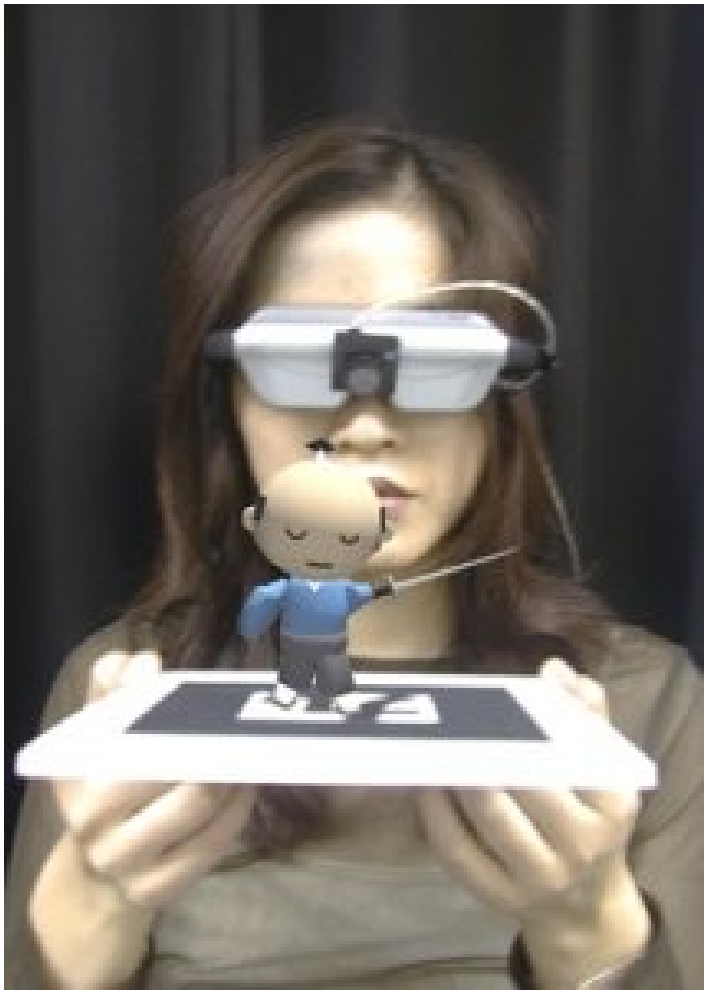
# What Is Augmented Reality (AR)?

- 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.

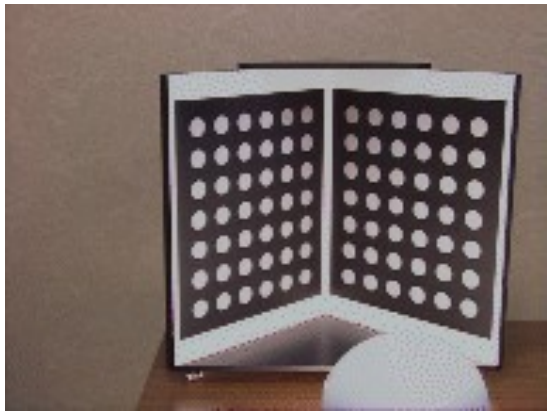
# Combining the Real and Virtual Worlds

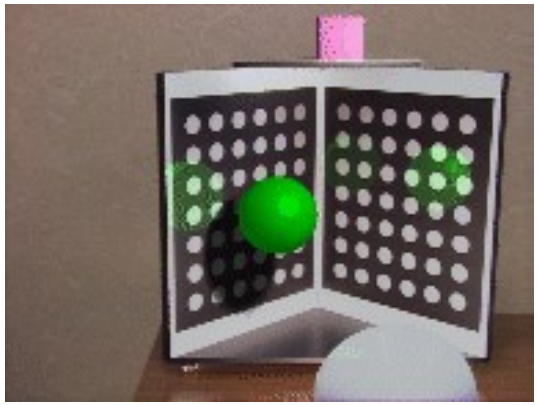
We need:

- 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:

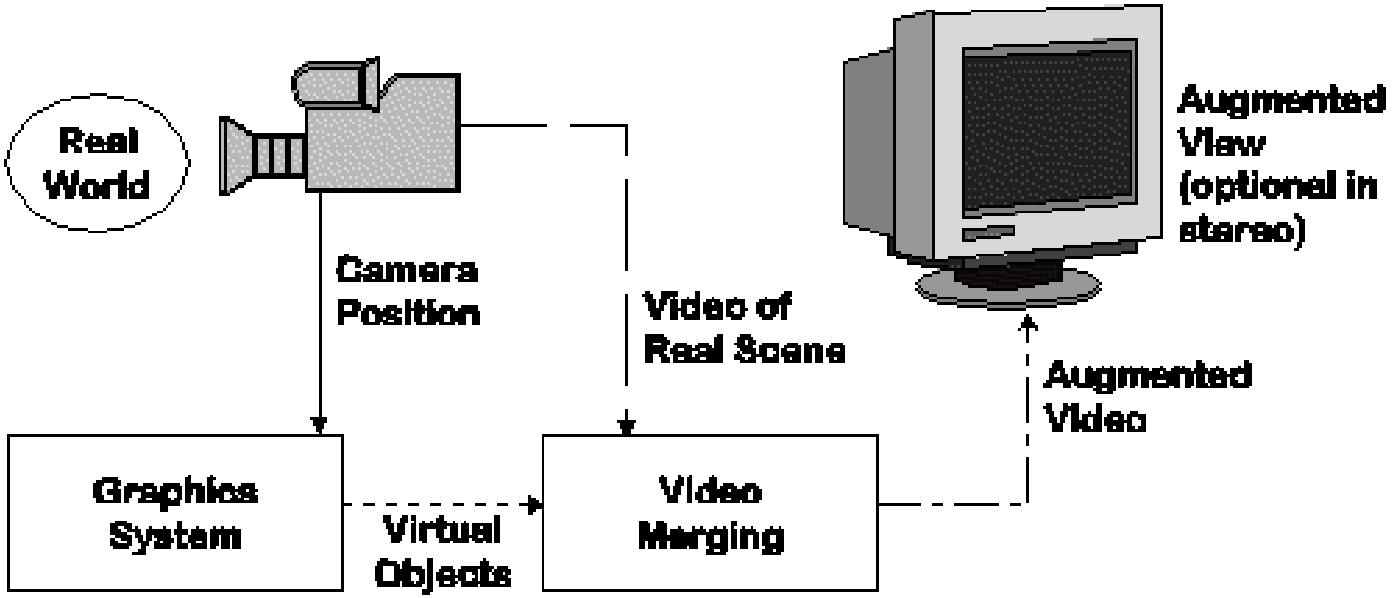
- Noise
  - Position and pose of camera with respect to the real scene
- Image distortions
- Time delays
  - In calculating the camera position

# Display Technologies

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

# Monitor Based Augmented Reality

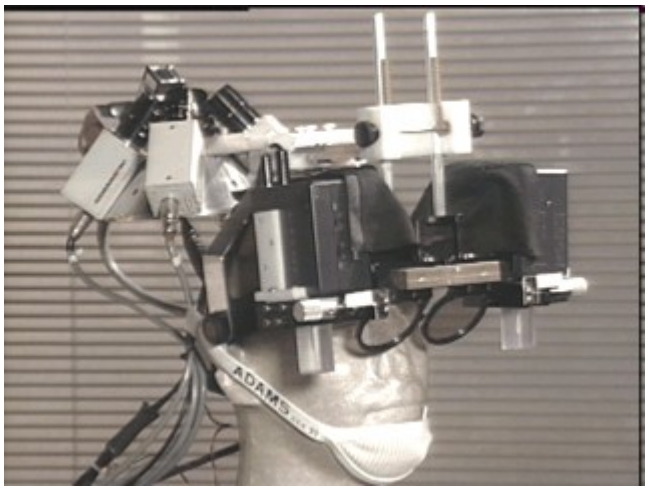
- Simplest available
- Treat laptop/PDA/cell phone as a window through which you can see AR world.
- Sunglasses demo



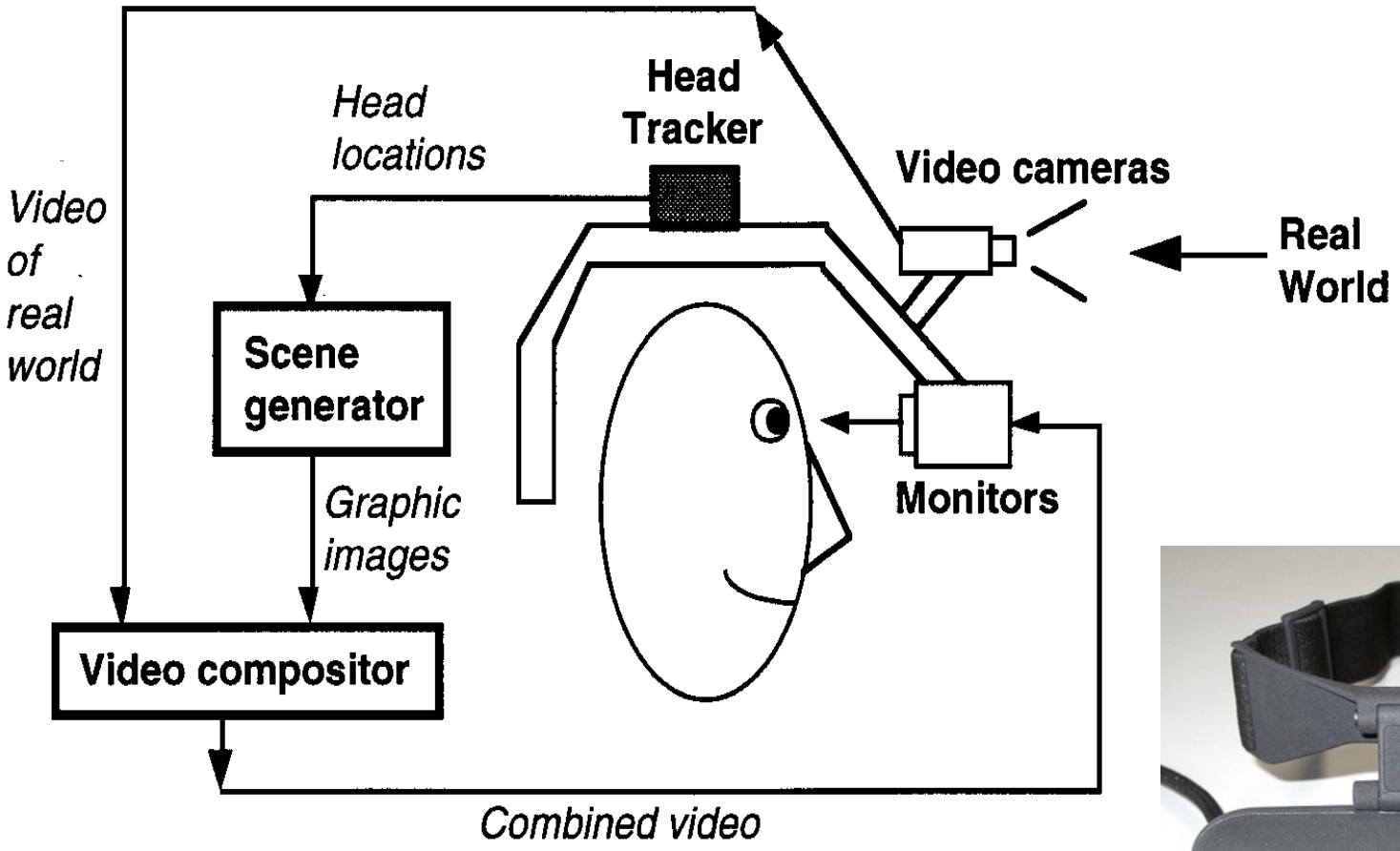
# Monitor Based AR

- 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

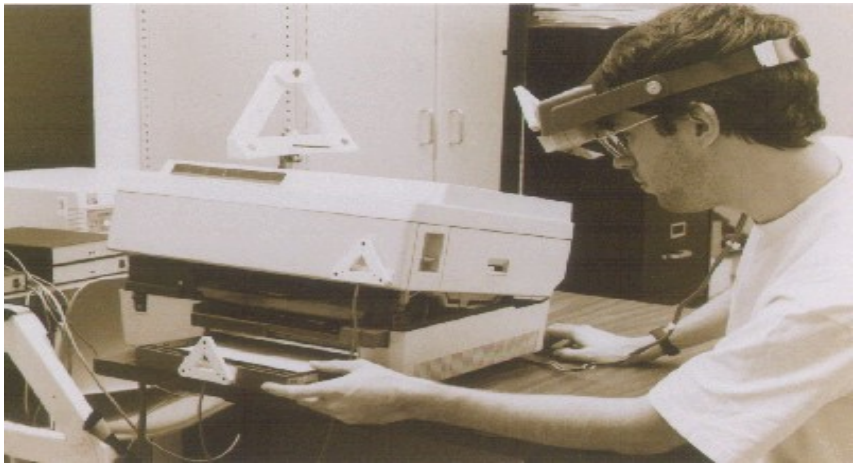
- Simplicity
- Resolution
- No eye offset

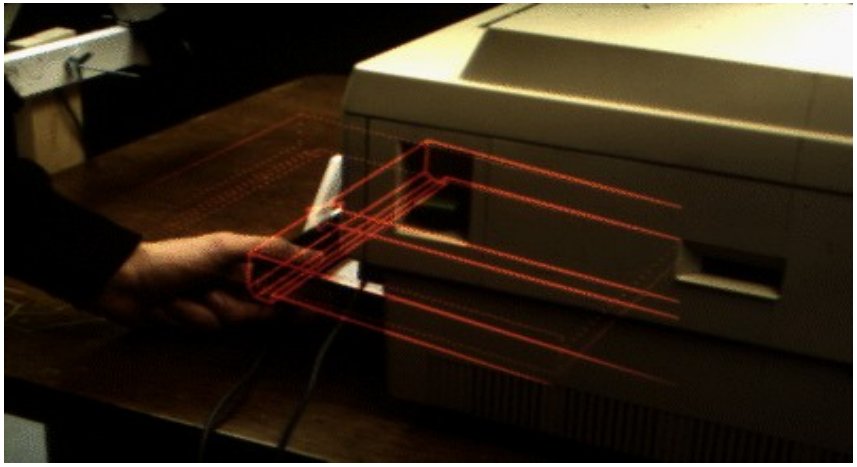
# Advantage of Monitor Displays

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

# Early Application

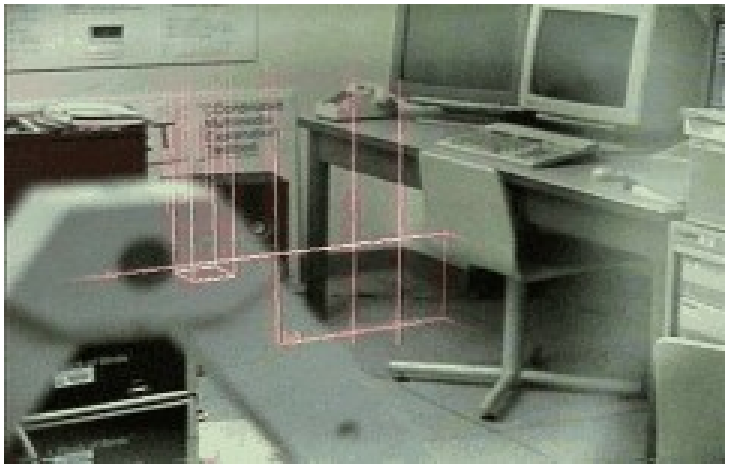
- KARMA (91)
  - Feiner
- Optical see-through HMD
- Knowledge-based assistant for maintenance
- Ultrasound trackers attached to assembly parts

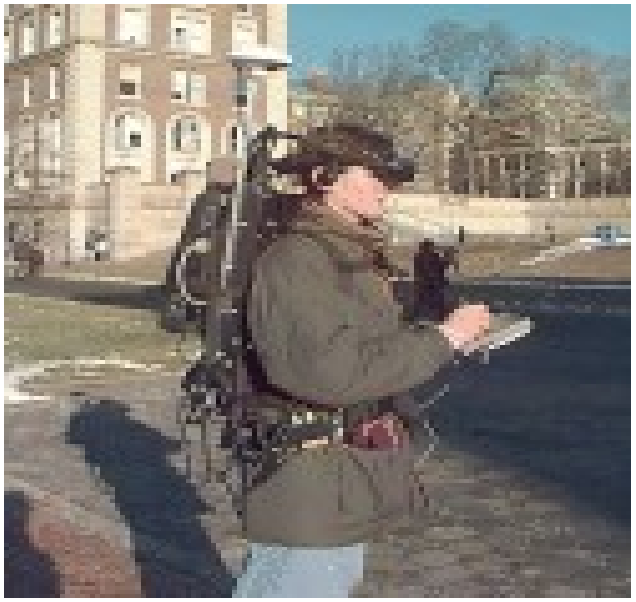




# Early Application

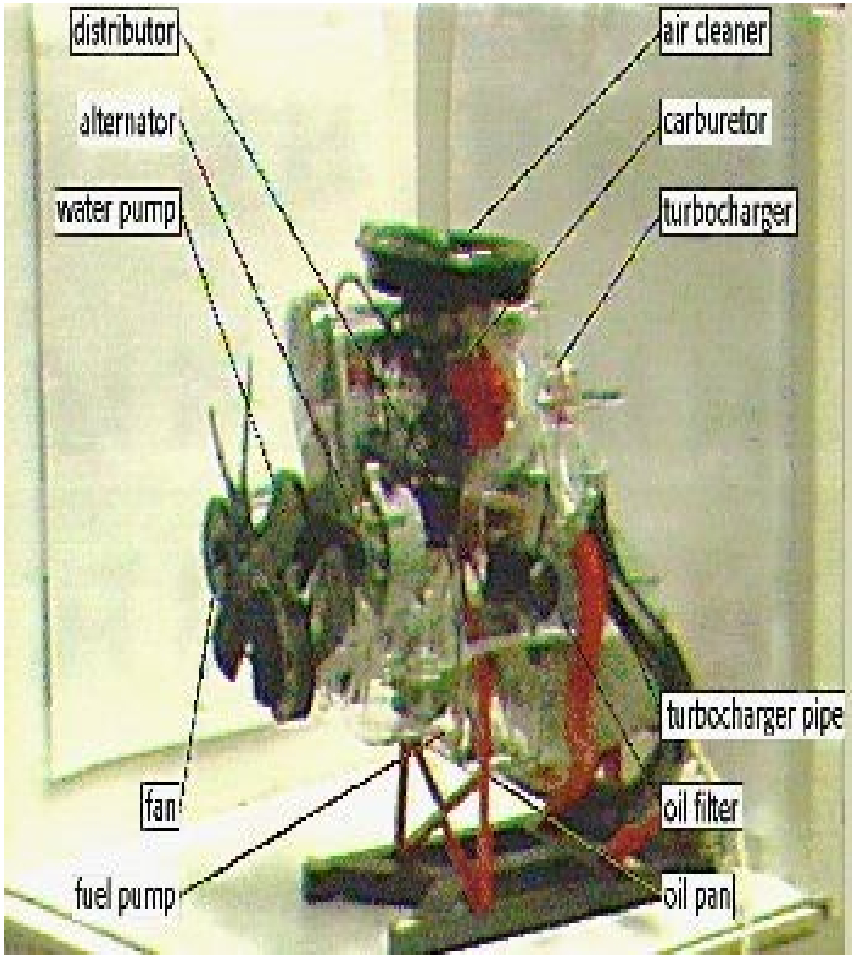
- Later – “architectural anatomy” - movie
- Tourguide - movie





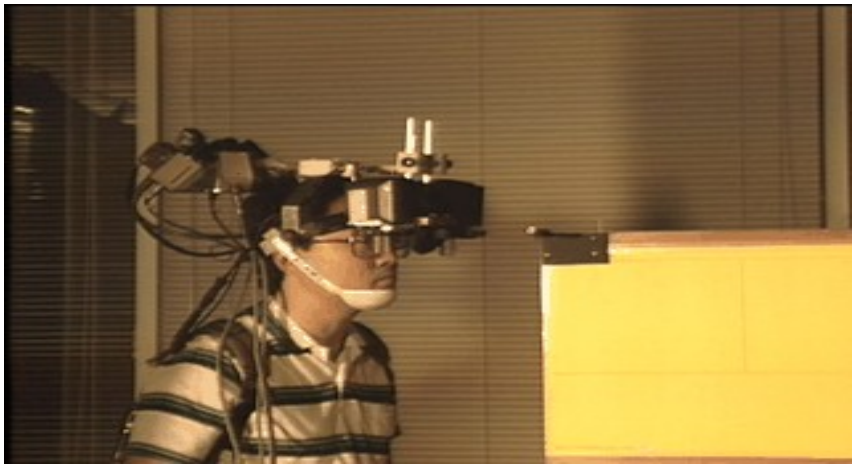
# More Mechanical

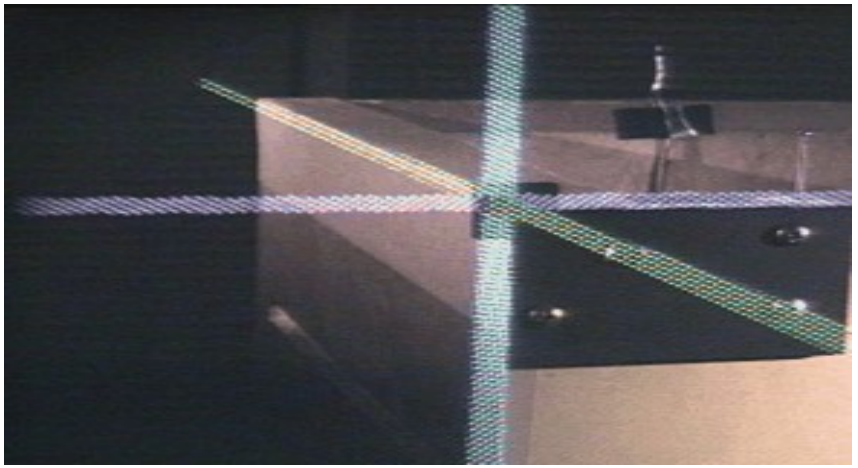
- ECRC



# 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