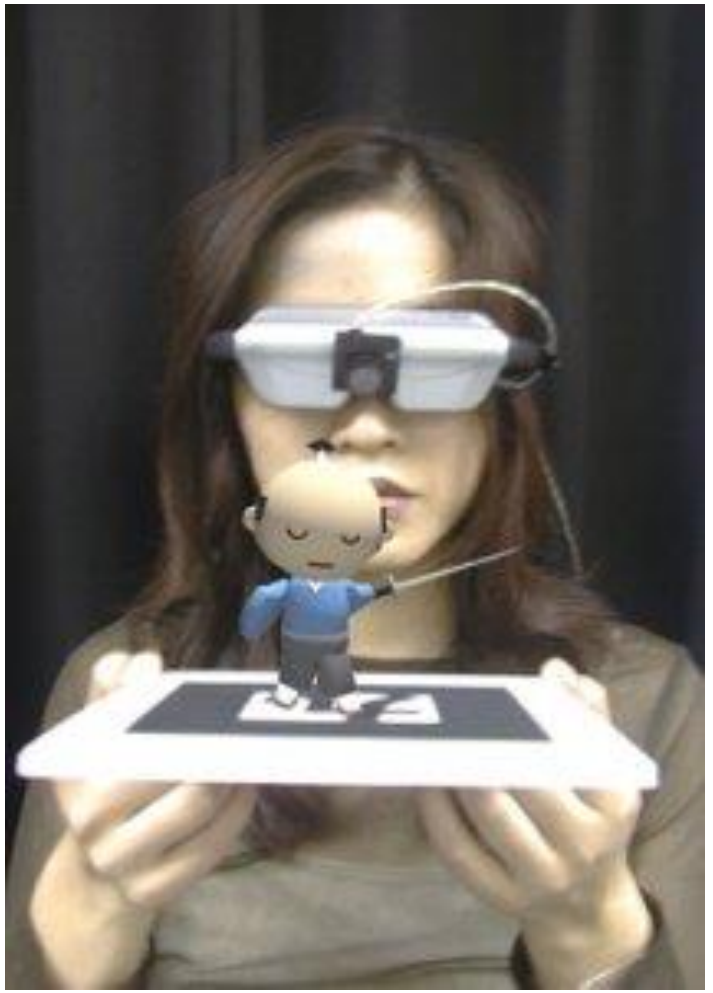
Augmented Reality

CPS592 – Visual Computing and Mixed Reality

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.
- Combines real and virtual realities
- Interactive in real time
- Not the same as “virtual reality”



Augmented Reality vs. Virtual Reality

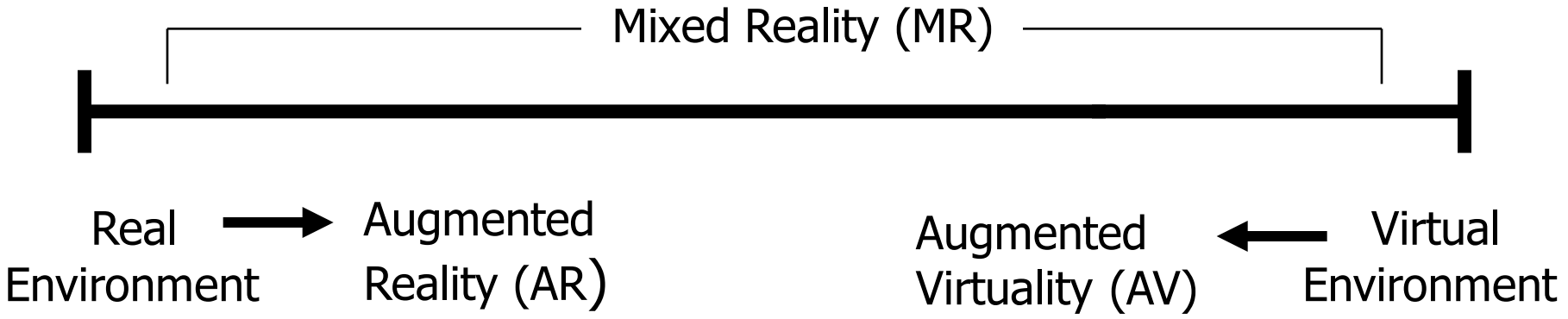
Augmented Reality

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

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



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.

Historical Background

- 1957-62 – Morton Heilig, Sensorama
- 1966 – Ivan Sutherland, head-mounted display
- 1975 – Myron Krueger, Videoplace
- 1989 – Jaron Lanier coined the term *Virtual Reality*
- 1992 – Tom Caudell coined the term *Augmented Reality*

Historical Timeline

- 1994 – Julie Martin, AR Theater
- 1999 – Hirokazu Kato, AR Toolkit
- 2000 – Bruce Thomas, ARQuake
- 2008-09 – Wikitude, AR Travel Guide and Navigation System
- 2009 – AR Toolkit ported to Adobe Flash
- 2012 - Vuforia

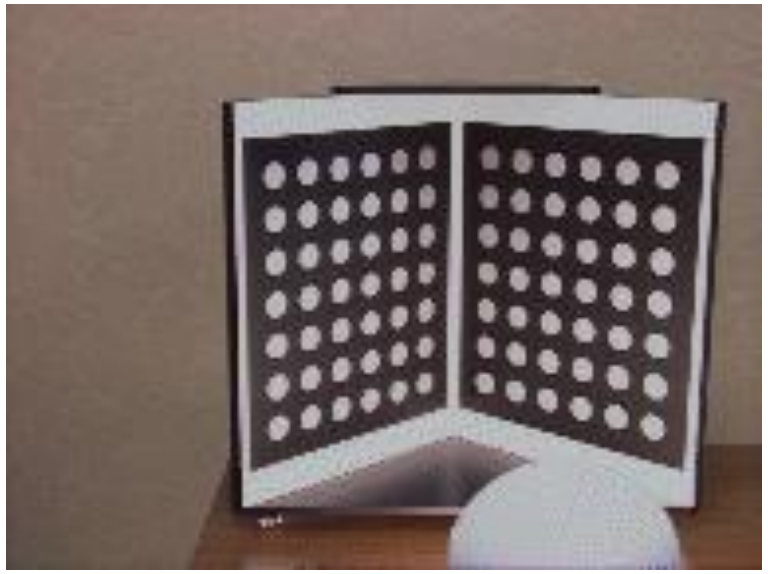
How Does AR Work?

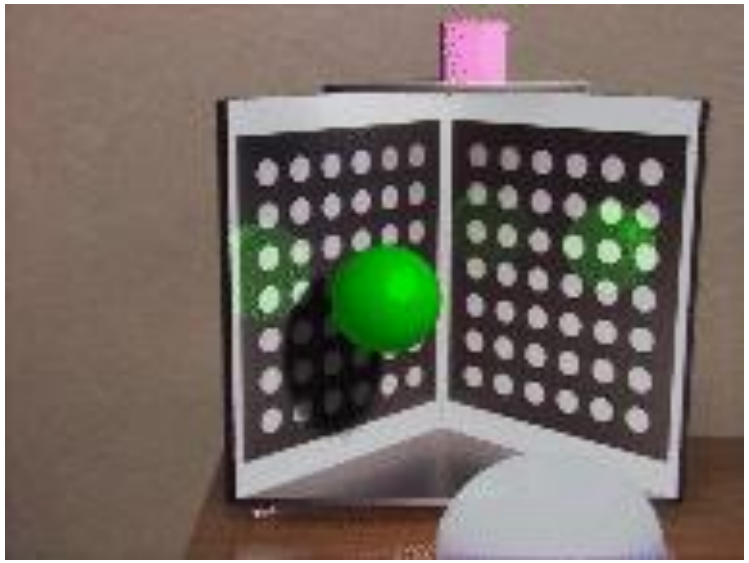
We need:

- 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

How Does AR Work?

- 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





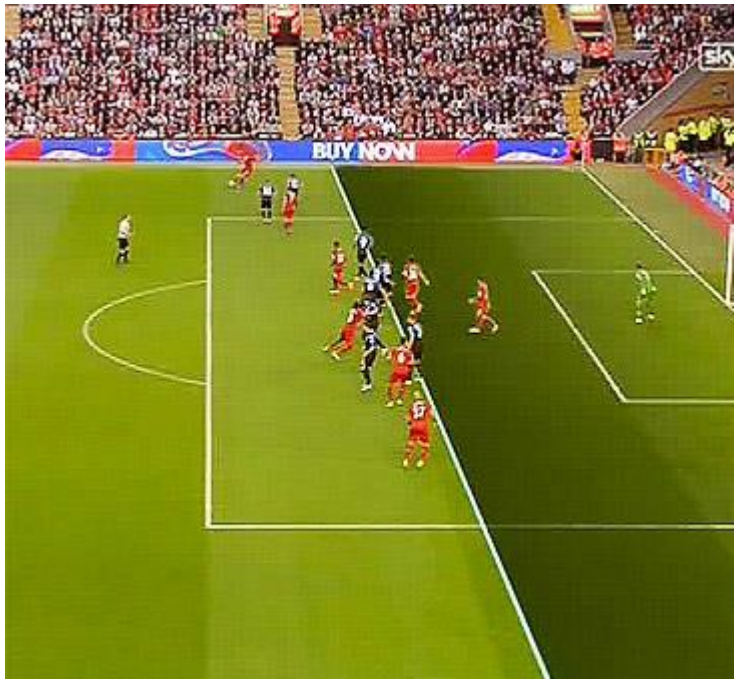
How Does AR Work?

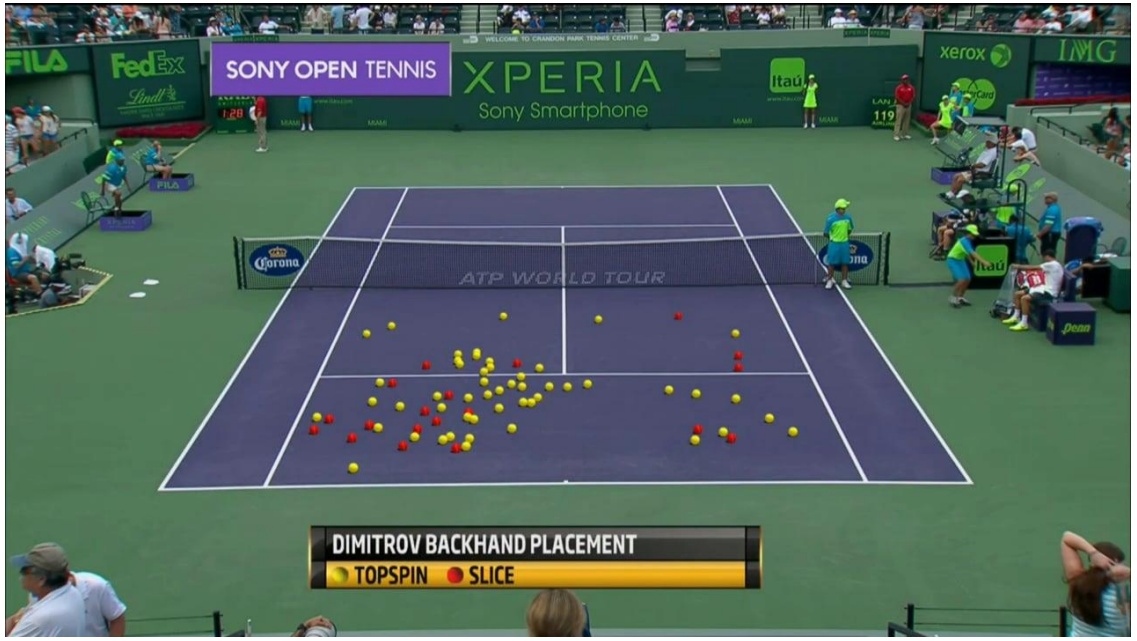
- Can be accomplished in two ways by:
  1. Looking at a screen showing visible and augmented objects

  2. Looking through a device using the generated screen display

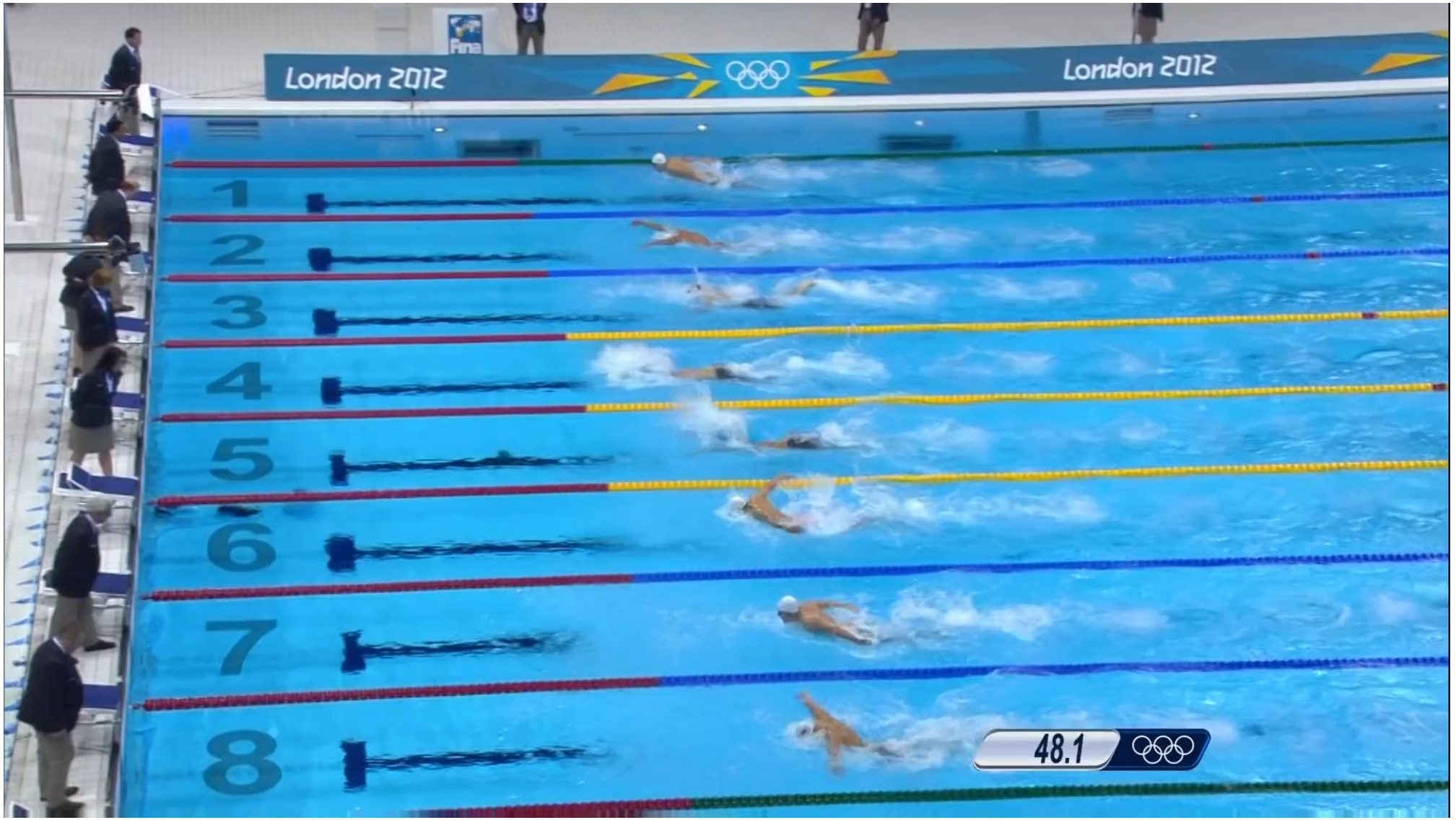
Examples: Looking at a Screen

- Offside line in a soccer match
- Giant logos or ads on athletic fields
- World record lines for swimming events





Examples

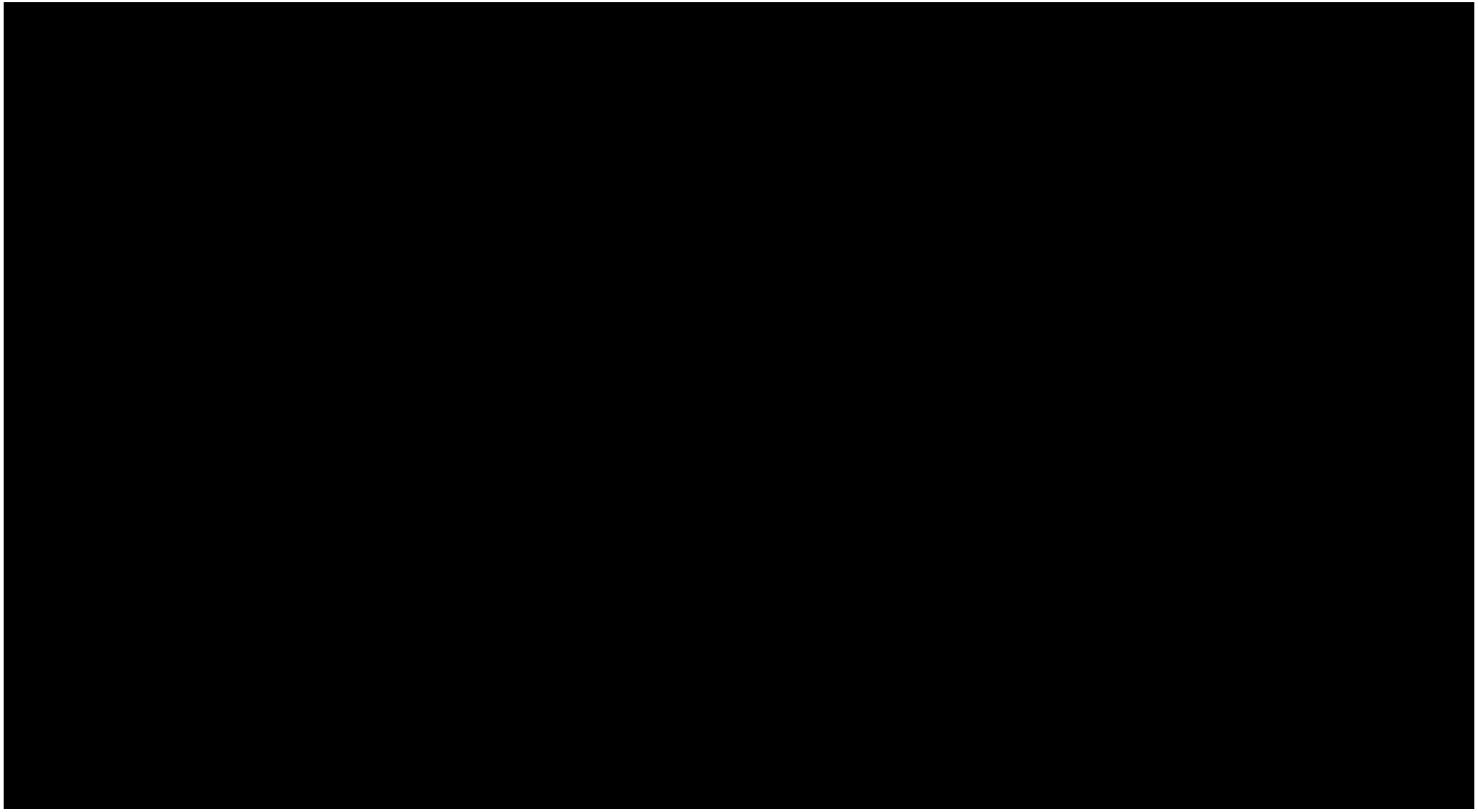


Examples

Examples: Looking Through Device

- Creative photography
- Navigation systems

Examples

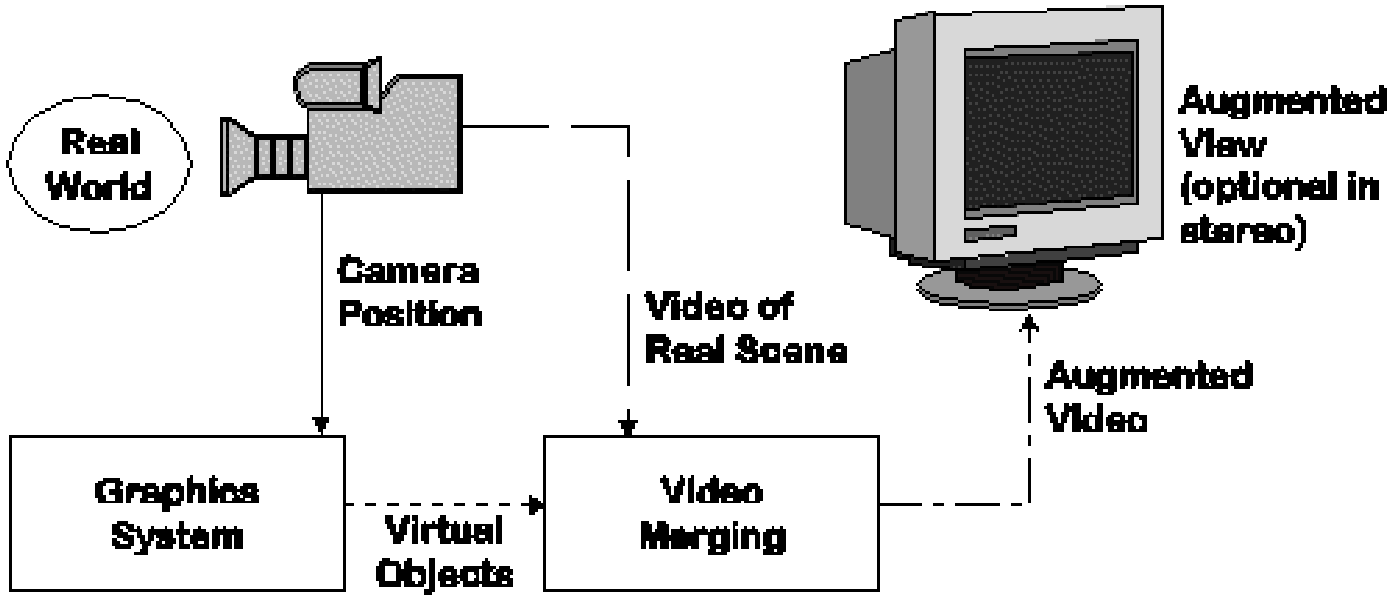


How to display?

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

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

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.

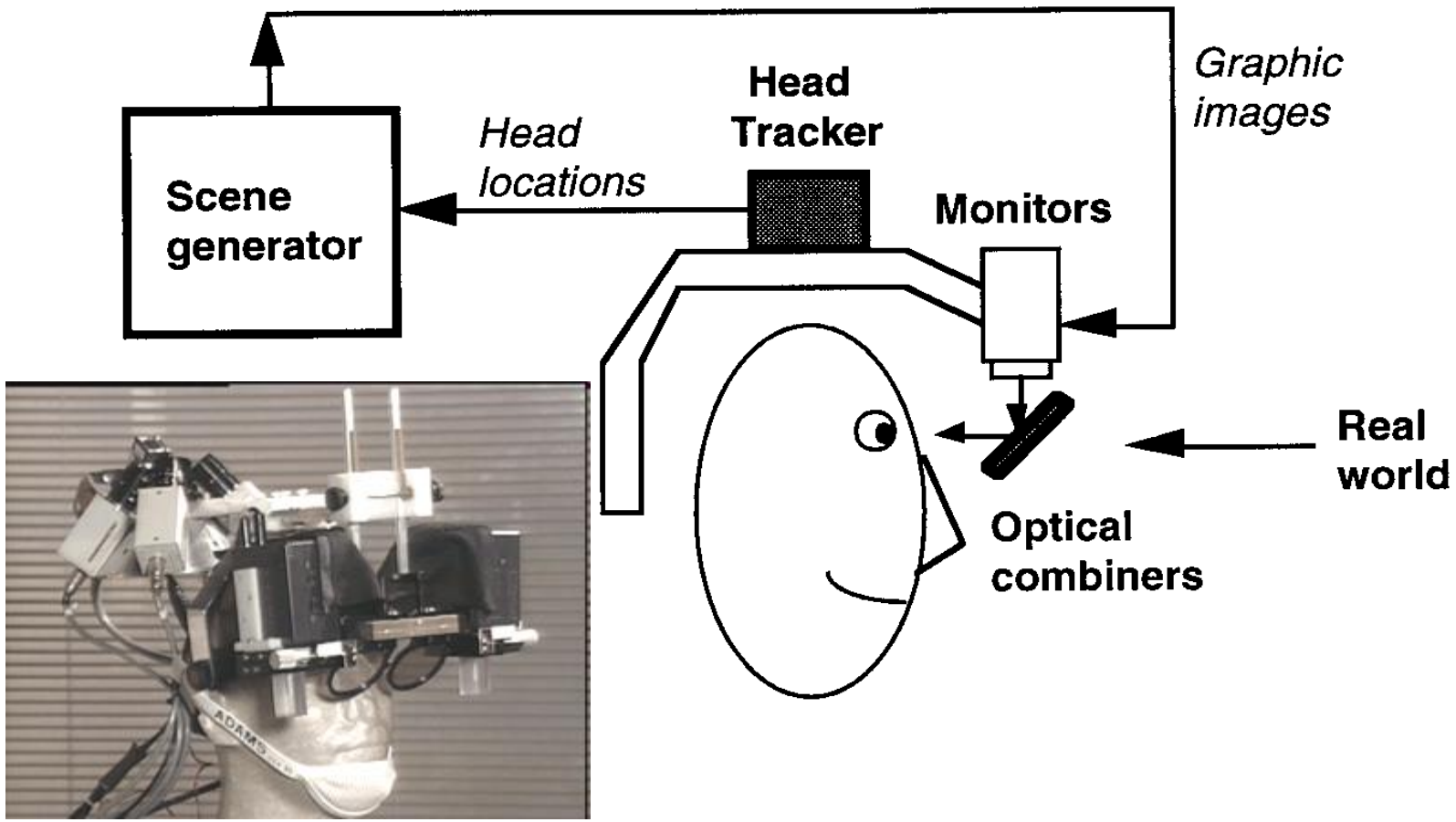
Head-Mounted / Heads-Up Displays

- Combines and displays physical world images and virtual graphical objects

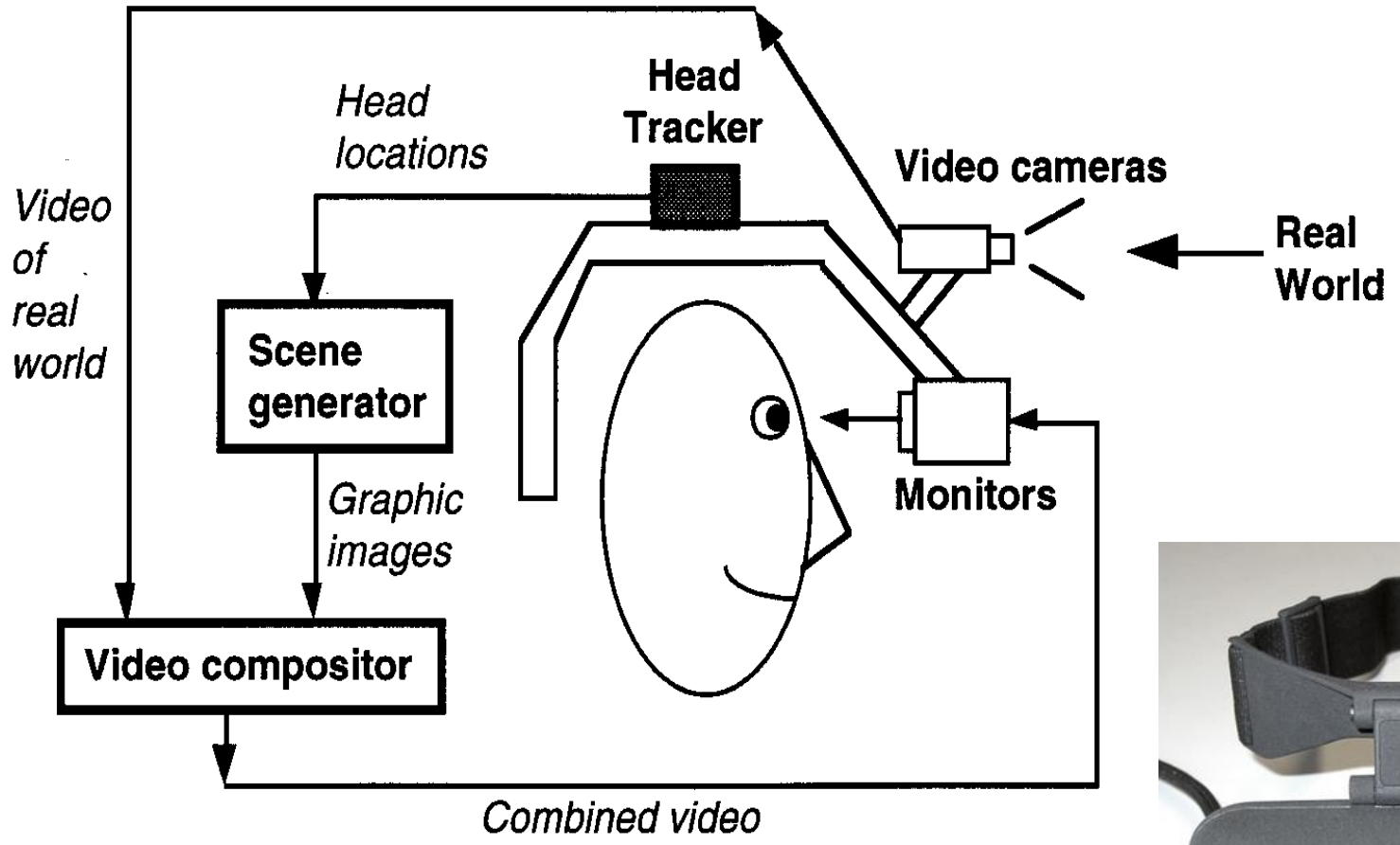
SVGA Head-Mounted Display

Vehicle Heads-Up Display

Optical see-through HMD



Video see-through HMD



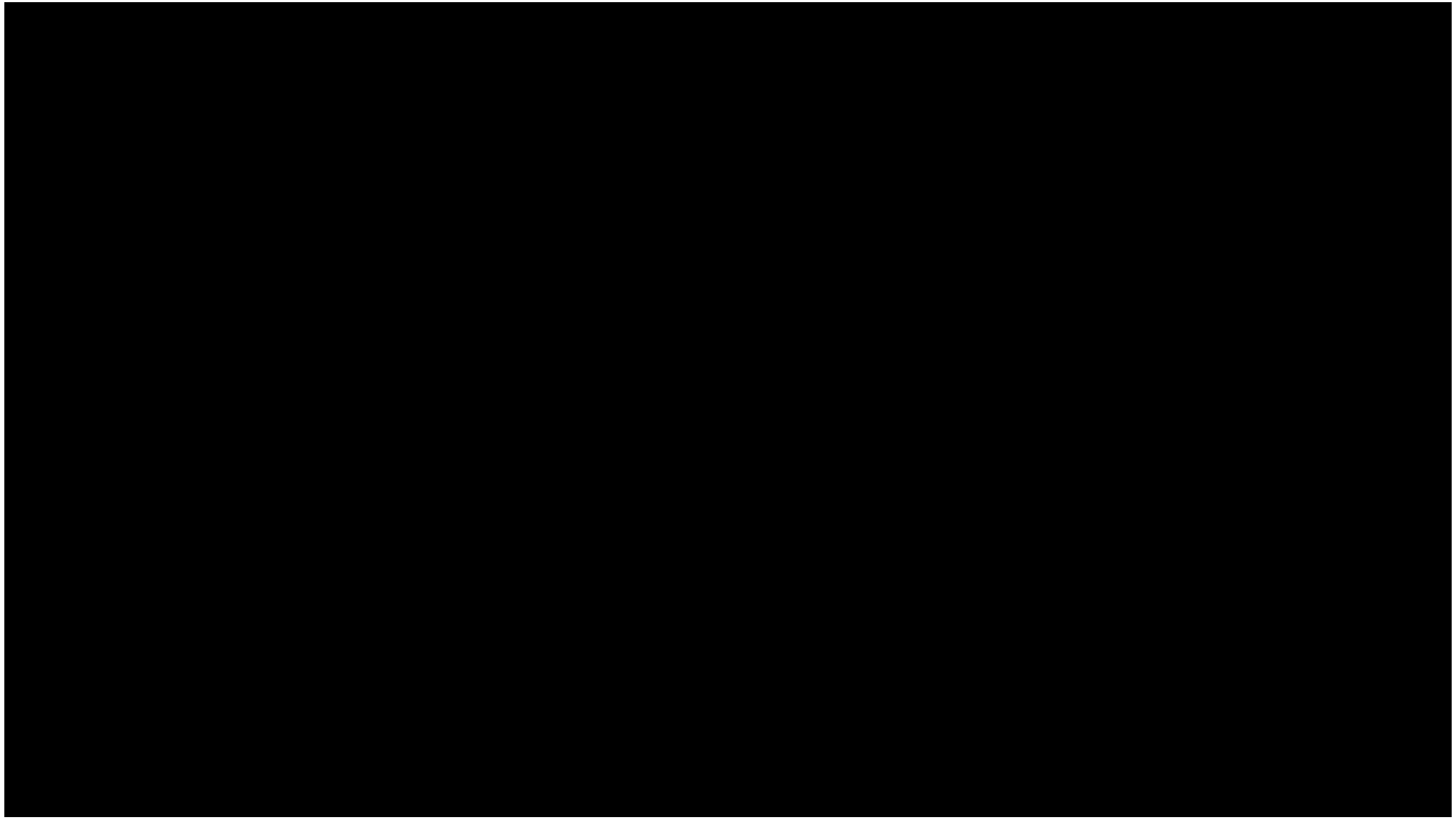
Advantages of Video see-through HMD

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

Advantages of Optical see-through HMD

- Simplicity
- Resolution
- No eye offset

New HMD

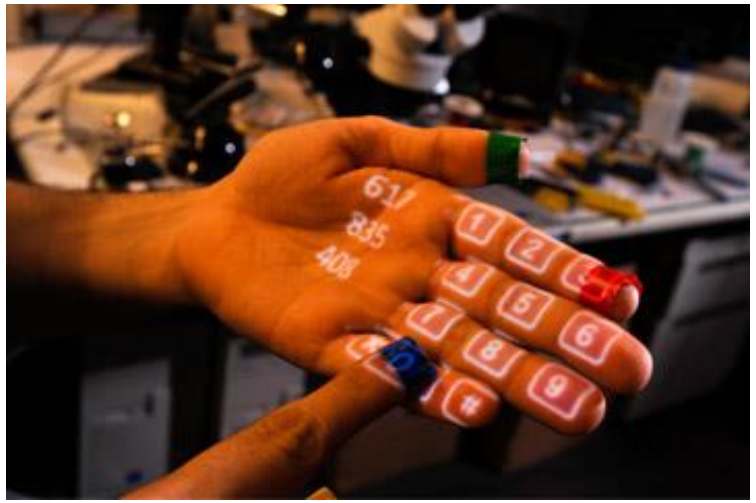


Handheld Displays

- Small handheld computing device
- Uses global positioning systems (GPS)

Spatial Displays

- Nothing to wear and/or carry
- Uses digital projectors to display information
- Marker-based and markerless devices



AR Phone Keypad

AR Keyboard

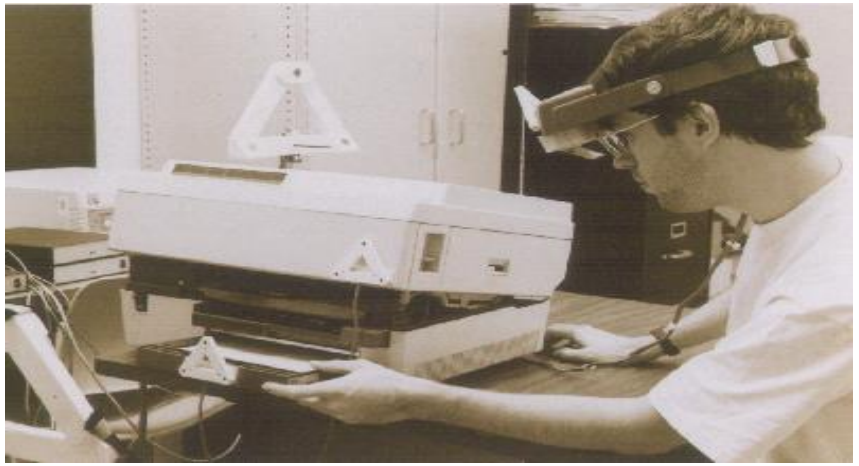
Spatial Displays

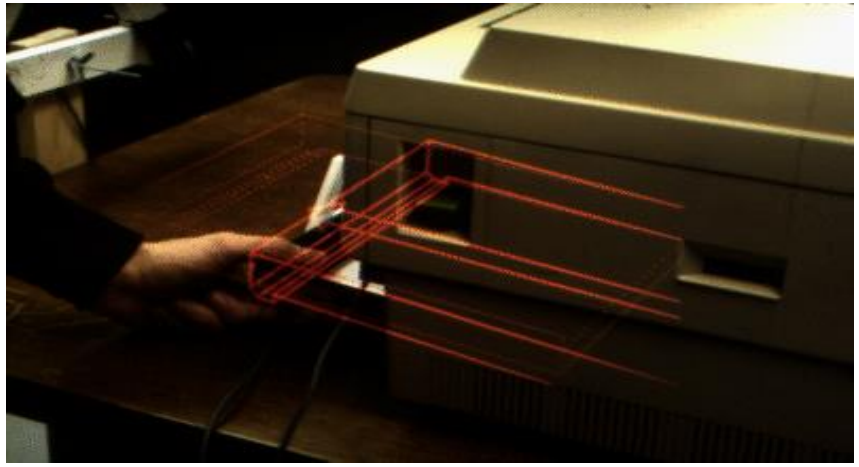
Applications: Combining real imagery with computer generated imagery

- Robot-assisted surgery
- Virtual real estate tours
- Virtual medical tours
- Urban planning
- Map-assisted navigation
- Computer games

Early Application

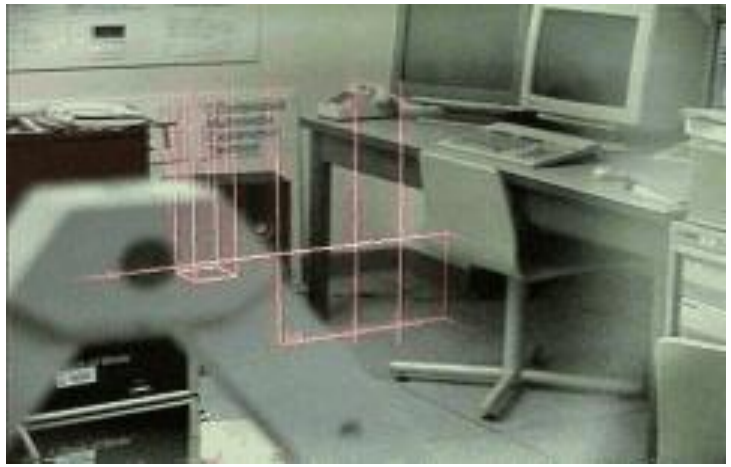
- KARMA (91)
- Optical see-through HMD
- Knowledge-based assistant for maintenance
- Ultrasound trackers attached to assembly parts





Early Application

- Later – “architectural anatomy”
- Tourguide



UNC - Medical

- Early 90’s
- Lots of work on reducing registration error

MIT Medical

- Laser-scanned patient
- LCD screen above patient

Modern AR Applications

- Wireless mobile devices
- Anywhere, anytime access
- State-of-the-art cell phones

Advertising Applications

- Promote products via interactive AR applications

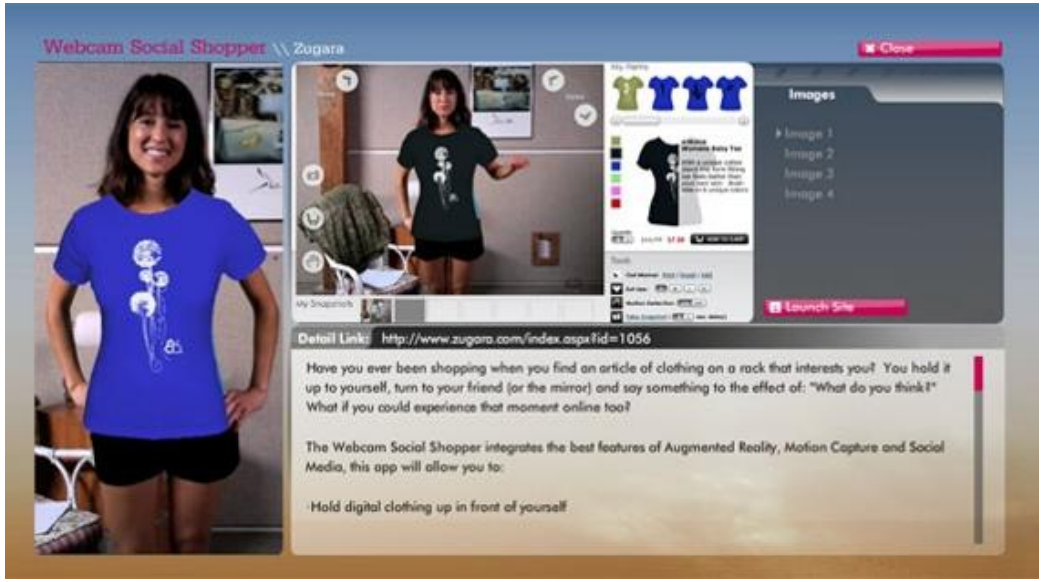
Movie character speaks to you when you pass her outdoor movie poster

City Sites Tour

Marketing Applications

- Assist consumers on location with ratings, reviews, and other information

Restaurant search



Social shopper

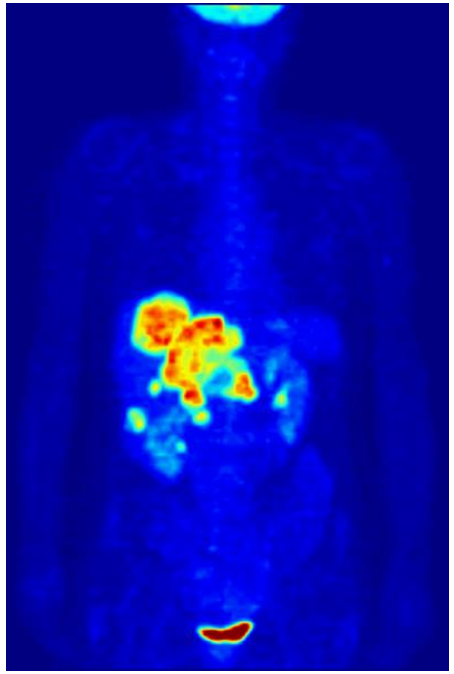
Industrial Applications

- Compare the data of digital mock-ups with physical mock-ups
- Provide instructions, specs, and training for mechanics and machine operators

Scientific Applications

- Visualize 3D phenomena
- Display interactive analysis of terrain characteristics

Terrain rendering



Whole body PET scan

Arts Applications

- Create art over real art
- Simulate construction projects
- Create virtual objects on locations

Arts Applications

- Launch interactive AR music videos
- Visit historical sites and step back in time

Arts Applications

- Project AR into musical stage shows
  - Duran Duran

Animated character at concert

Educational Applications

- Provide powerful contextual, explorative, and discovery learning experiences
- Show network learning
- Facilitate collaboration among distributed team members
- Create 3D graphics of curriculum content
- Overlay factual onto view of real world

Educational Applications

- Teach critical thinking, science, and social studies through AR gaming

Military Strategy Game

Racetrack Pit Strategy Game

Educational Applications

- Generate models in different settings
- Have books come alive

Other Educational Applications

- Astronomy
  - Google’s SkyMap
  - pUniverse
- Architecture
  - ARSights
- Computer Science
- Student Guides

Benefits of AR

- Exposure to learning experiences
- Connected to many learning opportunities
- Learn from anywhere and share with anyone
- Used to enhance collaborative tasks
- Support of seamless interaction between real and virtual environments
- Use of a tangible interface metaphor for object manipulation
- Ability to transition smoothly between reality and virtuality

Drawbacks of AR

- Accuracy
  - Large margin of error
- Standards
  - No open standards among AR platforms

Pending / Future Applications

- Expanding a PC screen into the real world
- Virtual everything
- Virtual gadgetry
- Virtual retinal displays
- AR-enabled contact lenses

Future Applications?

Summary

- What is AR?
  - The ability to overlay computer graphics onto the real world
- What can AR do?
  - Combines real and virtual realities to turn an empty space into a very rich educational experience
- How can AR be used in education?
  - Offers seamless interaction between the real and virtual worlds, a tangible interface metaphor, and a means for transitioning between real and virtual worlds to create learning opportunities and knowledge connections

Q&A