

Research in Augmented Reality

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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

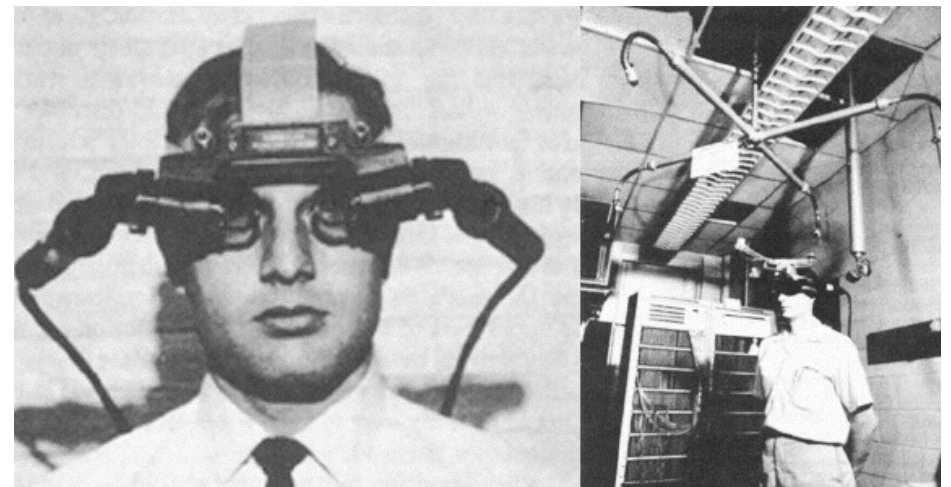
Washer Fluid
Empty

Fix Now

Fix Later

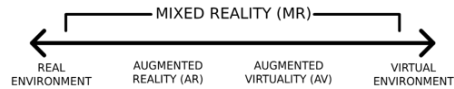
- Heads-Up viewing
- No standard input devices

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

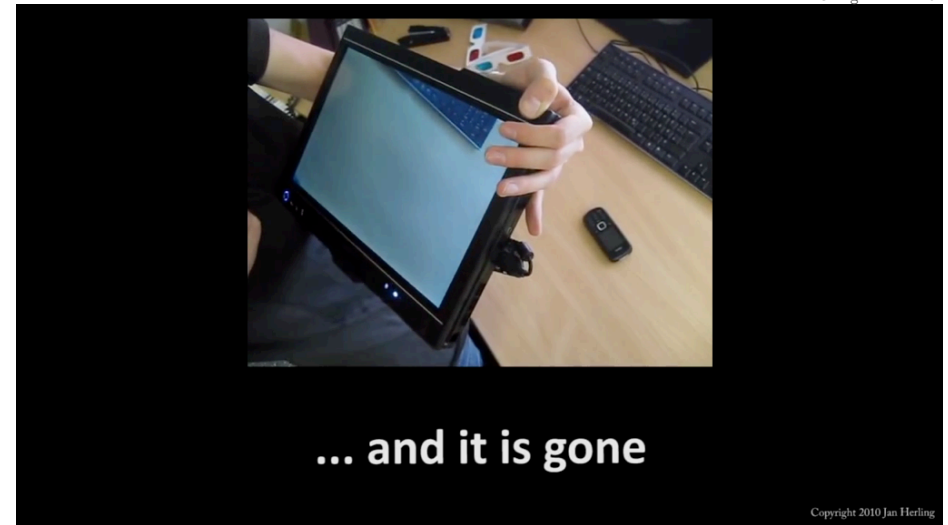


- Characteristics for AR system (Azuma 1997)
 - Combines real and virtual objects in a real environment
 - Registers (aligns) real and virtual objects with each other
 - Runs interactively and in real time



Diminished Reality

Herling ISMAR '10



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

AR Topics

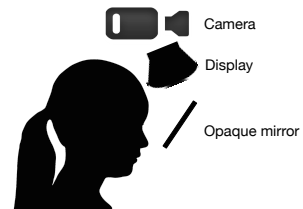
- Technologies
- Interaction
- Applications



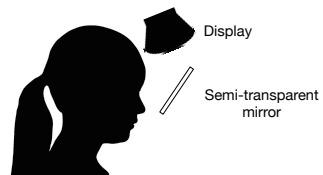
Technologies



Displays - HMD



Video see-through

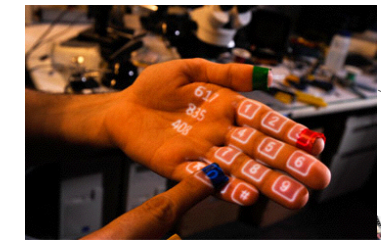


Optical see-through



Displays

- Handheld displays
- Projection displays



Mistry SIGRAPH'09

SixthSense

Mistry SIGRAPH'09



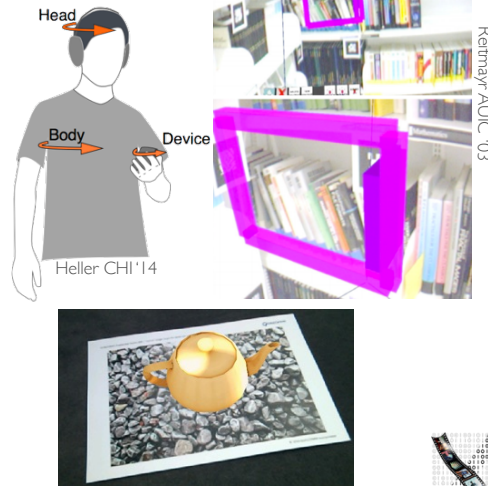
<https://www.youtube.com/watch?v=nZ-VjUKAsao>

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

Tracking

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



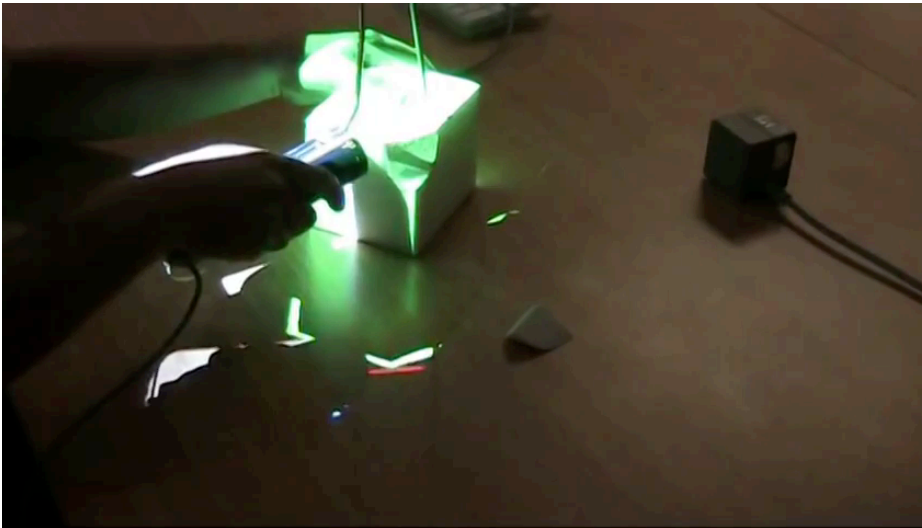
Interaction

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



TUI

Marner 3DUI '10



<https://www.youtube.com/watch?v=VPUT2I5jvTQ>



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

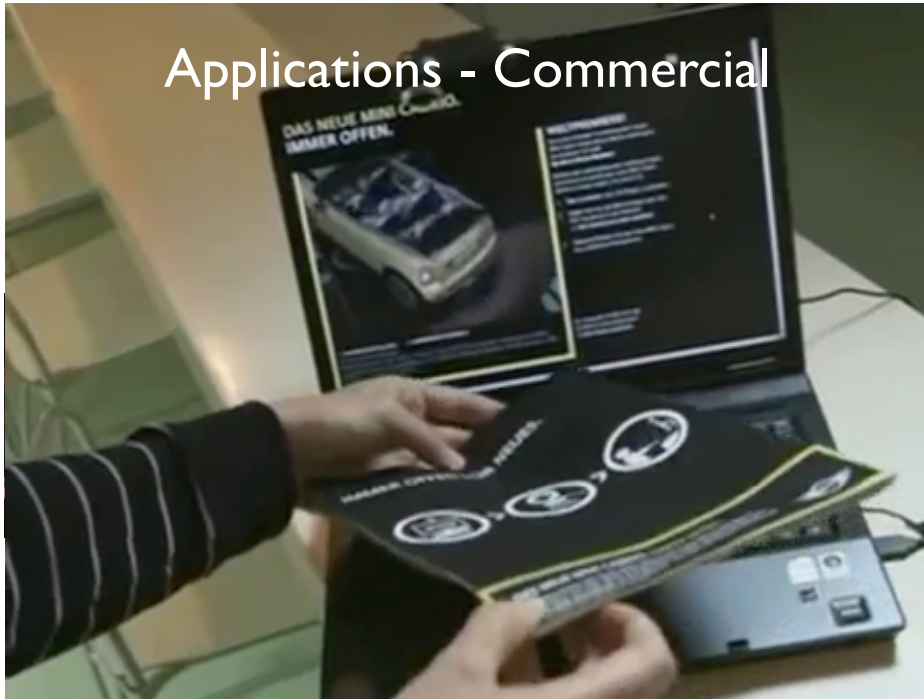
- Features
 - Enable user to focus on task rather than UI
 - Present private information
 - When wearable: keep hands free
- Location access
 - Geo-location, object recognition, image processing and dynamic tracking
- Apps (mobile browsers)
 - Navigation, public transportation, social media tags, in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



Applications



Applications - Commercial

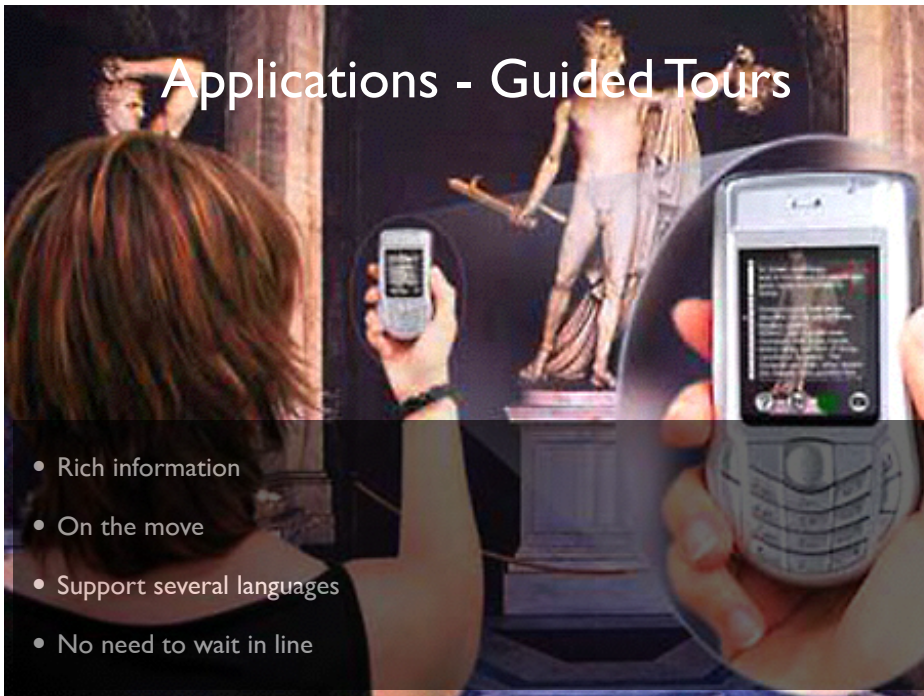


Applications - Medical



Bichlmeier IEEE '07

Applications - Guided Tours



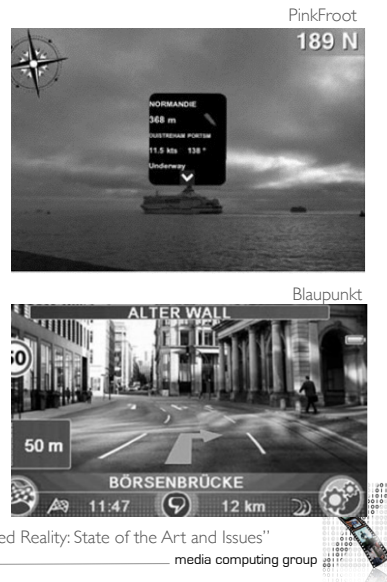
- Rich information
- On the move
- Support several languages
- No need to wait in line

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



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

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Applications - Training Systems

Anderson UIST '13

YouMove Enhancing Movement Training using an Augmented Reality Mirror

Fraser Anderson^{1,2}, Tovi Grossman¹, Justin Matejka¹, George Fitzmaurice¹

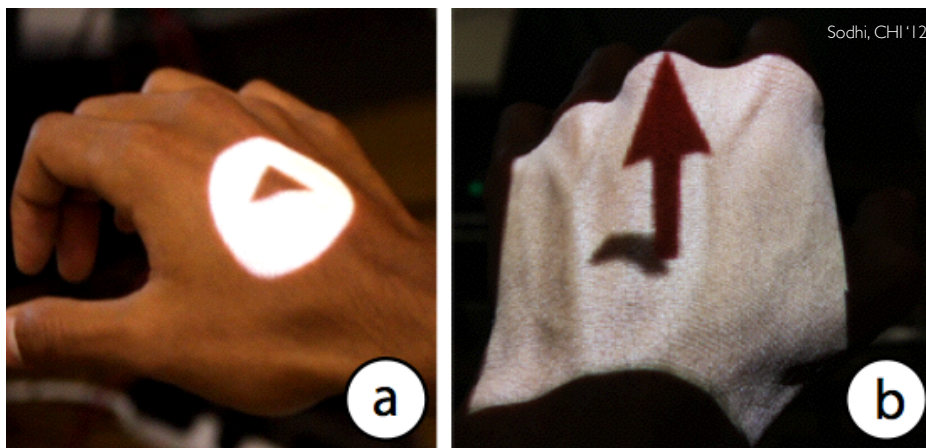
¹Autodesk Research
Toronto, ON, Canada

²University of Alberta
Edmonton, AB, Canada

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

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Applications - Training Systems

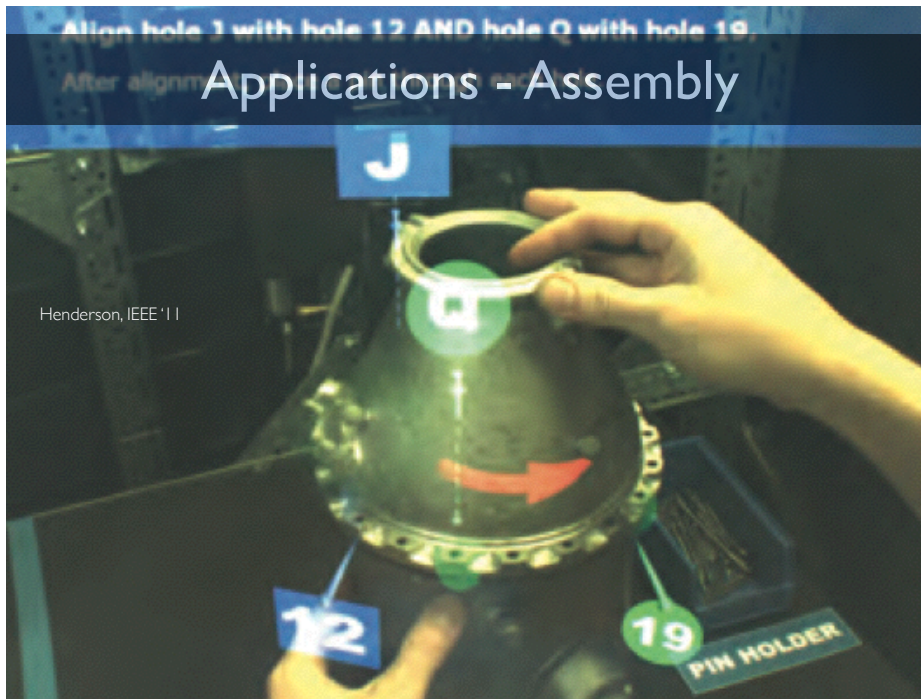


<https://www.youtube.com/watch?v=tfVY3EotrRw>

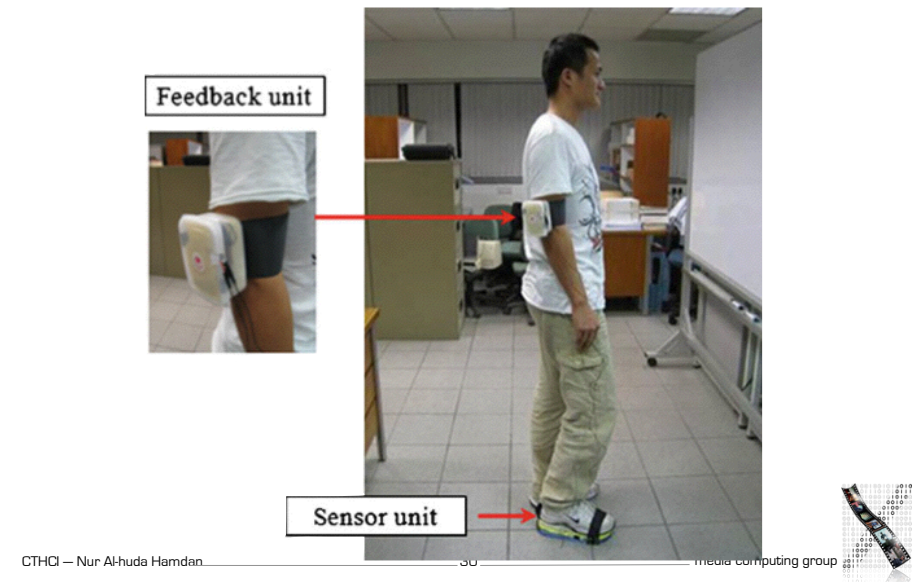
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Applications - Augmented Feedback





Applications - Rehabilitation



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



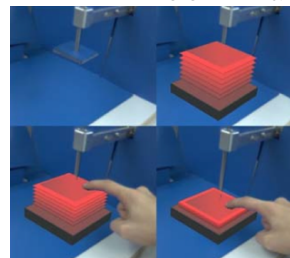
Evaluation Methods in AR

- Objective measurements
 - Measured numbers, reliable and repeatable, e.g., completion time, accuracy, object position
- Subjective measurements
 - Subjective judgment of people, e.g., from questionnaire and rankings

Gabbard and Swan IEEE Trans. '08

KzPmMc	KzPmMc	WzSpOw	KvWoZk
PwMxCp	PwMxCp	ZoSpSx	XvXzUc
MoWeVv	MoWeVv	ZiOwVv	SeCzMz
KzPmMc	KzPmMc	WzSpOw	KvWoZk
PwMxCp	PwMxCp	ZoSpSx	XvXzUc
MoWeVv	MoWeVv	ZiOwVv	SeCzMz
KzPmMc	KzPmMc	WzSpOw	KvWoZk
PwMxCp	PwMxCp	ZoSpSx	XvXzUc
MoWeVv	MoWeVv	ZiOwVv	SeCzMz

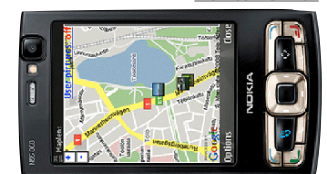
Knörlein ISMAR '09



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

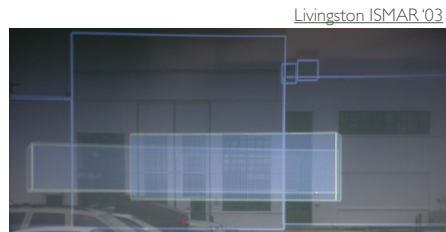
Morrison CHI '09



Visualisation Challenges

I. Depth sensing techniques

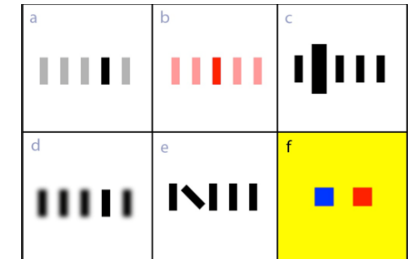
- Occlusion paradox
- Context preservation



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

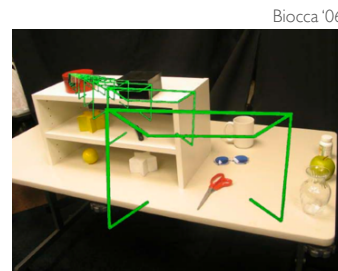


Mendez, '10: "On the Usage of Context for Augmented Reality Visualization"



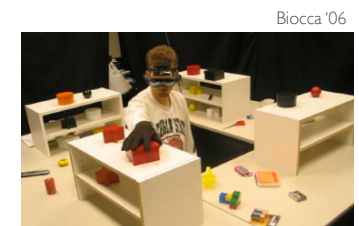
Exercise

- 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)



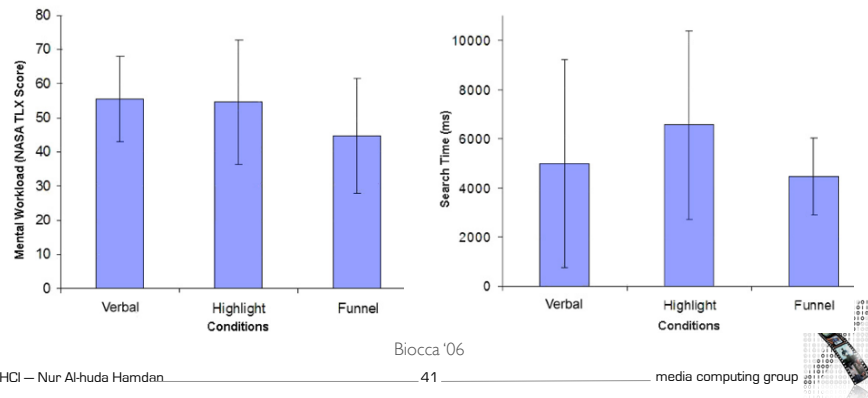
Attention Funnel User Study

- Within-subject, 14 participants
- IV: Attention direction technique (funnel, visual cue, verbal cue)
- DV: Search time, error, 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



Attention Funnel Results

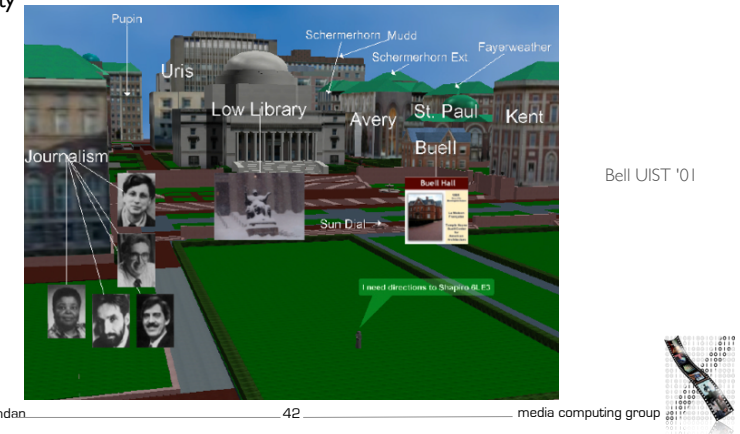
- Funnel decreased the visual search time by 22%
- Increased consistency of performance by 65%
- Significantly reduced workload



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

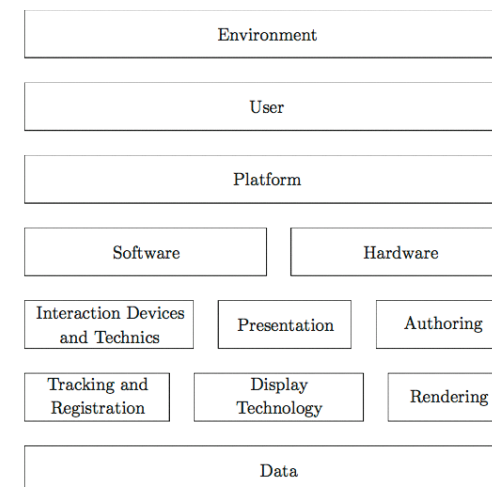


Future research in AR

- 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



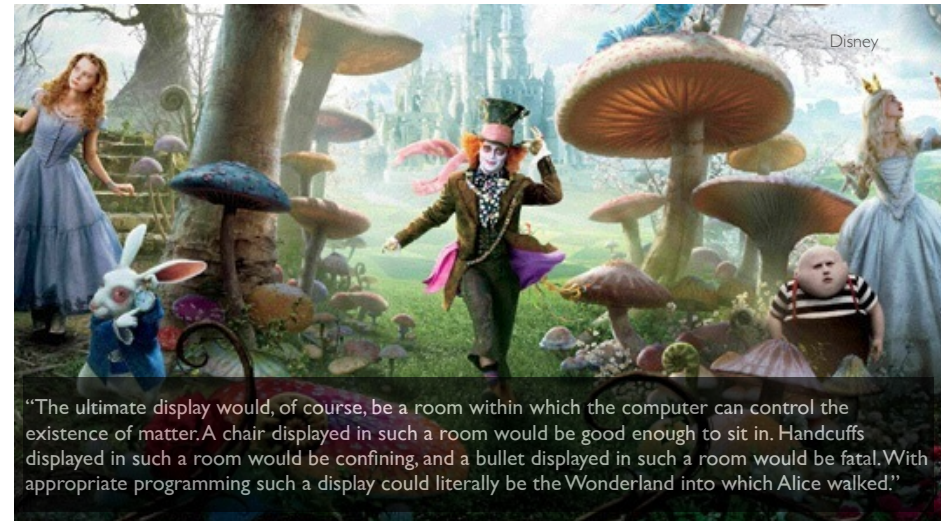
Summary

- 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."