3D User Interfaces

and

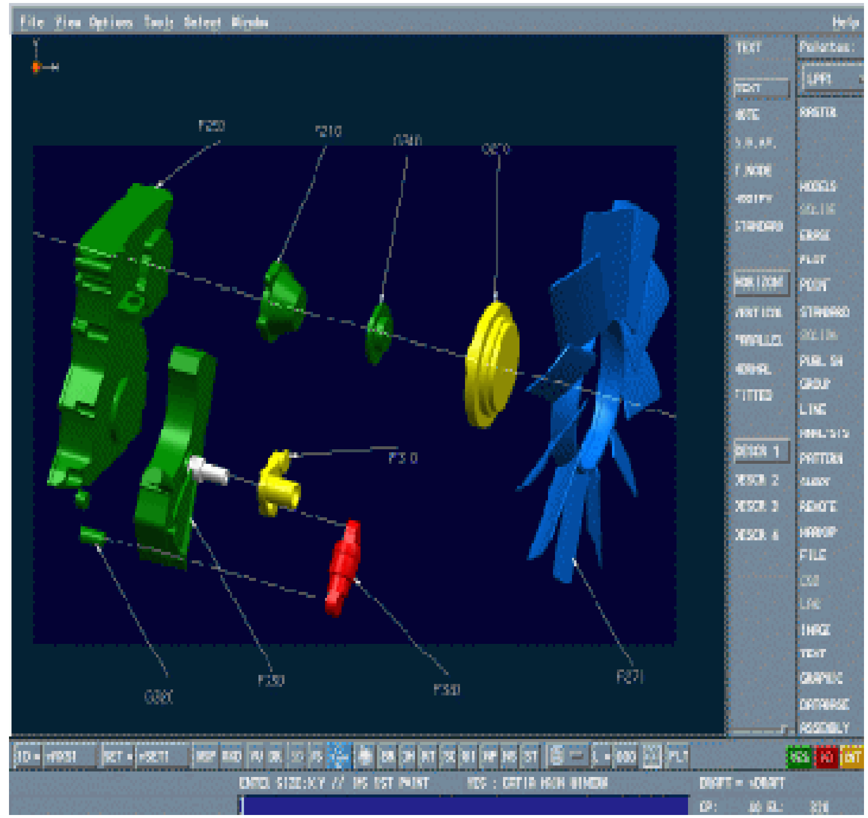
Augmented Reality

Applications

- Mechanical CAD
- 3D Animation
- Virtual Environments
- Scientific Visualization

Mechanical CAD

- Component design
- Assembly testing
- Mechanical properties analysis
- eg AutoCAD, Catia



3D Animation

- Entertainment
- Web sites
- Training
- eg alias|Wavefront, 3d studio, SoftImage

Virtual Environments

- Design
- Entertainment
- Training
- Education

Scientific Visualization

- Human imaging data
- Scalar and vector fields
  - The weather
  - Fluid flow
  - Light distribution
  - Temperature

3D Desktop?

Microsoft's Task Gallery project

http://research.microsoft.com/ui/TaskGallery/index.htm

Some videos

- Microsoft's Task Gallery Video
  - video
- Another 3D desktop interface
  - video

Other 3D interfaces

- Using Virtual Reality for 3D interaction
  - video

Input/Output Devices for 3D UI

- Display device examples
  - Head mounted displays (HMDs)

  - CAVEs
    (Cave Automatic Virtual Environment

  - Tiled wall display
  - Virtual retinal display

Input Devices

- Data gloves, pinch gloves

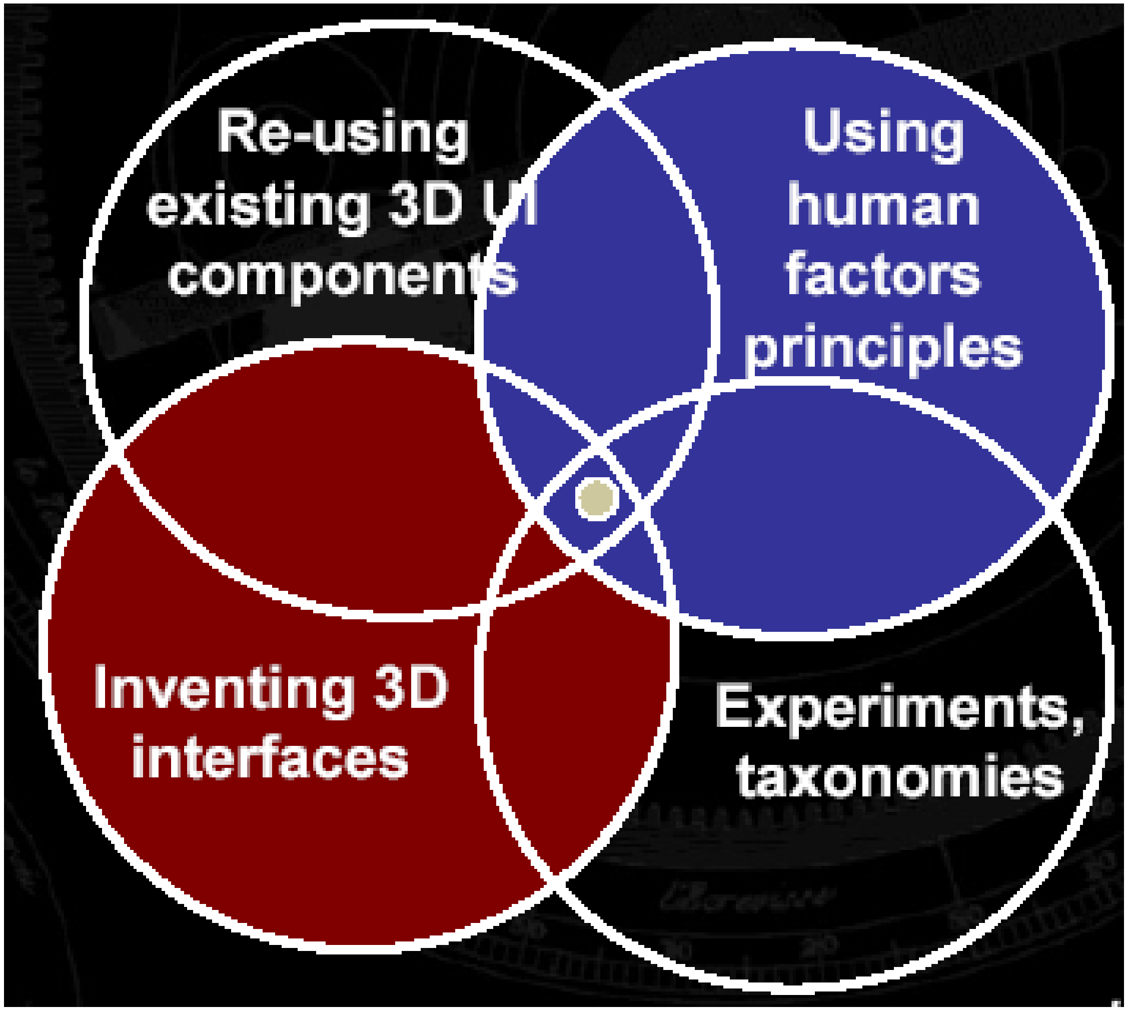
- 3D Mouse

Universal 3D interaction tasks

- Navigation: moving in the scene
- Selection: picking an object from a set
- Manipulation: modifying object properties
- System control: changing global system state

Modification with pen and tablet

Strategies in 3D UI design



Evaluation in 3D UI

- **How 3D UI evaluation is different?**
- **Physical issues**
  - User can’t see physical world in HMD
  - Think-aloud and speech incompatible
- **Evaluator issues**
  - Evaluator can break presence
  - Multiple evaluators usually needed

Evaluation in 3D UI

- **User issues**
  - Very few expert users
  - Evaluations must include rest breaks to avoid possible sickness
- **Evaluation type issues**
  - Lack of heuristics/guidelines
  - Choosing independent variables is difficult

When is a 3D UI successful?

- Users’ goals are realized
- User tasks done better, easier, or faster
- Users are not frustrated
- Users are not uncomfortable

Augmented Reality

Goals

Technology

What is Augmented Reality?

- 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.

What is the Goal of AR?

- To enhance a person's performance and perception of the world

- But, what is the ultimate goal????

The Ultimate Goal of AR

- Create a system such that no user CANNOT tell the difference between the real world and the virtual augmentation of it.

Augmented Reality vs. Virtual Reality

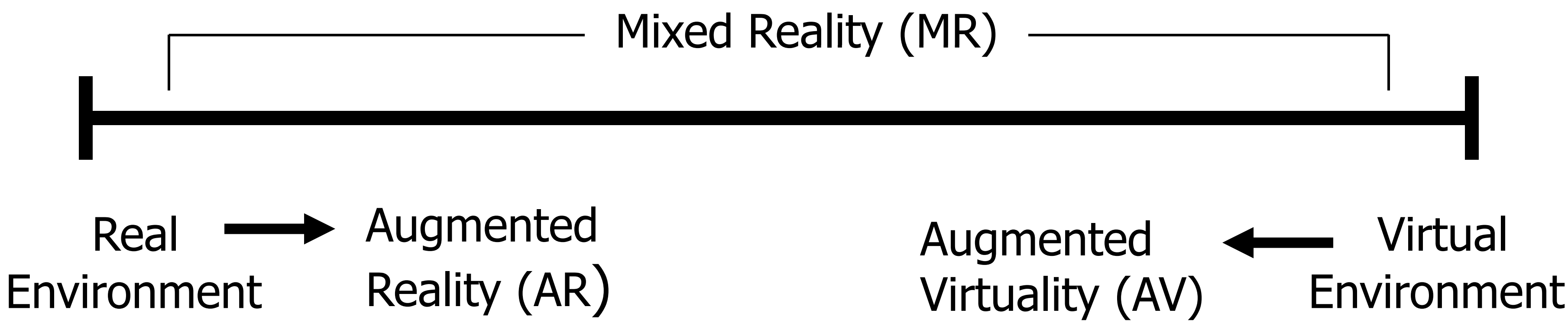
Augmented Reality

- 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:

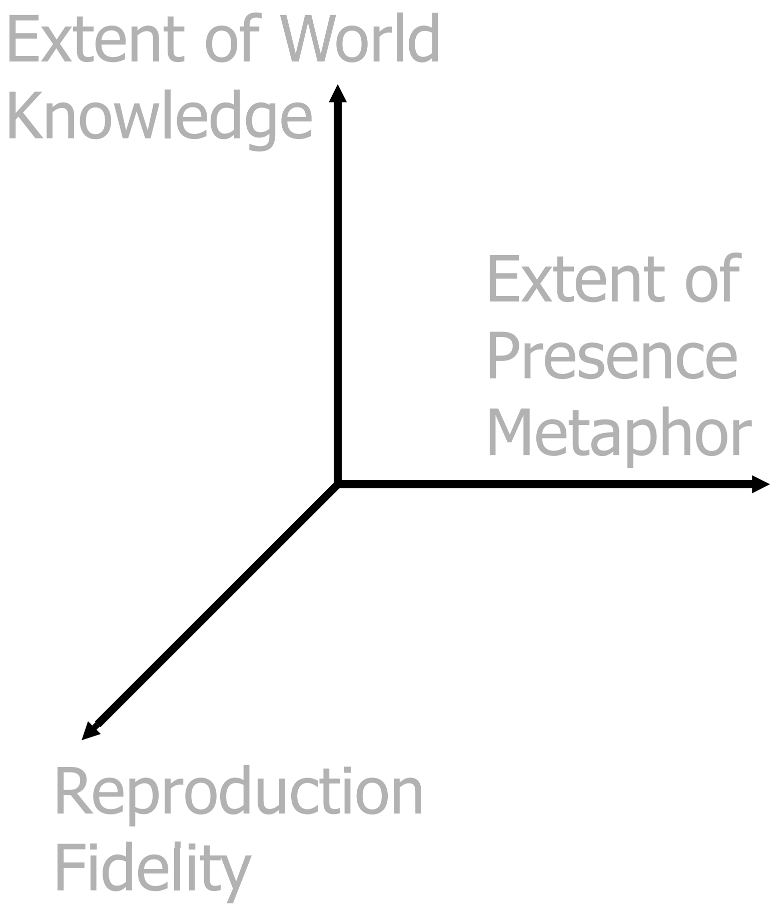
- Totally immersive environment
- Visual senses are under control of system (sometimes aural and proprioceptive senses too)

Miligram's Reality-Virtuality Continuum



Miligram 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.

Miligram's Taxonomy for Mixed Reality Displays



- Reproduction Fidelity – quality of computer generated imagery
- Extent of Presence Metaphor – level of immersion of the user within the displayed scene
- Extent of World Knowledge – knowledge of relationship between frames of reference for the real world, the camera viewing it, and the user

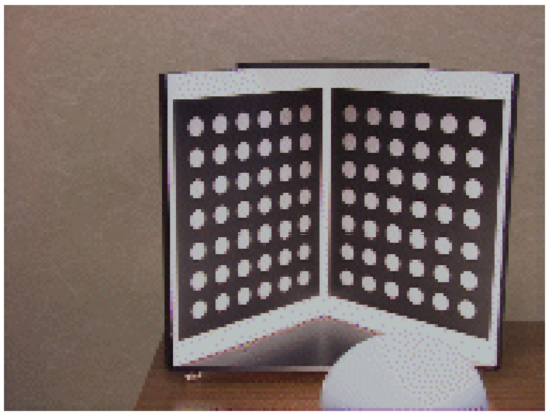
Combining the Real and Virtual Worlds

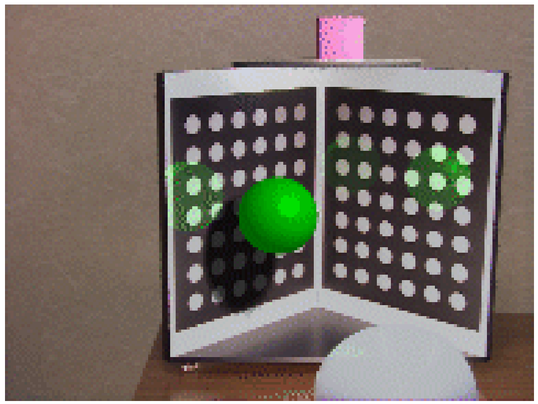
We need:

- 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

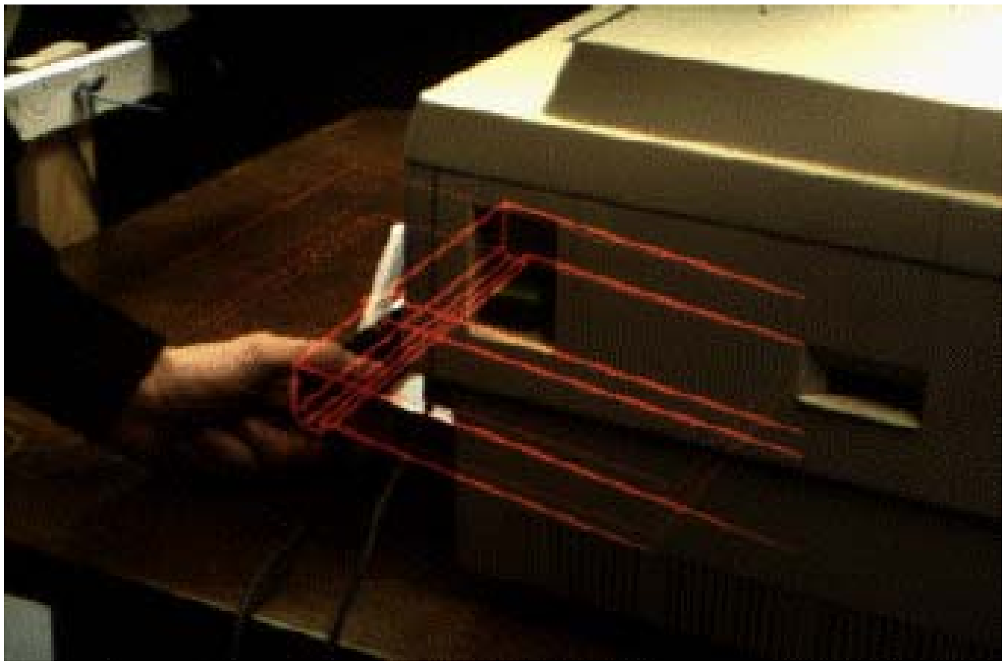
Combining the Real and Virtual Worlds (cont)

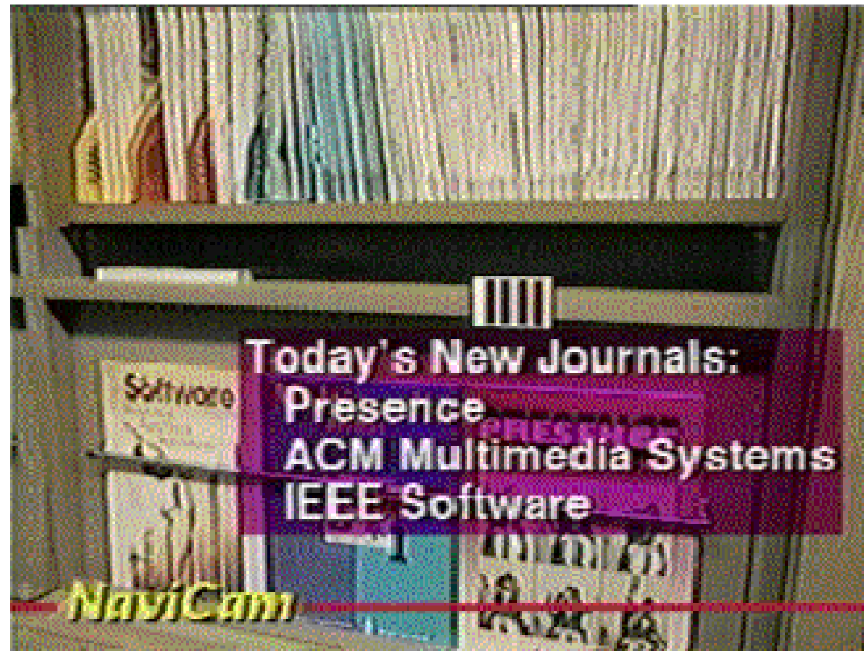
- Register models of all 3D objects of interest with their counterparts in the scene
- Track the objects over time when the user moves and interacts with the scene



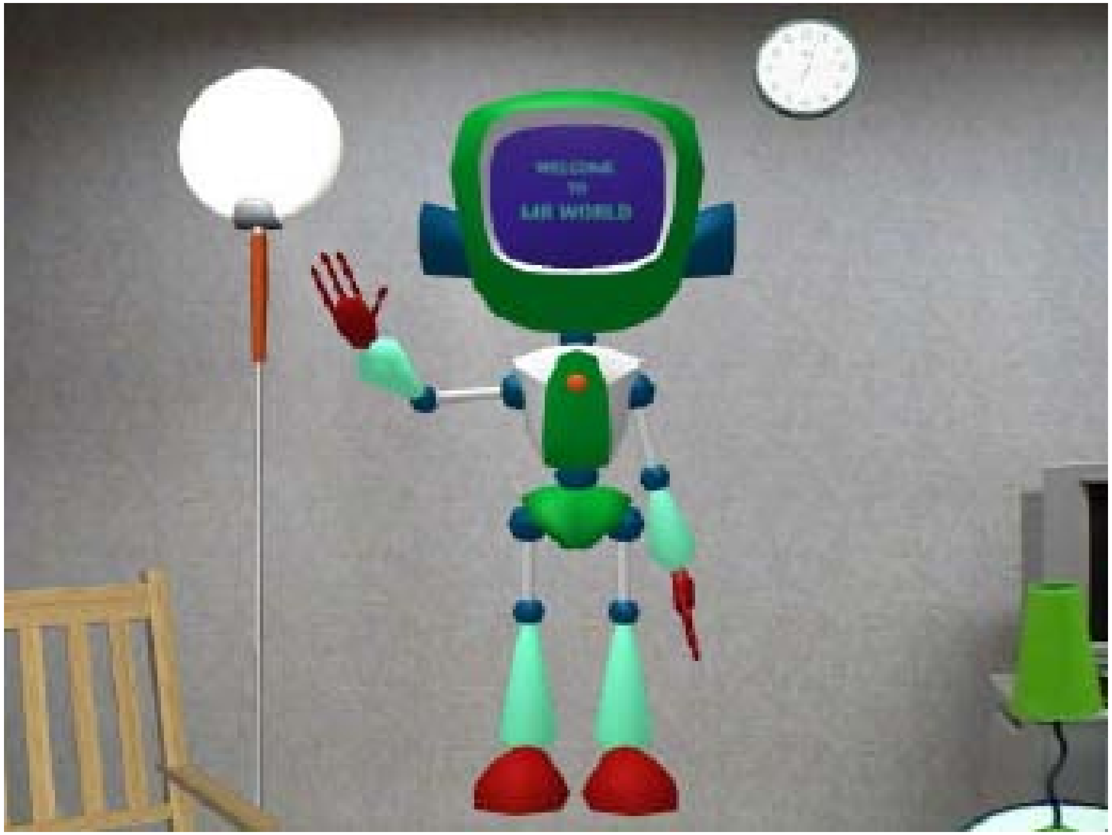


Combining the Real and Virtual Worlds (cont)





Conversational agents in AR



Example videos

- Augmented reality in a kitchen
  - video
- Augmented reality for outdoor video gaming
  - video

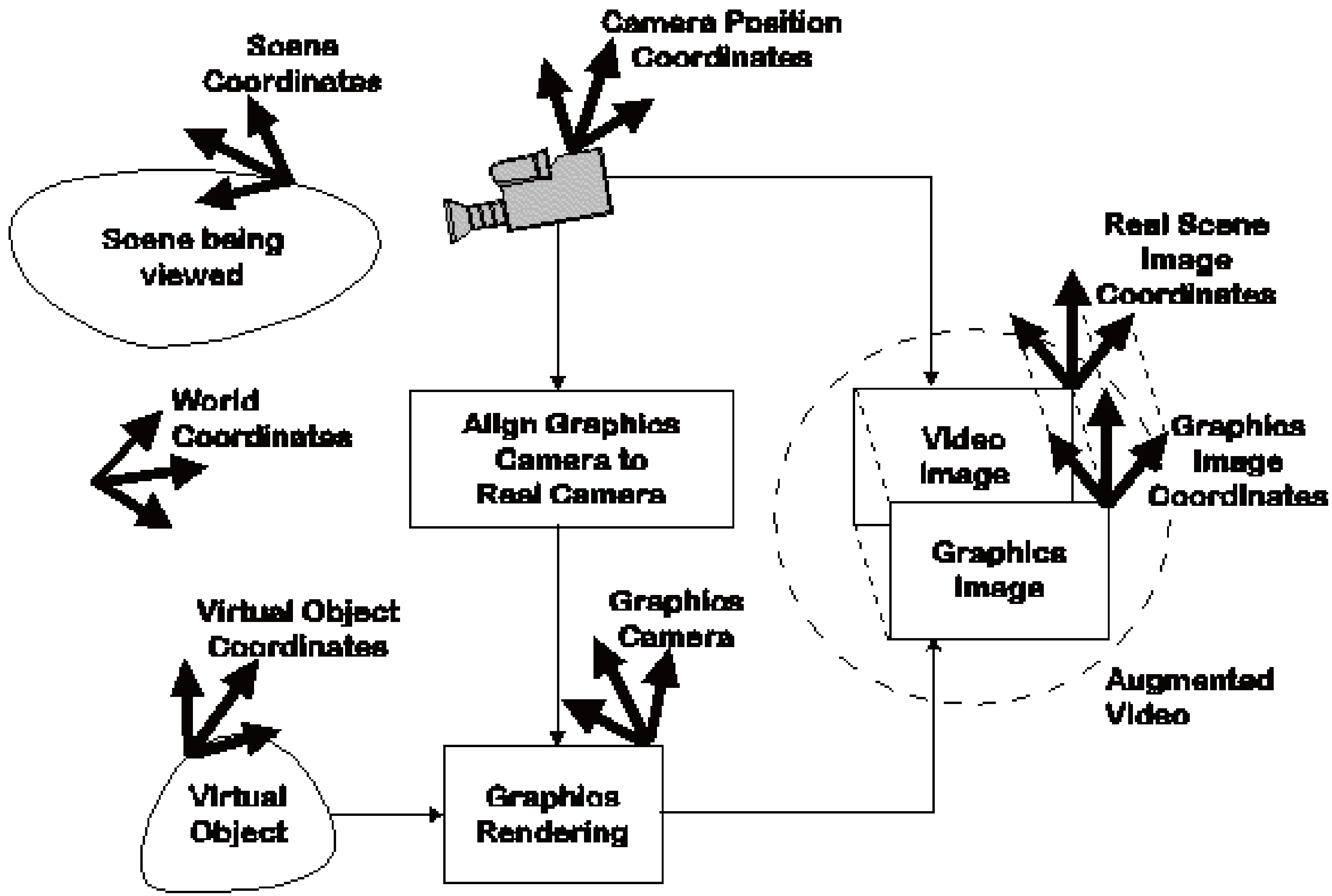
Realistic Merging

Requires:

- Objects to behave in physically plausible manners when manipulated
- Occlusion
- Collision detection
- Shadows

**All of this requires a very detailed description of the physical scene

Components of an Augmented Reality System



Research Activities

- Develop methods to register the two distinct sets of images and keep them registered in real-time
  - New work in this area has started to use computer vision techniques
- Develop new display technologies for merging the two images

Performance Issues

Augmented Reality systems are expected:

- To run in real-time so that the user can move around freely in the environment
- Show a properly rendered augmented image

Therefore, 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

Limitations for Updating the Generated Images

- Must be at 10 times/second
- More photorealistic graphics rendering
- Current technology does not support fully lit, shaded and ray-traced images of complex scenes

Failures in Registration

Failures in registration due to:

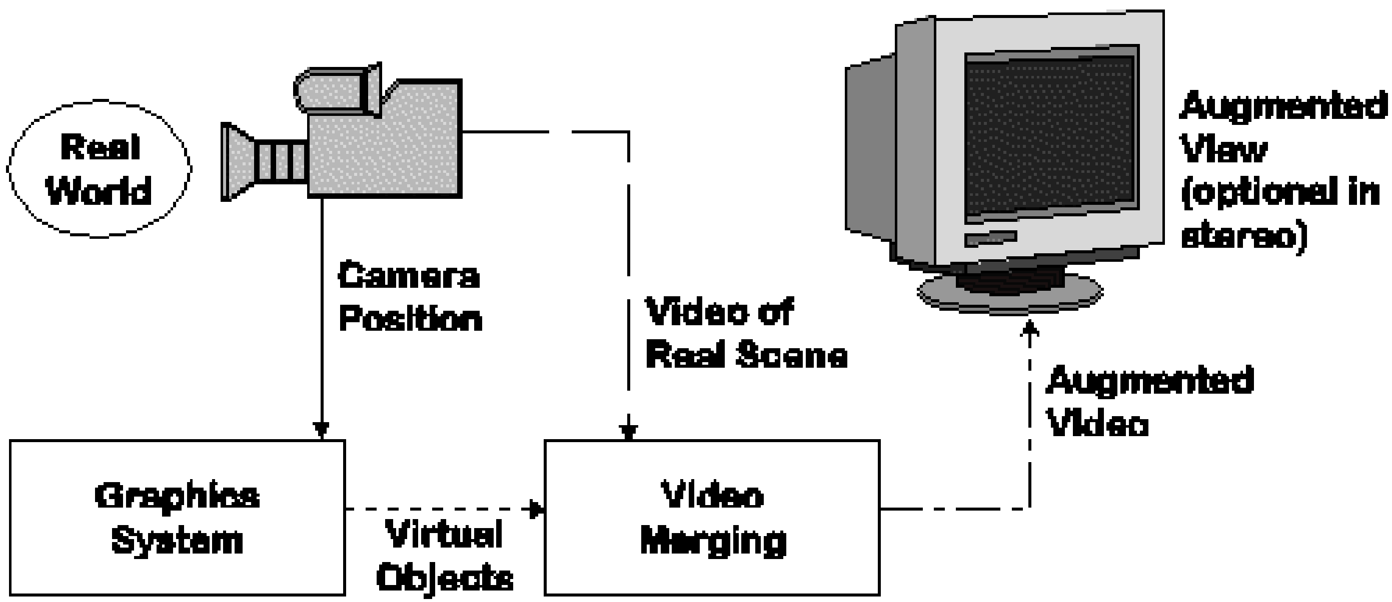
- Noise
  - Position and pose of camera with respect to the real scene
  - Fluctuations of values while the system is running
- Time delays
  - In calculating the camera position
  - In calculating the correct alignment of the graphics camera

Display Technologies

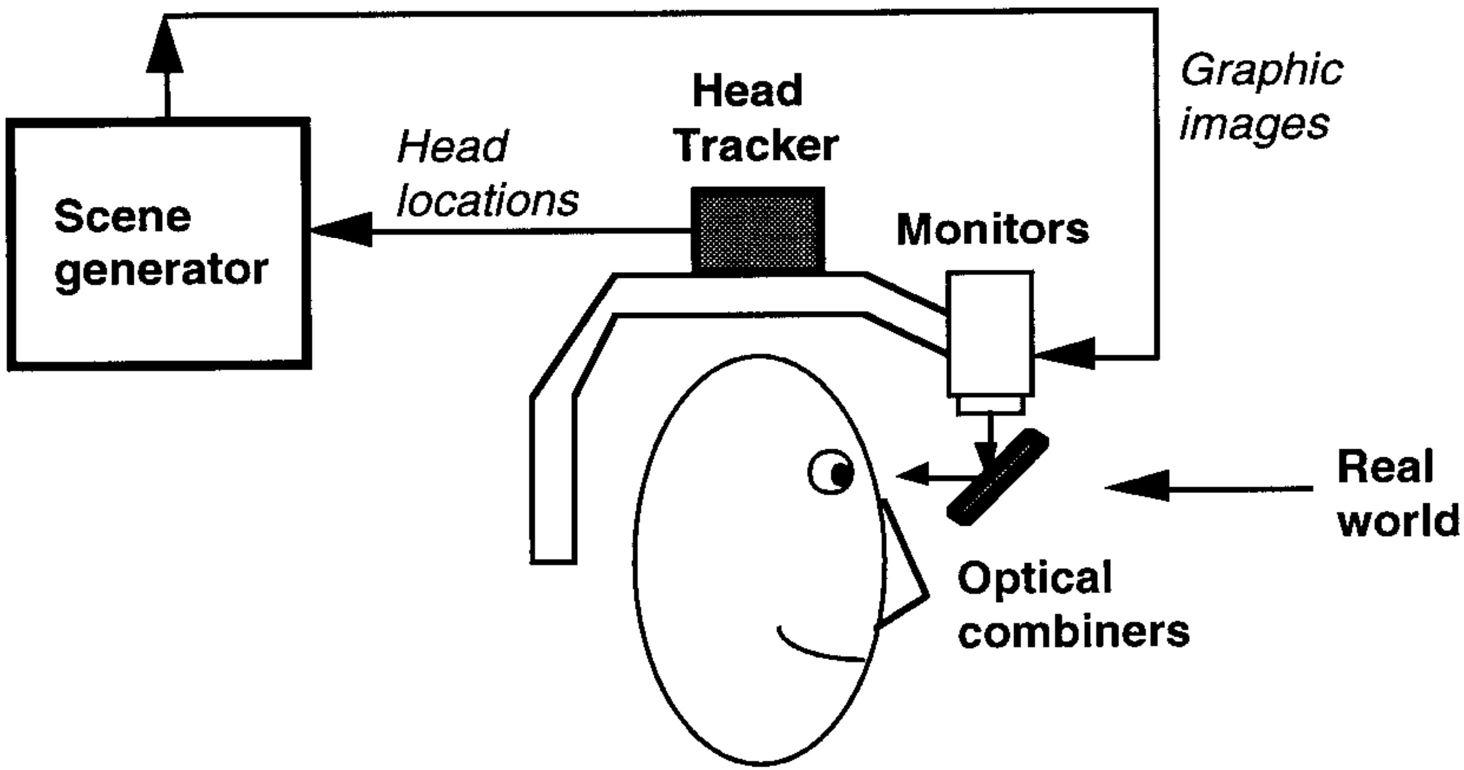
- Monitor Based
- Head Mounted Displays:
  - Video see-through
  - Optical see-through

Monitor Based Augmented Reality

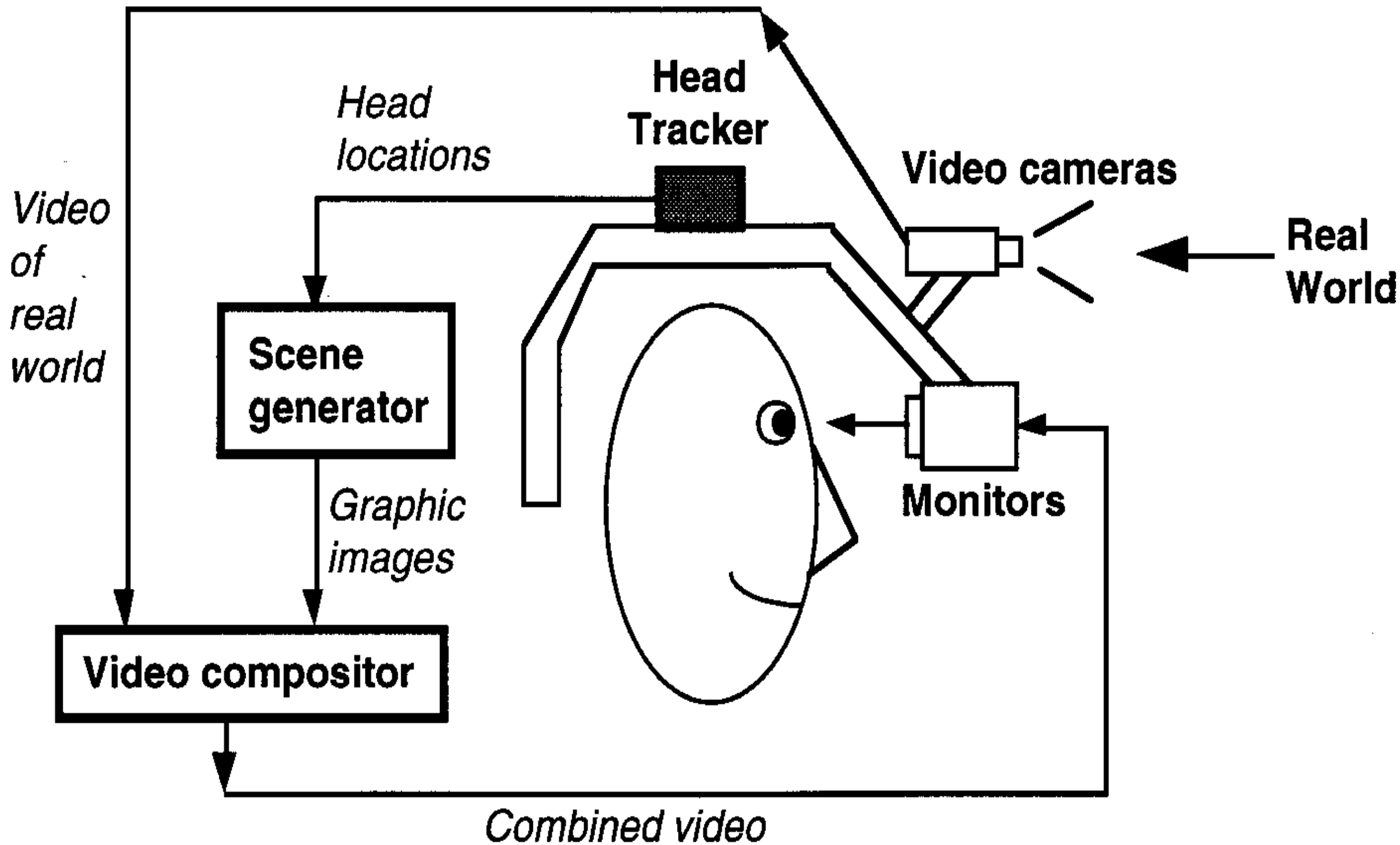
- Simplest available
- Little feeling of being immersed in environment



Optical see-through HMD



Video see-through HMD



Video Composition for Video see-through HMD

- Chroma-keying
  - Used for special effects
  - Background of computer graphics images is set to a specific color
  - Combining step replaces all colored areas with corresponding parts from video
- Depth Information
  - Combine real and virtual images by a pixel-by-pixel depth comparison

Advantages of Video see-through HMD

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

Advantages of Optical see-through HMD

- Simplicity
- Resolution
- No eye offset

Applications

- Medical
- Entertainment
- Military Training
- Engineering Design
- Robotics and Telerobotics
- Manufacturing, Maintenance, and Repair
- Consumer Design
- Hazard Detection
- Audio