

Interaction: Selection and Manipulation

CS 6334 Virtual Reality

Professor Yapeng Tian

The University of Texas at Dallas

Some slides of this lecture are courtesy Jin Ryong Kim and Yu Xiang

Manipulation

- Complex sensorimotor relationships
- Evolution and experience
- Robot manipulation, a grand challenge
- We can make manipulation simple in VR
 - Remapping



Avoid Gorilla Arms



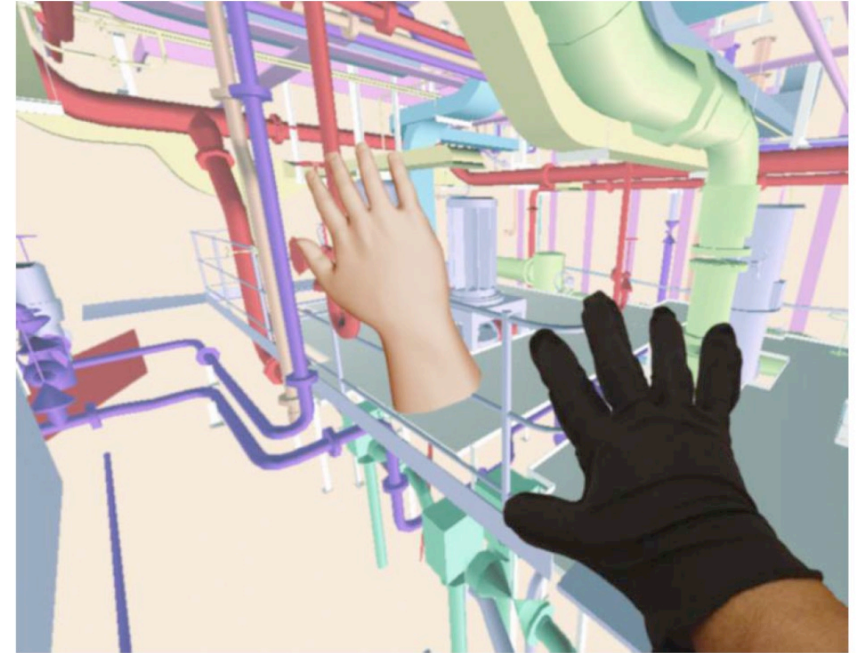
<https://www.youtube.com/watch?v=PJqbivkm0Ms&t=30s>

Selection

- The task of acquiring or identifying a particular object from the entire set of objects available
- In the real world
 - Picking up one object
 - Pointing to one object
 - Indicating one object by speech

Hand-based Grasping

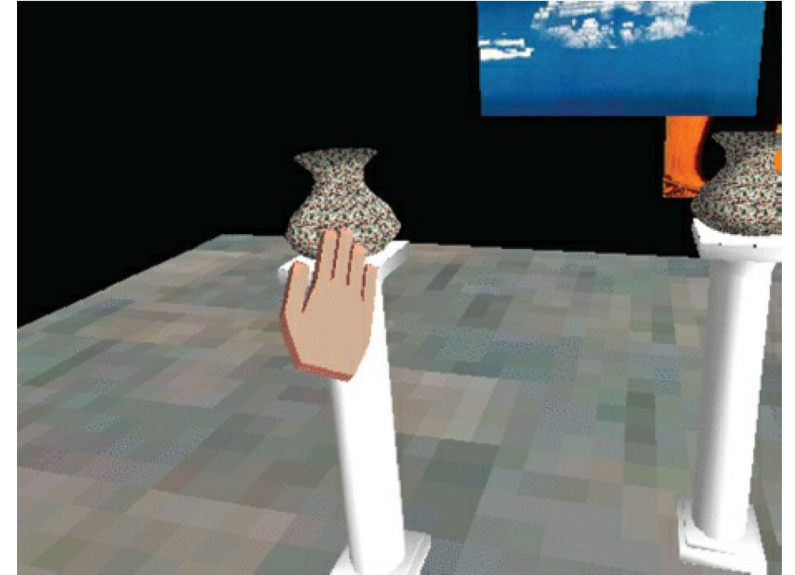
- Track the position and orientation of the user's dominant hand
- Represent the user's virtual hand as a single-point effector



A Survey of 3D Object Selection Techniques for Virtual Environments. Computers and Graphics, Elsevier, 2013, 37 (3), pp.121-136.

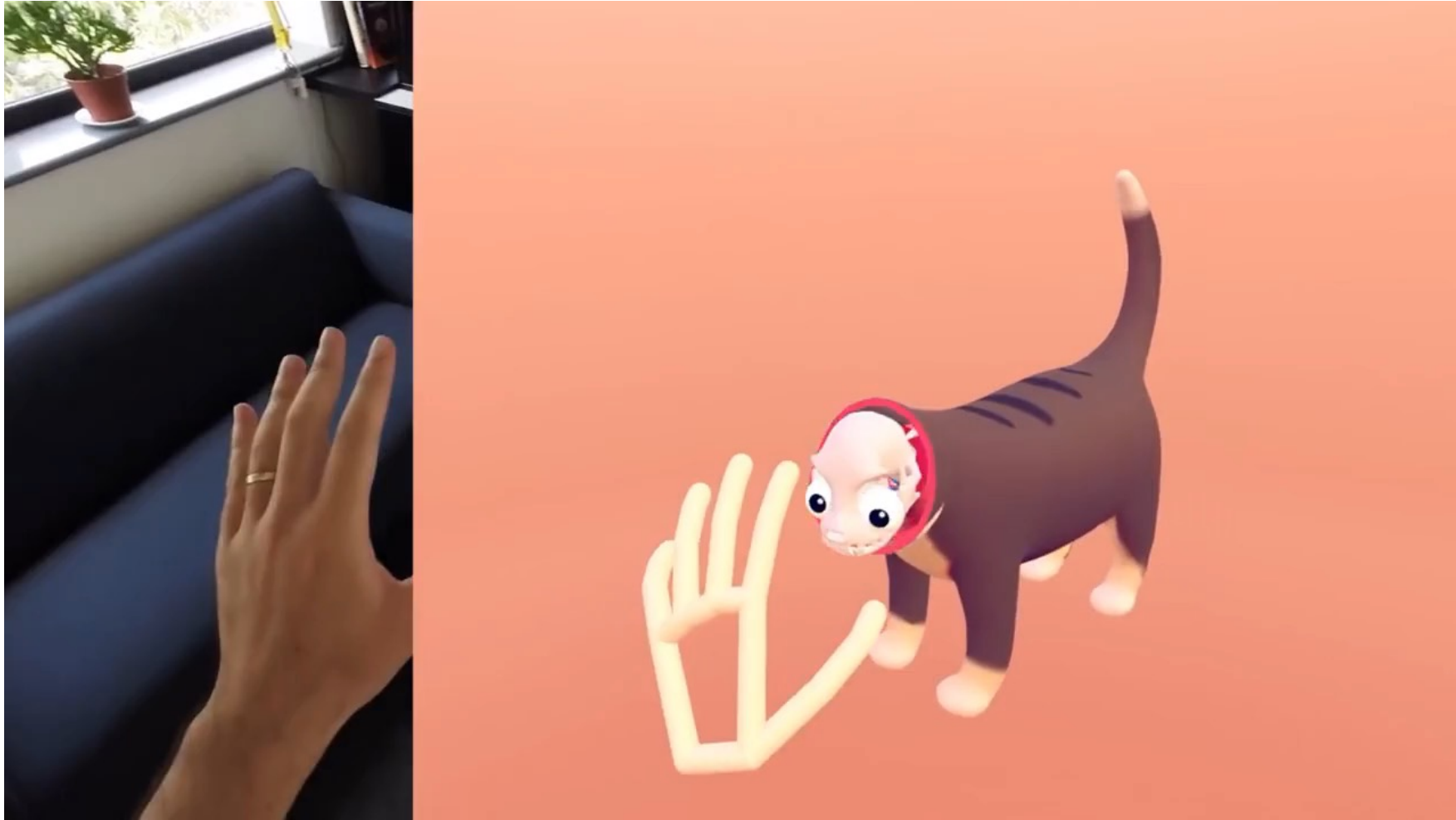
Simple Virtual Hand

- Uses a strict, one-to-one mapping of a 6-DOF hand tracker to a user's virtual hand
- Uses collisions to determine selection
- Most natural 3D manipulation technique
- Cannot select objects outside of the user's physical reach



<https://s3dit.cs.uni-potsdam.de/detail/1>

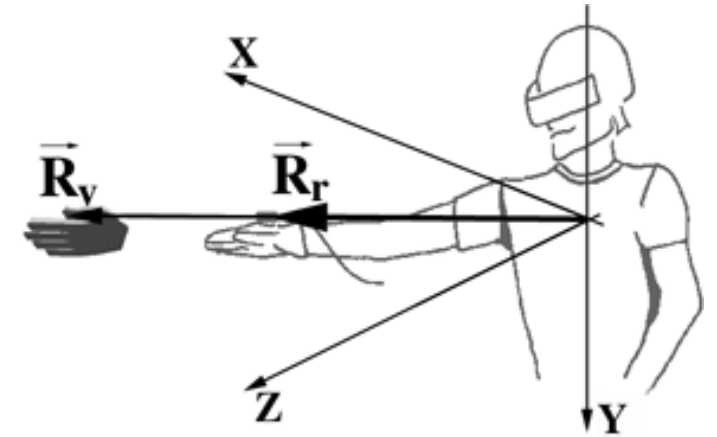
Simple Virtual Hand



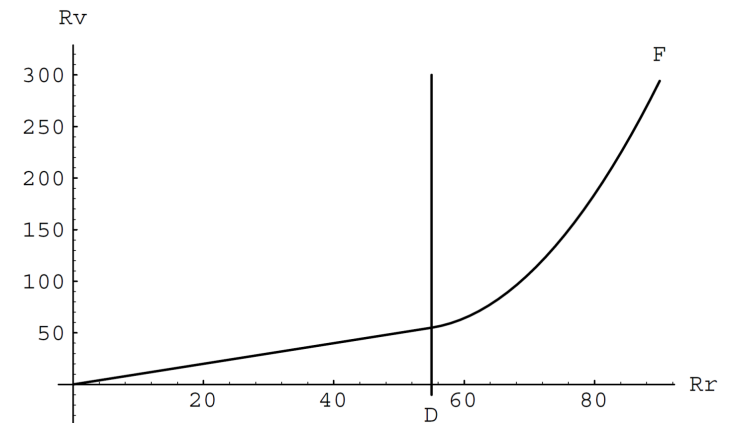
<https://www.thisiscoossal.com/2018/06/virtual-reality-cat-explorer/>

The Go-Go Interaction Technique

- Uses a threshold to separate near and remote interactions
- Within threshold, mapping is one to one
- Beyond threshold, a nonlinear mapping extends the virtual hand beyond the user's physical hand

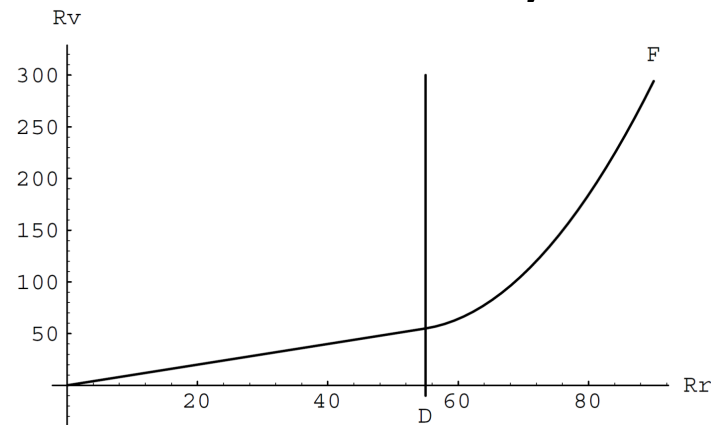


$$R_v = F(R_r) = \begin{cases} R_r & \text{if } R_r < D \\ R_r + k(R_r - D)^2 & \text{otherwise} \end{cases}$$



The Go-Go Interaction Technique

- Can select objects outside of the user's physical reach due to virtual hand extension
- Small objects are difficult to select beyond threshold due to nonlinear mapping



The Go-Go Interaction Technique: Non-linear Mapping for Direct Manipulation in VR.

Poupyrev et al. ACM Symposium on User Interface Software and Technology (UIST) 1996.

The Go-Go Interaction Technique



<https://youtu.be/WhA8n4IXeoY>

Finger-based Grasping

- Track fingers, i.e., hand pose, in the real world
- Allow users to manipulate objects with more precision
- Challenges
 - Haptic feedback
 - Mismatch in hand pose between the virtual world and the real world, e.g., fingers are not allowed to penetrate the virtual objects



GANerated Hands for Real-Time 3D Hand Tracking from Monocular RGB. Mueller et al.

Finger-based Grasping



<https://www.youtube.com/watch?v=4sPhLbHpywM>

Pointing

- Allow users to select and manipulate objects beyond their physical reach by pointing at the object
- Pro: Requires less physical hand movement from the user, better selection performance
- Con: expressive 6 DOF manipulation is impossible with pointing



Pointing

- Vector-based Pointing

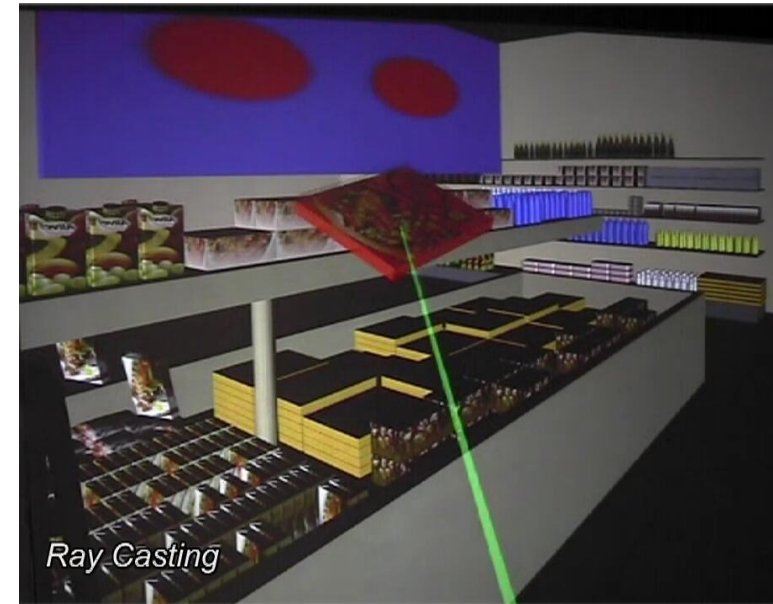
- Uses a vector to determine what object is manipulated
- Ray-casting
- Fishing reel
- Image-plane pointing

- Volume-based Pointing

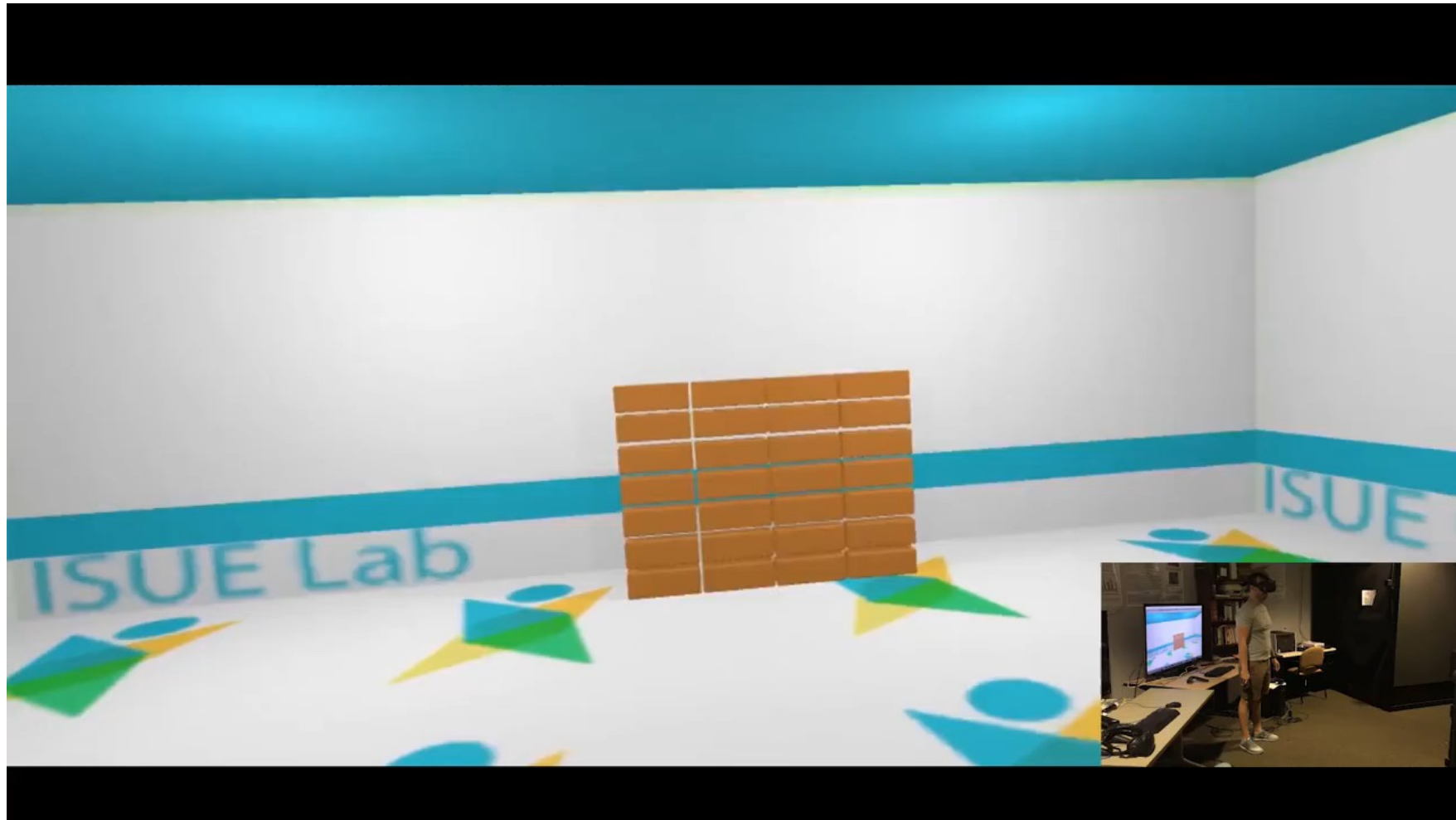
- Uses a volume to determine what is manipulated
- Flashlight
- Aperture selection
- Sphere-casting

Ray-Casting

- Uses the forward vector of a 6-DOF input device
- Uses an infinite ray to visually represent vector
- Uses a button to select first intersected object
- Can select objects outside of the user's physical reach due to the infinite vector
- Small or faraway objects are difficult to select
- Cannot select occluded objects



Ray-Casting



Fishing Reel

- Extends the basic concept of ray-casting
- Uses one button to push a selected object away
- Uses another button to bring a selected object closer

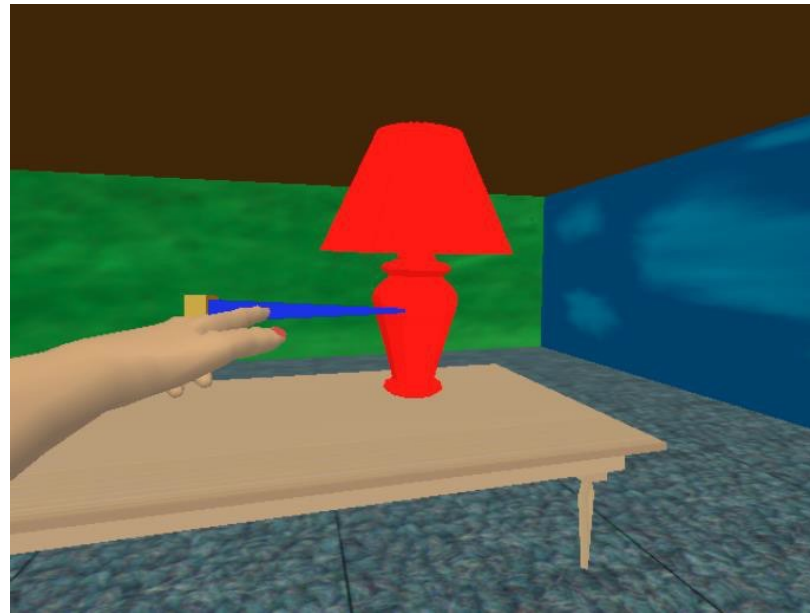
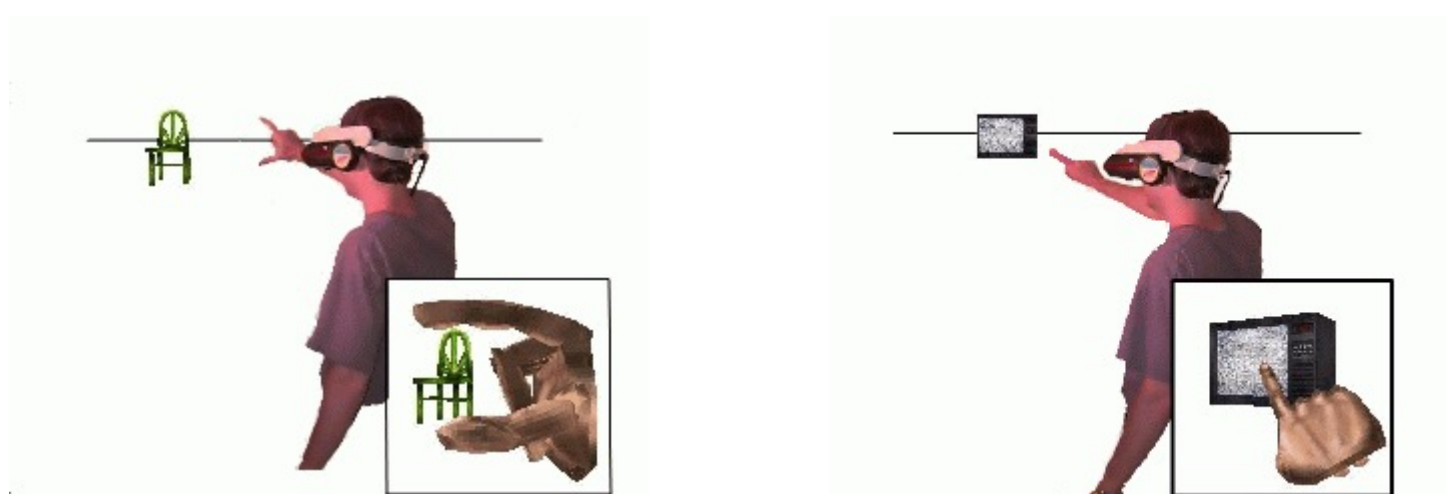


Image-Plane Pointing

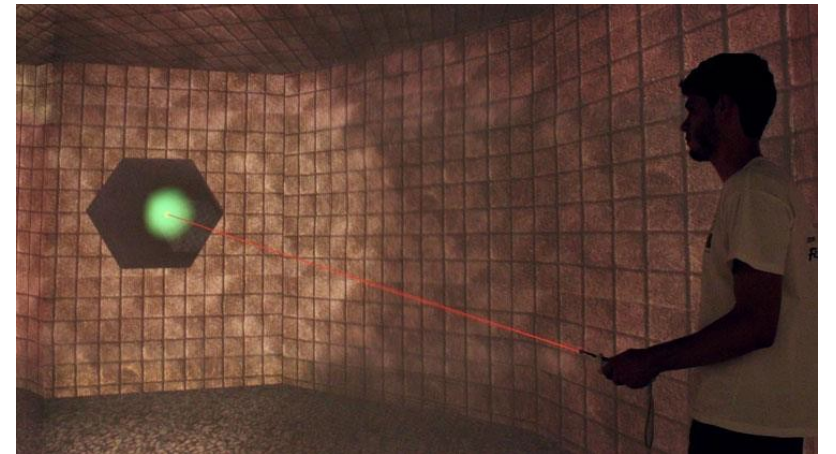
- Projects the 3D scene on a virtual image plane located in front of the user
- The user selects and manipulates 3D objects by touching and manipulating their 2D projections



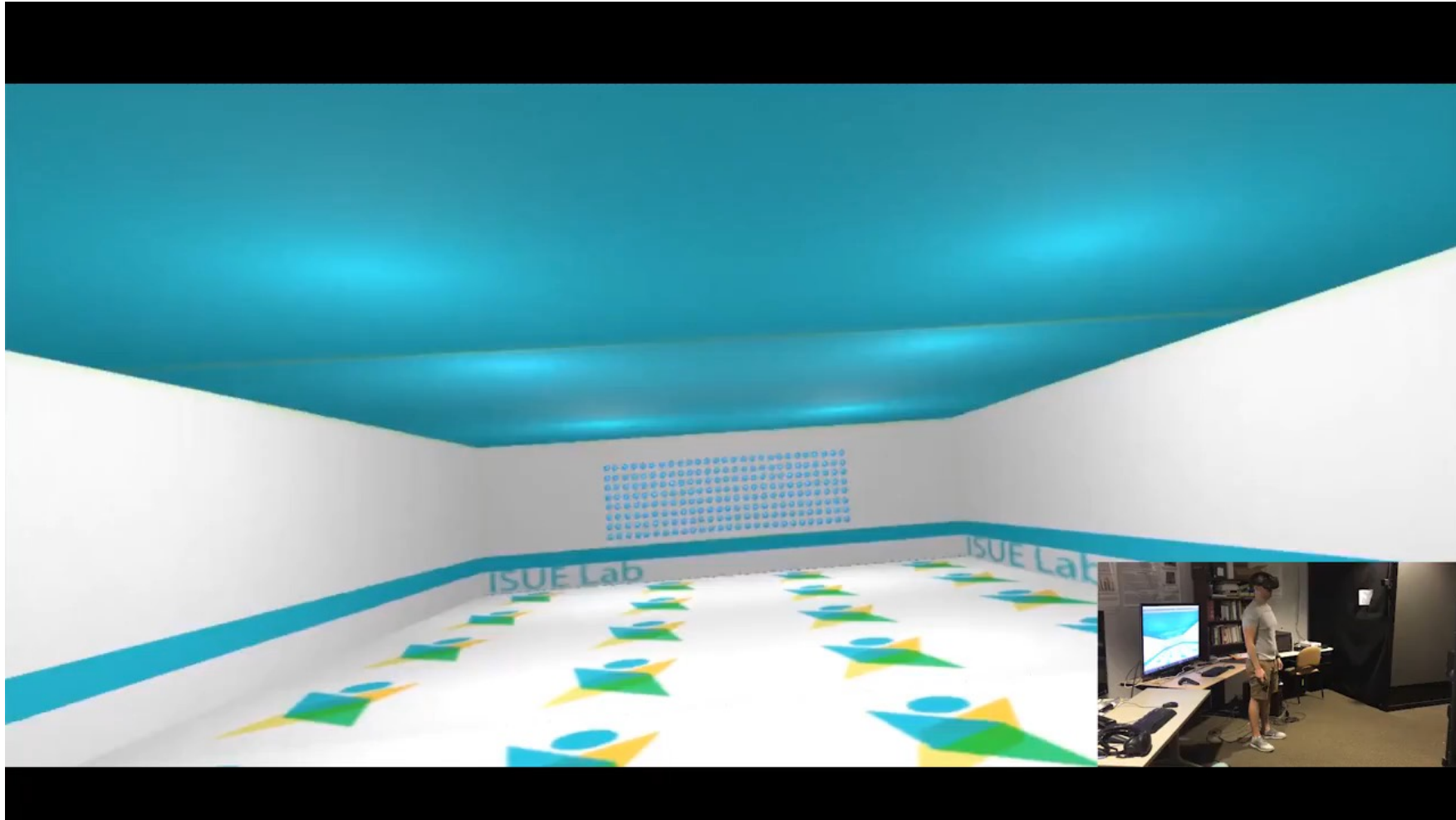
<http://www.cs.cmu.edu/~stage3/publications/97/conferences/3DSymposium/HeadCrusher/>

Flashlight

- Uses a cone to select objects within the volume
- Selects the object closest to the centerline
- If there's a tie, it selects the object closest to the cone's origin (i.e., the device)
- Requires less precision than ray-casting
- Can be difficult to use when multiple small objects are present

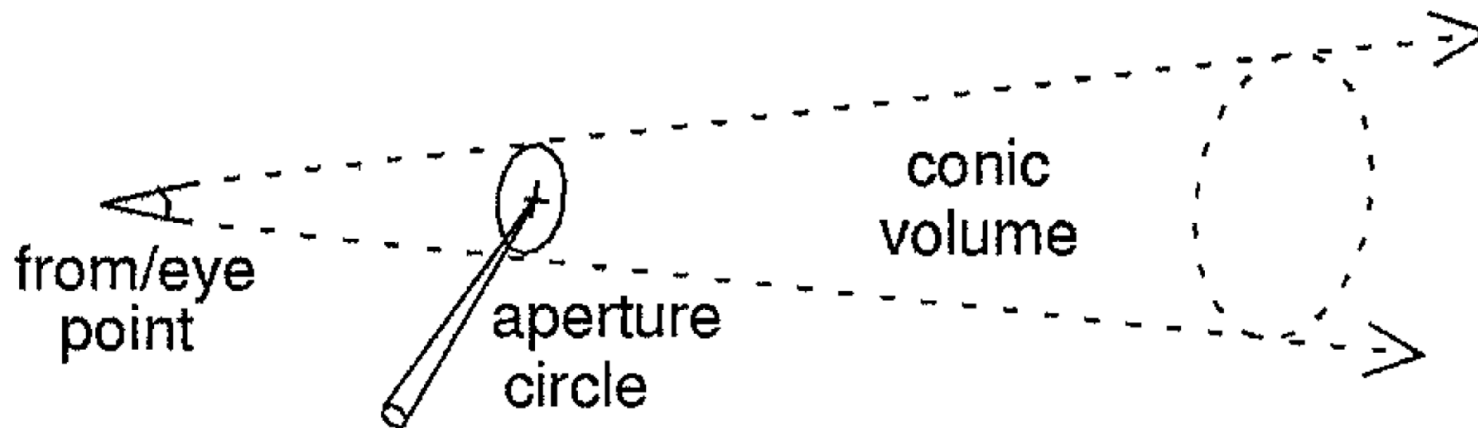


Flashlight



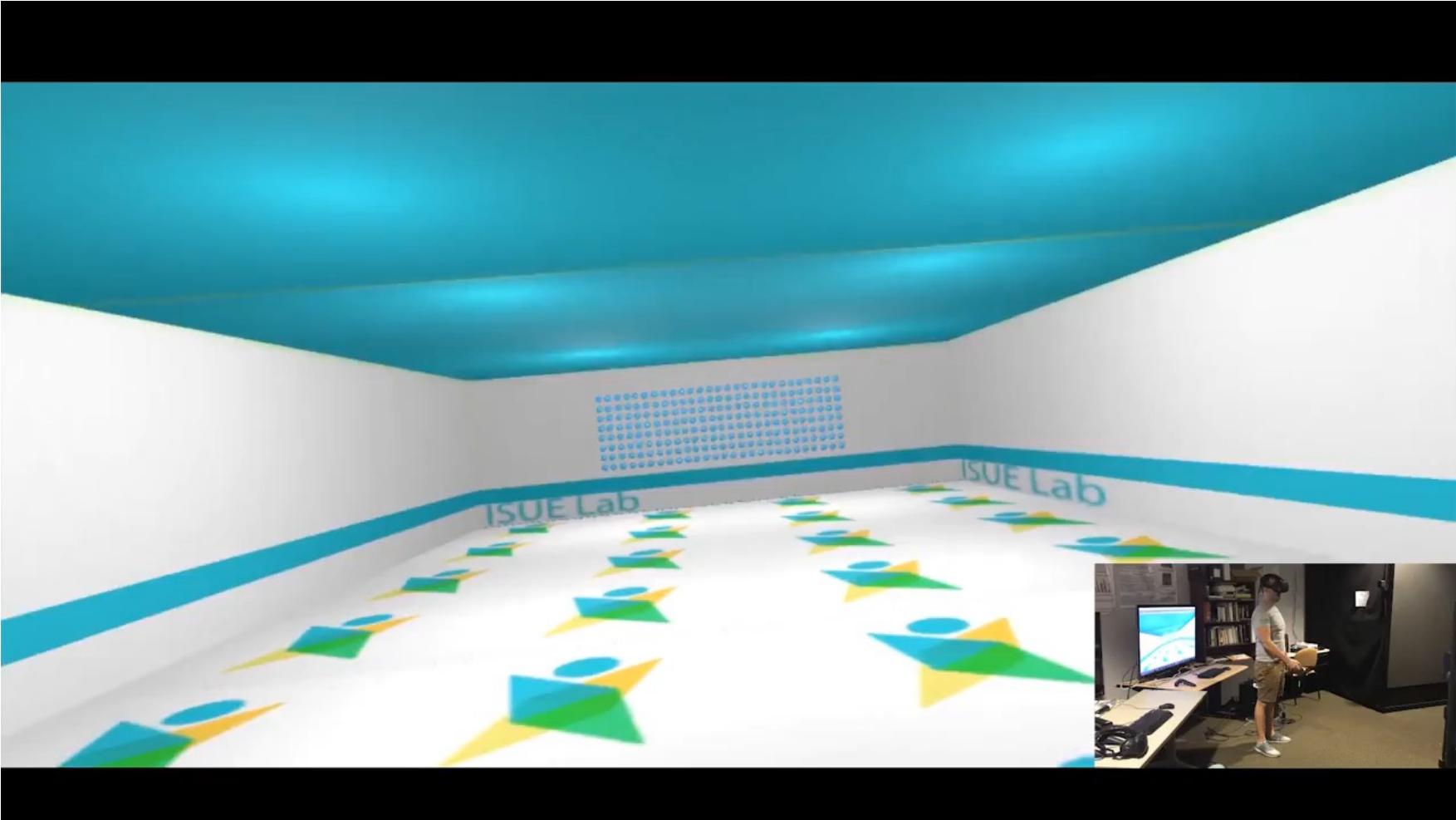
Aperture Selection

- Extends the basic concept of flashlight
- Allows the user to control the spread of the cone selection volume
- Allows the user to disambiguate among multiple objects by twisting the selection volume



Aperture Based Selection for Immersive Virtual Environments. Forsberg et al. UIST'96

Aperture Selection



Sphere-Casting

- A modified version of ray-casting
- Casts a sphere onto the nearest intersected surface



Rapid and accurate 3D selection by progressive refinement. Kopper et al. 3DUI'11.

Indirect Approaches

- Allow users to manipulate virtual objects without directly interacting with them
- Example, world in miniature



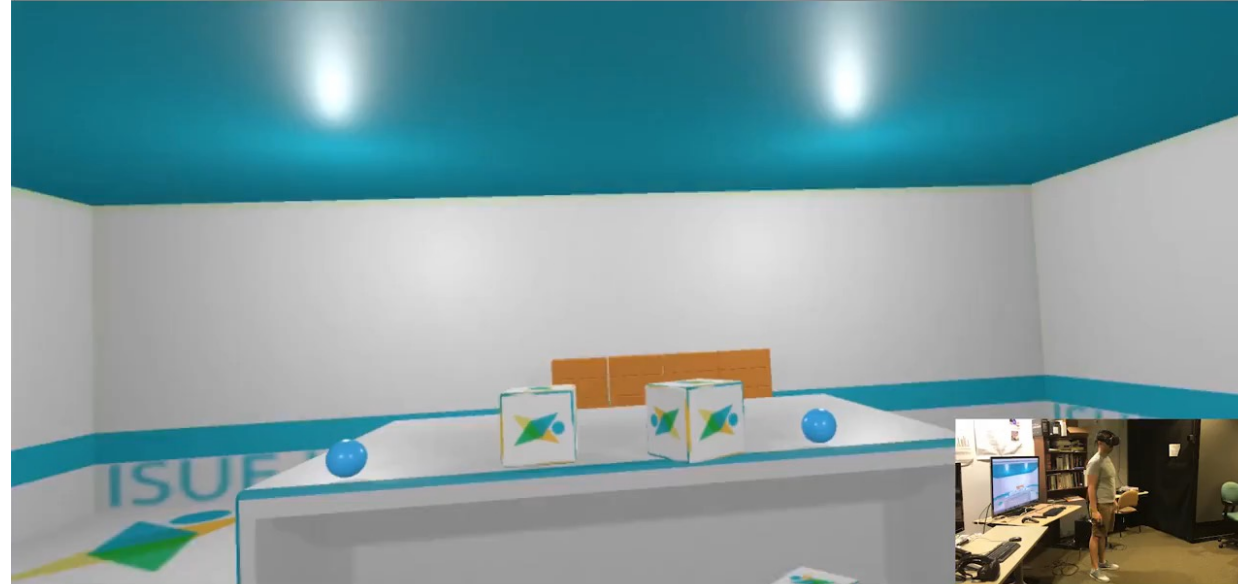
Bimanual Approaches

- Allow users to manipulate objects using both hands



Hybrid Approaches

- Combine multiple techniques to provide interactions
- Hand-centered Object Manipulation Extending Ray-casting (HOMER)
 - Uses ray-casting for selection
 - Uses Go-Go-like virtual hand for manipulation



Summary

- Grasping metaphors
- Pointing metaphors
- Indirect metaphors
- Bimanual metaphors
- Hybrid metaphors

Further Reading

- Section 10.3, Virtual Reality, Steven LaValle
- Chapter 7, 3D User Interfaces: Theory and Practice, LaViola et al.