Advanced Topics in Virtual Reality

Calibration and Registration

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2019

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Calibration and Registration

To produce a working 3D viewing and interaction experience, one has to calibrate all devices and register them to reality.

Calibration:

mapping tracker to real world position
mapping HMD to real world view

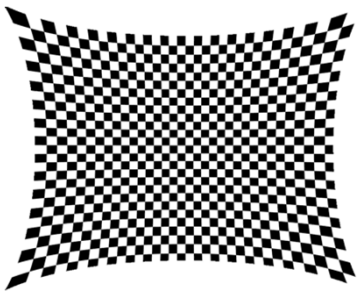
Registration:

for the set-up to work, all devices have to be „registered“ to each other in the same coordinate system

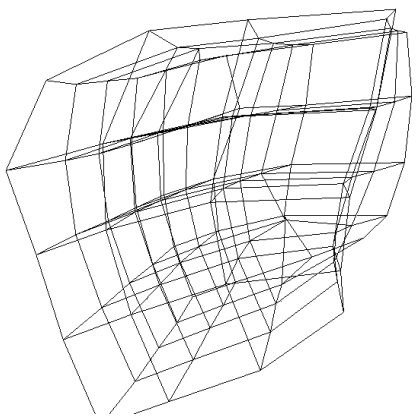
Calibration

Determine & correct non-linearities and scale factors, e.g.:

distortions of optics in a HMD:

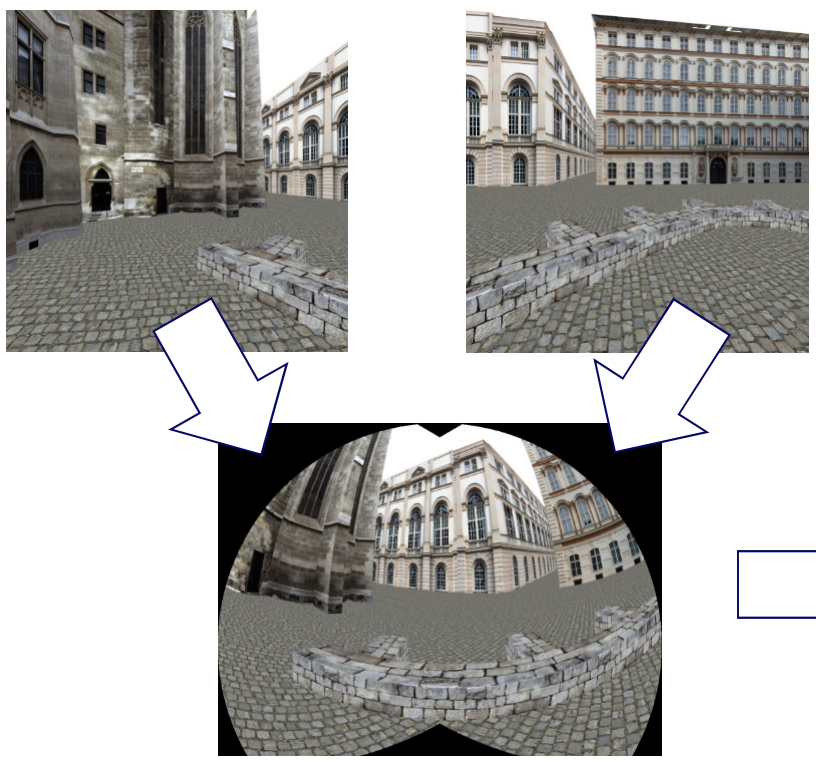


distortions of magnetic tracker:



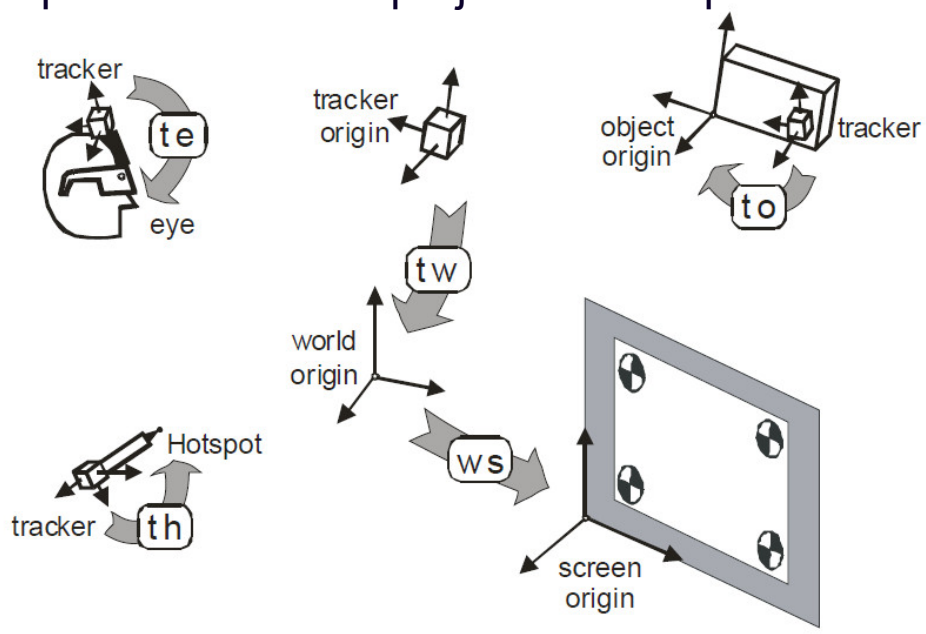
Calibration

mapping of image to projection screen::



Registration

registration parameters for a projection set-up



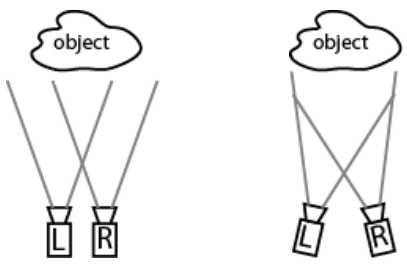
A. L. Fuhrmann, R. Splechtna, and J. Prikryl. „Comprehensive Calibration and Registration Procedures for Augmented Reality". In *Proceedings Eurographics Workshop on Virtual Environments, pages 219–228, Stuttgart, Germany, May 2001.*

Correct Stereoscopy

The stereoscopic effect depends heavily on the correct projection of left and right image.

Example: rendering for stereoscopic projection

Wrong:
offset or tilt

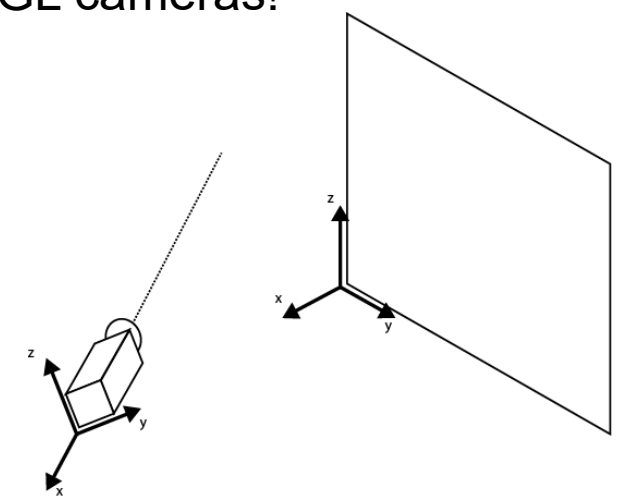


Correct:
off-axis projection

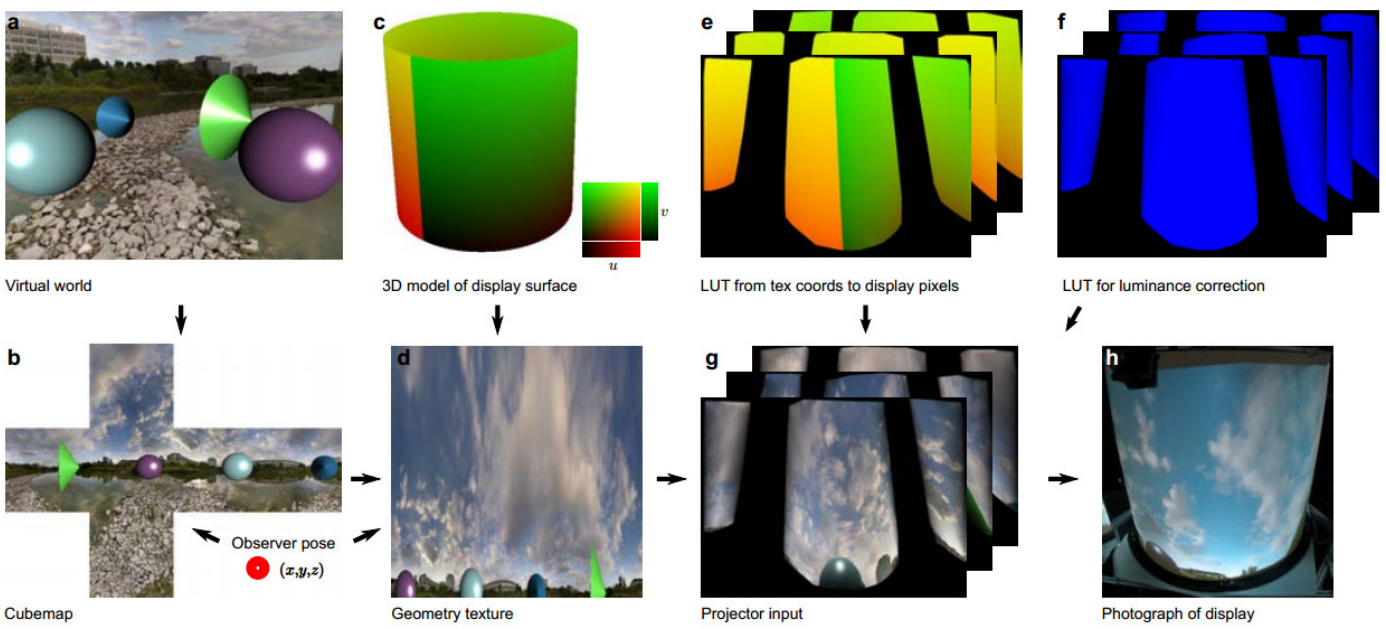
Correct Stereoscopy

A general camera model is necessary, where view plane and eye-point with viewing direction can be defined independently.

This is NOT generally possible in most render packages and OpenGL cameras!



Example: Calibration & Registration for FlyVR



Advanced Topics in Virtual Reality

Virtual Environments
System Setups

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VR setups

Categories:

- Immersive / Augmented (Mixed)
- Single / Multi user
- Local / Distributed

Immersive vs. Augmented setups

Immersive setup

- user sees only simulation
- pro:
  - whole visible world can be manipulated
  - less registration problems
- contra:
  - possible: disorientation & claustrophobia
  - collisions w/reality
  - whole environment must be generated (real objects too →real collisions!)

Immersive vs. Augmented setups

Augmented (Mixed) setup

- user sees real & virtual environment
- pro:
  - only virtual objects have to be displayed
  - social interaction possible
  - objects outside the simulation are visible (cars, other people, doors, etc.)
- contra:
  - registration between real & virtual world tricky (misregistration very visible)
  - navigation metaphors reduced

The CAVE

("CAVE Automatic Virtual Environment")

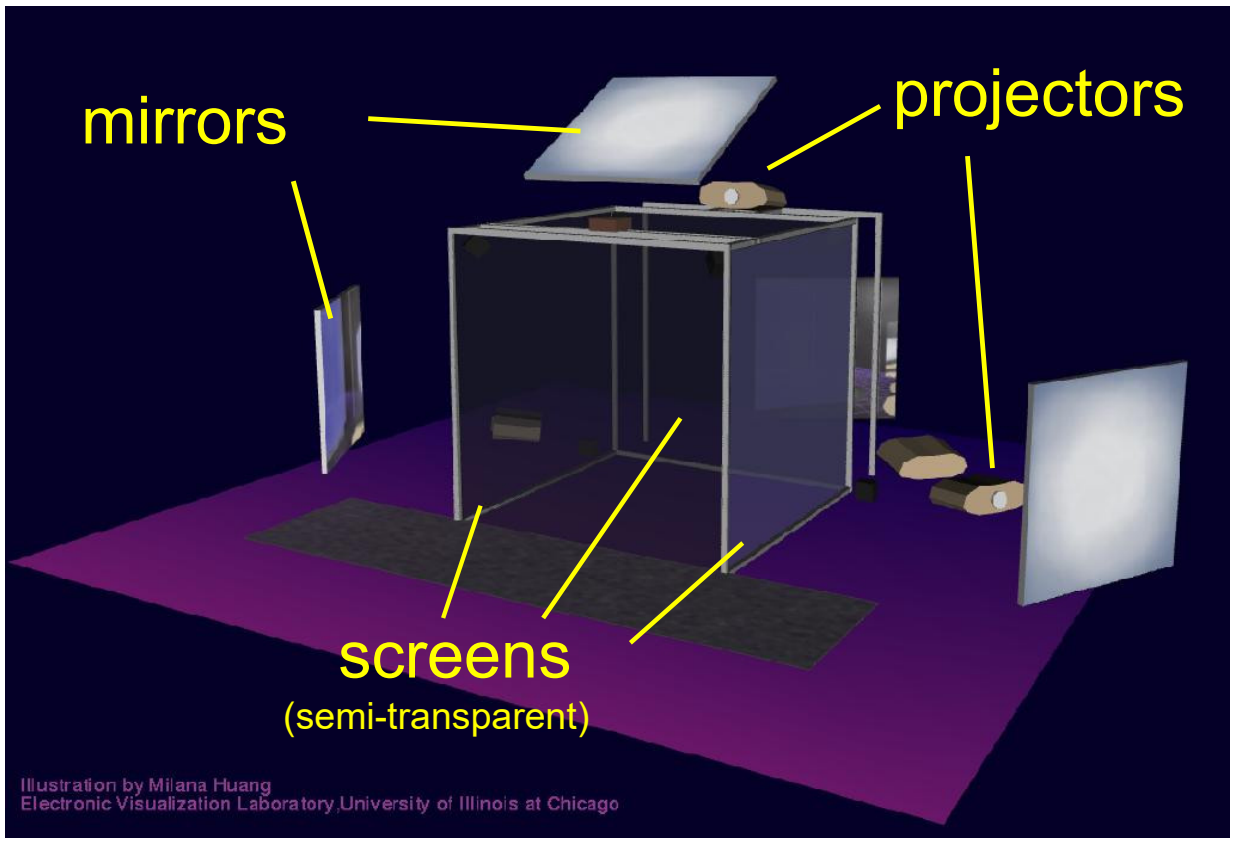
The "CAVE" consists of 3 to 6 back-projection screens. These screens form (parts of) a cubical room in which the user has a large view of the VE.

The CAVE

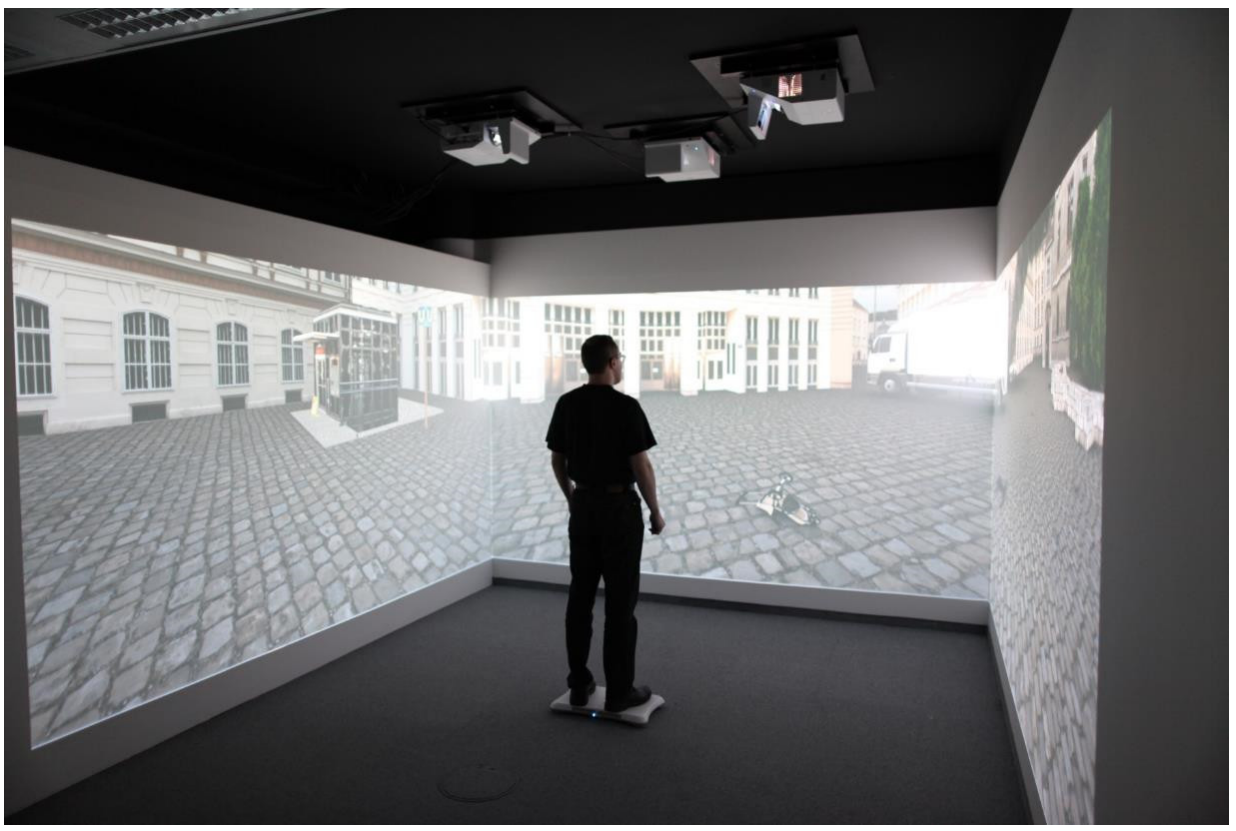
A CAVE user

- wears Shutter- or Pol-glasses
- has to be head-tracked
- uses a tracked input device

The CAVE – back projection



The CAVE – front projection



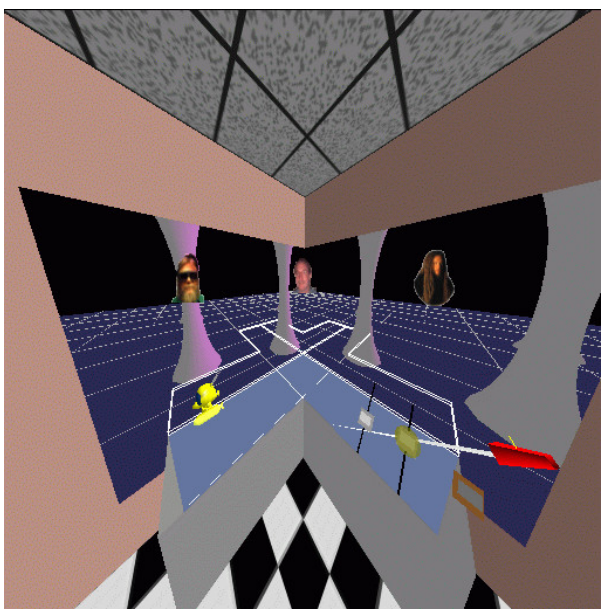
The CAVE – front vs. back projection

	Back	front
Space requirements	Larger than working volume	Working volume
Screen	Expensive, special corners	White wall
Vignetting	Extensive	Not noticeable
Shadows	None	When standing close
Polarization	Possible, but mediocre	Not really possible
Top & bottom projection	Possible	Not possible

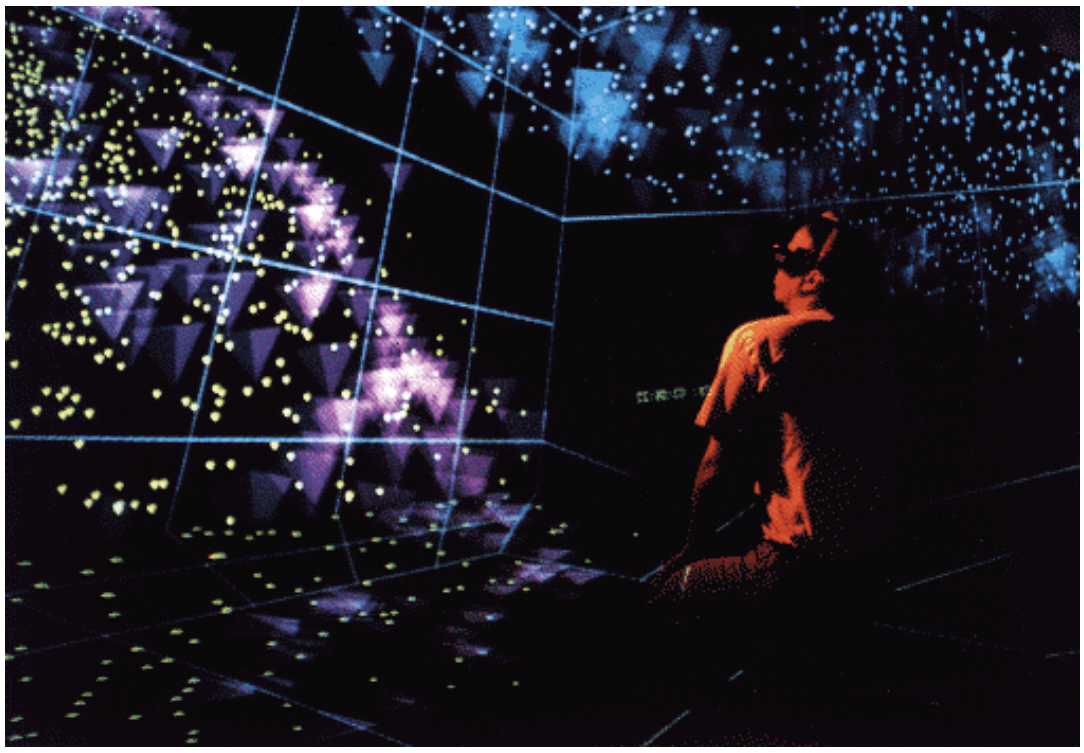
The CAVE

Images for the CAVE have to be calculated depending on the users and screens position.

From the wrong position, the images look like this:

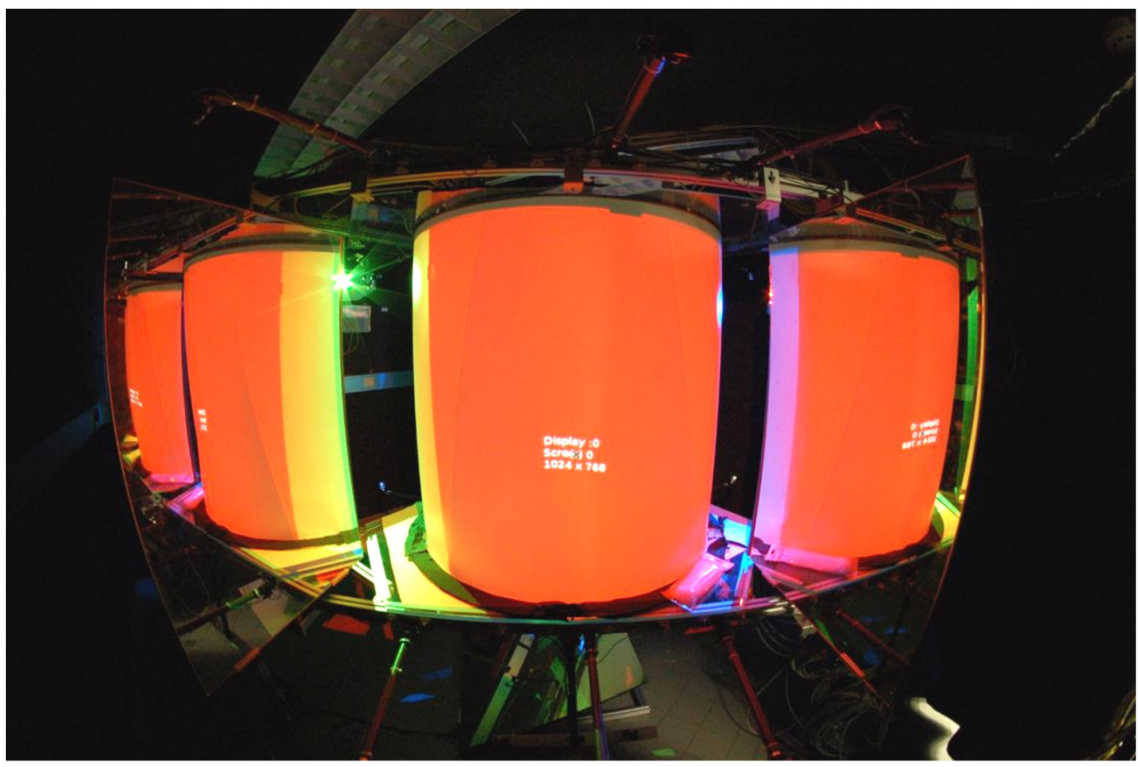


The CAVE

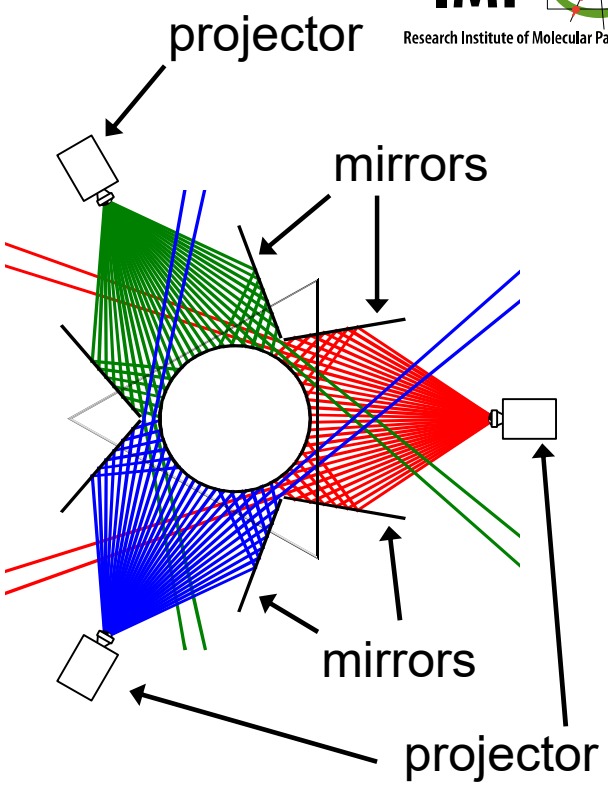


The FLYCAVE

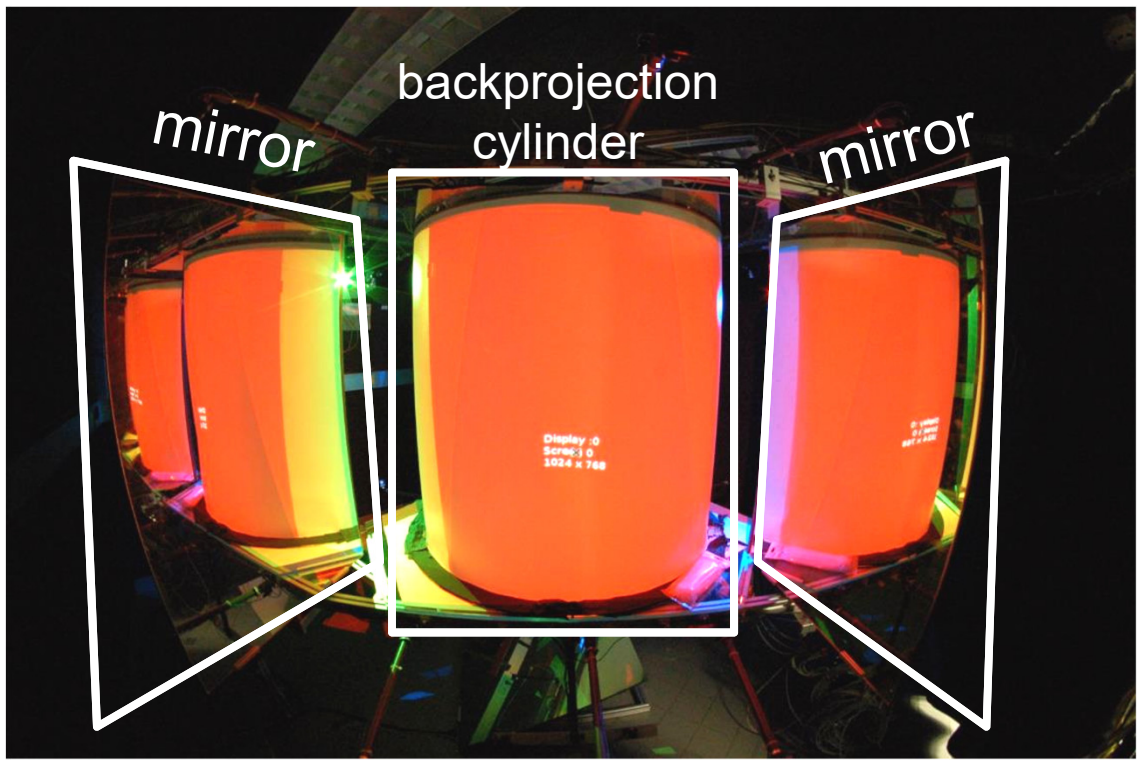
IMP Research Institute of Molecular Pathology



The FLYCAVE - display

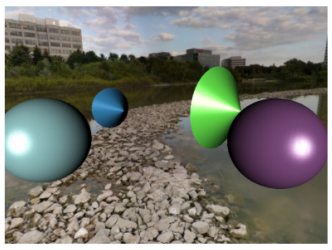


The FLYCAVE - display

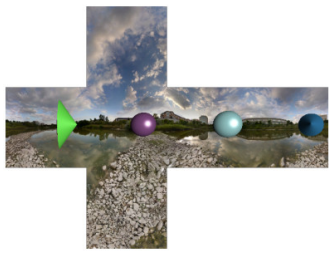


The FLYCAVE – rendering

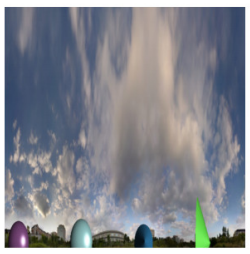
IMP
Research Institute of Molecular Pathology



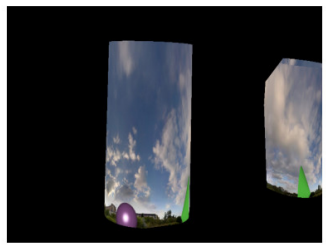
Virtual world
- arbitrary scene rendered with OpenSceneGraph (e.g. skybox and foreground objects above)
- drawn via user-created plugin
- defined in lab frame



Cubemap
- six camera views of virtual world
- from viewpoint of observer in lab frame

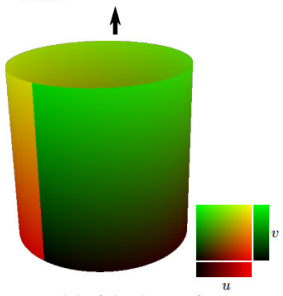


Geometry texture
- created by projecting cubemap onto 3D model of display surface in lab frame

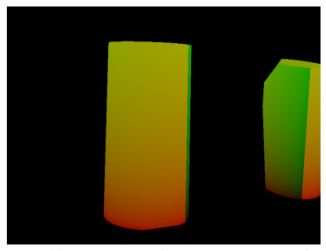


Display view
- created by lookup table from geometry texture coordinates to display pixels
- physically displayed

3D pose of observer
- defined in lab frame



3D model of display surface
- vertices defined in lab frame
- texture coordinates in arbitrary system
- measured during auto-calibration



LUT from tex coords to display pixels
- measured during auto-calibration

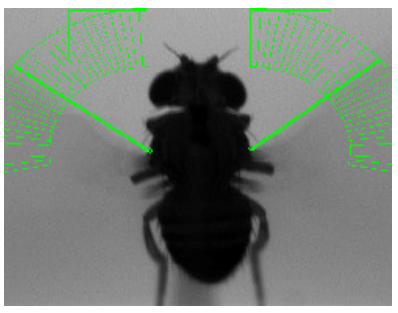
The FLYCAVE – tethered version

IMP
Research Institute of Molecular Pathology

Three images are projected via mirrors on a small, translucent ball

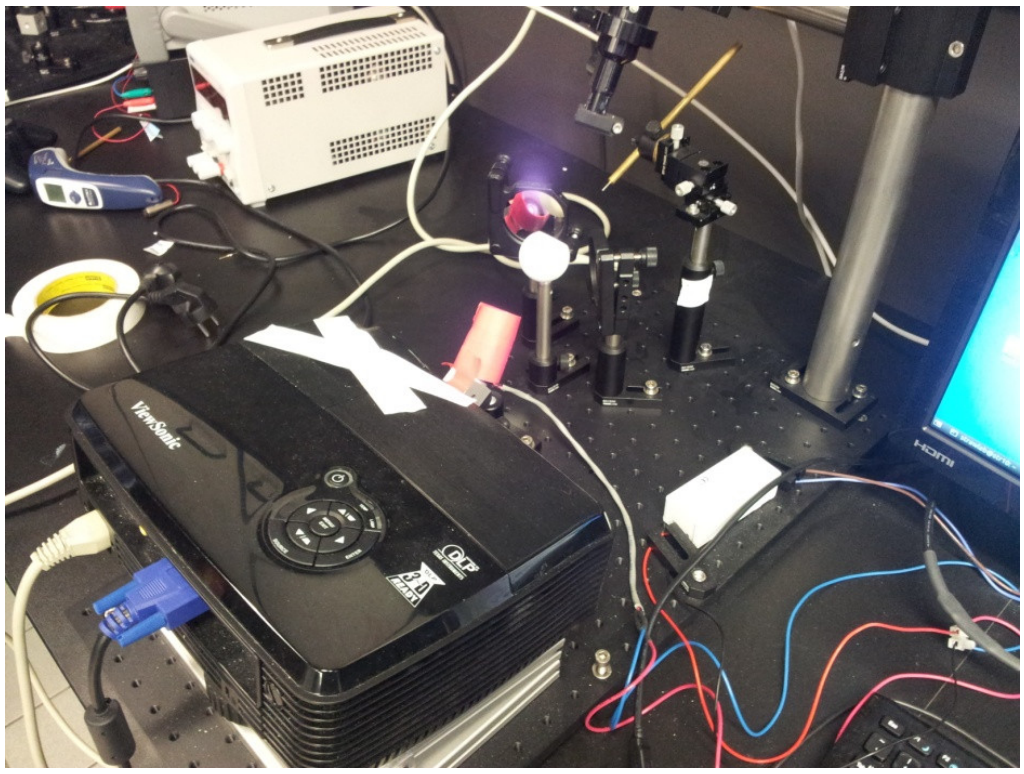
Inside the ball, a fly is anchored

The amplitudes of the fly's wings give its intended direction



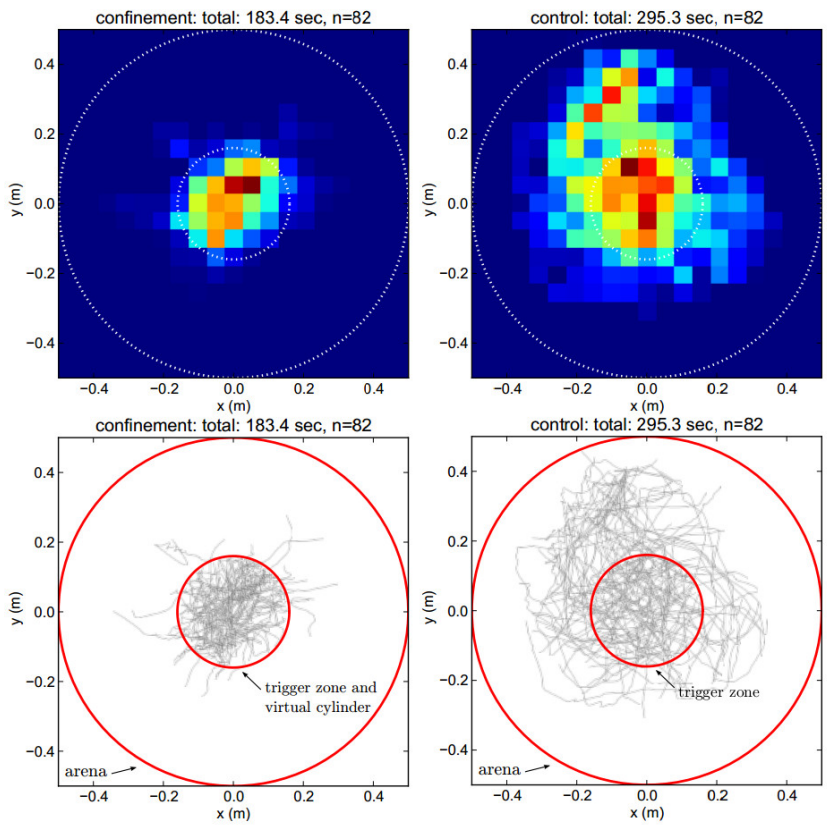
The FLYCAVE – tethered version

Research Institute of Molecular Pathology



The FLYCAVE – confinement results

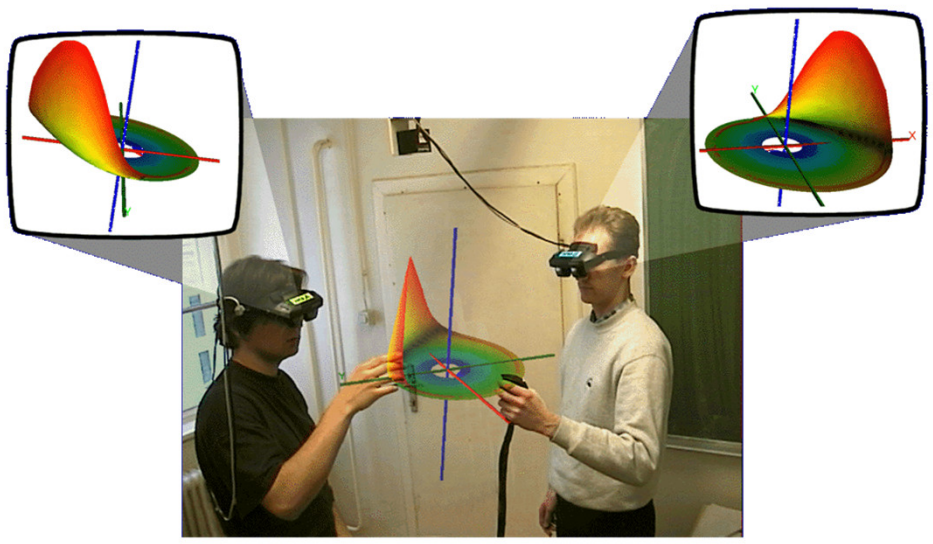
Research Institute of Molecular Pathology



Studierstube

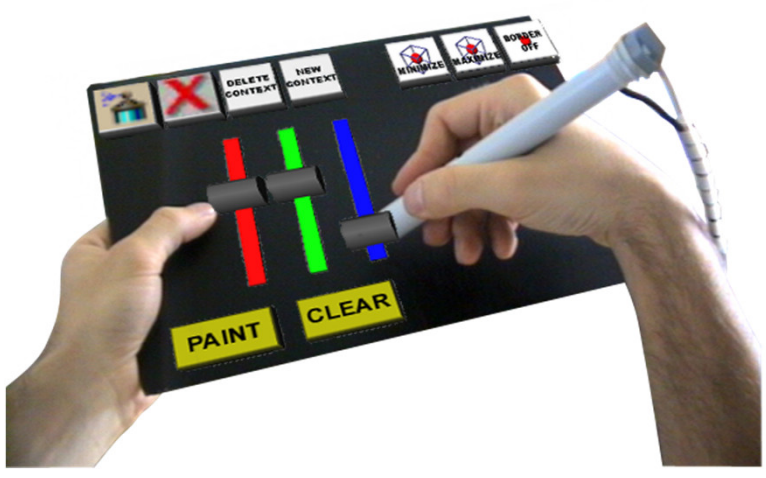
"Studierstube" is a multi-user local VE.

It uses see-through HMDs to let users share a common augmented workspace.

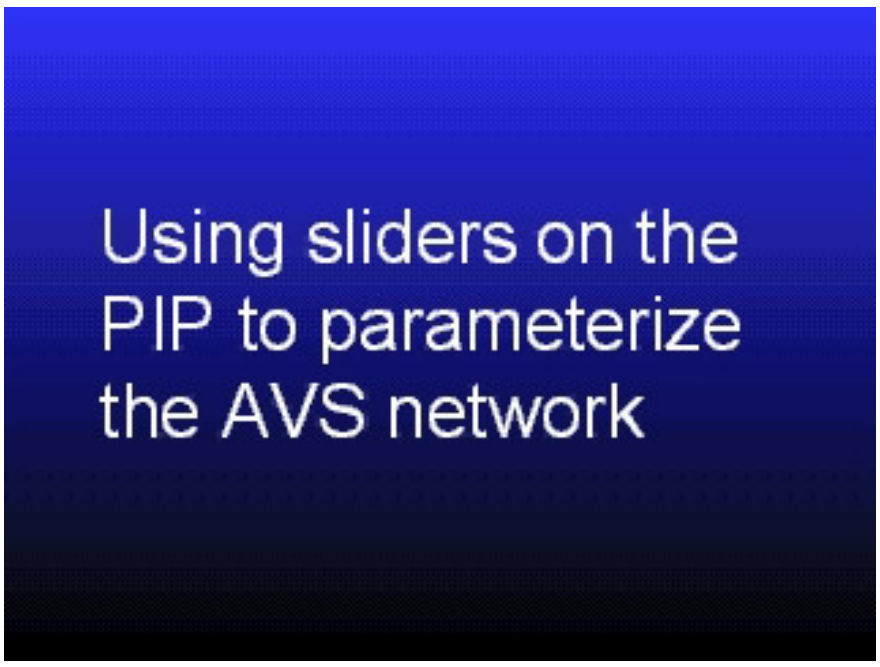


Studierstube

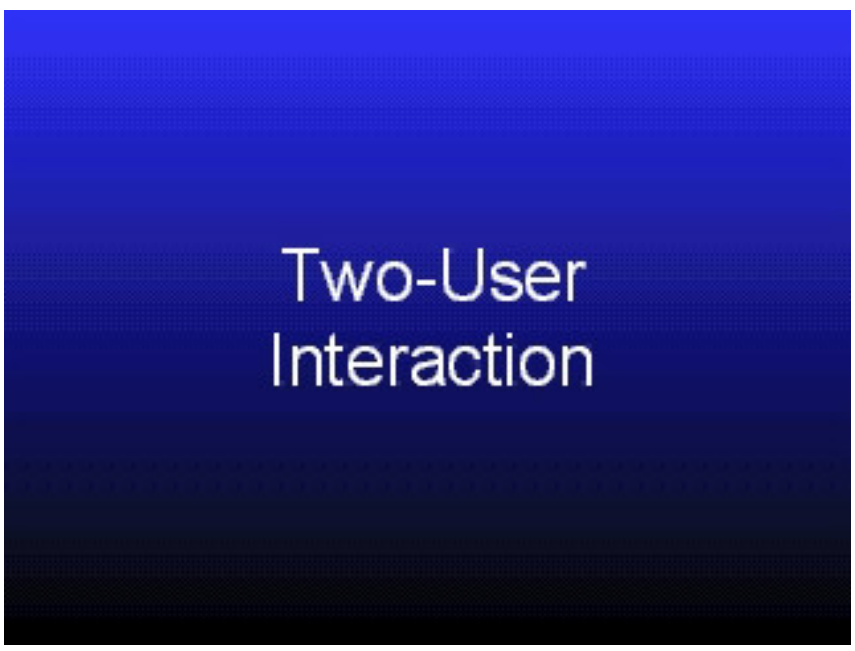
The main interface is the "**Personal Interaction Panel**" a pad and pen combination. The pad is augmented with 2D and 3D widgets, which can be manipulated by the pen.



Studierstube (video)

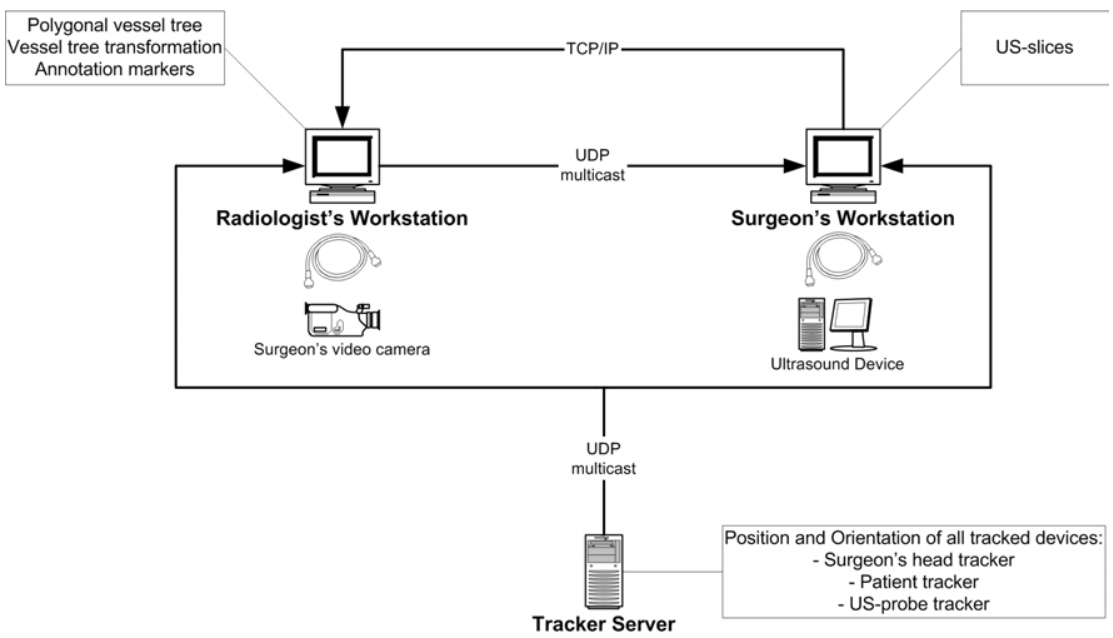


Studierstube (video)



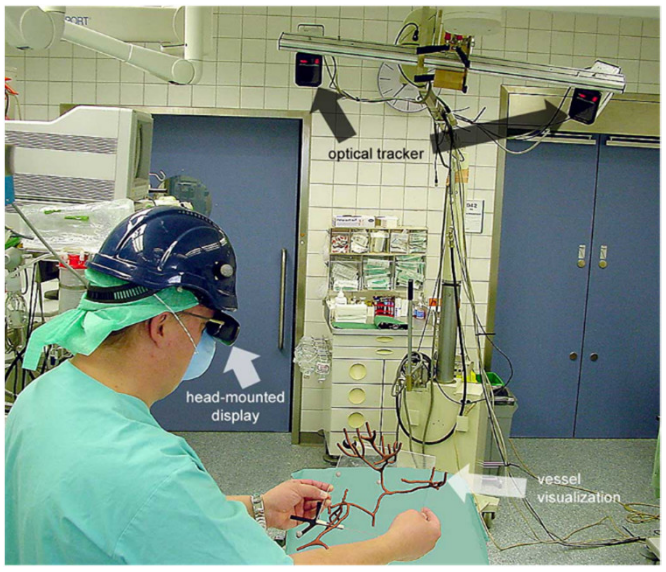
Studierstube (video)

ARAS – augmented reality aided surgery



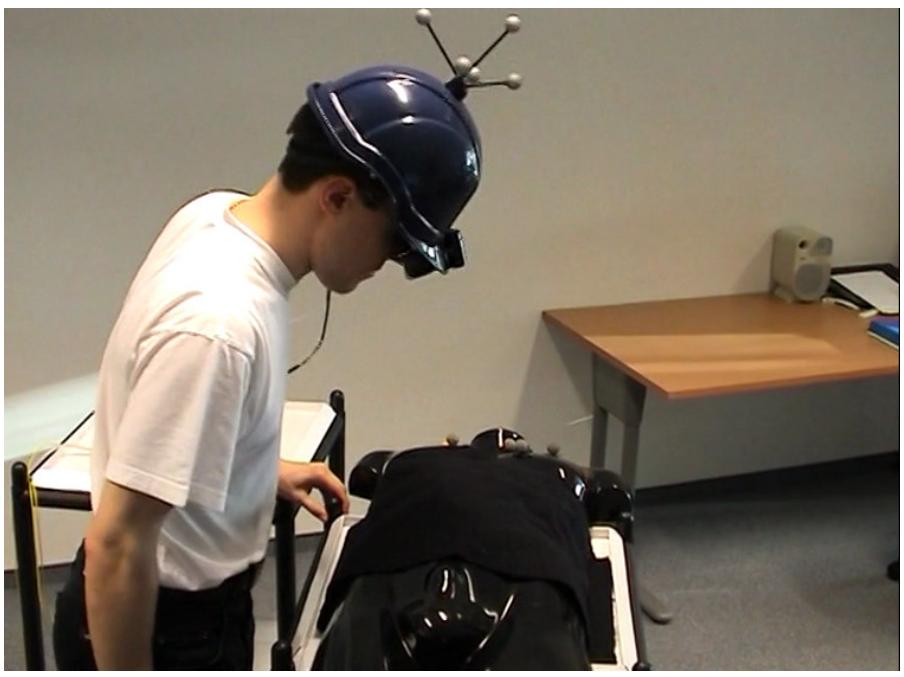
[Fuhrmann2002]

ARAS – augmented reality aided surgery



[Fuhrmann2002]

ARAS – augmented reality aided surgery



video [Fuhrmann2002]

Spherical Projection Setups

Non-planar screens – mostly spherical – screens used when large FoV is important.

E.g. architectural walkthroughs or car- or flight-simulators:

Motion Simulators

(hemi-)spherical projection in combination with a motion platform delivers an extremely immersive experience:

e.g.: military helicopter simulation

Blue-C

Developed @ ETH Zürich (Markus Gross & Oliver Staadt)

The blue-c system combines the CAVE with real-time image capture and 3D video

Blue-C

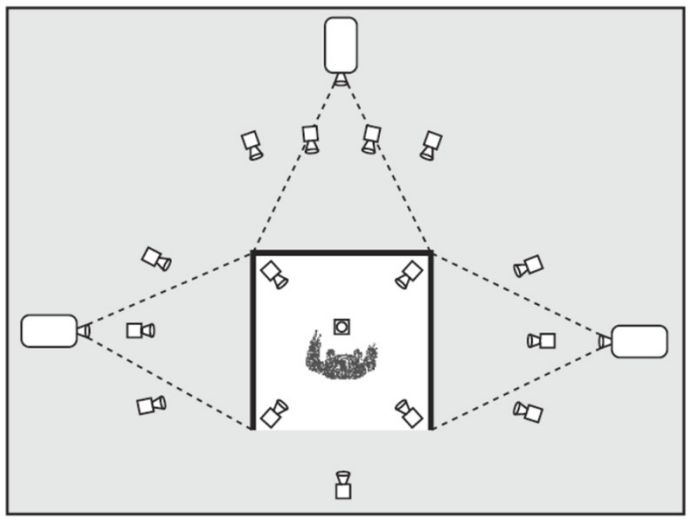
http://blue-c.ethz.ch/

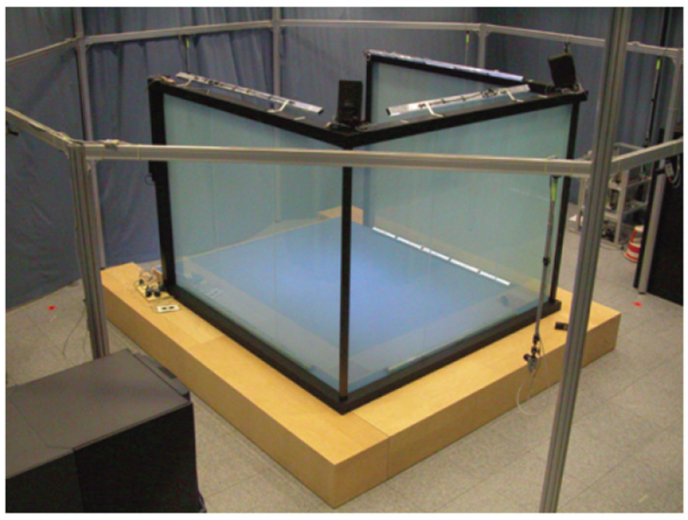
The blue-c system includes:

- a fully immersive three-dimensional stereo projection theatre
- real-time acquisition of multiple video streams
- three-dimensional human inlays reconstructed from video images
- voice and spatial sound rendering
- distributed computing architectures for real-time image processing and rendering
- a flexible communication layer adapting to network performance
- a scalable hard- and software architecture for both fixed and mobile installations

Blue-C

Back-projection screens can be switched to transparent →
cameras from outside CAVE can grab images→
3D reconstruction of user possible



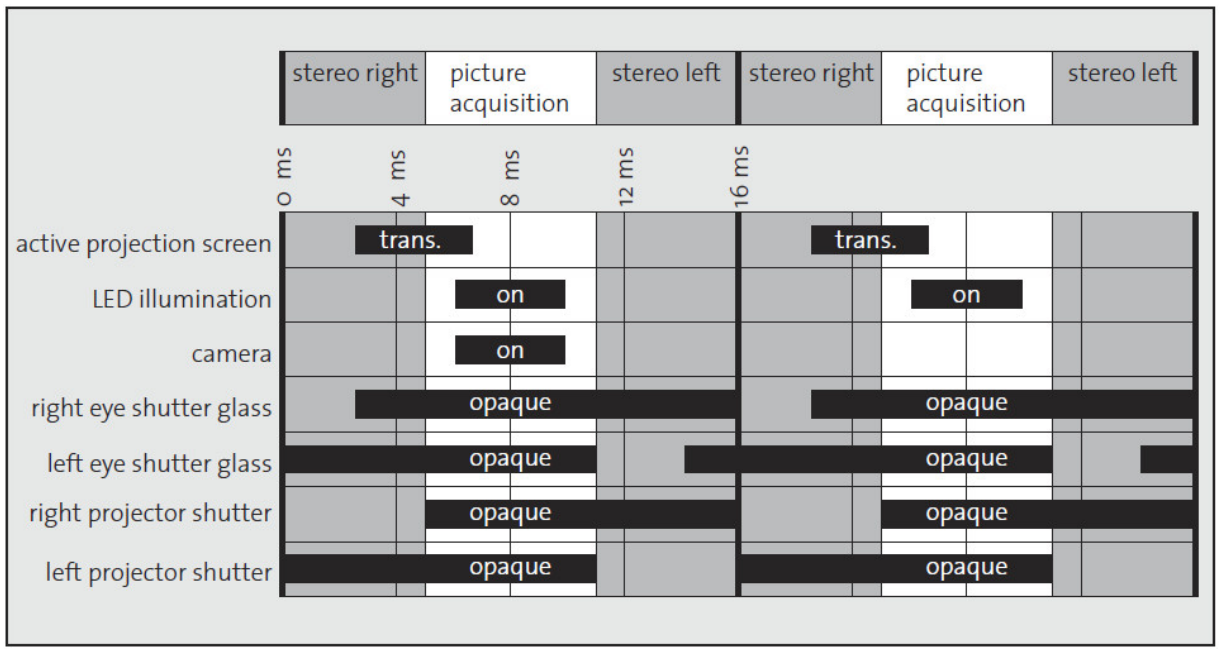


Blue-C

Capturing the user from a lot of cameras surrounding the system allows to reconstruct a 3D model, which can be rendered from different angles

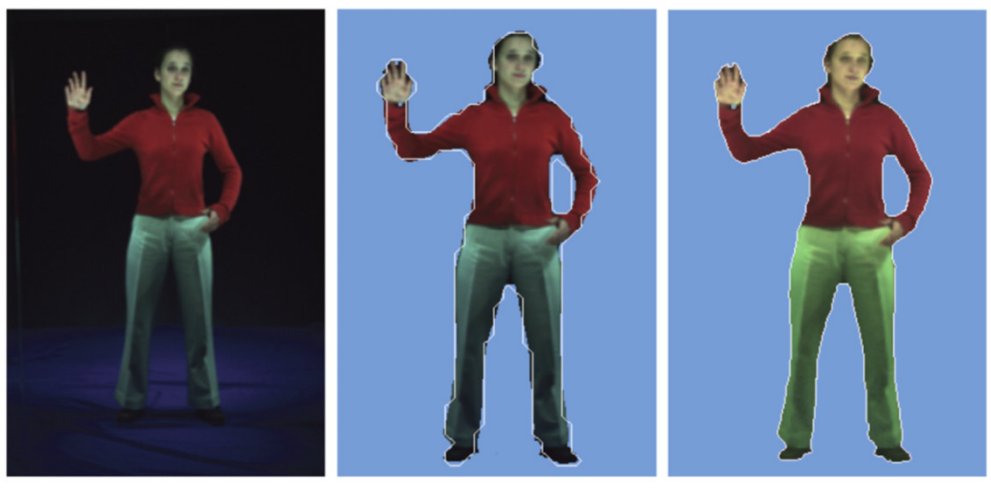
Blue-C

By using an additional phase, where both shutters of the glasses are opaque, the capturing can be performed invisible to the user:



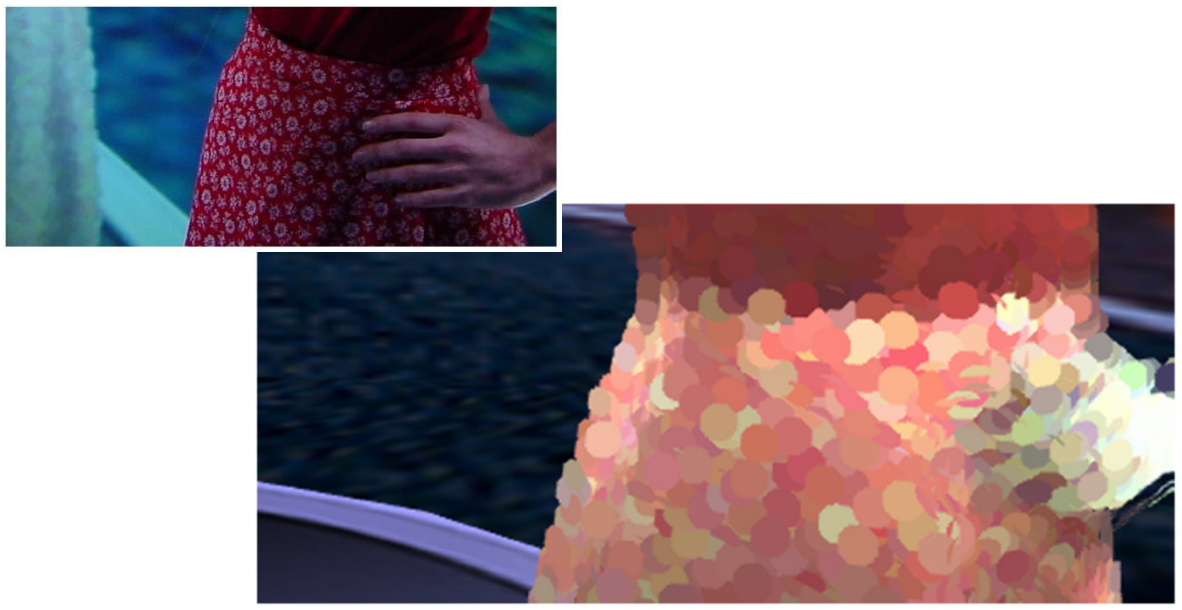
Blue-C

Background subtraction segments the image into user and background:



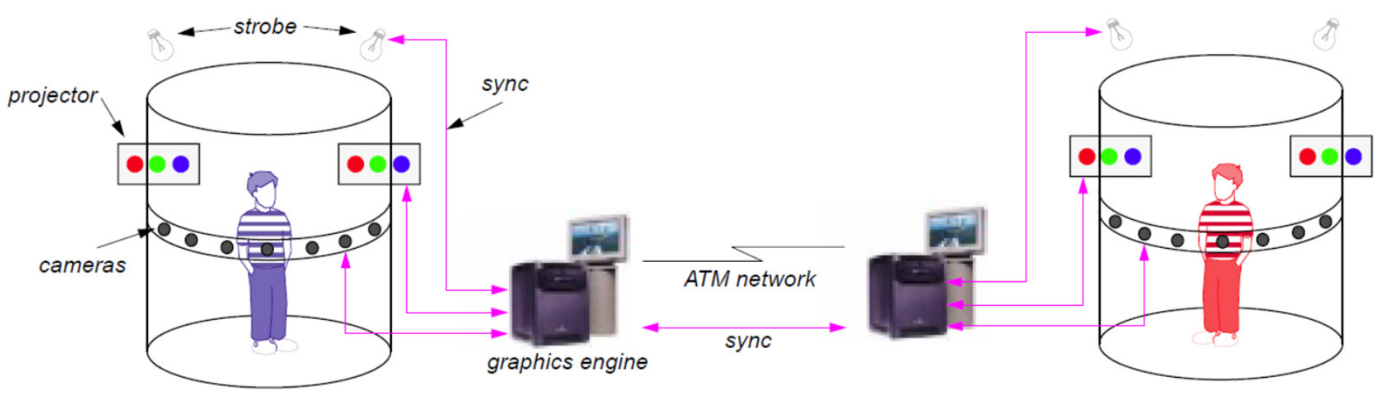
Blue-C

Many images & silhouettes from different viewpoint deliver 3D point stream:



Blue-C

3D holographic telephony, system setup:



Blue-C

video:

Motion Simulators

Motion platforms can be used to simulate acceleration.

Because humans do not recognize slow changes in acceleration, and because the gravity-vector can be used as substitute for ongoing accelerations (e.g. tilting), a relatively small range of motions is sufficient.

VirtuSphere

- Implements „walking“ in VR
- gigantic „Trackball“
- user inside
- moves in all direction
- ultrasound sensors deliver XY

Virtusphere

Advantages

- no physical constraints of (planar) movement

Disadvantages

- high inertia → movement difficult
- accident prone setup
- tracking & display has to be wireless or self-contained (mobile VR)

Virtuix Omni

Low-friction shoes!

Virtuix Omni

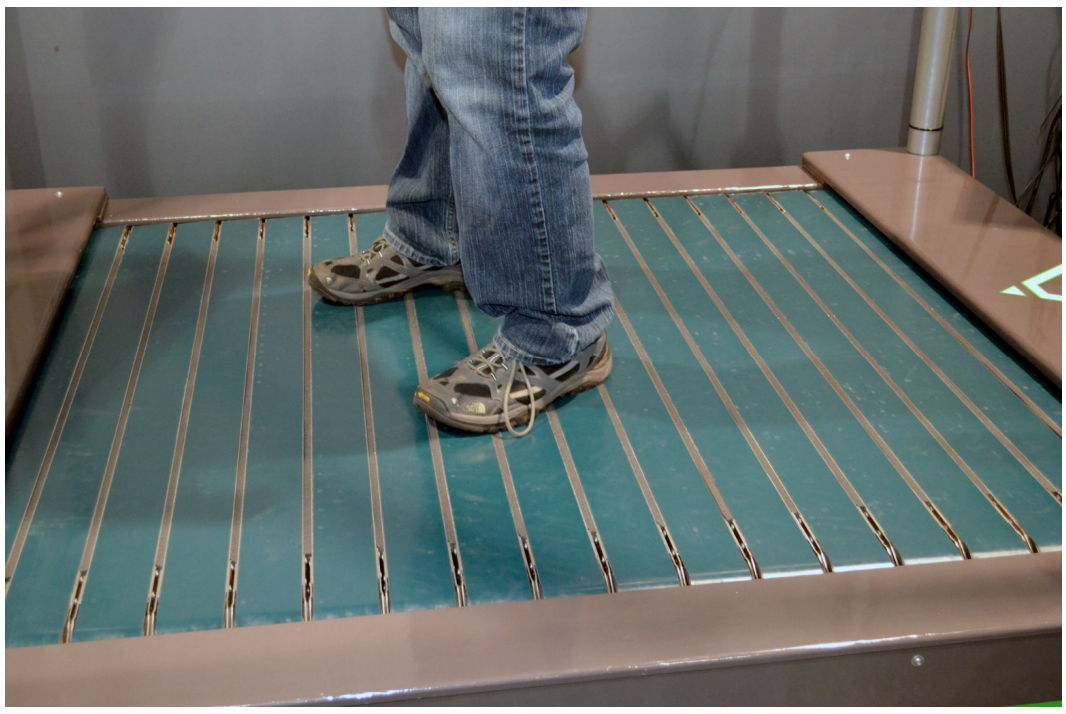
Socks!

CyberCarpet

- Implements „walking“ in VR
- omni-directional treadmill
- conveyor belt built from conveyor belts turned 90°

CyberCarpet (movie)

Infinadeck



End of Lecture

Evaluation:

- DO NOT FORGET TO EVALUATE!
- Den verwendeten Fragebogen können Sie über TUWIS++http://tuwis.tuwien.ac.at/ (Benutzername: Ihr Nachname; Passwort: Ihr persönliches TU-Passwort) abrufen.

LVA-NR.	Typ	Fragebogen	Modus	Bewertungszeitraum
186.156	VU	VO	e	SS 2012

End of Lecture

Lab-Project:

- 1-2 students per group
- max. 3 months
- work@home or VRVis
- own or given themes

Examn

- this semester (as early as possible)