
- ✓ Interaction tools (behavior)
- ✓ Interactive shared object
- ✓ Interaction protocol
 - x With interaction awareness
- ✓ Visualizers
 - x Dedicated to each device
- ✓ Workspaces
 - x For better awareness
- ✓ Avatars
 - x For better interaction
- ✓ A deployment over a network...

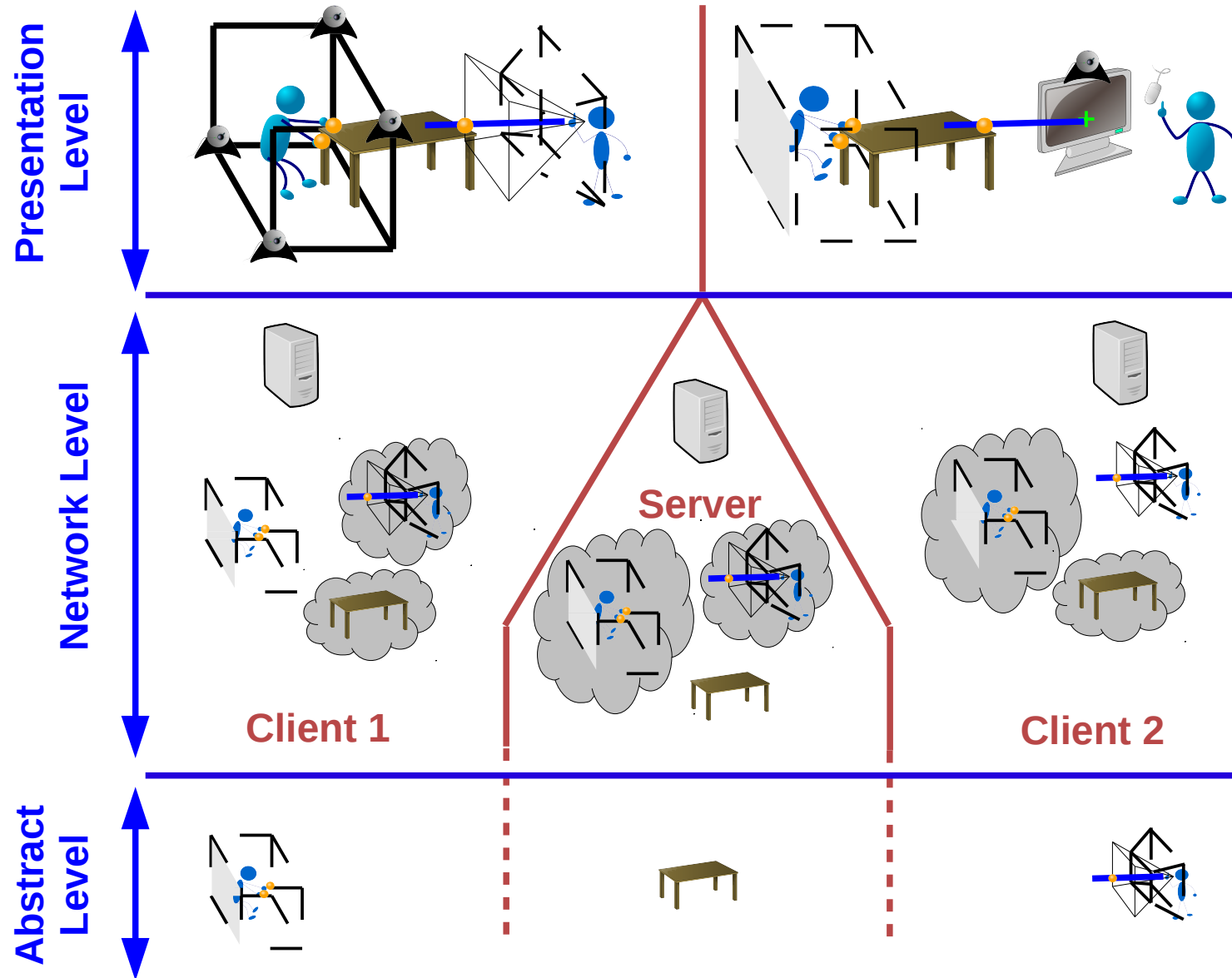


Designing a CVE : the expected result

- A deployment on each user's system...



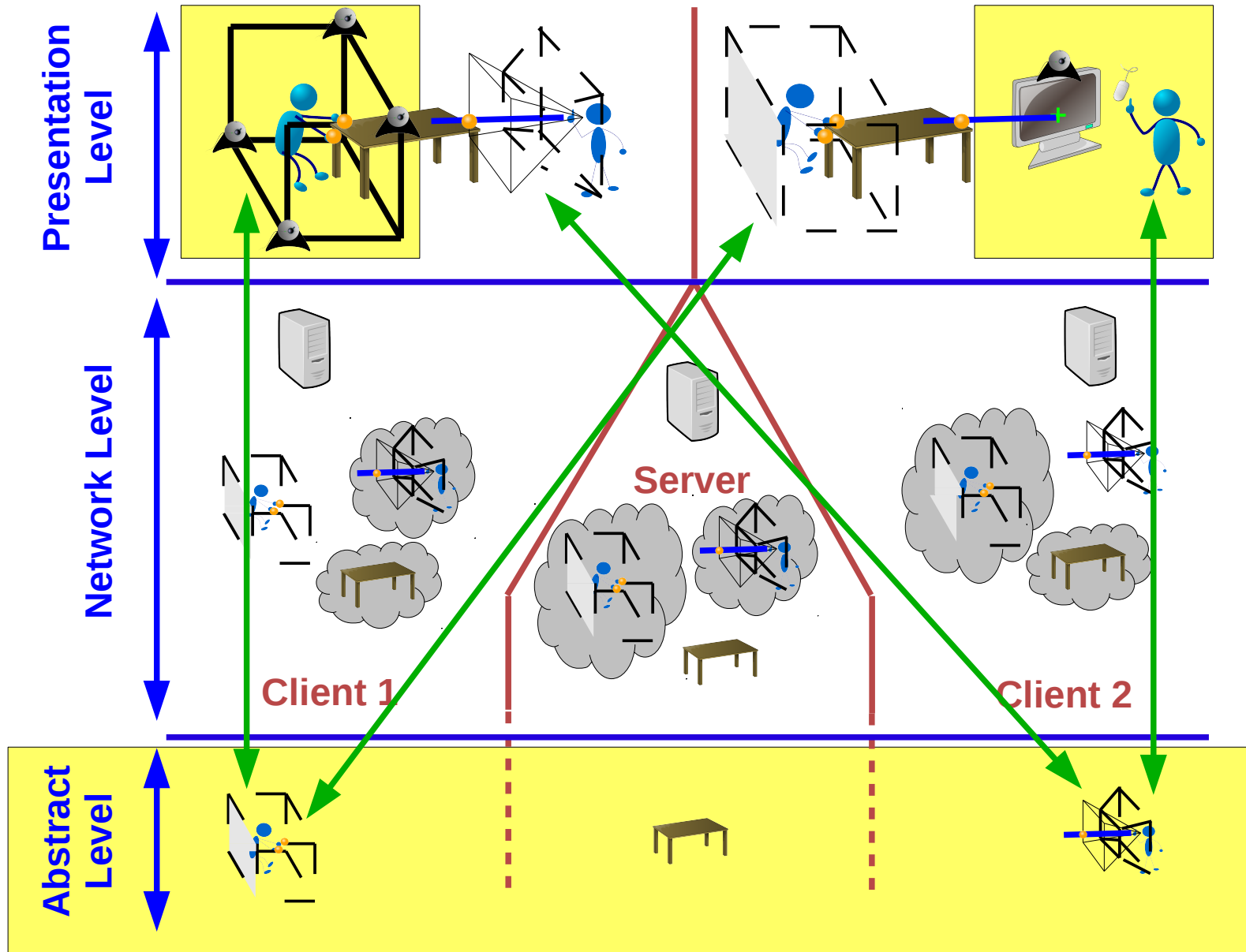
Designing a CVE : the architectural features



Schedule

- Introduction
- Workspace features
- Models for users' physical workspaces
- The IIVC concept
- A use case for the IIVC
- Conclusion and perspectives

Designing a CVE : the workspace features



Embedding the users' physical workspaces

- VR applications require to embed the user's physical environment into the virtual environment
 - ✓ To allow the user to move with its own body
 - ✓ To manage a virtual world bigger than the physical workspace
 - ✓ To enhance the user's understanding of the VE
 - ✓ To enhance other user's understanding of the collaboration
- Main issues
 - ✓ Lack of generality
 - ✗ Each VR system Makes it its own way in order to meet its particular requirements according to the devices and interaction techniques used
 - ✓ Only partial solutions
 - ✓ Most solutions rely too much on a scene-graph related to a specific 3D graphics API

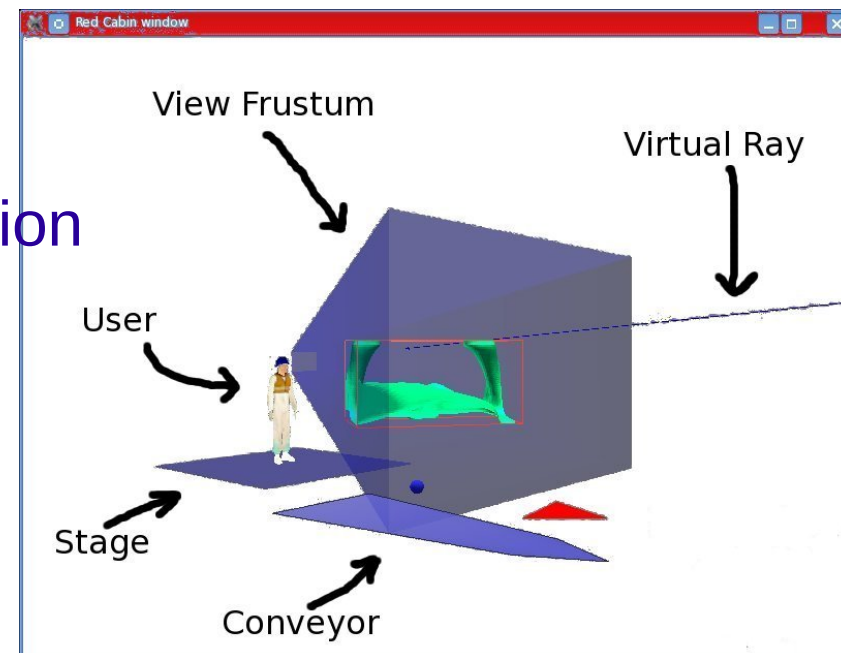
Related work about physical workspaces

- 3DM [Butterworth & al. 1992] proposes the magic carpet
 - ✓ The user can move on the magic carpet
 - ✓ The user navigates by moving the magic carpet
 - ✓ The user can carry tools with him when he navigates
- Embedding physical features of the users for collaboration
 - ✓ Users' Avatars [Leight & al. 1996]
 - ✓ Focus and Nimbus [Benford & al. 1994]
 - ✓ View frustum [Fraser & al. 1999]
- Software models for VR system design
 - ✓ Model of the user
 - × SVE [Kessler & al. 2000], Dive [Steed 2008]
 - ✓ Scene-graph-like solutions
 - × [Robinett & al. 2002], Dive [Hagsand 1996], Diverse [Kelso & al. 2002]
 - × Sensory workspaces [Mulder & al. 2004]

The Immersive Interactive Virtual Cabin

➤ A generic solution:

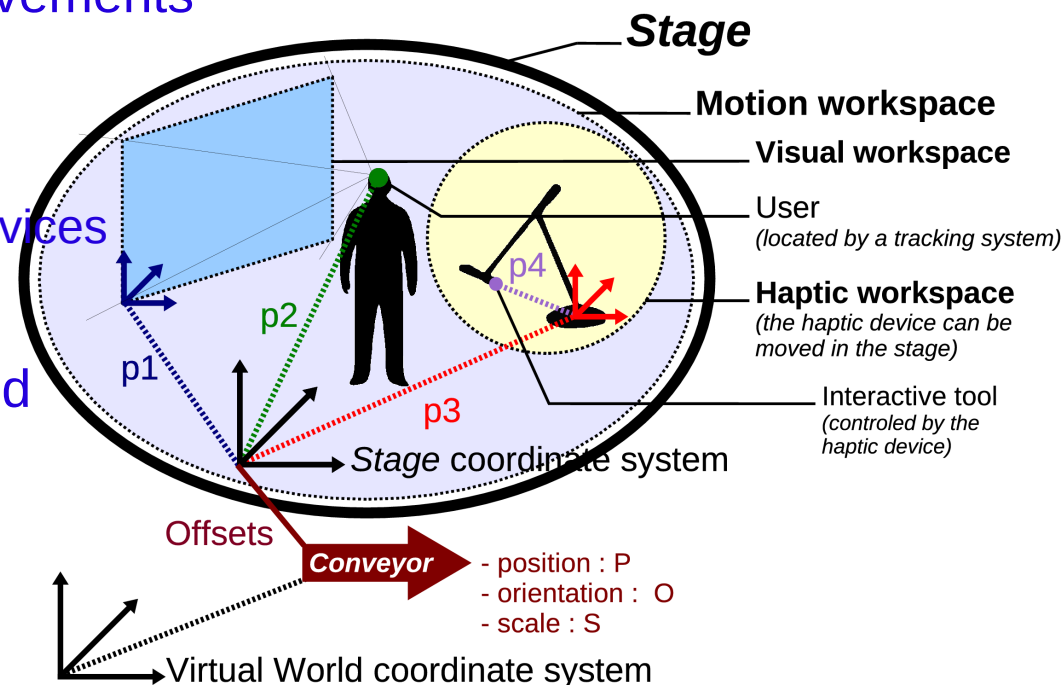
- ✓ That considers users' physical environment
 - x During the VR software design
 - x During the VR software deployment
 - x During the VR software use
- ✓ That makes the link between these 3 steps
- ✓ That proposes a high-level model
 - x To describe
 - x To configure
 - x To modify
- users' physical workspace organization
 - x Whatever the immersive devices used
- ✓ [Duval & Chauffaut 2006]
- ✓ [Fleury & al. 2010]



The hierarchy of workspaces

➤ A stage may contain different kinds of areas

- ✓ Motion/mobility workspaces
 - x Where the user makes real movements
- ✓ Visual/vision workspaces
 - x What the user can see
 - through and around display devices
- ✓ Sound workspaces
 - x Where the user perceives sound
- ✓ Interaction workspaces
 - x Where the user can interact
- ✓ Haptic workspaces
 - x Where the user can interact and receive haptic feedback



➤ The stage is the root of the hierarchy of workspaces

- ✓ Workspaces contain the virtual objects of the user
- ✓ Other objects of the virtual world are somewhere else

The IIVC main features

➤ Navigation

- ✓ Moving within the motion workspace
 - x The visual workspace is the “window” of the stage on the virtual world
- ✓ Moving the stage or the conveyor
 - x With any well-known navigation metaphor
 - x In relation to an object to study

➤ Interaction

- ✓ Using interaction tools
 - x Virtual hand, virtual ray
- ✓ Carrying interaction tools

The IIVC main features

➤ Awareness

- ✓ Embedding real objects within VE through the stage
- ✓ Co-locating real and virtual objects
- ✓ Representing the limits of the workspaces

➤ Collaboration

- ✓ Seeing the other users' IIVC
 - × Understanding other user's physical limitations
- ✓ Joining another user
- ✓ Traveling with another user
- ✓ Interacting with another user's conveyor
- ✓ Overlapping another conveyor

Collaborative use case for the IIVC

- Collaborative exploration of a virtual environment



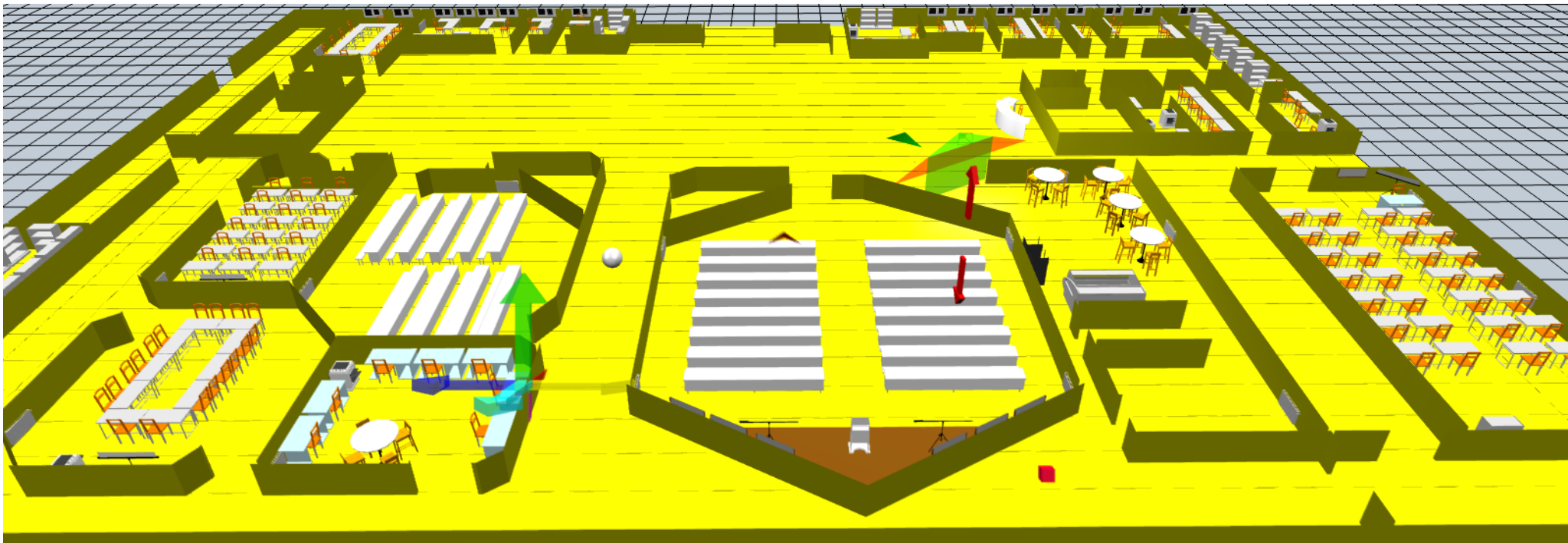
Collaborative use case for the IIVC

- The main user immersed in the Virtual Environment



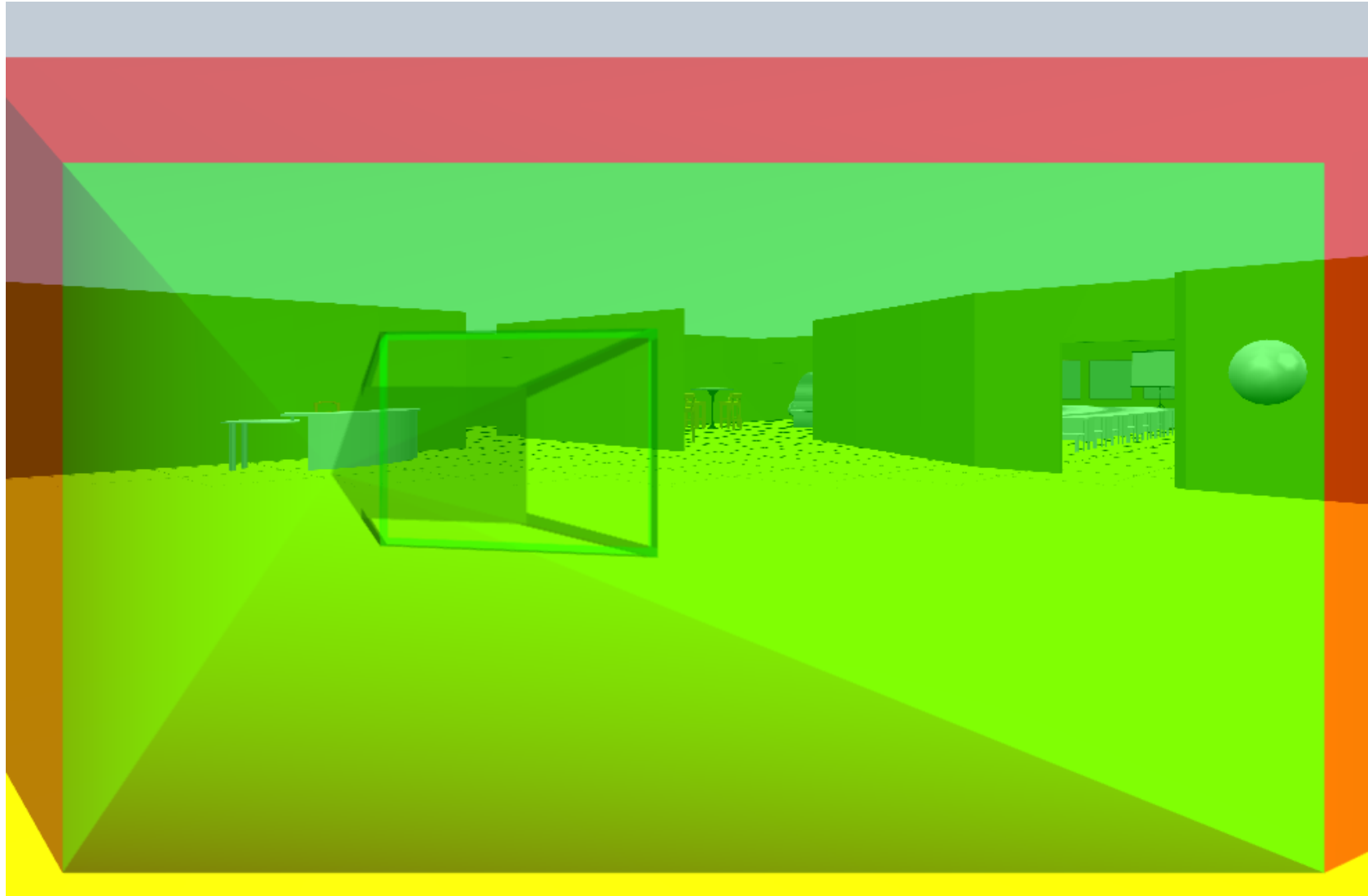
Collaborative use case for the IIVC

- The views of the helping user
 - ✓ He can see where is the main user



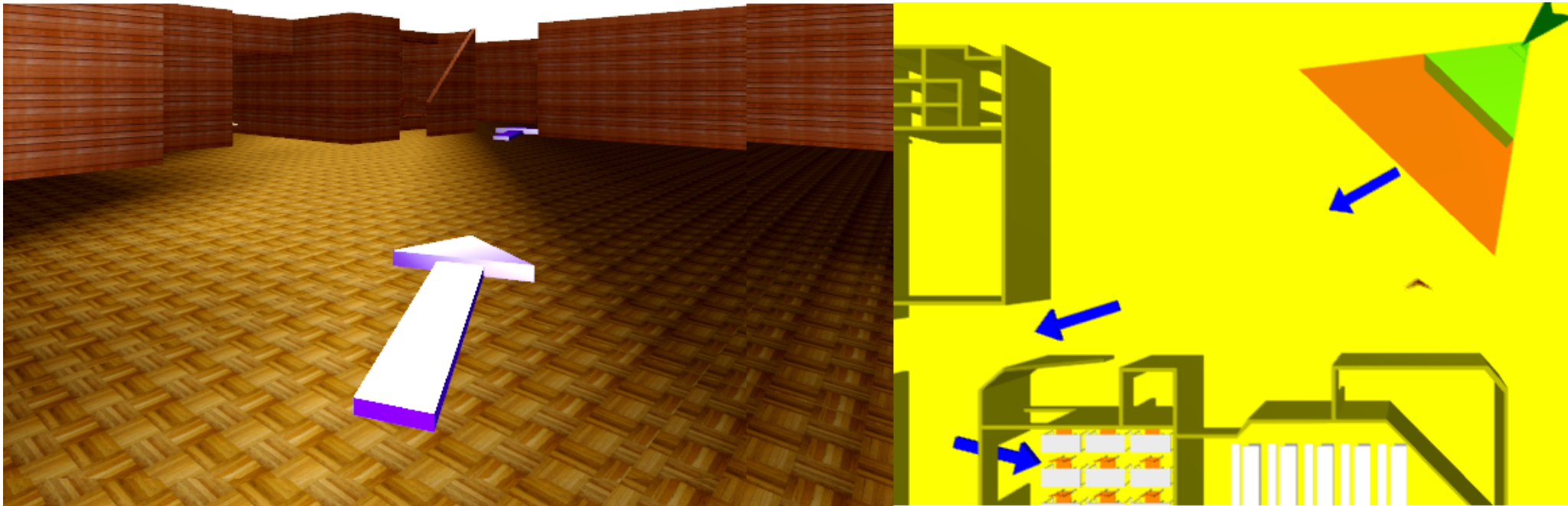
Collaborative use case for the IIVC

- The second of the helping user
 - ✓ He can see what the main user is looking at !



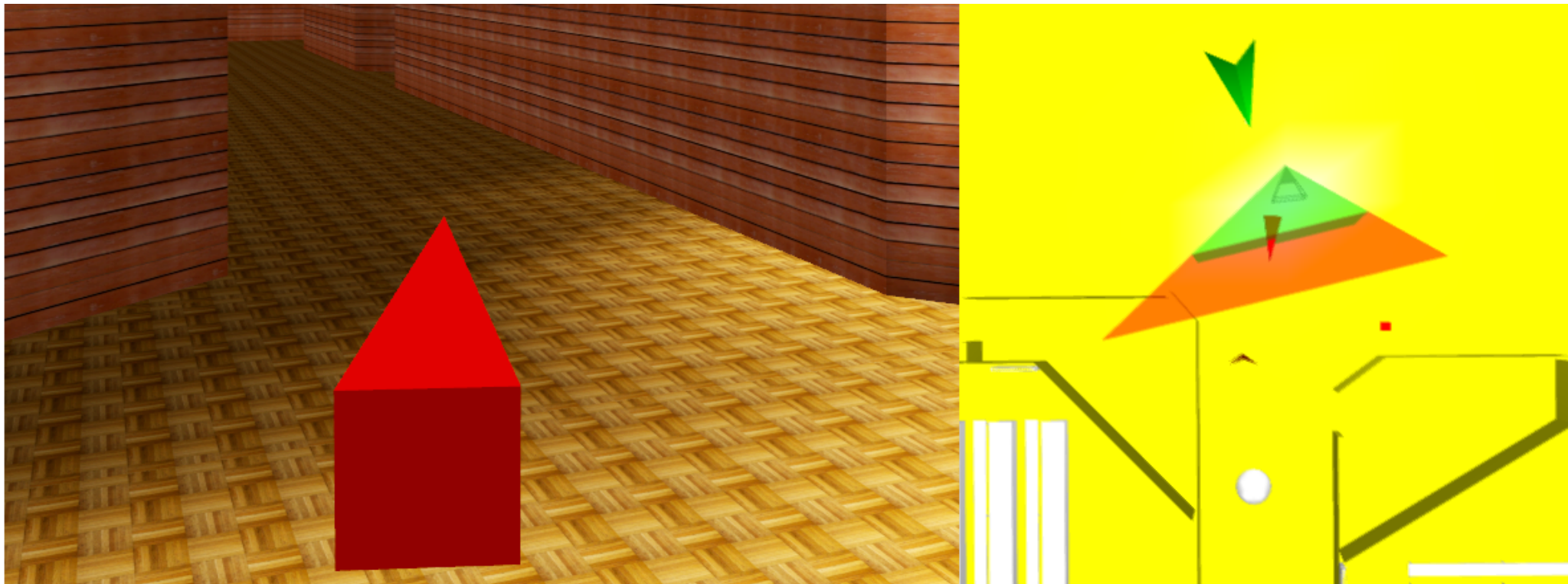
Collaborative use case for the IIVC

- To guide the main user
 - ✓ The helping user can draw 3D arrows thanks to his knowledge of where is the main user and what he is looking at



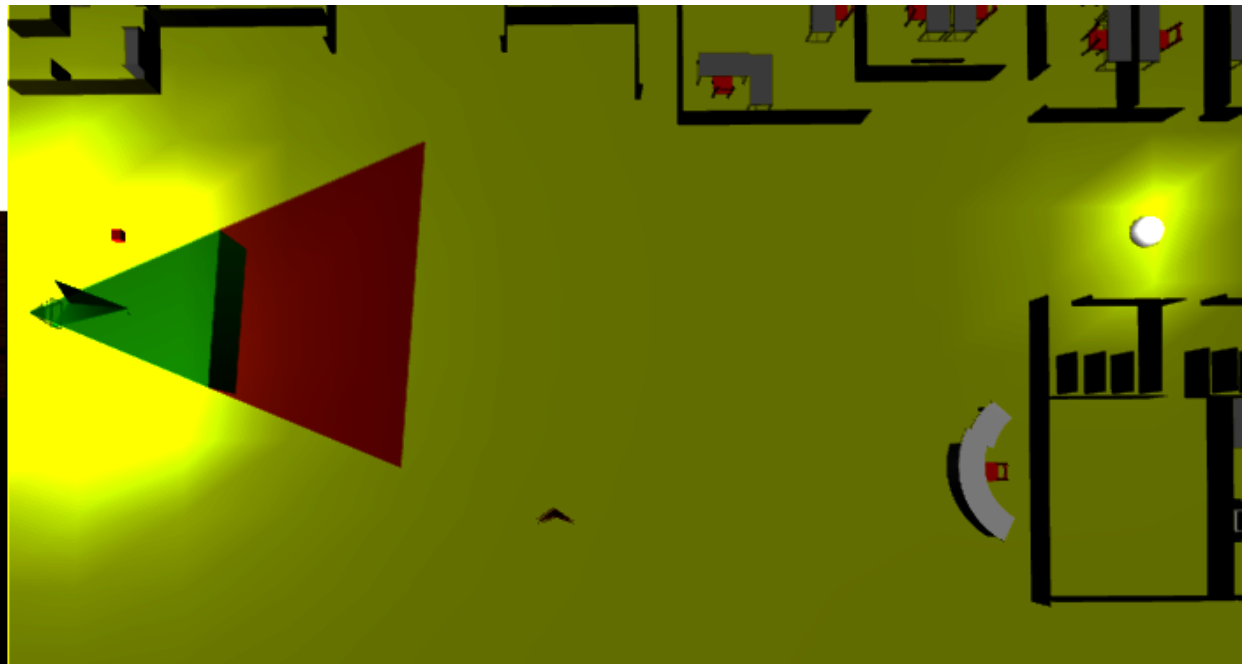
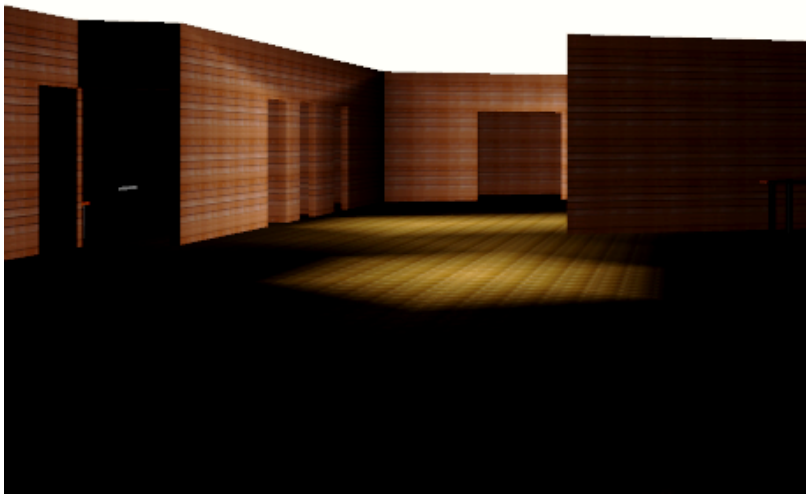
Collaborative use case for the IIVC

- To guide the main user
 - ✓ The helping user can control the north of a 3D compass thanks to his knowledge of where is the main user and what he is looking at



Collaborative use case for the IIVC

- To guide the main user
 - ✓ The helping user can move a light source thanks to his knowledge of where is the main user and what he is looking at, and the impact of the light on how the environment is influence by the guiding light



Conclusion

- The Immersive Interactive Virtual Cabin (IIVC)
 - ✓ Provides a generic software model to embed users' physical workspaces in a virtual environment
 - ✓ Is an abstraction of immersive devices which enables the VR developers to design applications without taking into consideration which immersive devices will be used
 - ✗ Can be adapted easily to a simple workstation or to a fully immersive device like a CAVE
 - ✓ Matches the real world with the virtual world to maintain head-tracking of users or co-location of real objects even if users navigate in the virtual world
 - ✗ So users have a better perception of the virtual environment
 - ✓ Can be used to enhance collaboration and communication between users sharing a CVE

Perspectives

- Improve collaboration, especially for immersive systems
 - ✓ Enhance the IIVC concept
 - x Provide more advanced operators
 - x Enhance awareness of interaction and collaboration capabilities
 - x Formalize IIVC description with languages such as X3D or Collada
 - x Propose new metaphors for collaborative interactions
 - ✓ It was the topic of the 3DUI 2012 contest
 - x We participated with the IIVC and dedicated guiding techniques
 - [Nguyen et al. 2012]
 - x We improved some of the techniques and made some evaluations
 - [Nguyen et al. 2013]