Einführung: Was ist AR? Anwendungsbeispiele

Vorlesung „Augmented Reality”

Prof. Dr. Andreas Butz

SS 2009

Organisatorisches

- Vorlesung: Mittwochs 8 Uhr c.t.,
  LMU Hauptgebäude, Raum M001
- Übungen (Fabian Hennecke, Sebastain Boring):
  Dienstag 16-18 Uhr (Raum A105, Amalienstr. 17),
  Freitag 10-12 Uhr (Raum A105, Amalienstr. 17)
  Beginn: Di, 28.4.

- Webseite: http://mimuc.de/ar
- Kontakt: butz@ifi.lmu.de, fabian.hennecke@ifi.lmu.de
- Credits: Folien teilweise von Dr. Martin Wagner

Überblick

- Von der Realität zur Virtualität
- Was ist Augmented Reality (AR)?
- Einordnung der Erweiterten Realität
- Funktionsweise eines generischen AR-Systems
- Vorlesungsinhalte
- Anwendungsbeispiele für AR

Von der Realität zur Virtualität

Realität

Erweiterte Realität (Augmented Reality – AR)

Erweiterte Virtualität (Augmented Virtuality)

Virtualität

(Virtual Reality – VR)

[Regenbrecht et al. 2003, Billinghurst 2002]

Milgrams Virtuality Continuum

- Milgram & Kishino: *A taxonomy of mixed reality visual displays*, IEICE Transactions on Information Systems, Vol E77-D, No.12 December 1994.
- Mixed Reality (MR) ist Oberbegriff über
  - Erweiterte Realität (Augmented Reality – AR)
  - Virtuelle Realität (Virtual Reality – VR)

Definition von AR nach Azuma

Drei Kriterien eines AR-Systems:

1. Kombination von realen und virtuellen Inhalten
2. Interaktiv in Echtzeit
3. Im 3D-Raum registriert

Kombination realer/virtueller Inhalte

- Kombination kann auch Dinge aus realer Welt entfernen („Diminished Reality“)
- Verschiedene Wahrnehmungskanäle
  - Visuell
  - Auditorisch
  - Haptisch
  - Olfaktorisch

Interaktiv in Echtzeit

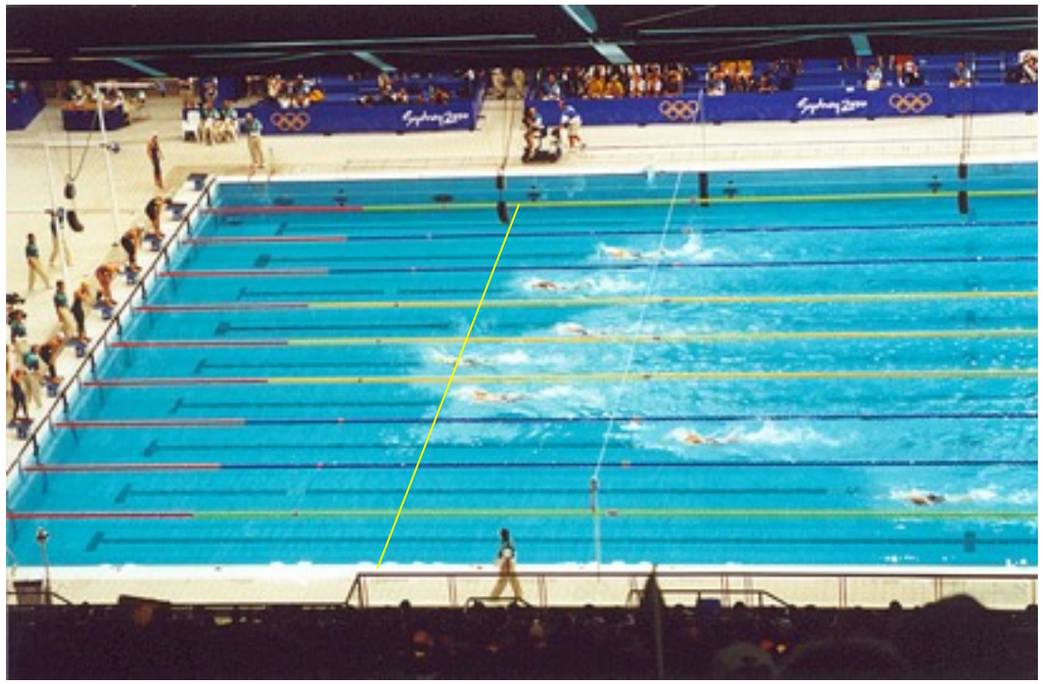
- „Herr der Ringe“ kombiniert reale und virtuelle Inhalte, ist aber nicht interaktiv
- Echtzeit macht AR schwierig:
  - Latenz i. A. < 100 ms
  - Bei visueller AR hohe Bildwiederholraten (> 30 fps) nötig

ARQuake [Piekarski, 2002]

Registrierung im 3D-Raum

Beleuchtung der virtuellen Szene reagiert auf die Position der „Sonne“

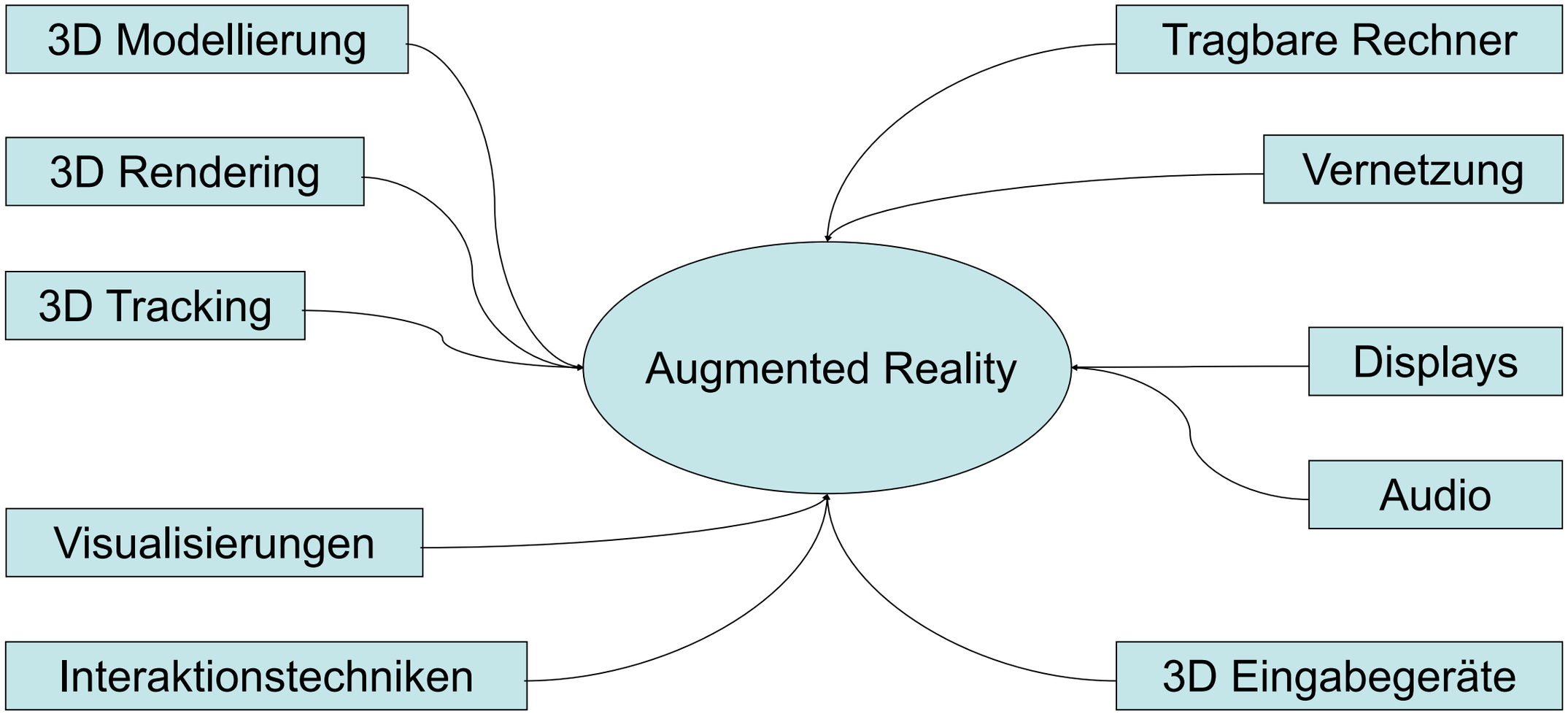
Kommerzielle AR Beispiele



AR innerhalb der Informatik

- AR ist ein Paradigma (siehe MMI1)
  - Andere Paradigmen (nicht immer klar getrennt):
    - Mobile computing
    - Wearable computing
    - Personal Computer
    - Virtual reality
    - ...
- Innerhalb der (vis.) AR verschiedene Ansätze:
  - Head Mounted Displays (HMDs)
  - Handheld AR
  - 2D Projektion in der phys. Umgebung
  - …

Was benötigt man für AR?



Ein Generisches AR-System

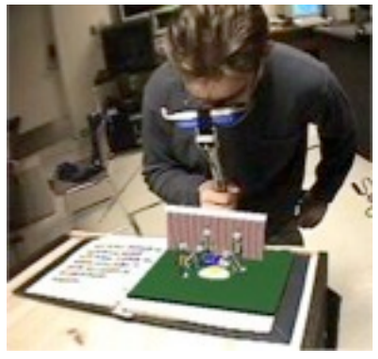
Sensorik

Realität

Tracking
(Ortsbestimmung)

Einbeziehung der Ortsinformation in virtuelle Welt

Virtualität



Rendering und
Realitätserweiterung

Kombination realer und virtueller Inhalte

Feedback an Benutzer

Vorlesungsinhalte

- Anwendungen der AR
- Tracking
- Displaytechnologien
- Programmierung von 3D Szenen
- Interaktionstechniken für AR
- Nichtvisuelle AR
- Softwaresysteme für AR
- Authoring von AR-Anwendungen
- Ausblick: Ubiquitous Computing

Anwendungen der AR

- Industrie
  - –Konstruktion, Reparatur
- Medizin
  - –Operationsunterstützung
- Transport
  - –KFZ, Flugzeuge
- Unterhaltung, Bildung
  - –Museen
  - –Fernsehen

Tracking (Ortsbestimmung)

- Grundlagen der 3D Geometrie
- Vorstellung verschiedener Trackingverfahren
- Sensorfusion
- Kamerabasiertes Tracking:
  - –Kameramodelle
  - –3D-Rekonstruktion aus 2D Daten

Displaytechnologien

- Head Mounted Displays (HMDs)
  - –See-through vs. Video-based
- Handheld displays
- Stationäre displays
- 2D Projektion in der phys. Umgebung
- 3D-Displays

Programmierung von 3D Szenen

- Szenengraphen
- Beschreibungsformate
- Modellierung realer Objekte zur korrekten Verdeckungsdarstellung
- Performanceaspekte

Interaktionstechniken für AR

- Techniken aus der VR
  - –3D-Eingabegeräte
  - –Selektion
  - –Manipulation
  - –Navigation
- Techniken aus der PC-Welt
  - –Menüs, Annotationen
- Techniken aus der phys. Umwelt
  - –Spezialisierte Werkzeuge
  - –Tangible UIs

Nichtvisuelle AR

- Räumliches Audio
  - Kopfhörer
  - Lautsprecher
- Haptik
- Force Feedback
- Gravitationssimulation
- Geruch

Softwaresysteme für AR

- Kurze Einführung in das Software Engineering
- Systemaspekte für AR
  - –Verteilung
  - –Echtzeitfähigkeit
  - –Designalternativen
- Überblick über existierende AR-Systeme

Authoring von AR-Anwendungen

- Problembereiche des Authoring
- Vorstellung von Authoringsystemen
  - –SILK
  - –Alice
  - –DART
  - –AMIRE
  - –Authoring of Tangible AR Applications

Ausblick: Ubiquitous Computing

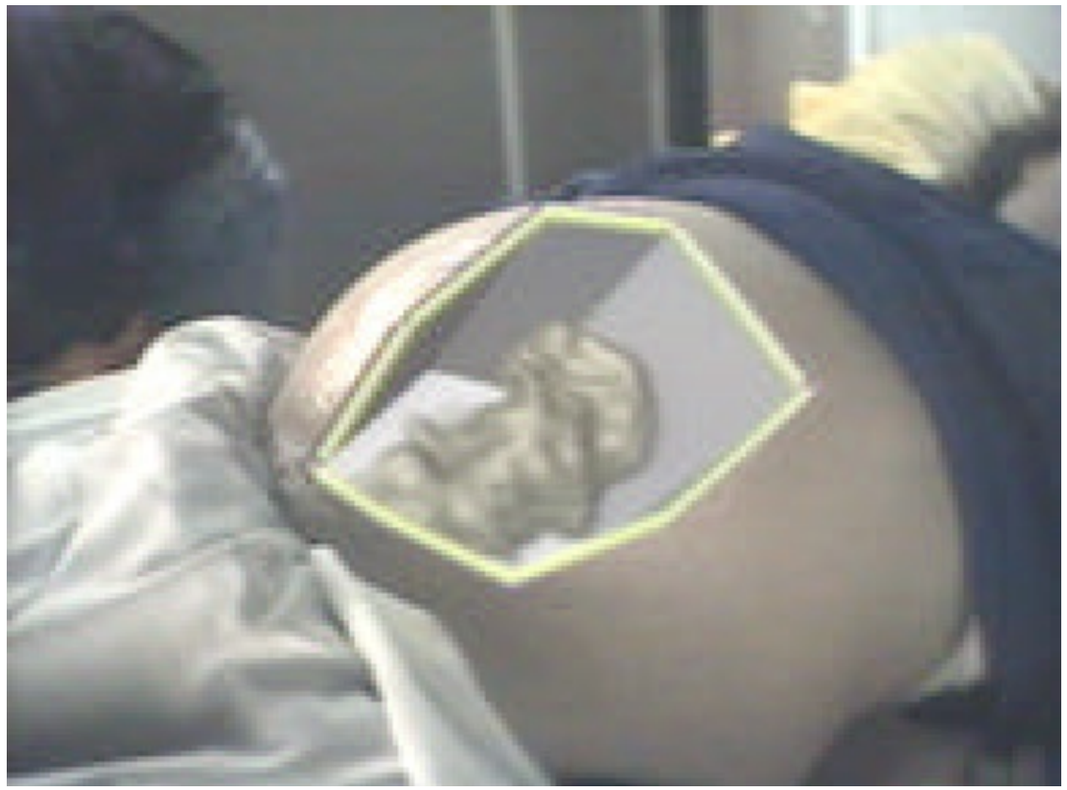
- Kernideen UbiComp
- AR zur Simulation von UbiComp
- AR als echter Teil von Ubicomp

Anwendungsbeispiele für AR

Anwendungen der AR

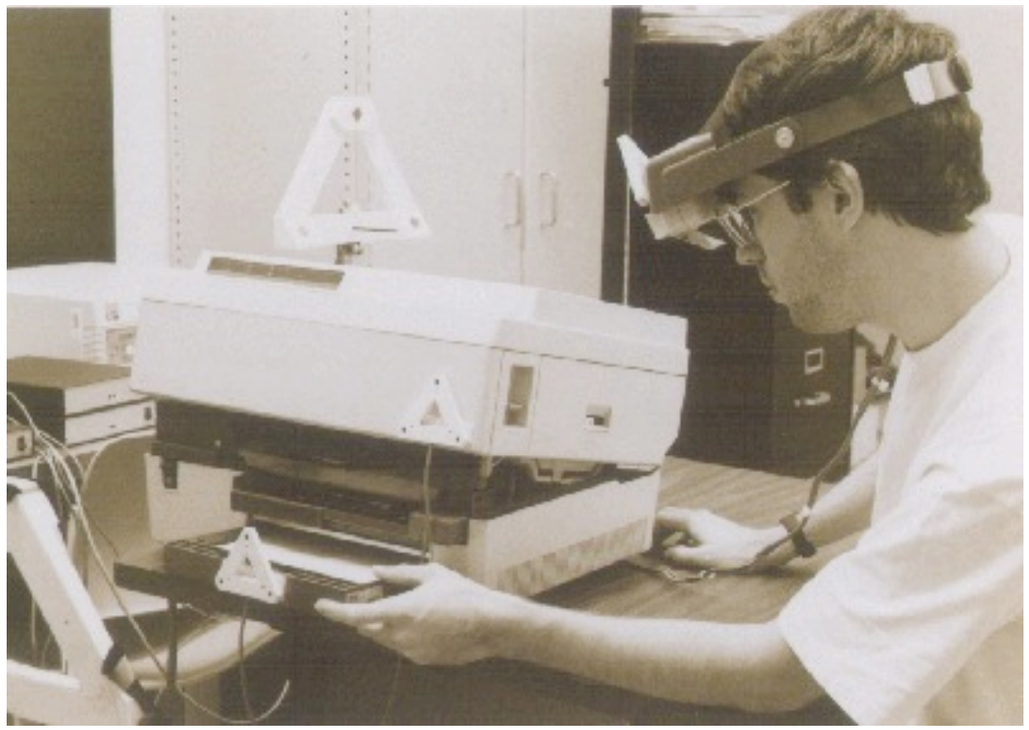
- Industrie
  - –Konstruktion, Reparatur
- Medizin
  - –Diagnose, Operationsunterstützung
- Transport
  - –KFZ, Flugzeuge
- Unterhaltung, Bildung
  - –Museen
  - –Fernsehen

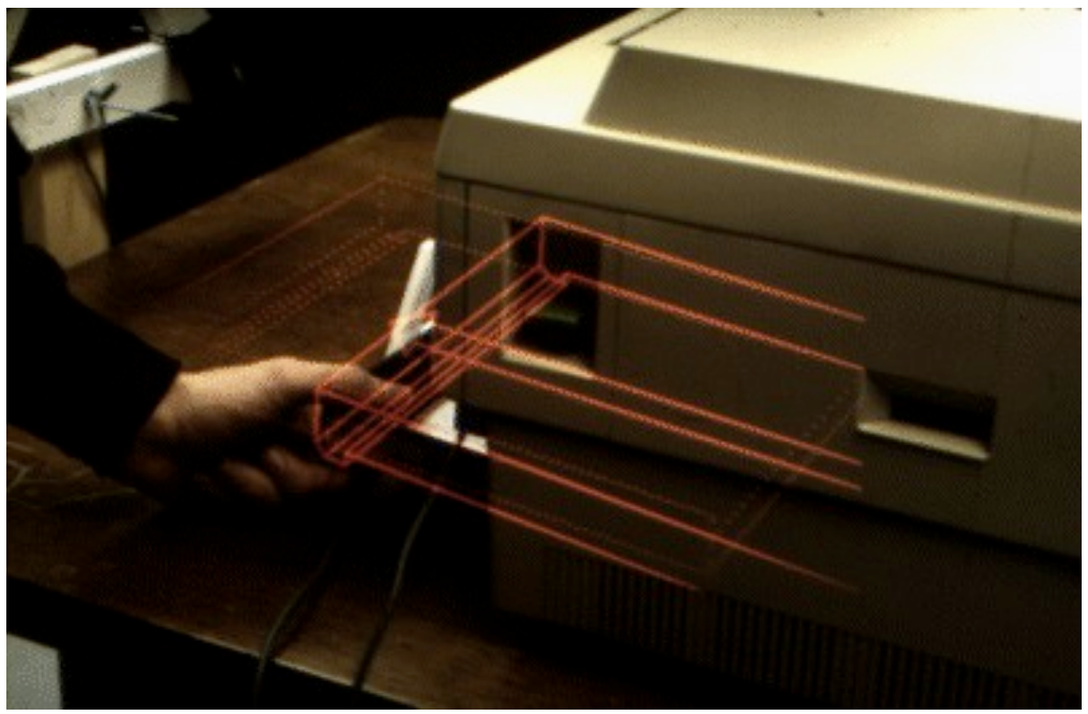
Medizin: UNC Chapel Hill, 1992



- Ultraschall-scan vom Bauch einer Schwangeren
- 3D-Rekonstruktion
- Überlagerung des Bildes mittels HMD
- → 3D-Stethoskop

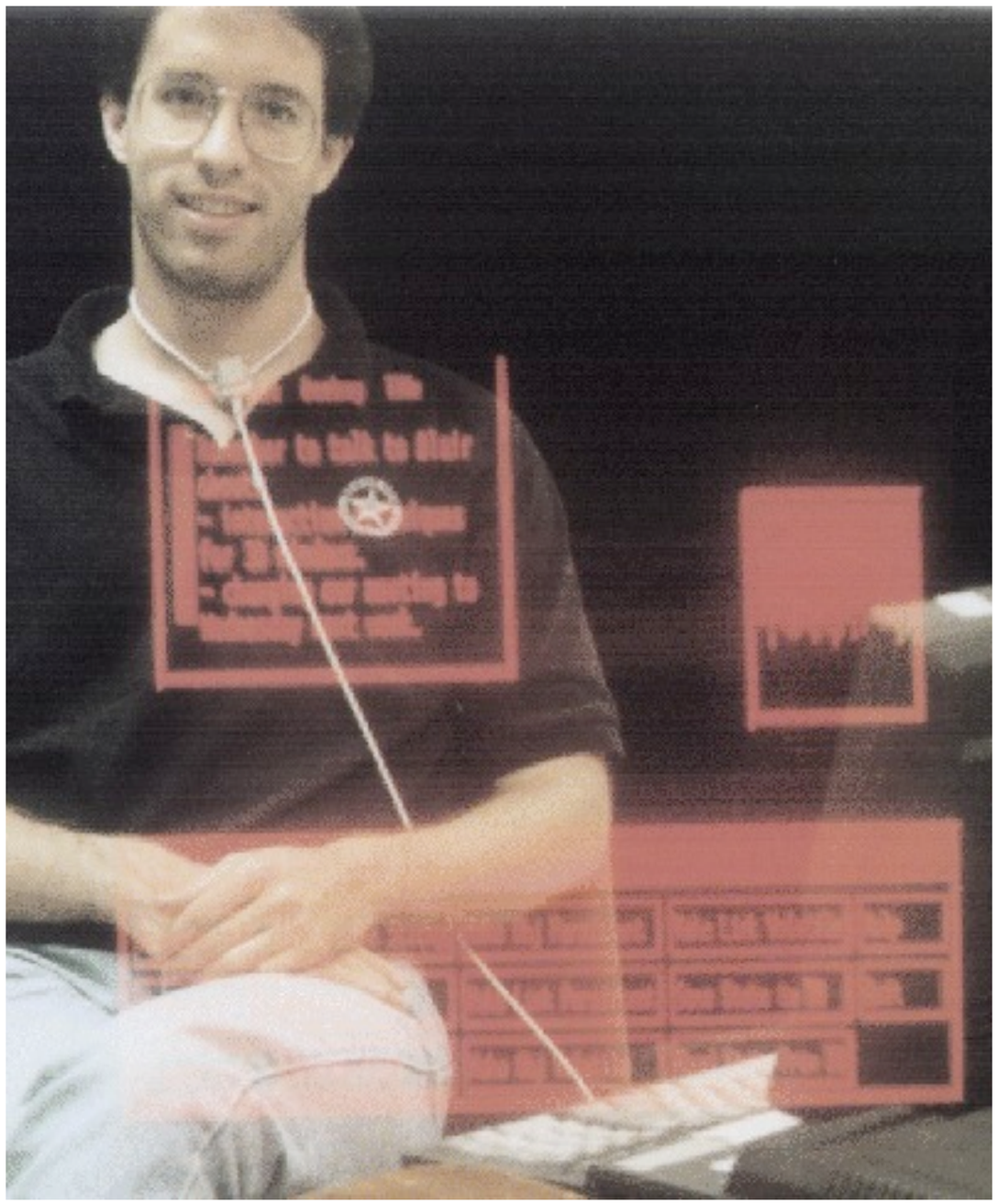
KARMA: Columbia University, 1993





- Use AR for technical maintenance
- Have a 3D model of a laser printer
- Instruct via HMD:
  - How to open it
  - What part to change
  - How to remove it
- Ultrasonic tracking
- Reflection Technologies „P4 Private Eye“ HMD
  - Monochrome LED
  - One eye only

Windows on the World: Columbia 1993

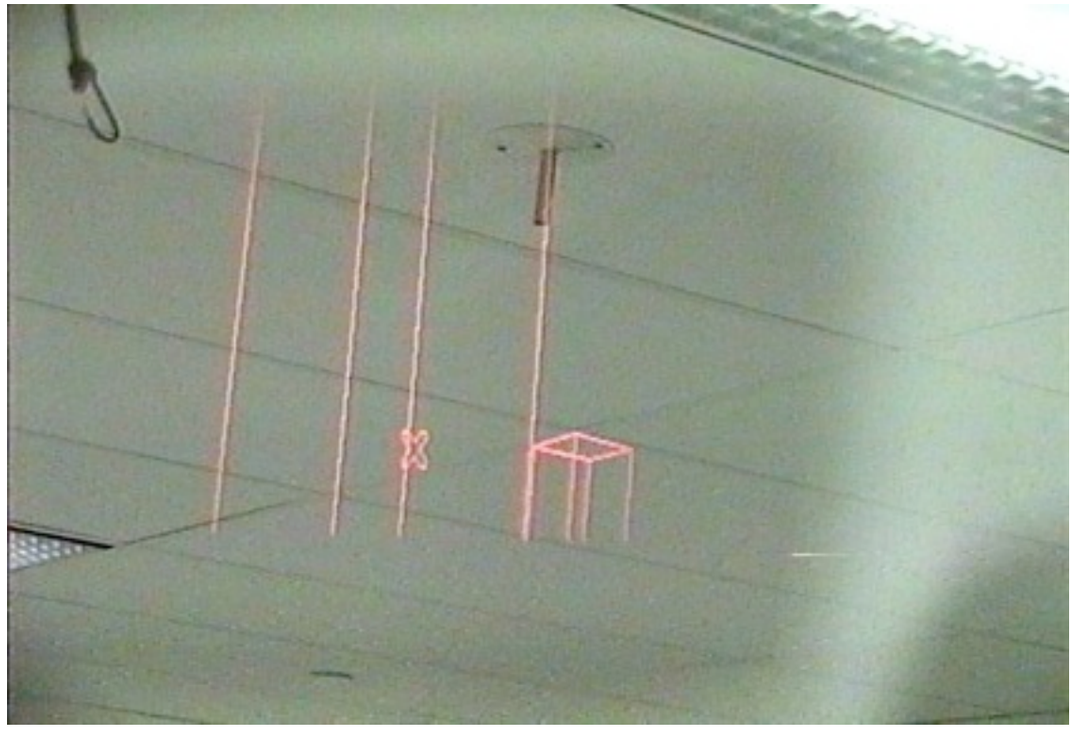


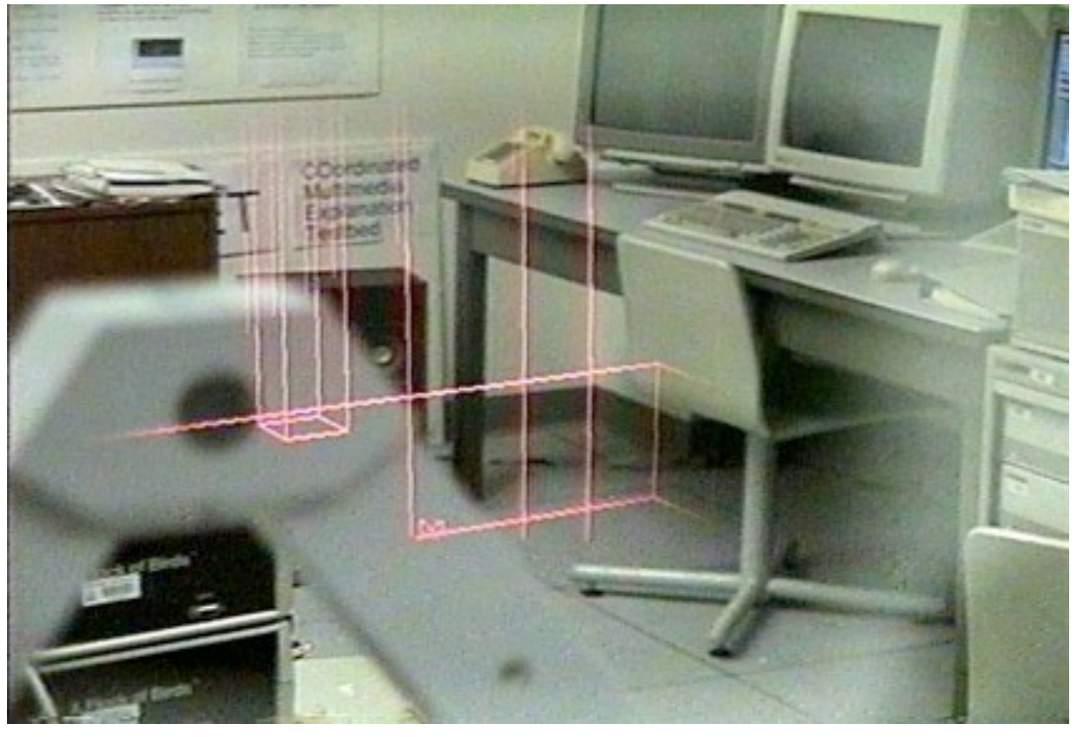
- Use HMD as an extension of regular screens
- Drag windows off the screen
- Arrange windows in the world
- Maked display screen substantially bigger

Construction: Boeing, 1994

- Assembly of wire harness for airplanes
- Assembled on a large board
- Traditionally tedious task
- Equip board with markers
- Show in HMD where to mount next wire

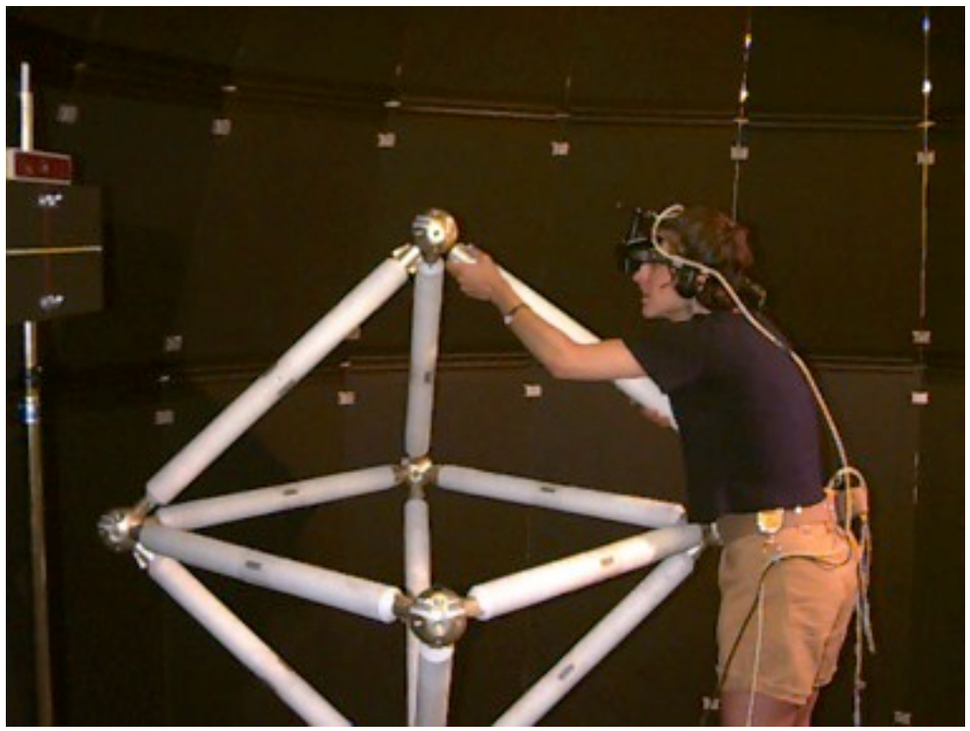
Architectural Anatomy: Columbia, 1994





- Reveal hidden structures in a building
- Get information about these structures

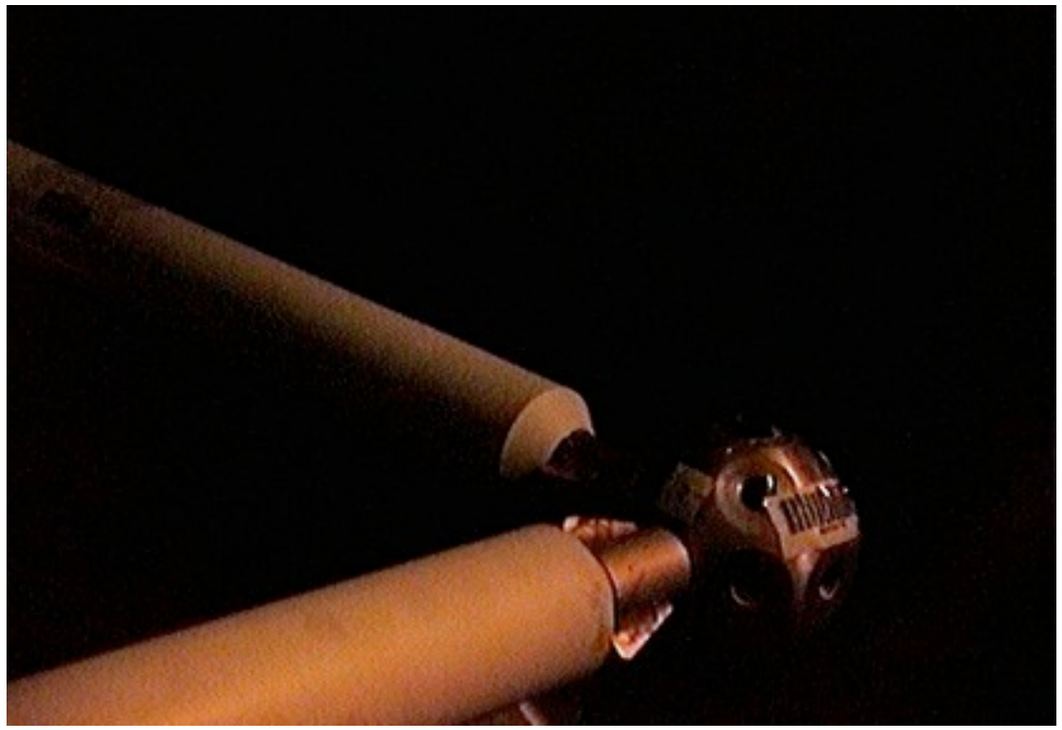
AR for Construction, Columbia, 1996

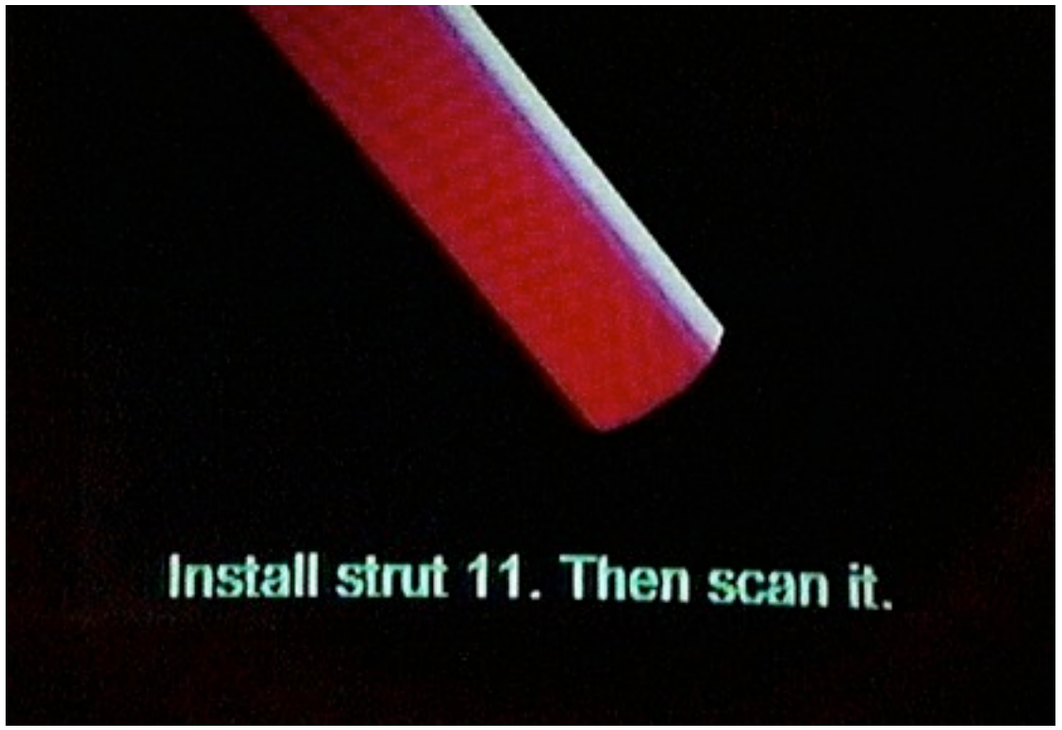


- Assembly of a „Space-Frame“ construction from single parts
- Given sequence of steps
- Use a barcode scanner to identify mounted parts

- Check if correct part has been mounted
- AR system shows the next part‘s position

AR for Construction, Columbia, 1996



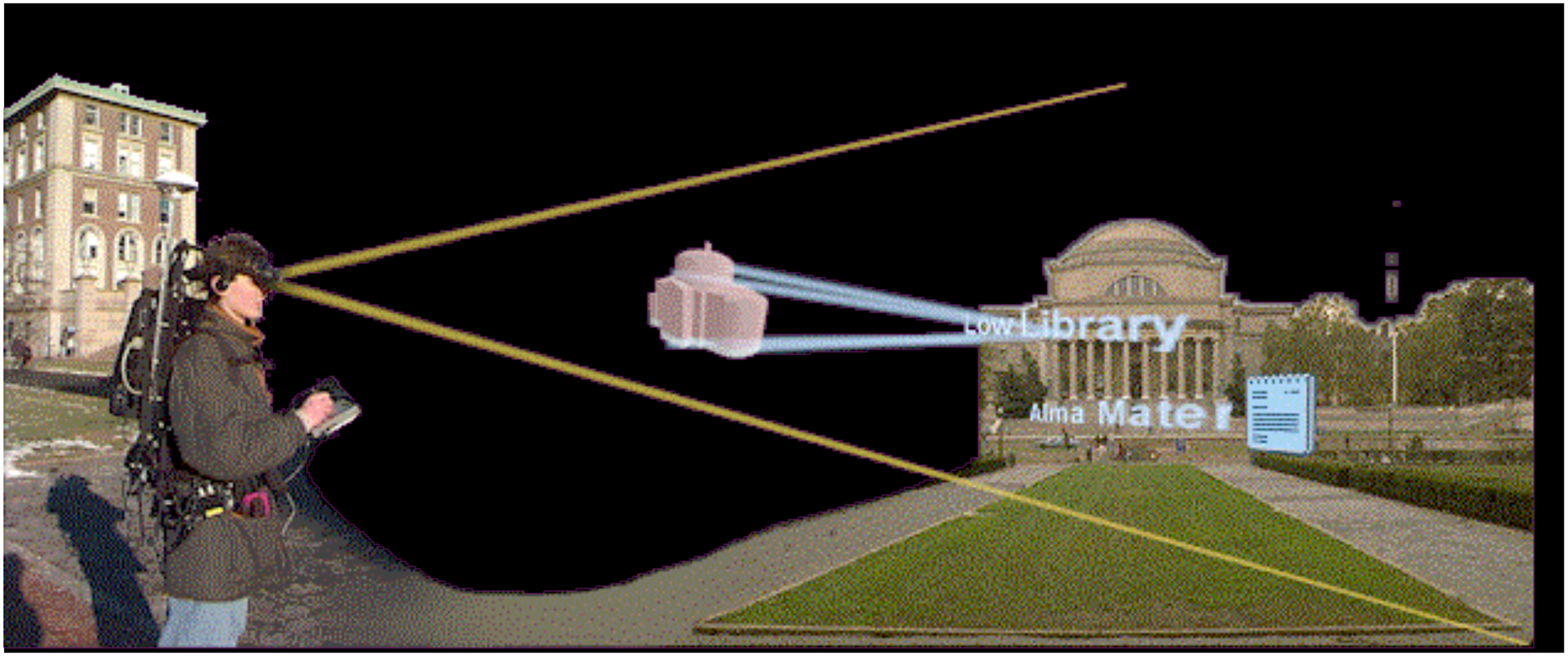


EMMIE: Columbia, 1998

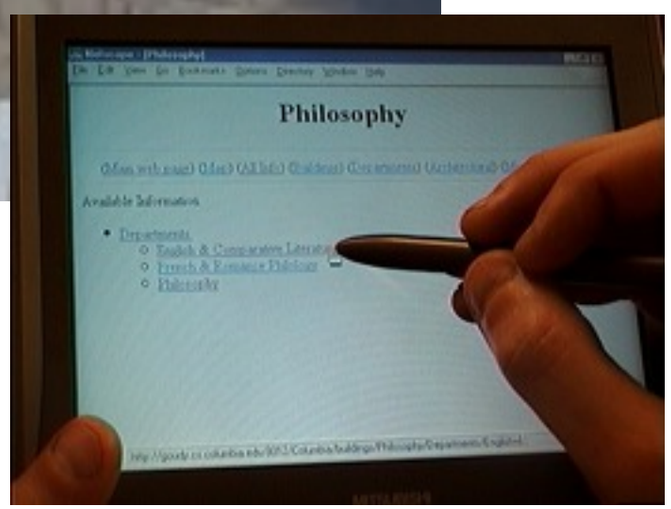
- Support a meeting
  - Several participants
  - Shared 3D world
  - With or w/o HMD
- 3D icons representing units of data
- 1:1 translation of desktop metaphor
- „Environment manager“ in analogy to window manager

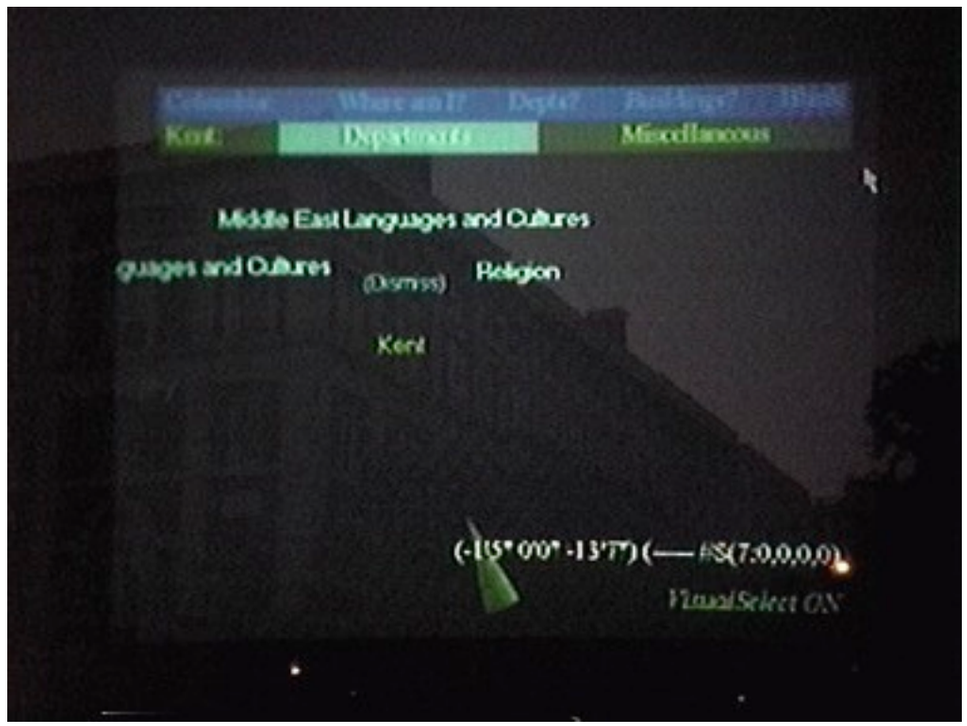
Mobile AR Systems: Columbia, 1997-now

- Augmented Reality system in a backpack
- Tracking by DGPS (centimeter level)
- Interaction via handheld devices
- Various applications

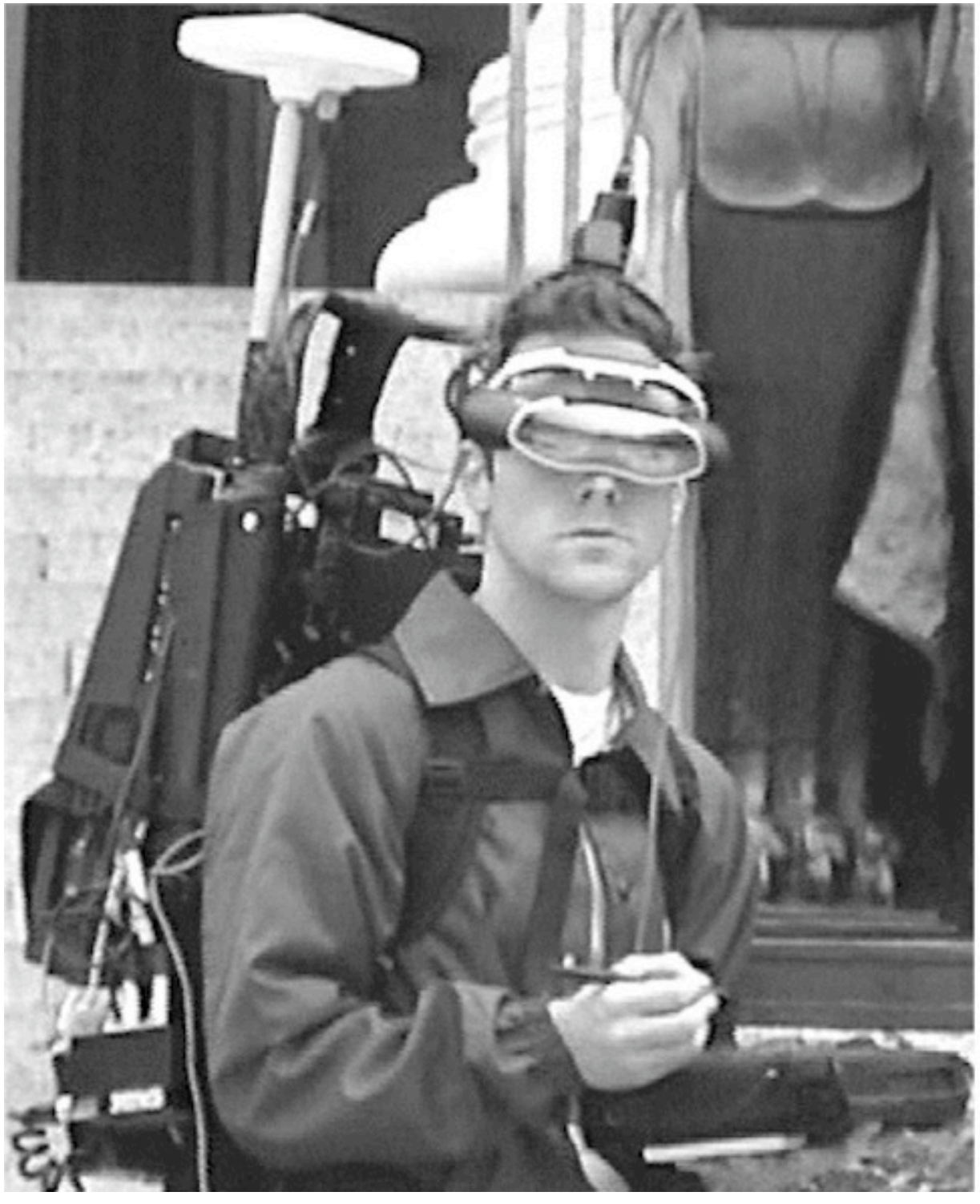


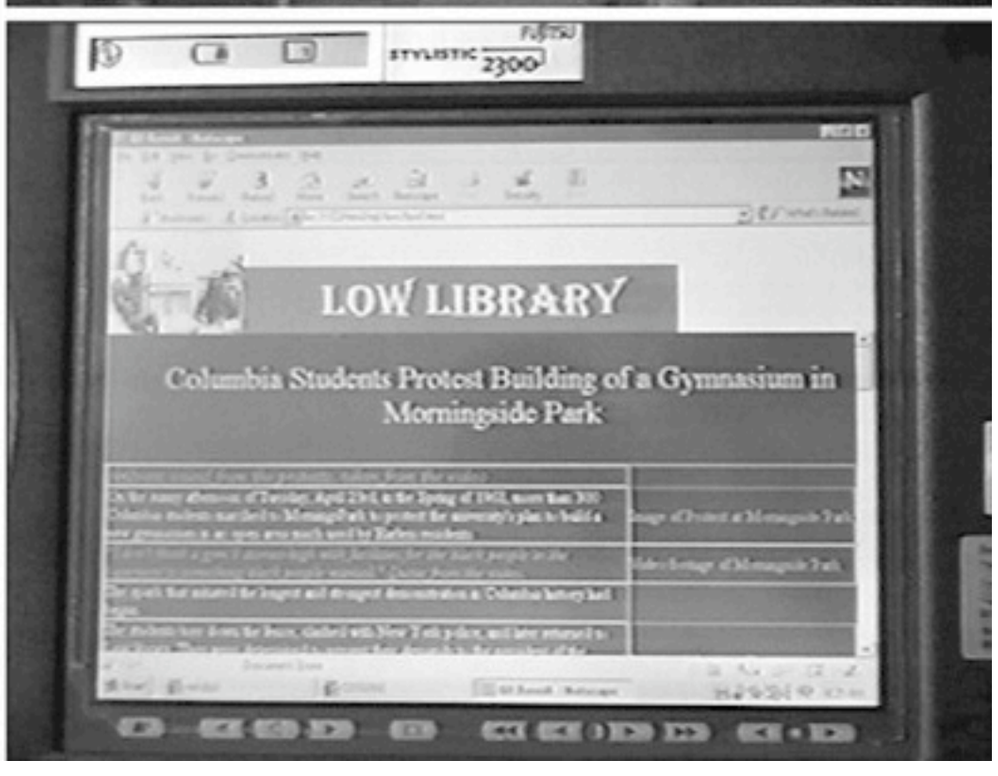
MARS: A Touring Machine, 1997





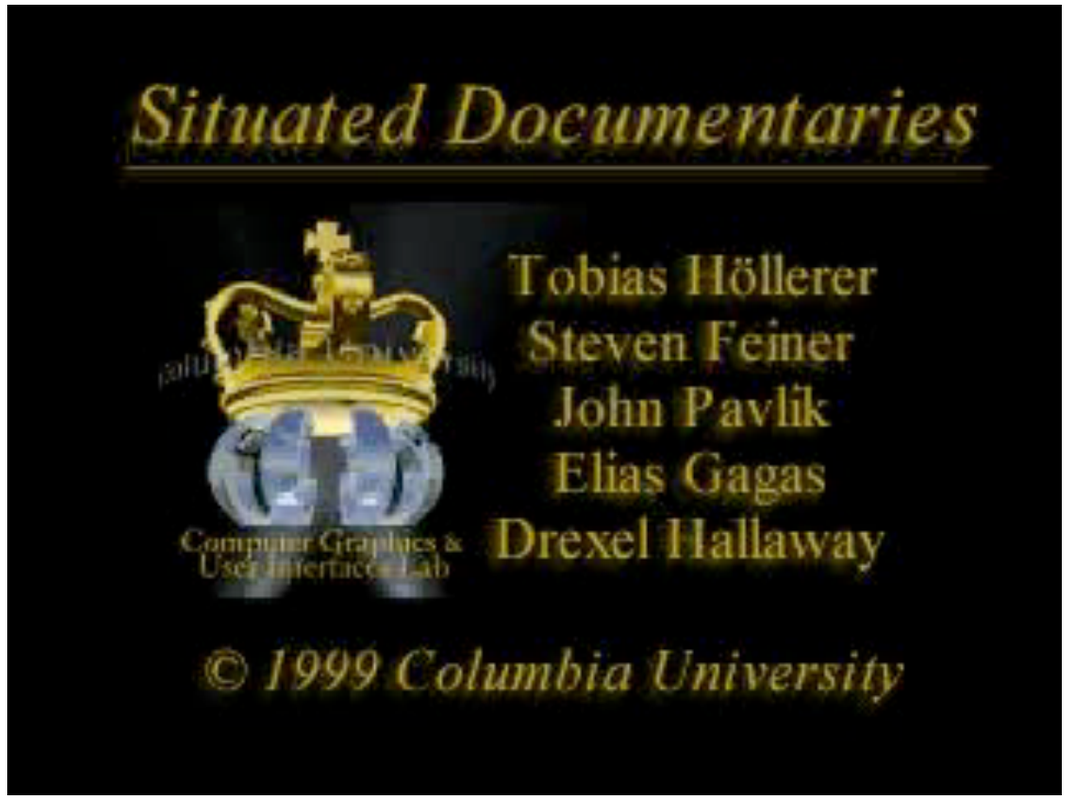
MARS: Situated documentaries, 1999





MARS: Situated documentaries, 1999

- Content produced in cooperation with journalists
- Stories „located“ on university campus
- Visible only through AR: flags
- Content playback in HMD
- Content playback o handheld
- Interaction in HMD and on Handheld

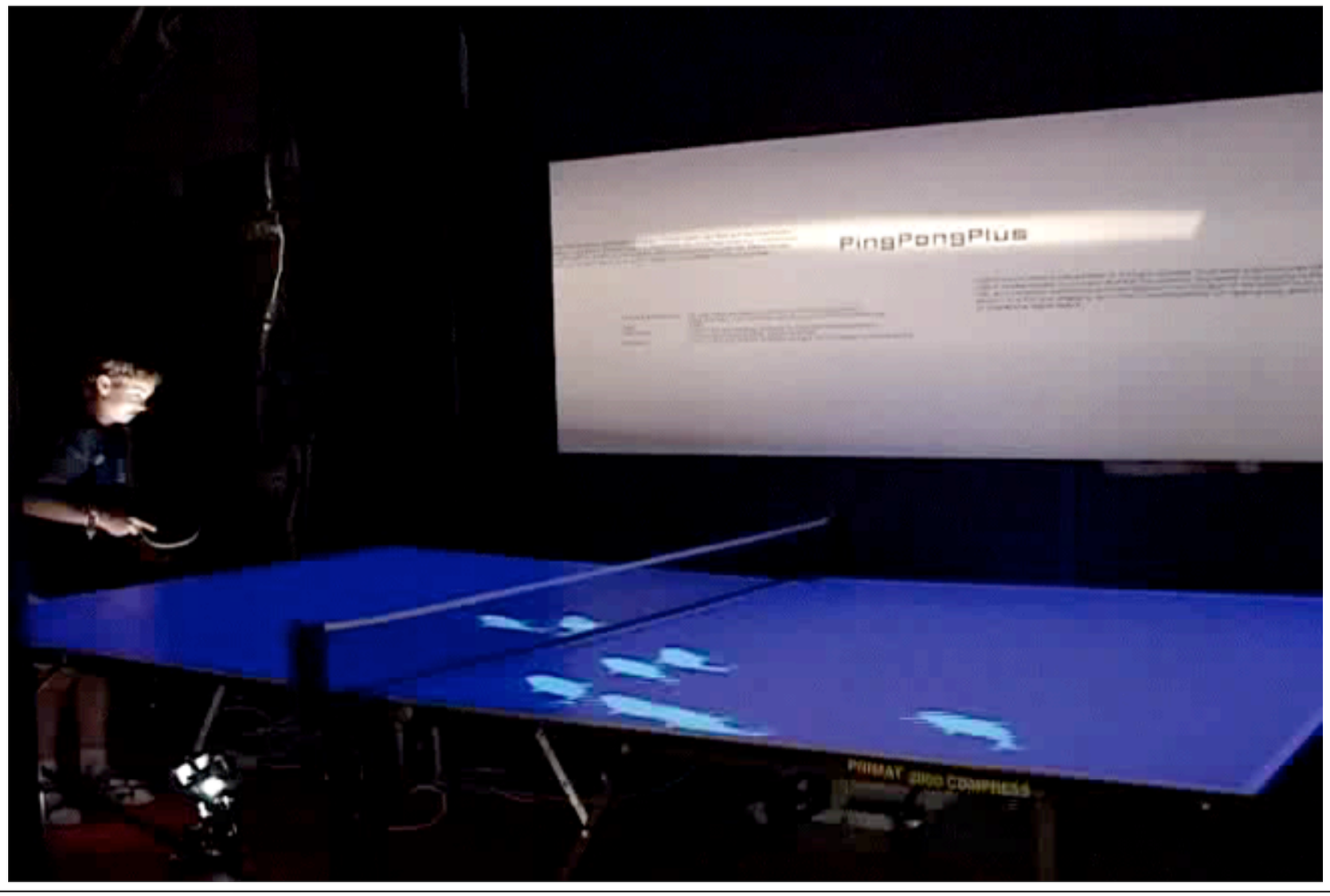


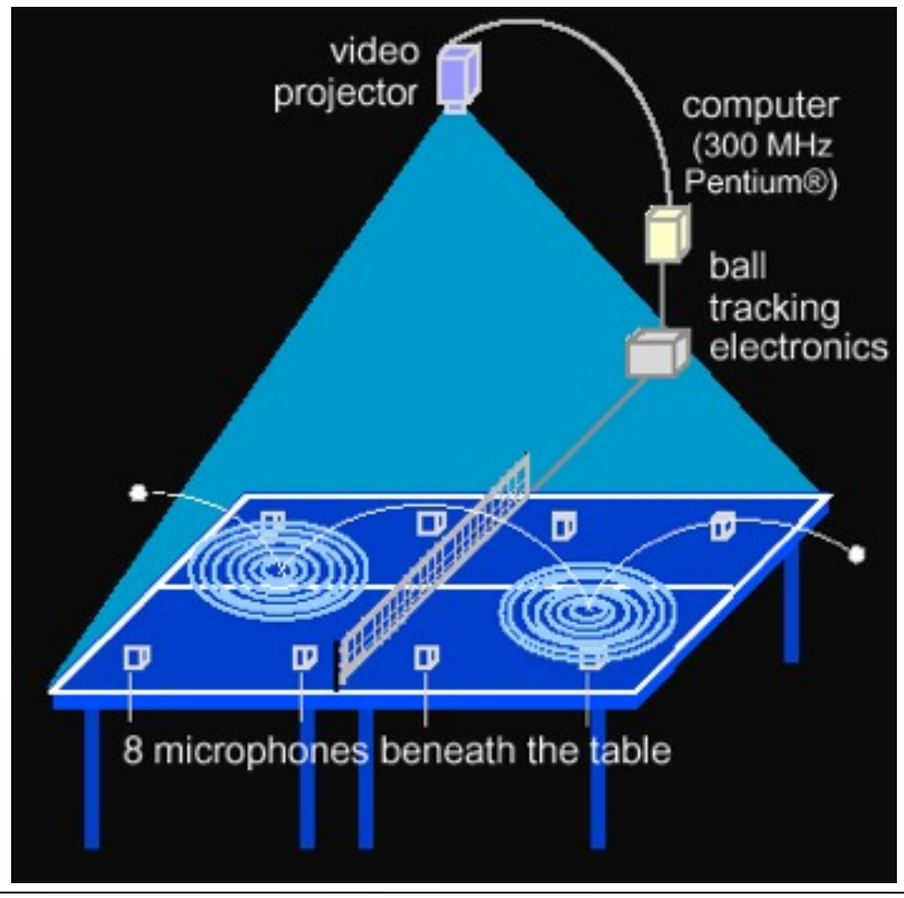
Archeology Visualization, Columbia 2003

- Record dig site surroundings as QTVR panorama
- Record detailed 3D model of
  - The actual dig site
  - The objects found
- Later: review what was found where
- Virtual visit of the dig site possible

PingPongPlus
(Ishii et al. SIGGRAPH 98)

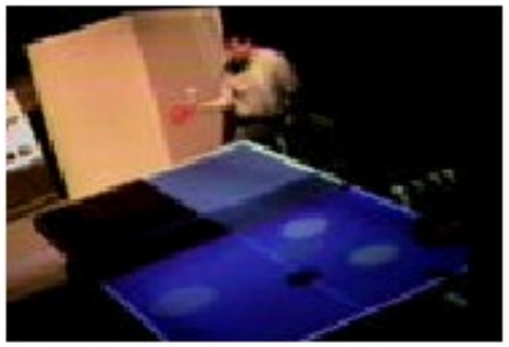
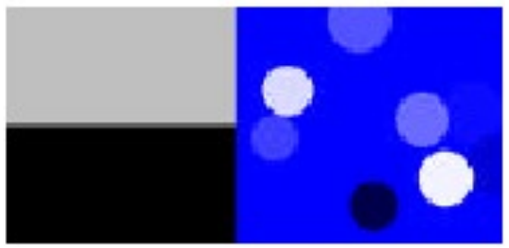
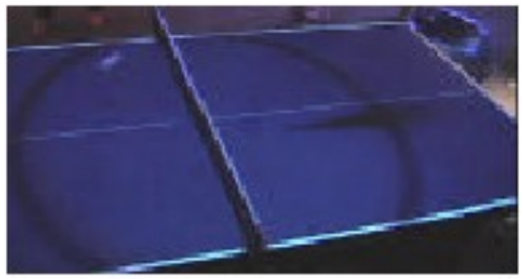
- Physical PingPong, Virtually augmented
- Additional game functionality

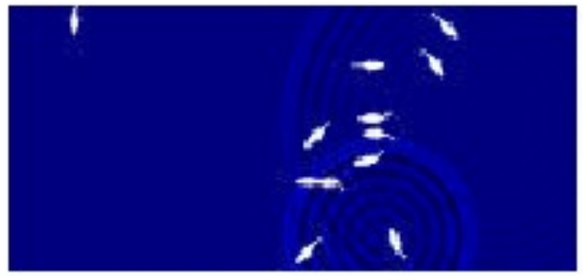
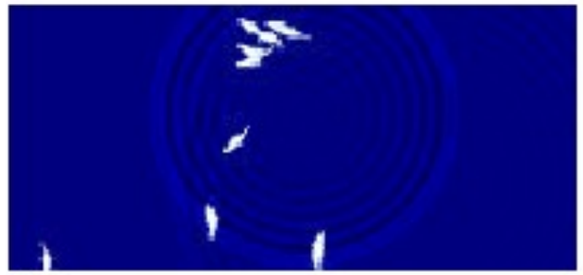
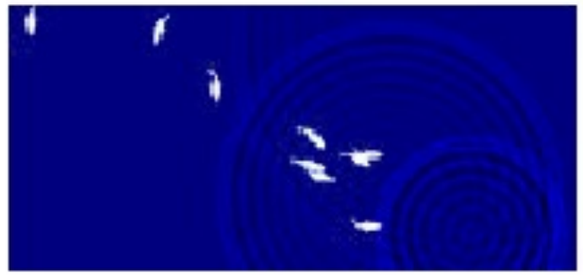


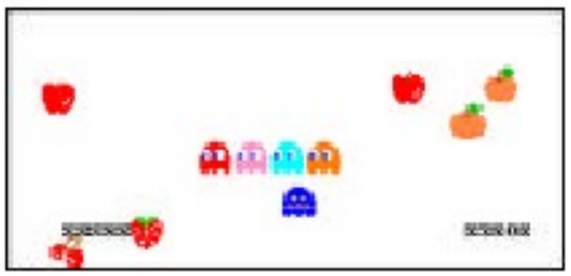


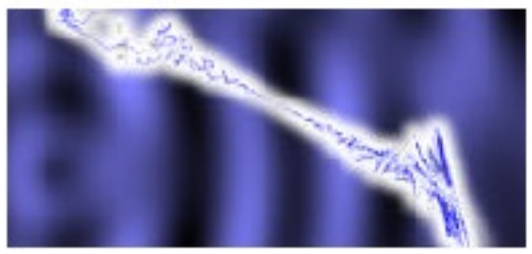
PingPongPlus variations



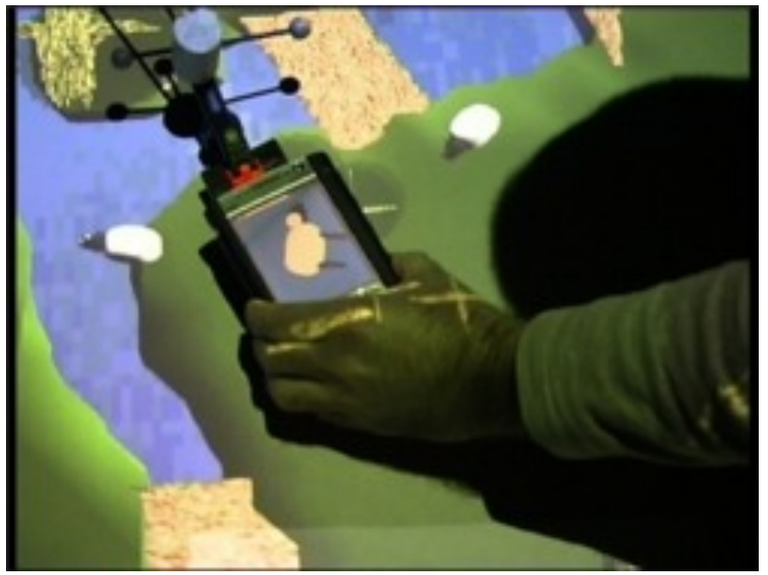






SHEEP: TUM AR Group, 2002

- „Pointless“ shepherding game
- Demonstrates possibilities of highly distributed AR applications:
  - Multimodal input
  - Multi user interaction
  - Multiple output devices
    - Projection table
    - See-through laptop
    - HMD
  - Interaction with PDA

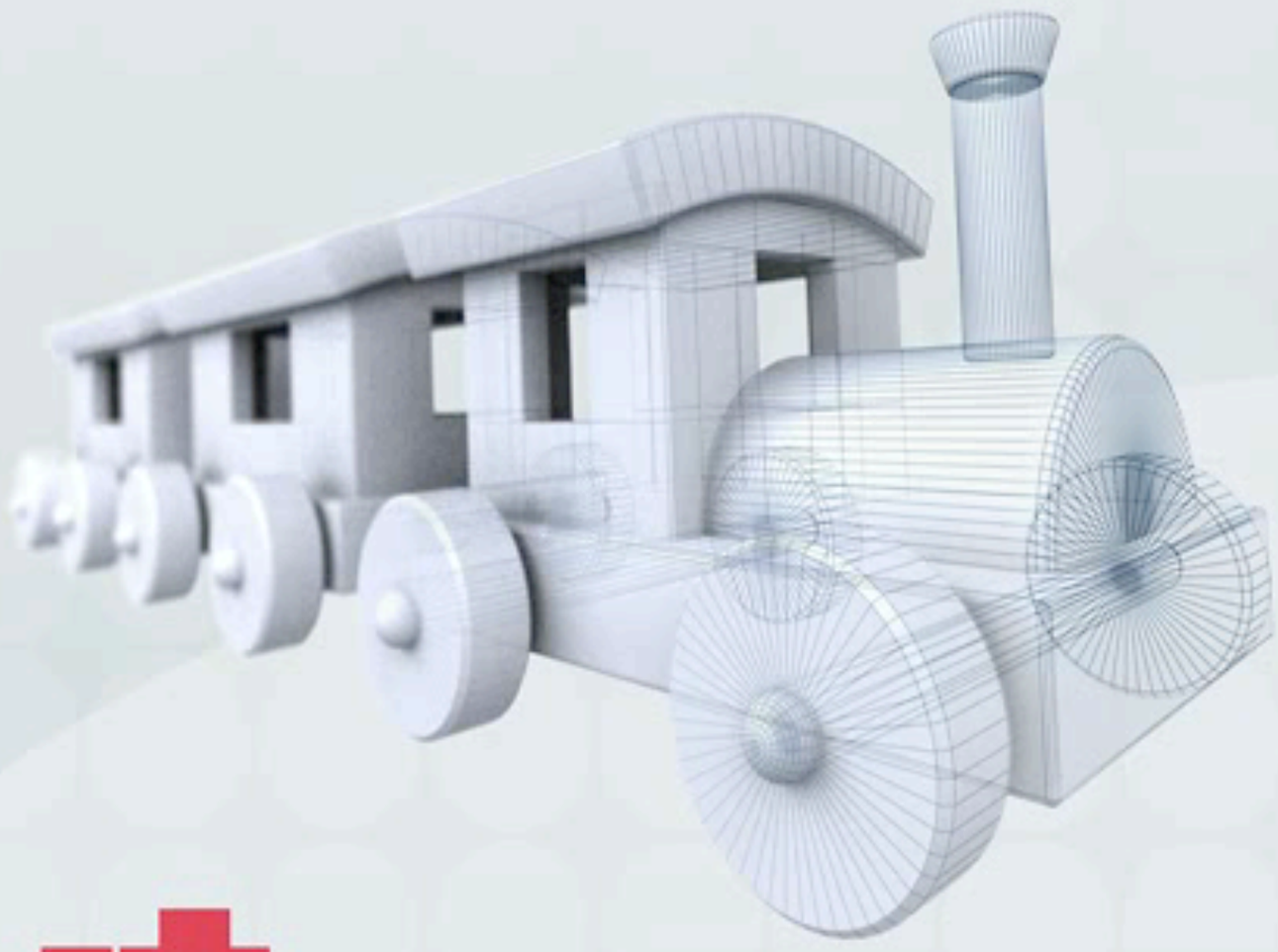


Invisible Train: Schmalstieg, 2004

- 2 players with handhelds with cameras
- Empty wooden toy train tracks with markers
- Trains only visible on the handheld
- Players can set the shunting switches
- Goal: avoid collisions as long as possible

the invisible train

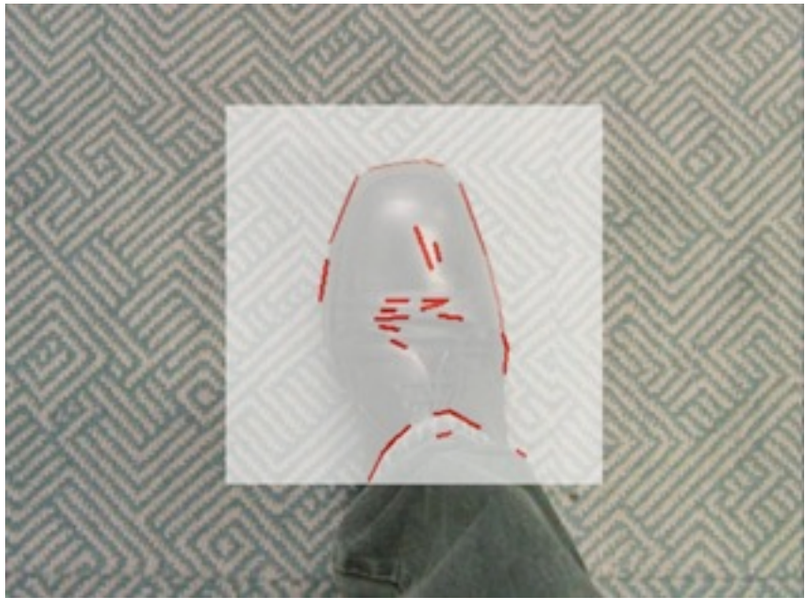
a collaborative handheld augmented reality game

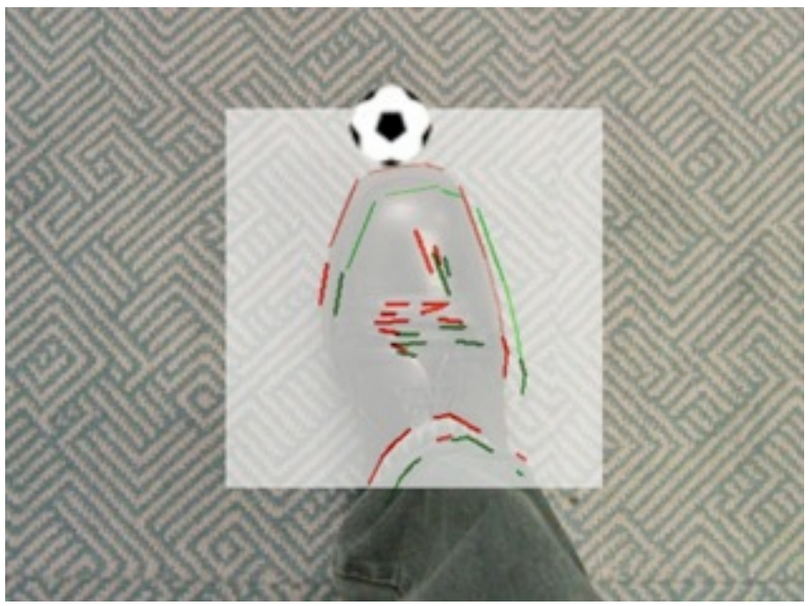


daniel wagner
thomas pintaric
dieter schmalstieg

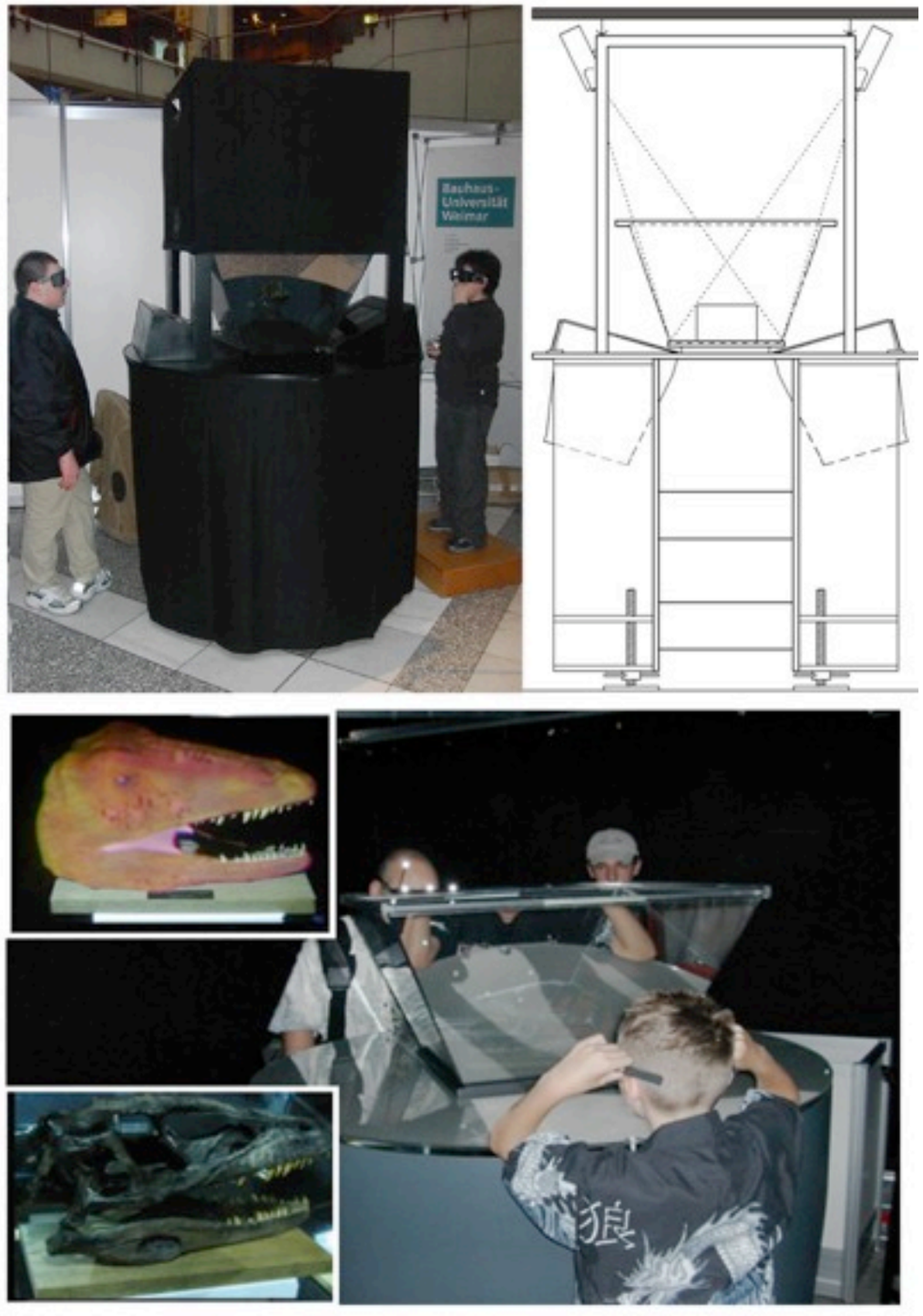
TUG Graz University of Technology
Erzherzog-Johann-University

AR-Soccer, Uni Paderborn, 2004



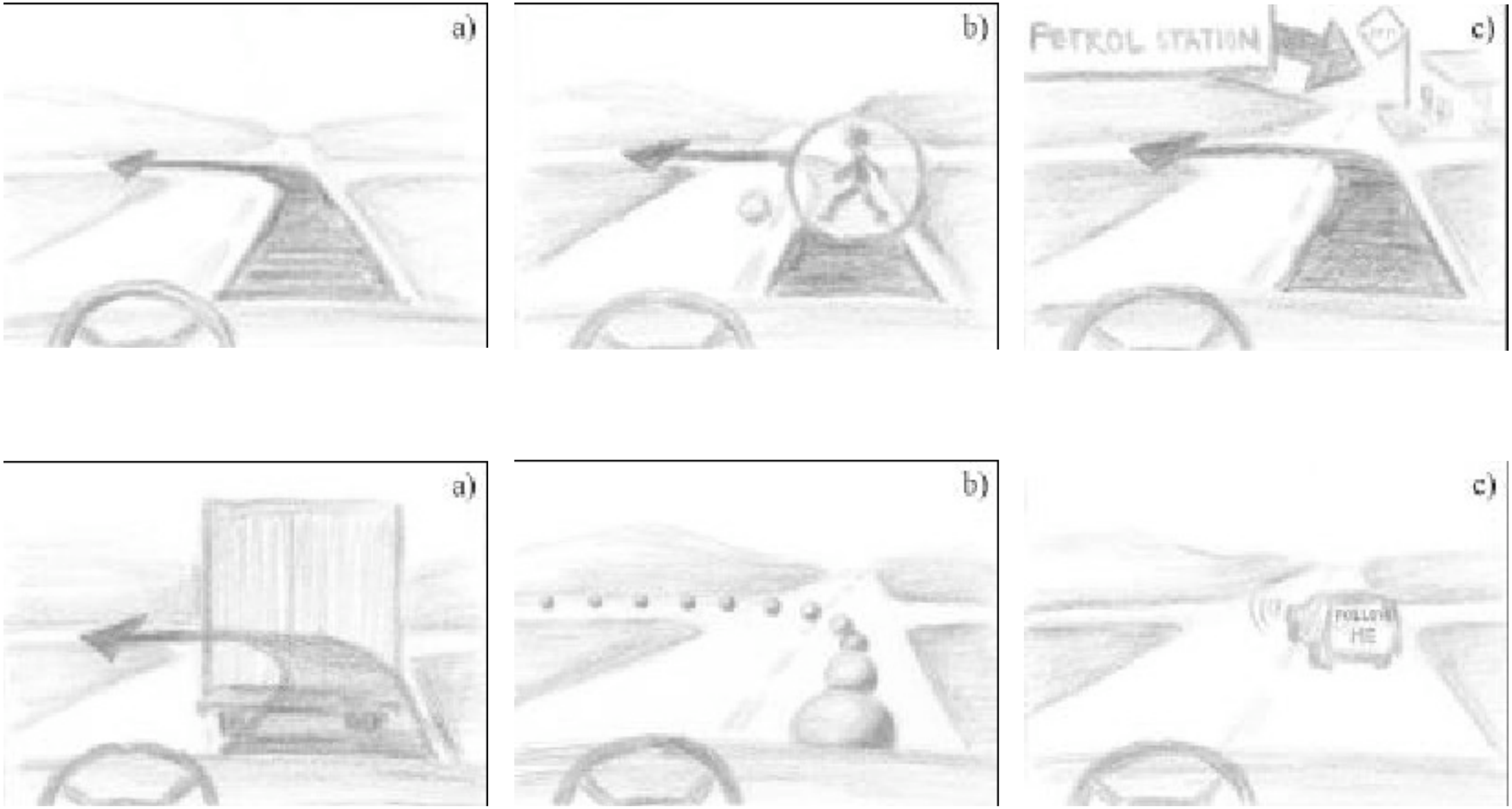


AR in Museums: Oliver Bimber, 2003-now



- Augmenting physical exhibits by
  - Additional information
  - 3D animation
- Camera-based tracking with markers
- Video-see-through
  - Laptops
  - Mobile phones

AR in car navigation, Siemens VDO 2004



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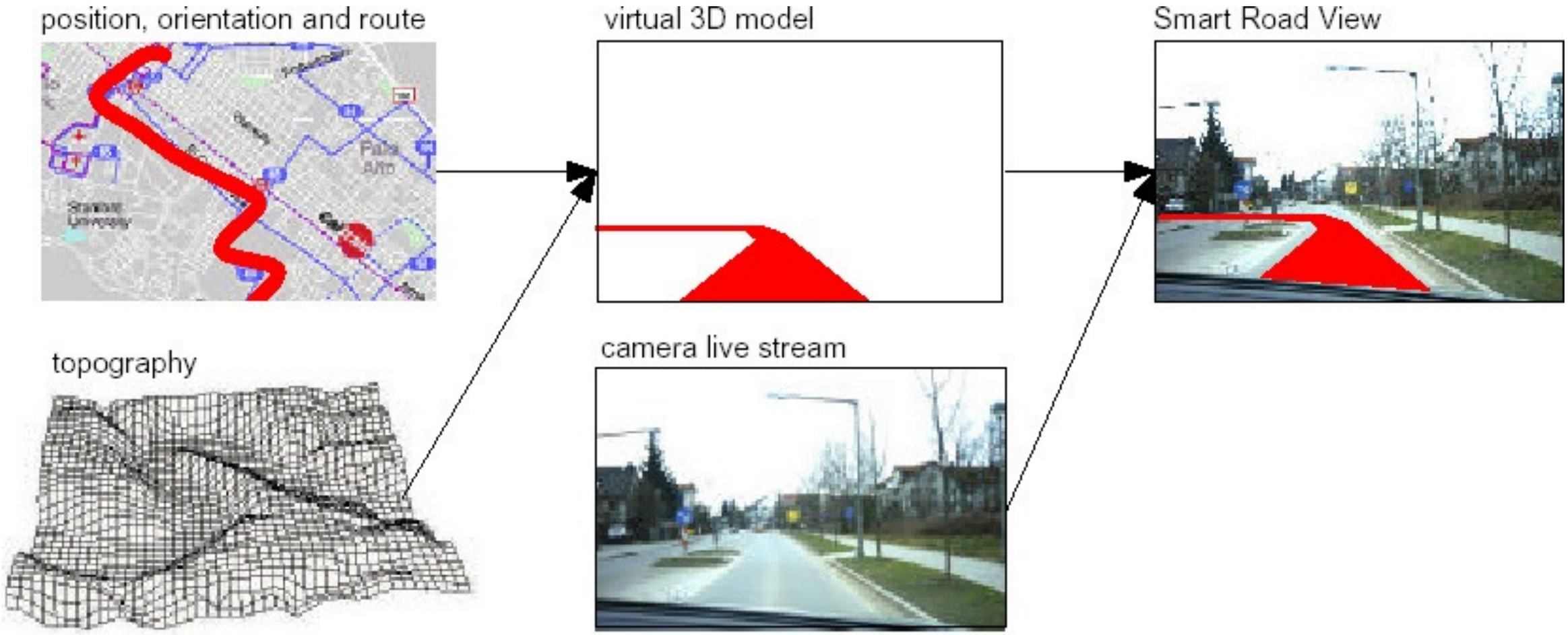
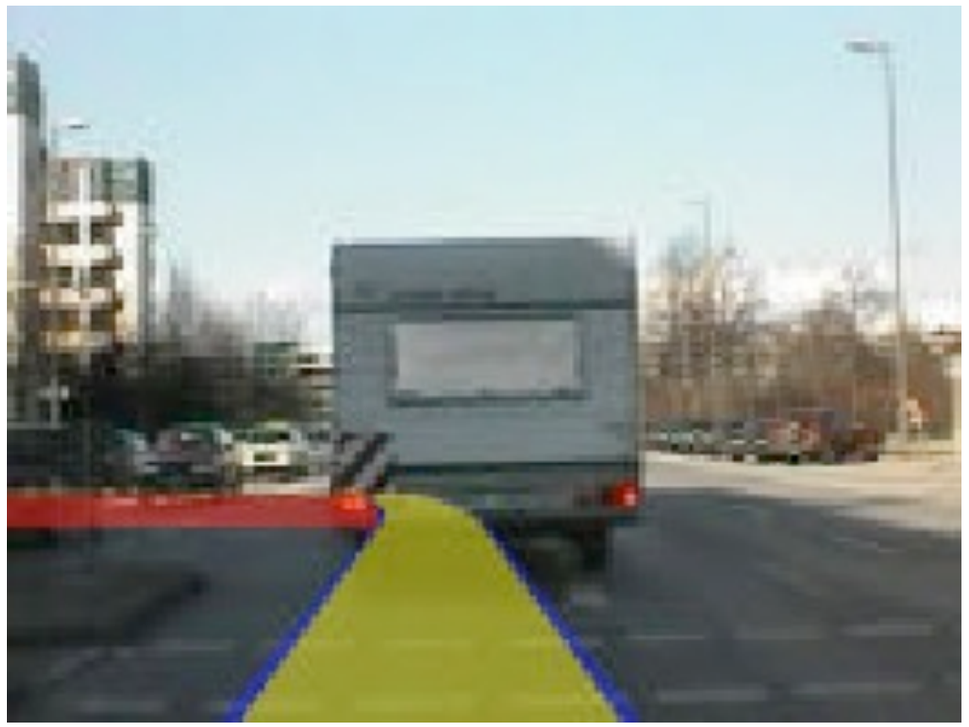
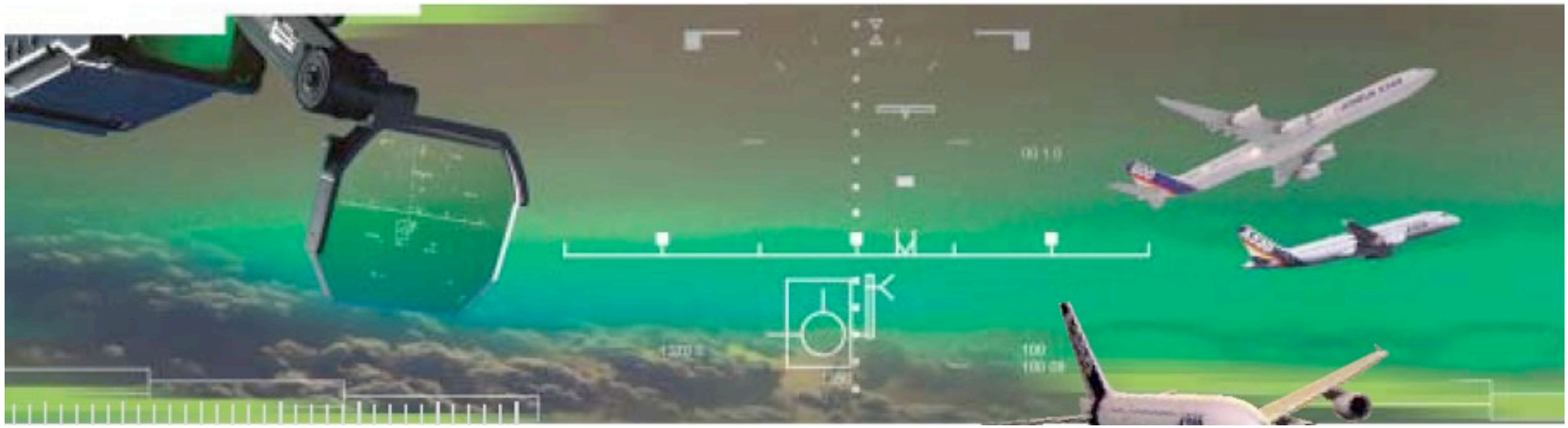


AR in car navigation, Siemens VDO 2004

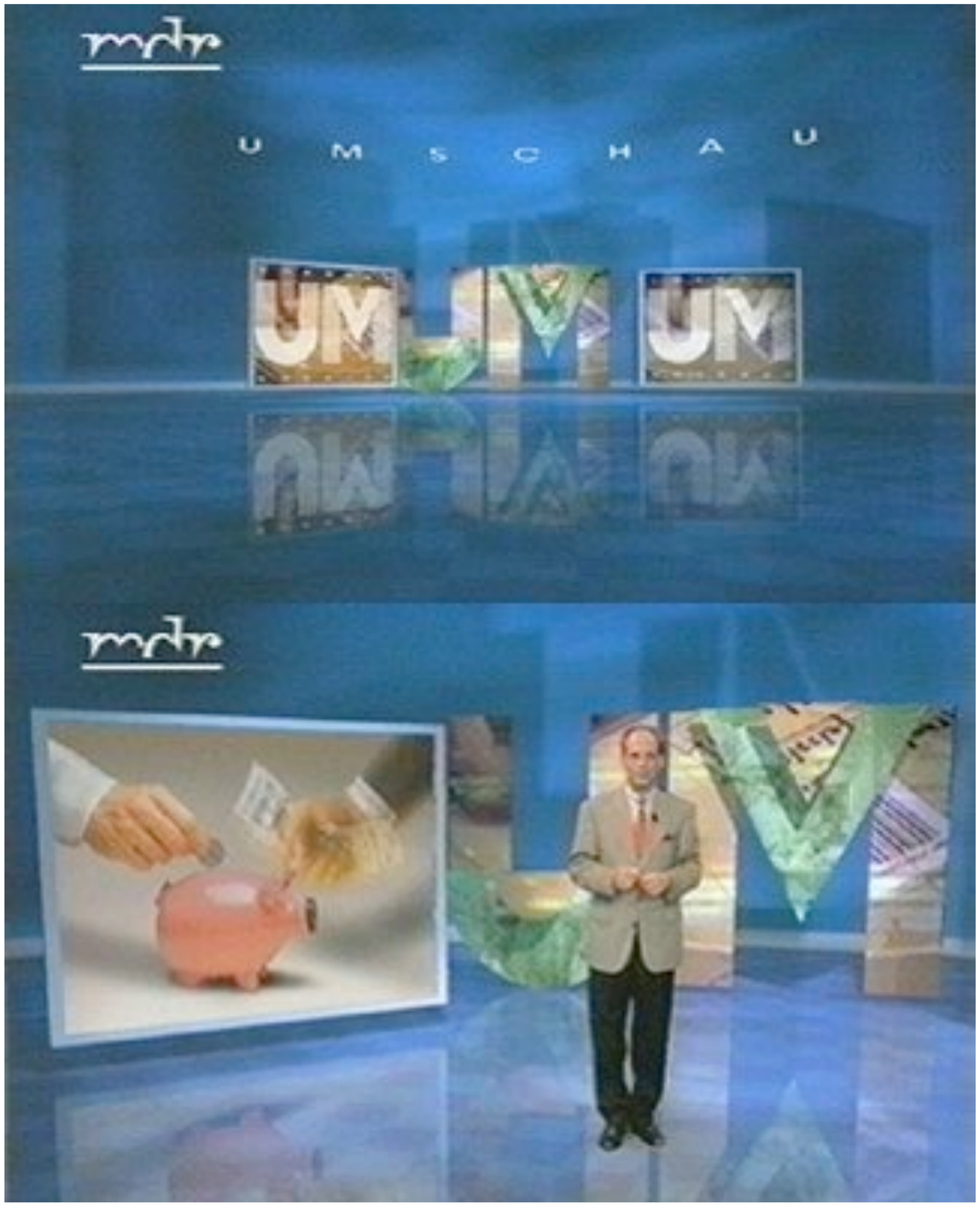


Head-up display in airplanes



- Manufactured by Thales Aviation
  - AMLCD (Active Matrix Liquid Crystal Display) glass
  - Can host innovative visualizations, such as
    - EVS (Enhanced Vision System)
    - SVS (Synthetic Vision System)
    - SGS (Surface Guidance System)
- Starting Dec. 2004, built into Airbus A318-380

Virtual Studios for TV production



- Track the camera
- Use a blue box to film live actor/reporter
- Create an animated 3D environment
- Mix the two in real time
- Interact with virtual objects

Links to original projects

- http://hci.rockwellscientific.com/AR/
- http://www.cs.columbia.edu/graphics/
- http://www.uni-weimar.de/~bimber/
- http://www.virtuelles-studio.info/