ARIVE

ARIVE Lecture Series
XR: Virtual and Augmented Reality

# Recap of our Terms, Definitions, and Concepts

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University of Otago, Dunedin, New Zealand

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# Outline

1. Defining VR, AR, MR, XR
2. XR Technology
   - Displays
   - Sense Augmentation
   - Localisation and Tracking
   - Interaction

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# Defining VR | AR | MR | XR

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# Definition VR | AR

- Computer generated environment
- Three-dimensional
- Interactive with real-time feedback
- *Sense of presence*


Job Simulator

Virtual Reality

Augmented Reality

*M. Bolas, 2011*

# Definition AR

Augmented Reality (AR) is a concept and technology delivering a computer-mediated reality that enhances physical reality with virtual reality creating the user's experience of just one reality. AR manipulates the judgment of reality in a way that neither physical nor virtual reality alone can provide.

ProcIEEE, 2014

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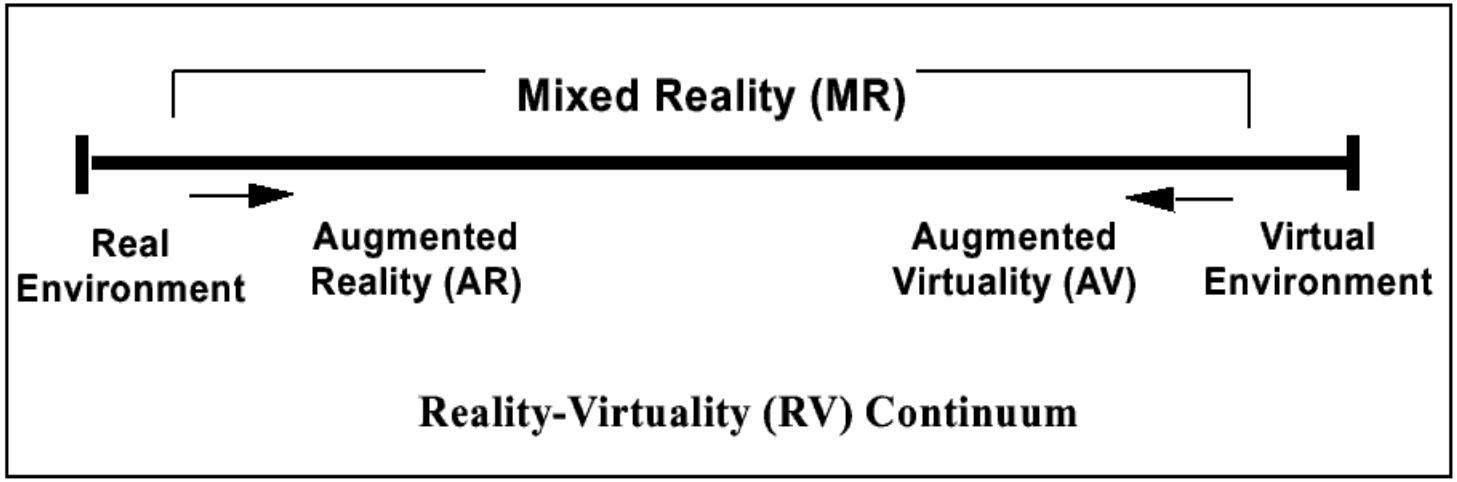
# Mixed Reality Continuum




Milgram & Kishino (1994)

Job Simulator

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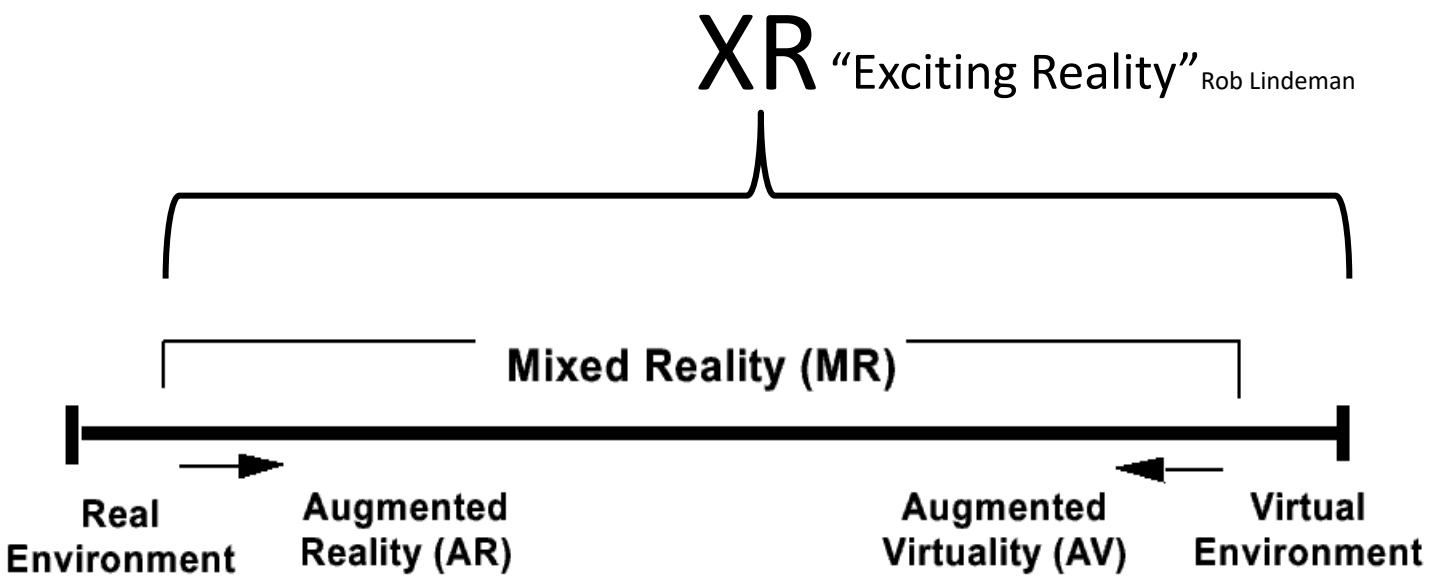
# XR


XR "Exciting Reality" Rob Lindeman
Mixed Reality (MR)
Real Environment
Augmented Reality (AR)
Augmented Virtuality (AV)
Virtual Environment

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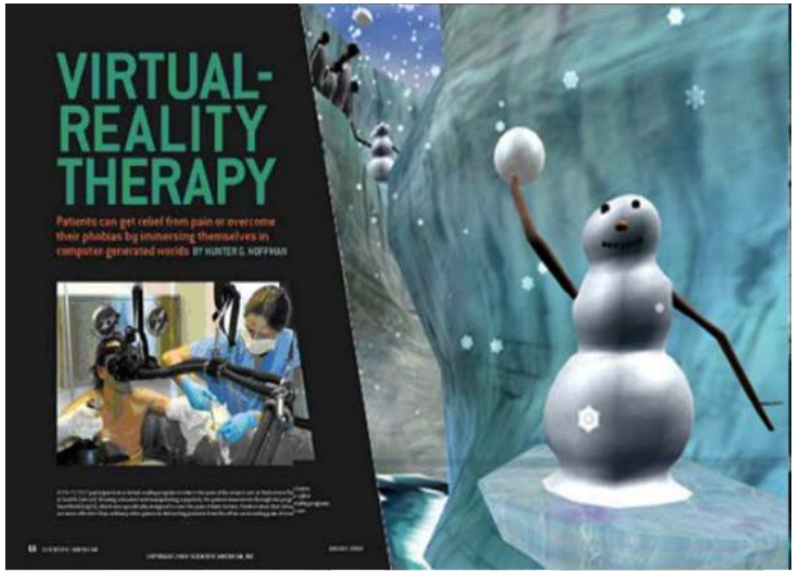
# XR Experiences

- Immersion
- Presence
- Telepresence




http://www.hitl.washington.edu/projects/vrpain/

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# Immersion

"the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant"

Slater and Wilbur 1997

"psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences"

Witmer and Singer 1998

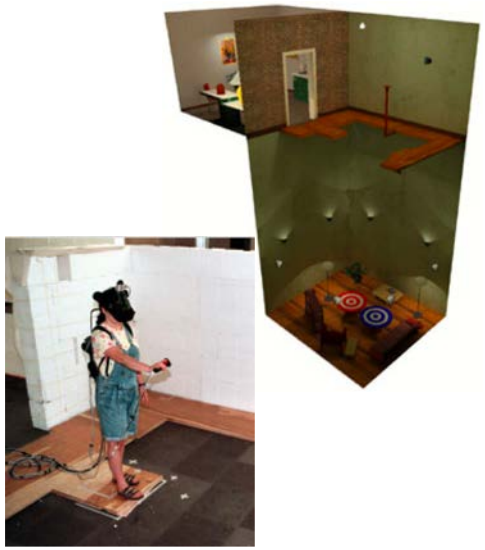
- Sounds
- Taste
- Smell
- Touch
- …

# Presence

"We understand the *sense of presence* as the *subjective* sense of being in a virtual environment. Importantly, the sense of presence can be separated from the ability of a technology to *immerse* a user."

Igroup

- Spatial Presence
- Social Presence
- Co-Presence
- Involvement
- Realism

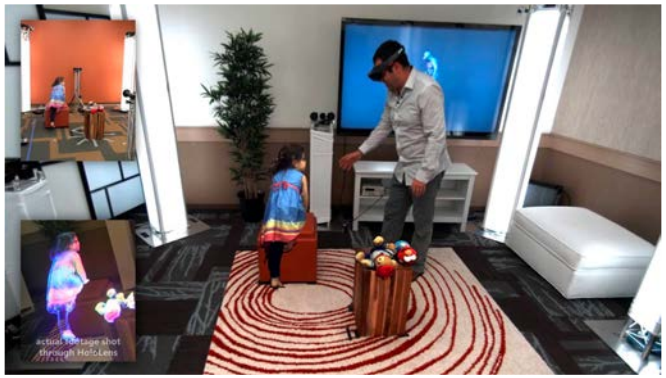


http://wwwx.cs.unc.edu/Research/eve/walk_exp/

# Telepresence

"At the worksite, the manipulators have the dexterity to allow the operator to perform normal human functions. At the control station, the operator receives sufficient quantity and quality of sensory feedback to provide a feeling of actual presence at the worksite."

Akin et al. 1983



Young et al. 2019

Holoportation

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# XR Technology

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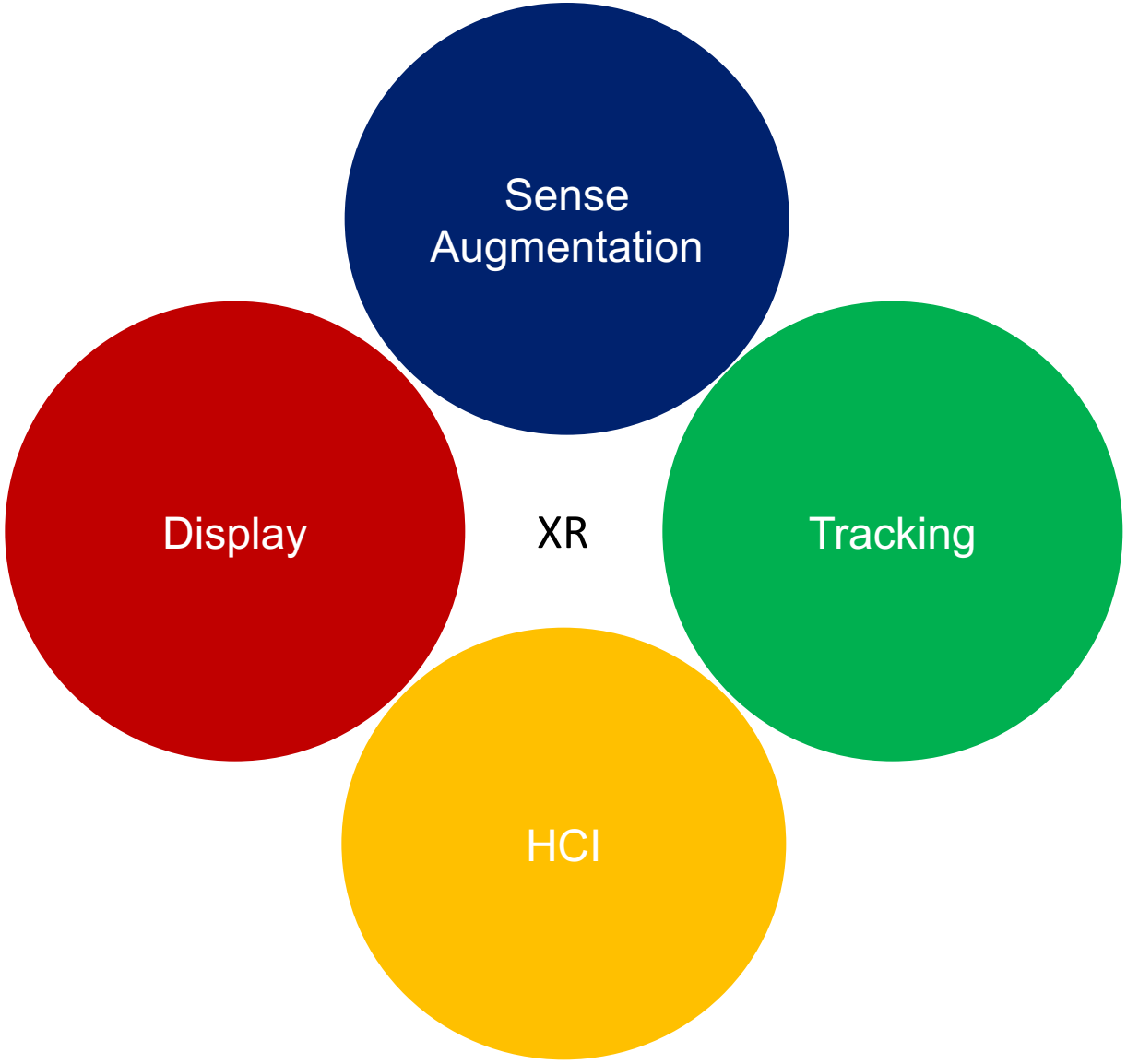
# XR Experience Elements

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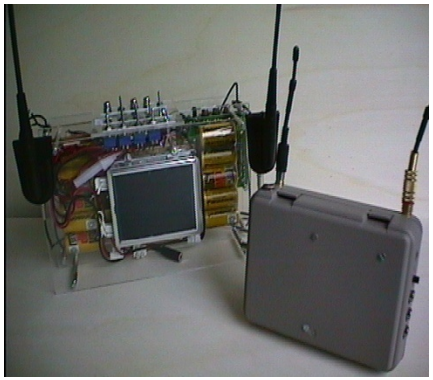
# Wearability

| wired | active devices | passive devices |
|---|---|---|
|  Bauhaus University Weimar |  Xybernaut |  DaimlerChrysler AG |
| + high fidelity<br>+ no time limits (run)<br>- small range<br>- disturbing cables | + lightweight<br>+ large area use<br>- low fidelity<br>- short run use | + lightweight<br>+ large area use<br>+/- fidelity (video)<br>- short run use<br>- sensitive RF transmission |

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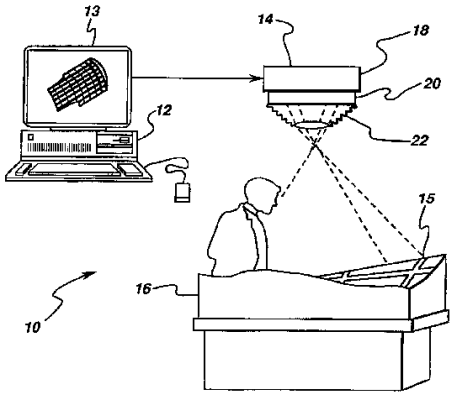
# Typical Forms of XR Displays

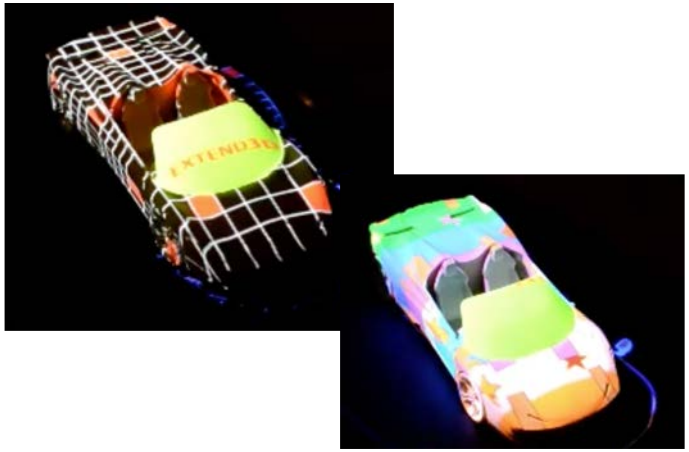
- Visual
  - Spatial AR:
    - Projection: onto screens
    - Projection: onto objects
    - Objects as displays (e.g. OLED)
  - VR Head-Mounted Display
  - Video-See-Through (VST)
    - head-worn displays
    - mobile devices
    - stationary screens
  - Optical See-Through (OST)
    - head-worn displays
    - stationary screens
- Haptic
  - Active: force feedback, tactile feedback
  - Passive: augmented objects
- Acoustic, Thermal, Olfactory, ...

# Spatial AR (SAR)

©Disney



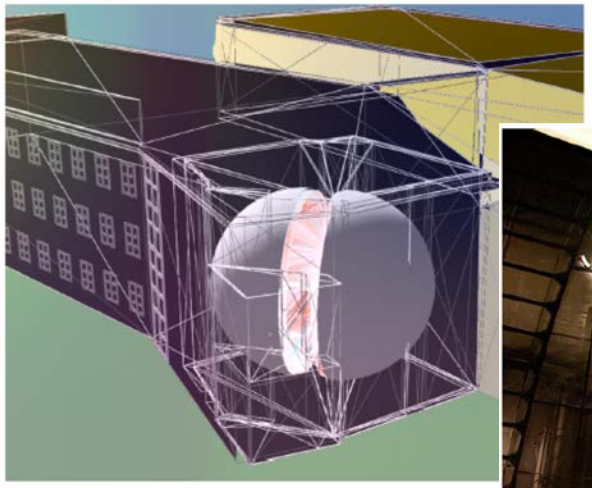

© GE, 1994



Resch et al. 2015

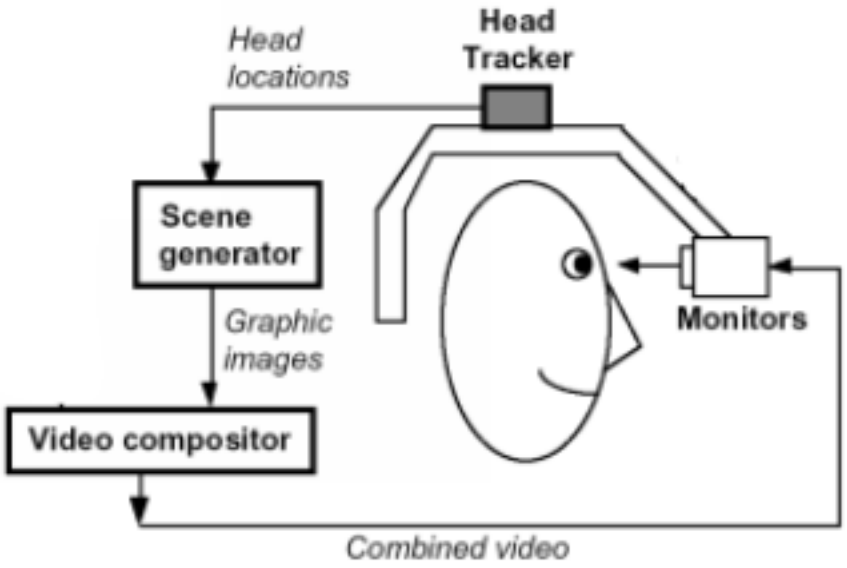
Office of the Future

# Cave Automatic Virtual Environment (CAVE)



AlloSphere

# VR Displays

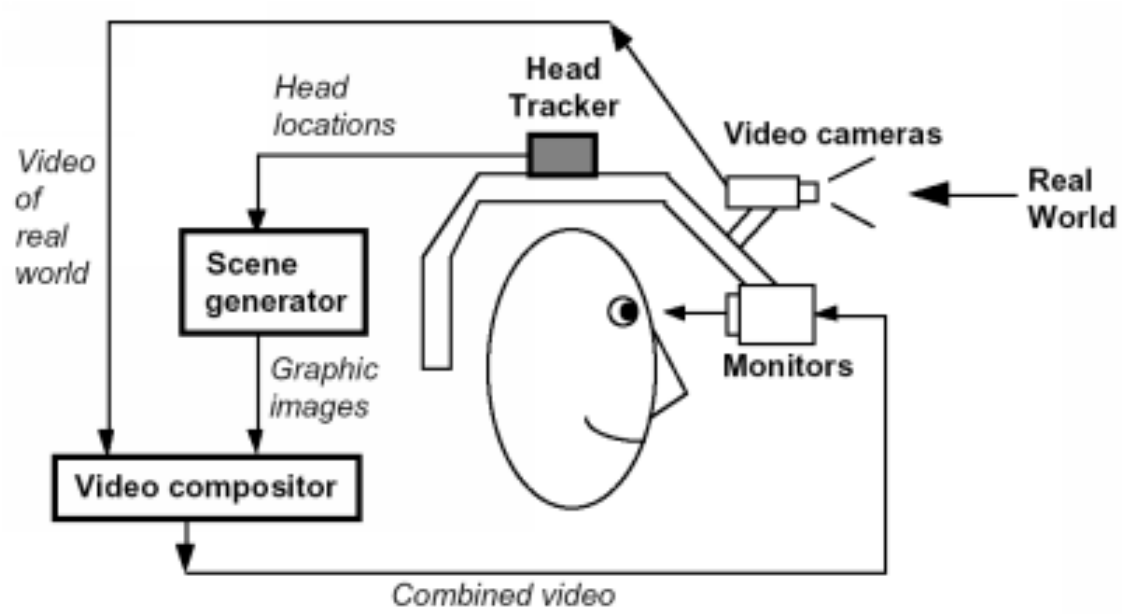




© HTC

© Google

# VST Displays

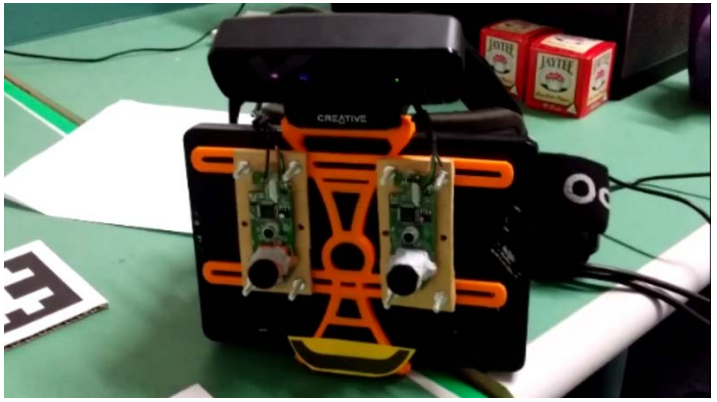




Azuma

# VST Head-Mounted Displays (HMDs)


Varjo XR1

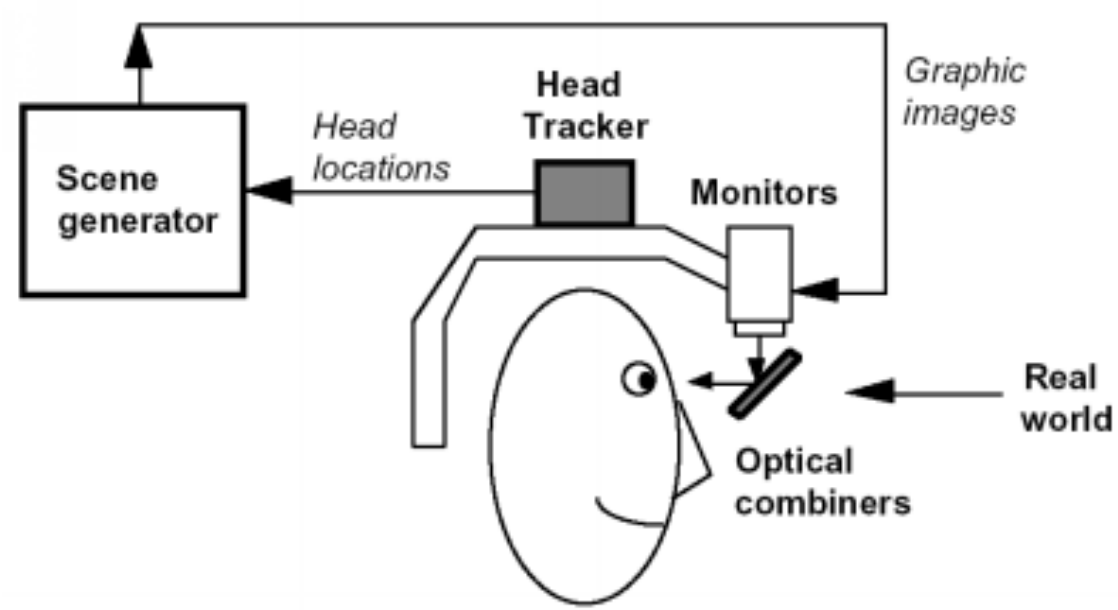




Visette45SXGA HMD

Vuzix Wrap 920

# OST


Graphic images
Head Tracker
Head locations
Scene generator
Monitors
Real world
Optical combiners

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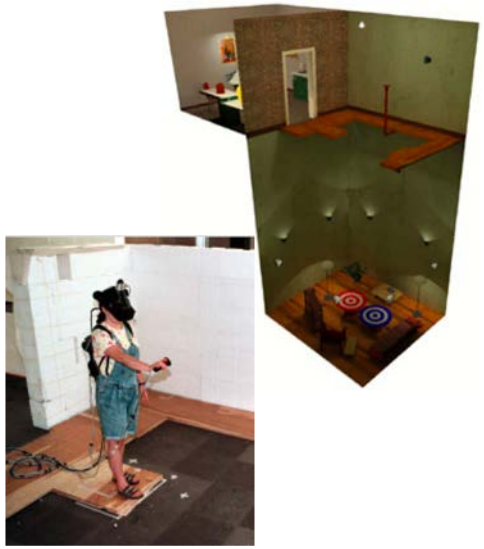
# OST

HMDs

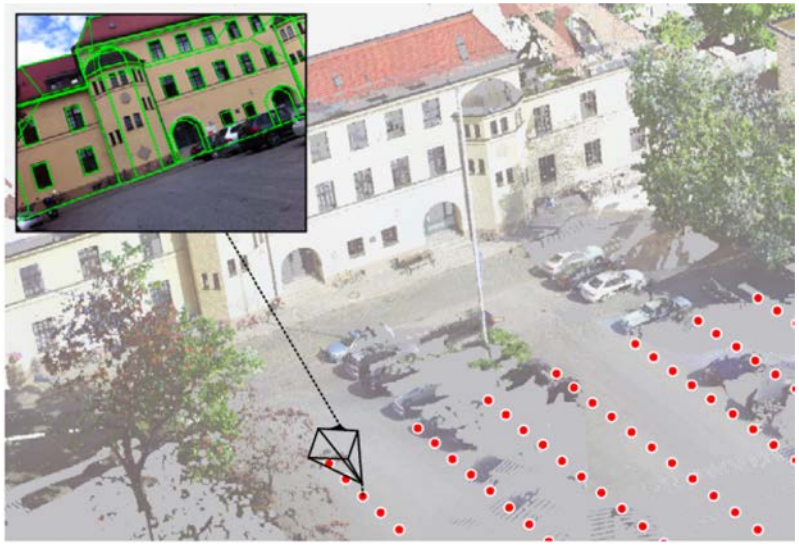

Stands

HUDs

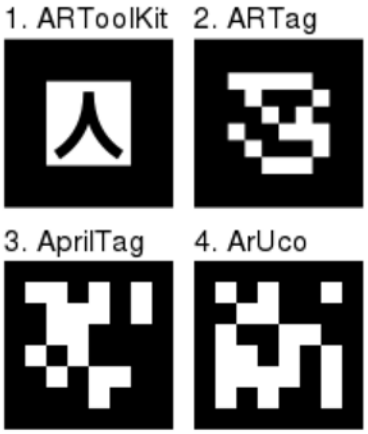
# Localisation and Tracking



http://wwwx.cs.unc.edu/Research/eve/walk_exp/

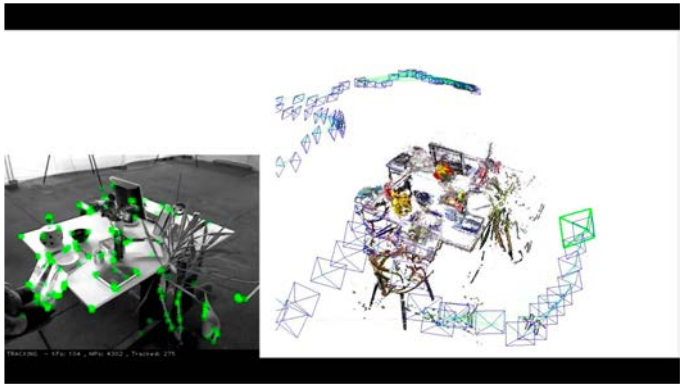


# Localisation and Tracking




Fiducial markers


PTAM

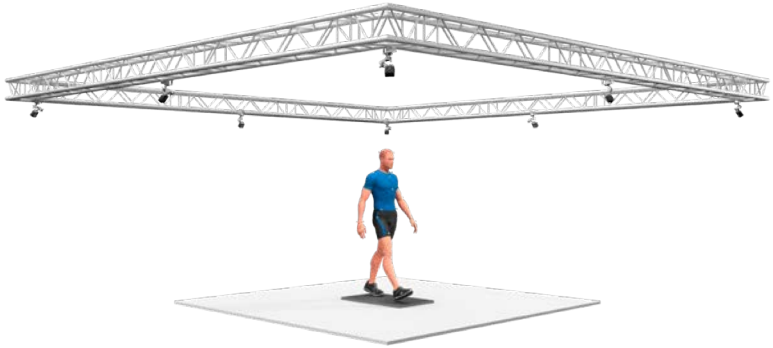


ORB-SLAM

SLAM Approaches

# Localisation and Tracking

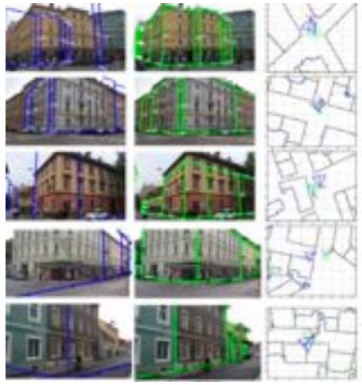

Inside-Out Tracking



Outside-In Tracking

# Localisation and Tracking

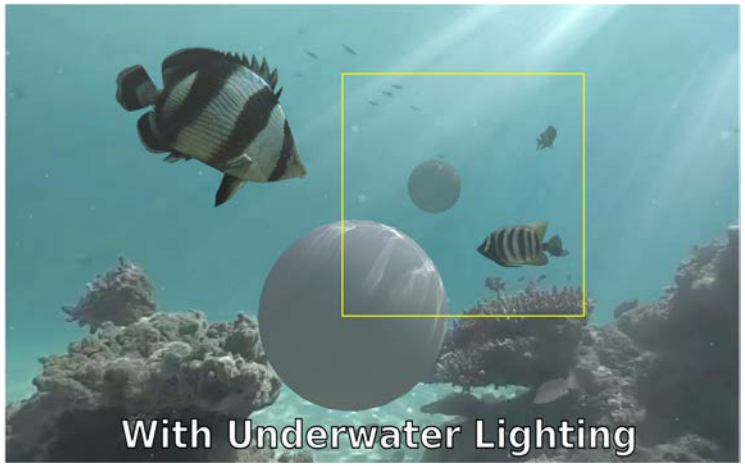

https://jensgrubert.wordpress.com/



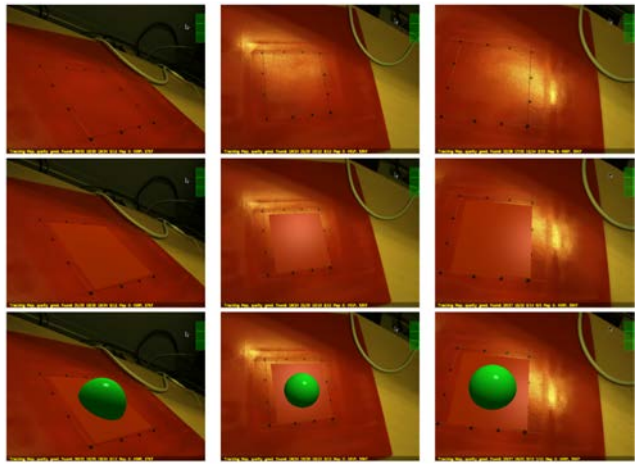
Arth et al. 2015


Rompapas et al. 2019

# Realistic Rendering




Thompson et al. 2019



Mashita et al. 2013

Volante et al. 2016

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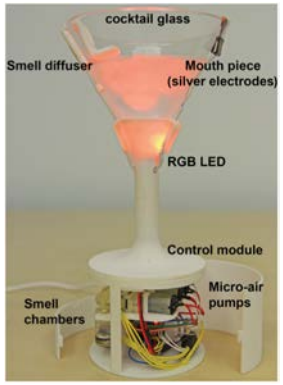
# Other Senses


Narumi et al. 2011




Ranasinghe et al. 2017



Schmidt et al. 2015

Zhang et al. 2016
The Gadget Show

# Interaction

- Problem, Chance, and Challenge: in most cases keyboard, mouse, or monitor un available

- Providing special devices (handheld, arm-worn, ...)
- Alternative input: speech, gesture, gaze
- Using tangible interfaces within the real environment

# Occlusion in Interaction


Virtual occludes Real


Semi-transparent


Real occludes Virtual


Correct Occlusion

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# Interaction

Colaço et al. 2013


Mohr et al. 2019


Gugenheimer et al. 2016

Lee et al. 2016

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- *Proceedings of the International Conference on Advances in Computer Ent*Zhang, E.Y., Cheok, A.D., Nishiguchi, S. and Morisawa, Y. Kissenger: development of a remote kissing device for affective communication. In *Proceedings of the International Conference on Advances in Computer Entertainment Technology*, pp. 1-6, 2016.
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# Further Readings


- Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of communication*, *42*(4), 73-93.
- ...

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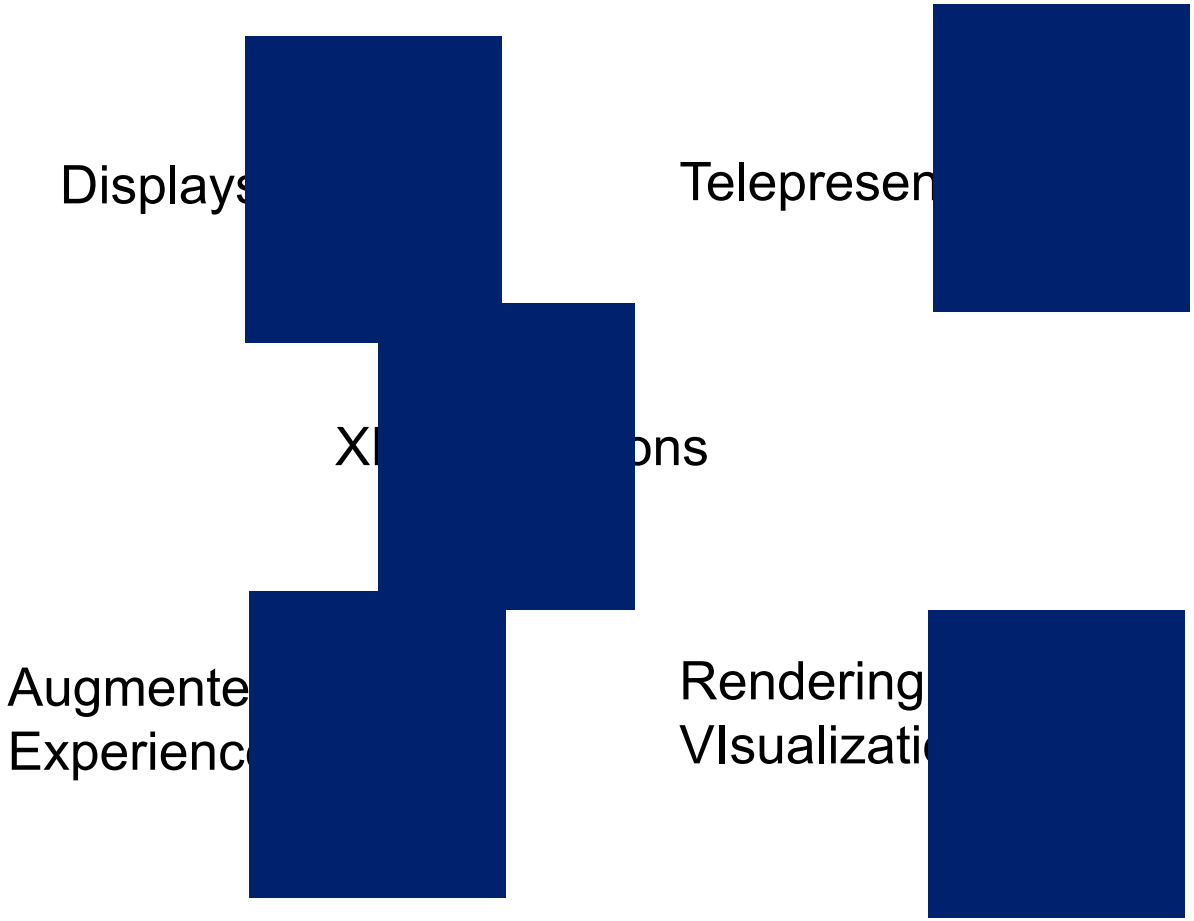
# XR Technology: Computing Systems

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# XR Applications

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*** MATERIAL ***

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# Mixed Reality Technology

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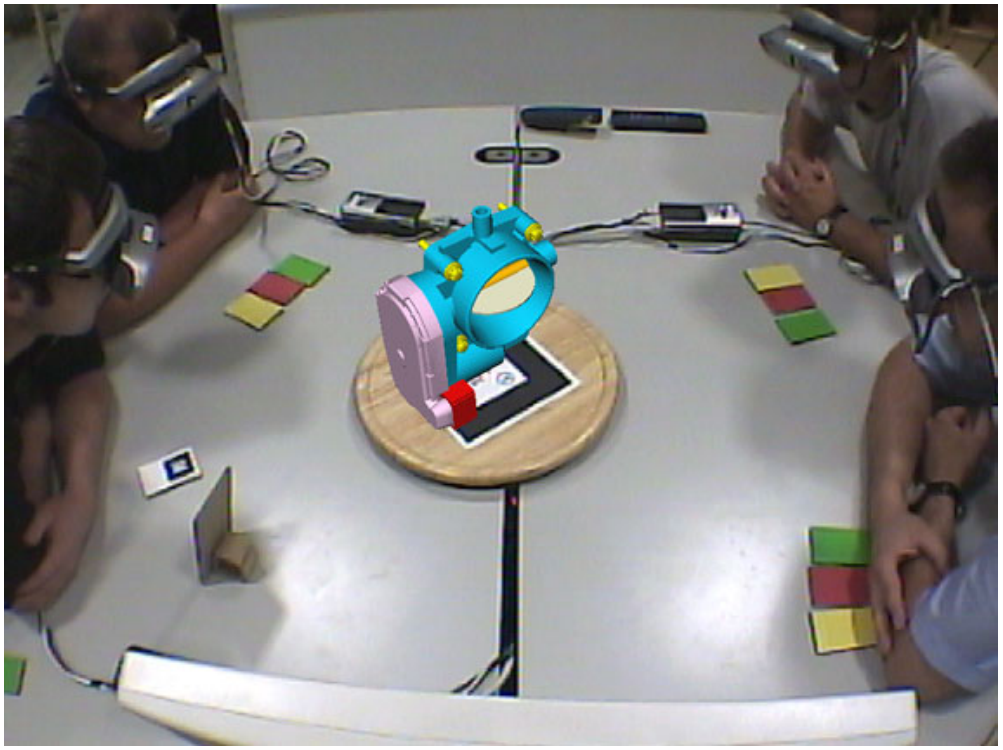
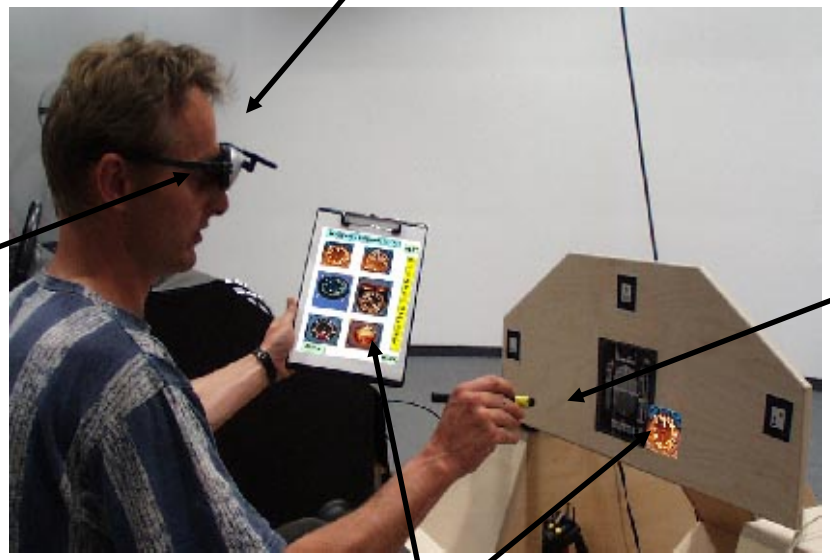
# Application Example::Collaborative Design Review

RegenbrechtWagnerMagicMeeting.avi (6:48-)



# MR Technology:: Principle of an AR Application

Tracking of user‘s head pose



Display of mixed world

Interaction device:
- tracking pose
- handling events

Provision of VR component

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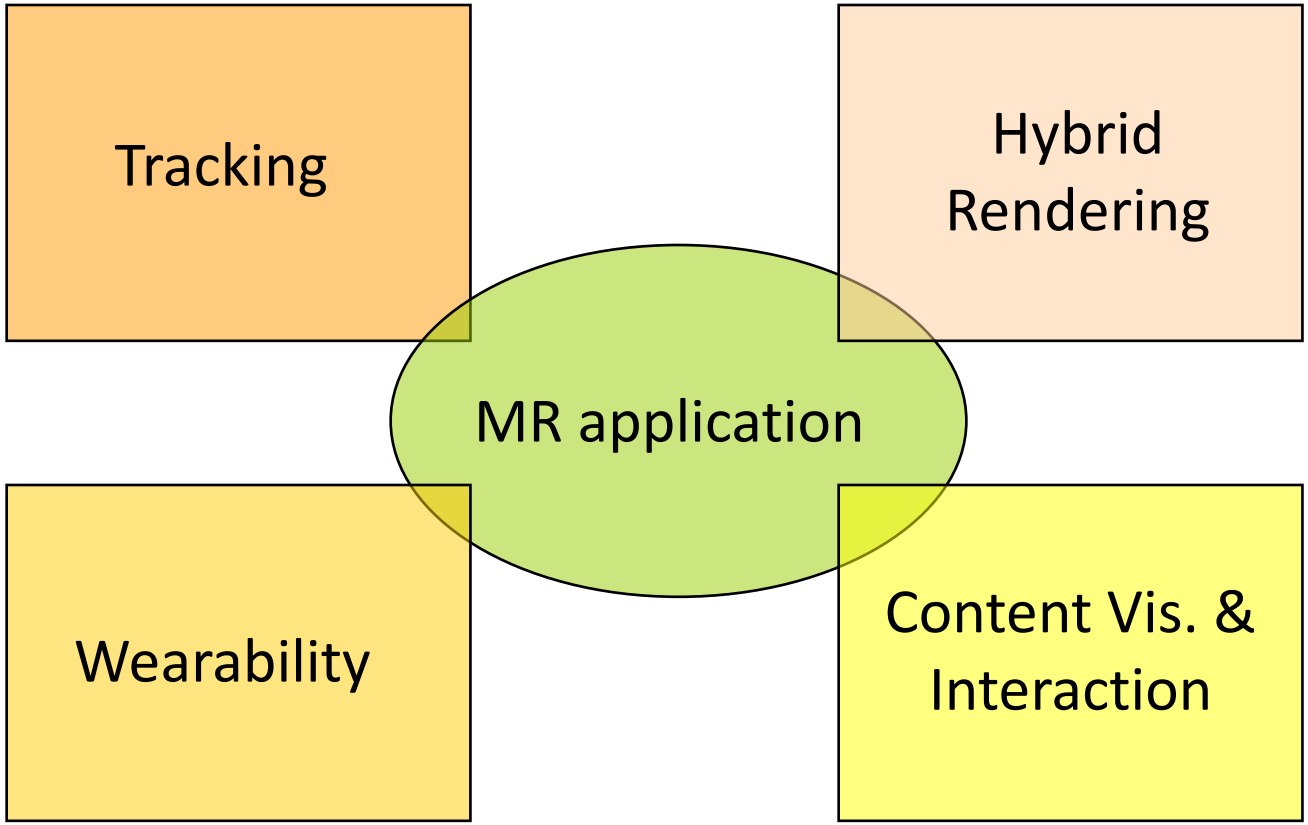
# MR Technology:: Contributing Technologies

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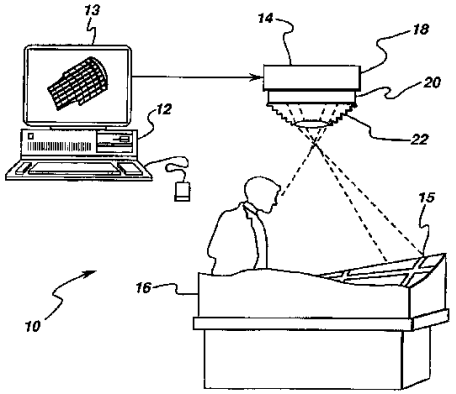
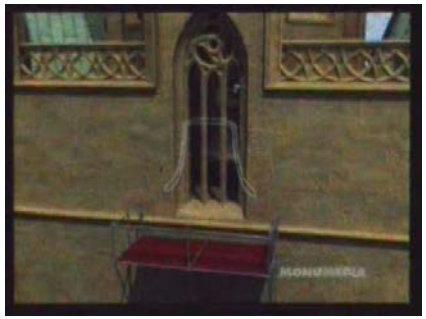
# MR Technology:: Typical Forms of MR Displays
(also used in ubiquitous and pervasive computing)

- Visual
  - Optical See-Through (OST)
    - head-worn displays
  - Video-See-Through (VST)
    - head-worn displays
    - mobile devices
    - stationary screens
  - Spatial AR:
    - Projection: onto screens
    - Projection: onto objects
    - Objects as displays (e.g. OLED)
- Haptic
  - Active: force feedback, tactile feedback
  - Passive: augmented objects
- Acoustic: diegetic effects, “Earcons”
- Thermal, Olfactory, ...

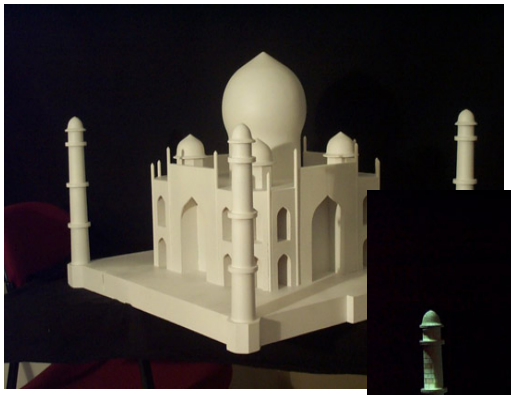
# MR Technology:: Spatial AR (SAR)

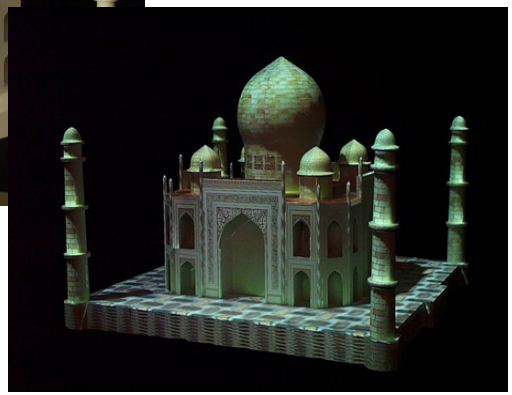



(c) GE, 1994



Smart Projectors, BUW





Shader Lamps

Office of the Future

# SAR

MSR_Dyadic230397.mp4 (5:58-)

# SAR Example

notredame-03.flv (00:41)

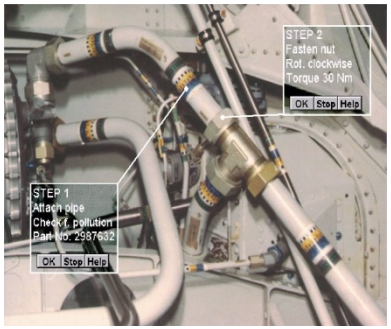
ARIVE

# Spatial AR

(c) Volkswagen

# MR Technology:: Application Scenarios

## assembly support



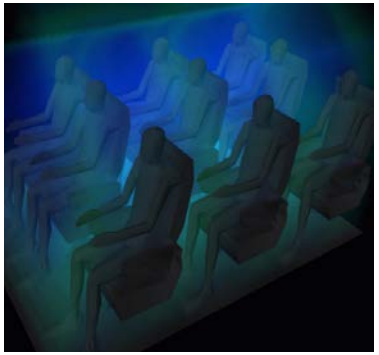

wireless tracking (medium fidelity)

annotation display with online database access

interaction with application and annotations

operations on large database

## volume data visualization



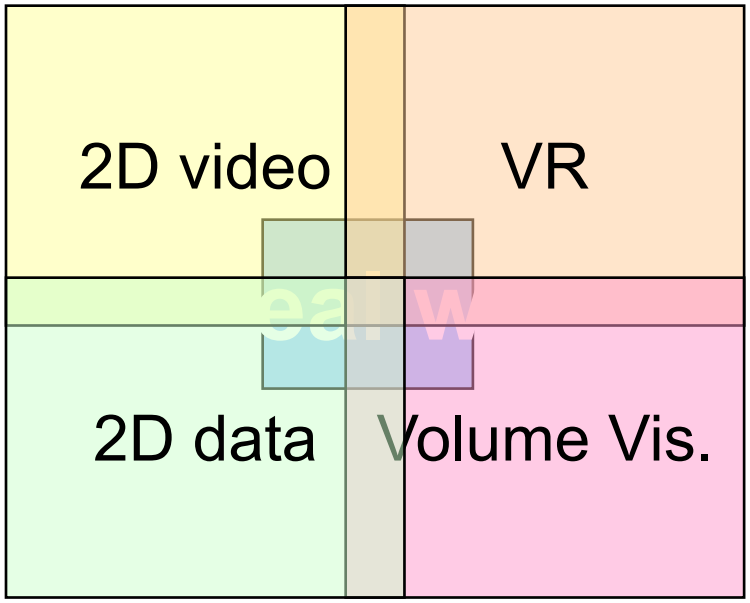
stationary tracking (high fidelity)

volume rendering with access to simulation data

interaction with real world elements

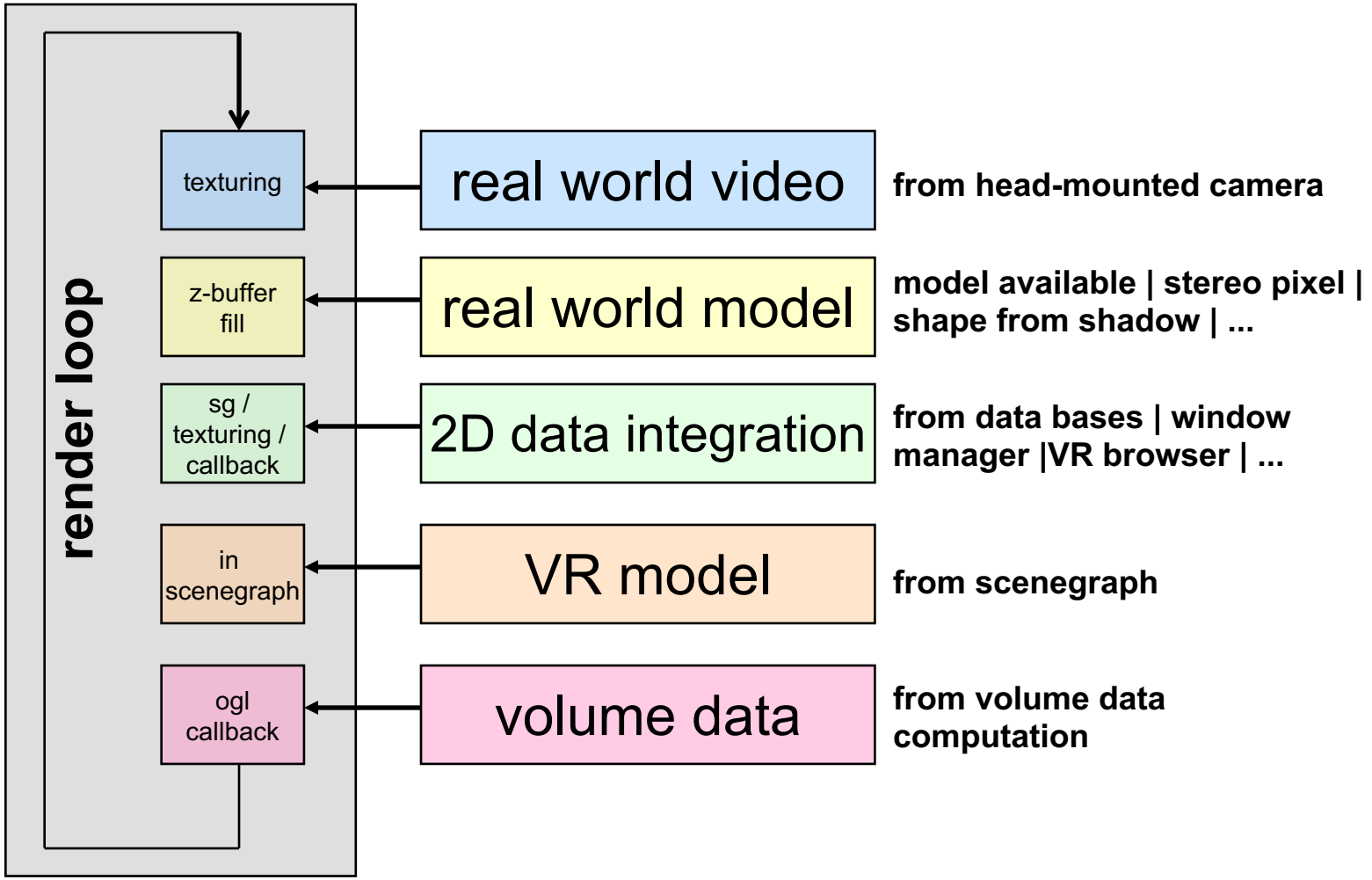
online (interpolated) simulation

# MR Technology:: Hybrid Rendering




- example: volume and VR data visualization in real world (VST)
- five domains involved
- each domain can occlude the others
- rendering into the same context
- problem fields: priority of rendering, detection of real world 3D data, mix of different rendering techniques, video fidelity, accurate match of domains

# MR Technology:: Render Loop



# MR Technology:: Tracking

Fidelity
(accuracy, low latency,
low jitter/noise,
pixelwise match)

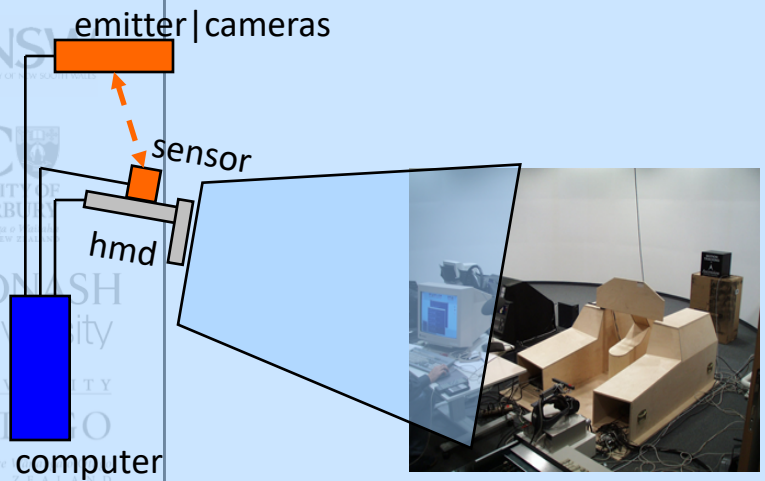
Cabling
(wireless ⇒ wearablity)

Distances
(meters...hangar dimensions,
coarse / fine tracking)

Instrumentation
(user, real world,
real world in view)

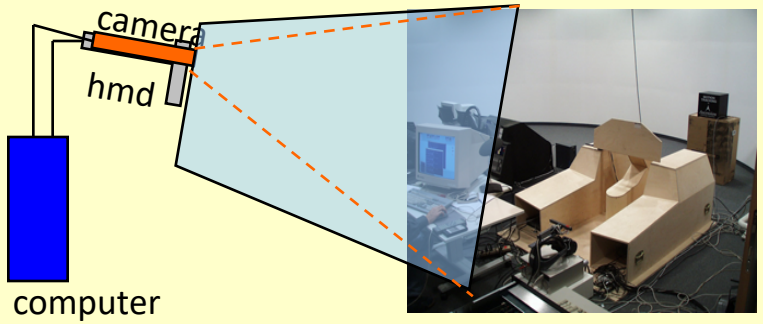
# MR Technology:: Tracking

## Outside-In




+ technology available
+ high accuracy possible
- short distances
- instrumentation of real world
- depends on env. conditions (light,metals,fields,...)

## Inside-Out



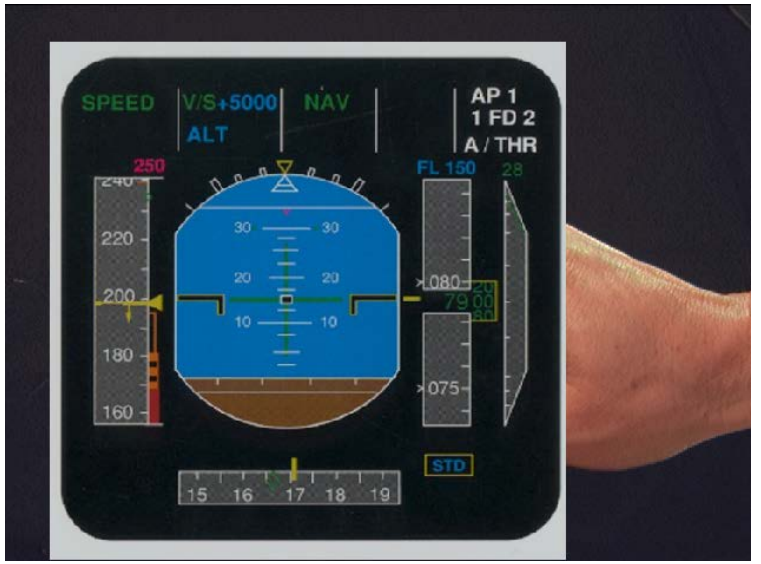

+ pixelwise accurate
+ large distance tracking possible
- often instrumentation of rw parts in view (markers)
- resolution (accuracy) within video limits
- influence of environmental light

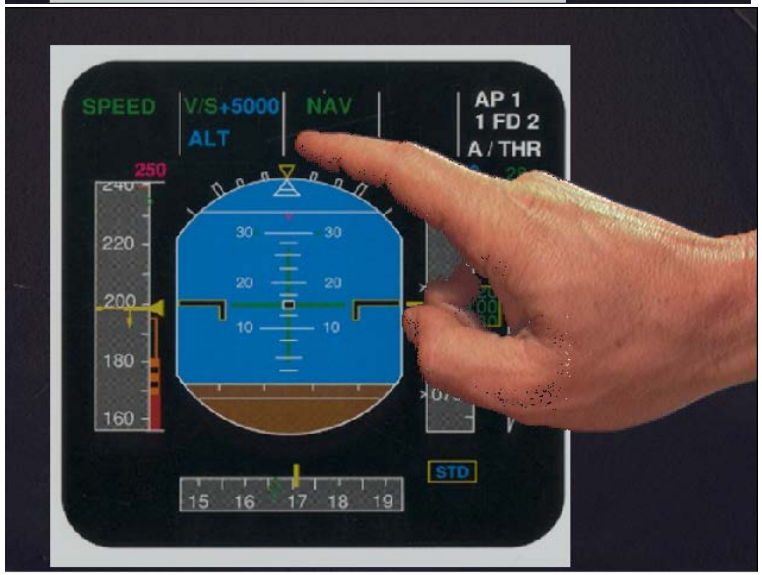
# MR Technology:: Interaction

- Problem, Chance, and Challenge: in most cases keyboard, mouse, or monitor un available

- Providing special devices (handheld, arm-worn, ...)
- Alternative input: speech, gesture
- Using tangible interfaces within the real environment

# MR Technology:: VST Interaction Issue



# The Occlusion/Interaction Problem

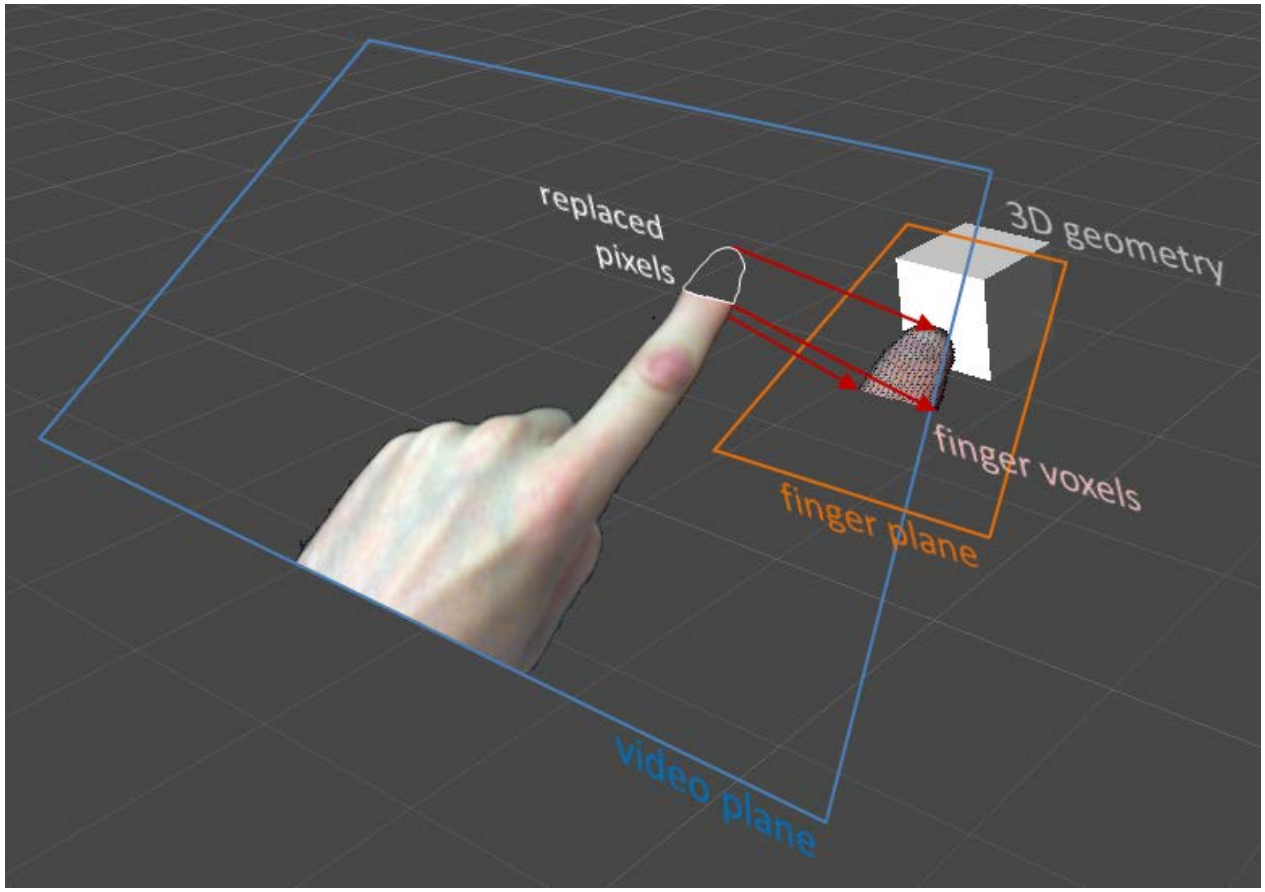

Virtual occludes Real


Semi-transparent


Real occludes Virtual

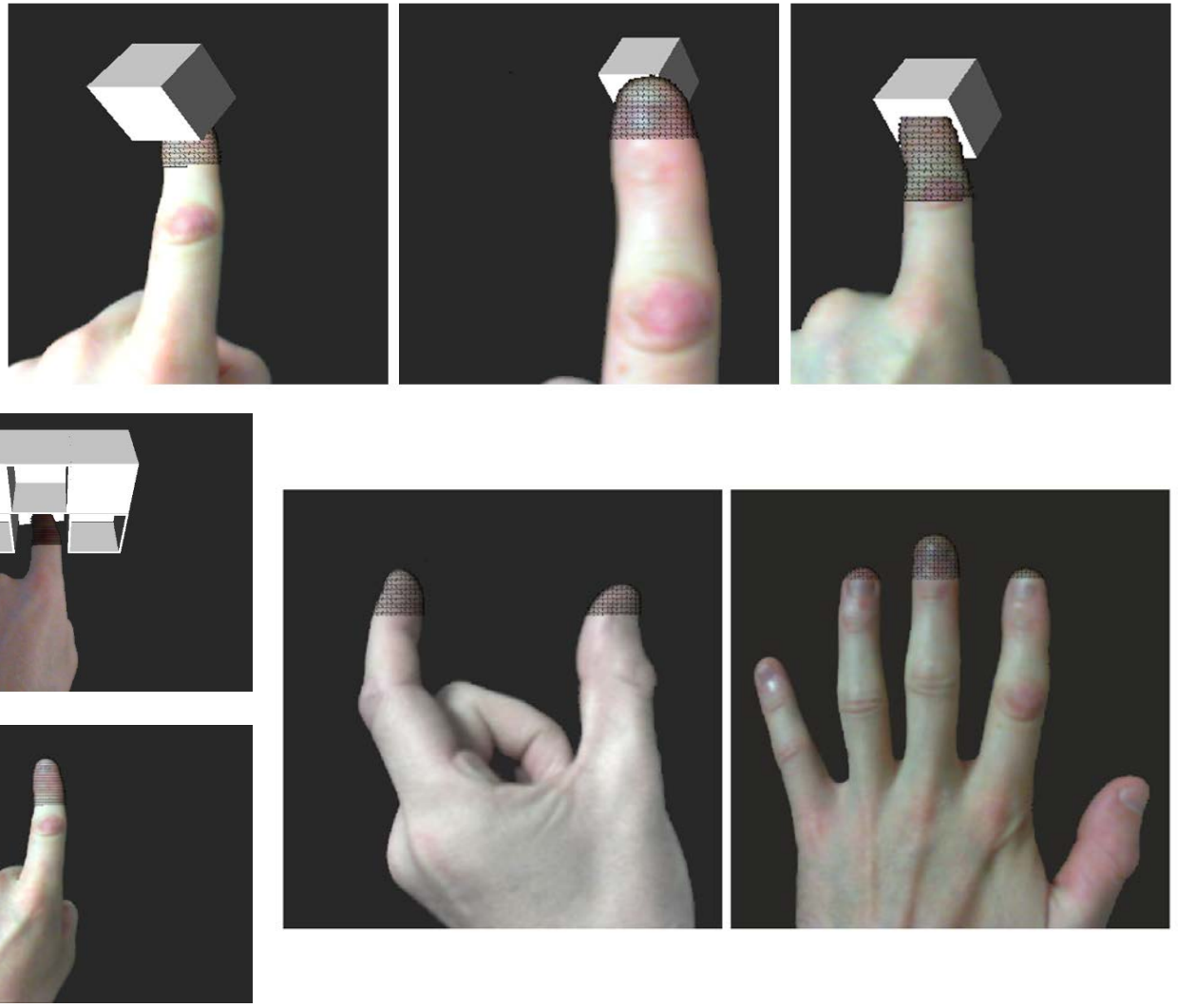

Correct Occlusion

# Example VoxelAR




ACM OZCHI'13

# Example VoxelAR



# MR Technology:: Wearability

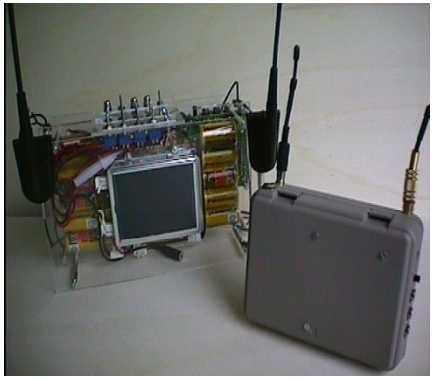
bringing display information to user

getting tracking information from user

getting interaction (device) information from user

lightweight
ergonomic
energy consumption
high fidelity
large area use
robust (environment, usage)
new interaction techniques
⇓
device(s) should disappear

# MR Technology:: Wearability

| wired | active devices | passive devices |
|---|---|---|
|  Bauhaus University Weimar |  Xybernaut |  DaimlerChrysler AG |
| + high fidelity<br>+ no time limits (run)<br>- small range<br>- disturbing cables | + lightweight<br>+ large area use<br>- low fidelity<br>- short run use | + lightweight<br>+ large area use<br>+/- fidelity (video)<br>- short run use<br>- sensitive RF transmission |

# MR Technology:: Content / Authoring

Content

- considering all kinds of multimedia information: text, picture, video, VR
- access to internal and external resources: files, databases, intranet, web

- Main bottleneck for acceptance is a closed data and process chain
- Instruction editor needs tools for the preparation of AR information display and flow

ARIVE

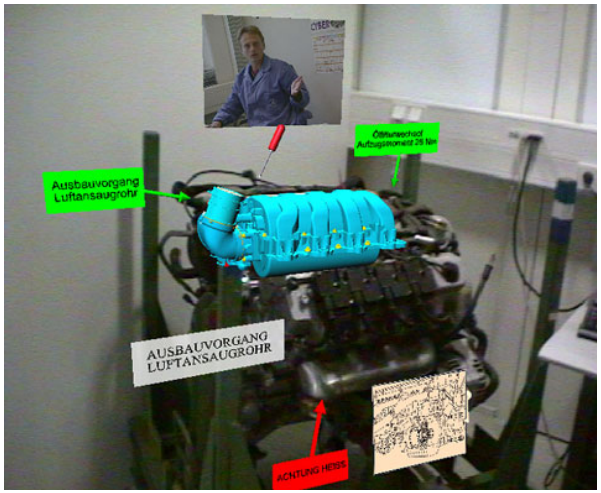

# Application Examples & Prototypes

# Application Examples:: Engine Maintenance

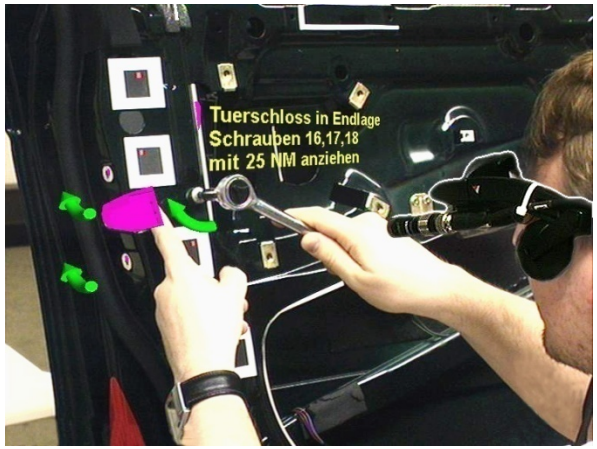
- Today: Garage information system on paper and CD-ROM
- Goal: Additional support for mechanic with AR
- Useful for seldom practiced or complicated tasks, for new product models, or „on the road“
- Placement of spatially aligned texts, graphics, videos, (animated) 3D models, or even videophone

Example:

- Standard-PC or Notebook computer
- Lightweight Head-Mounted Display (Sony Glasstron), mono
- Miniature camera (Toshiba)
- Finger-worn 4-way stick and button fot simple interaction tasks



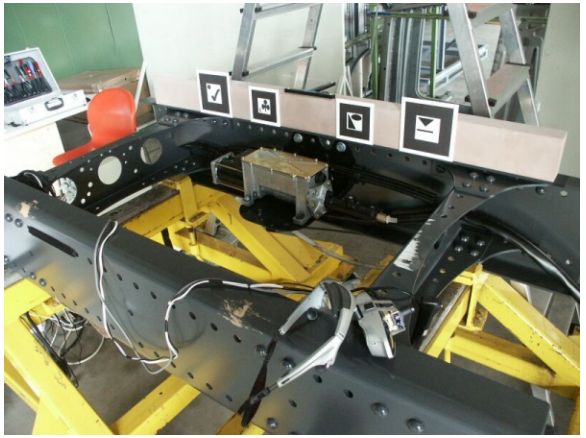

DaimlerChrysler




Fraunhofer IGD

# Application Examples:: Wire Placement

- Work for DaimlerChrysler truck unit
- Customers have a high degree of freedom in configuration of truck
- Almost no two trucks are identical, therefore wiring must be planned individually for almost every truck
- In production and production planning phase AR supports the interactive layout of wiring harnesses (tree-structured bundles of wires)
- Layout takes place on real girder

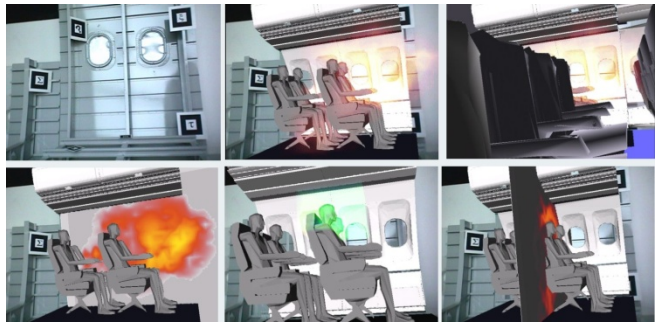



- Lightweight HMD + camera
- Standard PC running AR-system
- Two tracking systems: marker and optical

# Application Examples::CFD Visualisation

- Work for airplane manufacturer Airbus within ARVIKA project
- Airplane interior designs are unique (seats, linings, ...)
- Variants in design are typically shown w/ partial mockups (e.g. a couple of seat rows within airplane)
- Airstreams (temperatures, velocities, etc.) cannot be experienced
- AR visualizes Computational Fluid Dynamics data in form of voxels



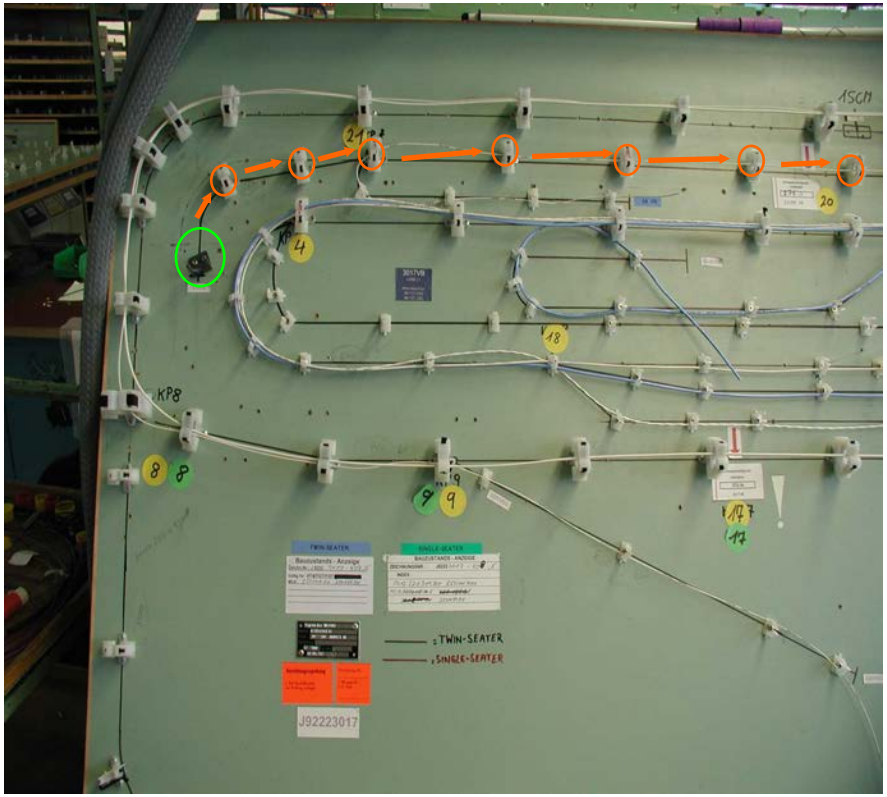
# Application Examples::Driver Safety Training

- Using AR for training drivers in car
- Display of all kind of driving situations, even those not presentable in reality (technological, organizational, safety reasons)
- Marker-based tracking + inertial tracking + car data (CAN bus)
- Lightweight HMD's
- Notebook computer on back seat
- tests with customer and users show promising results

# Application Examples::Wire and Pipe Mounting

Augmented visualization of mounting/intrusion instructions out of database

Boeing




EADS

# Application Examples::...more

## Design::Verification of prototype parts

**Problem: Prototype assembly errors**

Errors (derived from production) are recognized too late (during prototype assembly)

**Needed: Early check of:**

Accuracy of form an position
Geometry
Freeform surfaces

**Solution: AR overlay**

## Design::Comparison Experiment-Simulation

1. Before crashtest
   Check, if all components present

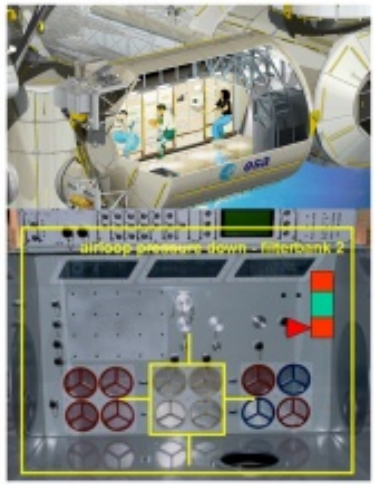

2. After crashtest
   Comparison

# Application Examples::...more

Service::Cybercompanion

DAIMLERCHRYSLER

astrium



Service::Tram maintanance

DAIMLERCHRYSLER

ADtranz

Connection between knowledge based diagnostic system and AR

ARIVE

# Audio Stickies

# Audio Stickies:
## Visually-guided Spatial Audio Annotations on a Mobile Augmented Reality Platform

ARIVE

# Audio Stickies::Intro/Motivation