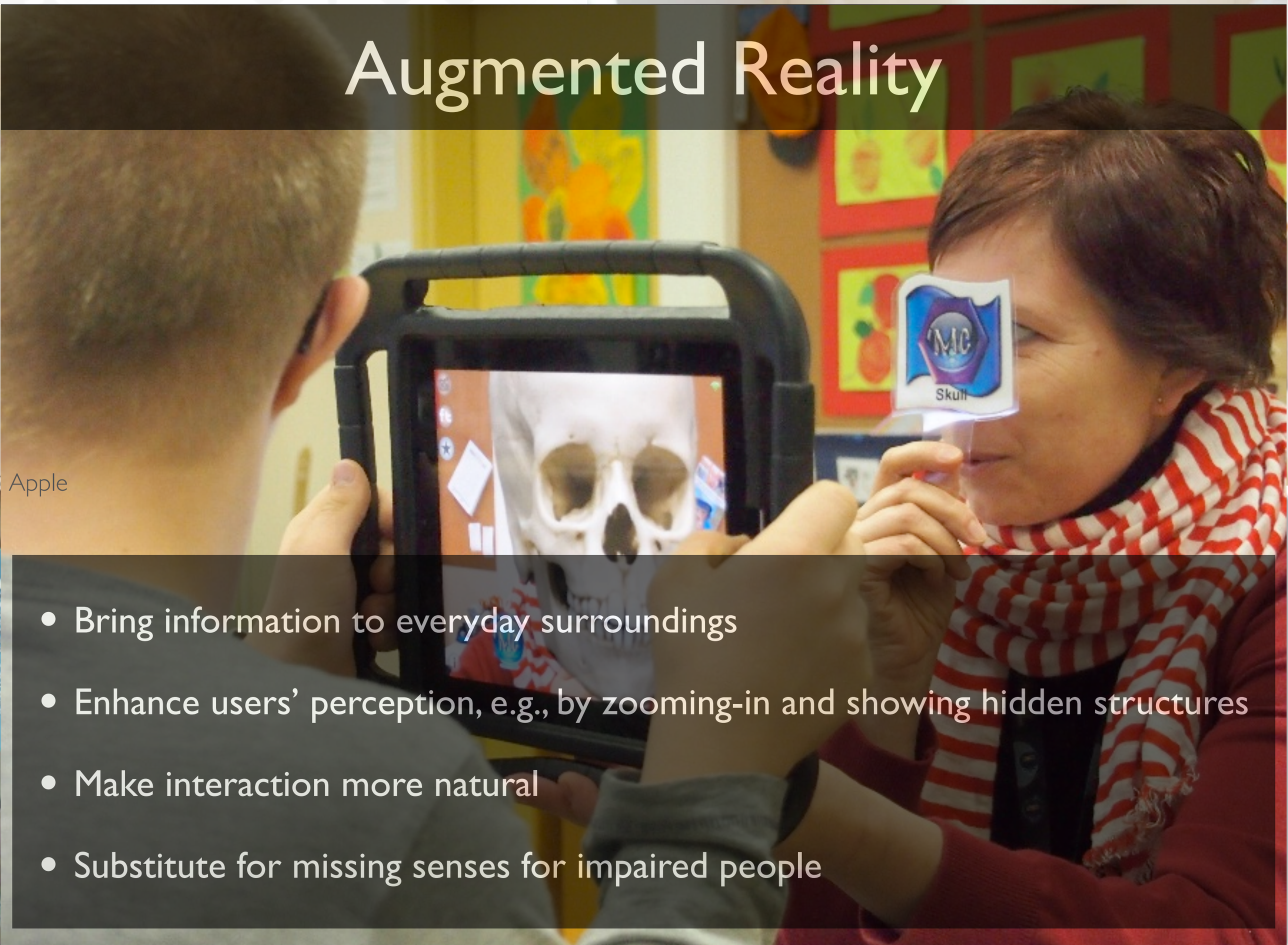
Research in Augmented Reality

Nur Al-huda Hamdan
Media Computing Group
RWTH Aachen University

http://hci.rwth-aachen.de/cthci

Augmented Reality



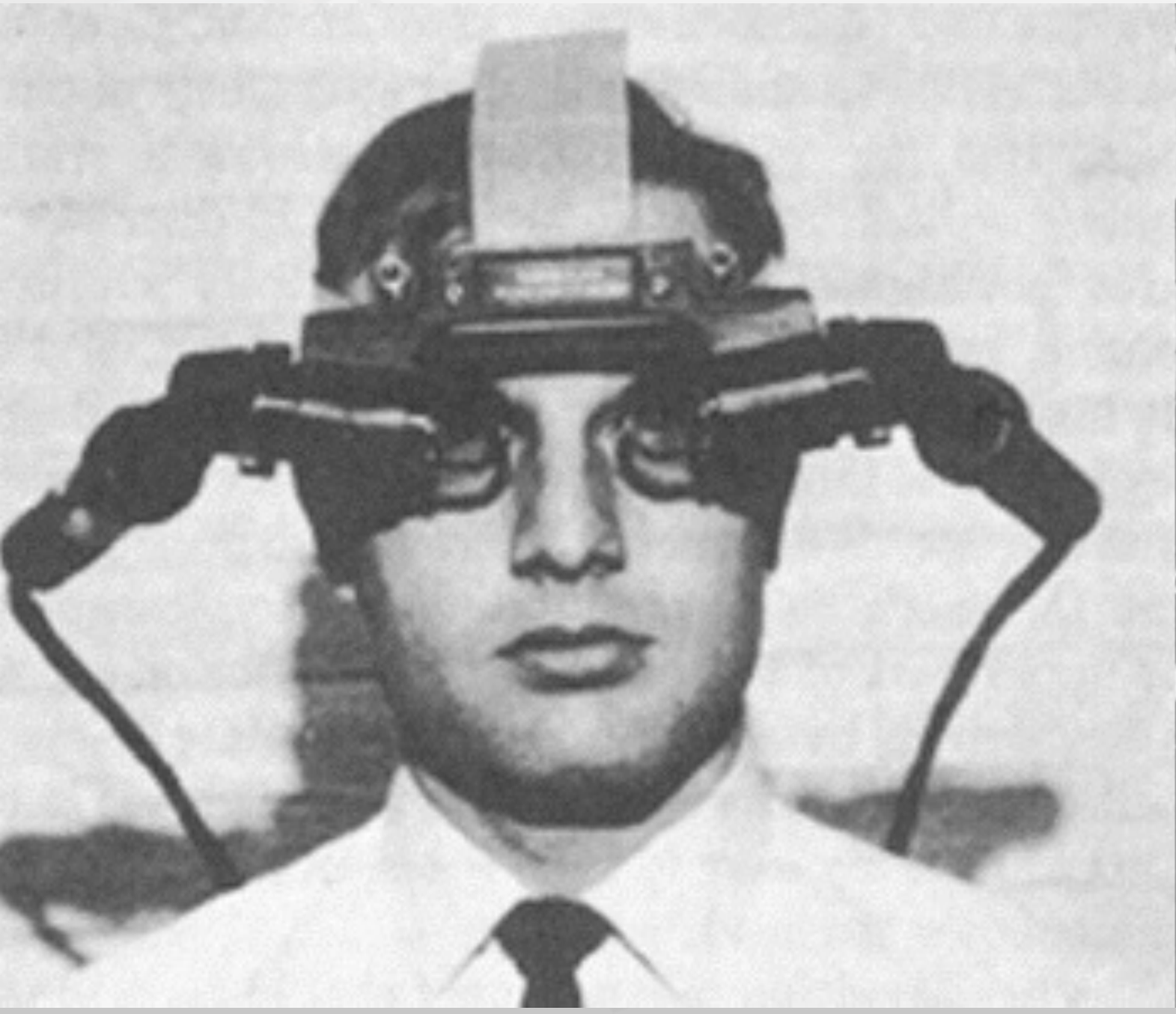
Apple

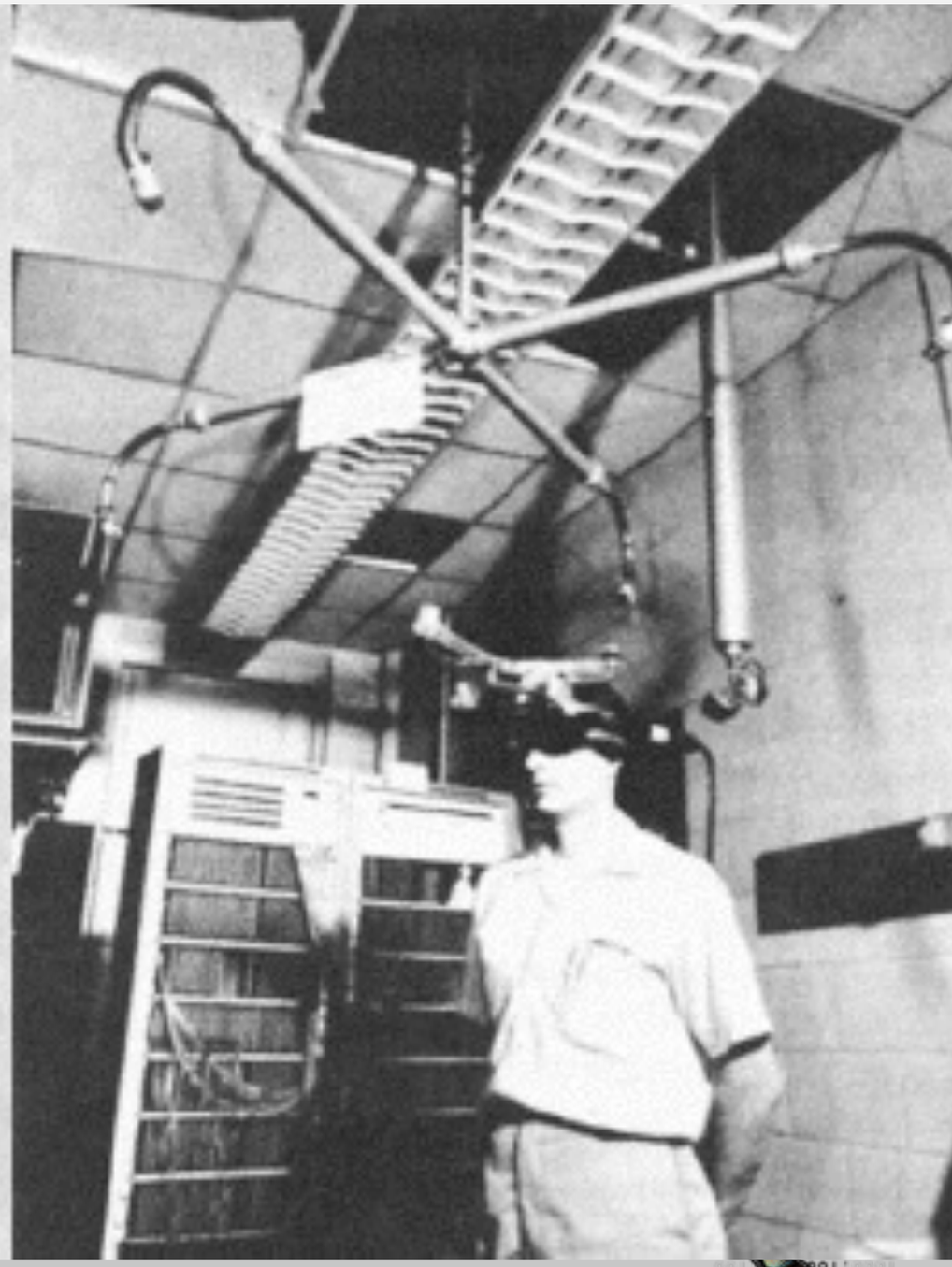
- Bring information to everyday surroundings
- Enhance users' perception, e.g., by zooming-in and showing hidden structures
- Make interaction more natural
- Substitute for missing senses for impaired people

Interaction Paradigm Shift

- Heads-Up viewing
- No standard input devices

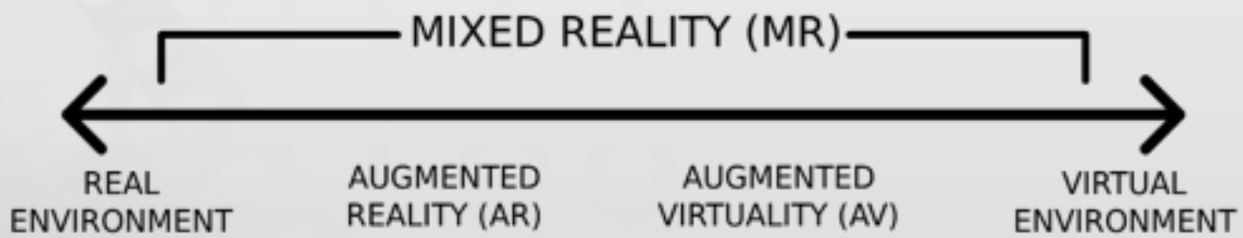
Ivan Sutherland 1986





Definitions

- Reality–Virtuality continuum (Milgram and Kishino 1994)
  - In AV and VE/VR the surrounding environment is virtual, in AR the surrounding environment is real



- Characteristics for AR system (Azuma 1997)
  - Combines real and virtual objects in a real environment
  - Registers (aligns) real and virtual objects with each other
  - Runs interactively and in real time

Diminished Reality

Herling ISMAR '10

https://www.youtube.com/watch?v=FgTq-AgYITE

AR Topics

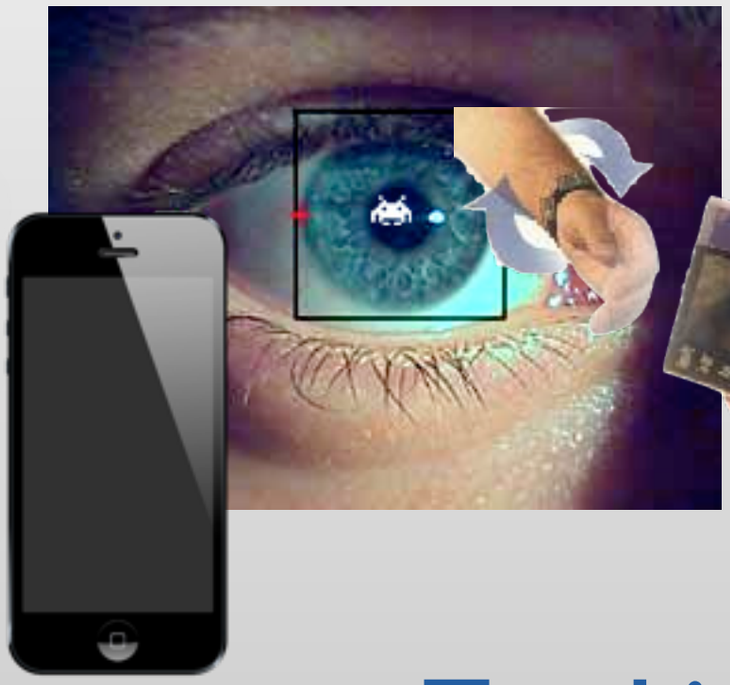
- Technologies
- Interaction
- Applications

Technologies

Output

Input

Reitmayr AUIC '03

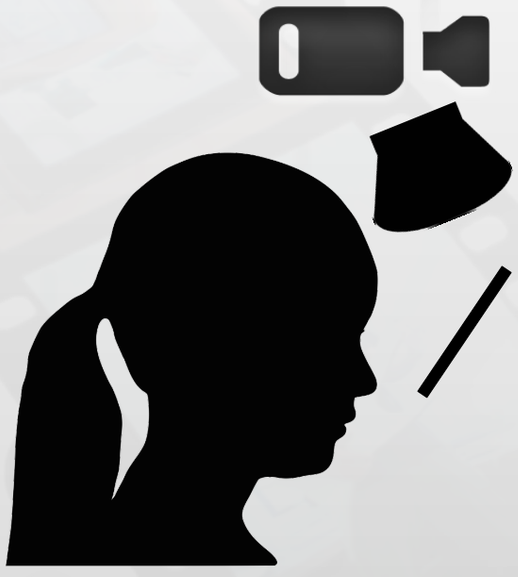


Feldman ISWC '05

Processors

Tracking sensors

Displays - HMD

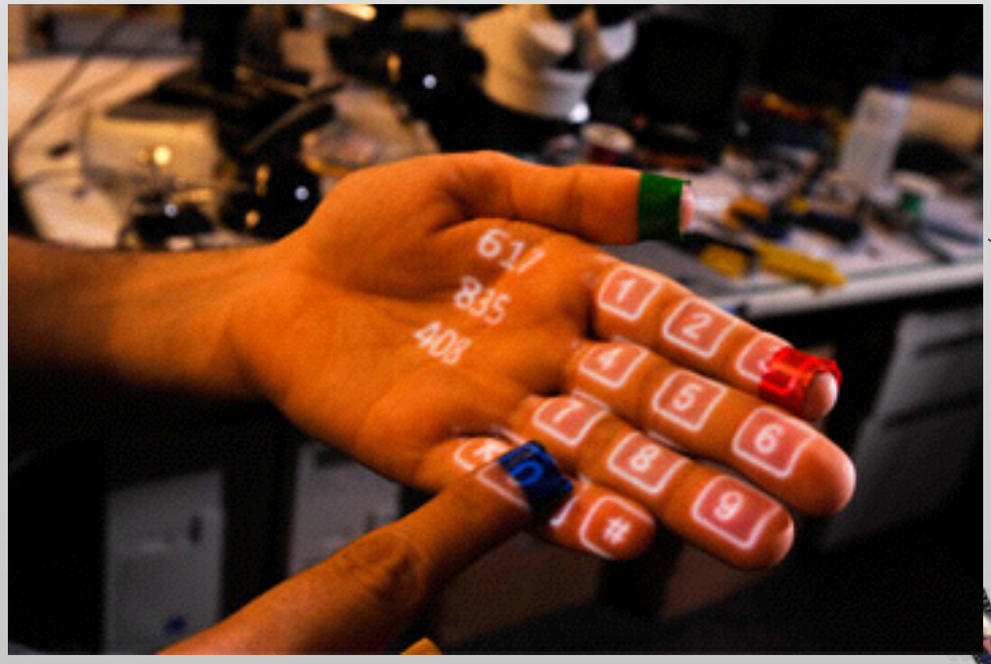


Video see-through

Optical see-through

Displays

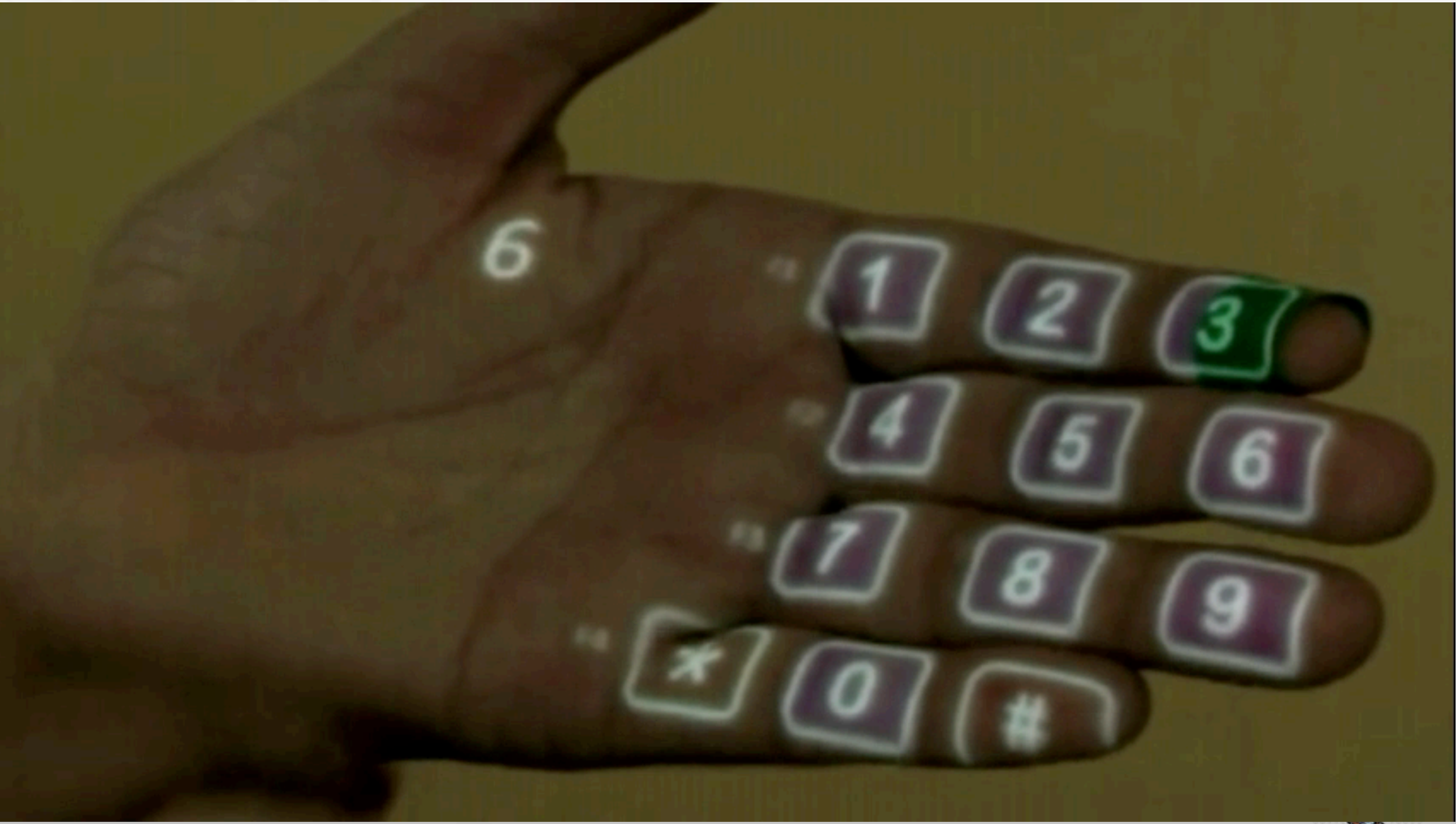
- Handheld displays
- Projection displays



Mistry SIGRAPH'09

SixthSense

Mistry SIGRAPH'09



https://www.youtube.com/watch?v=nZ-VjUKAsao

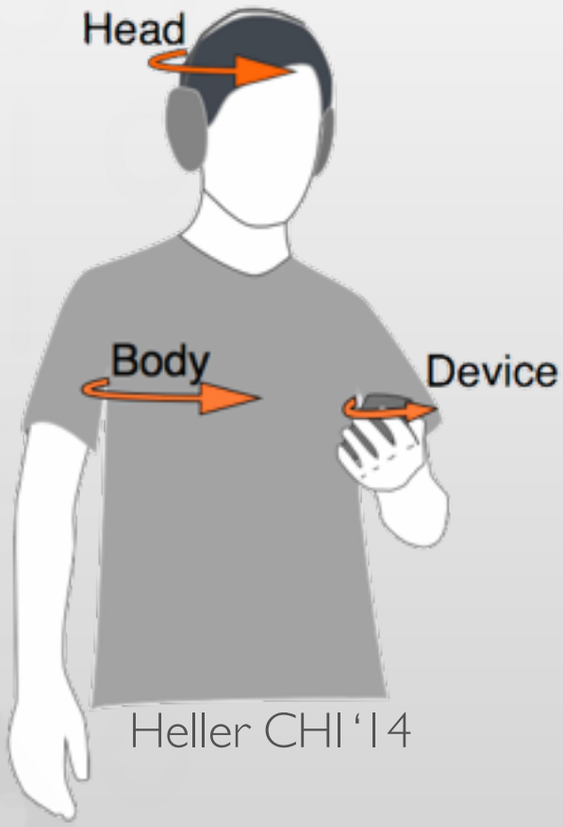
Comparison

	HMD Video see-through	HMD Optical see-through	Handheld	Projectors
Advan.	visual control, sync., less dependent on environment	more natural perception	portable, widespread, powerful, camera, tracking	displays directly onto physical objects' surfaces
Disadvan.	camera and processing, unnatural perception	time lag, jitter of virtual image	small display	(+/-) not user dependent

Carmigniani & Furht & Anisetti &Ceravolo & Damiani & Ivkovic, '11: "Augmented reality technologies, systems and applications"

Tracking

- Inertial sensors
  - Digital compasses and GPS, accelerometers, solid state compasses, wireless sensors, etc



Heller CHI '14


Reitmayr AUIC '03

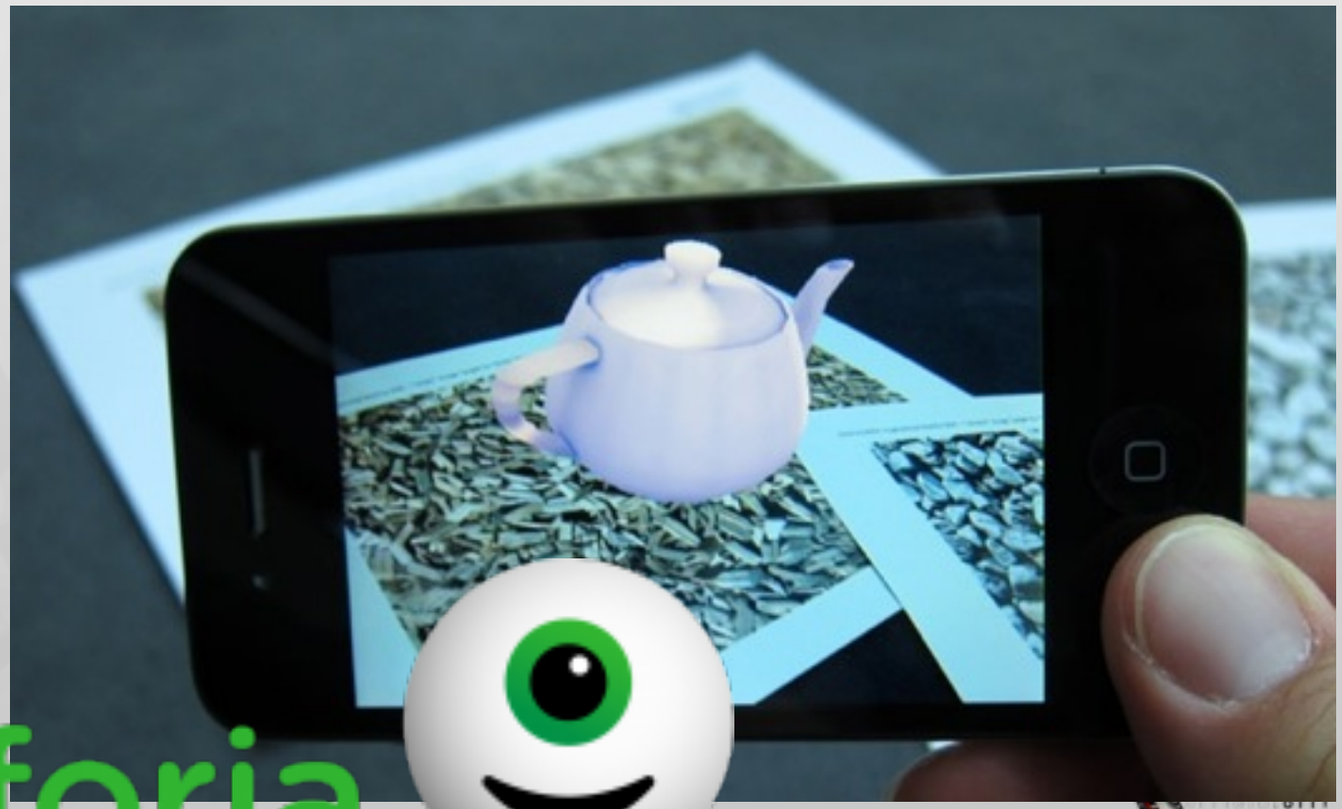
- Optical/Visual tracking
  - Marker systems, e.g., fiducial
  - Computer vision methods and depth cameras

Tracking Challenges

- Environment Sensing
  - User perspective: Adapt overlay to user's dynamic orientation
  - Scene perspective: Project overlay in visible and meaningful way, aligned with the real world
- Low latency
- Calibration
  - Both user and scene
- Choice of tracking technology depends on AR System (fixed/mobile, indoor/outdoor)

DIY AR SDKs

- Image recognition & tracking, 3D model rendering, video overlay and location based AR
- Define points of interest, attach information to them, and using corresponding app the information appears on the video flow
- SDKs
  - Wikitude, Vuforia, Layar, etc.



vuforia™
by Qualcomm

Interaction

- Gestures
- Tangibles
- Heterogeneous devices
  - Other displays
- Multimodal

Lee MITA '12

https://www.youtube.com/watch?v=Dso8wubI6mw

Mistry ICST '08

TUI

Marner 3DUI '10

https://www.youtube.com/watch?v=VPUT2I5JvT0

AR Systems

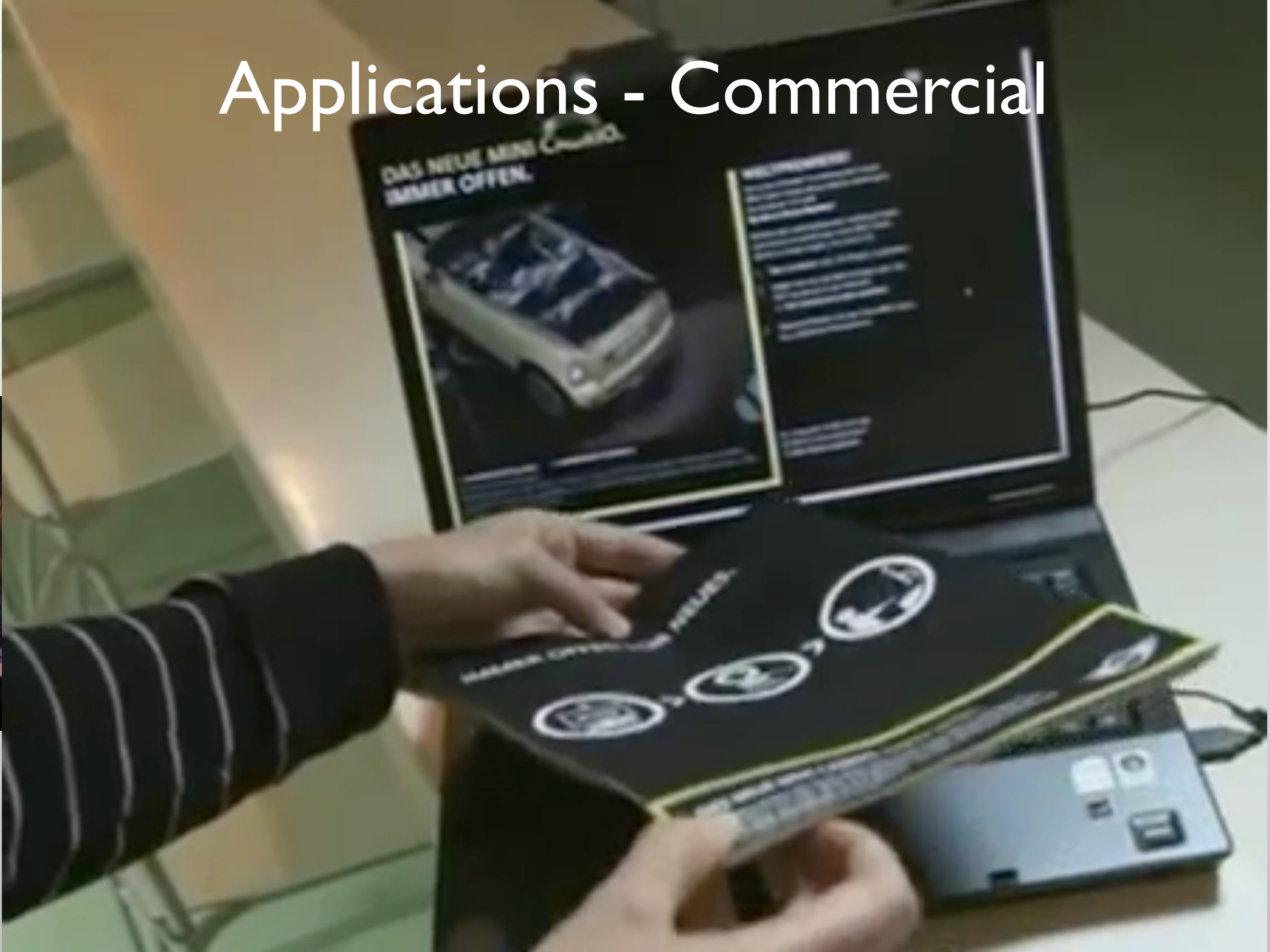
- Carmigniani and Furht categorized AR systems into five categories
  - Fixed indoor systems, fixed outdoor systems, mobile indoor systems, mobile outdoor systems, and mobile indoor and outdoor systems

Mobile AR

- Features
  - Enable user to focus on task rather than UI
  - Present private information
  - When wearable: keep hands free
- Location access
  - Geo-location, object recognition, image processing and dynamic tracking
- Apps (mobile browsers)
  - Navigation, public transportation, social media tags, in situ coupons and commercial offers, games, TV guide, in situ wikipedia, tourism
- Obstacles
  - GPS accuracy and limited screen

Applications

Applications - Commercial



Applications - Medical

Bichlmeier IEEE ‘07

Applications - Guided Tours

- Rich information
- On the move
- Support several languages
- No need to wait in line

Applications - Entertainment

Geographic Information System (GIS) + AR

- Augmented Maps
  - Represent the environment in a more natural and representative fashion

- Augmented Territories
  - Augment the environment itself to enhance users' interaction
  - Sea navigation
  - Road navigation
  - Augmenting underground constructions
  - Indoor navigation

PinkFroot

Blaupunkt

Hugues, Cieutat, and Guitton, '11: "GIS and Augmented Reality: State of the Art and Issues"

Applications - Training Systems

Anderson UIST '13

YouMove

Enhancing Movement Training using an Augmented Reality Mirror

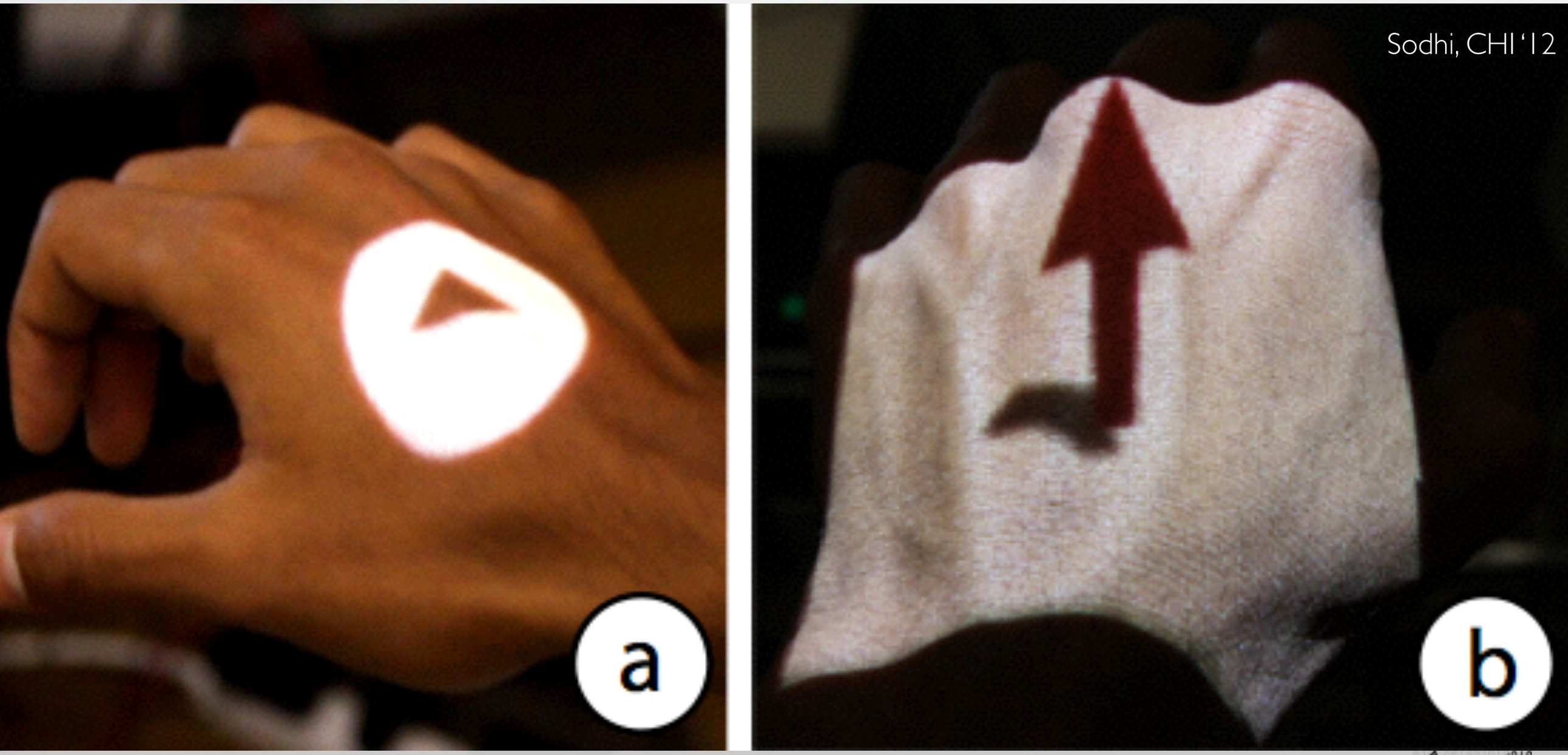
Fraser Anderson[1,2], Tovi Grossman[1], Justin Matejka[1], George Fitzmaurice[1]

[1]Autodesk Research
Toronto, ON, Canada

[2]University of Alberta
Edmonton, AB, Canada

https://www.youtube.com/watch?v=DsZ-9opi150

Applications - Training Systems

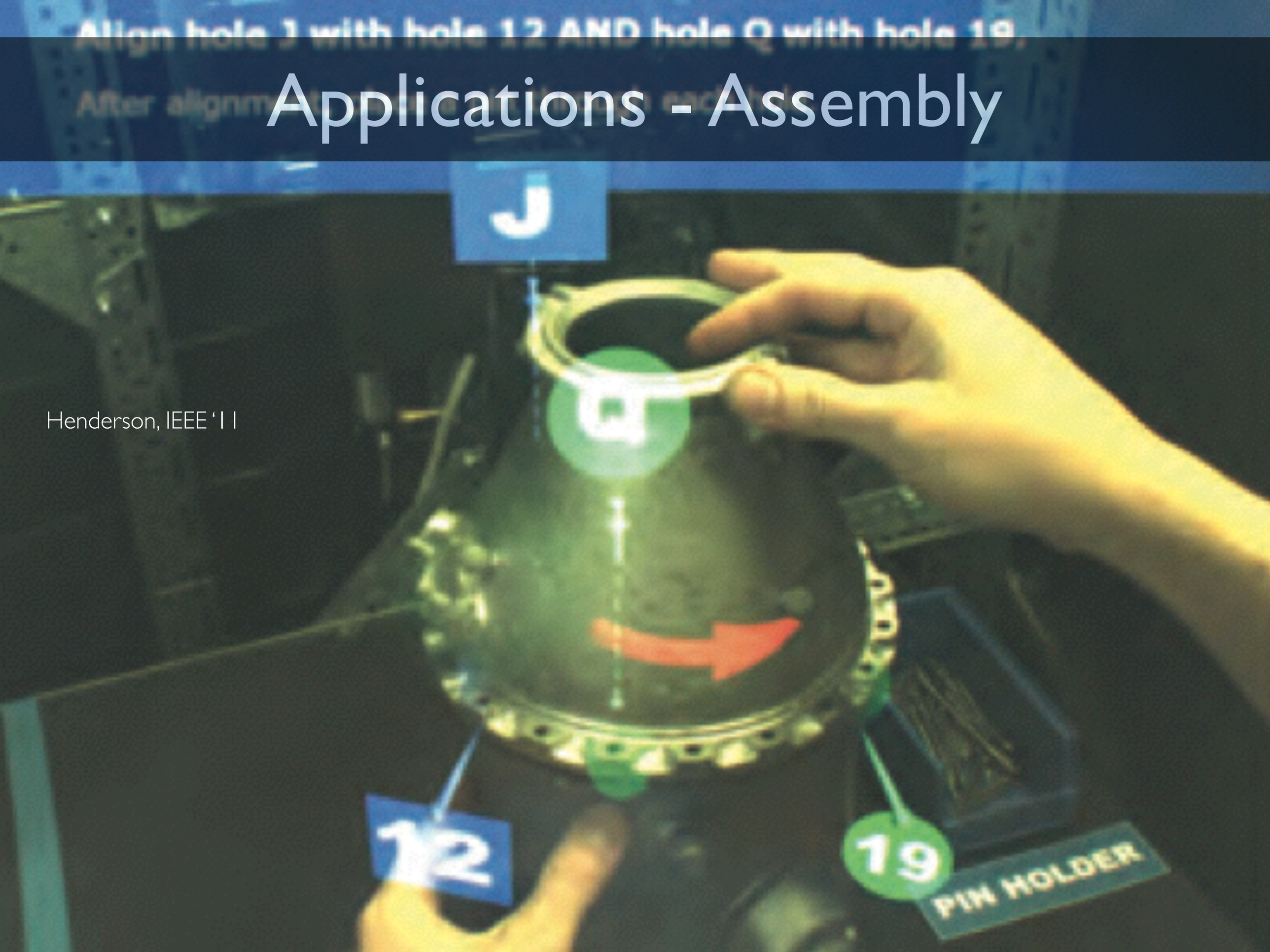


https://www.youtube.com/watch?v=tfWY3EotrRw

Applications - Augmented Feedback

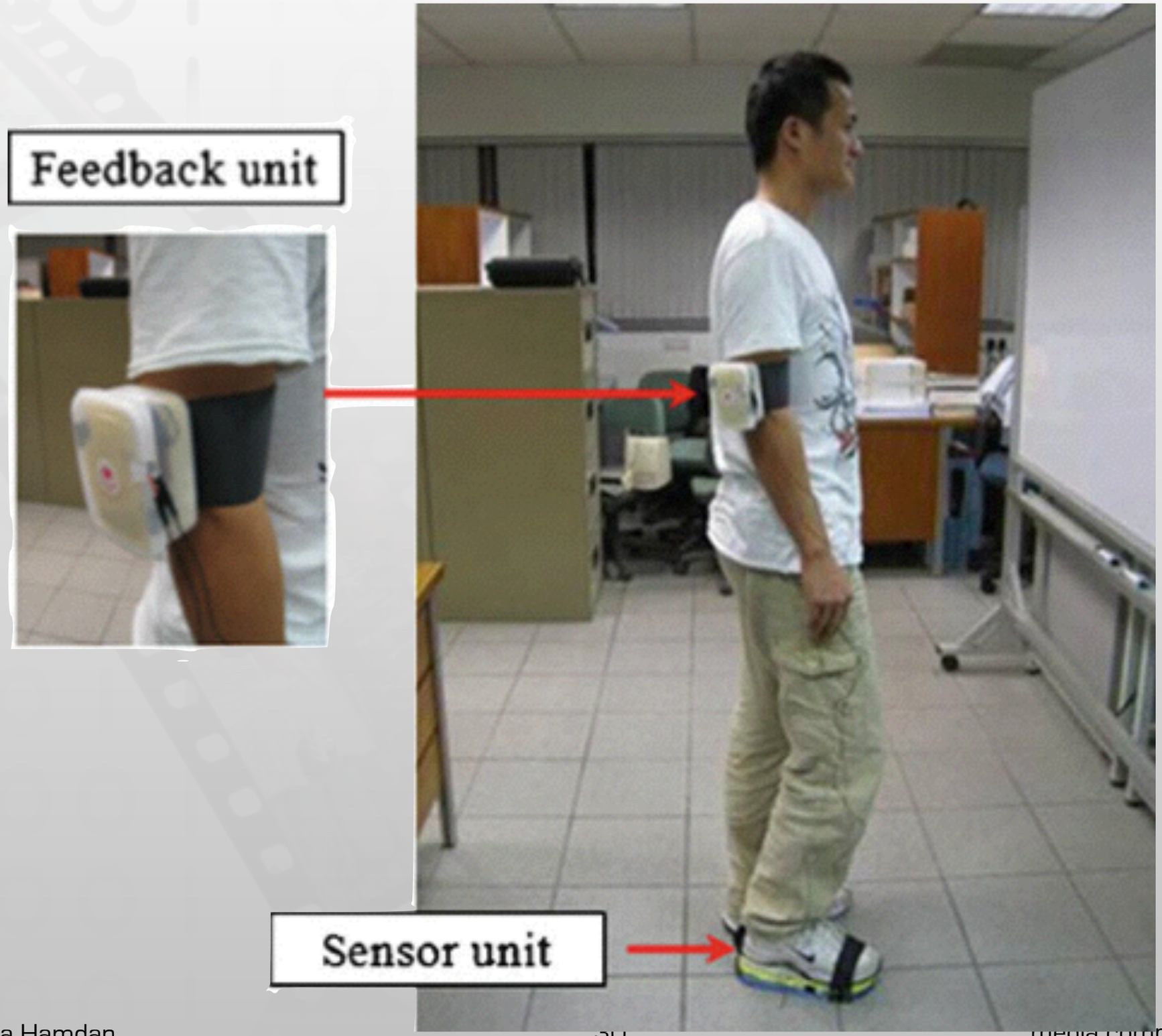
Mononen ‘07

Applications - Assembly



Henderson, IEEE '11

Applications - Rehabilitation



User Evaluation

User Evaluation

- A problem in AR research: not many user-based experiments
  - Technology is still not perfect
  - Depends on human perception, ergonomics, and attention models
  - Difficult to conduct in a well-controlled manner that is repeatable and reliable (On-off prototypes and variability)
  - Lack of suitable methods for evaluating AR interfaces
  - Who is the user? What problem are we solving? Who can evaluate the system?

User Evaluation

- Usability tests
  - Learnability, Efficiency, Memorability, Errors, and Satisfaction (Nielsen)
  - Early on in the research project, using e.g., think aloud method or heuristic evaluation
  - Allow for rapid iterative design
  - Cannot be generalized
- User studies to answer research questions
  - For example, user interaction (efficiency or accuracy), behaviour, collaboration, ergonomics, performance, experience, etc
  - Incremental knowledge

User-based Studies in AR

- Based on work conducted by Swan and Gabbard VR '05, most AR user evaluations fit into one of four categories:
  - Low-level tasks: understanding human perception and cognition in AR contexts
  - User task performance: how AR technology could impact underlying tasks
  - Examine user interaction and collaboration
  - System usability

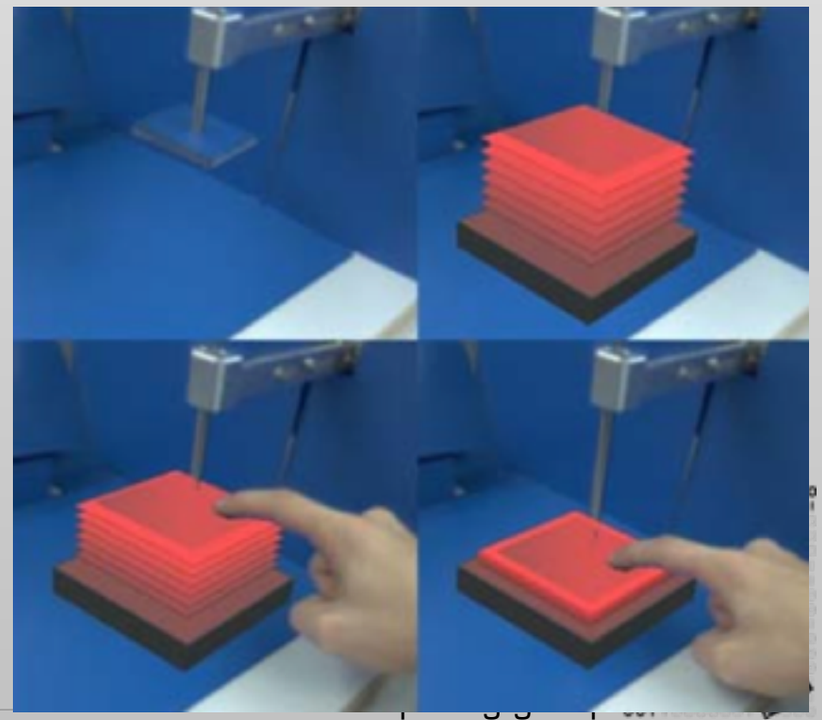
Evaluation Methods in AR

- Objective measurements
  - Measured numbers, reliable and repeatable, e.g., completion time, accuracy, object position

Gabbard and Swan IEEE Trans. '08

- Subjective measurements
  - Subjective judgment of people, e.g., from questionnaire and rankings

Knörlein ISMAR '09



Dünser and Billinghurst, '11: "Evaluating Augmented Reality Systems"

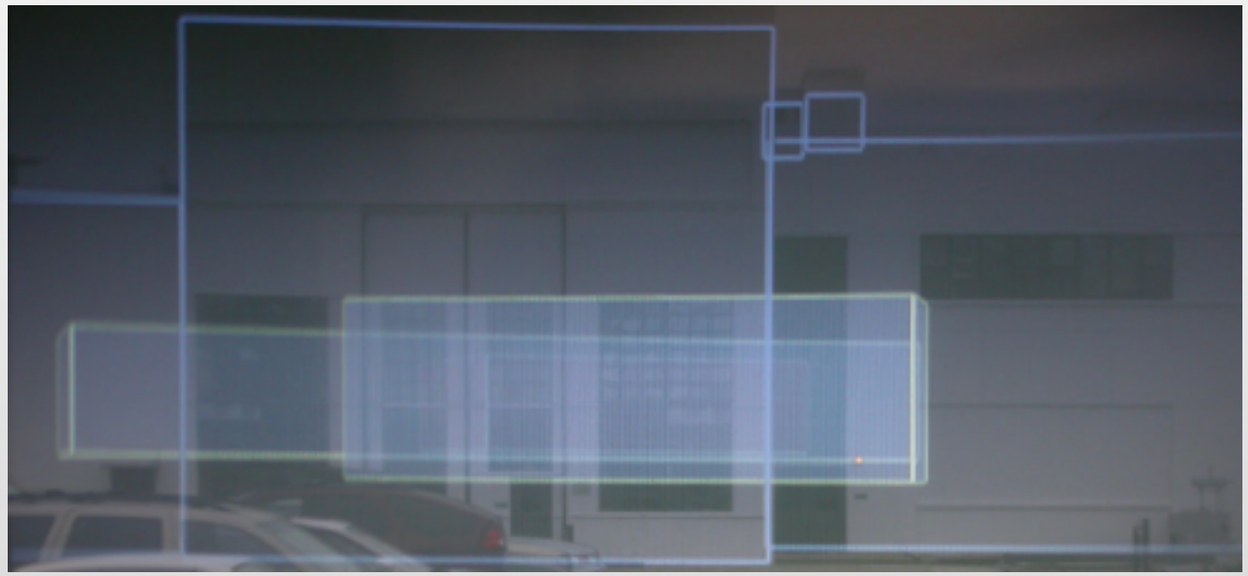
Evaluation Methods in AR

- Qualitative analysis
  - Data is gathered through observations and interviews
- Non User-Based techniques
  - Such as cognitive walkthroughs or heuristic evaluations with experts
- Informal testing
  - Reporting observations gathered during demonstration

Morrison CHI '09

Visualisation Challenges

Livingston ISMAR '03



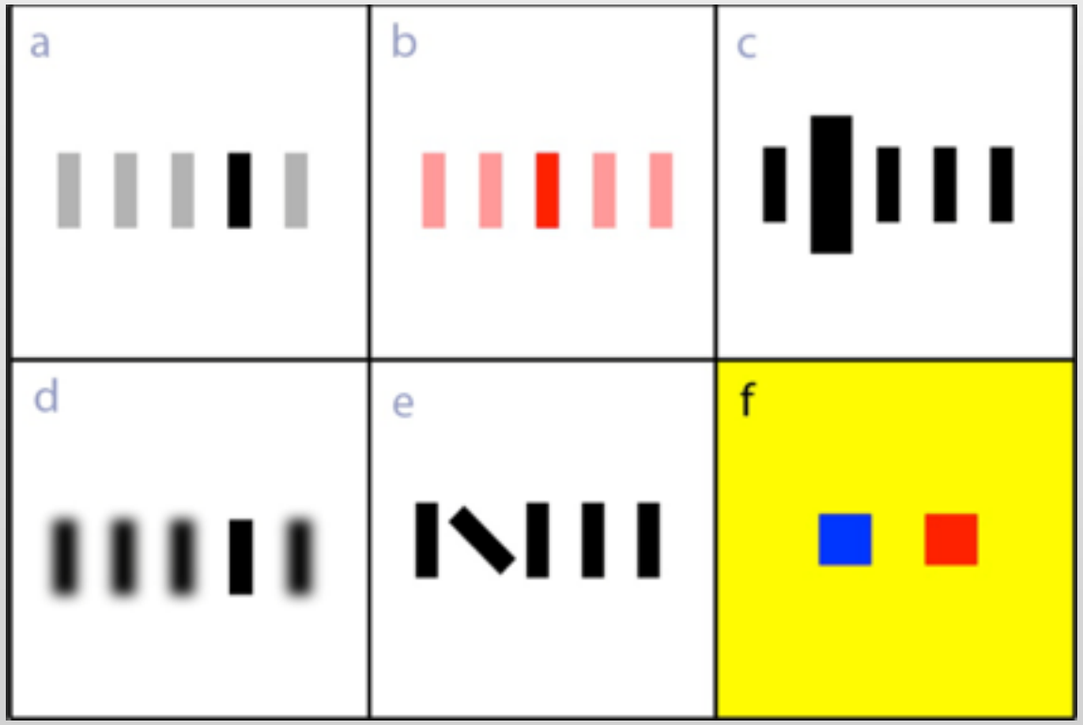
1. Depth sensing techniques
   - Occlusion paradox
   - Context preservation

Kalkofen ISMAR '07

Visualisation Challenges

2. Attention direction techniques

- Overlays, e.g., using arrows and circles; (+) visibility, (-) increase visual clutter
- Pixel-based, e.g., by manipulating the brightness, contrast, size, etc of parts of the image; (+) maintain scenes from visual pollution, (-) hard to perform in real time

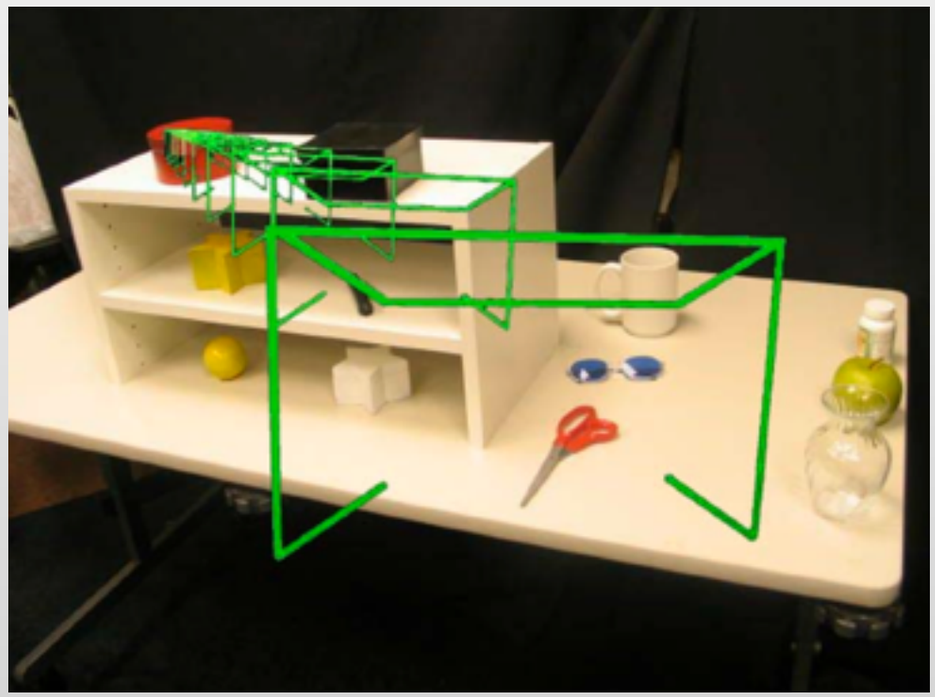


Mendez, '10: "On the Usage of Context for Augmented Reality Visualization"

Exercise

- Write a simplified study protocol to evaluate the attention funnel
- Attention funnel vs. visual cues (e.g., circle around object) and auditory cue telling the user what object to find
- IV, DV, hypothesis, study design, study setup (hardware)

Biocca '06



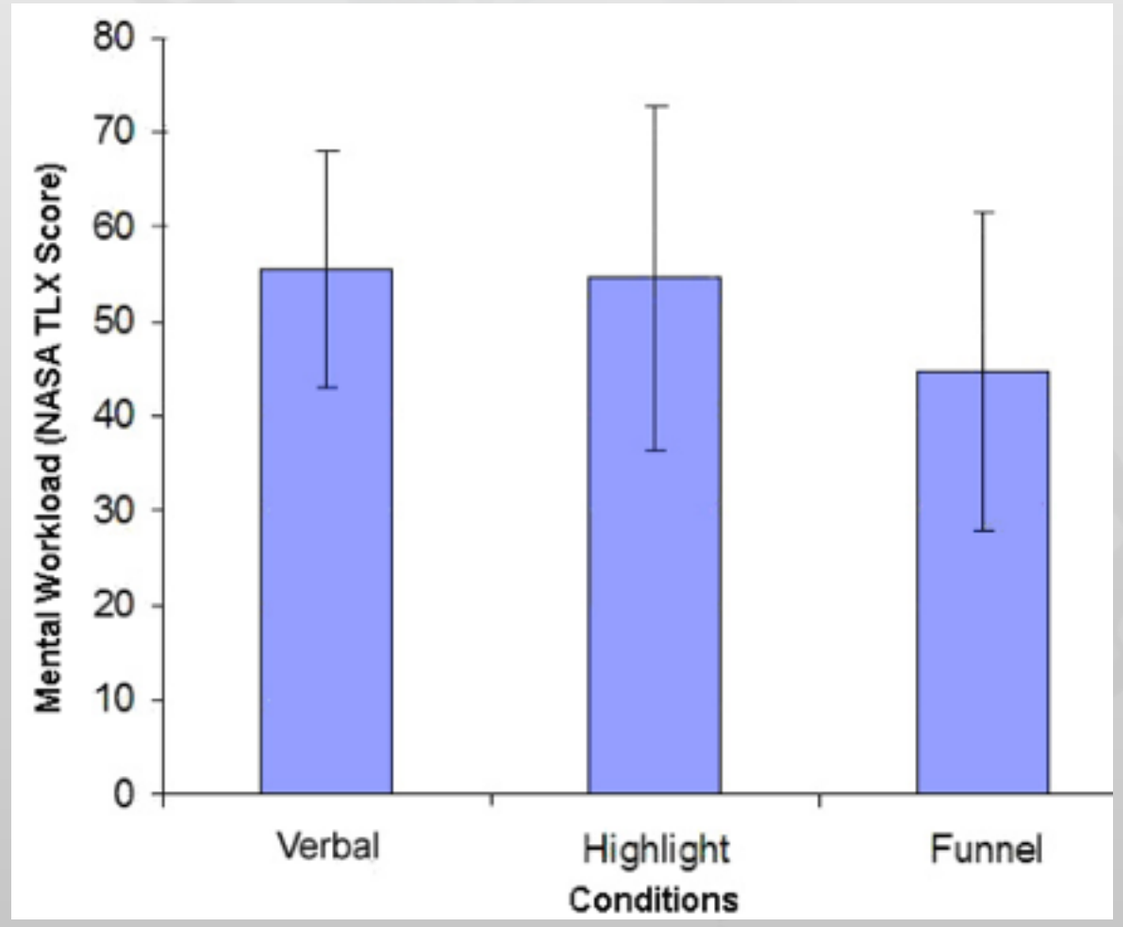
Attention Funnel User Study

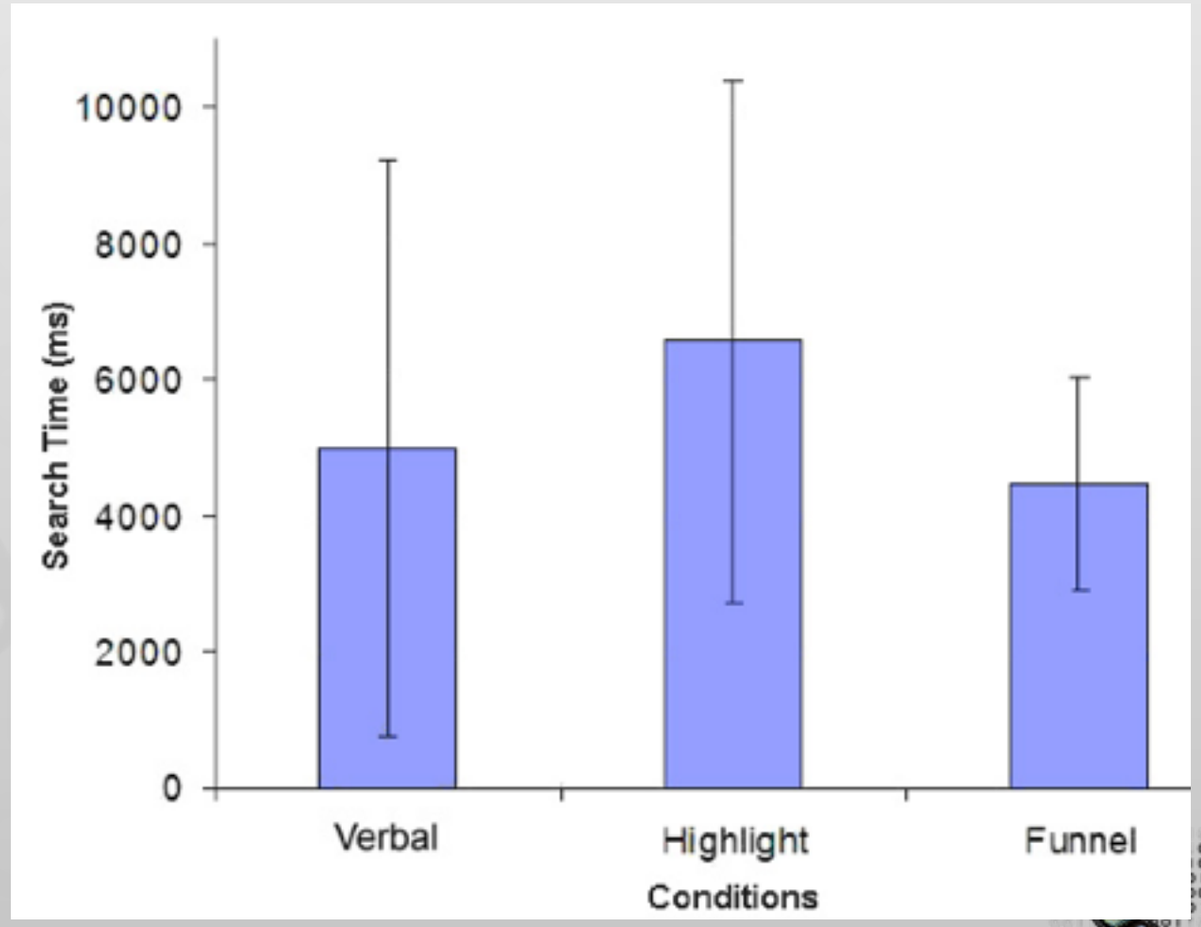
- Within-subject, 14 participants
- IV: Attention direction technique (funnel, visual cue, verbal cue)
- DV: Search time, error, and and mental workload (NASA TLX, online)
- HMD video see-through, ultrasonic/inertia hybrid tracking system, and a pressure sensor was attached to the thumb of a glove to capture the reaction time

Biocca '06

Attention Funnel Results

- Funnel decreased the visual search time by 22%
- Increased consistency of performance by 65%
- Significantly reduced workload



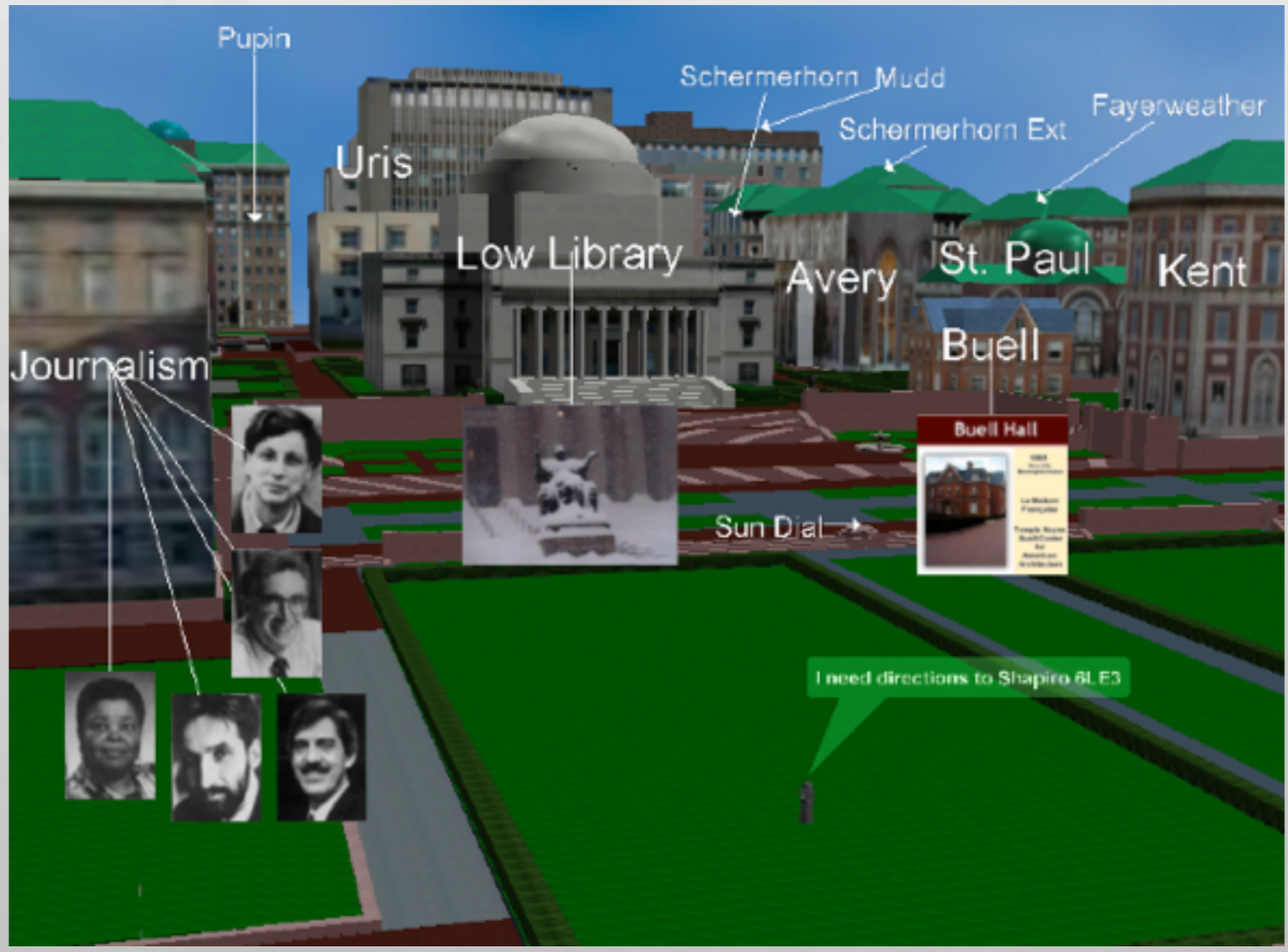


Biocca '06

Visualisation Challenges

3. View management

- How information should be represented in digital displays to avoid/ decrease visual clutter, distortion, and occlusion
- Related object properties: visibility, position, size, transparency, and priority

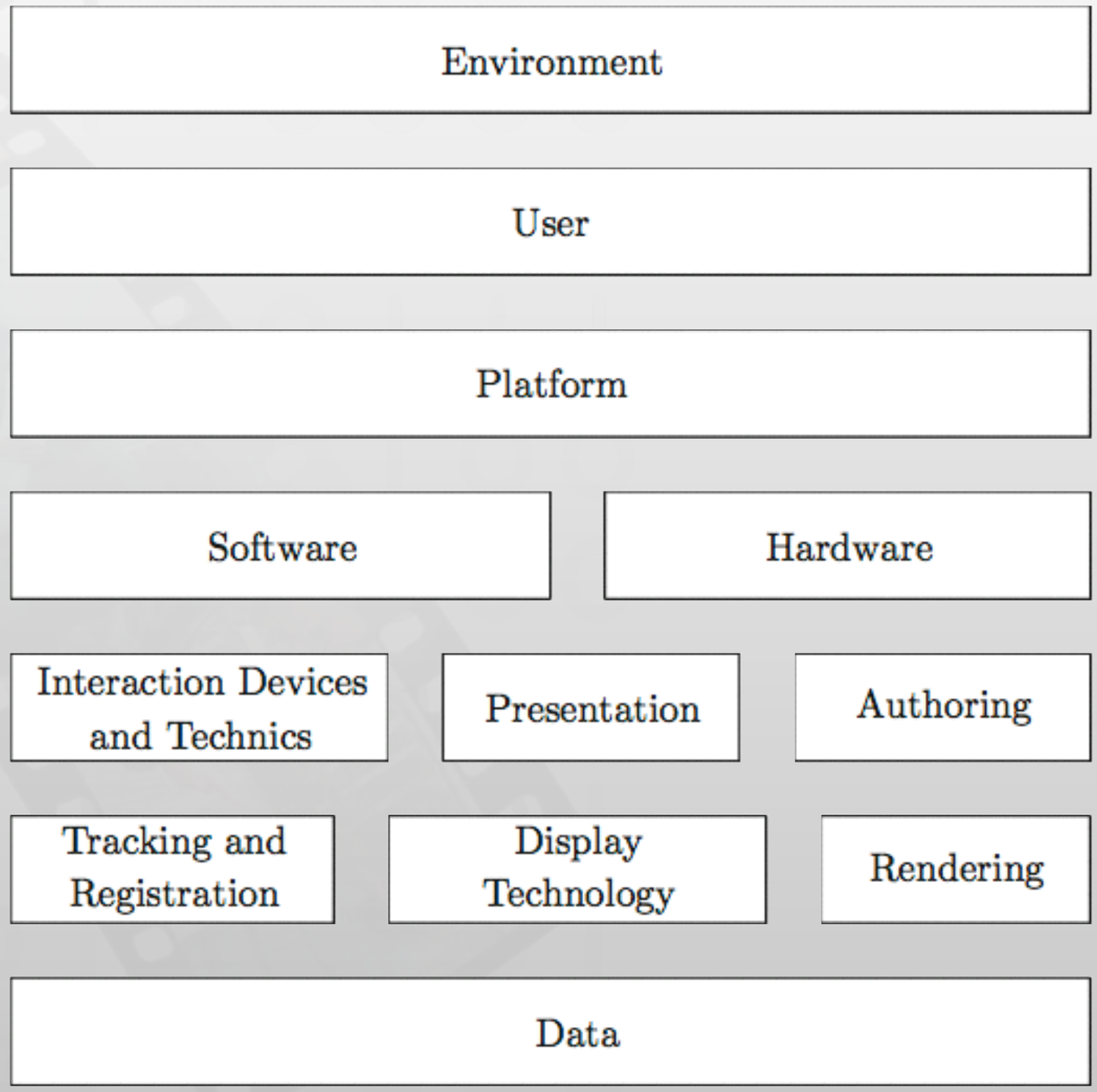


Bell UIST '01

Future research in AR

- Understand human perception and attention models
- Study the effect of AR on fatigue and strain
- Social acceptance
- Privacy
- Improved tracking systems and displays
  - Innovation: more compact and mobile lenses
- Improve in situ visualisations

AR Blocks



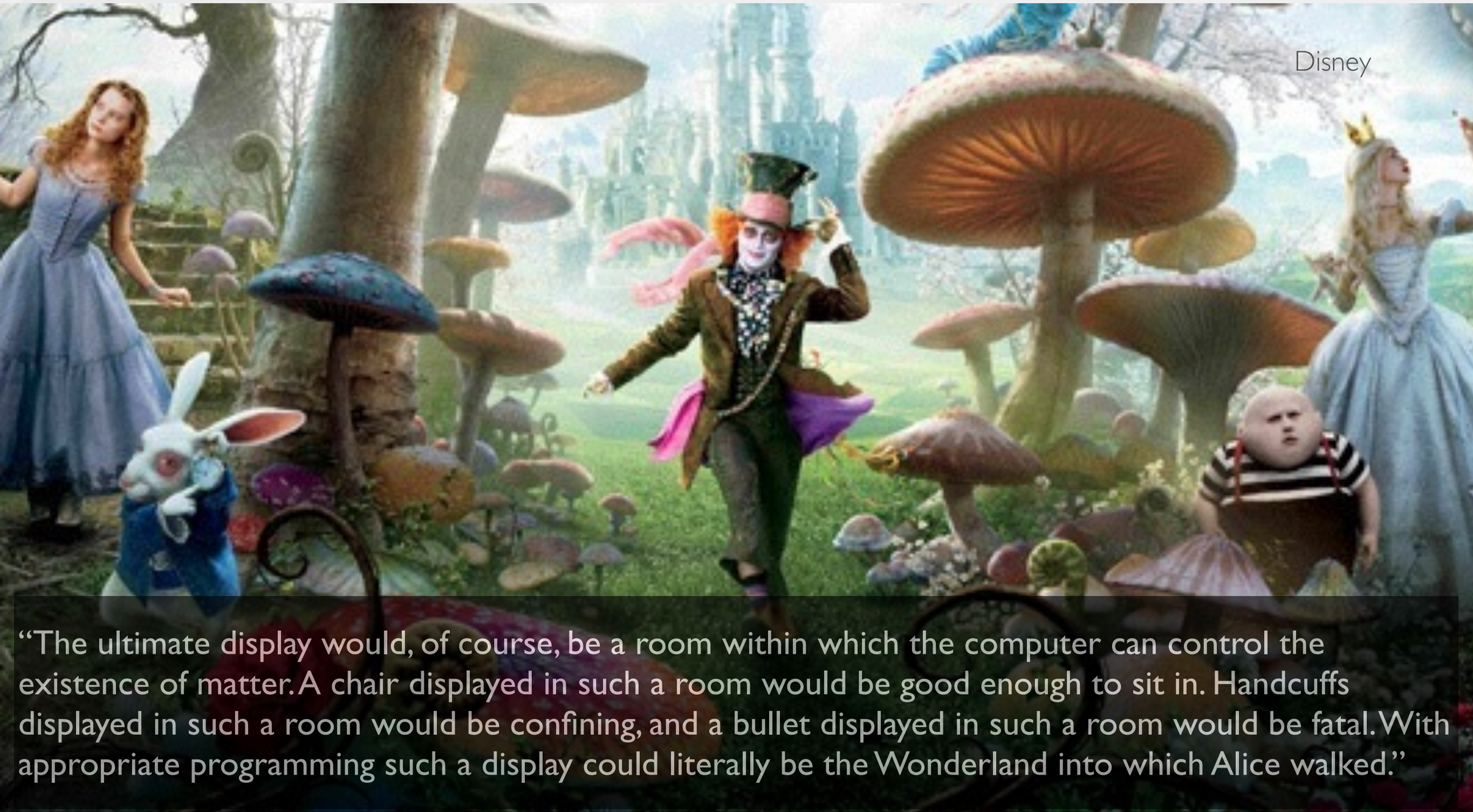
Hugues, Cieutat, and Guitton, '11: "GIS and Augmented Reality: State of the Art and Issues"

Summary

- Five barriers we must overcome
  - Technology
  - Methodologies to analyze and evaluate AR systems
  - Evaluation that manifests the value of AR systems
  - Safety and health issues
  - Usability

Wilson and M. D'Cruz, '06, "Virtual and interactive environments for work of the future"

The Ultimate Display ~ Sutherland



"The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked."