

CSE 165: 3D User Interaction

Lecture #3:
Selection and Manipulation

Announcements

- Sign up for video presentation
 - Deadline: Sunday, Jan 17, 11:59pm
 - Only need to pick a date now – you can choose the video later
- Homework Assignment 1 is due Sunday, Jan 24 at 11:59pm
- Late deadline: Jan 31 at 11:59pm

3D UI Presentations

- Baichuan Wu:
Introducing the Rain Blender Rig

Selection and Manipulation

On 2D Desktop

- Location selected with mouse cursor
- Action triggered with mouse button
 - 1-3 (sometimes more) buttons for different functionality
- Mouse wheel as shortcut for scroll bar interaction



On Touch Screens

- Examples: smart phone, tablet, laptop display
- Finger touches target location directly
 - Triggers action on touch
- Multi-touch and swiping for added functionality
 - E.g., pinch to zoom



Triggering an Action in 3D

With Controllers

- If a VR/AR system comes with controllers, actions can be triggered with the buttons on the controllers
- Challenge: not to overburden the user with memorizing button assignments



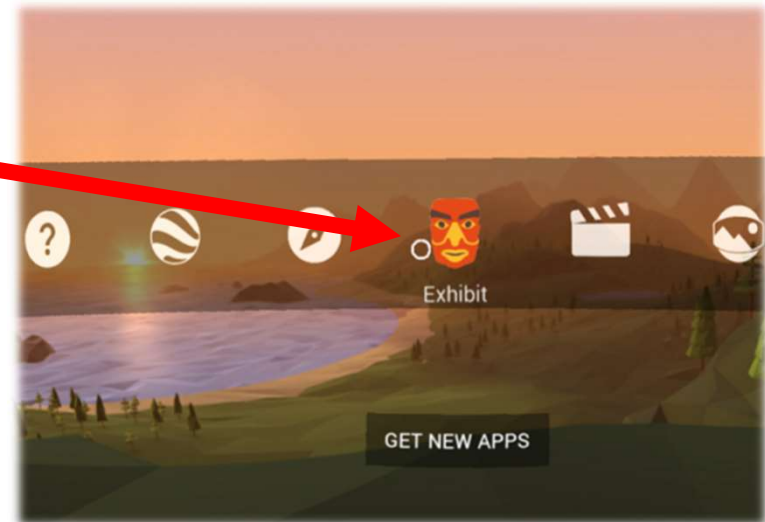
Without Controllers

- Some VR headsets do not come with controllers:
 - Google Cardboard
 - Other smartphone VR
 - Early Oculus (DK1 and DK2)



Selection by Gaze or Head Direction: Hover and Wait

- Crosshairs in center of screen
- Turn head in direction of selection location (Hover)
- Action triggers after specified amount of time (Wait)



Examples for Visual Indicators

- Radial widgets



- Slider widgets



- Hexagon fill

- <https://www.youtube.com/watch?v=uTH9NCxNvZI>

Why are Selection and Manipulation Important?

- Major methods of interaction with
 - physical environments
 - virtual environments
- Affect the quality of entire 3D interface
- Design of 3D manipulation techniques is difficult

Selection vs. Manipulation

- Selection: specifying one or more objects from a set
- Manipulation: modifying object properties (position, orientation, scale, shape, color, texture, behavior, etc.)

Goals of Selection

- Indicate action on object
- Query object
- Make object active
- Travel to object location
- Set up manipulation

Selection Performance

- Variables affecting user performance
 - Object distance from user
 - Object size
 - Density of objects in area
 - Presence of occluding objects

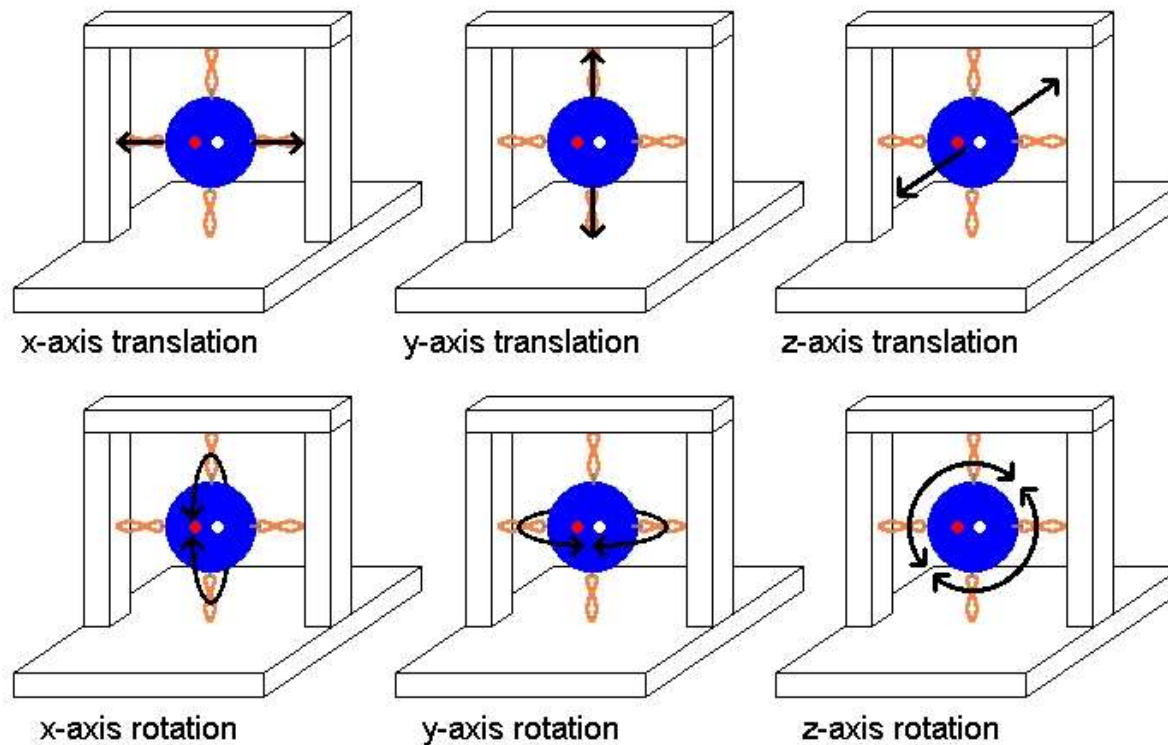
Canonical Parameters

- Selection
 - distance and direction to target
 - target size
 - density of objects around the target
 - number of targets to be selected
 - target occlusion
- Manipulation
 - Positioning
 - distance/direction to initial position
 - distance/direction to target position
 - translation distance
 - required precision of positioning
 - Rotation
 - distance to target
 - initial orientation
 - final orientation
 - amount of rotation

Degrees of Freedom (DOF)

- DOF: Set of independent displacements that specify completely the displaced or deformed position of a body or system.
- 3 DOF for position:
 - Moving up and down (heaving)
 - Moving left and right (swaying)
 - Moving forward and backward (surging)
- 3 DOF for orientation:
 - Tilting up and down (pitching)
 - Turning left and right (yawing)
 - Tilting side to side (rolling)

6 Degrees of Freedom



Input Device Parameters

- Number of control dimensions
- Control integration: how many DOF are controlled simultaneously
- Force or incremental direction vs. position control (relative vs. absolute location)
- Form factor: impact on accuracy



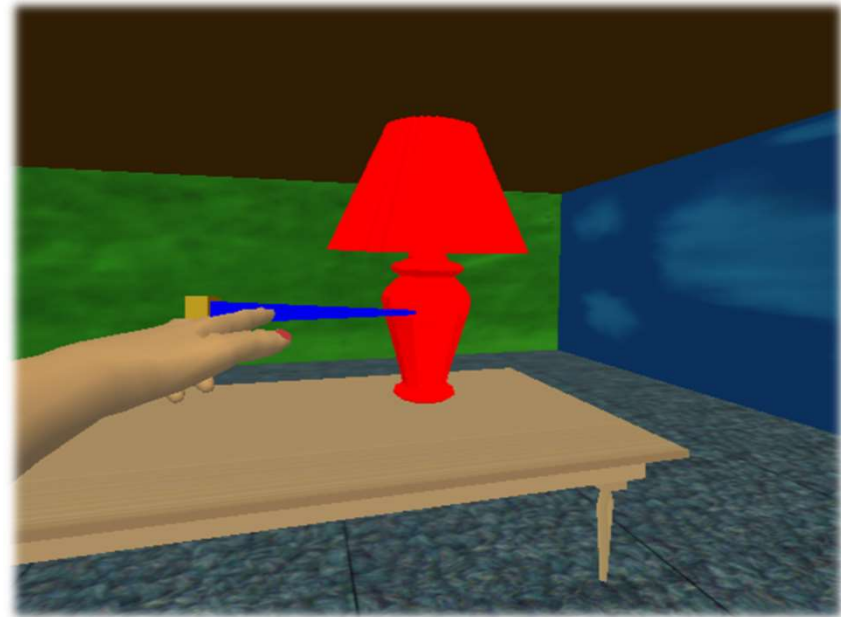
Sensor attached to hand

Isomorphic vs. Non-Isomorphic View

- Isomorphic
 - Geometrical on-to-one correspondence between hand motions in physical and virtual worlds
 - Natural interactions
- Non-Isomorphic
 - “Magic” virtual tools (laser beams, rubber arms, etc.)

Ray-Casting

- User points at objects with virtual ray
- Ray defines and visualizes pointing direction
- First intersected object is selected



$$\mathbf{p}(\alpha) = \mathbf{h} + \alpha \cdot \vec{\mathbf{p}}$$

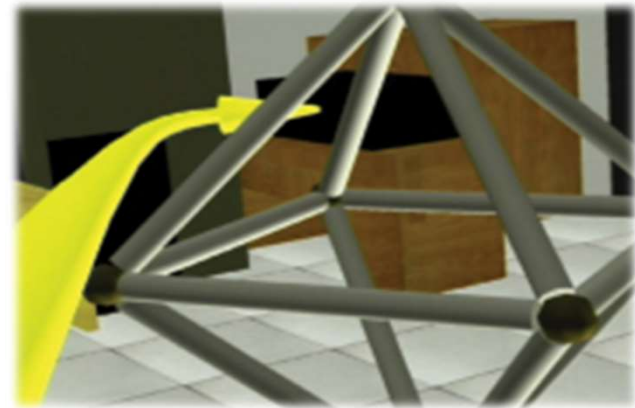
\mathbf{h} = 3D position of virtual hand

$\vec{\mathbf{p}}$ = ray attached to \mathbf{h}

$0 < \alpha < \infty$ determined by first object intersection

Two-Handed Pointing

- Ray casting with 2 hands
- More control
 - Distance between hands controls length
 - Allows pointing at things behind other things



$$\mathbf{p}(\alpha) = \mathbf{h}_l + \alpha \cdot (\mathbf{h}_r - \mathbf{h}_l)$$

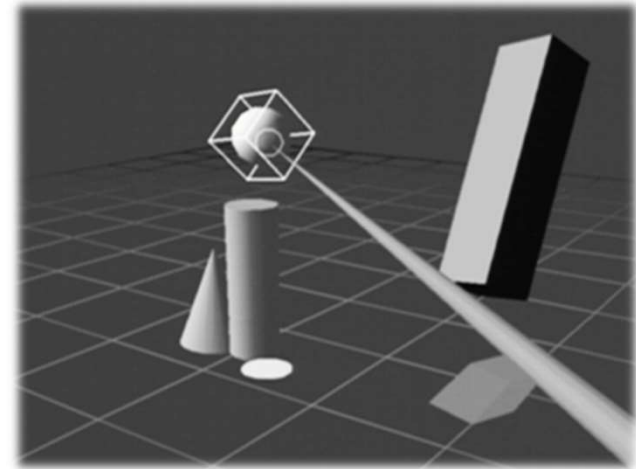
$0 < \alpha < \infty$ is fixed

\mathbf{h}_l = 3D position of left hand

\mathbf{h}_r = 3D position of right hand

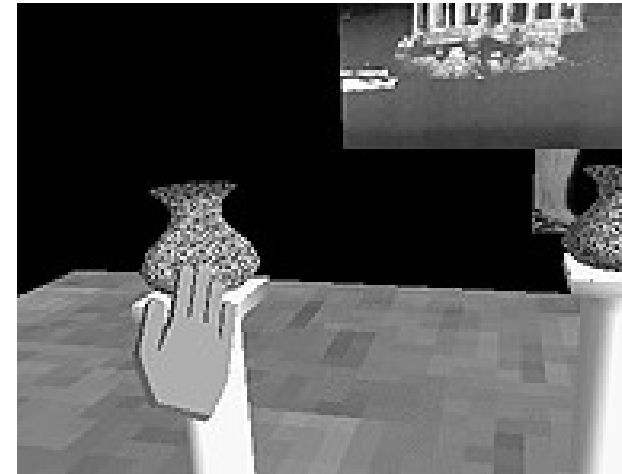
Flashlight

- Does not need precision
- Conic selection volume
 - Tip of cone in wand
 - Cone direction determined by wand direction
 - Fixed cone size
- If multiple objects in cone
 - Object closer to center line of cone is selected
 - If multiple objects are equally close to center line: select object closer to device



Virtual Hand

- Select and manipulate directly with hand
- Hand represented as 3D cursor
- Intersection between cursor and object indicates selection



$$\mathbf{p}_v = \alpha \cdot \mathbf{p}_r, \mathbf{R}_v = \mathbf{R}_r$$

$\mathbf{p}_r, \mathbf{R}_r$ = position and orientation of real hand

$\mathbf{p}_v, \mathbf{R}_v$ = position and orientation of hand in VE

α = fixed scaling factor

Go-Go

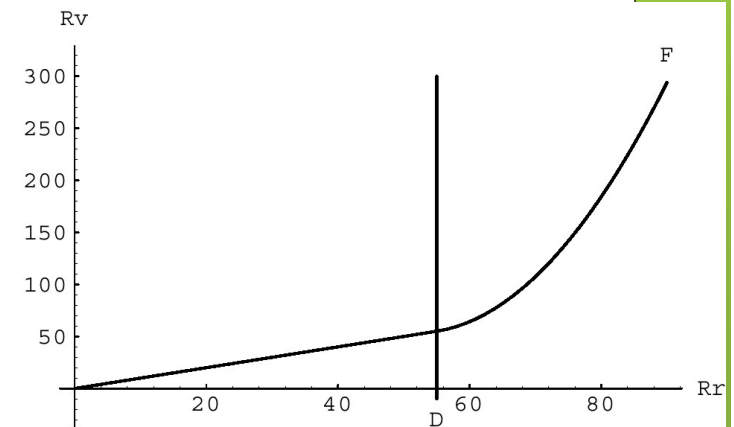
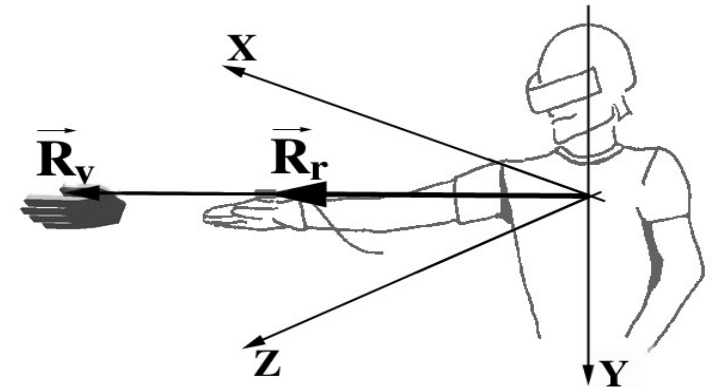
- By Ivan Poupyrev, 1996
- Arm-extension technique
- Touch objects to select, like simple virtual hand
- Non-linear mapping between physical and virtual hand position
- Requires torso position
- Local and distant regions

$$r_v = F(r_r) = \begin{cases} r_r & \text{if } r_r \leq D \\ r_r + \alpha(r_r - D)^2 & \text{otherwise} \end{cases}$$

where r_r = length of $\vec{\mathbf{R}}_r$

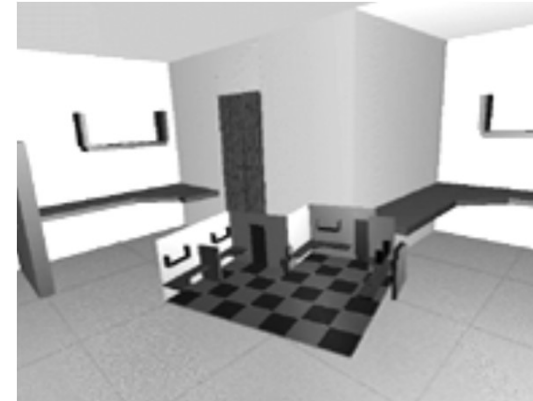
r_v = length of $\vec{\mathbf{R}}_v$

D, α are constants



World-in-Miniature (WIM)

- By Stoakley, 1995
- “Dollhouse” world held in user’s hand
- Miniature objects can be manipulated directly
- Moving miniature objects affects full-scale objects
- Can also be used for navigation



Voodoo Doll

- Pierce et al. 1999
- Two-handed technique
- Builds upon image plane and WIM techniques
- Developed for pinch gloves
 - Requires finger pose tracking
- Creates copies of objects (dolls) for manipulation
- Non-dominant hand: stationary frame of reference
- Dominant hand: defines position and orientation

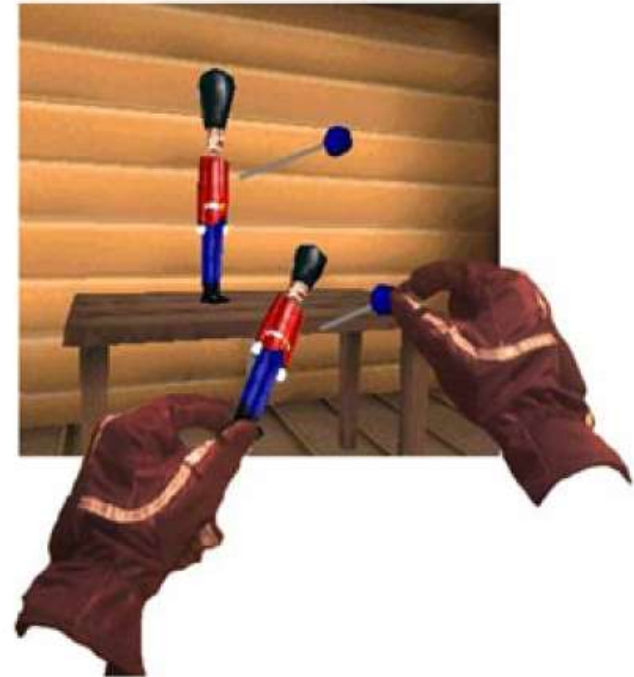
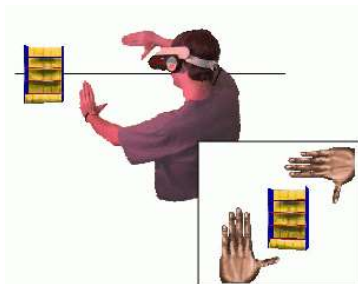


Image Plane Techniques

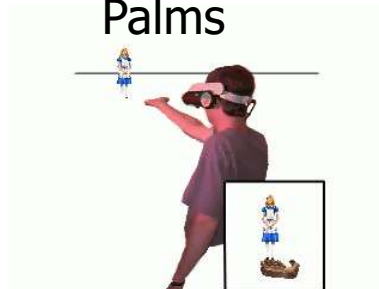
- Require only 2 DOF
 - Selection based on 2D projections
 - Use virtual image plane in front of user
 - Dependent on head/eye position



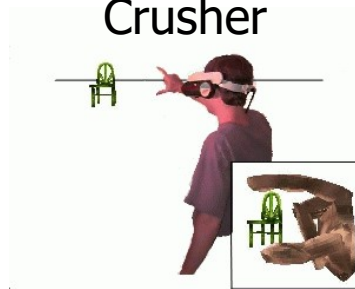
Framing



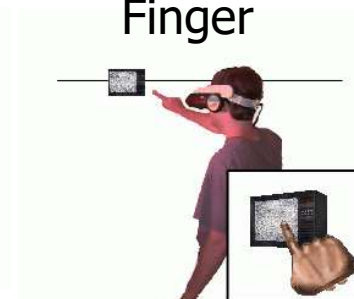
Lifting
Palms



Head-
Crusher



Sticky
Finger



Forced Perspective

- Museum of Simulation Technology
 - <http://www.youtube.com/watch?v=HOfl06X16c>



Other Interactions at a Distance

- Summoning and Superpowers: Designing VR Interactions at a Distance
 - <http://blog.leapmotion.com/summoning-superpowers-designing-vr-interactions-distance/>

Technique Classification by Metaphor

- Manipulation techniques
 - Egocentric metaphor
 - Virtual pointer metaphor
 - Ray-casting
 - Two-handed pointing
 - Flashlight
 - Image plane
 - Forced Perspective
 - Direct manipulation
 - "Classical" virtual hand
 - Go-Go
 - Exocentric metaphor
 - World-in-miniature
 - Hybrid techniques
 - Voodoo Dolls

