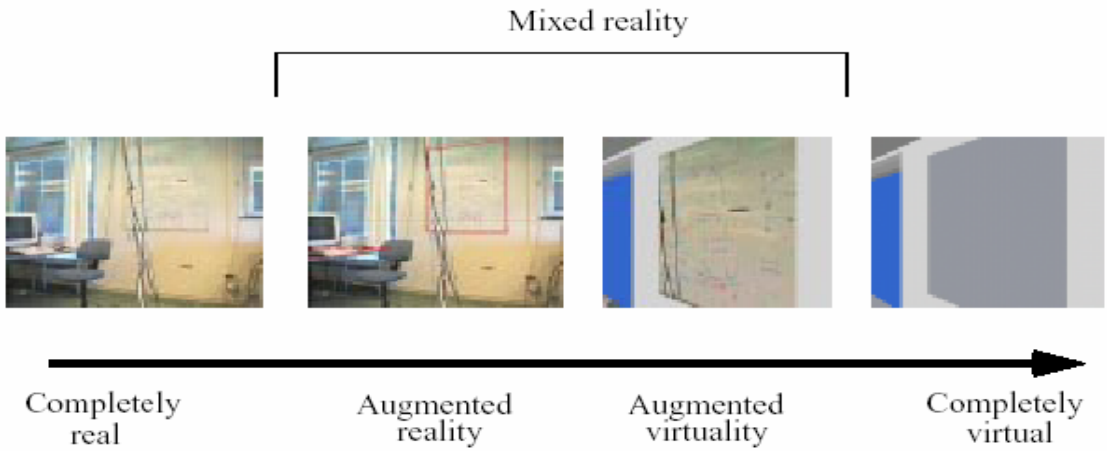
# Game Design
## - The Reality-Virtuality Continuum -

Prof. Dr. Andreas Schrader
ISNM International School of New Media
University of Lübeck
Willy-Brandt-Allee 31a
23554 Lübeck
Germany
schrader@isnm.de

# Mixed Reality

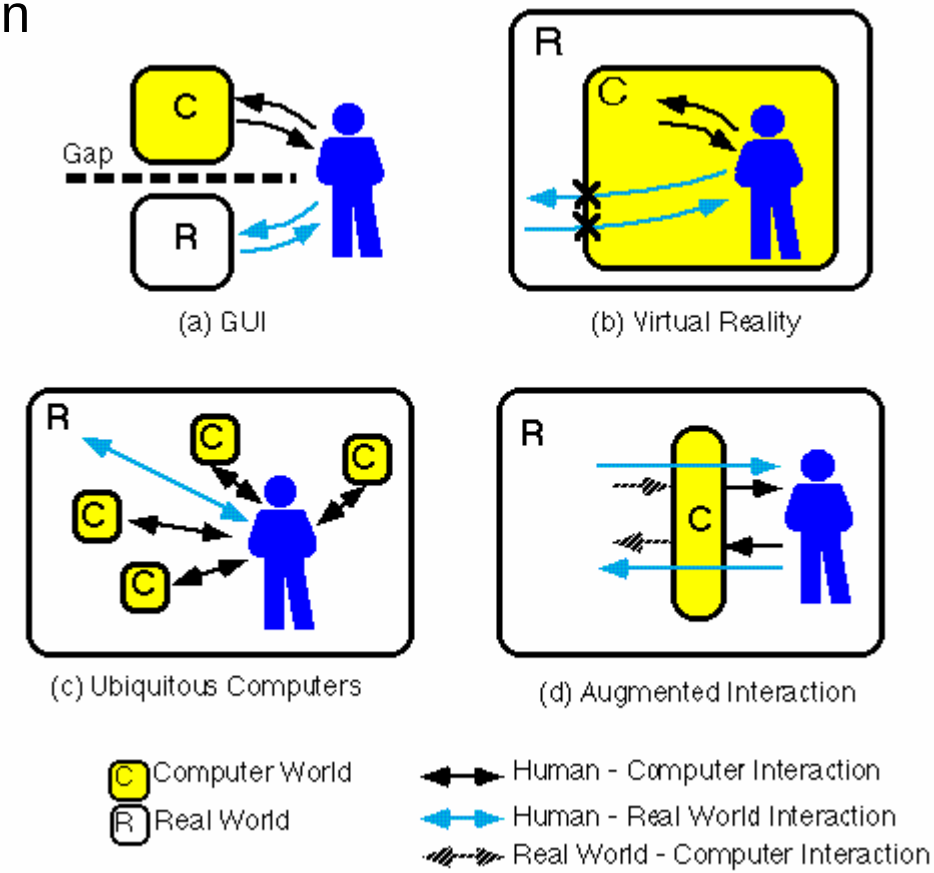
- The Reality-Virtuality Continuum

P. Milgram, H. Takemura, A. Utsumi, F. Kishino:
Augmented Reality: A class of Displays on the Reality-Virtuality Continuum
SPIE Vol. 2351, Telemanipulator and Telepresence Technologies, 1994.



# Augmented Reality

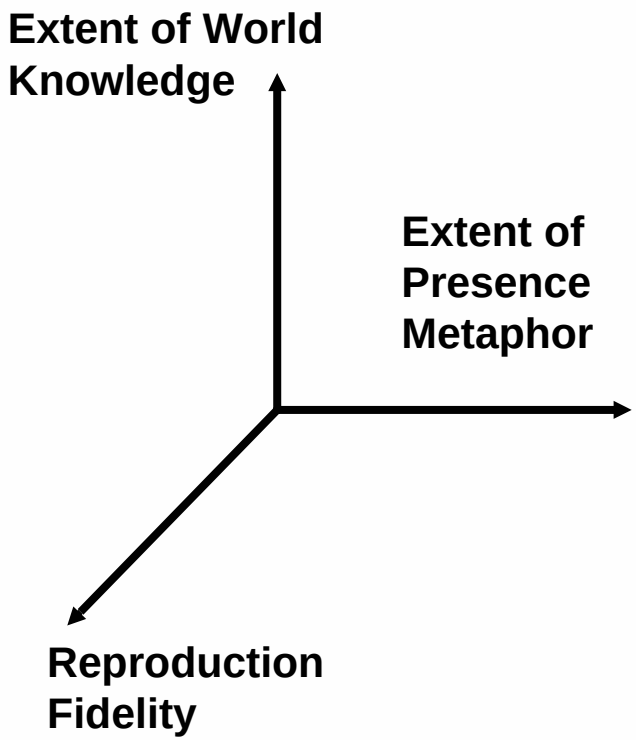
- Goal: enhance the real world sensation with useful information
- Users see real ***and*** virtual objects
- Location-dependent additional information can be provided (display menu cards for restaurants)
- The real sensation can be partially disabled (replace all billboards with pictures from last holiday ...)
- Photo-realism not necessarily first goal but in the ultimative system, people cannot decide whether parts are virtual or real




Source: http://www.csl.sony.co.jp/person/rekimoto/uist95/uist95.html

# Mixed Reality

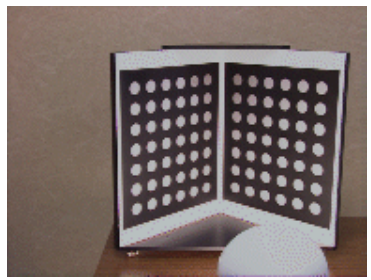
- Milgram's Taxonomy for mixed reality
  - Reproduction fidelity – quality of computer generated imagery
  - Extent of Presence Metaphor – level of immersion of the user within the displayed scene
  - Extent of World Knowledge – knowledge of relationships between frames of reference for the real world, the camera viewing it, and the user

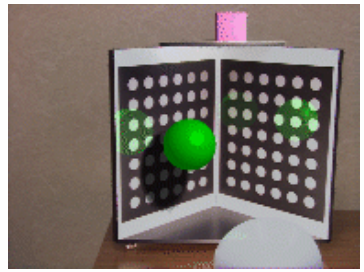



Source: http://vered.rose.utoronto.ca/publication/1994/Milgram_Takemura_SPIE1994.pdf

# Mixed Reality

- What do we need for the combination of read and virtual worlds?
  - Precise models
  - Locations and optical properties of the viewer (or camera) and the display
  - Calibration of all devices
  - Combination of all local coordinate systems centered on the devices and the objects in the scene in a global coordinate system
  - Registration of models of all 3D object of interest with their counterparts in the scene
  - Tracking of objects over time when the user moves and interacts with scene
  - Realistic merging requires:
    - Objects to behave in physically plausible manner when manipulated
    - Occlusion
    - Collision detection
    - Shadows
    - Detailed description of the physical scene

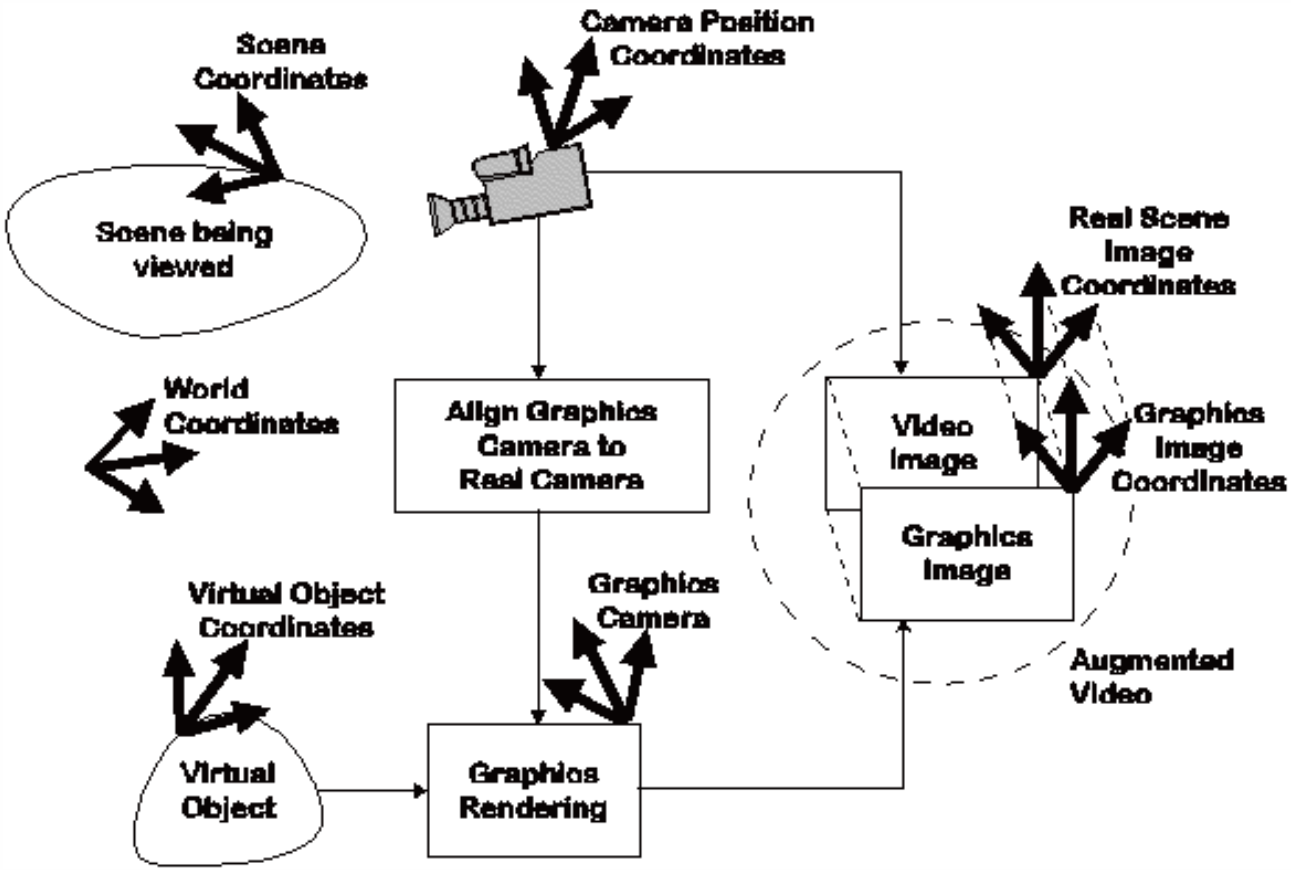




Source: Cindy Robertson (Georgia Tech)

# Mixed Reality

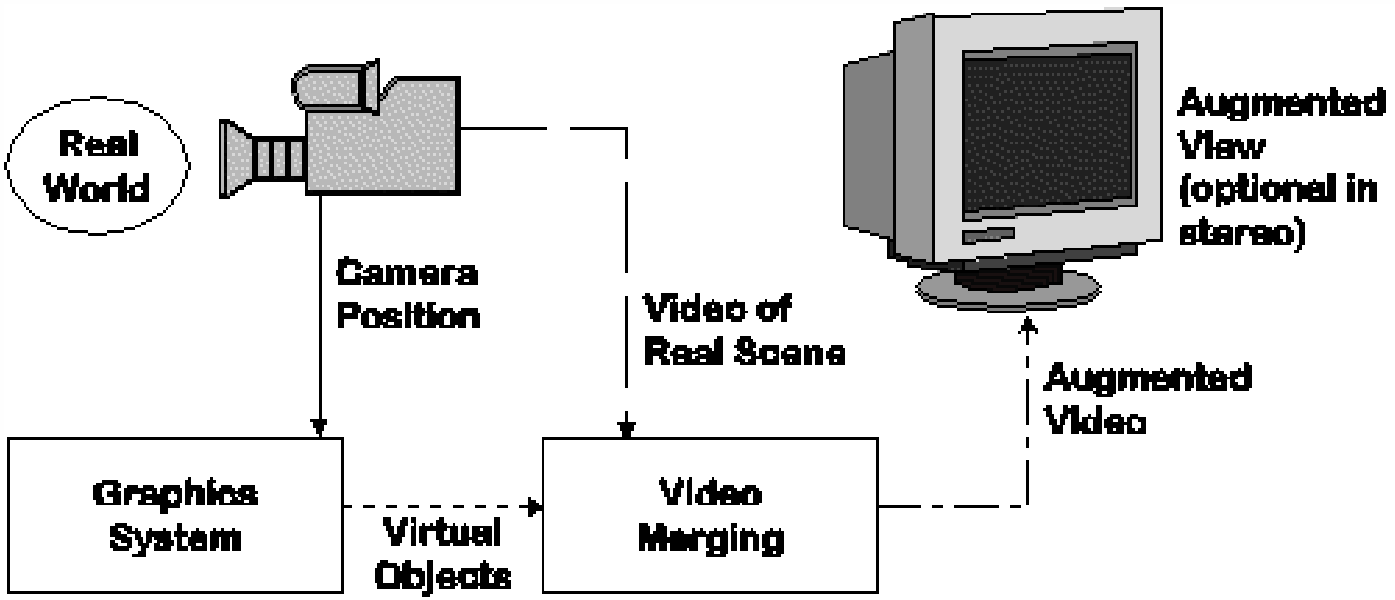
- Components of a mixed reality system




Source: Cindy Robertson (Georgia Tech)

# Mixed Reality

- Display Technologies
  - ***Monitor based***
    - Simplest technique
    - Little feeling of beeing immersed in environment




Source: Cindy Robertson (Georgia Tech)

# Augmented Reality

- Display Technologies
  - ***Head-Mounted-Displays***
    - Main idea: enhance the human eye with artificial visual information super-imposed on real light from the environment
    - Ian Sutherland started the development 1966
    - Many different technologies available
    - Applications are mainly in medical and military areas
    - Today you can buy HMD-displays in shops
    - A comprehensive market overview can be found at (http://www.stereo3d.com/hmd.htm)
    - Prices go from a few hundred to 100.000 €

Ivan Sutherland 1966

Cornegie Mellon University, 1995

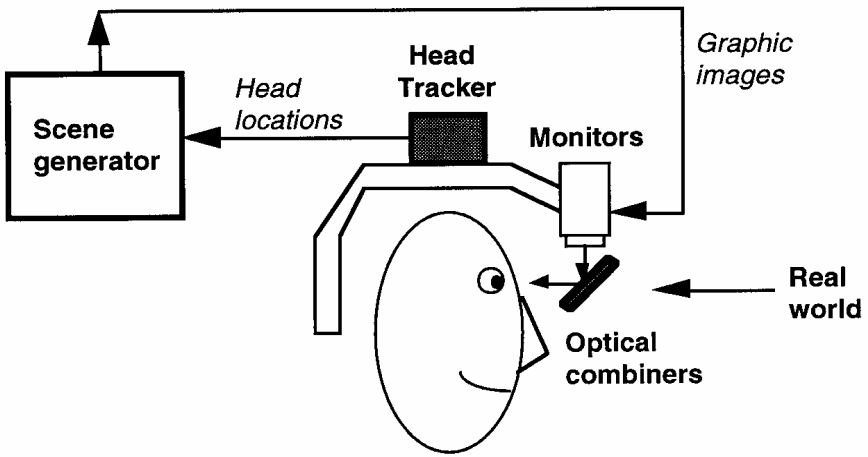
Frog Design 2004

Source: PC Magazine, http://www-2.cs.cmu.edu/~wearable/navigator.html

# Mixed Reality

- Display Technologies
  - ***Optical see-through Head Mounted Display***
    - Advantages:
      - Simple
      - No resolution limitations for real world picture
    - Disadvantages:
      - Delay for virtual image may cause offset in motions
      - Only bright objects can overpaint the reality, because ~30% of the real worlds image and ~70% of the virtual image can be seen in the displays

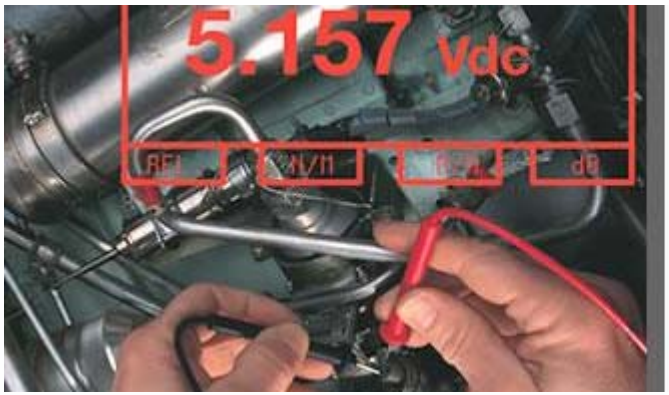
**Example: Glasstron (Sony)**




Source: Cindy Robertson (Georgia Tech), http://www.vrealities.com/hmd.html

# Mixed Reality

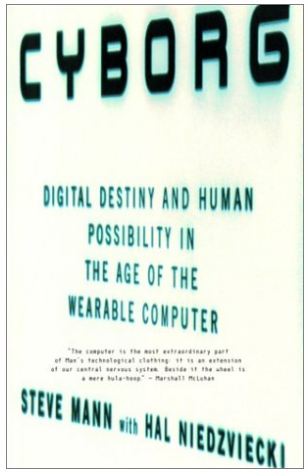
- Display Technologies
  - ***Optical see-through Head Mounted Display***
    - Example: Nomad (Microvision)
      - SVGA 800x600 pixels
      - 20:1 @ 10-30° C
      - Monochrome red




Source: http://www.microvision.com/nomad/index.html

# Mixed Reality

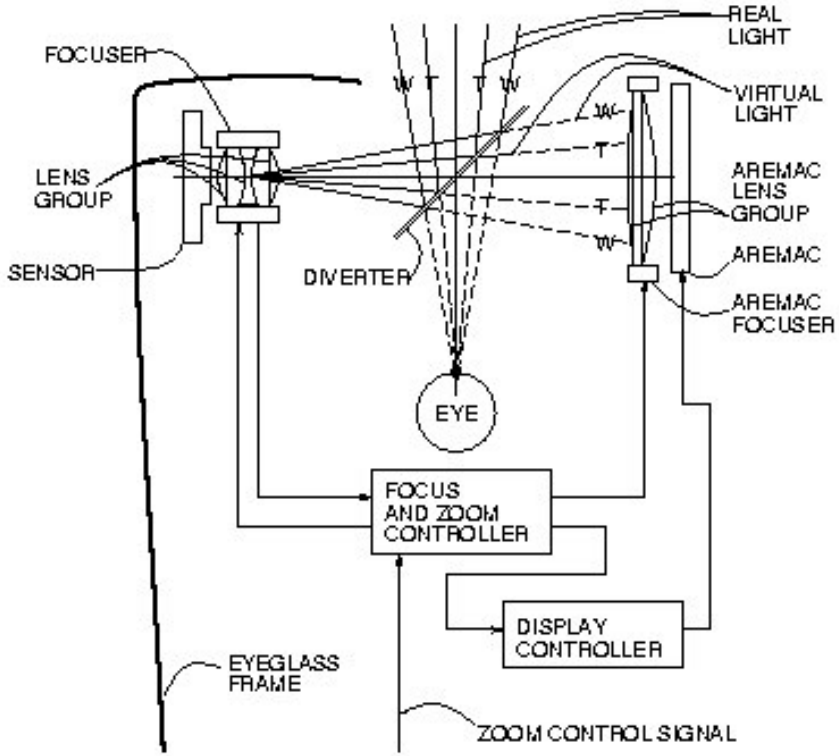
- Steven Mann (MIT, now Toronto University)
  - Started to develop ‚Cyborg' equipment in school
  - Since the 1980s he is constantly warrying his ‚WearComp'
  - His main research is for privacy and social impacts
  - He noticed two main trends:
    - The technology disminished (everthing moved into sunglasses)
    - His ‚Cyborg'-feeling is growing over the years


Source: http://www.eecg.toronto.edu/~mann/, http://wearcam.org/mann.html

# Mixed Reality

- Example: ***aremac*** (EyeTap)
  - Used by Steve Mann
  - Mixes real and virtual light
  - Sensors are used to detect what the user sees
  - An augmented, diminished, or otherwise processed visual perception is presented to the user with appropriate focal distance and tonal range
  - Aremic visual results and environmental light have collinear rays and appear spatially aligned in the user's field of view (FOV)




Source: http://eyetap.org/research/eyetap.html

# Mixed Reality

- Example: ***Reality Window Manager*** (EyeTap)
  - Window manager for XWindows that overlays xterms and other windows onto planar patched in the environment
  - Allows for real-time tracking, replacement and rendering


**Commercial sign replaced by message**

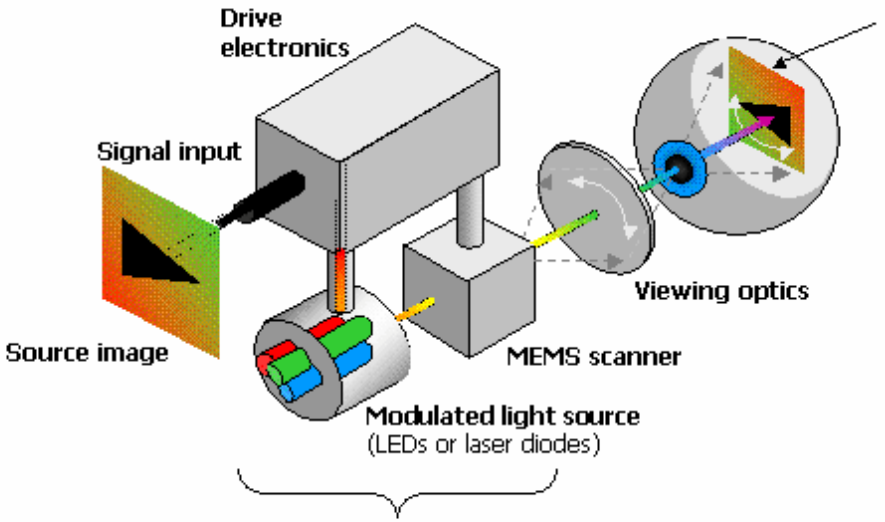

**Billboard replaced by a web browser**

Source: http://eyetap.org/research/medr/rwm.html

# Mixed Reality

- Display Technologies

## NEAR-EYE SCANNED BEAM DISPLAY DIAGRAM

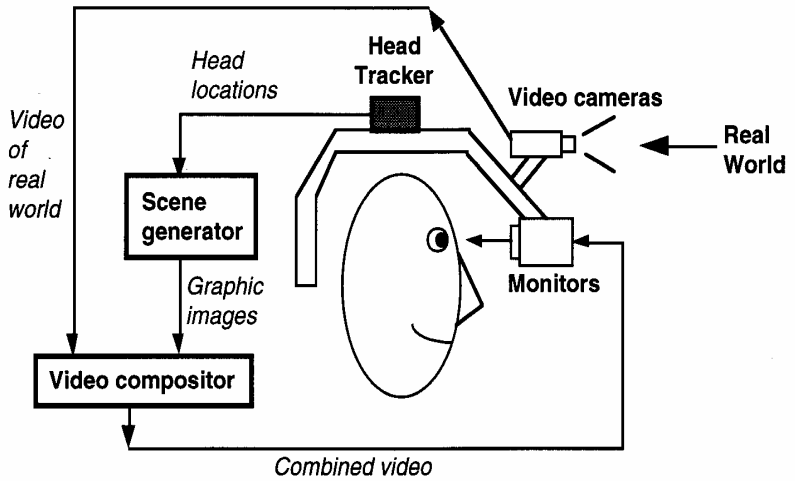



Source: http://www.microvision.com/nomad/index.html

# Mixed Reality

- Display Technologies
  - ***Video see-through Head Mounted Display***
    - Advantages:
      - No delay, since virtual and real images can be synchronized
      - Easy to control visual behavior like brightness or shadows
      - Virtual image can completely overpaint the real image
    - Disadvantages:
      - Delay between mechanical and seen motion can cause motion sickness
      - Real world image has the same (low) resolution as the display has

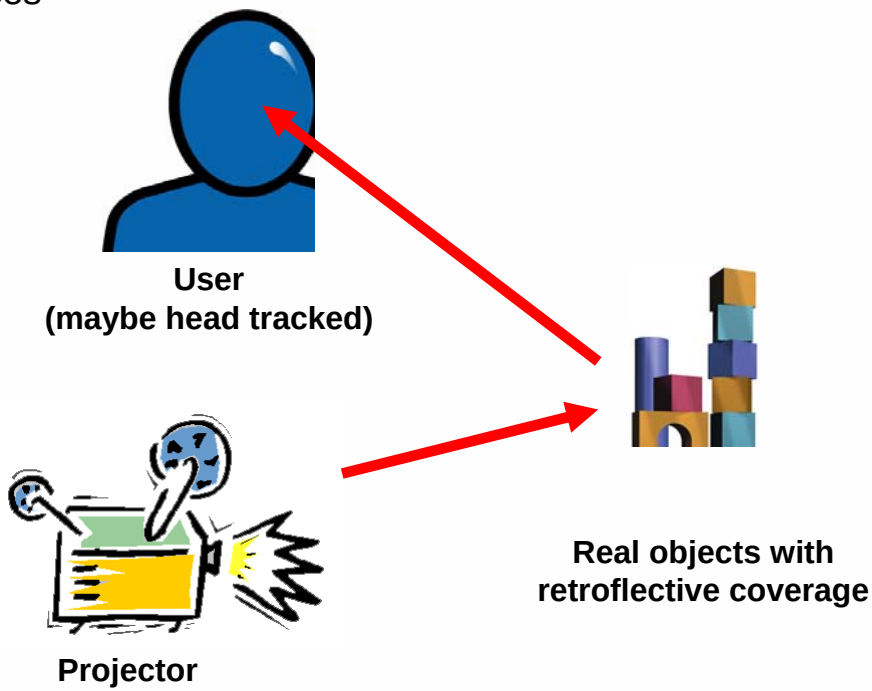
**Example: COASTAR (Mixed Reality System Lab Inc.)**




Source: Cindy Robertson (Georgia Tech), http://citeseer.nj.nec.com/takagi00development.html

# Mixed Reality

- Display Technologies
  - ***Projector-based***
    - Advantages:
      - User is completely free of devices
    - Disadvantages:
      - User can be ‚in the way‘
      - Limited accuracy
      - Only one viewing direction




Source: http://www.cs.unc.edu/~debug/papers/DSLpaint/

# Mixed Reality

- Display Technologies
  - ***Projector-based***
    - Example: University of North Carolina at Chapel-Hill

Ramesh Raskar, Greg Welch, Wei-Chao Chen.
**Table-Top Spatially-Augmented Reality: Bringing Physical Models to Life with Projected Imagery**
Second International Workshop on Augmented Reality (IWAR'99), October 20-21, 1999, San Francisco, CA.


D, Bandyopadhyay, R. Raska, H. Fuchs:
**Dynamic Shader Lamps:**
**Painting on Real Objects**
The Second IEEE and ACM International Symposium on Augmented Reality (ISAR'01) New York, NY, October 29-30, 2001.

Source: http://www.cs.unc.edu/~debug/papers/DSLpaint/, http://www.cs.unc.edu/~raskar/Office/index.html#pub

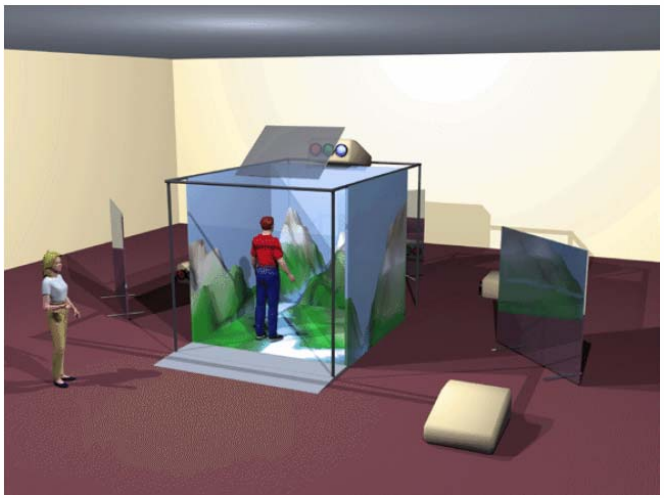
# Mixed Reality

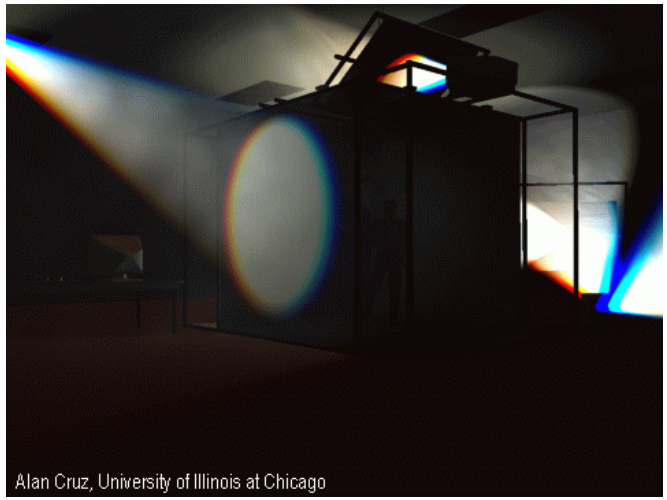
- Display Technologies
  - ***Projector-based***
    - Example: Virtual Keyboard
      - LED projection of keyboard onto a flat surface
      - Infrared motion detectors sense movements of fingers
      - Also mouse and touchpad controls

Source: PC Magazine, http://www.ibizpda.com/

# Mixed Reality

- Virtual Reality Technologies
  - ***CAVE***
  - Projection based virtual reality system developed at the Electronic Visualization Lab of the University of Illinois at Chicago in 1992
  - A cave is a box of about 3x3x3 meters
  - One side is open (entrance), 8 walls are just as a projection space for 3-dimensional graphics (special shutter glasses are used for stereo effects)



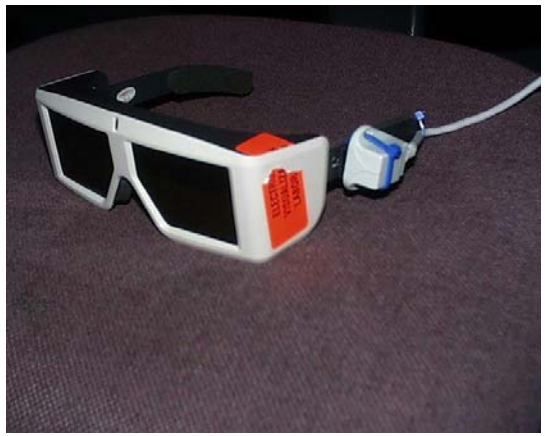



Source: http://www.aec.at/en/center/project.asp?iProjectID=11197, http://www.evl.uic.edu/pape/CAVE/

# Mixed Reality

- Virtual Reality Technologies
  - ***CAVE***
  - A magnetic emitter is positioned above the CAVE.
  - The location of users are tracked by magnetic field sensors in the LCD glasses and in the ‚Wand' – a kind of 3D mouse with a pressure-sensitive joystick
  - Graphics are projected to the left and right eye alternatively at 96 fps
  - The direction of the user's view is tracked by infrared detectors

WAND device



LCD glasses

Source: http://www.evl.uic.edu/pape/CAVE/

# Mixed Reality

- Virtual Reality Technologies
  - ***CAVE***
    - Advantages:
      - Allows for simultaneously usage by many participants
      - Users do not need to wear helmets
    - Disadvantages
      - Enormous effort in control hardware
      - Very expensive
    - You can visit one of the few European CAVEs at the Ars Electronica Center in Linz

Source: http://www.aec.at/en/center/project.asp?iProjectID=11197

# Augmented Reality

- Augmented Reality can be done with video ...
  - Example shopping or travel guidance systems


Source: http://www.howstuffworks.com/augmented-reality.htm

# Augmented Reality

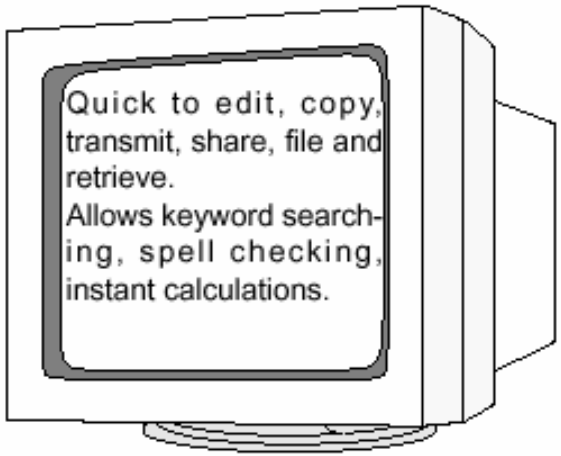
- ... and audio
  - But augmented audio is not always much appreciated ...



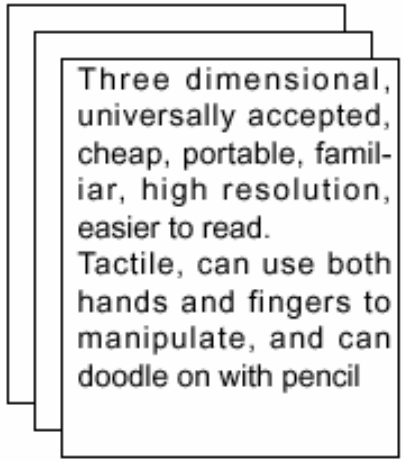

Source: http://www.dilbert.com

# Augmented Reality

- Example: ***Digital Desk*** (Wellner, Xerox, 1992)
  - Both electronic and paper documents have their advantages




Electronic documents
on a virtual desk



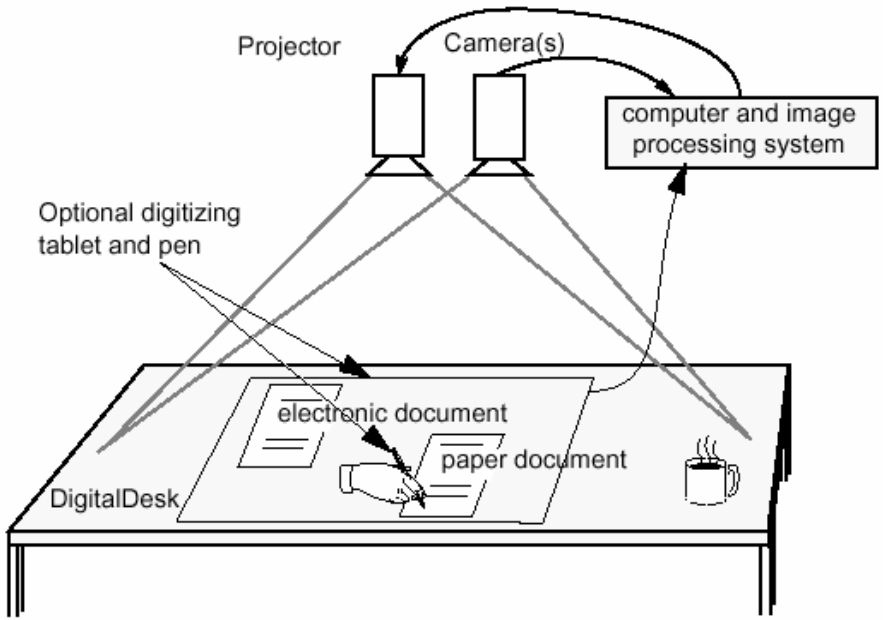

Paper documents
on a real desk

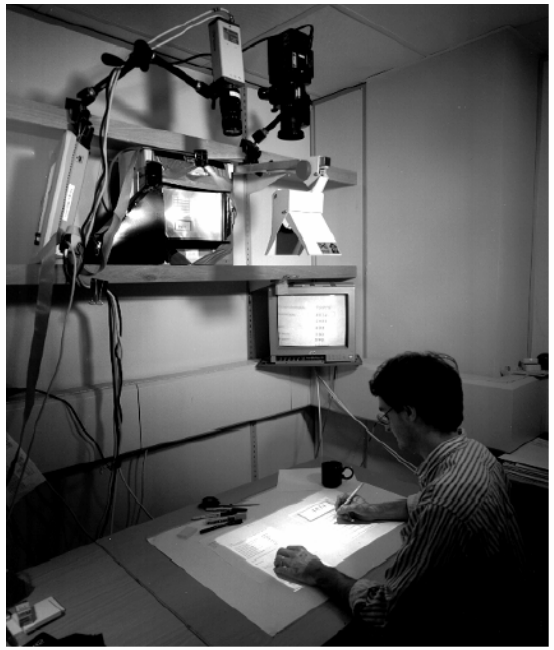
P. Wellner: "*DigitalDesk*",
Communications of the ACM, 36(7), pp. 87--96, July 1993.

Also: http://www.xrce.xerox.com/competencies/image-processing/past-projects/history.html,
http://citeseer.nj.nec.com/wellner93interacting.html

# Augmented Reality

- Example: ***Digital Desk*** (Wellner, Xerox, 1992)
  - Extending the desktop methaphor to the real desk
  - Virtual (displayed) and real documents share the same space

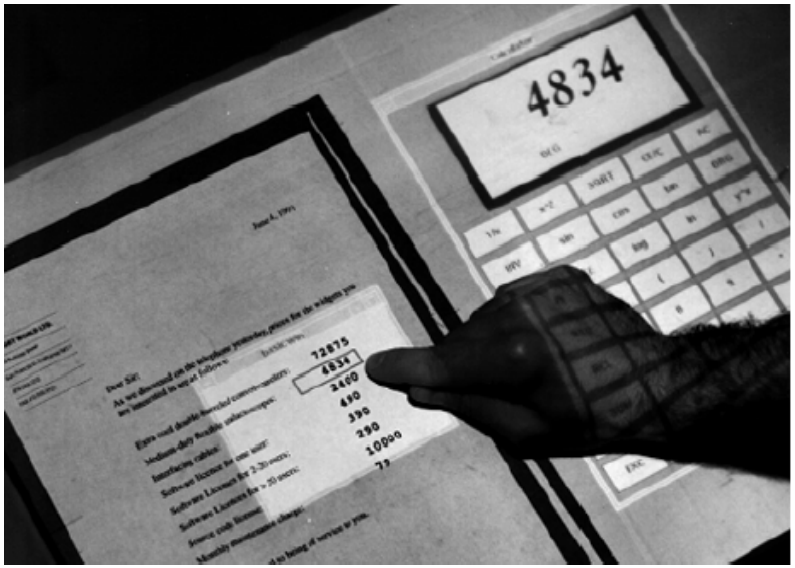


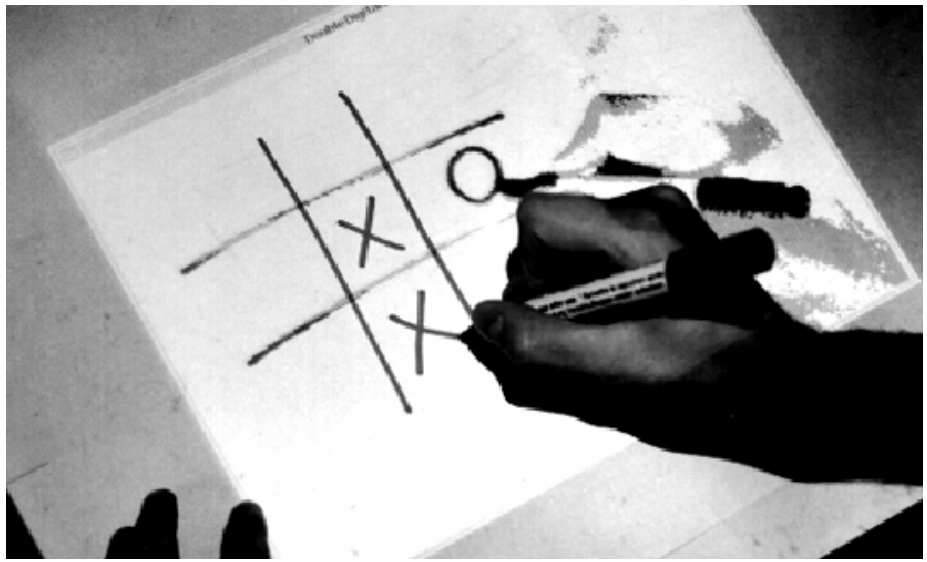
Source: http://www.xrce.xerox.com/competencies/image-processing/past-projects/history.html,

# Augmented Reality

- Example: ***Digital Desk*** (Wellner, Xerox, 1992)
  - Allows for intuitive user patterns




User selects the text „4834“ on a sheet of paper, the system recognizes the text and displays the result as an input for the virtual calculator on the right side.



DoubleDesk: The user is drawing on paper, while the system displays the remote player as a virtual copy of the real action on the remote location. Both players have the same impression.

Source: http://www.xrce.xerox.com/competencies/image-processing/past-projects/history.html,

# Augmented Reality

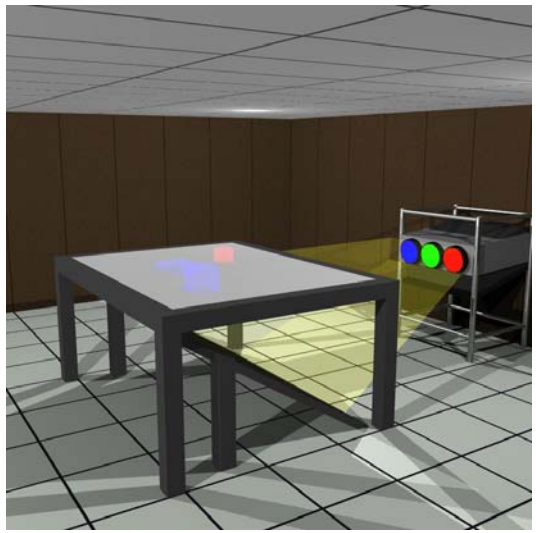
- Example: ***Digital Desk*** (Wellner, Xerox, 1992)

**Video**

Source: http://www.xrce.xerox.com/competencies/image-processing/past-projects/history.html,

# Augmented Reality

- Example: ***Responsive Desk*** (GMD/Berkeley, 1997)
  - Combines the Digital Desk metaphor with 3D virtual reality
  - Computer-generated stereoscopic images are projected onto a horizontal tabletop display surface via a projector-and-mirrors system
  - Scene is viewed through shutter glasses to generate the 3D effect



Source: http://www.graphics.stanford.edu/projects/RWB/

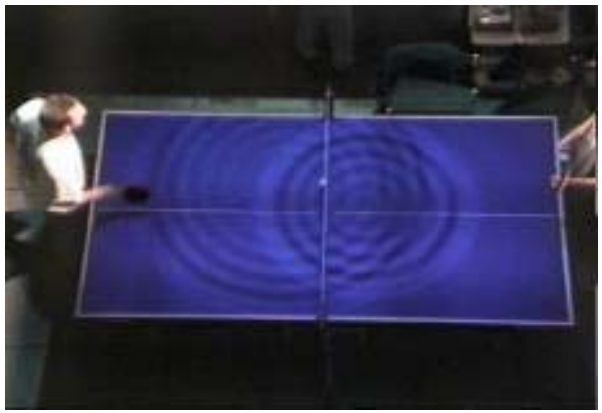
# Augmented Reality

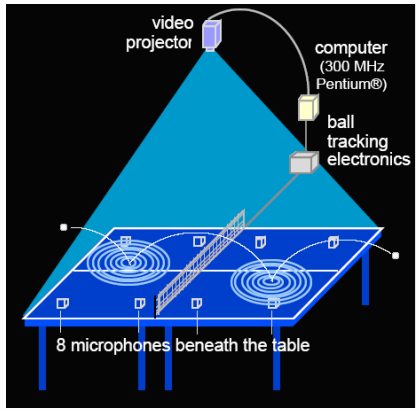
- Augmented Reality in Game Design


Source: http://www.infotech.oulu.fi/Annual/2000/VIRGIN.html

# Augmented Reality

- Augmented Reality in Game Design
  - Example: ***PingPong Plus*** (MIT Tangible Media Lab)
    - Full-body motion in physical space with digital augmentation
    - Sound-based ball tracking technology
    - The ping pong game is augmented and transformed with dynamic graphics and sound, determined by the position of impact, and the rhythm and style of play






Ishii, H., Wisneski, C., Orbanes, J., Chun, B., and Paradiso, J.,
**PingPongPlus: Design of an Athletic-Tangible Interface for Computer-Supported Cooperative Play**
in *Proceedings of Conference on Human Factors in Computing Systems* (***CHI '99***),
Pittsburgh, Pennsylvania USA, May 15-20, 1999, ACM Press, pp. 394-401.

Source: http://tangible.media.mit.edu/projects/PingPongPlus/PingPongPlus.htm
Video at http://tangible.media.mit.edu/projects/PingPongPlus/mpeg_hires.mov

# Augmented Reality

- Augmented Reality in Game Design
  - Example: ***Three Angry Men***
    - (Interactive Media Technology Center, Atlanta and Augmented Environments Lab, Georgia Institute of Technology)
    - AR version of the 20th century play „Twelve Angry Men“ (Reginald Rose)
    - Experiment to present a dramatic narrative to experience the same story from multiple points of view
    - The participants are in a physical ‚jury-room‘ with 3 virtual characters (augmented videos through HMD) debate a trial on murder
    - Goal: dramatize the idea of different people perceiving events differently

Source: http://www.imtc.gatech.edu/projects/technology/3angry.html, http://www.cc.gatech.edu/projects/ael/

# Augmented Reality

- Augmented Reality in Game Design
  - Example: ***Three Angry Men***
    - Participants can occupy the position of each juror and temporarily enter the character‘s mind and hear the inner thoughts (location tracking technology)
    - Six minute scene is not perceived linearly but as a mixture of the three points of view
    - Each participant has a different experience depending on her movement

Source: http://www.imtc.gatech.edu/projects/technology/3angry.html, http://www.cc.gatech.edu/projects/ael/

# Augmented Reality

- Augmented Reality in Game Design
  - Example: ***Virtual Moskity Hunting*** (Siemens)
    - Game on mobile phone SX1
    - Embedded camera shows real world
    - Virtual moskitos (mozzies) are superimposed
    - Players have to turn around the see all moskitos
    - Moskitos get killed by pressing the joystick button
    - 1 Minute time

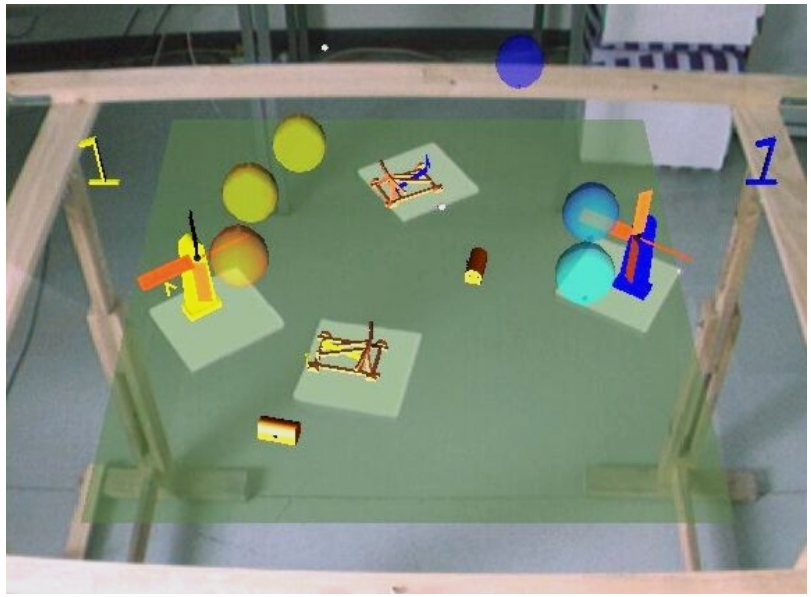


Augmented Reality
Soccer on PDA
Siemens C-LAB
http://mb5.net/images/game_design/images/praxissemester.pdf

Sources: http://www.siemens.com/index.jsp?sdc_p=t8c175suo1064046pnfl0m&sdc_sid=15545872840&

# Augmented Reality

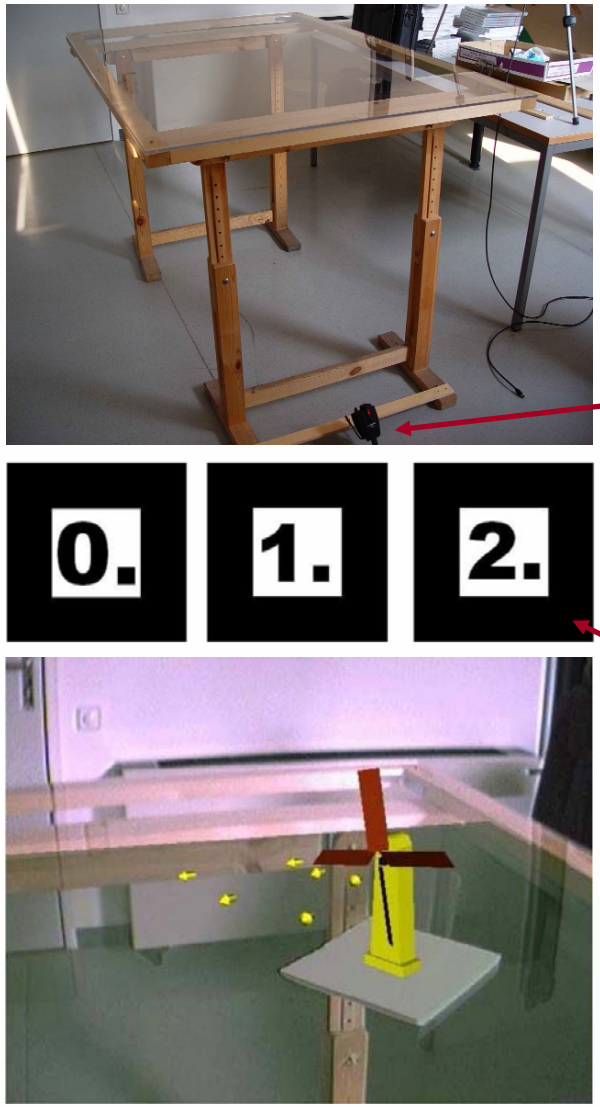
- Augmented Reality in Game Design
  - Example: ***Studierstube - Tangible Augmented Reality***
  - (University of Vienna)
    - A combination of a tangible user interface with augmented reality
    - Players see a 3-dimensional graphical presentation
    - Special interfaces allow for easy manipulation of objects
    - Several computer games have been implemented to test the concept



Sources: http://www.cg.tuwien.ac.at/~cu/tangibleAR/

# Augmented Reality

- Augmented Reality in Game Design
  - Example: ***Studierstube***
    - More intuitive way of interaction between machine and users
    - Supports several players since it is not restricted to a single screen/keyboard
    - Three-dimensional presentation increases the realism of the game
    - Glass table with camera below avoids occlusion of markers by users
    - Marker-based optical tracking
    - Virtual objects are placed on top of the markers
    - Only visible through HMD
    - Developed using the ARToolkit




Sources: http://www.cg.tuwien.ac.at/~cu/tangibleAR/

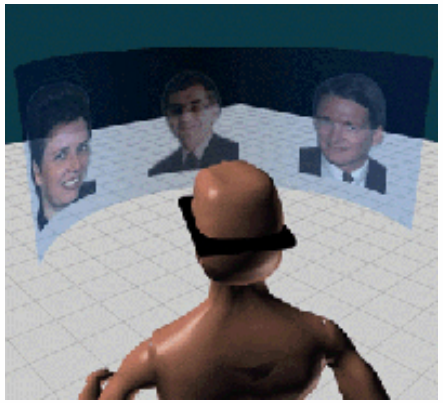
# Augmented Reality

- Augmented Reality in Game Design
  - Example: ***Studierstube***


Sources: http://www.cg.tuwien.ac.at/~cu/tangibleAR/

# Augmented Virtuality

- ***Augmented Virtuality***: A complete virtual environment is augmented with real object presentations
  - Avatars with real people faces in virtual shops
  - Stills and videos of real objects in virtual museums
  - Virtuality does not necessarily requires CAVE technology



Karl-Petter Akesson:
Augmented Virtuality: A method to automatically augment virtual worlds with video images, Master Thesis, SICS, Sweden, 1996.

Source: http://www.sics.se/~kalle/projects/Master_Thesis/index.html,
http://vered.rose.utoronto.ca/publication/1994/Milgram_Takemura_SPIE1994.pdf

# Augmented Virtuality

- Example: ***LeMo*** (Lebendiges virtuelles Museum Online)
  - VRML based web pages with real pictures of exhibition objects arranged in the virtual space


Source: www.dhm.de/lemo

# Augmented Virtuality

- Commercial Applications
  - Manufacturing
  - Maintenance
  - Repair
  - Consumer and Engineering Design
  - Hazard Detection
  - (Tele-)Robotics
  - Medical
  - Military Training
  - Etc.


**Advertisement**

**Sports**

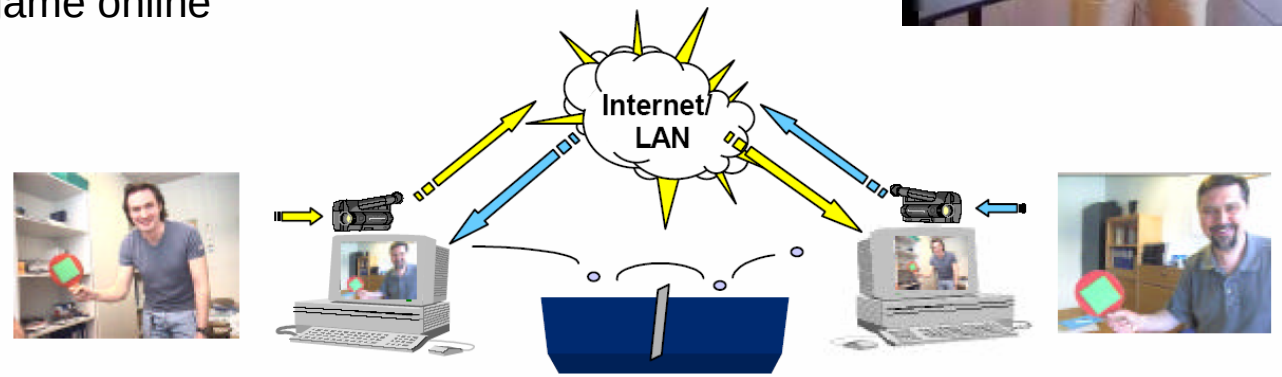
**Entertainment**

**News**

Source: http://www.orad.tv/index.htm

# Augmented Virtuality

- Augmented Virtuality in Game Design
  - Example: ***CamBall*** (VTT Information Technology – Multimedia Group)
    - Augmented virtual table tennis game
    - Internet/LAN based using real rackets
    - Only web camera is necessary
    - The camera image is streamed in real time
    - The rackets have paper stickers in green to detect player movements
    - Multicast version allows others to watch the game online




Source: http://www.vtt.fi/multimedia/index_iv.html, http://www.vtt.fi/multimedia/camball/camball.html

# Augmented Virtuality

- Augmented Virtuality in Game Design
  - Example: ***AquaGauntlet™***
  - National Japan Research Project (1997-2001)
  - AquaGauntlet utilizes 3D mixed reality spaces
    - Video see-through HMD
    - Multi-player
    - Reflection of real world scenes onto virtual objects
    - Spatial sound effects
    - Gunshots and explosions are sensable physically through speaker vibrations
    - Gesture-based action commands
    - Opponent actions are visualized (gun fire, shields, etc.)



Source: www.mr-system.com/project/aquagauntlet/, webster.fh-hagenberg.at/staff/haller/cgr2_20032004/09-Concepts-AugmentedReality.pdf

# Augmented Virtuality

- Augmented Virtuality in Game Design
  - Example: ***Myst***
    - Real person videos superimposed into virtual world

Source: http://www.mystrevelation.com,

# Mixed Reality

- Mixed Reality in Game Design
  - Example: ***Gulliver's Box***
  - Mixed Reality Lab of the National University of Singapore, the Human Interface Lab of Osaka University's Graduate School of Engineering Science, the Ars Electronica Futurelab and Zaxel Systems Inc.

Source: http://www.aec.at/en/center/project.asp?iProjectID=12286

# Mixed Reality

- Mixed Reality in Game Design
  - Example: ***Gulliver's Box***
  - Recording Room
    - Visitors can record themselves (green screen effect)
    - A transparent box („Magic Cup") as a tangible interface houses the figures from the recording room or other animated characters
  - Stage – The main playing space
    - Scenery can be decided
    - Characters can be placed by changing the position of the box


Magic Cup

Recording Room

Stage

Source: http://www.aec.at/en/center/project.asp?iProjectID=12286

# Mixed Reality

- Mixed Reality in Game Design
  - Example: ***Gulliver's Box***
  - If two figures approach one another, they interact
  - The characters and recordings can be viewed on the stage using a HMD
  - The objects can be picked up, moved, set down, copied or erased using the magic cups – shaking changes the function

Source: http://www.aec.at/en/center/project.asp?iProjectID=12286

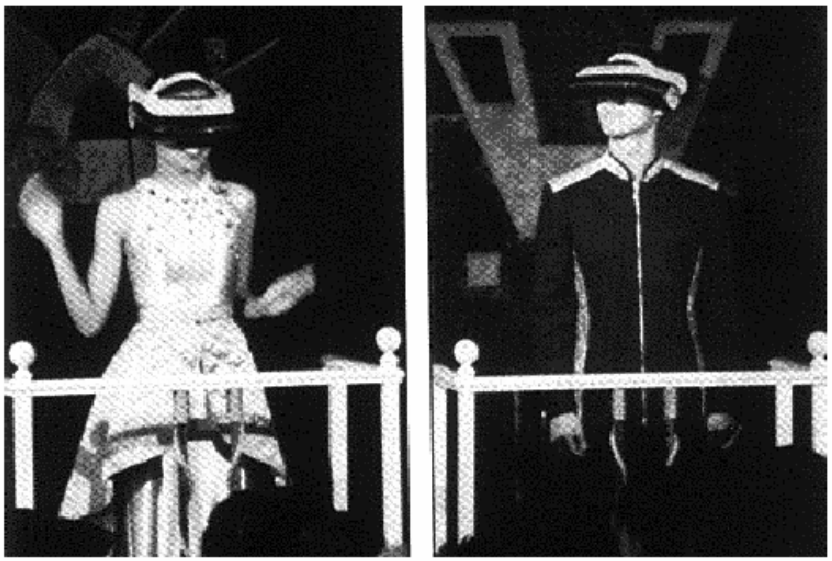
# Virtual Reality

- ***Virtual Reality*** – Should we replace our boring reality with a more exciting one?


Source: Schmalstieg (University of Vienna)

# Virtual Reality

- Virtual Reality tries for ***eliminating the reality***
- Goal
  - Create a perfect aural, visual, and other media sensation such that people forget the real environment and dive into another world

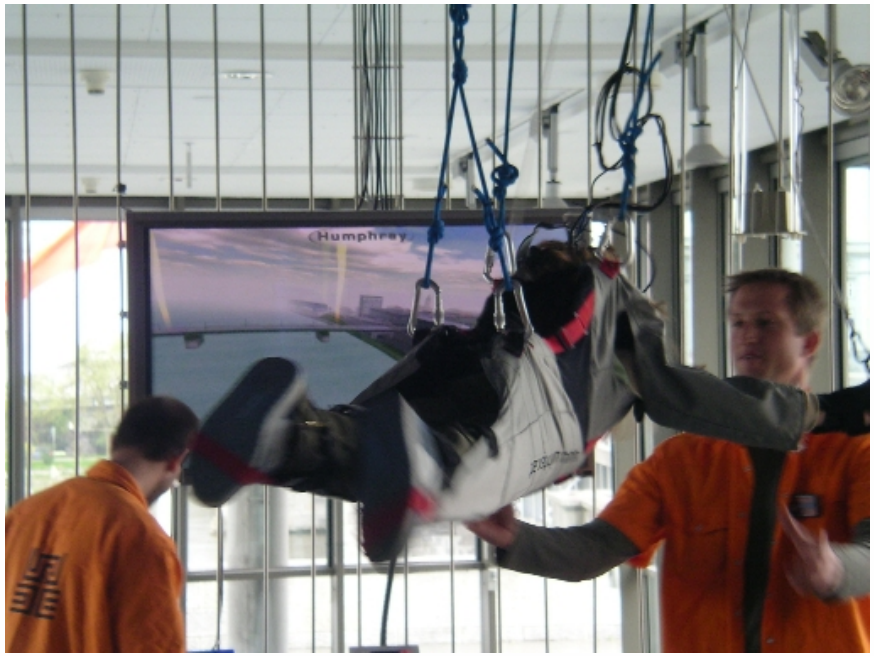


**Virtual Weddings**

**Virtual Bungee Jumping**

# Virtual Reality

- Why?
  - Participants can join at distant locations
  - Physical limitations can be avoided
  - Dangerous situations can be trained

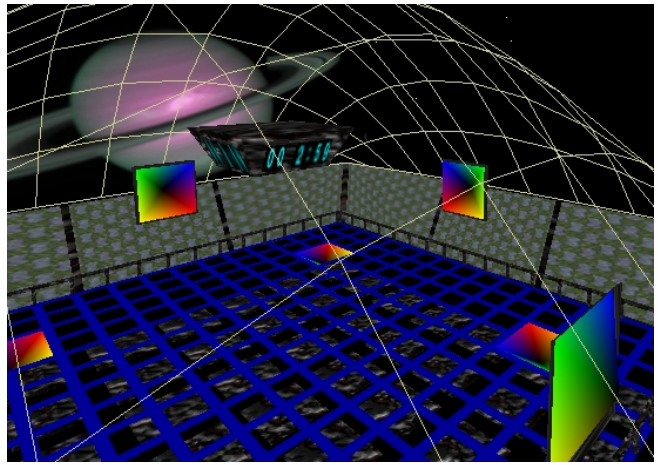


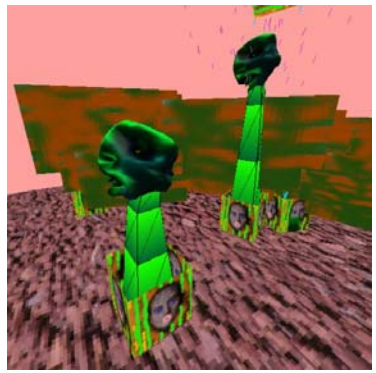

Humphrey Flight Simulator, Ars Electronica Center, Linz, Austria

Source: http://www.aec.at/en/center/project.asp?iProjectID=12280

# Virtual Reality

- Virtual Reality in Gaming
  - Example: Games in the CAVE
    - CAVE Quake III Arena
    - Gladiator
    - CAVE Doom
    - Battalion
    - Jacks

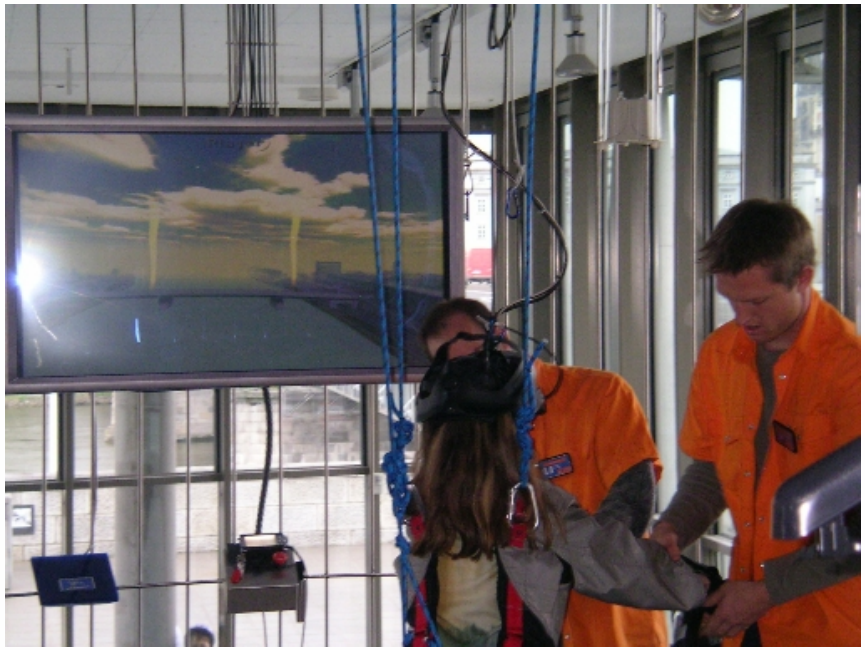




Source: http://www.ncsa.uiuc.edu/VR/cavernus/shared.html

# Virtual Reality

- Why not?
  - Expensive Equipment with complex setup
  - Usually many helping hand needed
  - Some people get sick



Humphrey Flight Simulator, Ars Electronica Center, Linz, Austria

The R&R Virtual Reality Chair

# Augmented Reality

- Useful Links
  - Columbia University
    - Computer Graphics and User Interfaces Labs
    - http://www1.cs.columbia.edu/graphics
  - The Georgia Institute of Technology
    - Augmented Environments Laboratory
    - http://www.cc.gatech.edu/projects/ael/
  - Sony
    - Augmented Reality and Computer Augmented Environmens Link Collection
    - http://www.csl.sony.co.jp/project/ar/ref.html
  - AR-PDA
    - German research project for AR on PDAs
    - http://www.ar-pda.com/
  - Christiane Ulbricht: Tangible Augmented Reality für Computerspiele
    - Diplomarbeit,
    - Technische Universität Wien, Institut für Softwaretechnik und interaktive Systeme
    - 2002