Add Vuforia Engine to Unity

1. https://developer.vuforia.com/downloads/sdk
2. Import the script from Unity's menu Assets -> Import package -> Custom Package.
3. When you click Import, it will prompt you with a popup, asking to:
    a. Add Vuforia Engine Package.
    b. Upgrade the project to the latest version if it already references a Vuforia Engine package.
    c. Press Update and the Vuforia Engine SDK will be installed.

Add Vuforia Engine Package from the Package Manager

1. Click to download Vofira
2. First, download the package.
3. In Unity, open the Package Manager from Window -> Package Manager and click the + icon.
4. Select ***Add package from disk***

Introduction to Augmented Reality (AR)

Pavan Kumar B N
CSE, IIIT Sri City.

Introduction to Augmented Reality (AR)

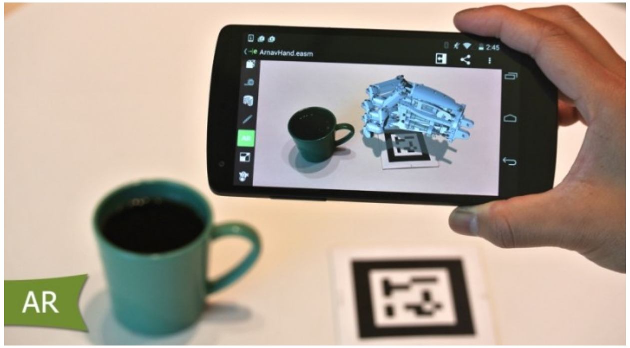
Introduction to Augmented Reality

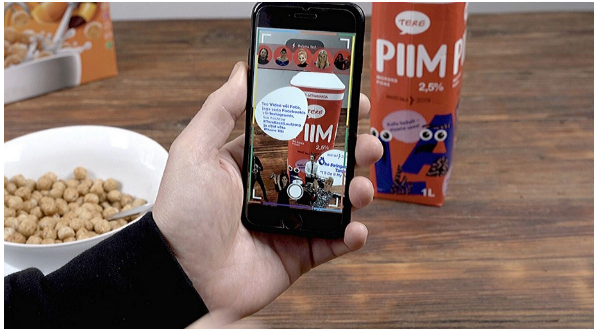
Introduction to Augmented Reality

How it Works (Types of AR)

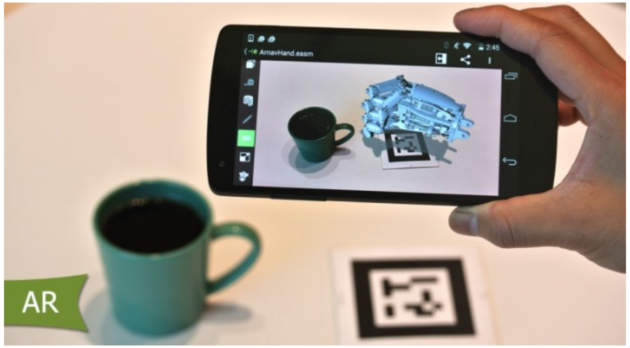
Projection-based AR

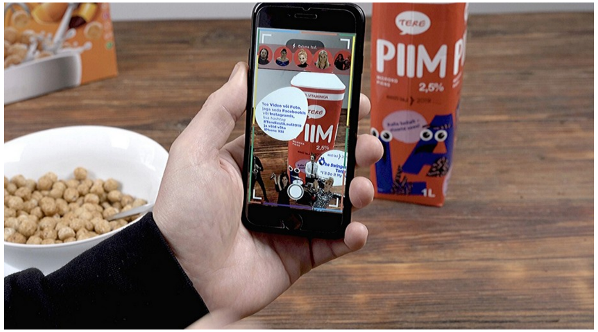
Recoginition-based AR





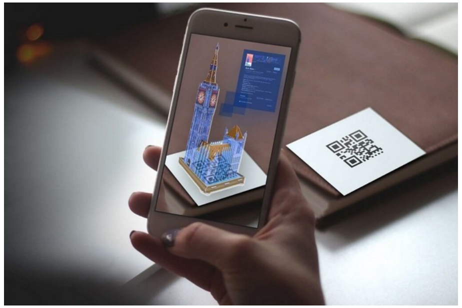
Recoginition-based AR

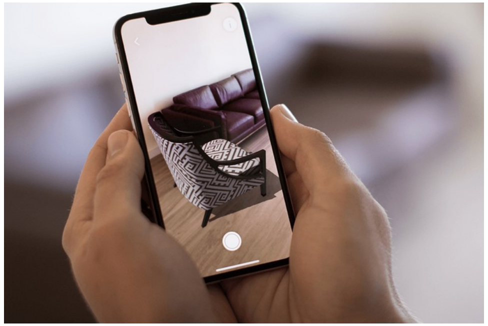




Marker-based

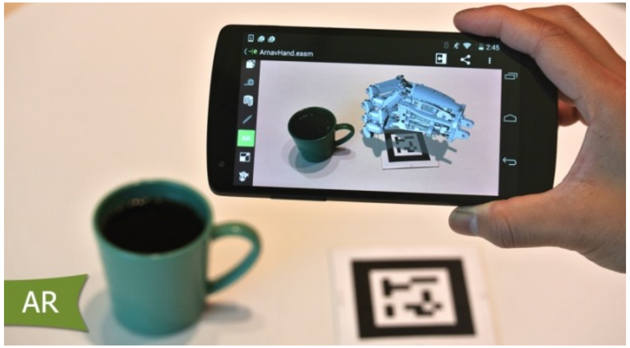
Markerless-based

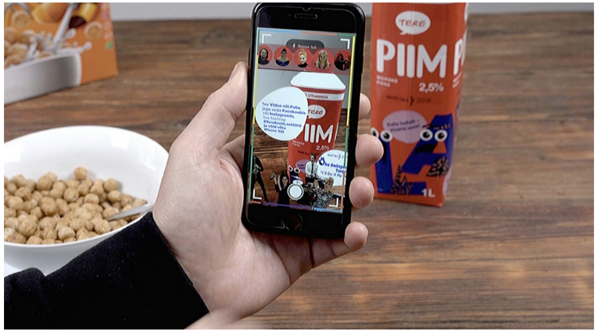




SDKs – ARKit (Apple) and ARCore (Google)

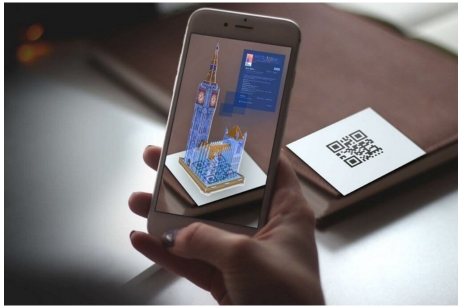
Recoginition-based AR

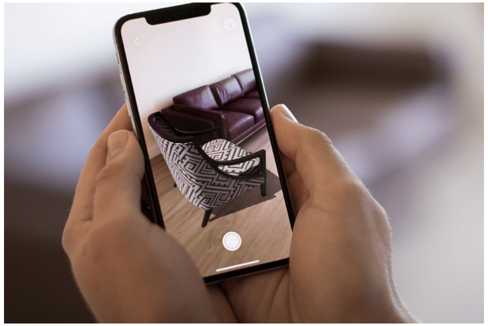




Marker-based

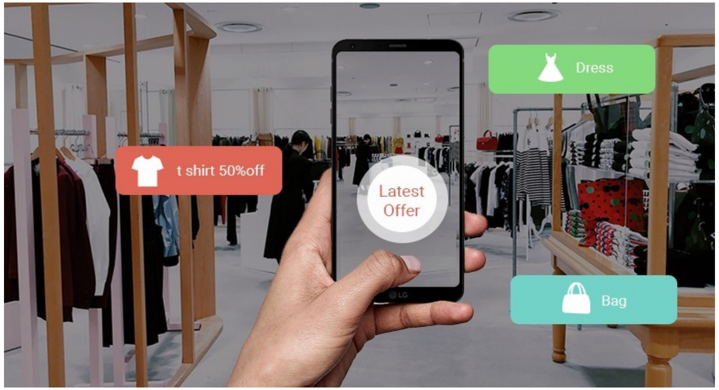
Markerless-based





IKEA’s Furniture App

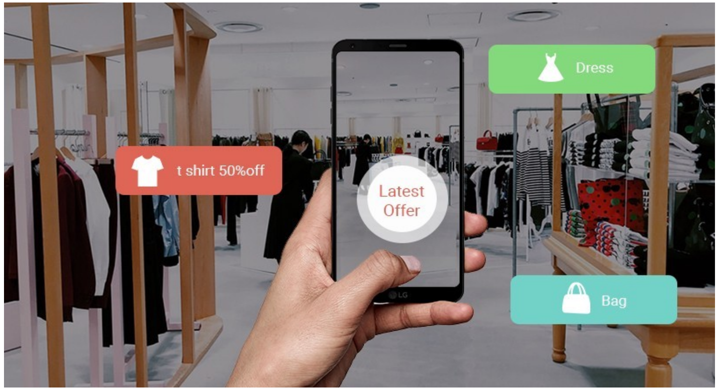
Location-based AR



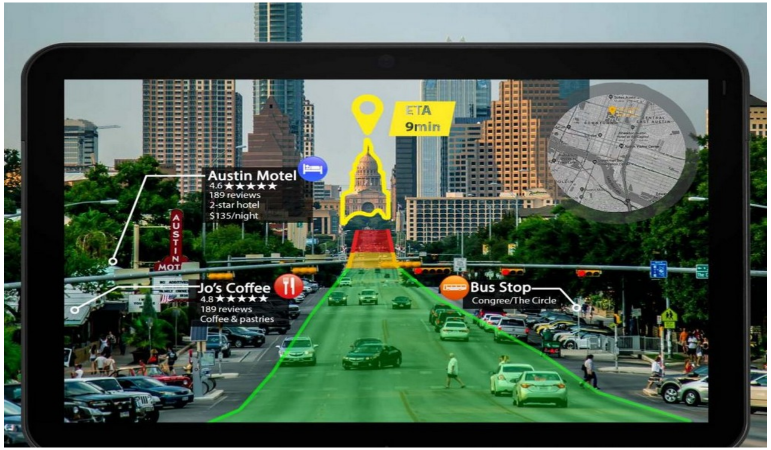
Location-based AR

Widely implemented AR technique due to easy avaibality of GPS.

Mostly used to help travelers and shoppers.

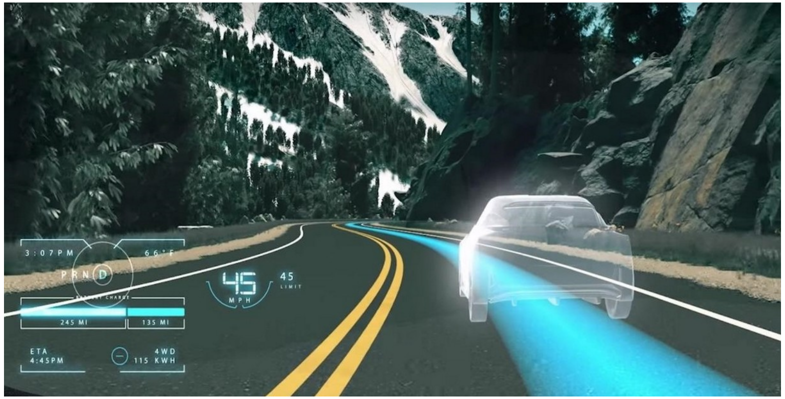


Outline AR

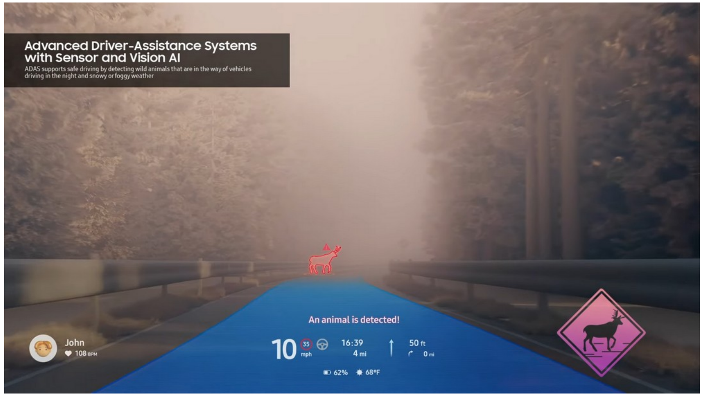

ETA
9min
Austin Motel
4.6
189 reviews
2-star hotel
$135/night
Jo's Coffee
4.8
189 reviews
Coffee & pastries
Bus Stop

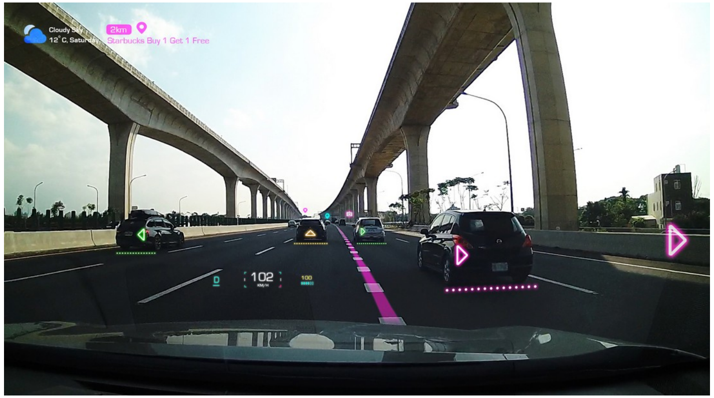

45
85%
SAFETY LEVEL
BUY 2 FOR 1
11:50
LTE
20 km
LANE


SPEED LIMIT 25
270mi.
13
MPH
0.2 miles
00 min
00:10
0.6 mi.
kW


3:07PM
66°F
PRND
245 MI
135 MI
45
MPH
45
LIMIT
ETA
4:45PM
4WD
115 KWH

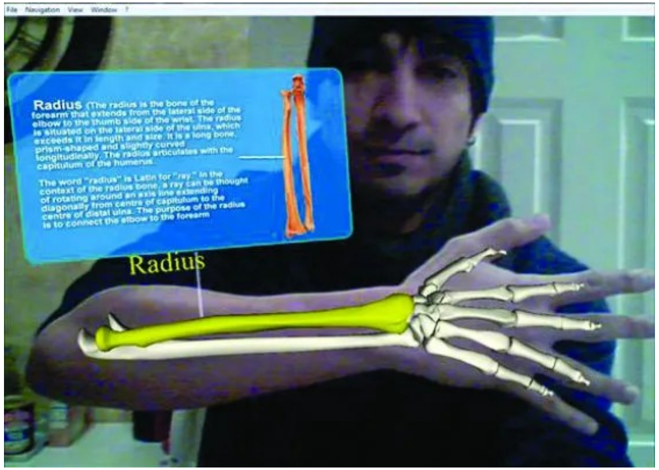
Outline AR

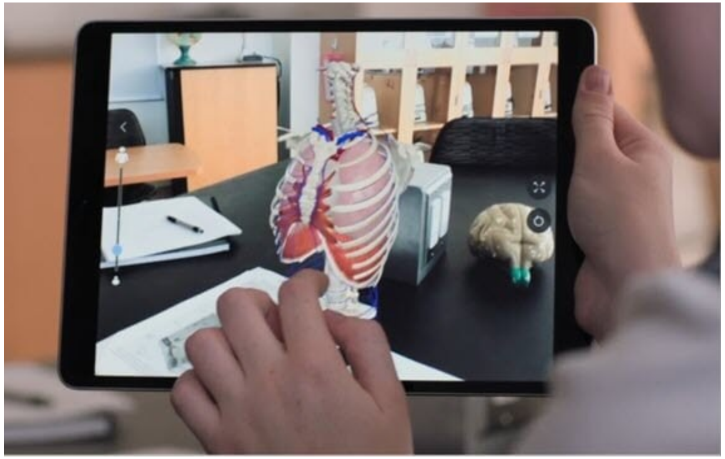




Outlining the ROAD can help in FOGGY weather

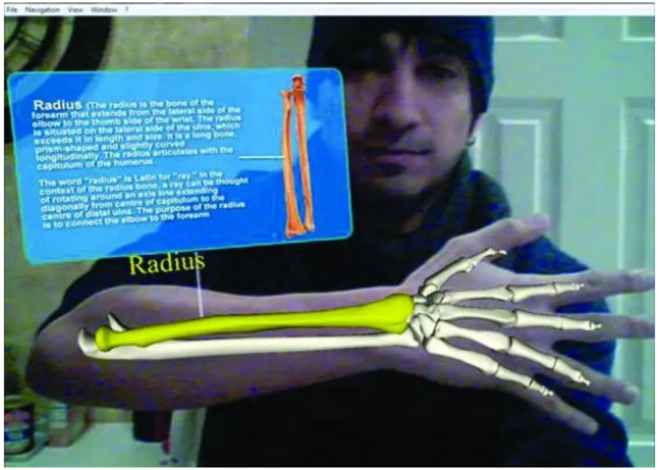
Superimposition-based AR

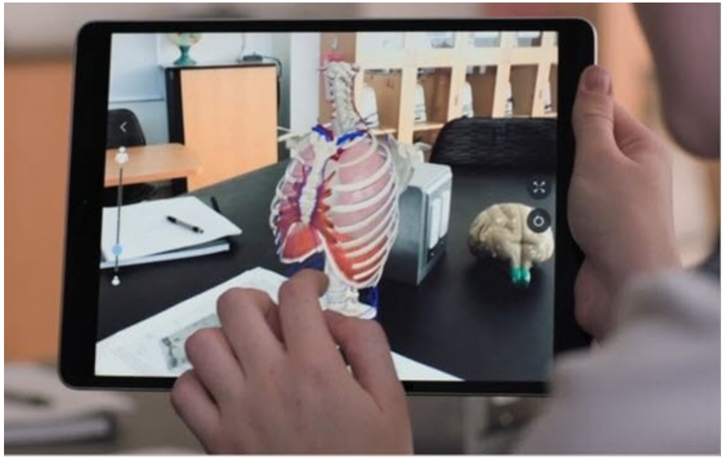


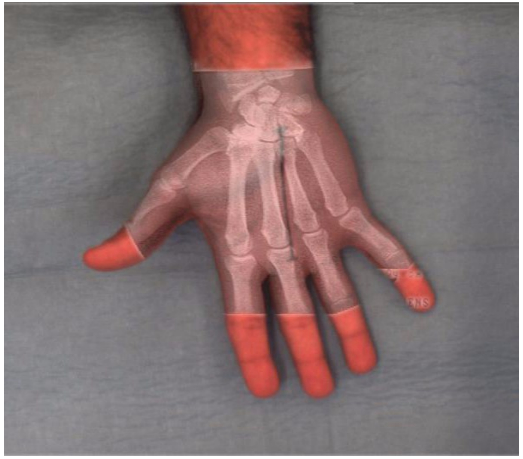


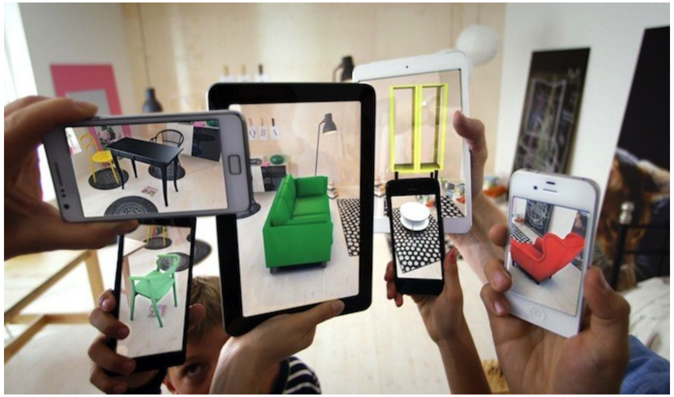
Provides an ALTERNATE view of the object in Concern

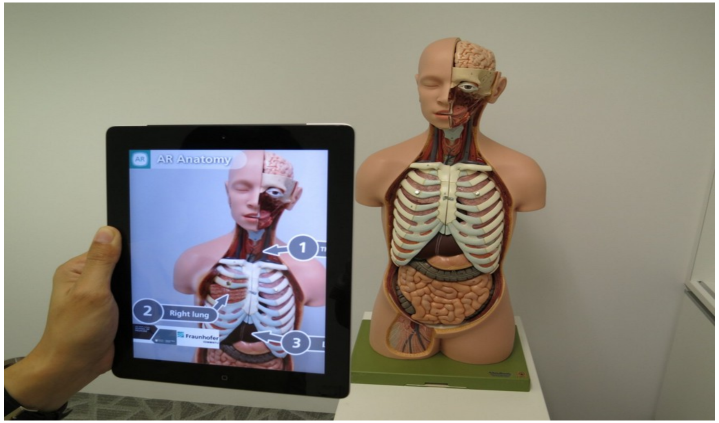
Superimposition-based AR

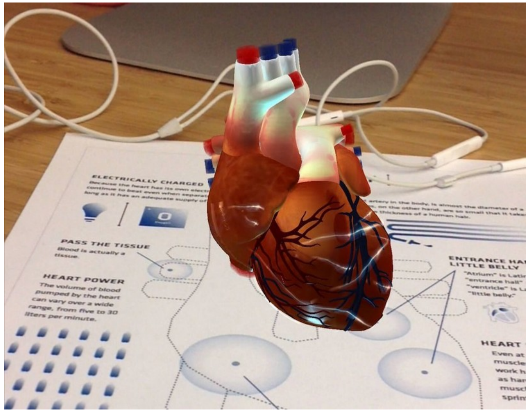












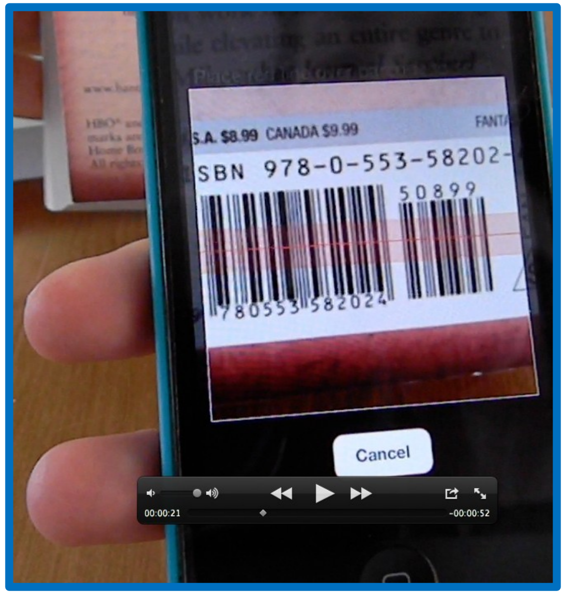
Leaders in AR Hardware: Market

Why Augmented Reality

- Images presented in games, movies, and other media are detached from our physical surroundings
- Main interest we have in our daily life, which is not directed toward some virtual world, but rather toward the ***real world*** surrounding us

Location Based Services

Barcode for Supermarket

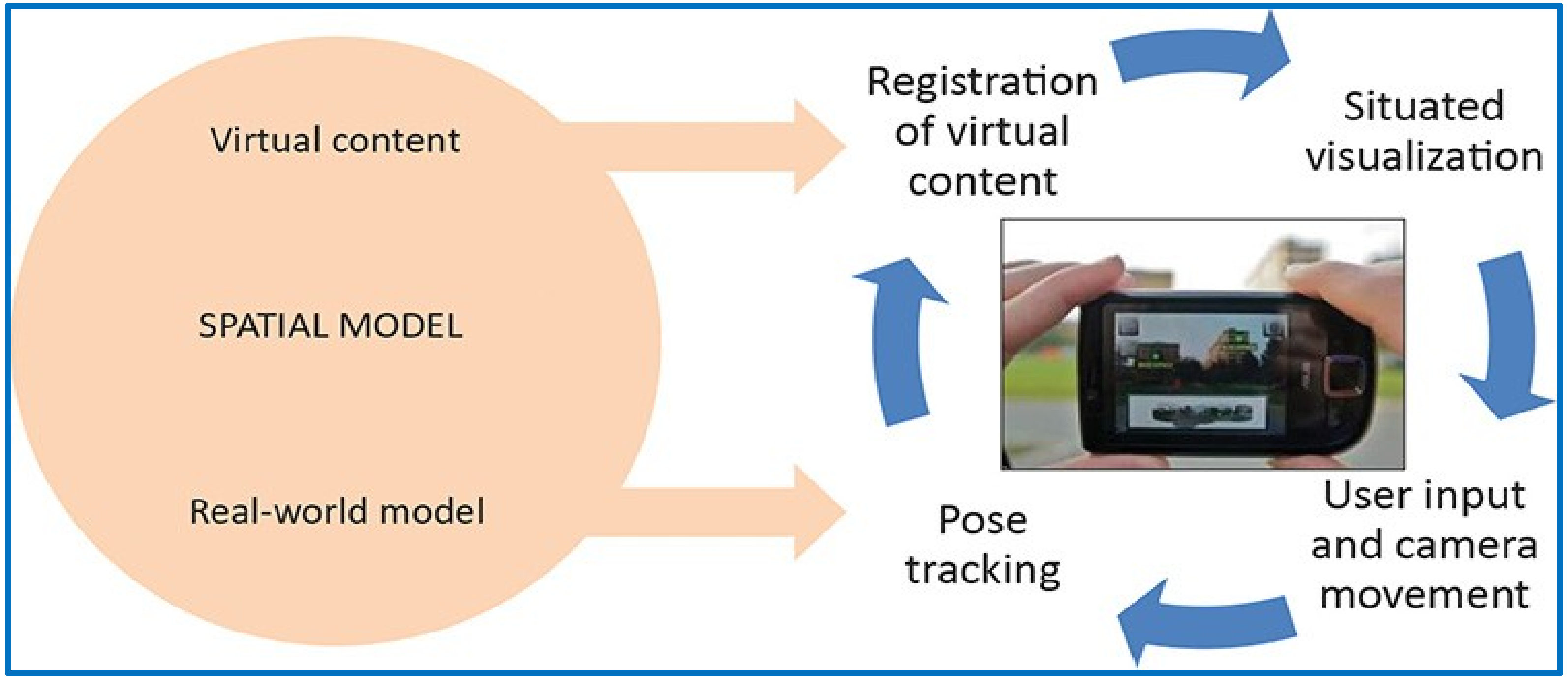


Barcode for books

Why Augmented Reality

- Augmented reality holds the promise of creating direct, automatic, and actionable links between the physical world and electronic information.

- A lot of technological advancement has occurred in the field of location-based computing and services, which is sometimes referred to as ***situated computing***



AR uses a feedback loop between human user and computer system

A Brief History

"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."

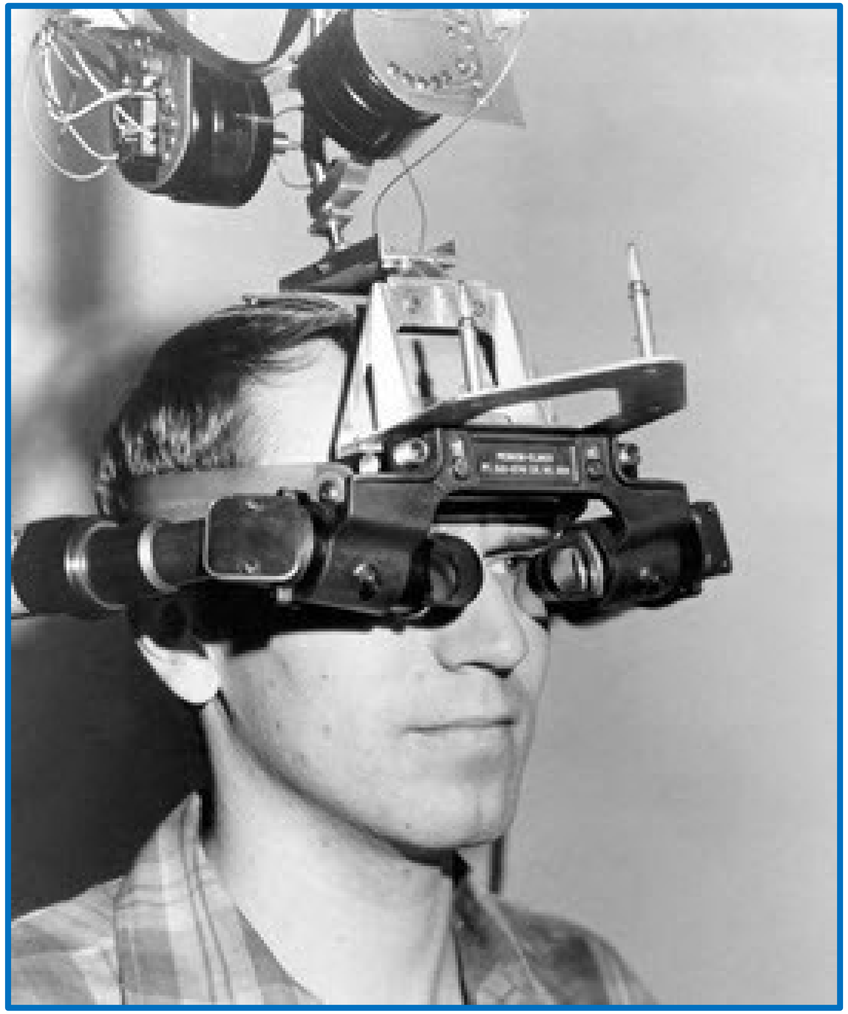
- Ivan Sutherland

Sword of Damocles

- The Sword of Damocles was the nickname of the world's first head-mounted display, built in 1968. Courtesy of Ivan Sutherland

- Advances in computing performance of the 1980s and early 1990s were ultimately required for AR to emerge as an independent field of research

- Myron Krueger, Dan Sandin, Scott Fisher experimented with many concepts of mixing human interaction with computer-generated overlays on video for interactive art experiences



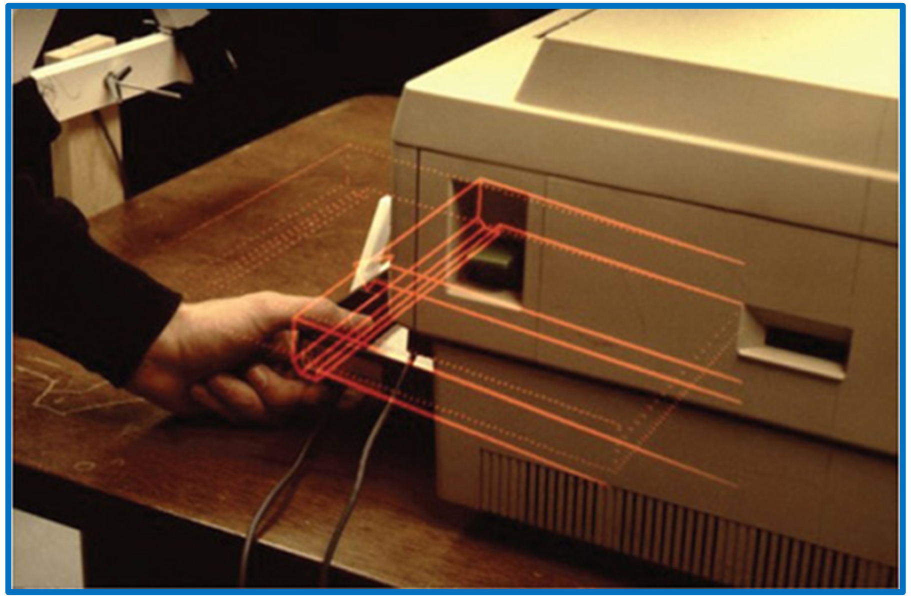
Guide the assembly of wire bundles for aircraft

- 1992 marked the birth of the term **“Augmented Reality.”**

- Caudell and Mizell [1992] at Boeing, sought to assist workers in an airplane factory by displaying wire bundle assembly schematics in a see-through HMD.

KARMA

- In 1993, Feiner introduced **KARMA**, a system that incorporated knowledge-based AR
- Automatically inferring appropriate instruction sequences for repair and maintenance procedures



KARMA was the first knowledge-driven AR application

Medical AR

- In 1994, at the University of North Carolina compelling medical AR application was developed.
- It was capable of letting a physician observe a fetus directly within a pregnant patient

View inside the womb of an expecting mother

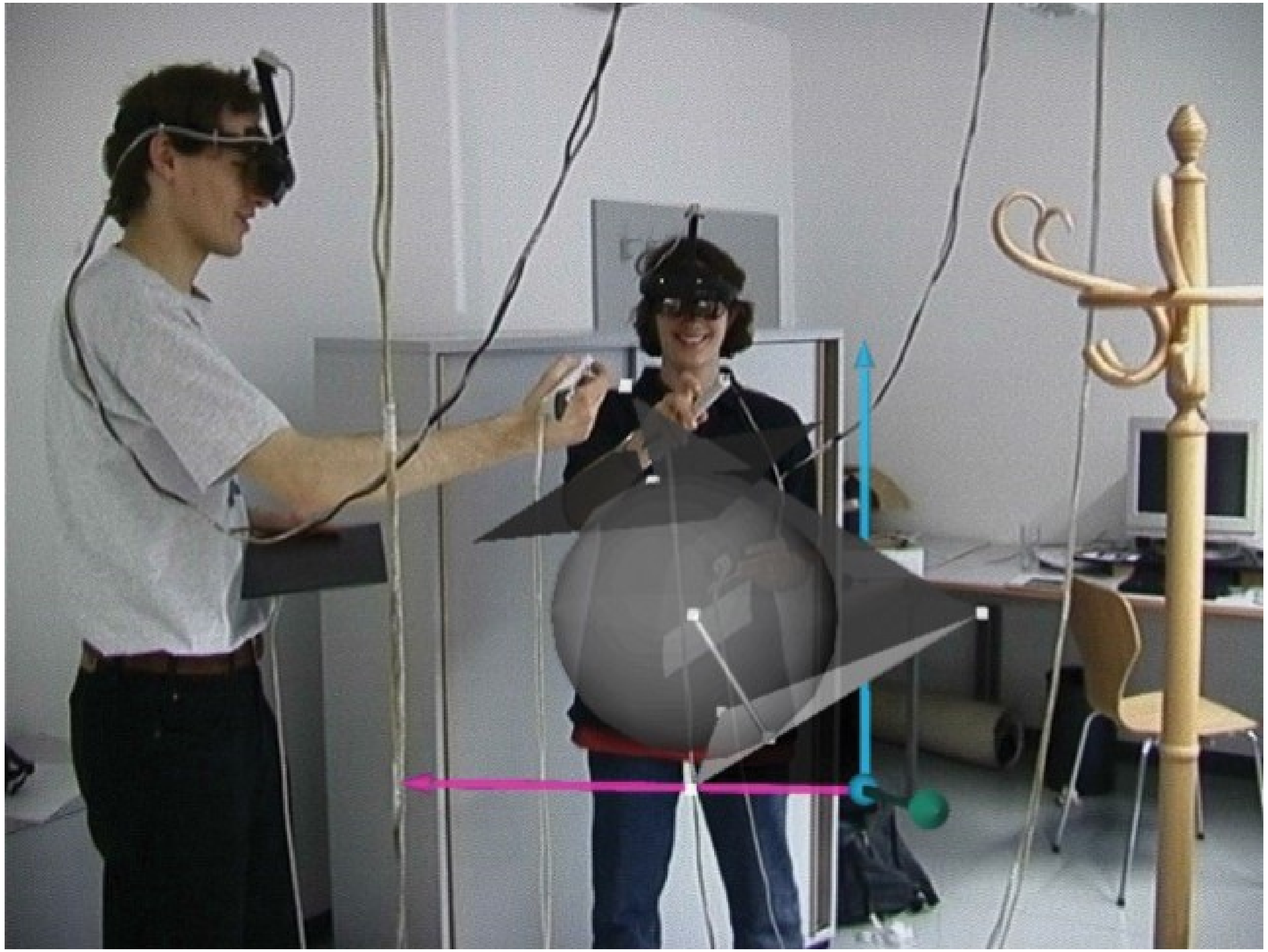
Studierstube

- In 1996, Schmalstieg developed first collaborative AR system called Studierstube

- Multiple users could experience virtual objects in the same shared space

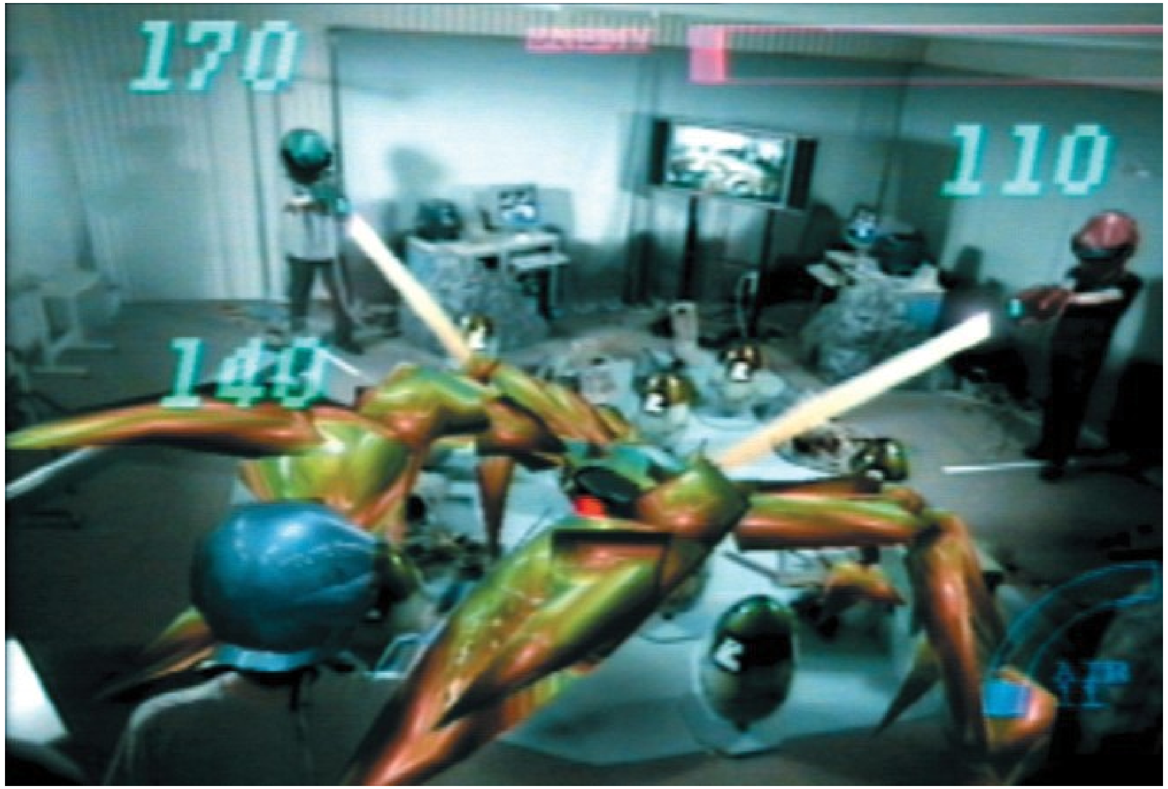
- One of the showcase applications was a geometry course

- Studierstube system was teaching geometry in AR to high school students



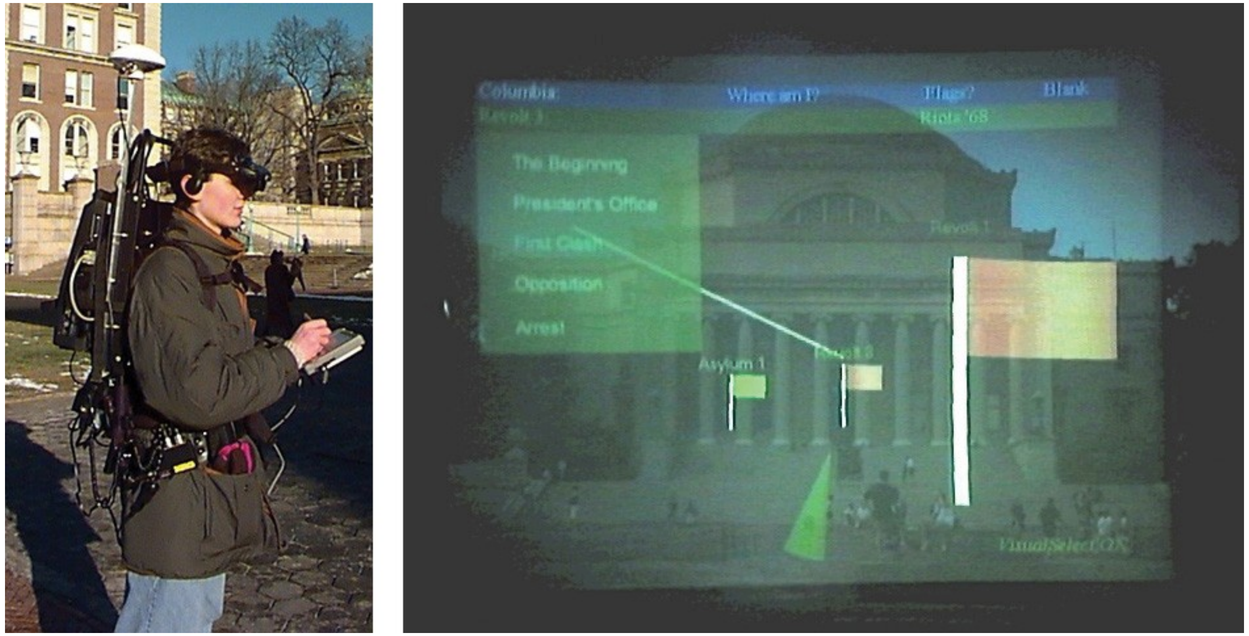
Japanese Influence on games

- From 1997 to 2001, the Japanese government and Canon Inc. jointly funded the Mixed Reality Systems Laboratory.
- One of the largest industrial research facility for mixed reality (MR)
- First coaxial stereo video see-through HMD, the COASTAR was developed
- *RV-Border Guards* was a multiuser shooting game developed in Canon’s Mixed Reality Systems Laboratory



Touring Machine

- In 1997, Feiner et al. developed the first outdoor AR system, the Touring Machine
- The Touring Machine uses a see-through HMD with GPS and orientation tracking
- Delivering mobile 3D graphics via this system required a backpack holding a computer, various sensors, and an early tablet computer for input



The Touring Machine was the first outdoor AR system (left). Image of the *Situated Documentaries* AR campus tour guide running on a 1999 version of the Touring Machine (right).

ARQuake

- in 1998, Thomas et al. published their work on the construction of an outdoor AR navigation system.

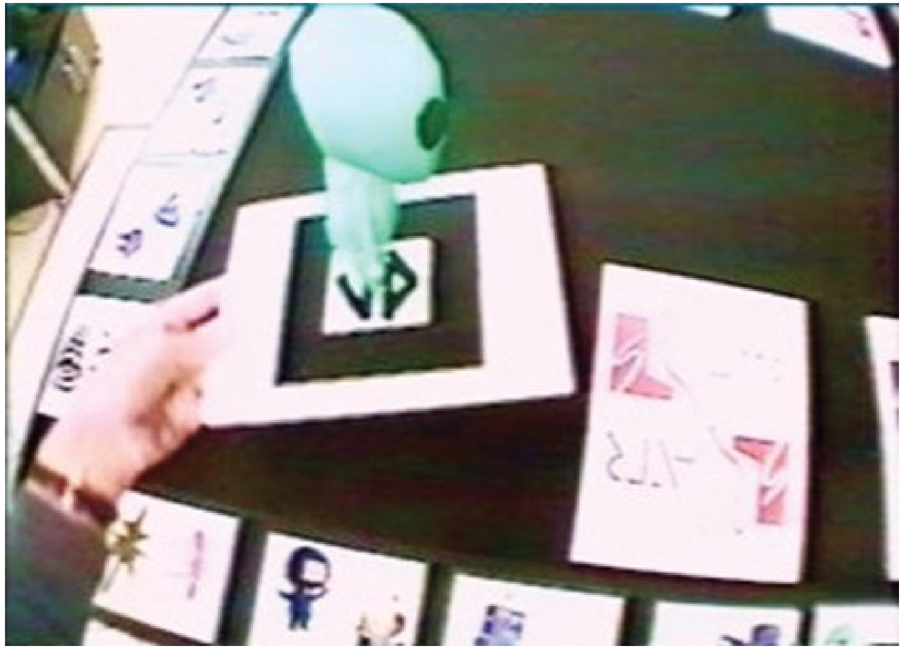
- This platform was used for advanced applications, such as 3D surveying, but is most famous for delivering the first outdoor AR game, ARQuake

Screenshot of ARQuake, the first outdoor AR game

ARToolKit

- ARToolKit, the first open-source software platform for AR

- It featured a 3D tracking library using black-and-white fiducials, which could easily be manufactured on a laser printer



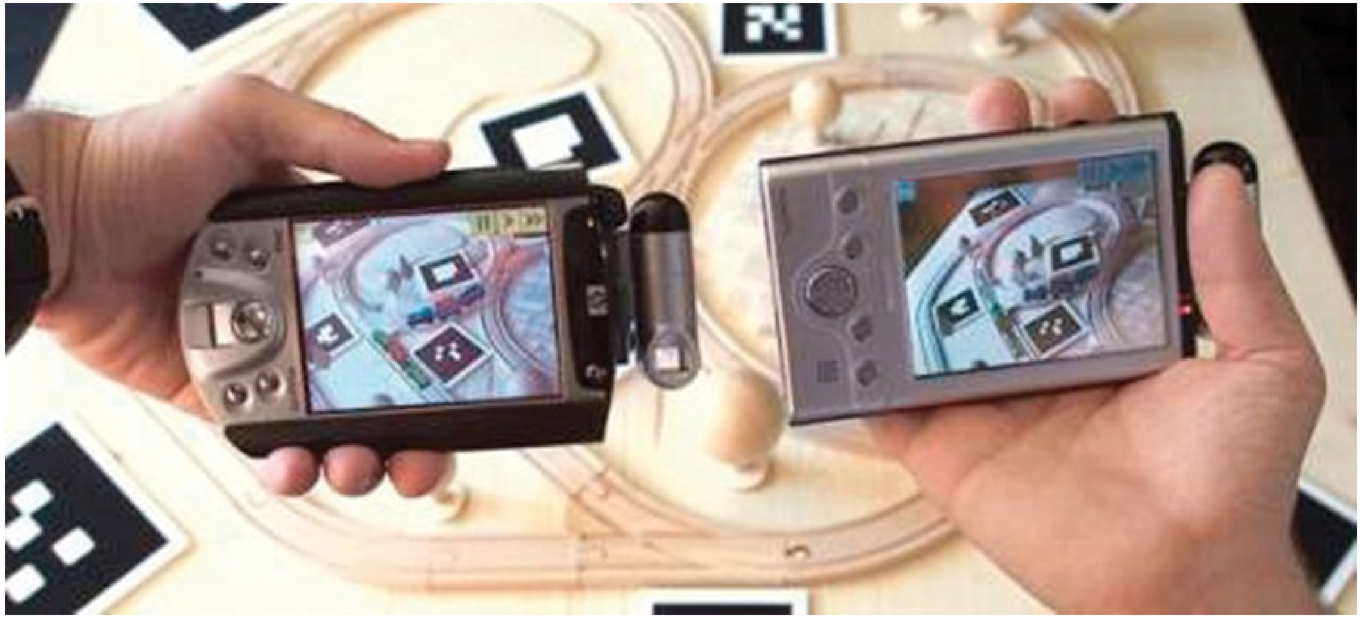
A person holding a square marker of ARToolKit

https://chev.me/arucogen/

https://docs.opencv.org/4.5.3/d5/dae/tutorial_aruco_detection.html

Invisible Trains

- In 2003, Wagner and Schmalstieg presented the first handheld AR system running autonomously on a “personal digital assistant”
- Train, a multiplayer handheld AR game was experienced by thousands of visitors at the SIGGRAPH Emerging Technologies show floor.



Virtual Trains on Real Wooden tracks

Vuforia AR Engine

- 2008, for the first truly usable natural feature tracking system for smartphones was introduced
- Today, AR developers can choose among many software platforms, but these model systems continue to represent important directions for researchers.

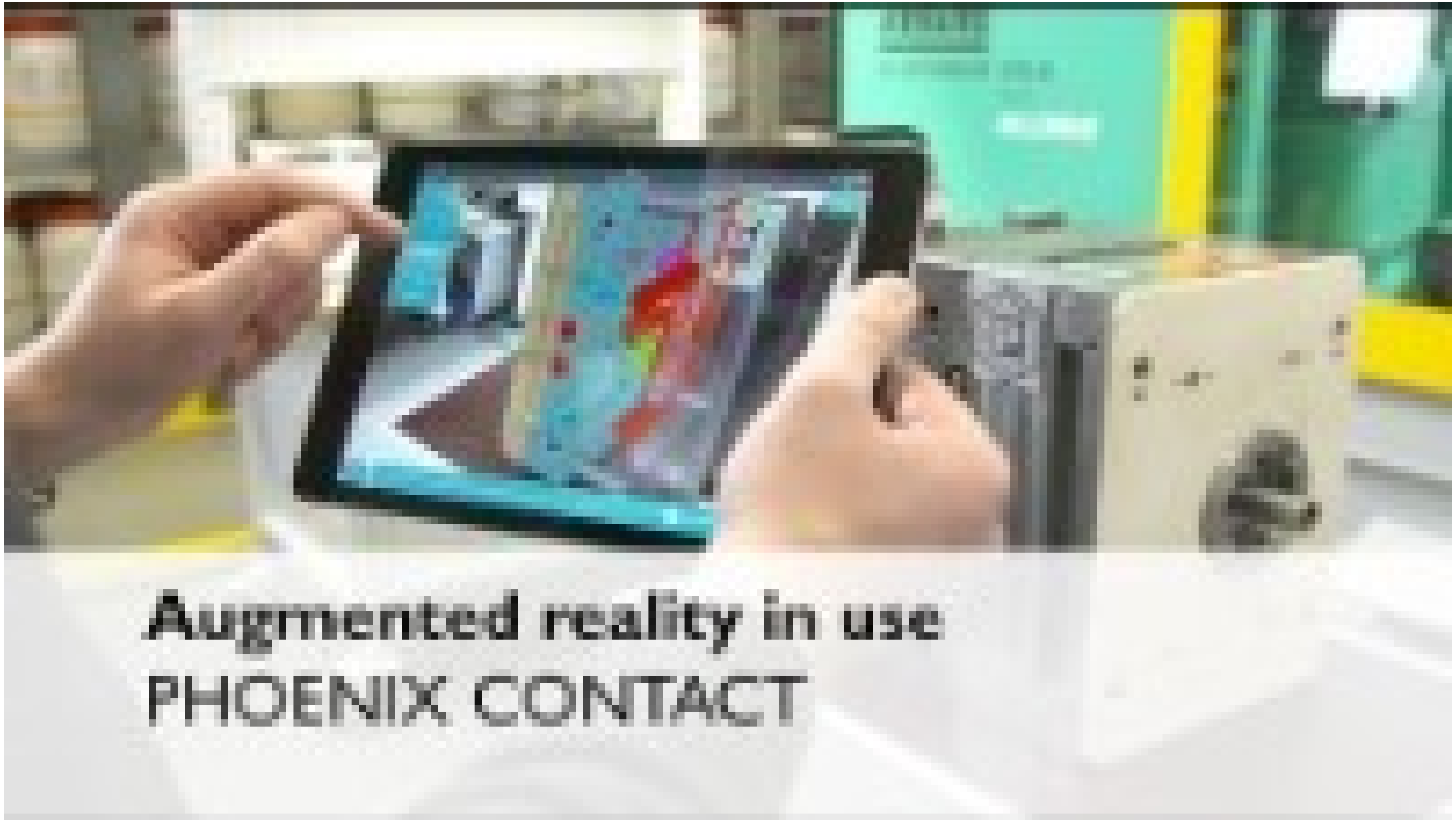
Vuforia AR Engine

- 2008, for the first truly usable natural feature tracking system for smartphones was introduced

- Today, AR developers can choose among many software platforms, but these model systems continue to represent important directions for researchers.

Where is AR useful in contemporary world?

Industry and Construction



Industry and Construction

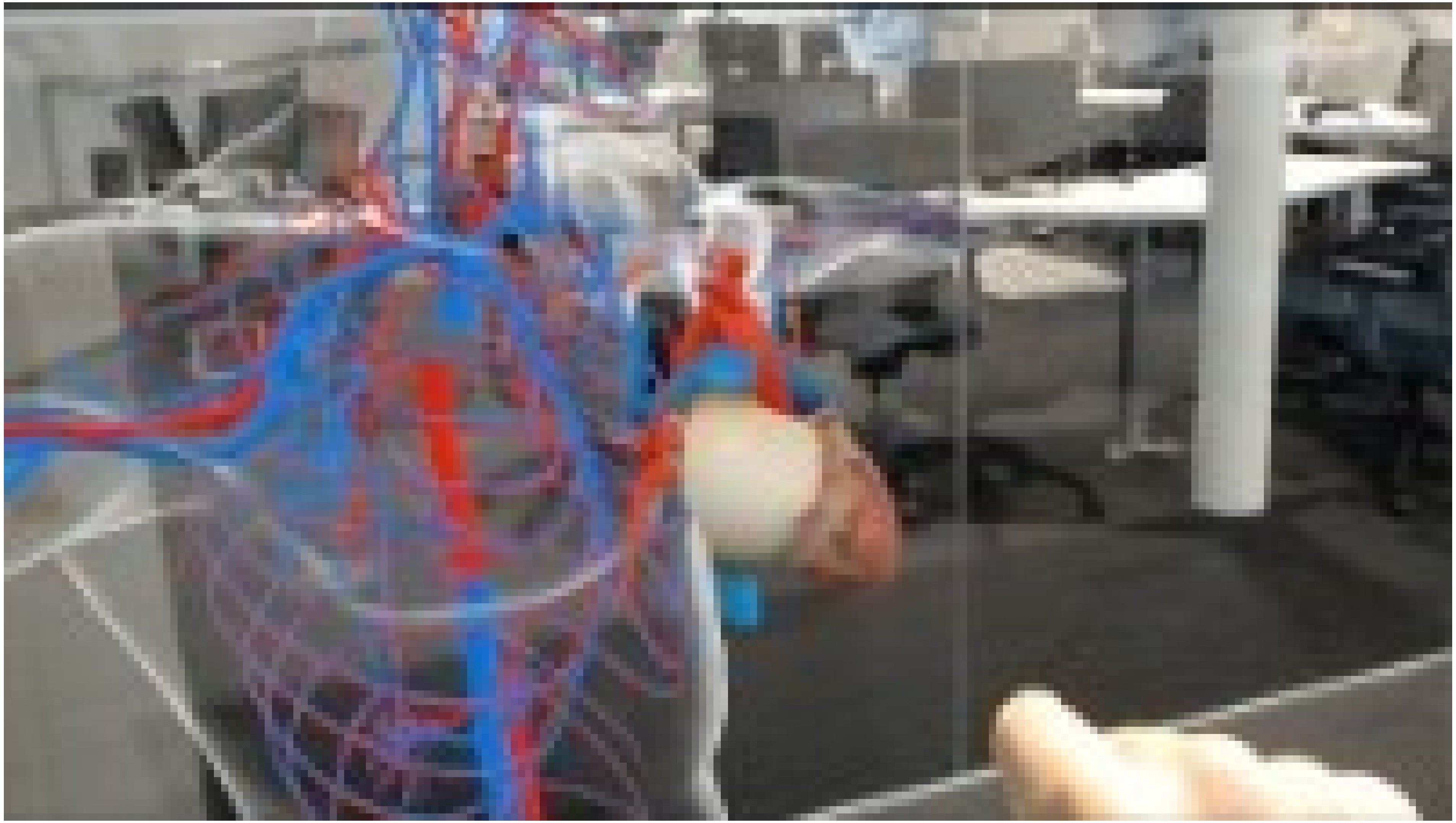
Industry and Construction

Maintenance and Training

Maintenance and Training

Medical

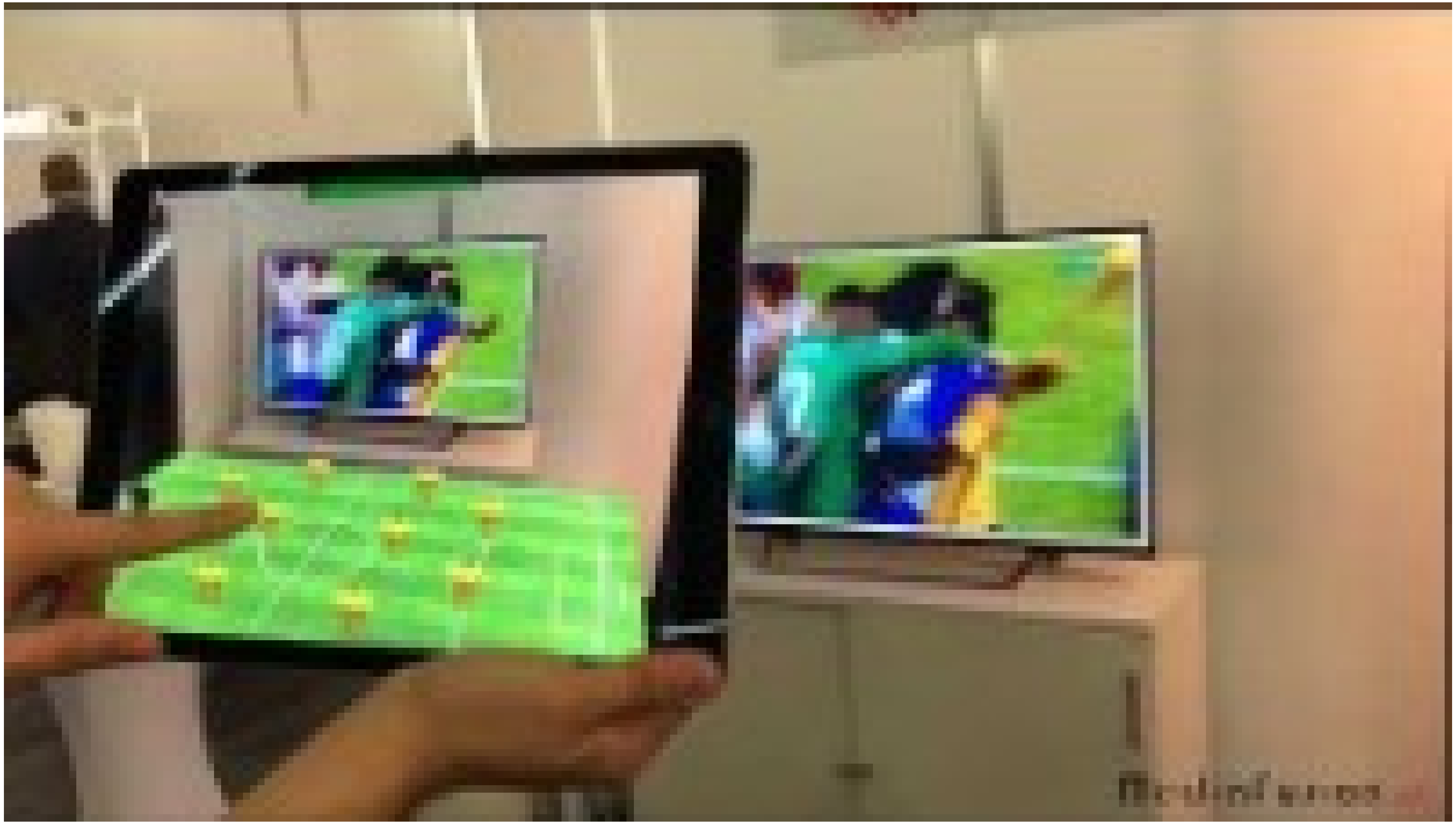
Medical



Personal Information Display

Navigation

Television



Television

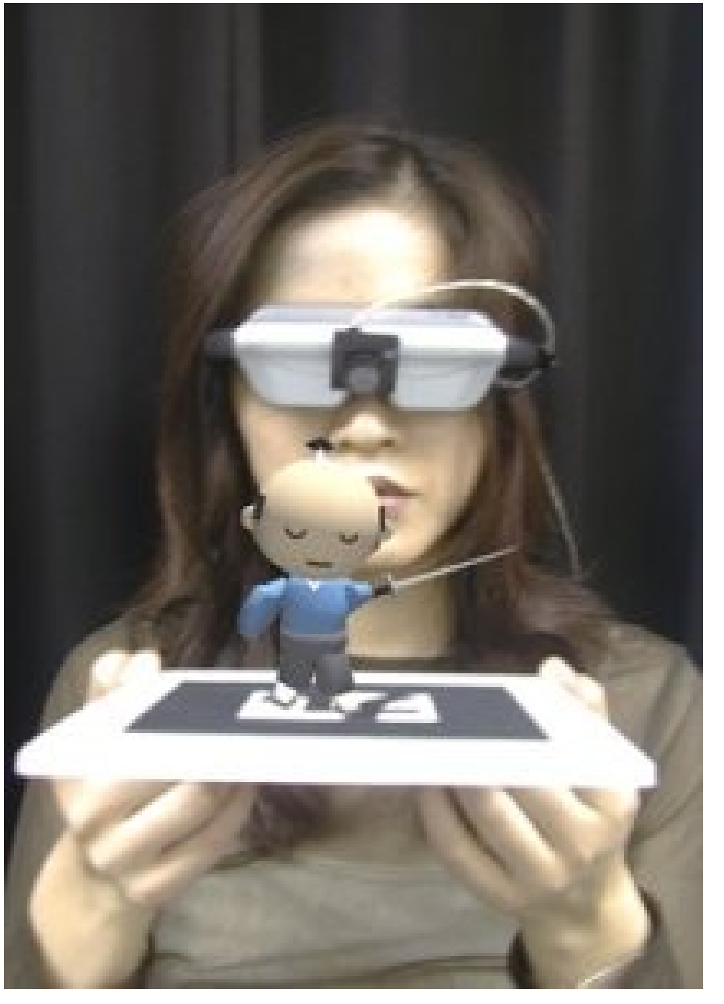
E-Commerce and Marketing

E-Commerce and Marketing

Games

What Is Augmented Reality (AR)?

- A combination of
  - a real scene viewed by a user and
  - a virtual scene generated by a computer that augments the scene with additional information.
  - ARToolkit demo movie
  - T-immersion 2004 video



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 and 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

Milgram’s Reality-Virtuality Continuum

Mixed Reality (MR)

Real Environment → Augmented Reality (AR)

Augmented Virtuality (AV) ← Virtual Environment

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.

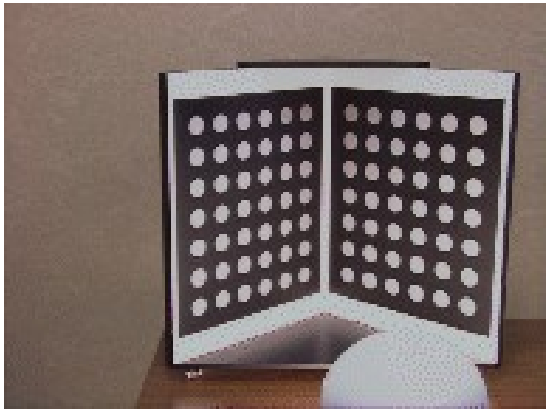
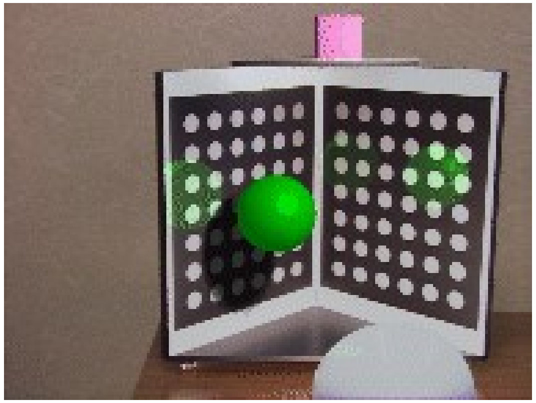
Combining the Real and Virtual Worlds

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 manners when manipulated
- Occlusion
- Collision detection
- Shadows

Research Activities

- Develop methods to register the two distinct sets (real, virtual) of images and keep them registered in real-time
  - This often reduces to finding the position of a camera relative to some fiducial markers
- Develop new display technologies for merging the two images

Performance Issues

Two performance criteria are placed on the system:

- Update rate for generating the augmenting image
- Accuracy of the registration of the real and virtual image
  - Update rate can limit registration accuracy as well
  - Brooks paper – “1 ms = 1mm error”

Failures in Registration

Failures in registration due to:

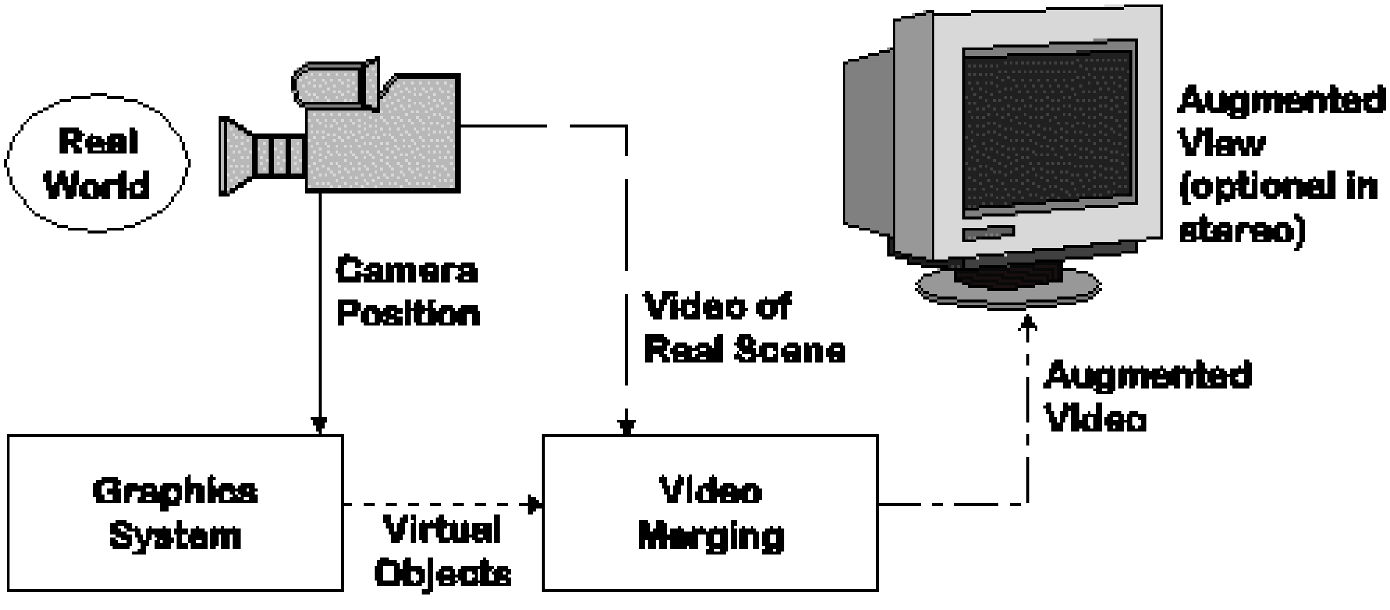
- Noise
  - Position and pose of camera with respect to the real scene
- Image distortions
- Time delays
  - In calculating the camera position

Display Technologies

- Monitor Based
  - Laptops
  - Cell phones
  - Projectors (more Ubiquitous Computing)
- Head Mounted Displays:
  - Video see-through
  - Optical see-through

Monitor Based Augmented Reality

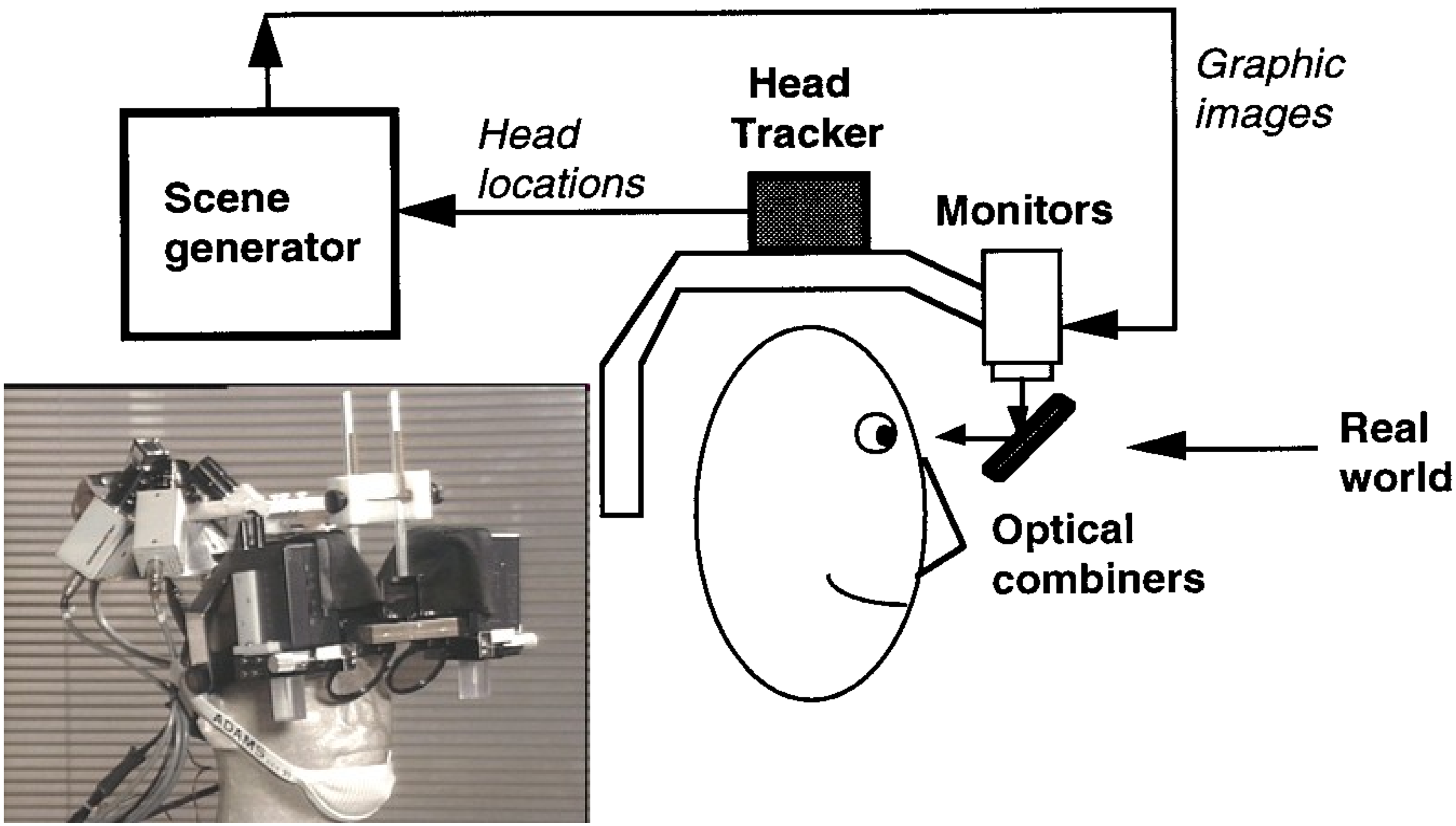
- Simplest available
- Treat laptop/PDA/cell phone as a window through which you can see AR world.
- Sunglasses demo



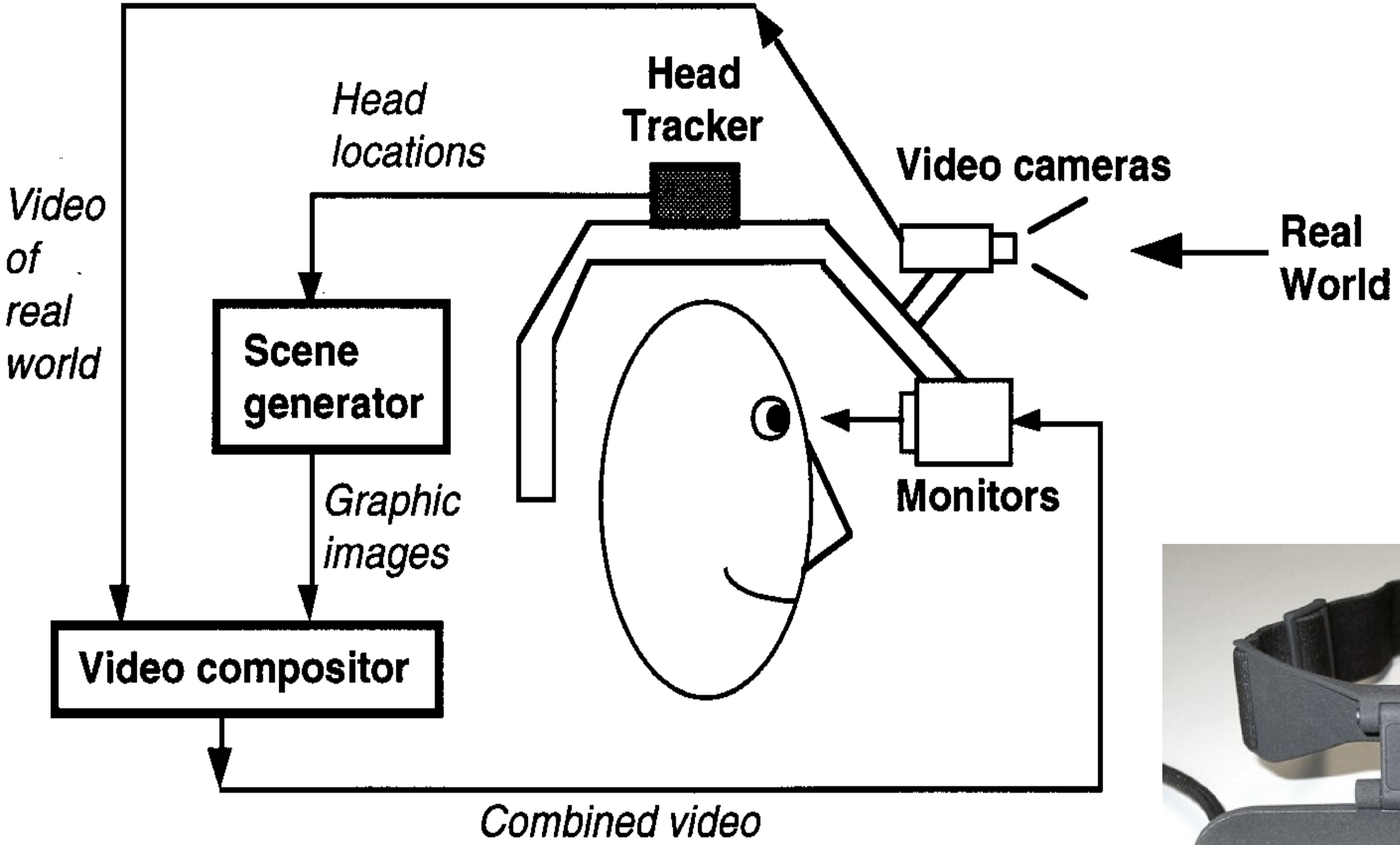
Monitor Based AR

- Successful commercialization
  - Yellow line in football broadcasts
  - Glowing hockey puck
  - Replace times square billboards with own commercials during New Year’s Eve broadcasts
  - Baseball cards
  - Ad campaigns

Optical see-through HMD



Video see-through HMD



Advantages of Video see-through HMD

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

Advantages of Optical see-through HMD

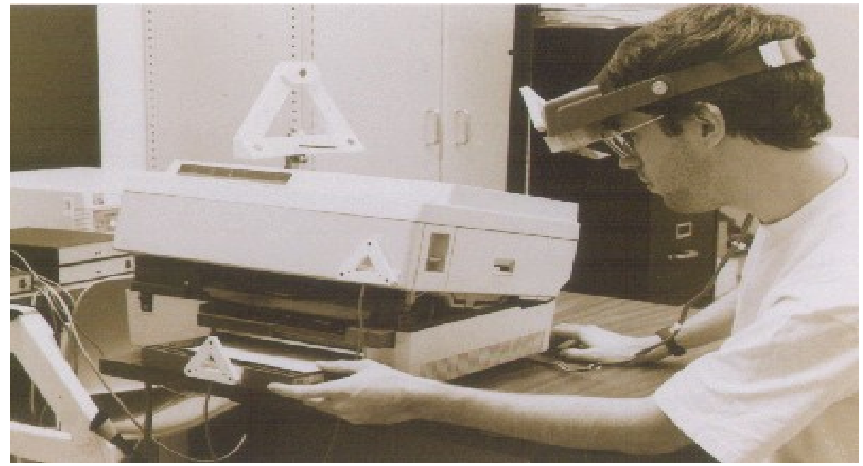
- Simplicity
- Resolution
- No eye offset

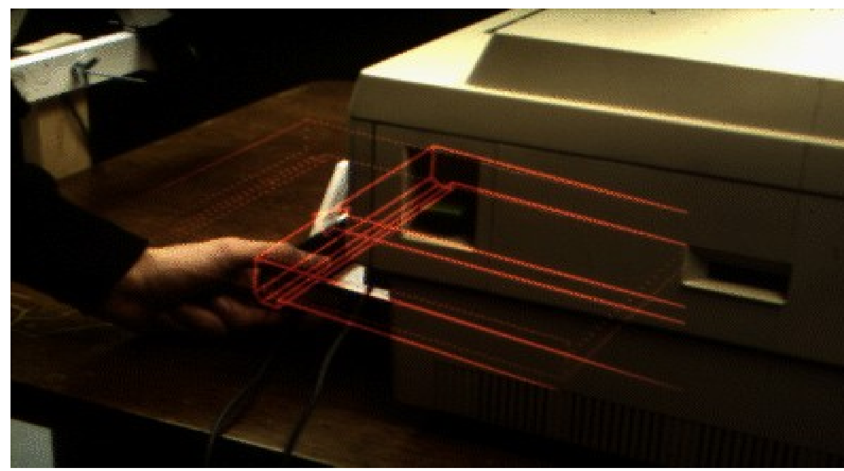
Advantage of Monitor Displays

- Consumer-level equipment
- Most practical
- A lot of current research aimed here
- Other current active area is a flip-down optical display.

Early Application

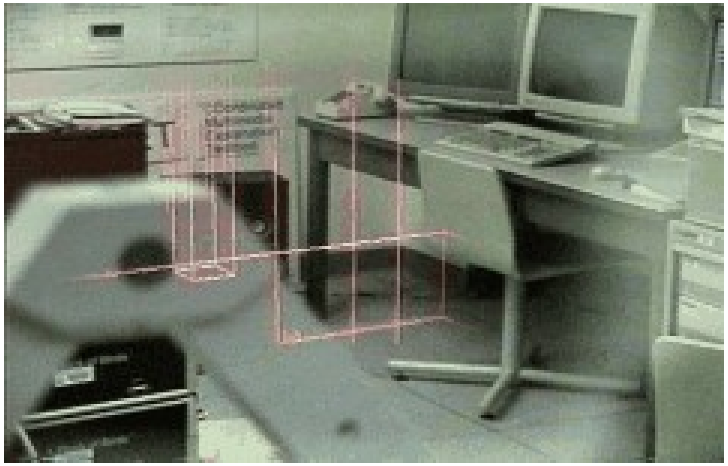
- KARMA (91)
  - Feiner
- Optical see-through HMD
- Knowledge-based assistant for maintenance
- Ultrasound trackers attached to assembly parts

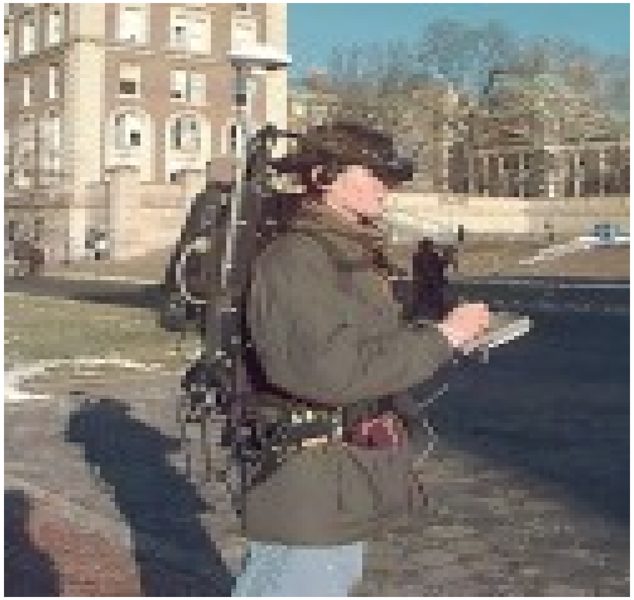




Early Application

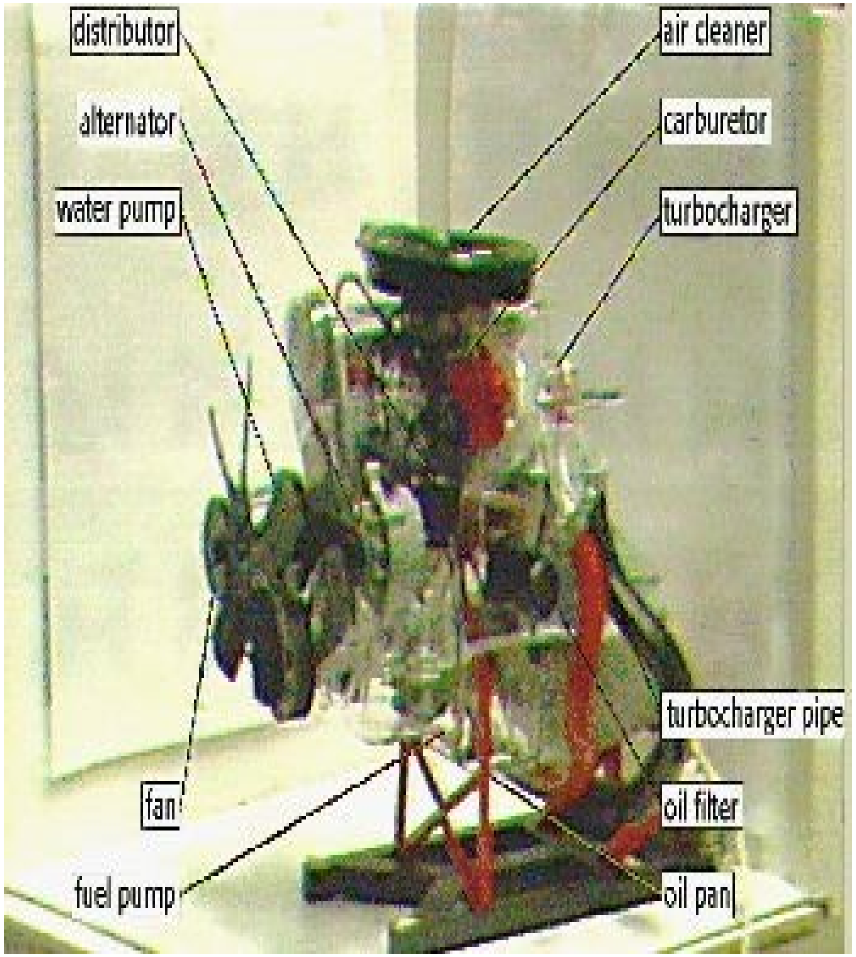
- Later – "architectural anatomy" - movie
- Tourguide - movie





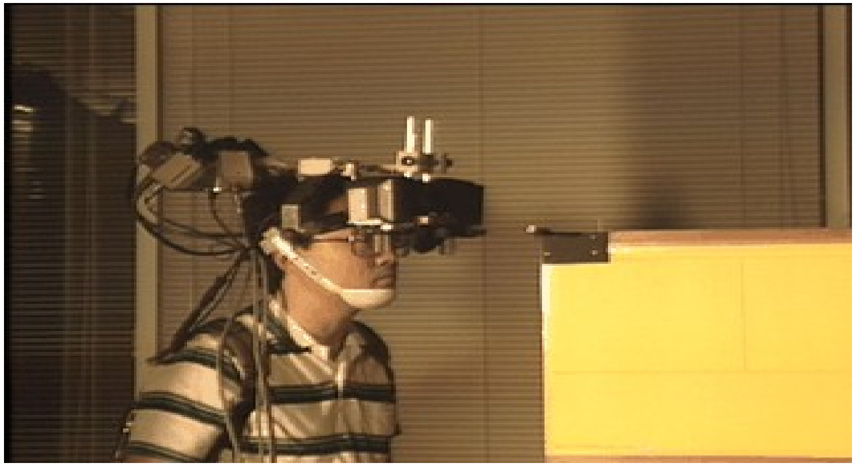
More Mechanical

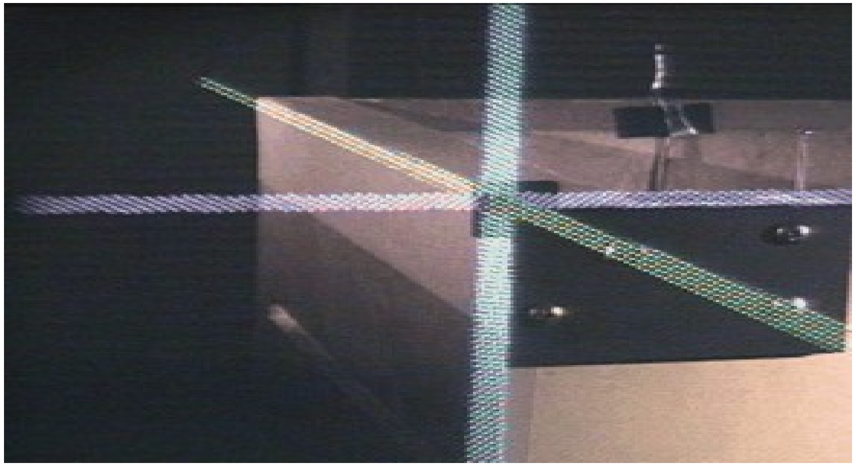
- ECRC



UNC - Medical

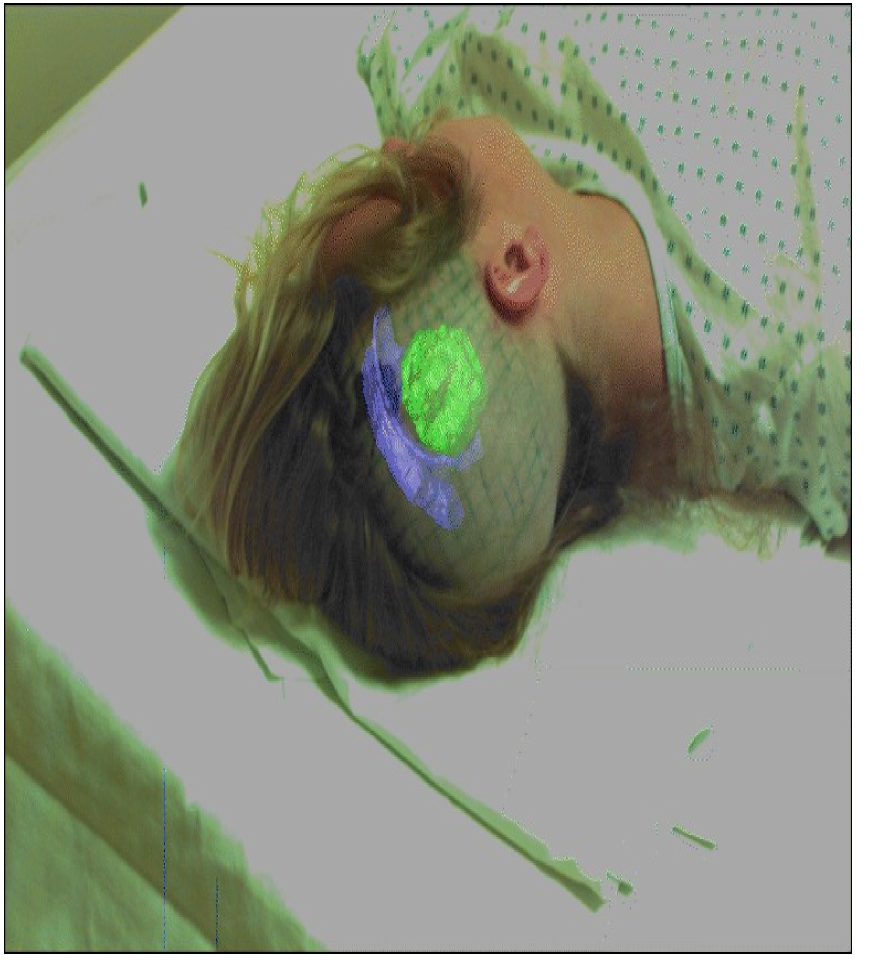
- Early 90's
- Lots of work on reducing registration error
  - Explain movie
  - Teapot movie
- Medical applications
  - movie





MIT Medical

- Laser-scanned patient
- LCD screen above patient



AR Instructional

- Reality provides a natural interface
  - MagicBook movie

AR Games

- ARQuake

AR

- Lots of new applications

chapter 9

evaluation techniques

Evaluation Techniques

- Evaluation
  - tests usability and functionality of system
  - occurs in laboratory, field and/or in collaboration with users
  - evaluates both design and implementation
  - should be considered at all stages in the design life cycle

Goals of Evaluation

- assess extent of system functionality
- assess effect of interface on user
- identify specific problems

Evaluating Designs

Cognitive Walkthrough
Heuristic Evaluation
Review-based evaluation

Cognitive Walkthrough

Proposed by Polson *et al.*
- evaluates design on how well it supports user in learning task
- usually performed by expert in cognitive psychology
- expert 'walks though' design to identify potential problems using psychological principles
- forms used to guide analysis

Cognitive Walkthrough (ctd)

- For each task walkthrough considers
  - what impact will interaction have on user?
  - what cognitive processes are required?
  - what learning problems may occur?
- Analysis focuses on goals and knowledge: does the design lead the user to generate the correct goals?

Heuristic Evaluation

- Proposed by Nielsen and Molich.
- usability criteria (heuristics) are identified
- design examined by experts to see if these are violated
- Example heuristics
  - system behaviour is predictable
  - system behaviour is consistent
  - feedback is provided
- Heuristic evaluation `debugs' design.

Review-based evaluation

- Results from the literature used to support or refute parts of design.
- Care needed to ensure results are transferable to new design.
- Model-based evaluation
- Cognitive models used to filter design options
  e.g. GOMS prediction of user performance.
- Design rationale can also provide useful evaluation information

Evaluating through user Participation

Laboratory studies

- Advantages:
  - specialist equipment available
  - uninterrupted environment
- Disadvantages:
  - lack of context
  - difficult to observe several users cooperating
- Appropriate
  - if system location is dangerous or impractical for constrained single user systems to allow controlled manipulation of use

Field Studies

- Advantages:
  - natural environment
  - context retained (though observation may alter it)
  - longitudinal studies possible
- Disadvantages:
  - distractions
  - noise
- Appropriate
  - where context is crucial for longitudinal studies

Evaluating Implementations

Requires an artefact:
simulation, prototype,
full implementation

Experimental evaluation

- controlled evaluation of specific aspects of interactive behaviour
- evaluator chooses hypothesis to be tested
- a number of experimental conditions are considered which differ only in the value of some controlled variable.
- changes in behavioural measure are attributed to different conditions

Experimental factors

- Subjects
  - who – representative, sufficient sample
- Variables
  - things to modify and measure
- Hypothesis
  - what you'd like to show
- Experimental design
  - how you are going to do it

Variables

- independent variable (IV)

  characteristic changed to produce different conditions

  e.g. interface style, number of menu items
- dependent variable (DV)

  characteristics measured in the experiment

  e.g. time taken, number of errors.

Hypothesis

- prediction of outcome
  - framed in terms of IV and DV

  e.g. "error rate will increase as font size decreases"
- null hypothesis:
  - states no difference between conditions
  - aim is to disprove this

  e.g. null hyp. = "no change with font size"

Experimental design

- within groups design
  - each subject performs experiment under each condition.
  - transfer of learning possible
  - less costly and less likely to suffer from user variation.
- between groups design
  - each subject performs under only one condition
  - no transfer of learning
  - more users required
  - variation can bias results.

Analysis of data

- Before you start to do any statistics:
  - look at data
  - save original data
- Choice of statistical technique depends on
  - type of data
  - information required
- Type of data
  - discrete - finite number of values
  - continuous - any value

Analysis - types of test

- parametric
  - assume normal distribution
  - robust
  - powerful
- non-parametric
  - do not assume normal distribution
  - less powerful
  - more reliable
- contingency table
  - classify data by discrete attributes
  - count number of data items in each group

Analysis of data (cont.)

- What information is required?
  - is there a difference?
  - how big is the difference?
  - how accurate is the estimate?
- Parametric and non-parametric tests mainly address first of these

Experimental studies on groups

More difficult than single-user experiments

Problems with:
- subject groups
- choice of task
- data gathering
- analysis

Subject groups

larger number of subjects
⇒ more expensive

longer time to `settle down'
… even more variation!

difficult to timetable

so … often only three or four groups

The task

must encourage cooperation

perhaps involve multiple channels

options:
- creative task — e.g. *'write a short report on …'*
- decision games — e.g. desert survival task
- control task — e.g. ARKola bottling plant

Data gathering

several video cameras
+ direct logging of application

problems:
- synchronisation
- sheer volume!

one solution:
- record from each perspective

Analysis

N.B. vast variation between groups

solutions:

- within groups experiments
- micro-analysis (e.g., gaps in speech)
- anecdotal and qualitative analysis

look at interactions between group and media

controlled experiments may `waste' resources!

Field studies

Experiments dominated by group formation

Field studies more realistic:

distributed cognition ⇒ work studied in context

real action is *situated action*

physical and social environment both crucial

Contrast:

psychology – controlled experiment

sociology and anthropology – open study and rich data

Observational Methods

Think Aloud
Cooperative evaluation
Protocol analysis
Automated analysis
Post-task walkthroughs

Think Aloud

- user observed performing task
- user asked to describe what he is doing and why, what he thinks is happening etc.
- Advantages
  - simplicity - requires little expertise
  - can provide useful insight
  - can show how system is actually use
- Disadvantages
  - subjective
  - selective
  - act of describing may alter task performance

Cooperative evaluation

- variation on think aloud
- user collaborates in evaluation
- both user and evaluator can ask each other questions throughout
- Additional advantages
  - less constrained and easier to use
  - user is encouraged to criticize system
  - clarification possible

Protocol analysis

- paper and pencil – cheap, limited to writing speed
- audio – good for think aloud, difficult to match with other protocols
- video – accurate and realistic, needs special equipment, obtrusive
- computer logging – automatic and unobtrusive, large amounts of data difficult to analyze
- user notebooks – coarse and subjective, useful insights, good for longitudinal studies
- Mixed use in practice.
- audio/video transcription difficult and requires skill.
- Some automatic support tools available

automated analysis – EVA

- Workplace project
- Post task walkthrough
  - user reacts on action after the event
  - used to fill in intention
- Advantages
  - analyst has time to focus on relevant incidents
  - avoid excessive interruption of task
- Disadvantages
  - lack of freshness
  - may be post-hoc interpretation of events

post-task walkthroughs

- transcript played back to participant for comment
  - immediately → fresh in mind
  - delayed → evaluator has time to identify questions
- useful to identify reasons for actions and alternatives considered
- necessary in cases where think aloud is not possible

Query Techniques

Interviews
Questionnaires

Interviews

- analyst questions user on one-to -one basis usually based on prepared questions
- informal, subjective and relatively cheap
- Advantages
  - can be varied to suit context
  - issues can be explored more fully
  - can elicit user views and identify unanticipated problems
- Disadvantages
  - very subjective
  - time consuming

Questionnaires

- Set of fixed questions given to users
- Advantages
  - quick and reaches large user group
  - can be analyzed more rigorously
- Disadvantages
  - less flexible
  - less probing

Questionnaires (ctd)

- Need careful design
  - what information is required?
  - how are answers to be analyzed?
- Styles of question
  - general
  - open-ended
  - scalar
  - multi-choice
  - ranked

Physiological methods

Eye tracking
Physiological measurement

eye tracking

- head or desk mounted equipment tracks the position of the eye
- eye movement reflects the amount of cognitive processing a display requires
- measurements include
  - fixations: eye maintains stable position. Number and duration indicate level of difficulty with display
  - saccades: rapid eye movement from one point of interest to another
  - scan paths: moving straight to a target with a short fixation at the target is optimal

physiological measurements

- emotional response linked to physical changes
- these may help determine a user's reaction to an interface
- measurements include:
  - heart activity, including blood pressure, volume and pulse.
  - activity of sweat glands: Galvanic Skin Response (GSR)
  - electrical activity in muscle: electromyogram (EMG)
  - electrical activity in brain: electroencephalogram (EEG)
- some difficulty in interpreting these physiological responses - more research needed

Choosing an Evaluation Method

when in process:	design vs. implementation
style of evaluation:	laboratory vs. field
how objective:	subjective vs. objective
type of measures:	qualitative vs. quantitative
level of information:	high level vs. low level
level of interference:	obtrusive vs. unobtrusive
resources available:	time, subjects, equipment, expertise