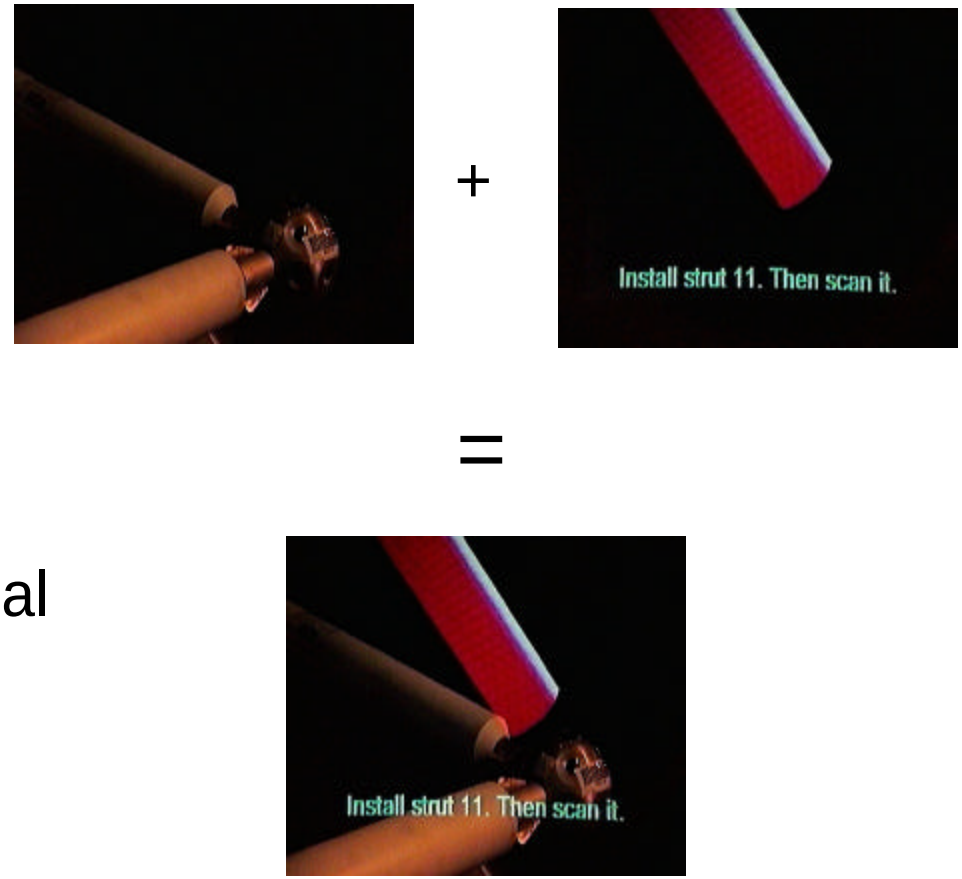
CS 563 Advanced Topics in Computer Graphics
Recent Advances In Augmented Reality

by Kutty S Banerjee

Augmented Reality

- Pick A Real World Scene
- Add your Virtual Objects in it
- Delete Real World Objects
- **Not** *Virtual Reality* since Environment Real



http://www1.cs.columbia.edu/

Talk Layout

What Makes Augmented Reality Work?

- Display (*where the image forms*)
- Tracking (get pos+orient info)
- Environment Sensing (*see the world*)
- Visualization and Rendering (*paint a picture*)
- Applications

Topic Layout

- Key *Idea*
- Different *Implementations*
- Key *Challenges*




Display System

Idea and Types

- The image seen by user formed
- Major Types of Displays
  - Head-worn displays (HWD)
  - Handheld Displays
  - Projection Displays

Head-Worn Display (HWD)

http://www.lsi.upc.es/

Head-Worn Display (HWD)

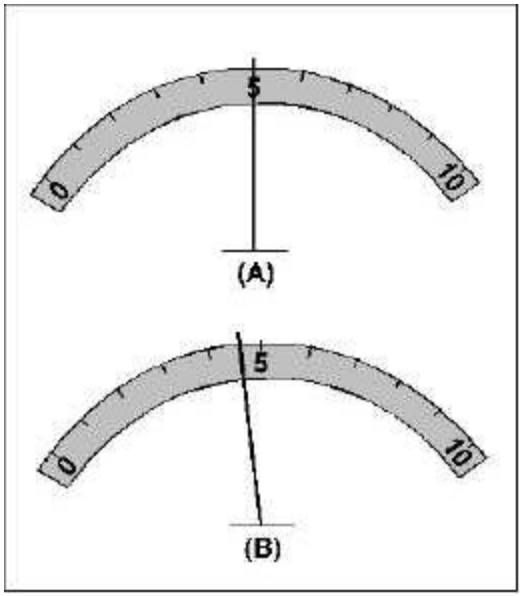
- Optical See-Through
  - View real world like normal glasses
  - Virtual world images *added* to image formed
- Video See-Through
  - Real World video captured
  - *Augmented* with Virtual world images
  - Finally displayed
- Virtual Retinal Display
  - Image formed directly on retina
  - Advantage : Higher FOV

Issues and Limitations

- Brightness
- Size and dimensions
- Resolution
- Parallax Error (?)

Parallax Error

- Distance between eye and lens
- Eye sees slightly different image than lens image
- When viewed straight, correct reading
- When viewed from angle, different reading
- Solution: Most meters place mirrors!!



http://www.tpub.com

Handhelds and Projection Displays

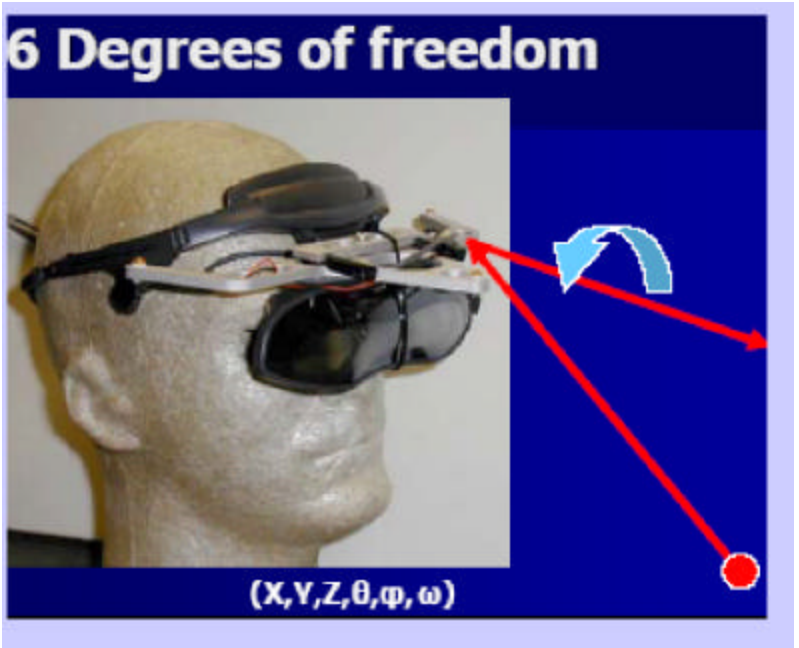
- Camera attached to handhelds to view augmented reality[see video *virtual_train*]
- *Projection Display:* Virtual images projected directly on real world objects

Tracking

Key Idea

- Little Background: Imagine there is a machine(*ref point*) that sees the whole world.
- But we need to tell the machine our position and view position for it to tell us something about world view.
- Question is: Since we (wearing HWD- *target*) are moving, need to report position + orientation to this machine.
- *Forget for time being: what info machine gives us and what info we see (see later!!)*

- In short, ***Ref*** wants to figure pos, orientation of ***target***!!
- Identify HWD by
  - Position
    - X, Y, Z coordinates
  - Orientation
    - Euler angles
      - Pitch, Yaw, Roll angles



Virtual Environment Tracking: Hourri Abdallahi

Tracking:Performance Analysis

- Accuracy: Measure of error in position, orientation reported
- Resolution: Smallest change in pos,orientation detected
- Update Rate: Rate of updation of pos,orient info at host comp
- Lag: Delay b/w change in pos,orient and report to host comp
- Working Volume: Volume within which tracker measures pos,orient within specified accuracy and resolution.

"Position Trackers for Head Mounted Display Systems: A survey" Devesh Kumar Bhatnagar"

Magnetic Trackers

AC

- Transmitter (ref) has mutually perpendicular electromagnetic coils
- AC supply sets up rotating magnetic field
- Induces current in Receiver (target)
- Current at receiver is function of pos, orient of receiver

DC

- To avoid eddy current, transmitter excited with short DC pulses.

Drawbacks:

- Presence of ferro magnetic material, magnetic field causes interference.

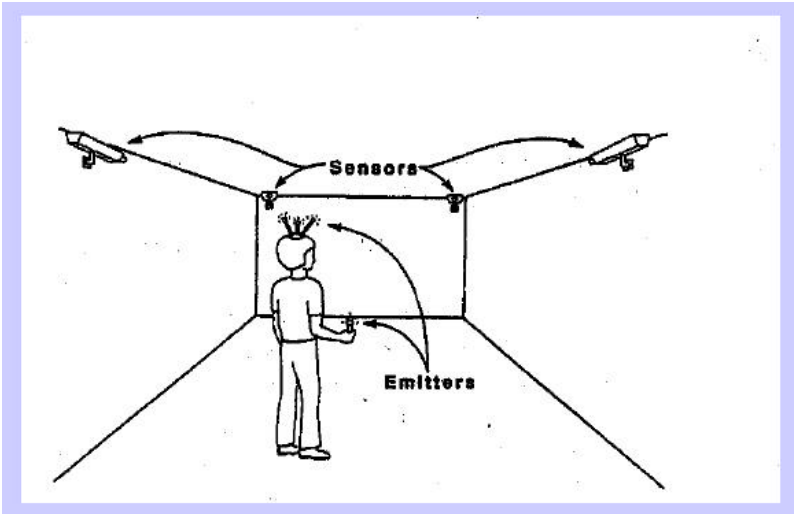
"Fundamentals of Wearable Computers and Augmented Reality: Woodrow Barfield"

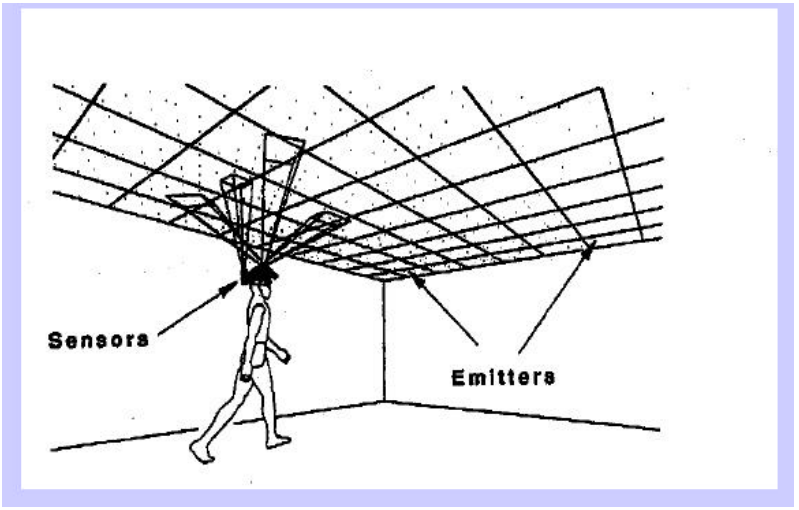
Acoustic Trackers

- Ultrasonic waves fired at target (HWD)
- Using RADAR principle target located.
- Disadvantages : Obstructions present b/w target and ref causes distortion.
- Speed of sound in air limits “updation rate”

Optical Trackers

- Light reflected and received by sensor
- Outside-In
  - Reflector is Target
  - Sensor is Ref
- Inside-Out:
  - Reflector is Ref
  - Sensor is Target





Virtual Environment Tracking: Hourri Abdallahi

Performance Analysis

	Magnetic Trackers	Acoustic Trackers	Optical Trackers	Mechanical Trackers
Accuracy & Resolution	High Adversely affected by ferromagnetic and metallic objects in the environment	High Adversely affected by ultrasonic noise	High Adversely affected by ambient infrared radiation	High
Working Volume	Small	Small	Practically unlimited	Very small
Lag	Low	High	Low	Low
Effects of obstructions	None if the obstructions are not metallic or ferromagnetic	Increase in inaccuracies; loss of tracking ability in extreme cases	Increase in inaccuracies; loss of tracking ability in extreme cases	Loss of tracking ability in areas that cannot be reached because of the obstructions
Convenience of use	Easy to use	Easy to use	Inside-out systems require special environments and are heavy. Outside-in systems are more convenient to use.	Very inconvenient User motion is restricted.

[Devesh Bhatnagar, 1993]

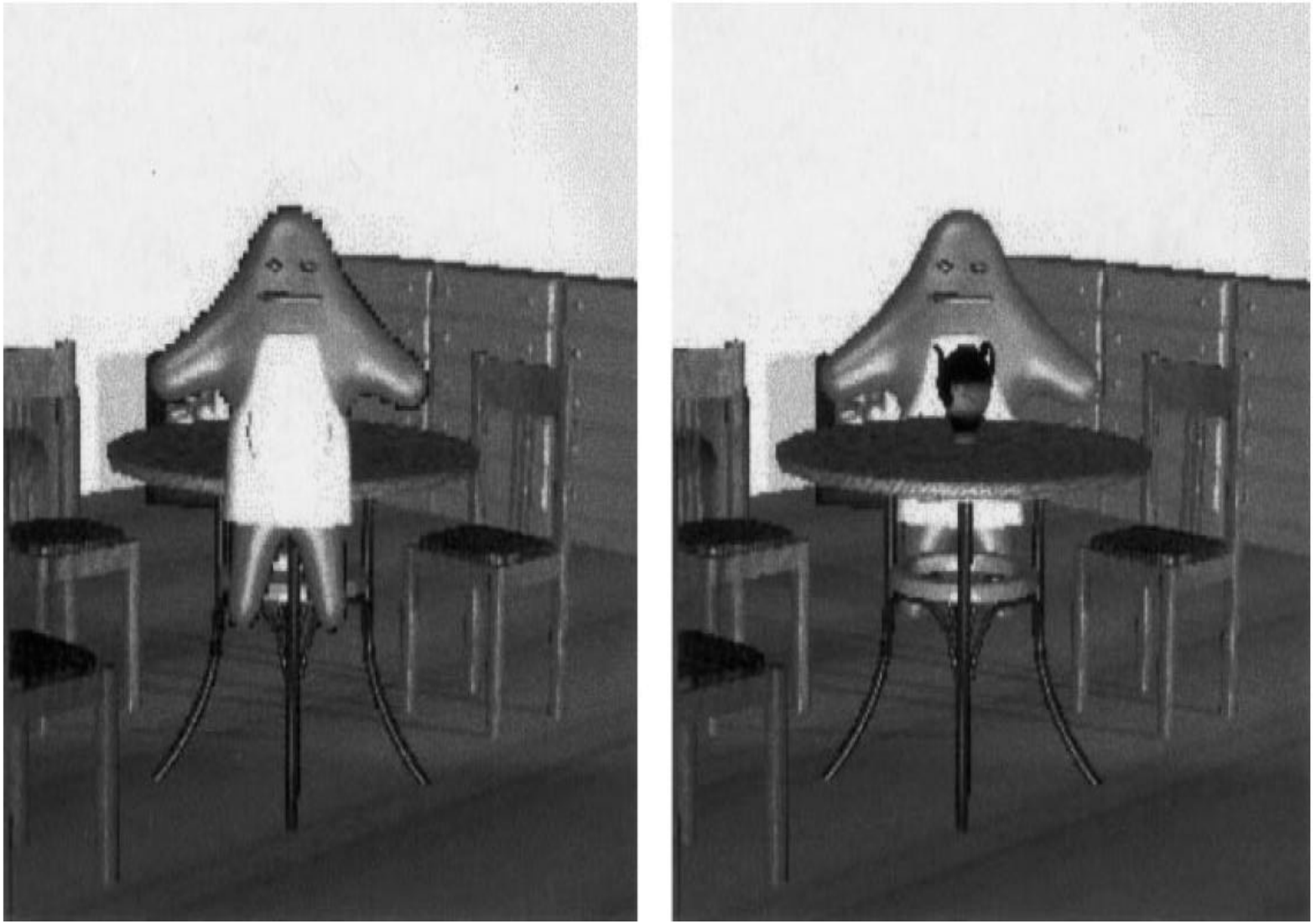



Environment Sensing

Depth Information

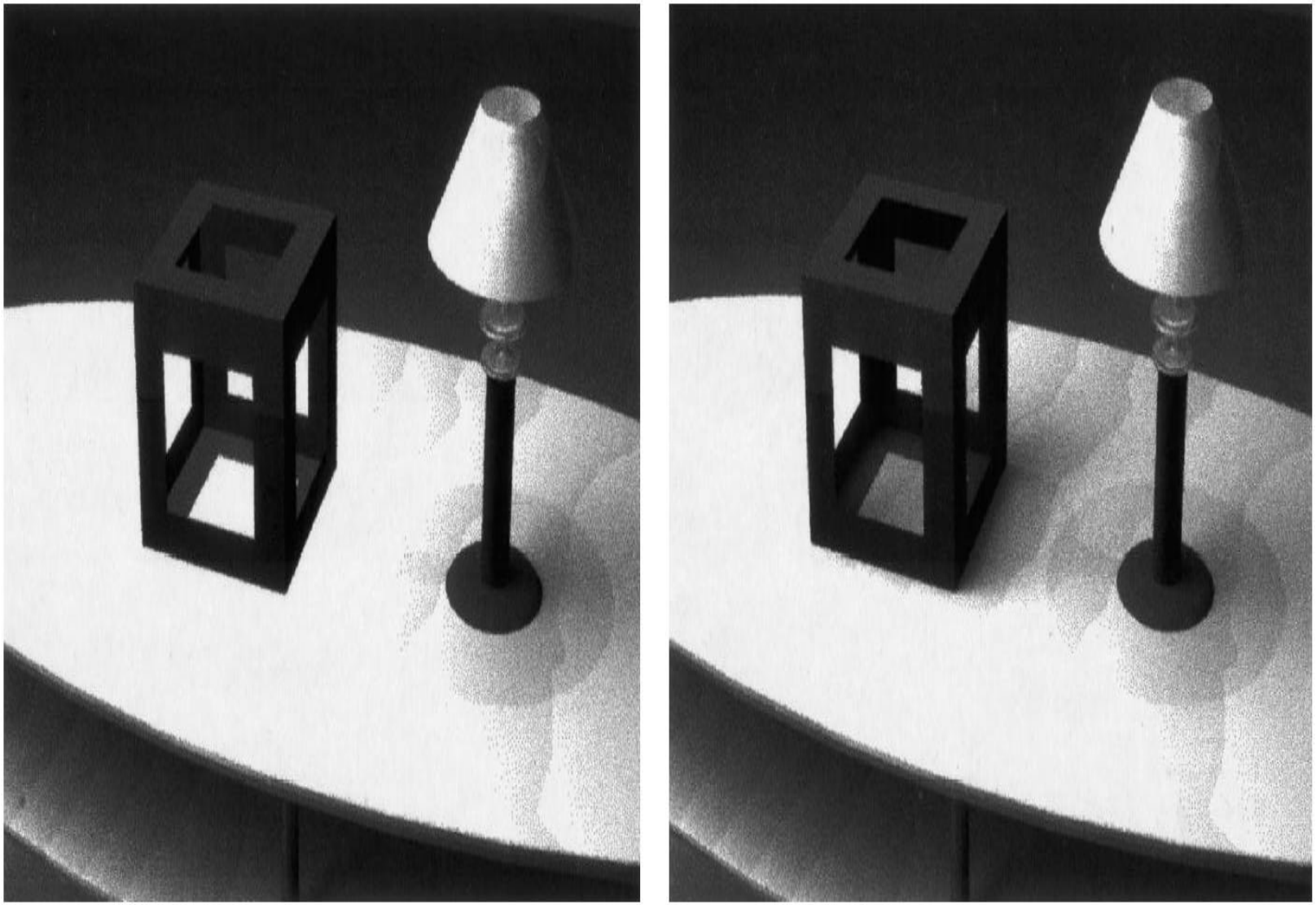
- Occlusion of Real World Objects
  - Depth information
- Shadow Formation
  - Again requires depth information
- Therefore, *Not Just sufficient to video capture world view from HWD*

Occlusion



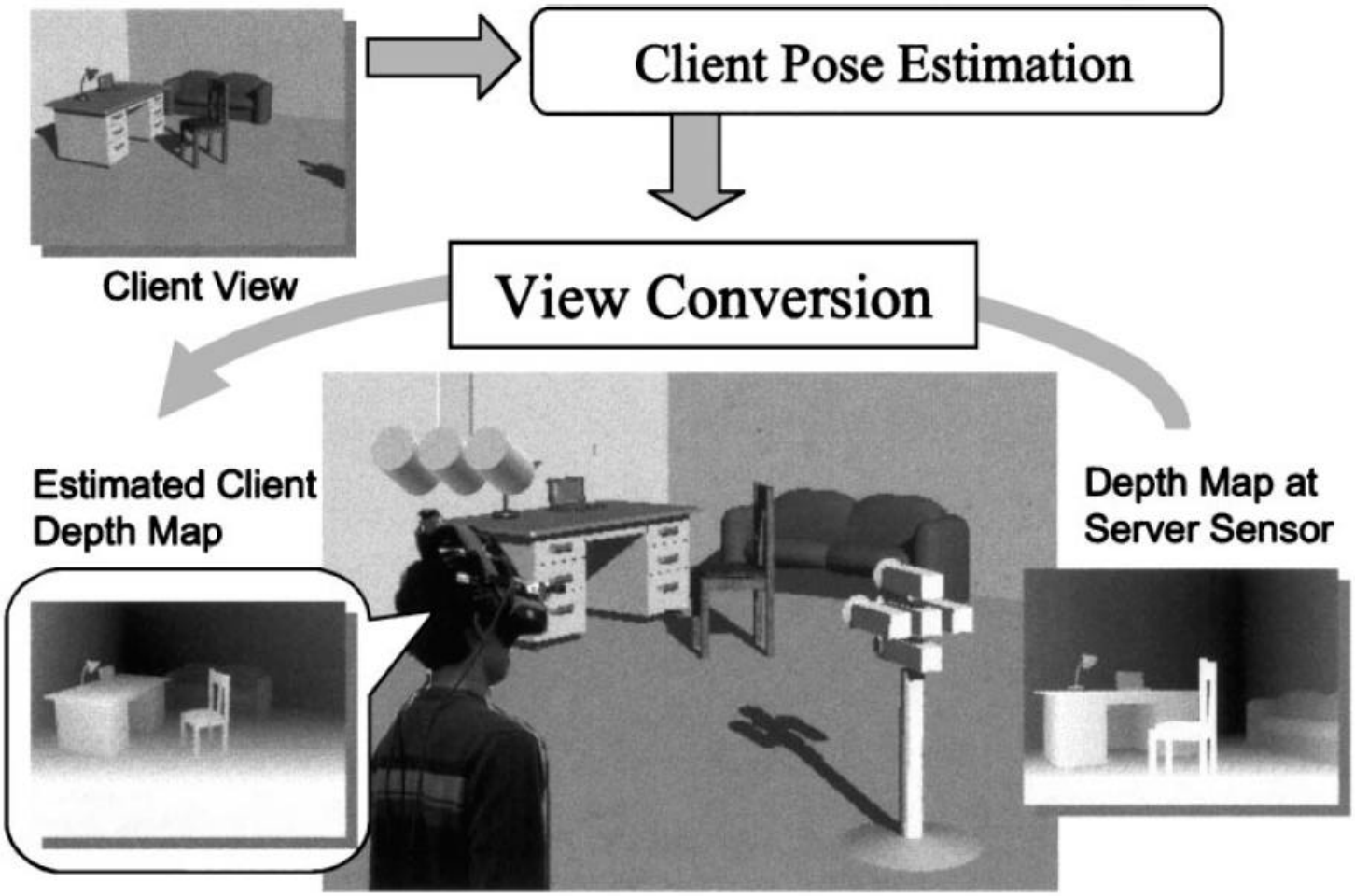
Share-Z: Client/Server Depth Sensing for See-Through Head-Mounted Displays

Shadow Formation



Share-Z: Client/Server Depth Sensing for See-Through Head-`Mounted Displays

Client Server Model



Share-Z: Client/Server Depth Sensing for See-Through Head-`Mounted Displays

Client Server

- Server has world depth information
- Client sees video of world
- Reads Server depth info
- Does view, depth calculation
- Client keeps track of HWD position, orientation




Visualization, Rendering

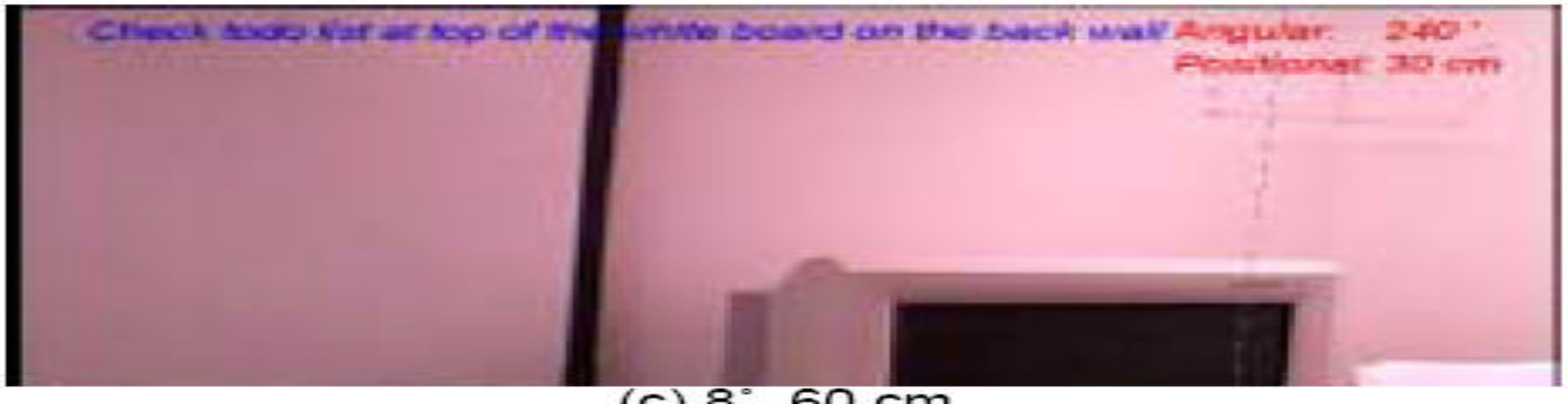
Registration Error

- AR System must “*register*” computer image with real world image.
- Remember parallax problem?
- Consider real world meter virtual image is arrow on the meter showing reading
- Minor tracking error can lead to wrong reading.-> **Registration Error!!**
- Solution: **Level of Error Filtering (LOE)**
- Similar to LOD (Level of Details)
- In LOD different distances, diff models
- In LOE, different registration errors, diff virtual objects.

LOE

(a) 0.5˚, 1.2 cm

(b) 2˚, 20cm



(c) 8˚, 60 cm

Adapting to Dynamic Registration Errors Using Level of Error (LOE) Filtering

Rendering Requirements

- Virtual objects need to appear realistic
- Need to capture lighting and scene information of real world
- Photo realistic rendering ? But Real time requirements!!

Application

Applications

- WPI project: ECE & BioMedical, Augmented Reality for Fire Fighters -> Map of Building
- Marine Navigation
- Entertainment

  [video]