Virtual Reality and Virtual Enterprise

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Goal of this talk

- Drawing attention to the potential use of Virtual Reality in VE applications
- Acquaint audience with principles and basics of VR
- Some examples of potential use of VR in VE

Outline

- Possibilities of the use of VR in VE
- Use cases (related to VE)
- Data Visualization in VR
- Specific applications of VR (AR …)
- Hardware for VR
- Conclusion

Virtual Enterprise

- In Wikipedia there are given 8 definitions of VE (out of many)
- We can assume that a VE is an entity geographically dispersed where information and knowledge between individual parts is shared by means of IT
- One of possible methods for knowledge and information sharing in a way that is user-friendly is Virtual Reality

Virtual Reality

- Virtual Reality (VR) is used in many research areas
- E.g. virtual cities, flight simulators, surgical operation planning etc.
- VR penetrates in new fields of research
- VR allows to visualize in very realistic way huge amount of data that could have not been analyzed by means of traditional methods

Breeding Environments, Dynamic Virtual Organizations, and Professional Virtual Communities

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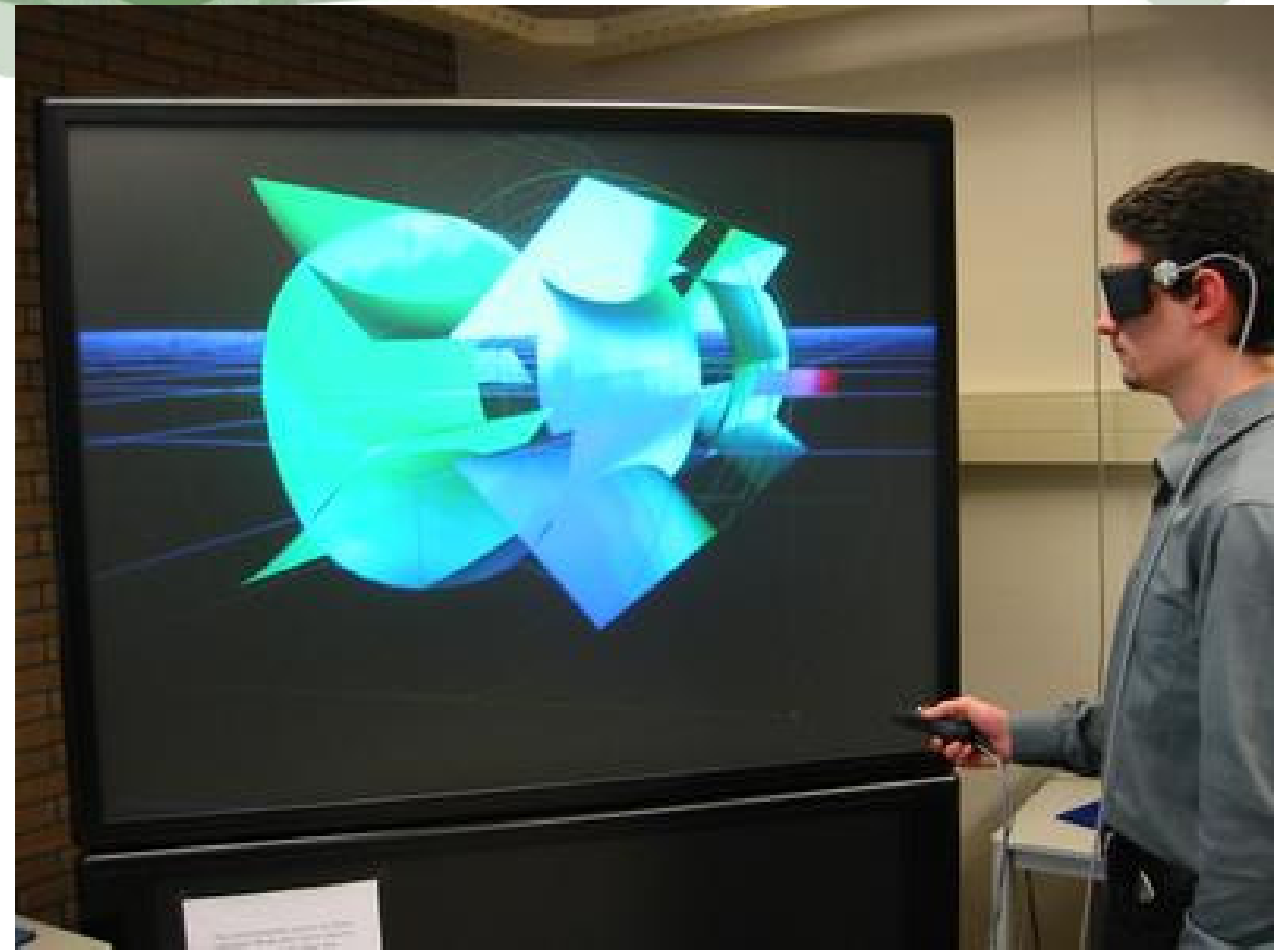


Processes in Virtual Enterprise

- In Virtual Enterprise there are many complex processes running
- Visualization of Virtual Enterprise processes can help to optimize these processes, minimize the time necessary for their implementation etc.
- This is especially true for processes where human factors should be taken into account

Visualization of processes in Virtual Enterprise

- Information technologies nowadays allow the user to visualize wide spectrum of processes (including processes running in virtual enterprises)
- Visualization of these processes can present much more information to the user than any other alternative method
- We can create virtual worlds where people from VE can meet (virtually) and exchange & evaluate information about these processes

Virtual Enterprise and Visualization

- Visualization is a key issue
- It helps to understand better processes running in an enterprise (simulation, analysis, interaction with elements participating in processes etc.)

- It is necessary to have at disposal technologies by means of which we can implement these visualizations (considering above mentioned features)

Visualization tools for Virtual Enterprise

- There should be correspondence between real enterprise and Virtual Enterprise
- The tools should be able to create 3D models of an enterprise + simulation and visualization of processes in VE
- Other tools should be able to perform interaction with such a model

Virtual Worlds

- It is possible to create virtual worlds that can be linked up with real world
- It is possible to communicate in these virtual worlds (being geographically dispersed)
- It is possible to present data, ideas, concepts etc. using visualization techniques by means of which the communication is more intensive

Use Case I

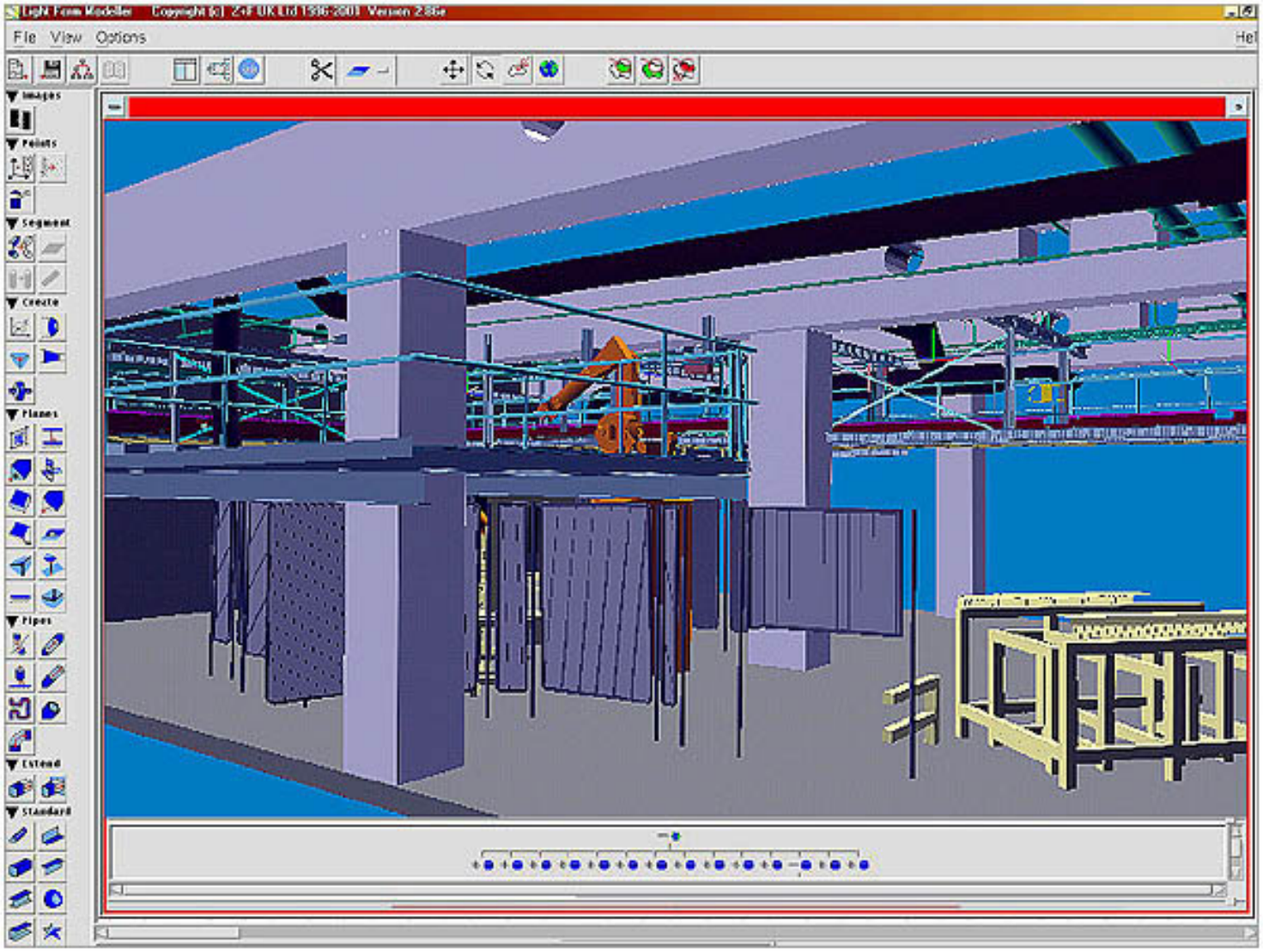
- It is necessary to place objects (machines, tables, coffee makers etc. in factory hall)
- We can make design of such a layout by means of scissors, paper, glue etc. in STATIC way
- When we would like to investigate whether we can move a 3D object through the factory hall, then checking for potential collisions is a complex problem

Use Case I

- Possible solution to this problem is creation of a 3D model of the factory hall, creation of 3D model of the object that will move through the hall
- Then we will move the object along the intended trajectory and we will check this trajectory for collision in 3D space (not only in the floor plan)

Use Case I

- What do we need?
- System for creation of 3D models (factory hall, objects that will be moved etc.)
- Tools for performing interaction with the model (moving objects, having various views on the model, performing virtual walkthroughs etc.)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Use of Virtual Reality

- By means of Virtual Reality we can freely move in the factory model (having feeling of “being there”)
- We can select and manipulate objects in the factory (we can then easily compare various versions of the hall layout)
- What properties do we expect from Virtual Reality (to be able to perform above mentioned activities)?

Virtual Reality (VR)

- VR entails the use of advanced technologies (computers and various multimedia peripherals) to produce a simulated (virtual) environment that users perceive as comparable to real world objects and scenes

Virtual Reality (VR)

- With the aid of specially designed transducers and sensors, users interact with displayed images, moving and manipulating virtual objects, and performing other actions that give feeling of actual presence in virtual environment (we speak about immersion)
- This means – we need some special hardware for VR

Virtual Reality (VR)

- VR permits users to interact with model (or environment) in safety while providing a control over the simulation of processes. Such a control is usually not possible in real-life situations (e.g. dangerous environment)

Use Case II

- Product design and manufacturing
- Traditional iterative product analysis leads to time consuming development and thus to high costs
- During traditional design process series of life-sized wooden mock-ups have to be built and reviewed
- NASA during development of space shuttle created wood and plastic life size model

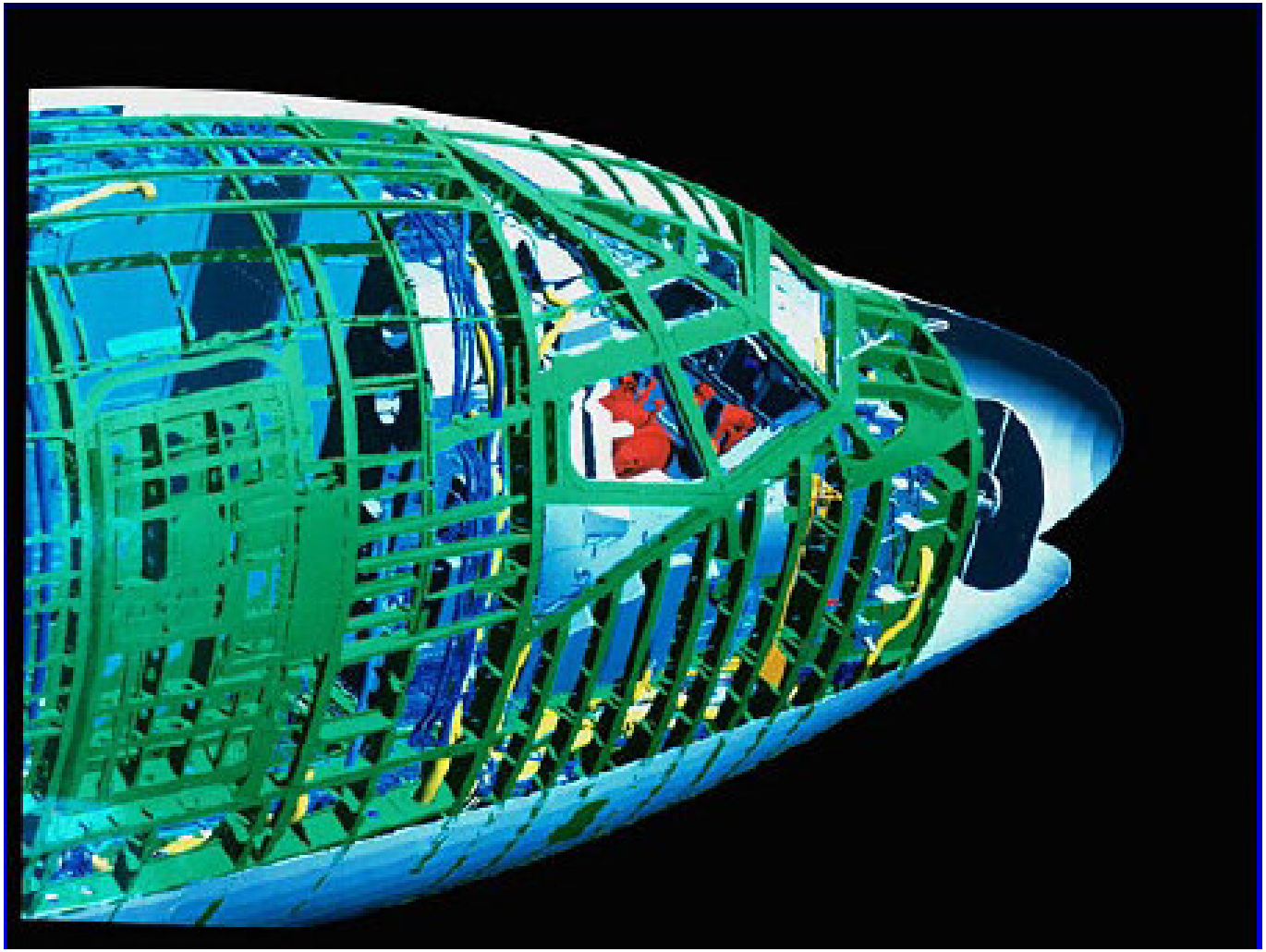
Use Case II

- Creation of computer models has relatively long tradition
- There are many CAD systems by means of which we can create a model stored in computer (AutoCAD, Pro/E, SolidWork etc.)
- The weakness of these systems is their nor very good suitability for interactive evaluation of the model (detail research of the model is also not possible)

Use Case II

- VR provides a tool in 3D environments to allow a design to be explored exhaustively
- VR utilizes advanced computer and visual technologies to provide a virtual environment for product development
- In many situation the immersion plays an important role in exploration of the model

VR in Boeing



Virtual Reality

- VR has three features characterized as 3I:
- Immersion, Interactivity, Information intensity
- Immersion = feeling as being in real world
- Interactivity = interaction with objects in 3D
- Information intensity = humans senses are much more involved that in traditional systems (in high end VR also other senses than vision)

Modeling in VR

- Geometric modeling
- Kinematics modeling
- Physical modeling
- Behavior modeling

Geometric modeling

- Virtual world space definition
- Virtual observer location
- Perspective projection
- 3D object description (b-rep, space curves, 3D surfaces and patches etc.)
- Transformations (rotation, scaling, translation, ….)

Kinematics modeling

- Motion is represented by a mathematical model of its motion capabilities
- It concerns mainly behavior of individual parts and joints that connect these parts together
- Applied e.g. in robotics

Physical modeling

- Collision detection
- Illumination models
- Reflection models
- Physical properties of materials used for designed object production should be taken into account

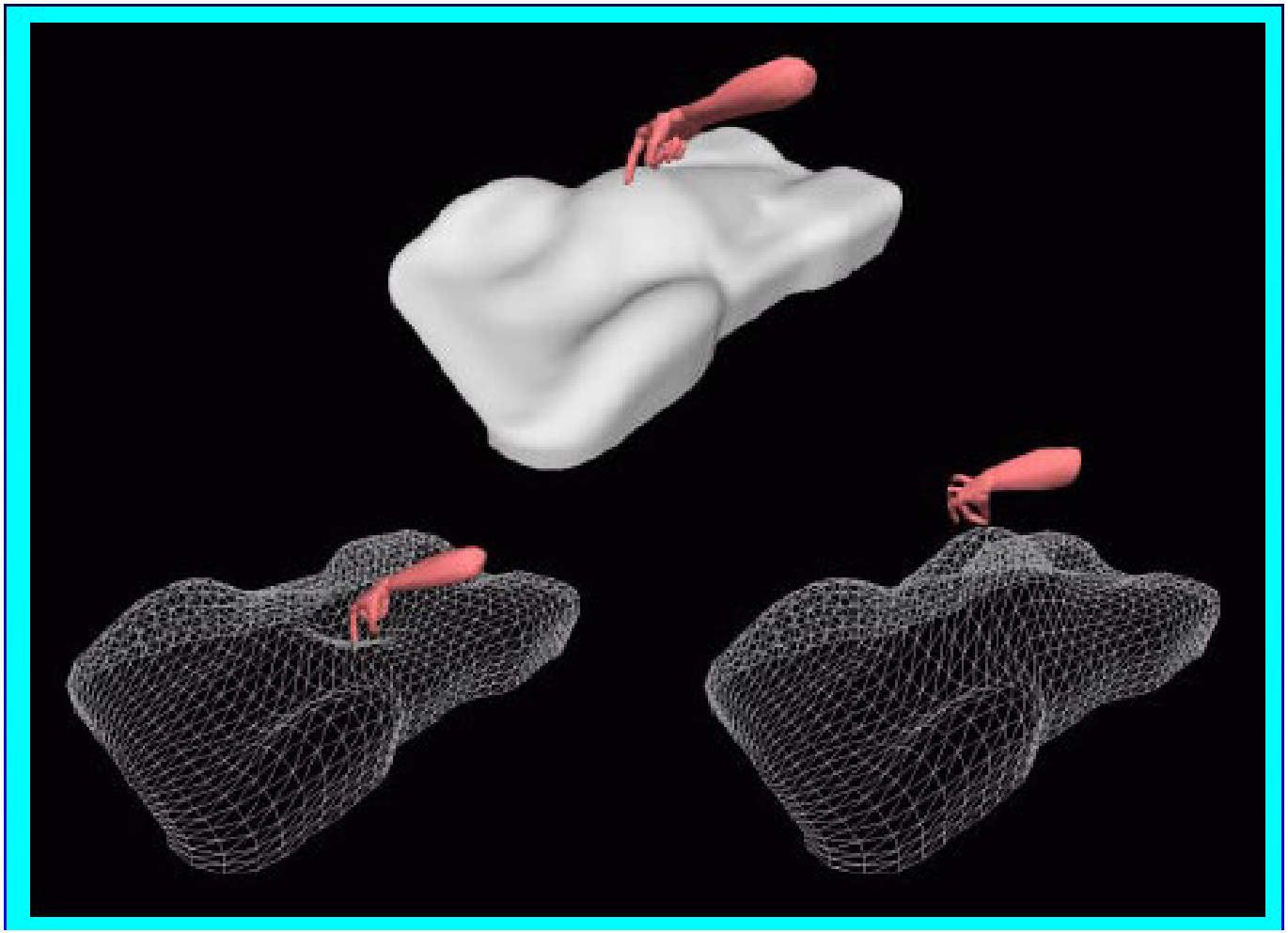
Behavior modeling

- Deformation of objects
- Animation of objects
- Animation of virtual environment (virtual world)
- Manipulation for a convincing simulation
- Interactive navigation in virtual world

Models for VR

- Mostly created by means of CAD systems
- Conversion into VR environment used for particular application (including VR hardware)
- There is no universal standard for VR
- For application like CAVE etc. special data formats are used (e.g. Eon)
- CAD data are converted into these specific formats

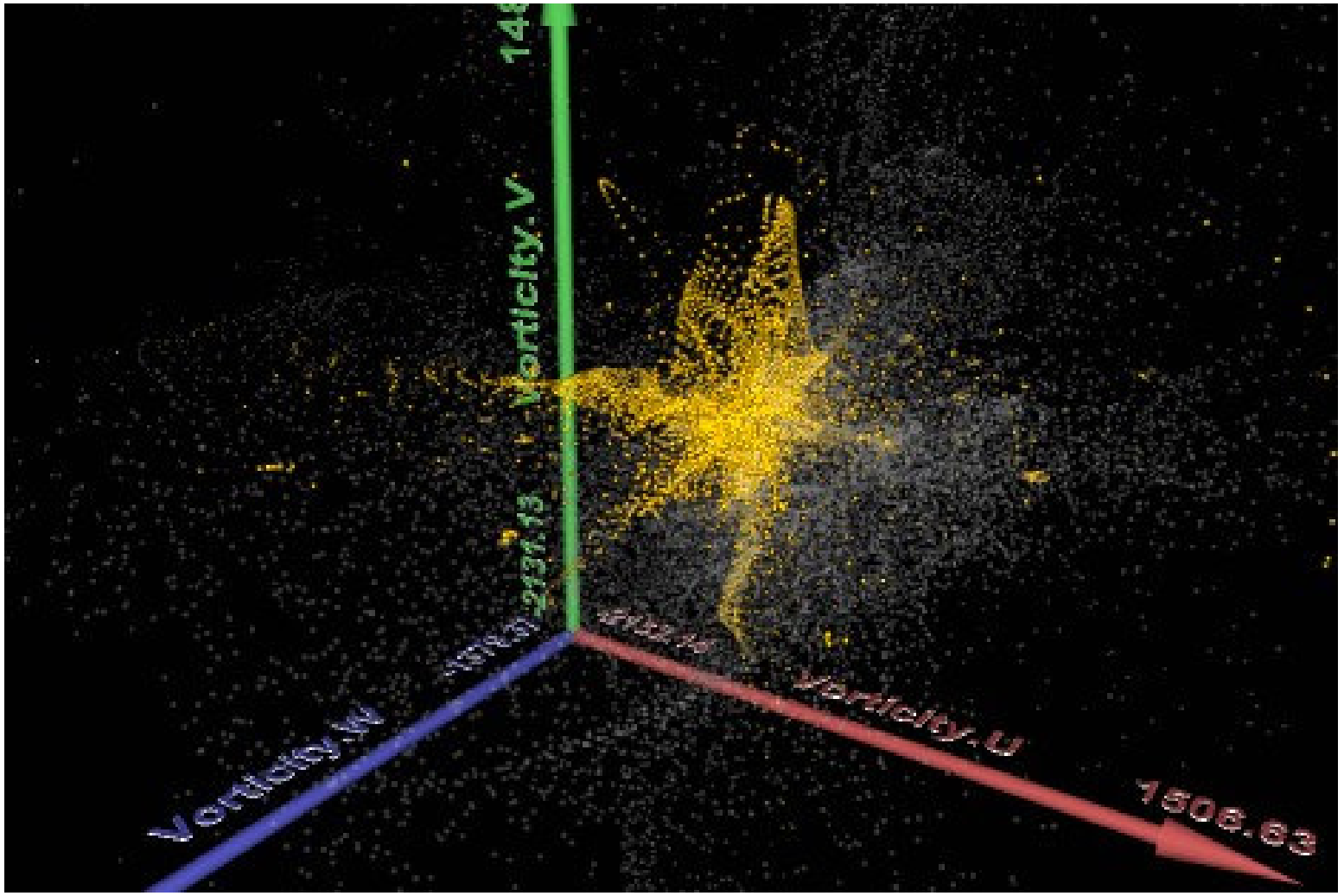
Interaction with object



Crashed car in VR – General Motors

Visualization of data

- Scientific visualization: visualization of data obtained by means of measurements or simulation
- Information visualization: visualization of data of general character (business data, behavior of software systems etc.)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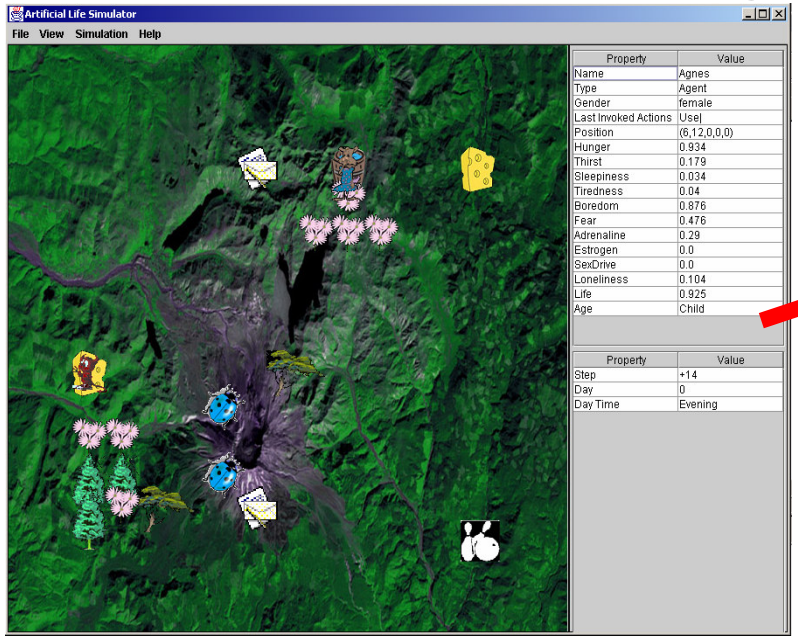
Case Study: A Life

- Behaviour based ALife
  - Bottom-up approach
- Virtual creatures
  - Evolve
  - Fulfil their internal needs and long term goals
  - Primarily must survive
- Stress on internal structure of creatures
  - Internal parameters (hunger, sleepiness, sex-drive…)
  - Action selection (move, attack, sleep, eat…)

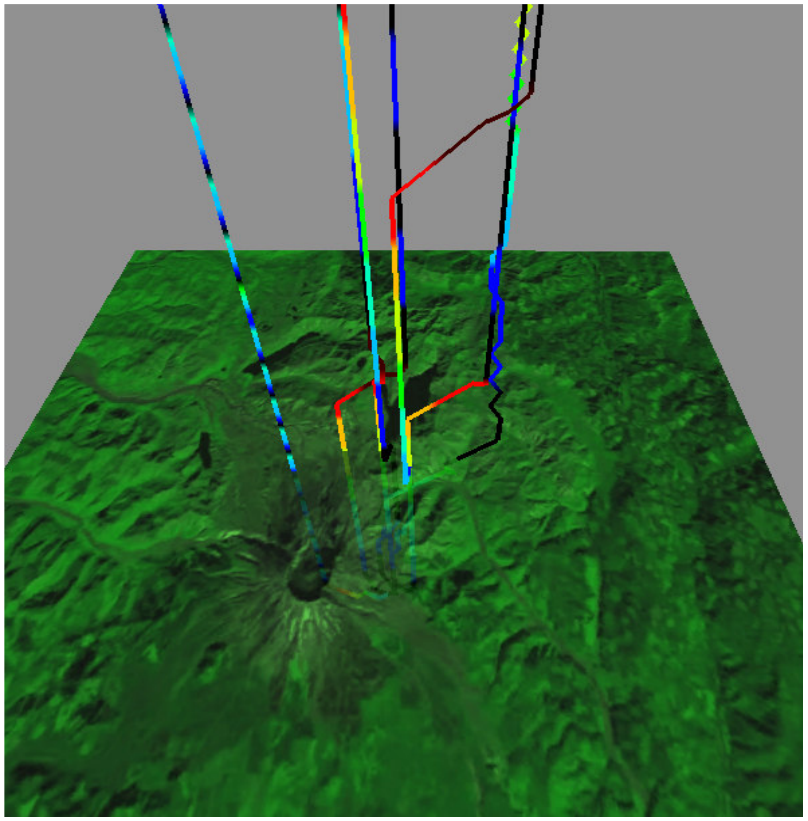
- Artificial Life Simulator ALS
  - agents exploit CZAR internal architecture
  - developed by the Mobile Robots Group at CTU Prague



Property	Value
Name	Agnes
Type	Agent
Gender	female
Last Invoked Actions	Use|
Position	(6,12,0,0,0)
Hunger	0.946
Thirst	0.181
Sleepiness	0.034
Tiredness	0.04
Boredom	0.875
Fear	0.292
Adrenaline	0.29
Estrogen	0.0
SexDrive	0.0
Loneliness	0.105
Life	0.954
Age	Child

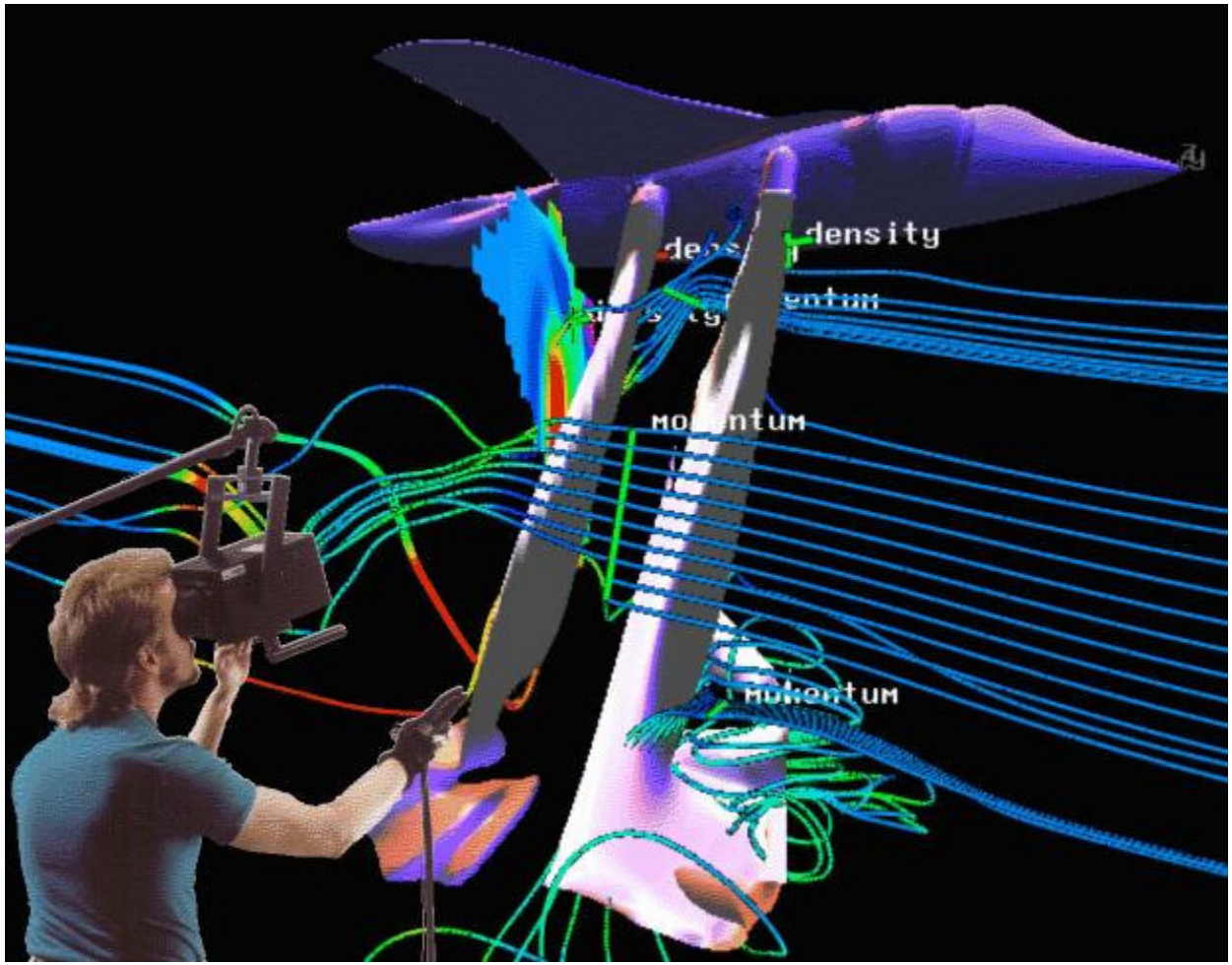
Property	Value
Step	+15
Day	0
Day Time	Day

Visualization of history – cutting plane



- Parameters
  - Colour palette
  - Glyphs
- Reduction of parameter count
  - Weighting
  - Clustering
  - …
- Environment
  - 2D cutting plane
  - Proximity context

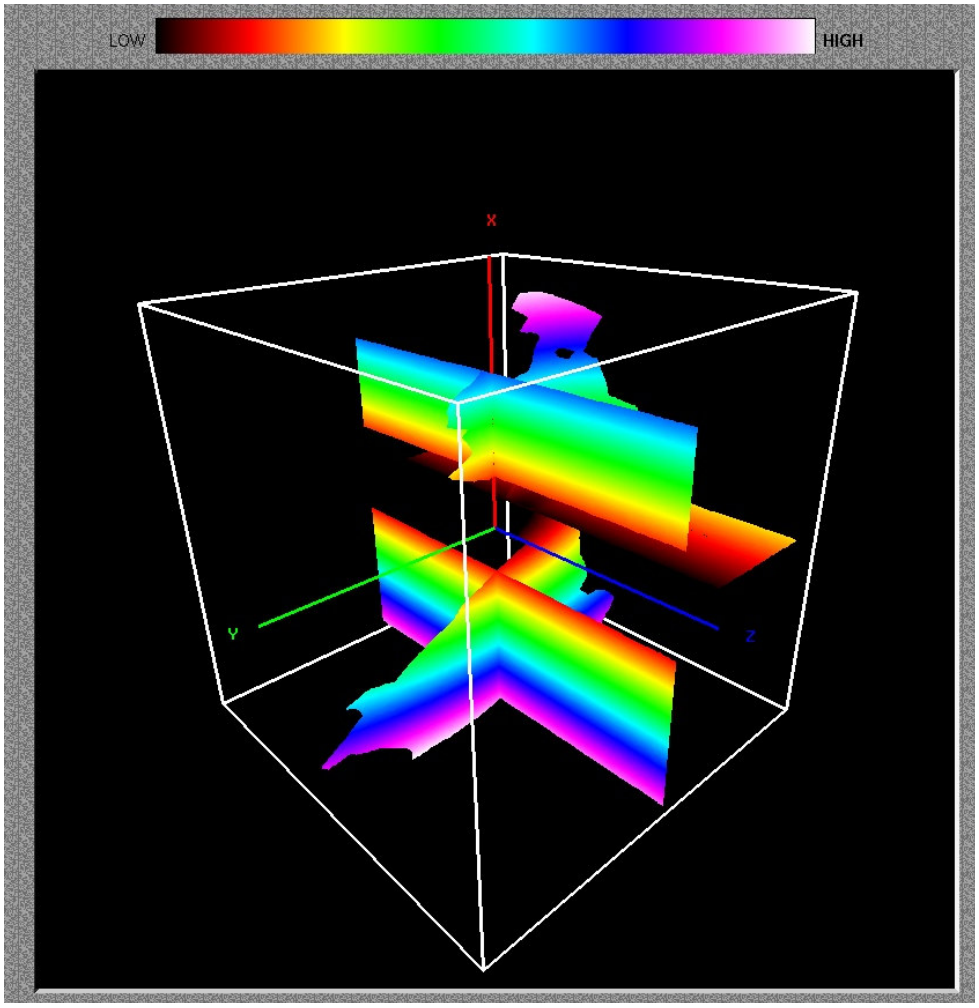
NASA Virtual Wind Tunnel

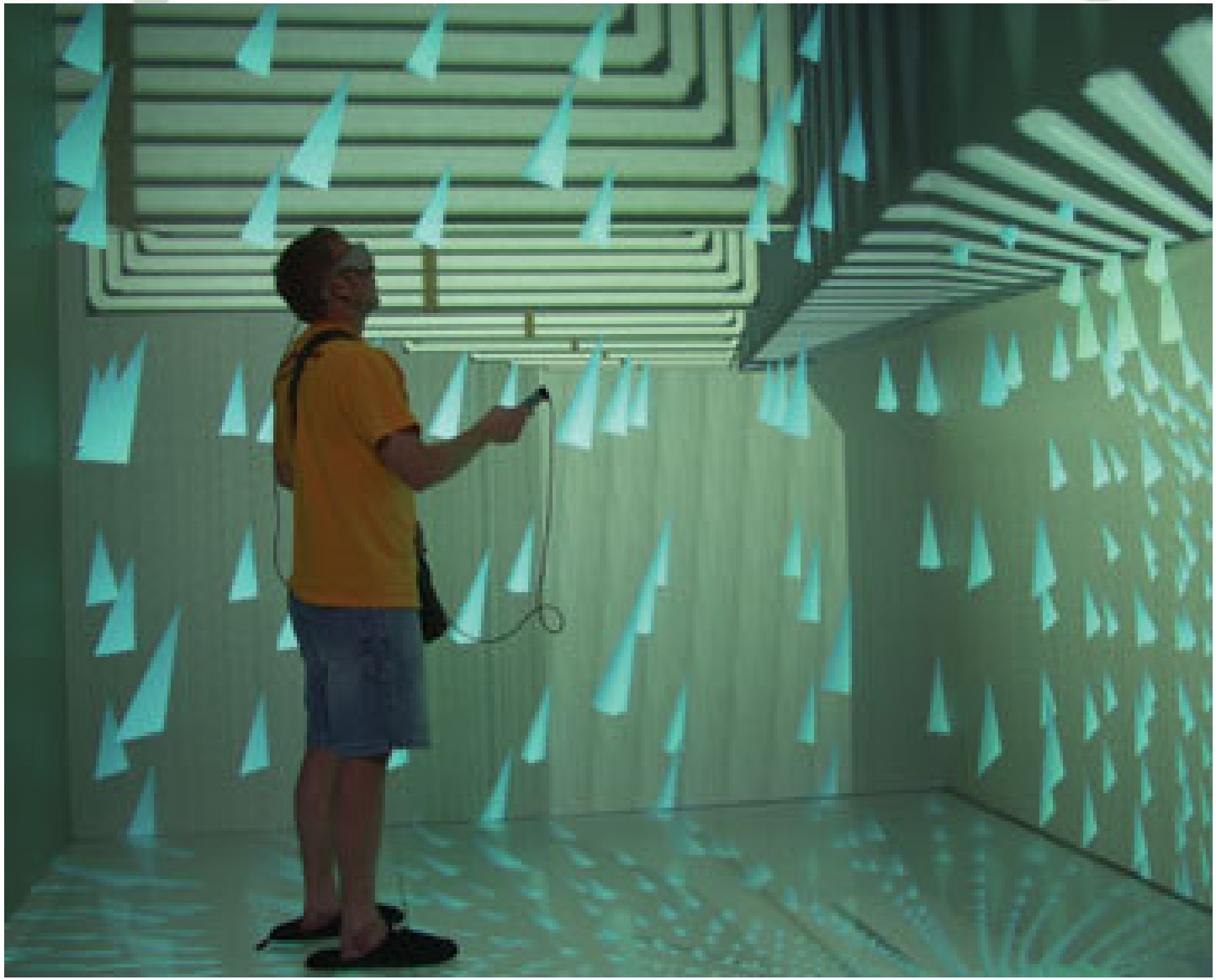


Visualization of business data

[3D Trading Floor]

Cutting planes





Other VR applications

- VR applications in “browser environment”
- User has tools for navigation in 3D scenes
- User can identify objects in the scene
- Manipulation with selected objects
- Programming language for description of objects and virtual worlds – VRML (Virtual Reality Mark-Up Language)

Meetings in Virtual Worlds (usage of Avatars)

Jaques, Reliciente and Joe meet in Secondlife

They discuss a topic using the chat and/or IM facilities of Secondlife

After a while, they feel they desire to continue the discussion on a phone

The group seeks a location designed as a conference room.

As the avatars sit down, they are entered as participants in the conference

As soon as the conference owner sits down…

… the real-word phones of all three persons are connected in a conference call

Use Case III

- Assembly planning and Examination
- Problems mostly arise from the fact that different parts of the product are designed by different design teams
- Digital model can be derived from CAD data and used for VR based assembly planning and examination

Use Case III

- Product assembly is simulated in virtual environment
- Simulation scenario must be prepared in advance
- This scenario includes info about degrees of freedom of individual parts, info about behavior of these parts, behavior of tools used for assembly etc.

Use Case III

- Example 1: assembly of satellite parts in outer space (no gravitation, specific conditions for work etc. => simulation necessary => VR can help)
- Example 2: assembly of parts of cables on sea bed (very deep sea => assembly is done remotely by a robot controlled from ship => simulation necessary => VR)

Use Case III

- Cost and Time efficiency
- Equipment or VR is very expensive
- VR removes the necessity to produce wooden mock-ups => saves time and money
- VR allows to perform simulations with high degree of realism (not available with other technologies)

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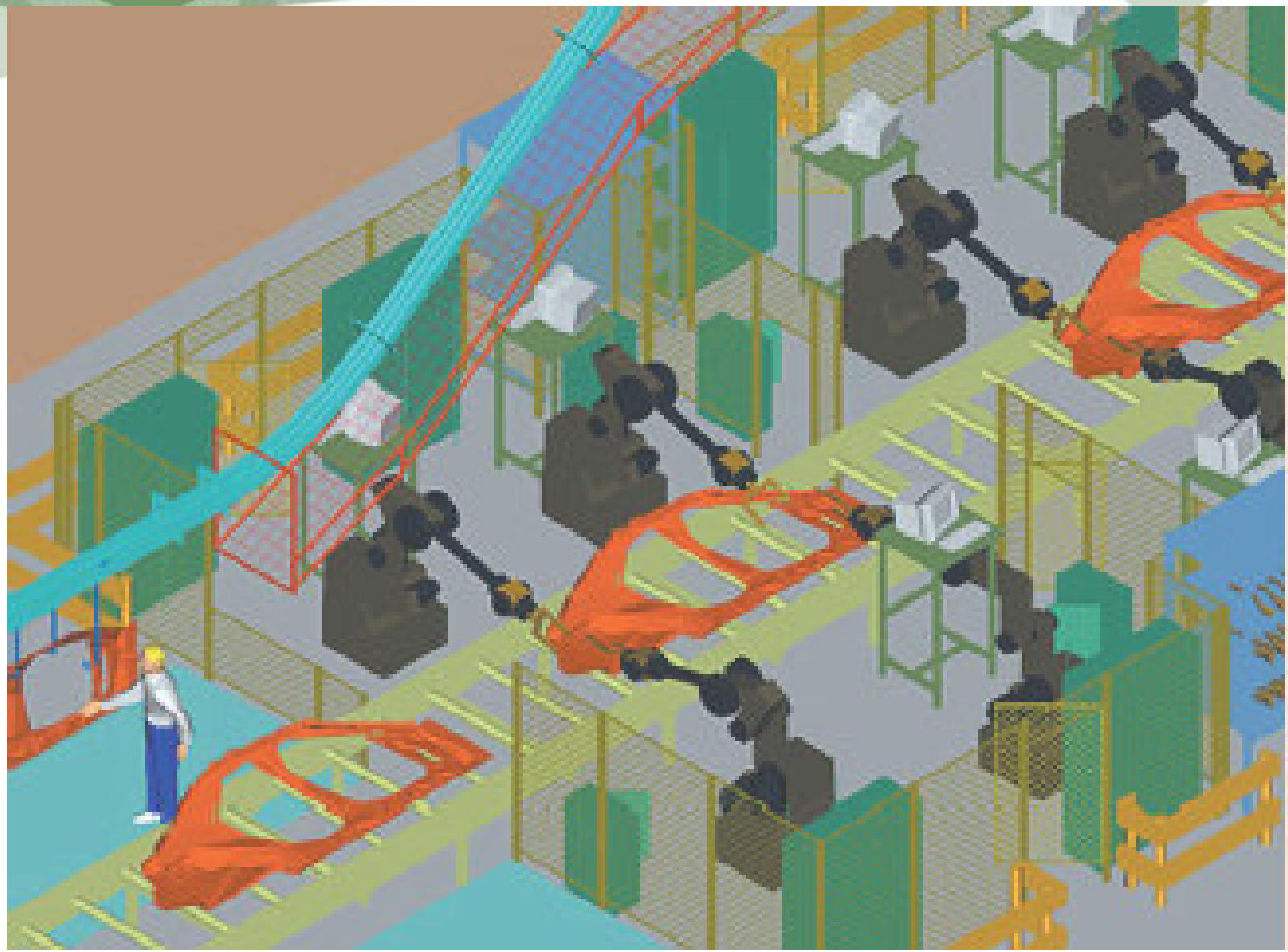
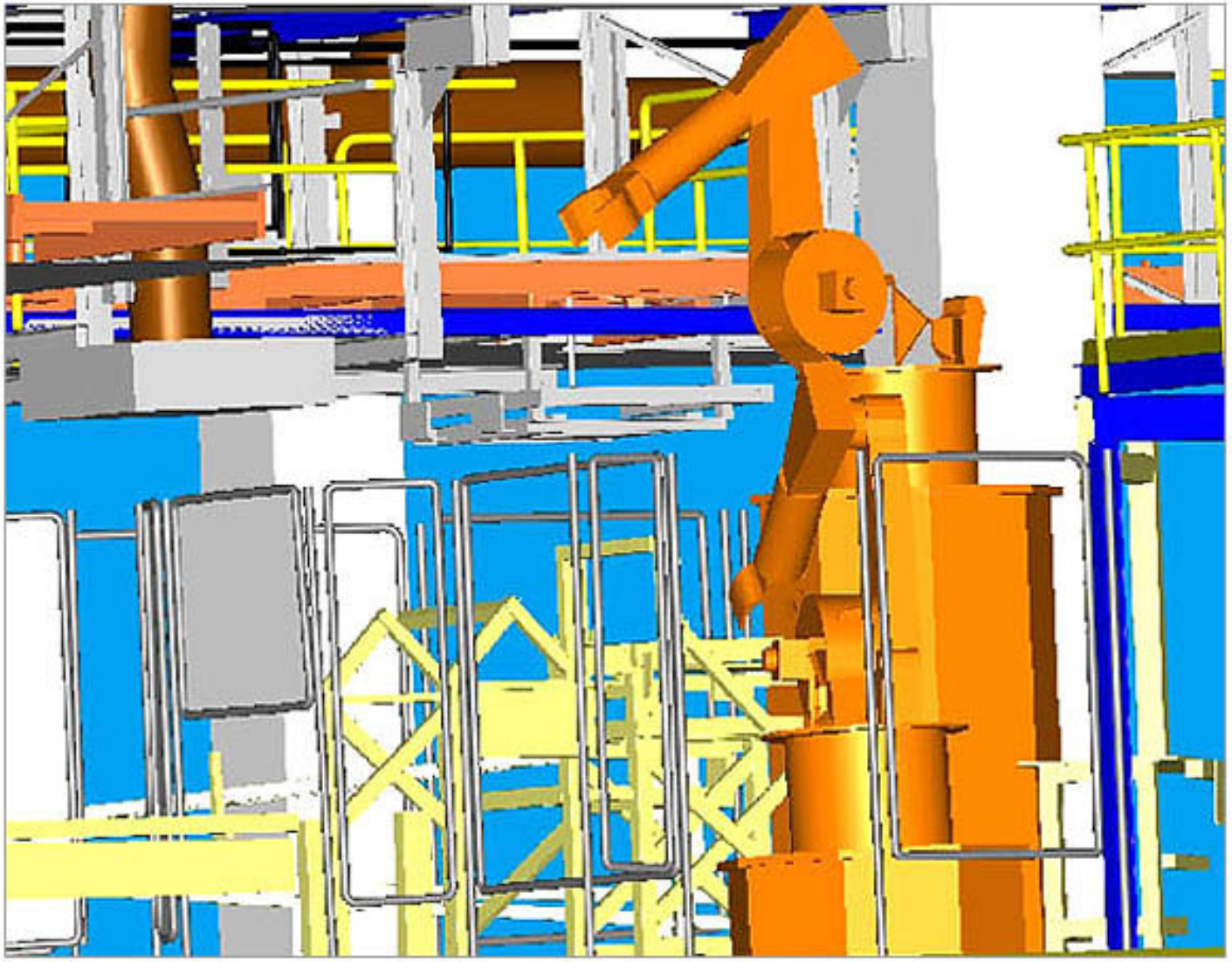
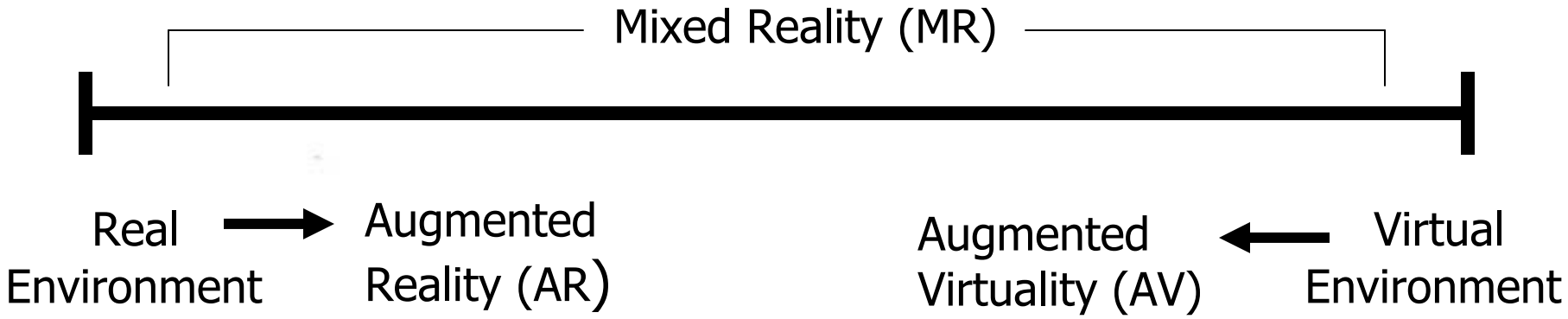




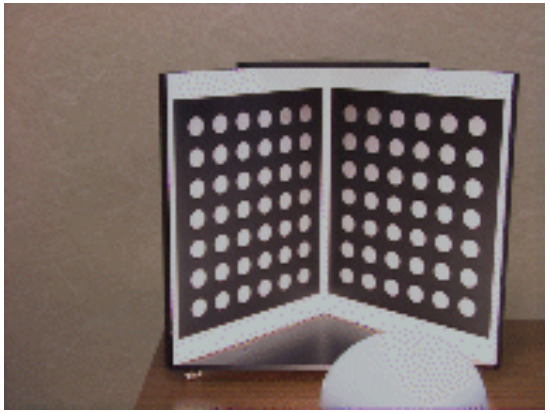
Miligram's Reality-Virtuality Continuum

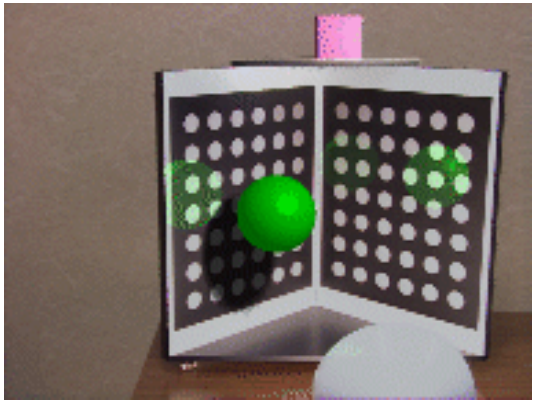


Miligram coined the term "Augmented Virtuality" to identify systems which are mostly synthetic with some real world imagery added such as texture mapping video onto virtual objects.

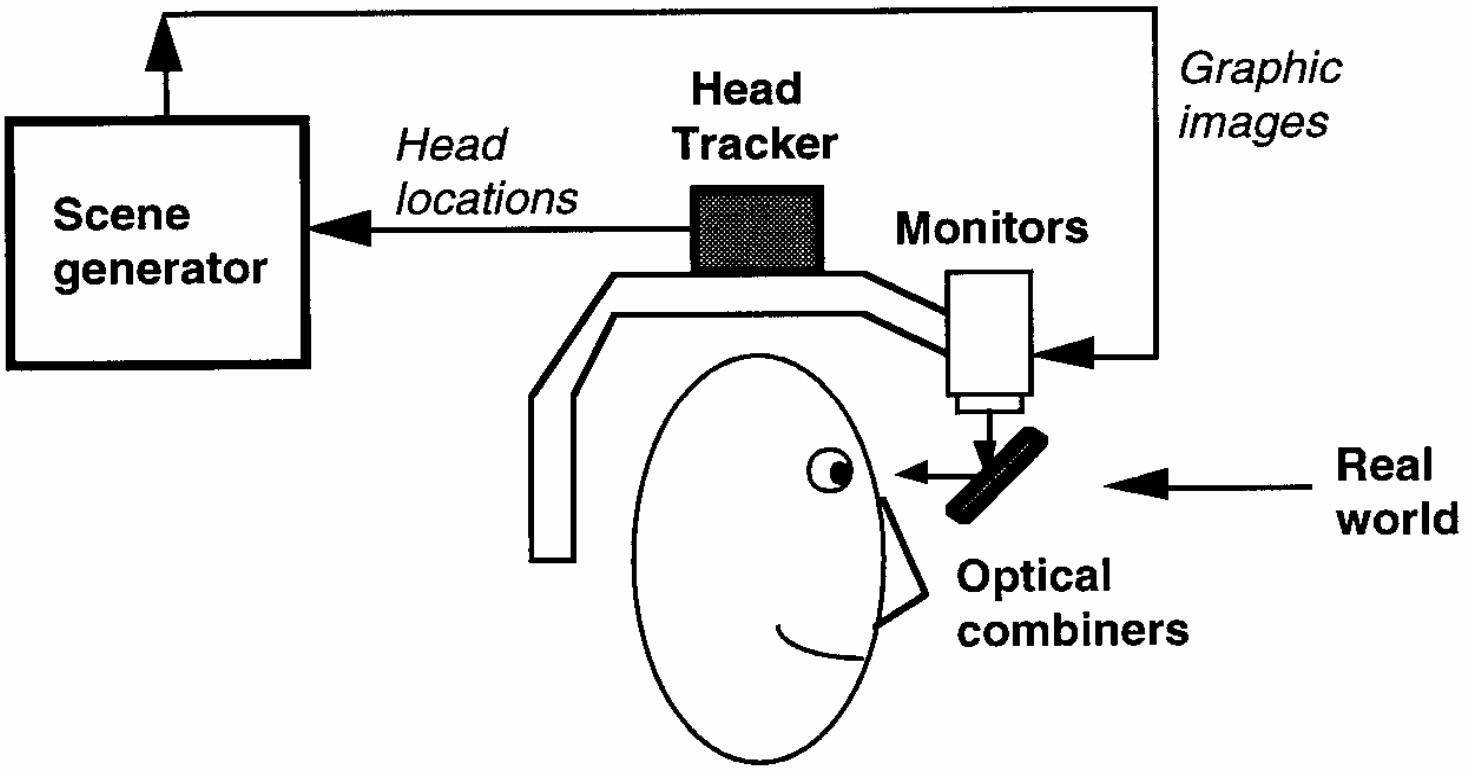
Combining the Real and Virtual Worlds (cont)

- Register models of all 3D objects of interest with their counterparts in the scene
- Track the objects over time when the user moves and interacts with the scene



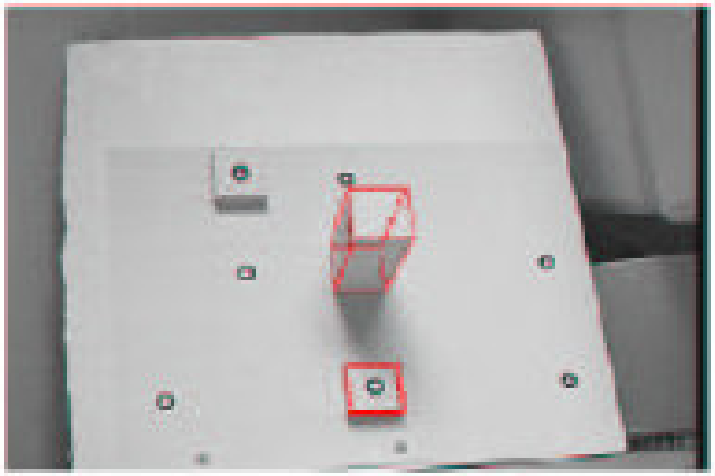
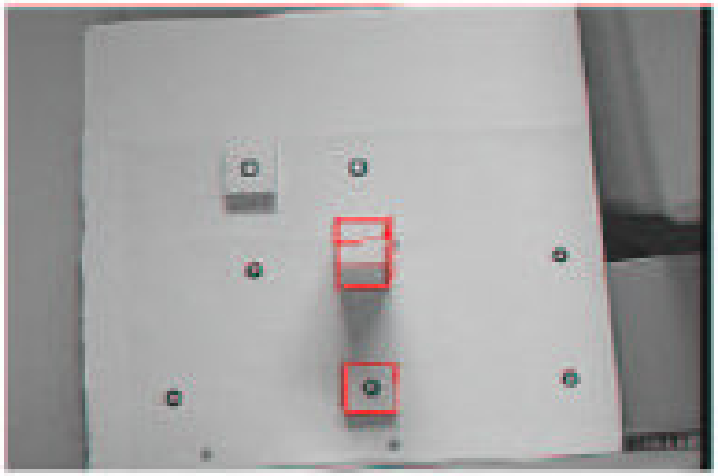
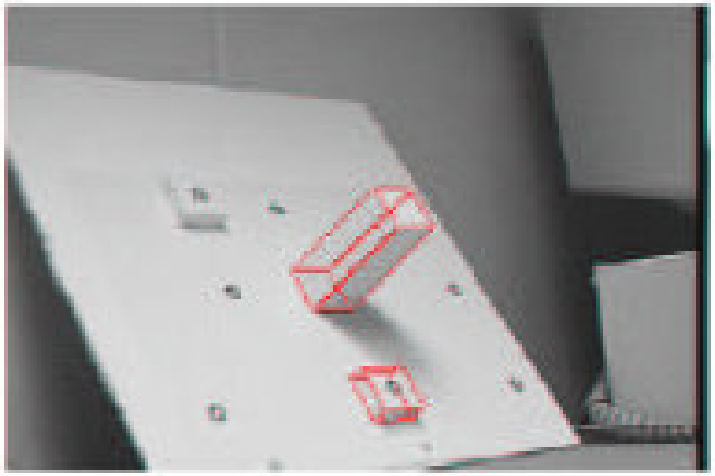
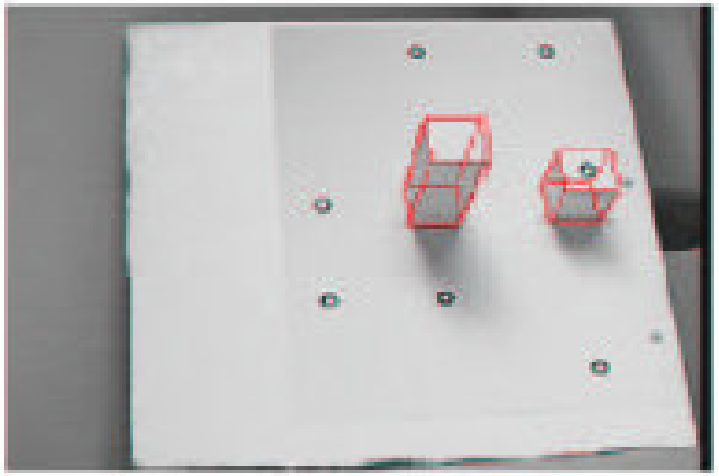


Optical see-through HMD

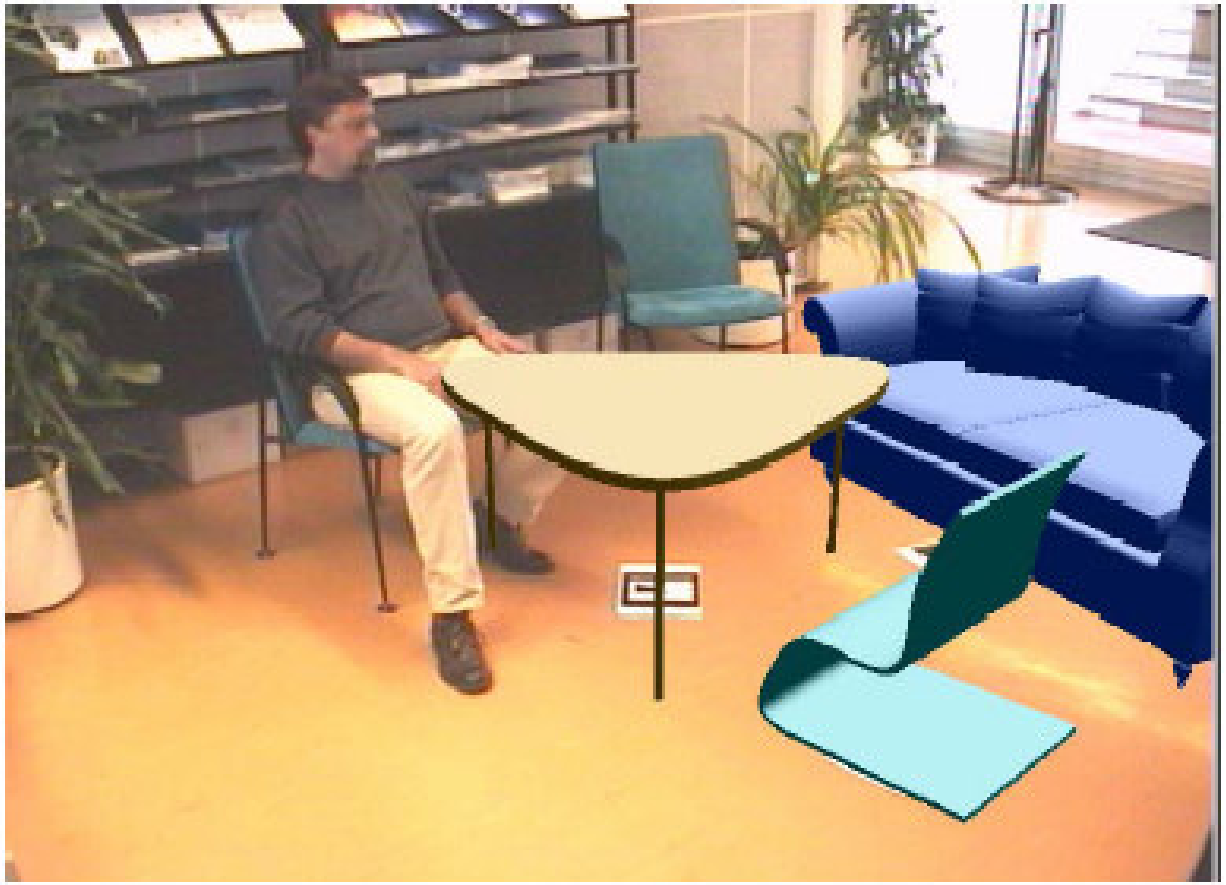


Augmented Reality

Augmented reality application - UCSD

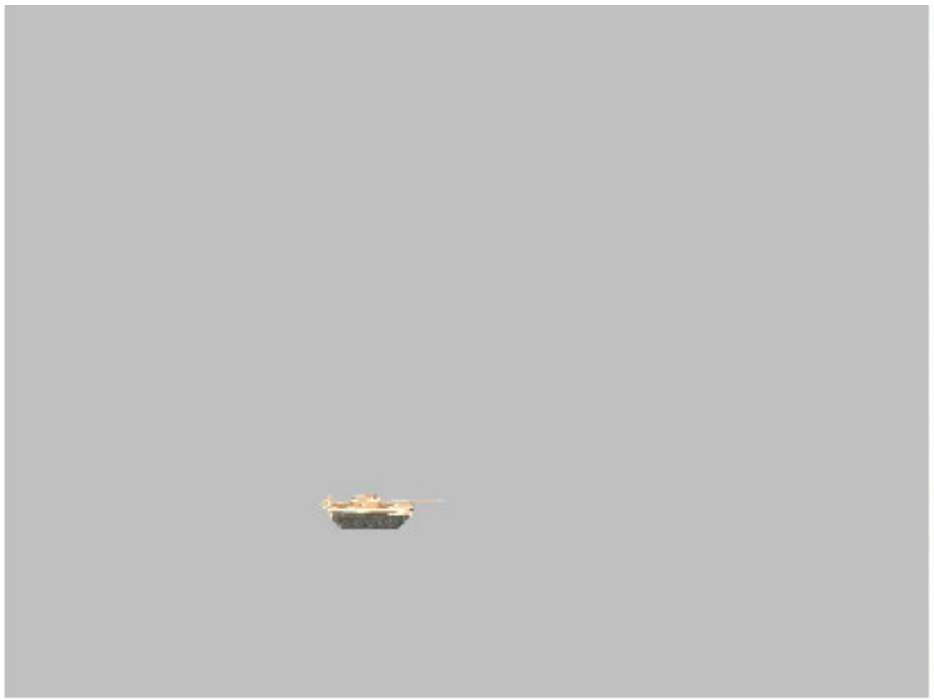





AR in room layout design



VTT

Virtual Robot in AR - UCF



Characteristics of VR systems

- 3D space & objects represented in computer memory
- real time (RT) rendering
- RT manipulation with objects
- RT navigation in VR space
- multimedia content (audio, image, video)
- interaction, animation

Why Virtual Reality (VR)

a) The 3rd dimension (3D) is already here (games, CAD, TV, movies)

b) Appropriate power of PCs (CPU, graphics card)

c) VR & WWW

"Low cost" VR

- It is possible to create 3D models and perform walkthrough through them
- This activity is supported by specific browsers (Cortona, Blaxsun etc.)
- Typical application: walkthrough in virtual cities (CGG project: Virtual Old Prague)
- No specific hardware is necessary
- Advantage: possibility to work in shared environment (network)

Features of VRML 97

- **V**irtual **R**eality **M**odeling **L**anguage (ISO/IEC 14772-1:19**97** standard)
- VR for WWW (standalone or network-based worlds)
- VRML browsers as plug-ins to WWW browser
- extendable, public, text format (*.wrl)

VRML Features (cntd.)

- B-rep geometrical models (facets)
- Animation and deformation (key-frame)
- Interaction (sensors & events)
- Possibility to use external programming languages (JavaScript, Java)

VRML Browsers

- Global information inside virtual worlds

  Viewpoint

- Navigation modes:

  Walk, ***Fly***, ***Examine***

  - collision detection

  - gravity

Basic VRML features

a) Geometry & transformations
(static tree structure)

b) Appearance
(color, texture, sound, background)

c) Dynamics & Interaction
(events sent among VRML nodes)

VRML Applications

a) Visualization

b) Simulation (Mechanical engineering)

c) Design

d) Commercial presentations

e) etc...

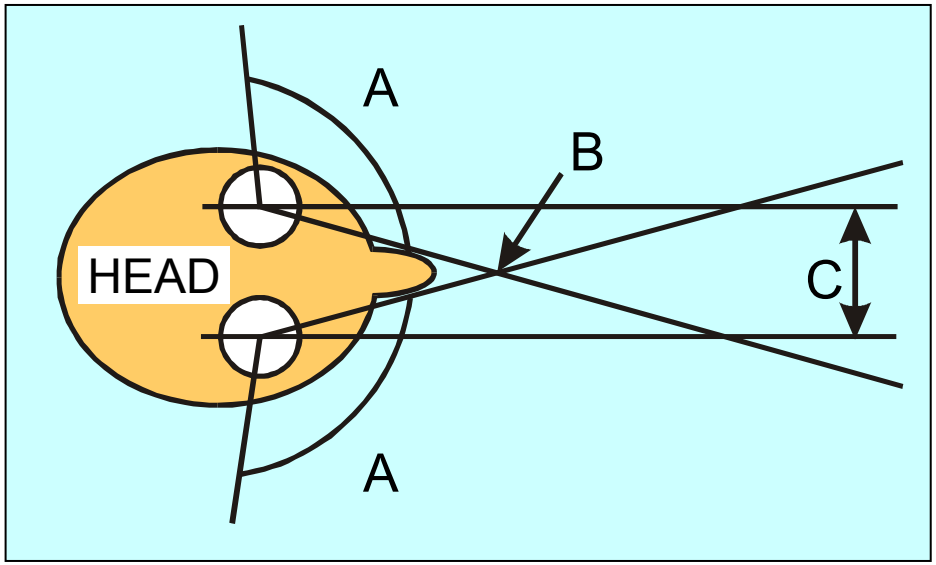
Hardware for Virtual Reality

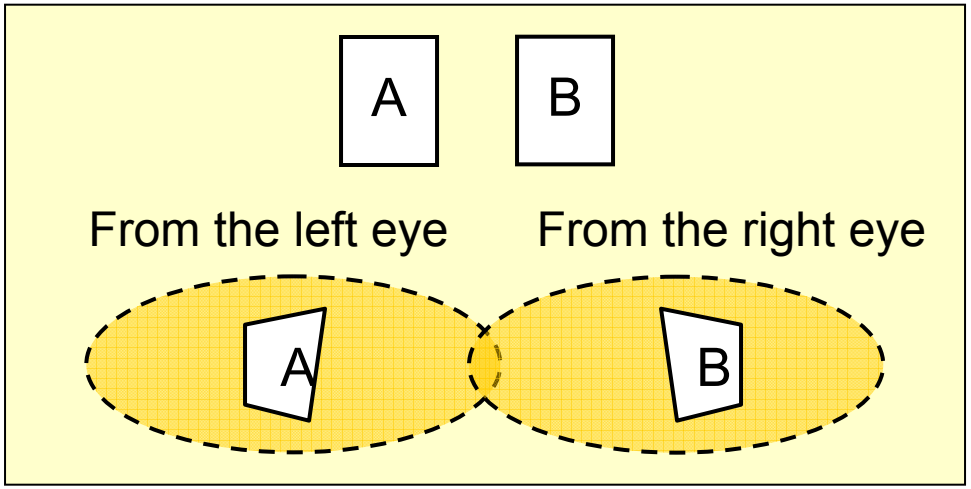
- VR Devices
- Human factors
- VR Applications

VR devices for:

- **Sight** (display technologies)
- **Hearing** (3D sound, voice synthesis)
- **Touch** (force & tactile feedback)
- **Interaction** (input & tracking devices)

3D vision = stereoscopic viewing



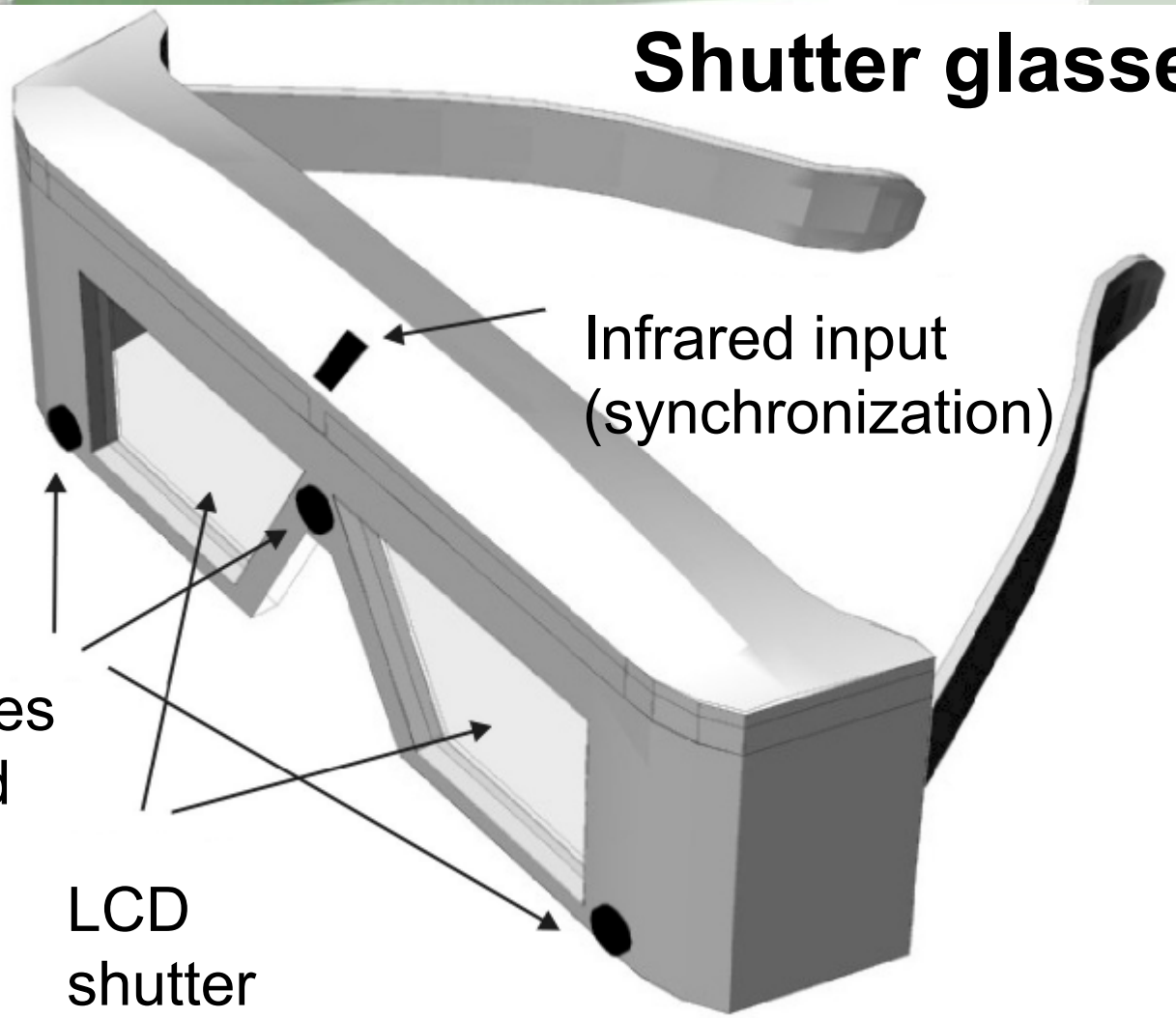


Display principles

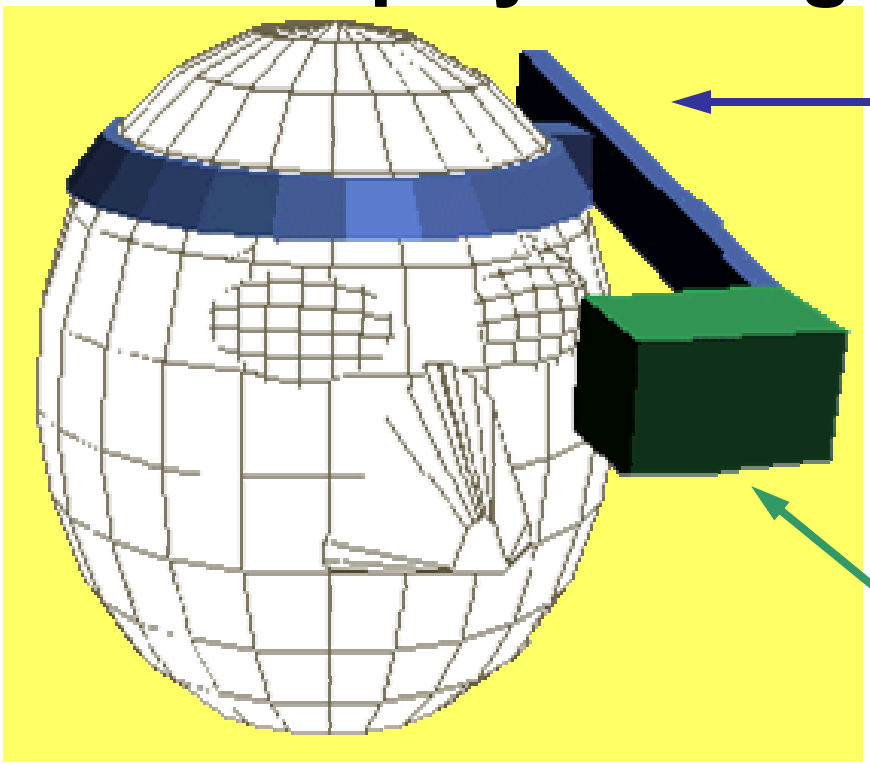
- **Stereoscopic filters** (color or polarized light)
- **Flicker Lens** (shutter glasses)
- **Head Mounted Displays** (stereo image & stereo sound)

- *Static viewer position versus tracking*

Shutter glasses



Display for augmented VR

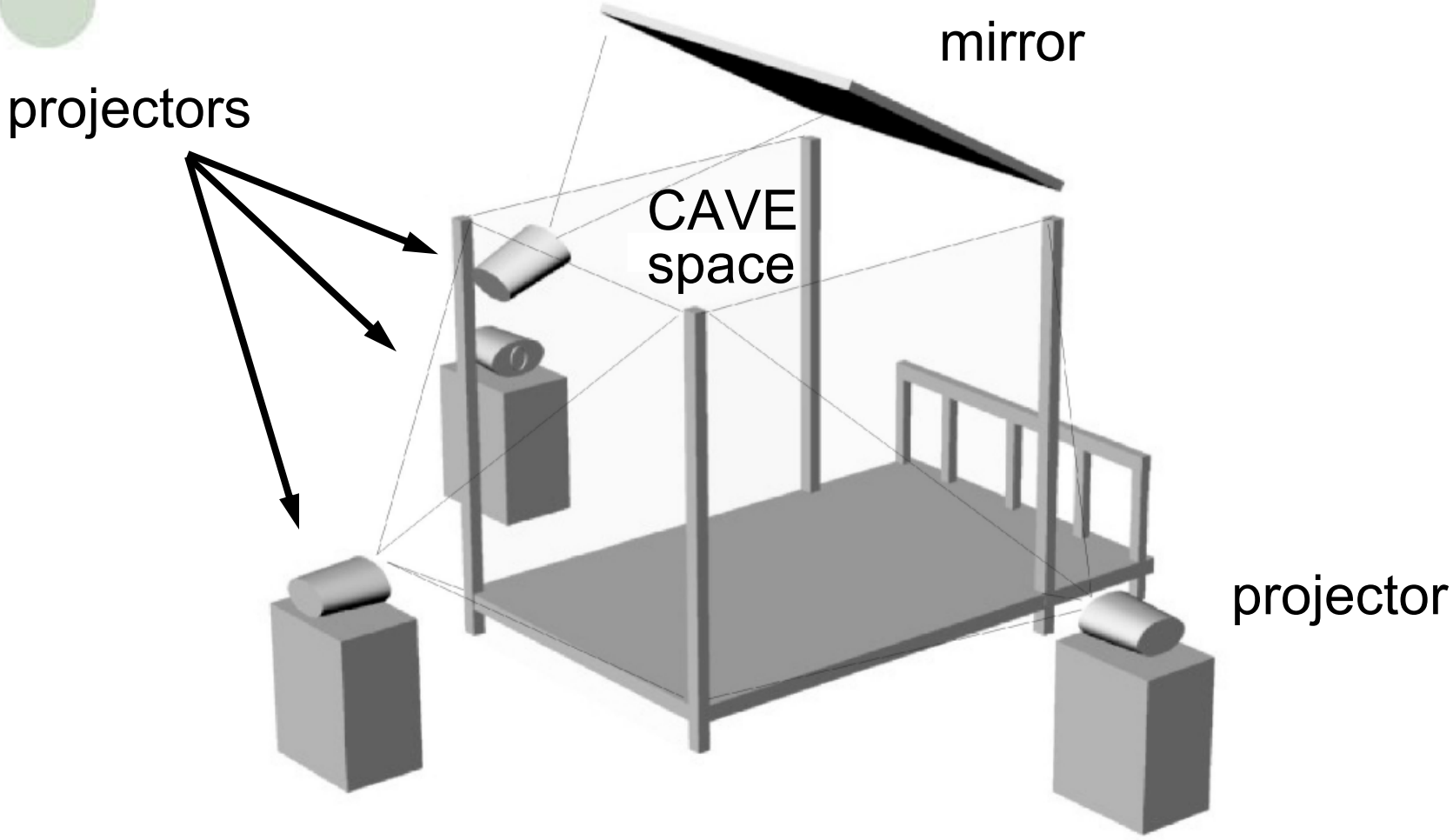


Tracking & receiving apparatus

Mini LCD Display

Immersive projection techniques

- **CAVE**
  (Cave Automatic Virtual Environment)
  1992, Univ. Illinois, 10x10x10 feet,
  crystal eyes
- **Immersive Wall, Workbench**
  for cooperating teams,
  large screen(s), crystal eyes, gloves



CAVE

Hearing

- **3D sound synthesis** (distance, echo)
- **Voice synthesis** (MUDVR)
- **Voice recognition** (input devices)
  - "I have got an e-mail"
  - "I have got any male"

Gloves

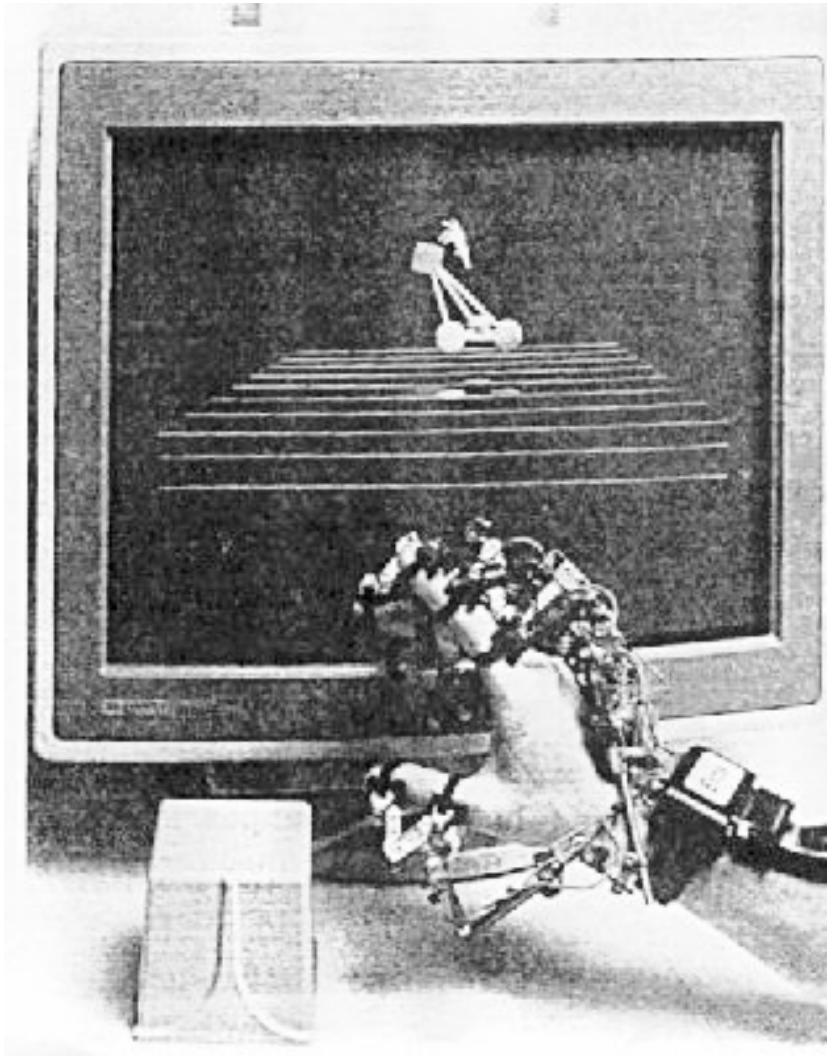
- **Input devices**
  (navigation and controlling via gestures)
- **I/O devices:** force feedback

- Gesture recognition: *static* versus *dynamic*

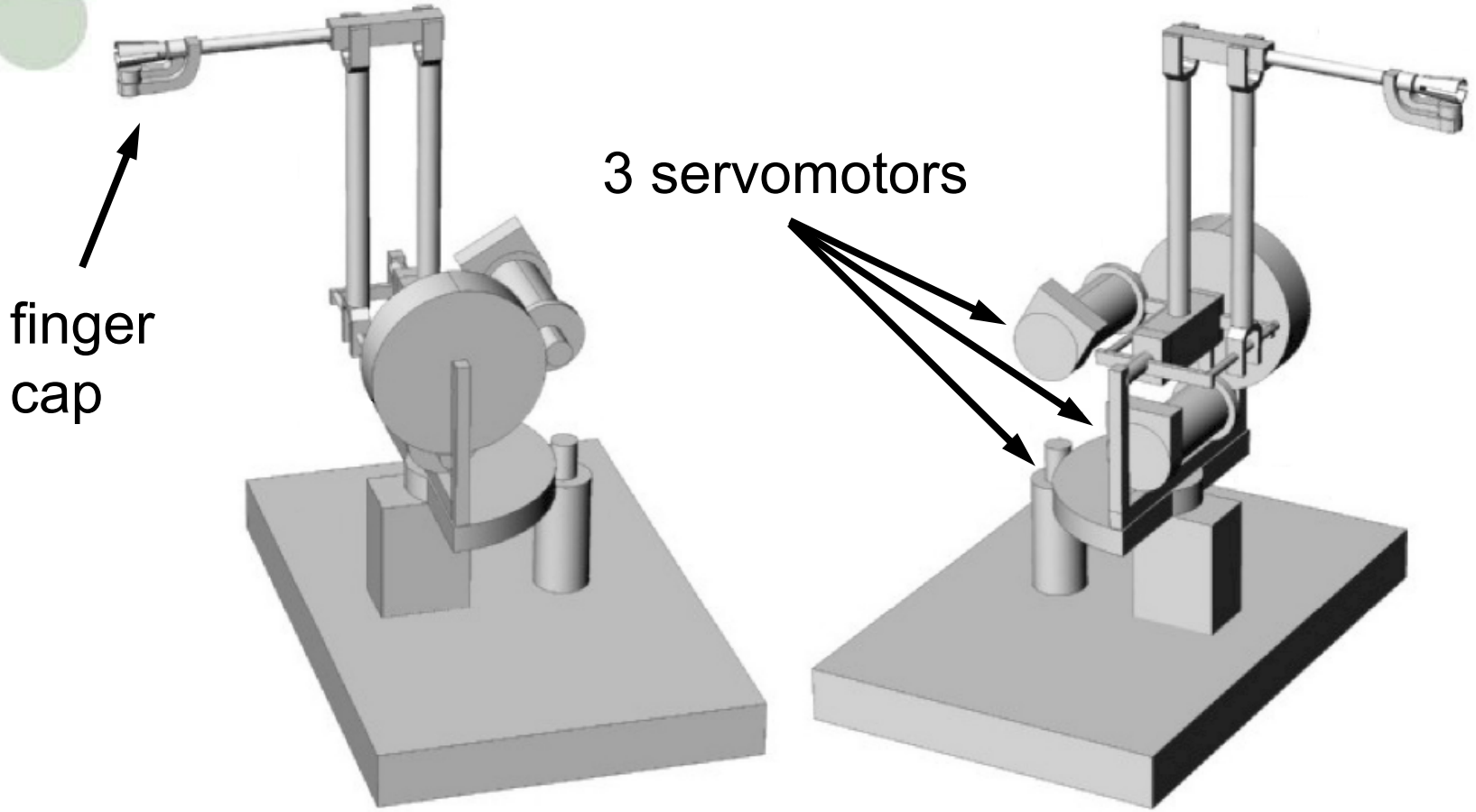
Simple data glove (*Mattel*)

Power Glove

Force feedback glove



Dexterous Hand Master



Phantom

Tracking devices

- **Mechanical** (3D mouse, glove)
- **Optical** (IR)
- **Electromagnetic** (gravity)
- **Acoustic** (ultrasonic)

- *Multiple sensor devices:* ***Data suits***

Special devices for immersive VR

- **Simulated rides** (motion seat)
- **Flight simulators** (motion platform)
- **VR cabins/cinemas**
  (motion platform, multiple screens)

Conclusion

- VR can help in investigation and analysis of various processes in VE
- Allows life-like simulations (and the following visualization) of process with high level of realism
- It is necessary to integrate VR methods both in the research dealing with VE and in corresponding education

Some references and further reading

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VR is fun

Cy-Visor DH4400VP

E N D

Thank you for your attention