CIS 4930-001: Introduction to Augmented and Virtual Reality

Introduction to Augmented Reality

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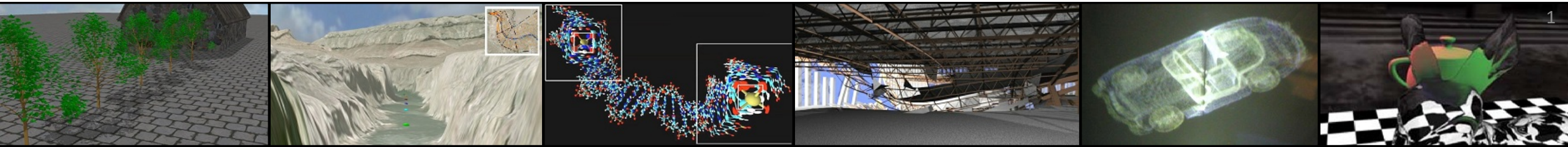
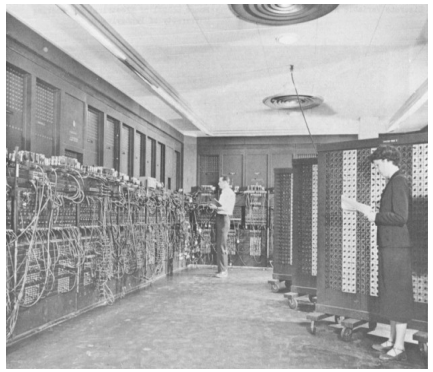


Trend Towards Invisible Interfaces

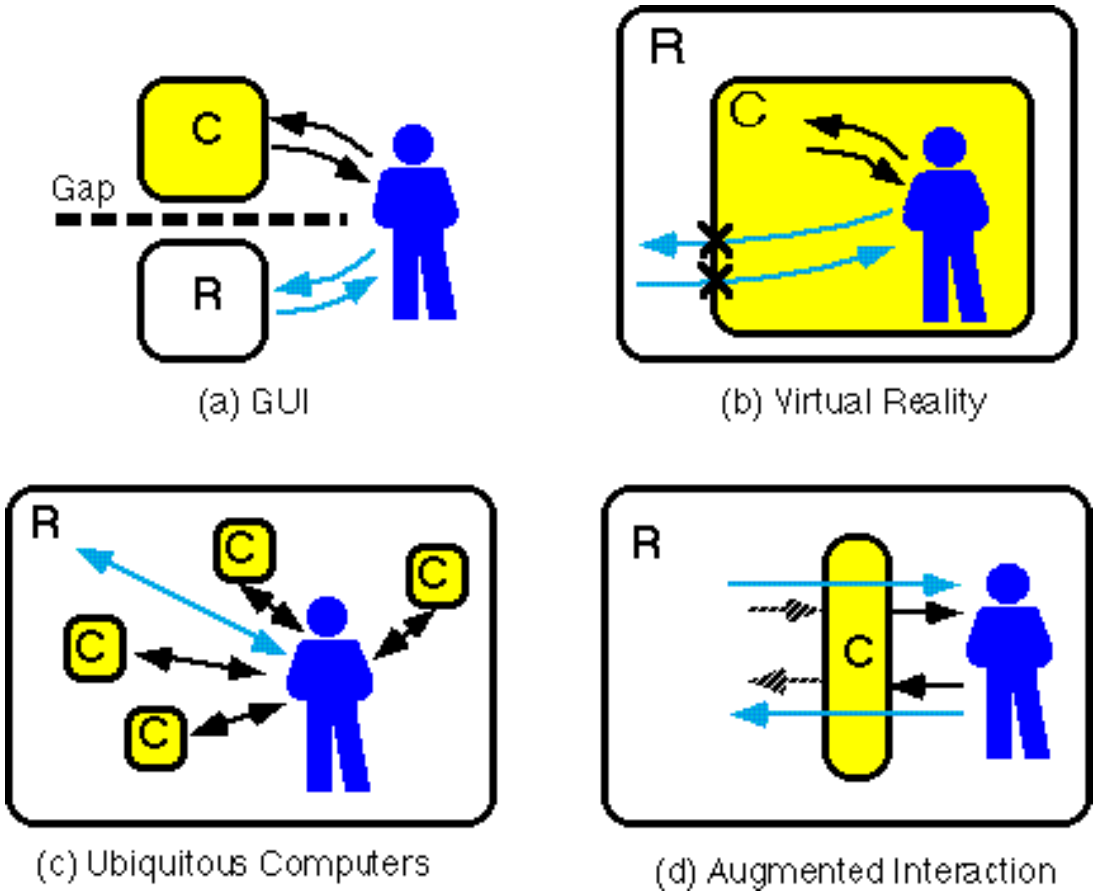



Trend from room scale to invisible computing

Making Computers Invisible

- hide the computer in the real world
  - Ubiquitous Computing
- put the user inside the computer
  - Virtual Reality

MAKING INTERFACES INVISIBLE



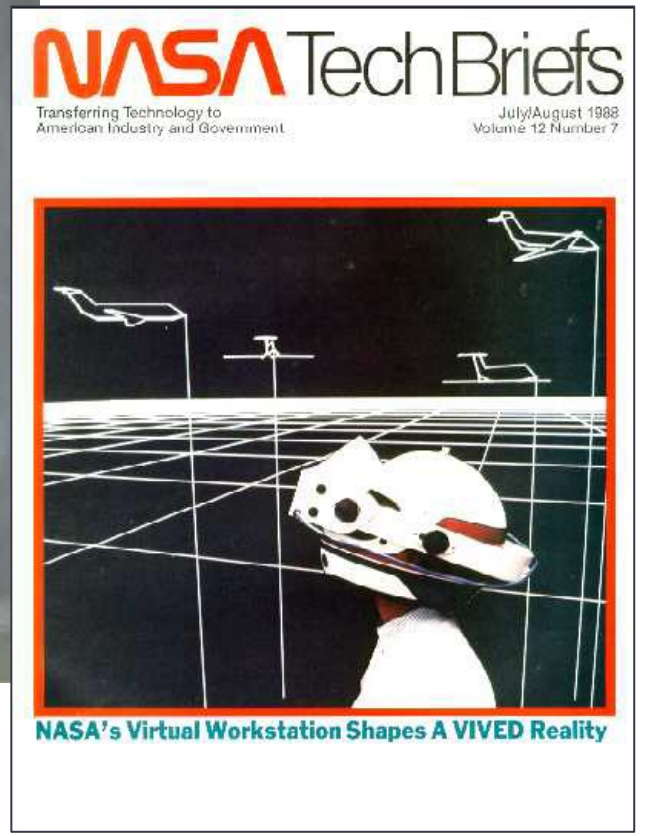
REKIMOTO, J. AND NAGAO, K. 1995. THE WORLD THROUGH THE COMPUTER: COMPUTER AUGMENTED INTERACTION WITH REAL WORLD ENVIRONMENTS. IN *PROCEEDINGS OF THE 8TH ANNUAL ACM SYMPOSIUM ON USER INTERFACE AND SOFTWARE TECHNOLOGY. UIST '95*. ACM, NEW YORK, NY, 29-36.

Graphical User Interfaces

Separation between real and digital worlds

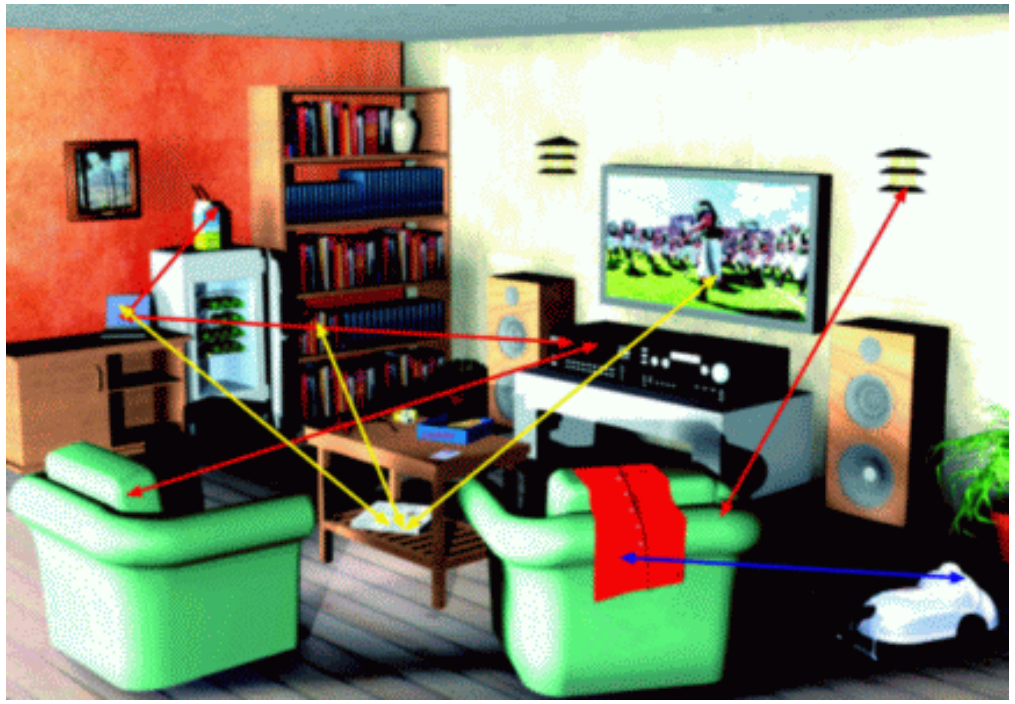
- WIMP (Windows, Icons, Menus, Pointer) metaphor

VIRTUAL REALITY



CIRCA 1985

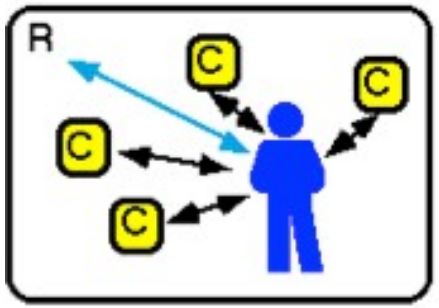
Ubiquitous Computing



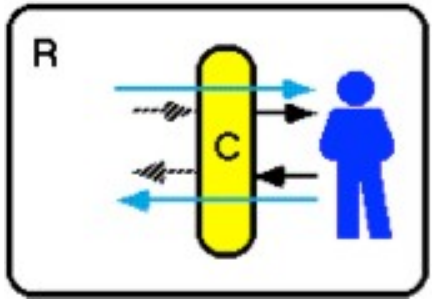
Computing and sensing embedded in real world

- Particle devices, RFID, motes, arduino, etc

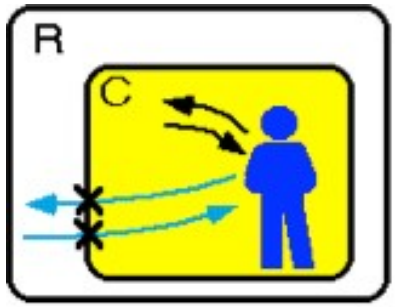
From Reality to Virtual Reality



Ubiquitous Computing



Augmented Reality



Virtual Reality

Augmented Reality

1977 – Star Wars

Augmented Reality

Defining Characteristics [Azuma 97]

- Combines Real and Virtual Images
  - Both can be seen at the same time
- Interactive in real-time
  - The virtual content can be interacted with
- Registered in 3D
  - Virtual objects appear fixed in space

Azuma, R. T. (1997). A survey of augmented reality. Presence, 6(4), 355-385.

Augmented Reality vs. Virtual Reality

Augmented Reality

- System augments the real world scene
- User maintains a sense of presence in real world
- Needs a mechanism to combine virtual/real worlds
- Hard to register real and virtual

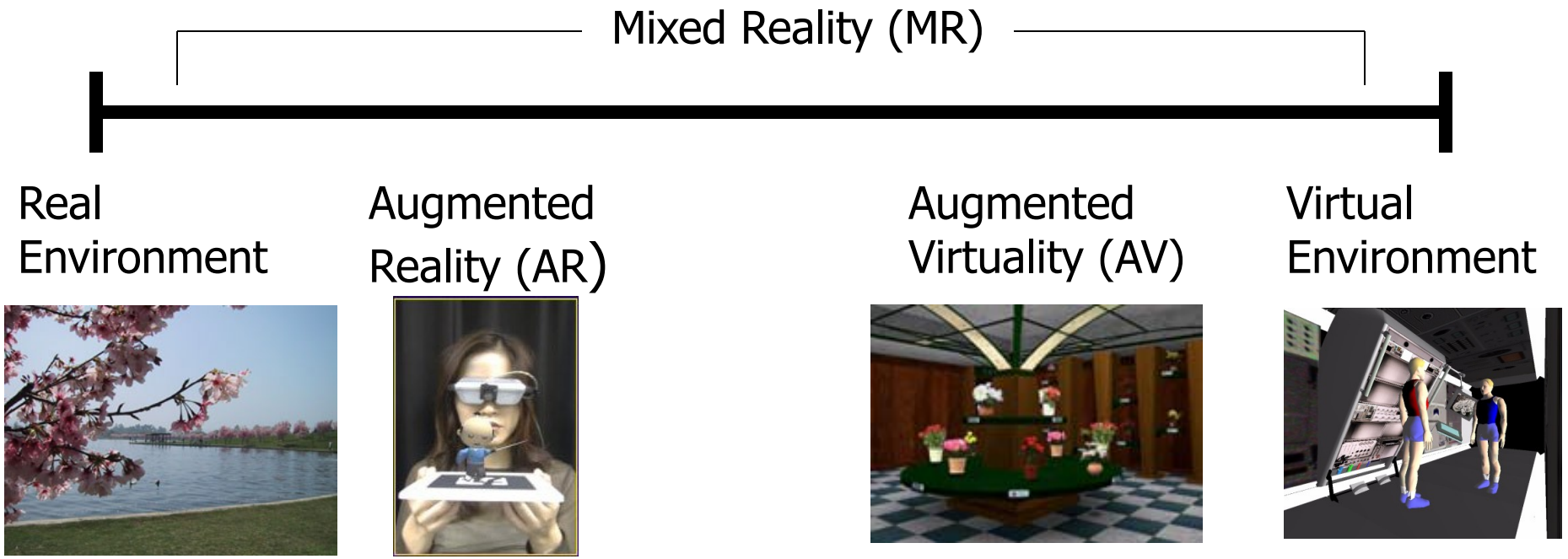
Virtual Reality

- Totally immersive environment
- Senses are under control of system
- Need a mechanism to feed virtual world to user
- Hard to make VR world interesting

Mixed reality

A system that combines real and virtual objects and information.

Milgram's Reality-Virtuality Continuum



Milgram coined the term "Augmented Virtuality" to identify systems which are mostly synthetic with some real world imagery added such as texture mapping video onto virtual objects.

P. Milgram and A. F. Kishino, Taxonomy of Mixed Reality Visual Displays. IEICE Transactions on Information and Systems, E77-D(12), pp. 1321-1329, 1994.

AUGMENTED VIRTUALITY

VR with windows into the real world

AR vs VR

	Virtual Reality *Replaces Reality*	**Augmented Reality** *Enhances Reality*
Scene Generation	Requires realistic images	Minimal rendering okay
Display Device	Fully immersive, wide field of view	Non-immersive, small field of view
Tracking	Low to medium accuracy is okay	The highest accuracy possible

Other Context: The Metaverse

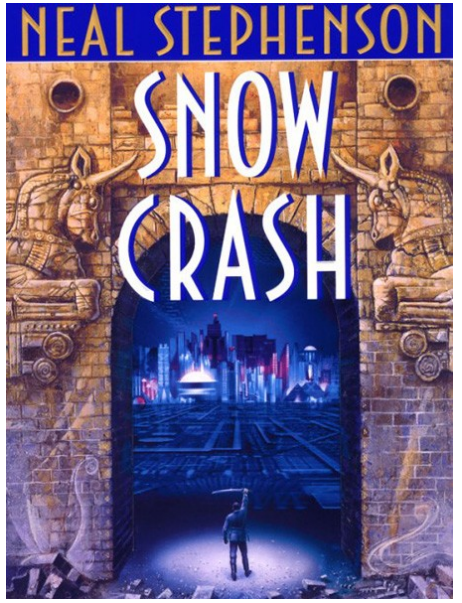
Neal Stephenson's "SnowCrash"

The Metaverse is the convergence of:

1. virtually enhanced physical reality
2. physically persistent virtual space

Metaverse Roadmap

- http://metaverseroadmap.org/



Metaverse Dimensions

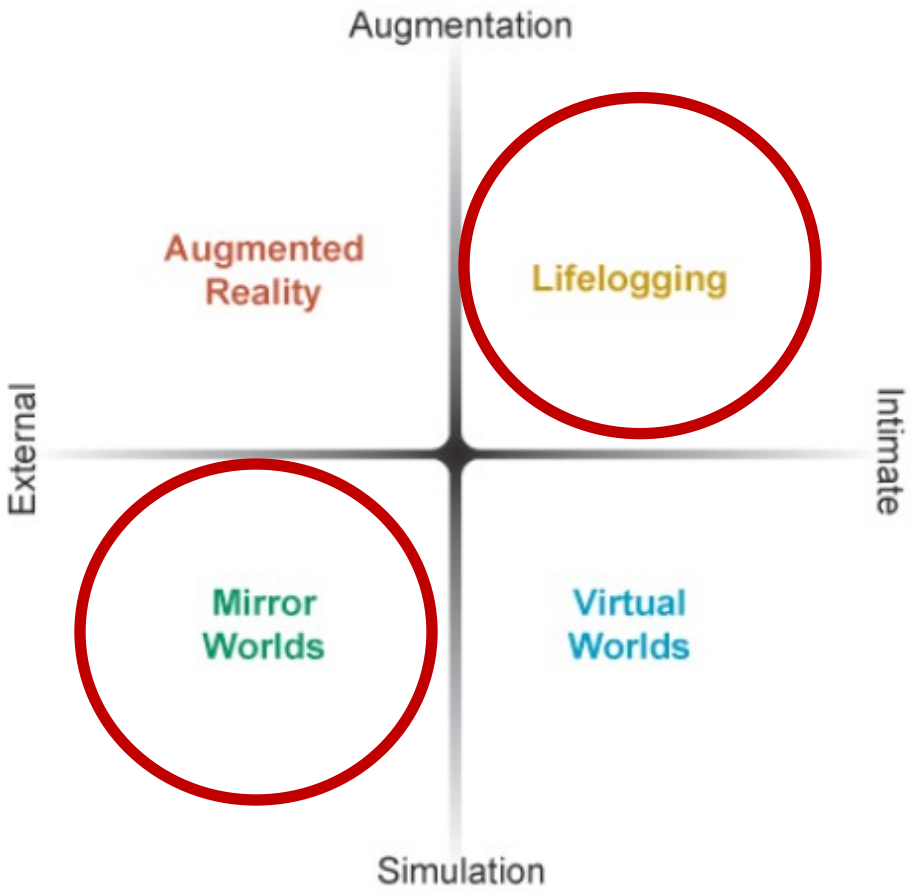
Augmentation technologies that layer information onto our perception of the physical environment

Simulation refers to technologies that model reality

Intimate technologies are focused inwardly, on the identity and actions of the individual or object

External technologies are focused outwardly, towards the world at large

Four Key Metaverse Components



Mirror Worlds

Mirror worlds are informationally-enhanced virtual models of the physical world.

- Google Earth, Street View, etc

LIFELOGGING

Technologies record and report the intimate states and life histories of objects and users

- Nokia LifeBlog, Nike+, FitBit

Narrative Clip

Wearable camera

- Automatic picture capture - 2 pics/minute
- http://getnarrative.com

AR Application Areas

Computer games

Map-assisted navigation

Urban planning / Design / construction

Tourism / Cultural heritage

Maintenance

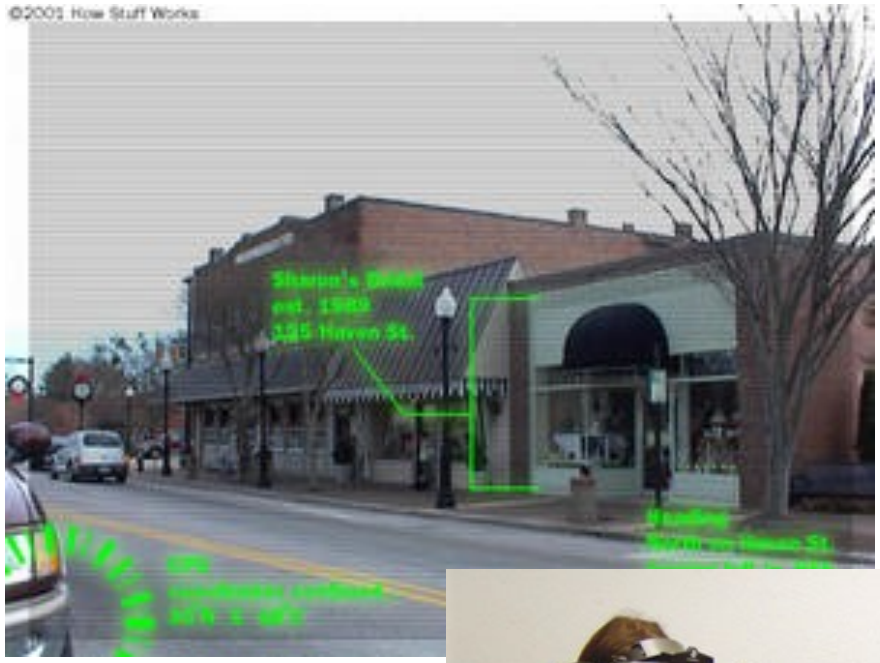
Training

Battlefield information display

Robot-assisted surgery

Virtual tours—real estate, medical facilities, etc.

AUGMENTED REALITY EXAMPLES



AR IN TELECONFERENCING

Person works at real desk

Remote collaborator represented by picture or video or "talking head"

Objects of discussion; e.g. a patient's brain image, might also be fused into visual field

FROM UNIVERSITY OF WASHINGTON HIT LAB

CNN Virtual View (2008)

https://youtu.be/v7fQ_EsMJMs

POKEMON GO

Microsoft Hololense

https://youtu.be/xgakdcEzVwg

Example: Haunted Book/AR Book

Camera hidden in lamp object

AR content seamlessly integrated into real book

Natural page turning/manipulation interaction

Scherrer, C., Pilet, J., Fua, P., & Lepetit, V. (2008, September). The haunted book. In Proceedings of the 7th IEEE/ACM international Symposium on Mixed and Augmented Reality (pp. 163-164). IEEE Computer Society.

AR Book Demo

https://youtu.be/XbsfamN78Tc

GAMING: ROCK-EM SOCK-EM

Shared AR Demo

Markerless tracking

Rockem Sockem Demo

https://youtu.be/hXtQ1QBMLIw

SALES AND MARKETING

Connect with brands and branded objects

Location Based Experiences

- Lynx Angels

Web based

- Rayban glasses

Mobile

- Ford Ka campaign

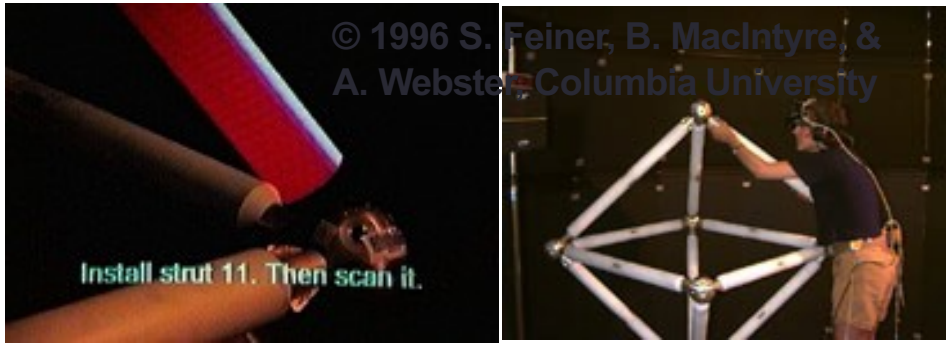
Print based

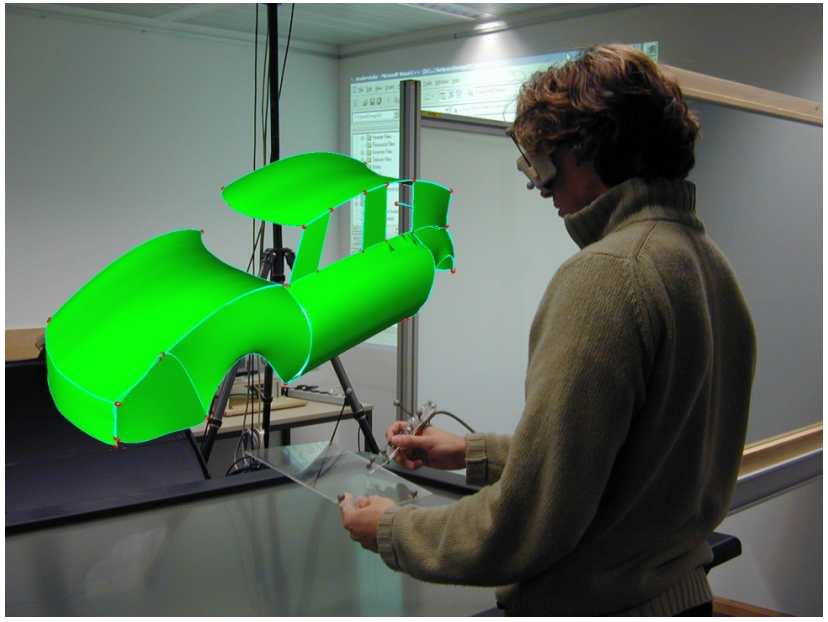
- Red Bull Magazine

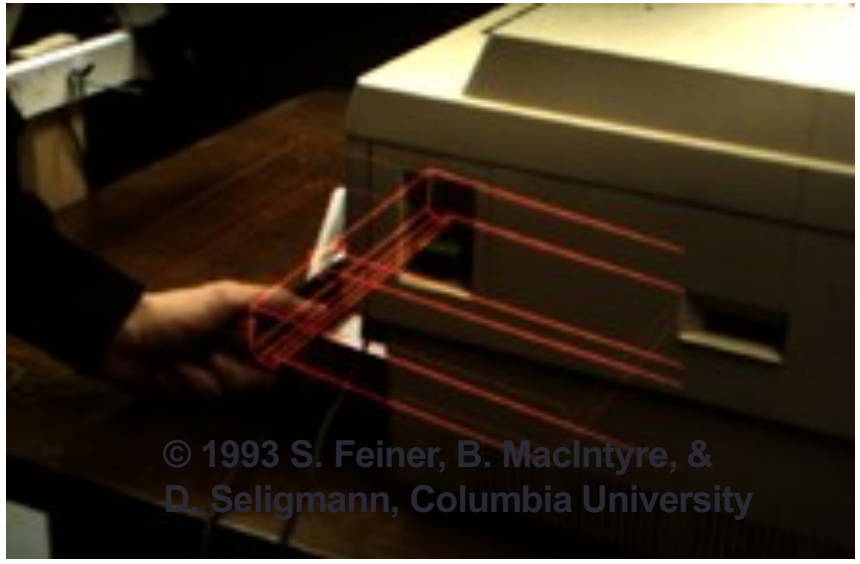
Pepsi AR Experience (2014)

https://youtu.be/Go9rf9GmYpM

Assembly and Maintenance



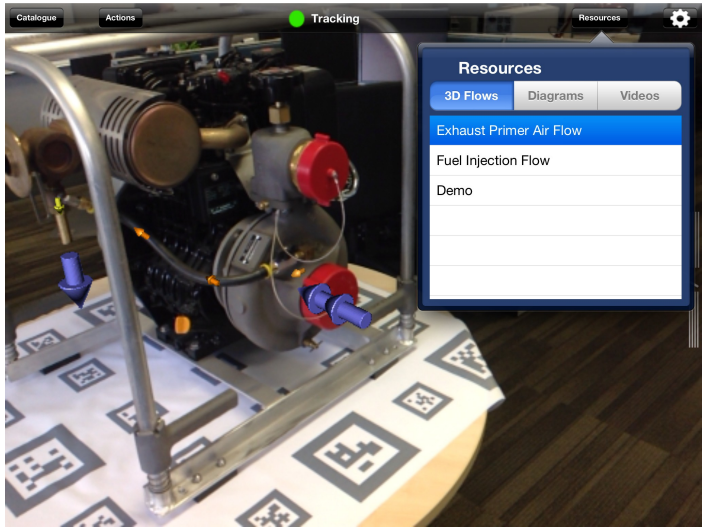




Maintenance Systems

Ngrain

- http://www.ngrain.com/
- Training authoring tool
- Model based AR tracking



ScopeAR

- http://www.scopear.com/
- Remote assistance
- Image based tracking

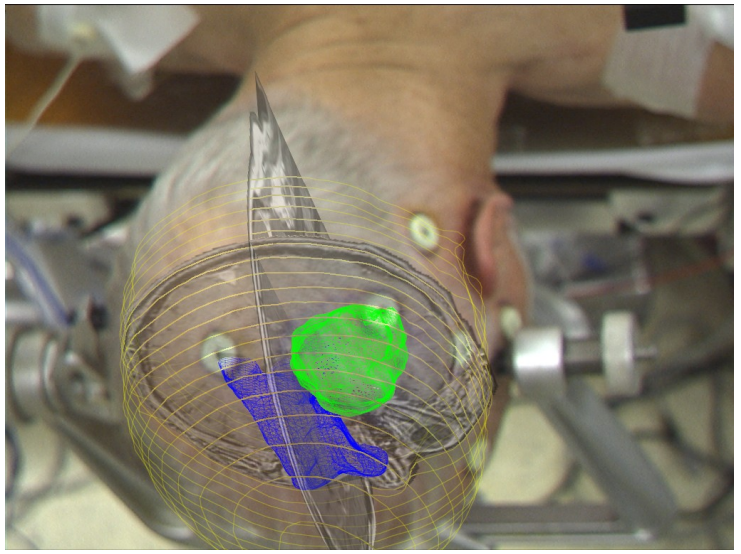
NGRAIN EXAMPLE

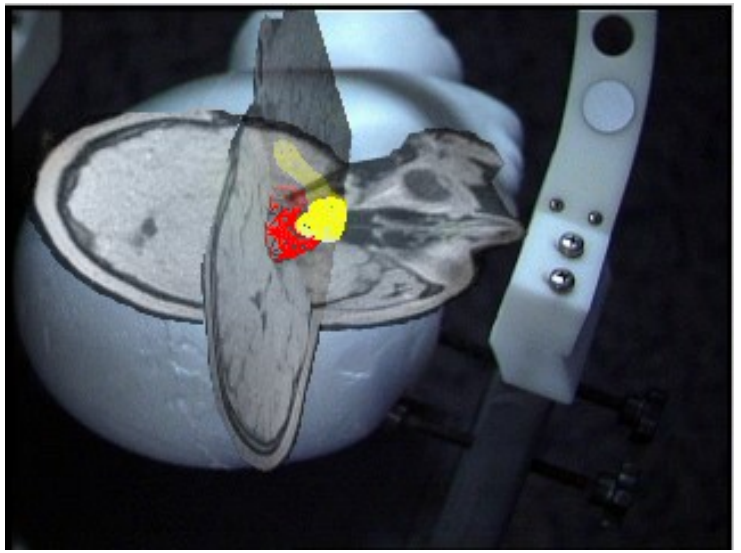
HTTPS://YOUTU.BE/XTHEAOBGZS4

Medical AR Trials

Sauer et al. 2000 at Siemens Corporate Research, NJ

Stereo video see through





F. Sauer, Ali Khamene, S. Vogt: An Augmented Reality Navigation System with a Single-Camera Tracker: System Design and Needle Biopsy Phantom Trial, MICCAI 2002

Medical Demo

https://youtu.be/kFQulgeYh7w

Interactive Museum Experiences

BlackMagic
- Virtual America's Cup
- 410,000 people in six months

MagicPlanet
- TeManawa science museum
- Virtual Astronomy
- Collaborative AR experience

AR Volcano
- Interactive AR kiosk
- Scienceworks museum, Melbourne

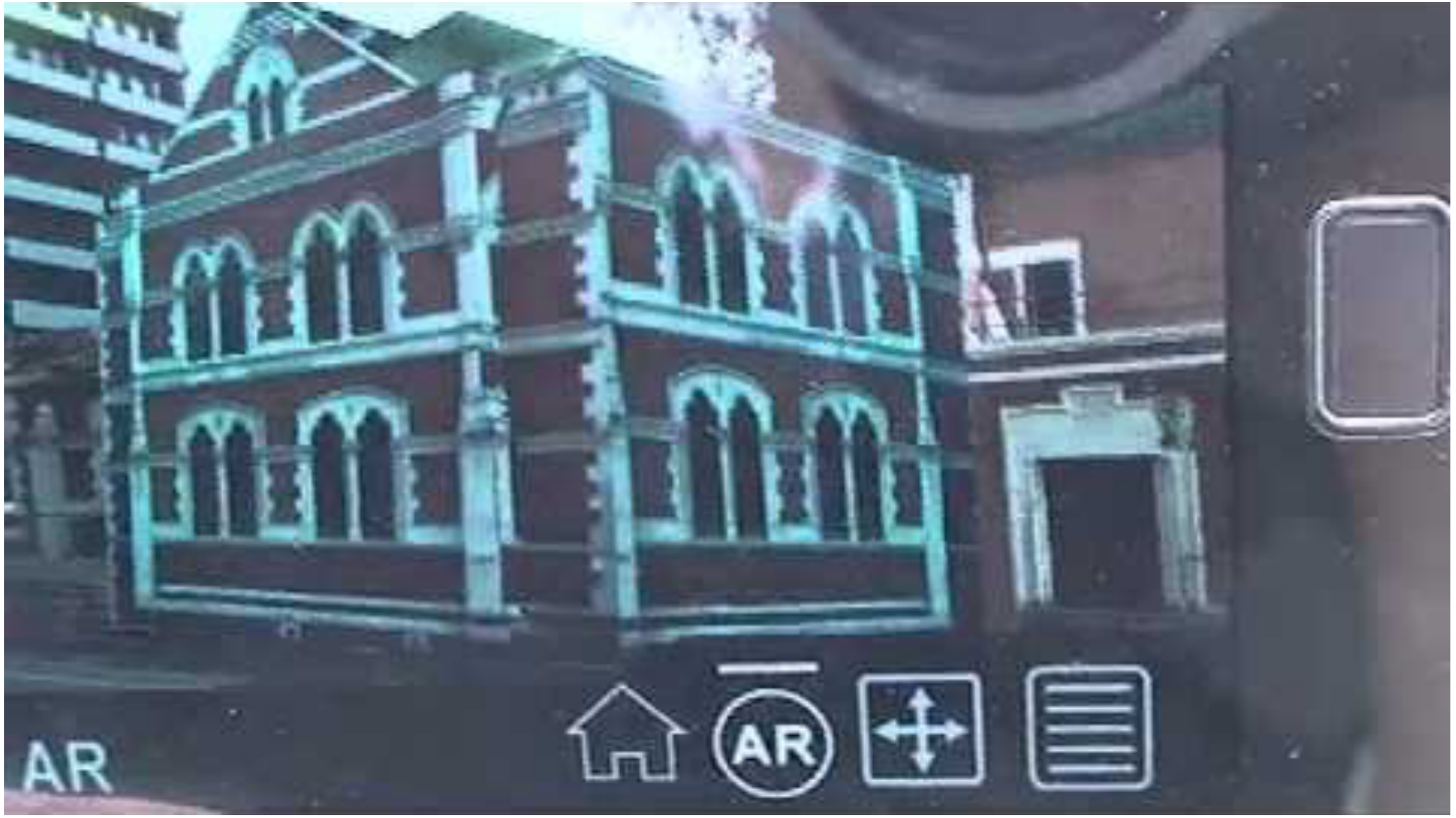
Digital Binocular Station

http://www.DigitalBinocularStation.com/

Digital Binocular Station

https://youtu.be/mqLAKBX0om4

CityViewAR Application



https://youtu.be/fDGRXxJx4SE

Collaboration Example: Holoportation

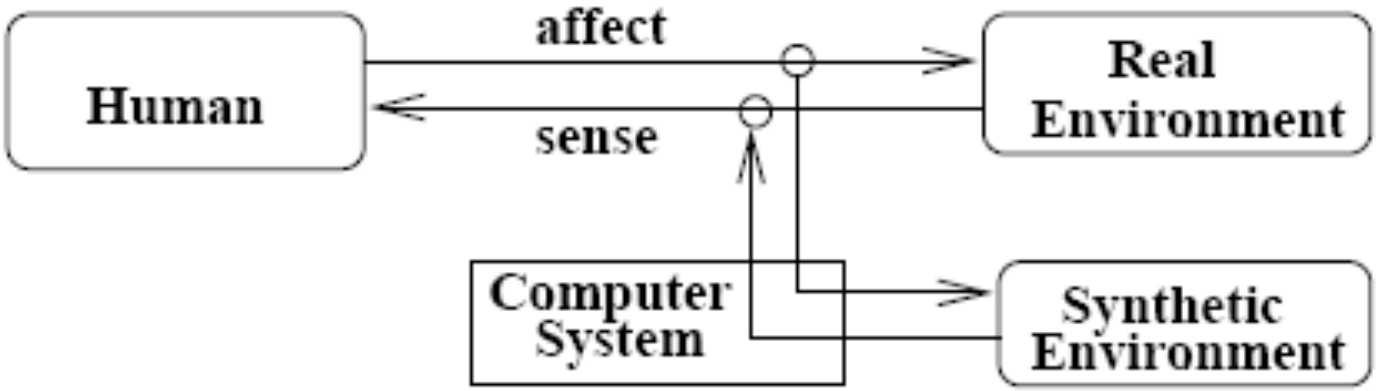
Augmented Reality + 3D capture + high bandwidth

http://research.microsoft.com/en-us/projects/holoportation/

HoloPortation Video

https://youtu.be/7d5906cfaM0

HUMAN OPERATING WITH AR



Think of a heads up display on your auto windshield, or on the instrument panel. What could be there to help you navigate?

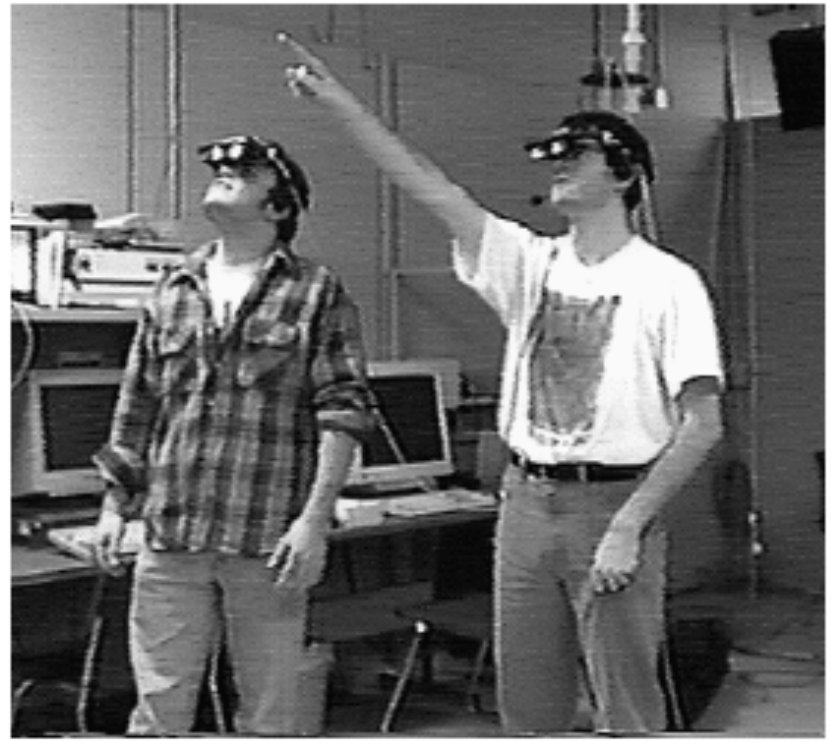
(Vectors to nearby eating places? Blinking objects we might collide with? Congestion of nearby intersections? Web pages?)

SPECIAL DEVICES NEEDED TO FUSE/REGISTER REAL AND GENERATED IMAGES

Computer Graphics Problem – Human sees graphics generated from 3D/2D models

Tracking/Pose Problem – Graphics system needs to know how the human is viewing the 3D environment

Optics Problem – Human sees both real and virtual environments



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DIFFICULT AUGMENTATION PROBLEM

Human very sensitive to misregistration

- Some applications OK – e.g. circuit board inspection

Tough calibration procedures for average user

Combining the Real and Virtual Worlds

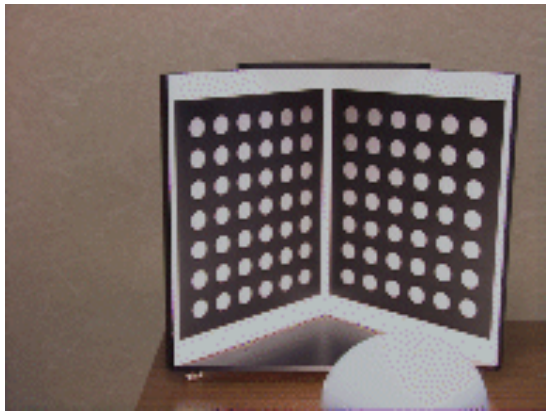
We need:

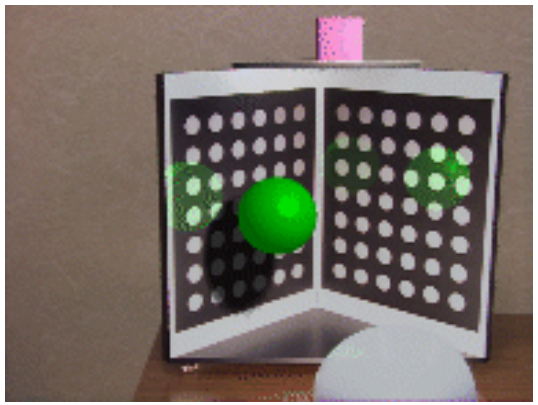
- Precise models
- Locations and optical properties of the viewer (or camera) and the display
- Calibration of all devices
- To combine all local coordinate systems centered on the devices and the objects in the scene in a global coordinate system

Combining the Real and Virtual Worlds (cont)

Register models of all 3D objects of interest with their counterparts in the scene

Track the objects over time when the user moves and interacts with the scene





Realistic Merging Requires

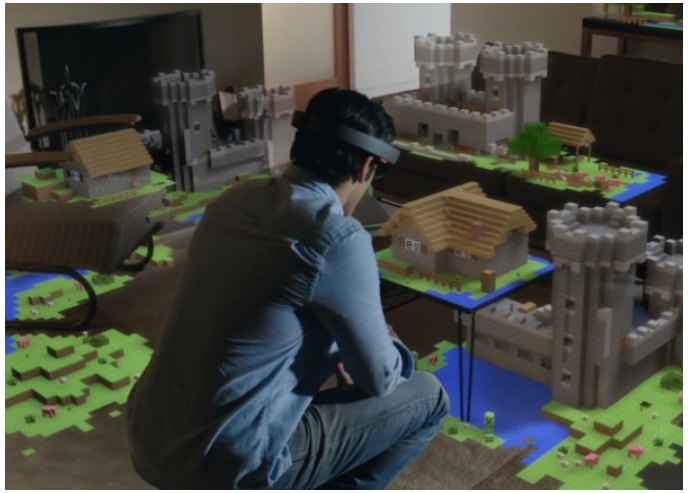
Objects to behave in physically plausible manner

- Occlusion
- Collision detection
- Shadows

STRONG VS. WEAK AR

Weak AR

- Imprecise tracking
- No knowledge of environment
- Limited interactivity
- Handheld AR



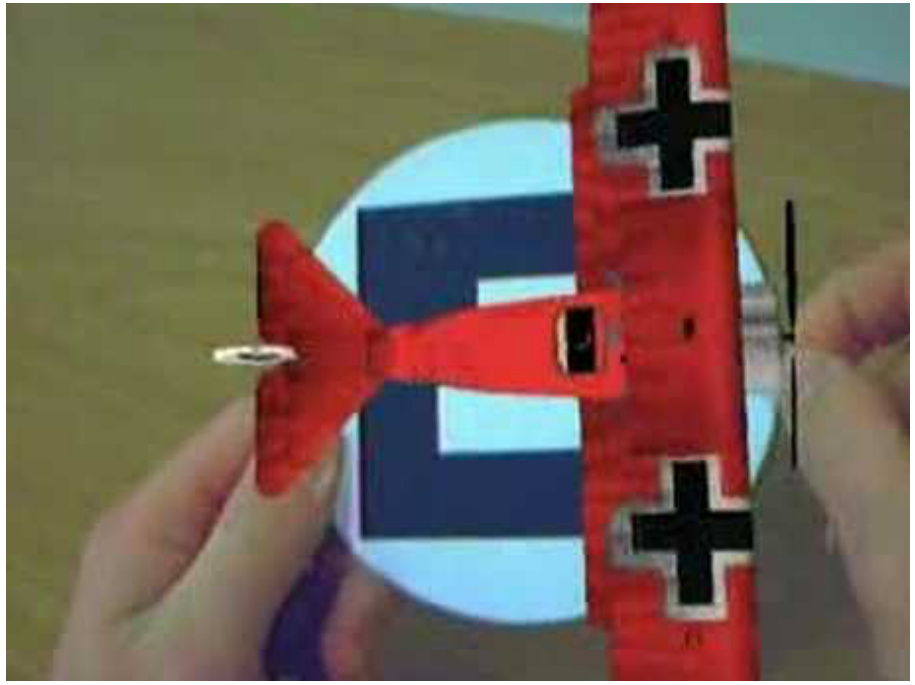
Strong AR

- Very accurate tracking
- Seamless integration into real world
- Natural interaction
- Head mounted AR

AR Tracking Examples

Optical / vision-based tracking

- Ensures portability
- Large number of tracked objects
- Registration and low latency are crucial for AR systems



Sourceless inertial orientation tracking

GPS (or other) position tracking

- Generally requires high accuracy
- GPS enables mobile (global) outdoor AR

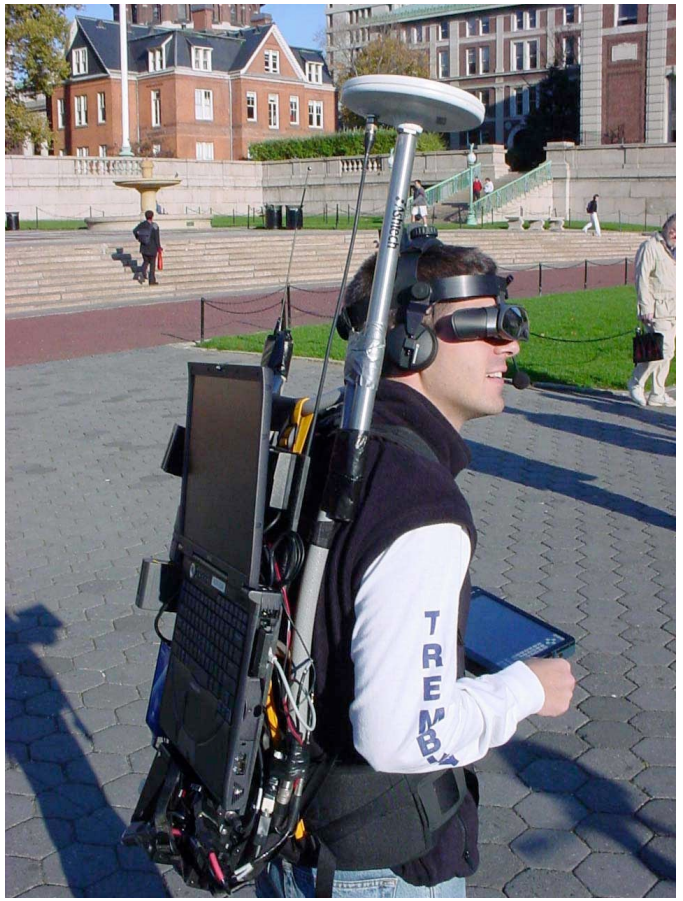
https://youtu.be/TqGAqAFlGg0

"Mobile" outdoor AR

1997 "Touring Machine"
Backpack systems (Feiner)

User wears/carries:

- Computer
- HMD
- Inertial tracker
- GPS unit/antenna
- Input device(s)



Performance Issues with Tracking

Accuracy of the registration of the real and virtual image

- Noise – position and pose of camera with respect to the real scene
- Image distortions

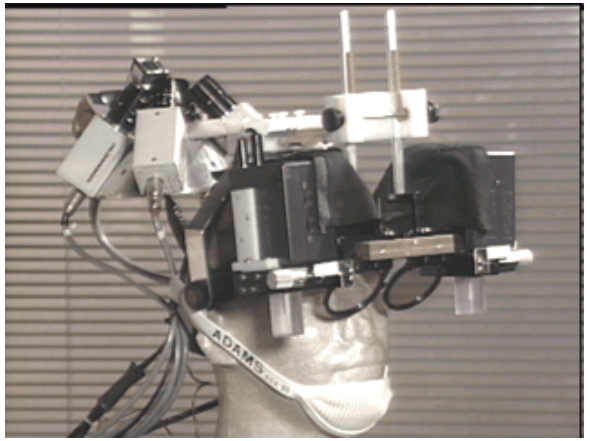
Time delays

- Update rate for generating the augmenting image
  - Can limit registration accuracy – "1 ms = 1mm error"

AR Display Technologies

Monitor Based

- Laptops
- Cell phones
- Projectors (more Ubiquitous Computing)



Head Mounted Displays

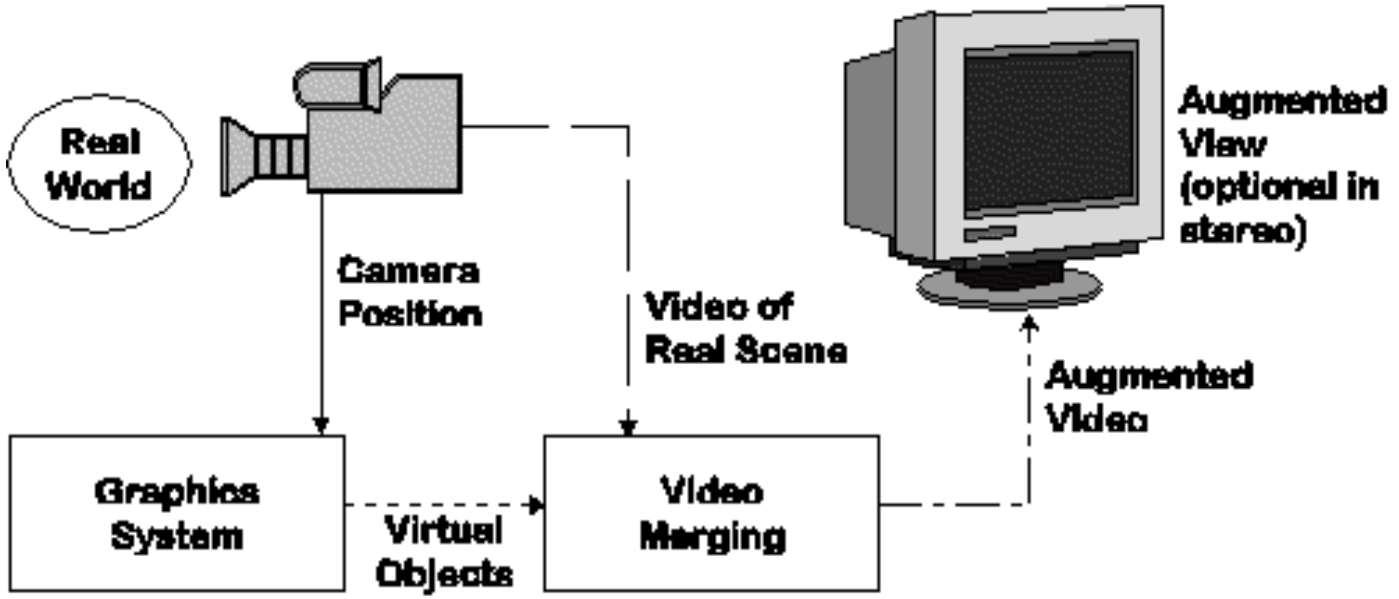
- Video see-through
- Optical see-through

Monitor Based Augmented Reality

Simplest available

Treat laptop/cell phone as a window through which you can see AR world.

Sunglasses demo



Monitor Based AR – Successful Commercialization

Yellow line in football broadcasts

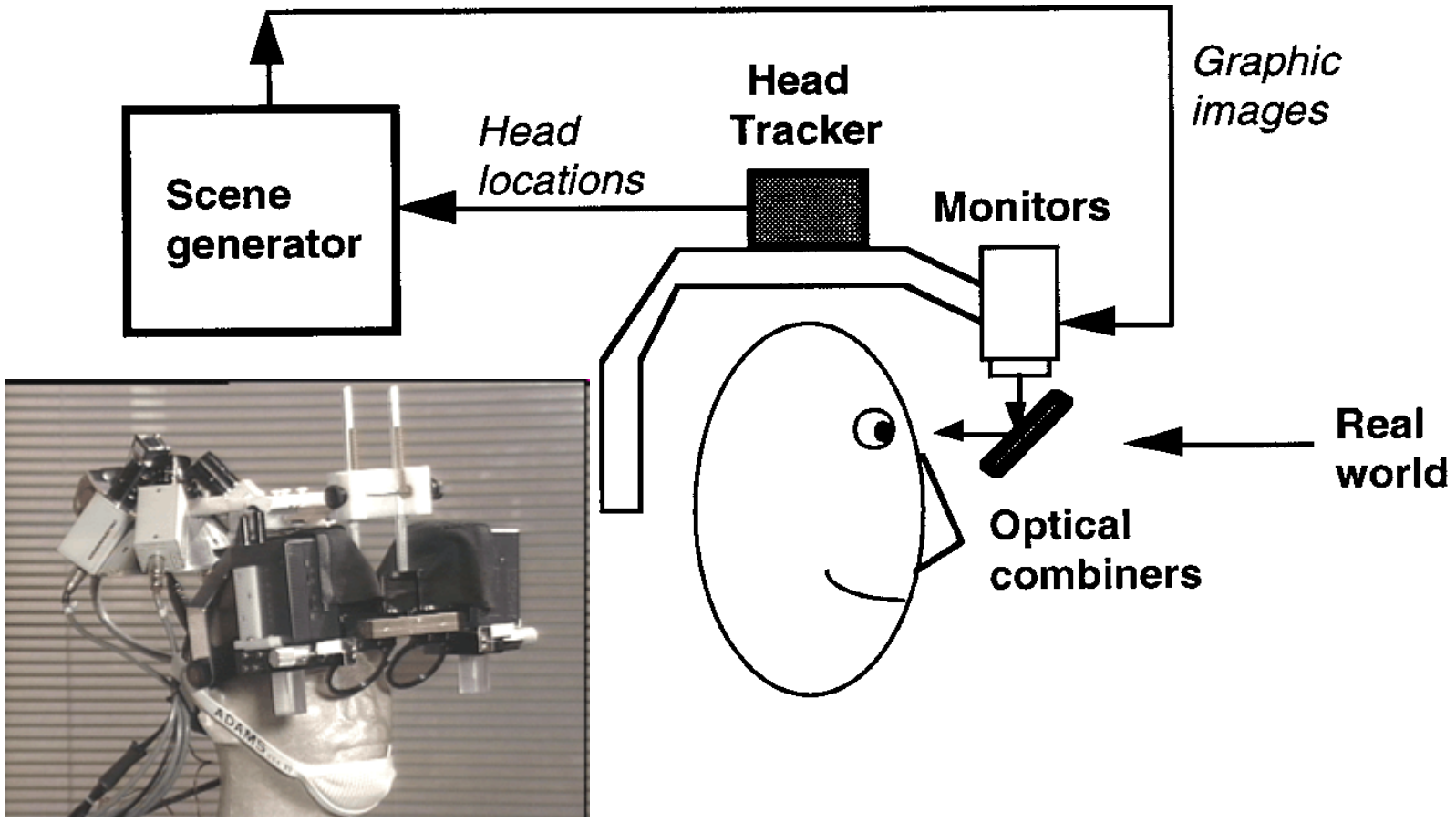
Glowing hockey puck

Replace times square billboards with own ads during broadcast

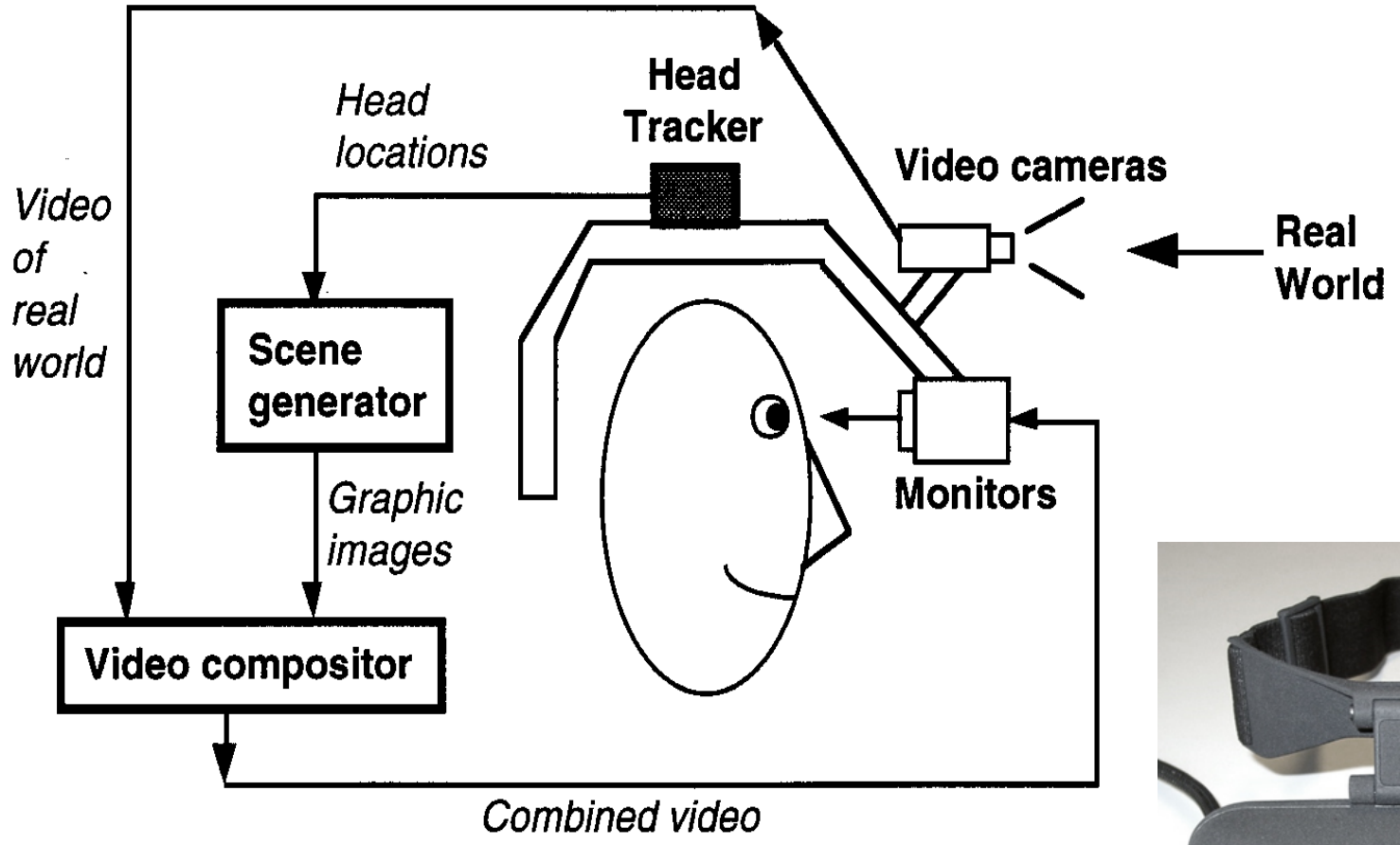
Baseball cards

Ad campaigns

OPTICAL SEE-THROUGH HMD



VIDEO SEE-THROUGH HMD



ADVANTAGES OF…

Monitor Displays

- Consumer-level equipment
- Most practical

Optical see-through HMD

- Simplicity
- Resolution
- No eye offset

Video see-through HMD

- Flexibility in composition strategies
- Real and virtual view delays can be matched

Technical Challenges in AR/MR

Occlusion and depth perception

Text display and legibility

Visual differences between real and virtual objects

Registration and tracking

Bulky HMDs and other equipment