

CSE 165: 3D User Interaction

Lecture #4:
Selection and Manipulation
Part 2: Techniques

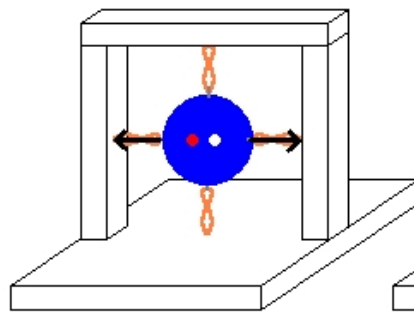
Announcements

- Sign up for video presentation
 - Deadline: Sunday Jan 20, 23:59pm
 - You only need to pick a date now – you can choose the video later
- Homework Project 1
 - Due Friday January 25 at 3pm

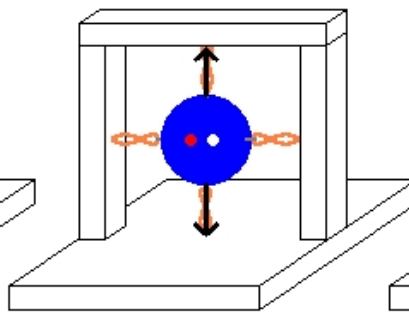
Degrees of Freedom (DOF)

- 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)

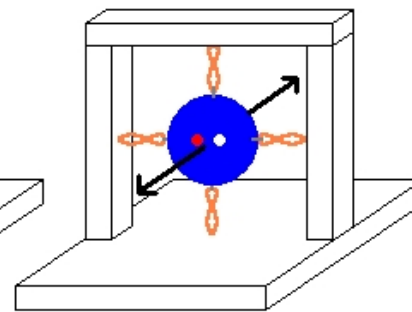
6 Degrees of Freedom



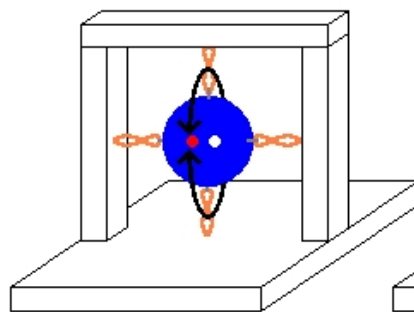
x-axis translation



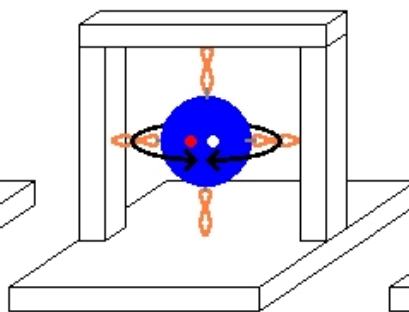
y-axis translation



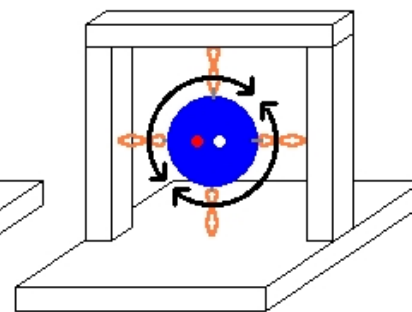
z-axis translation



x-axis rotation



y-axis rotation



z-axis rotation

Input Device Parameters

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



Sensor attached to hand



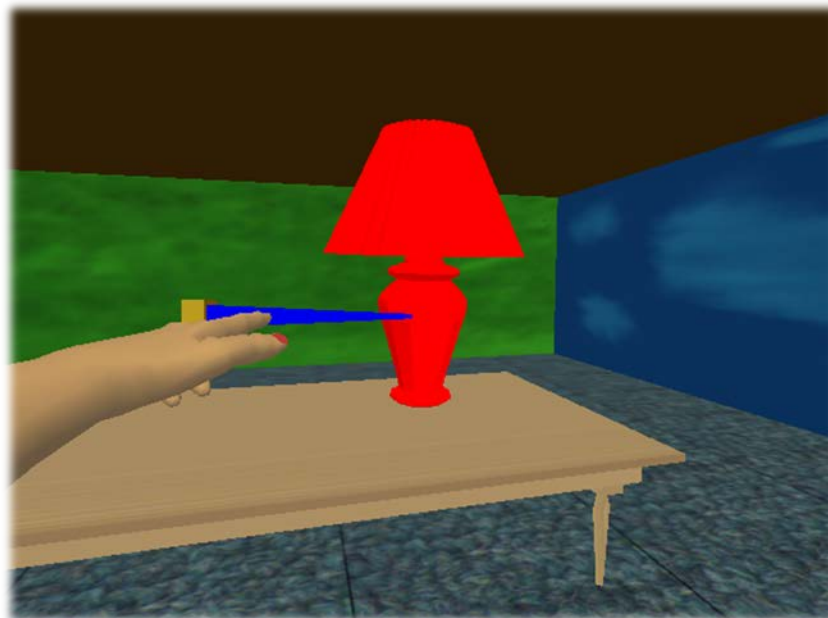
Sensor rolled
with fingers

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



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

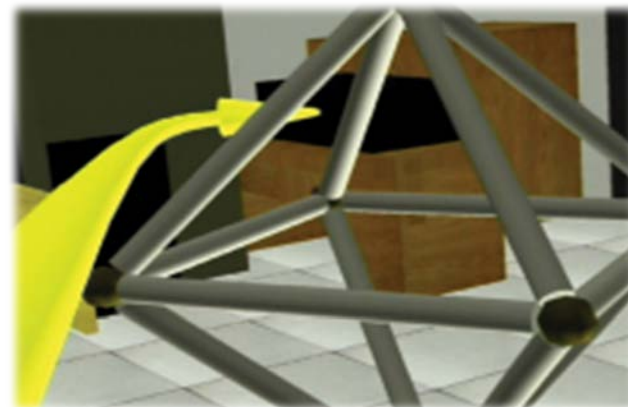
\mathbf{h} = 3D position of virtual hand

$\vec{\mathbf{p}}$ = 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



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

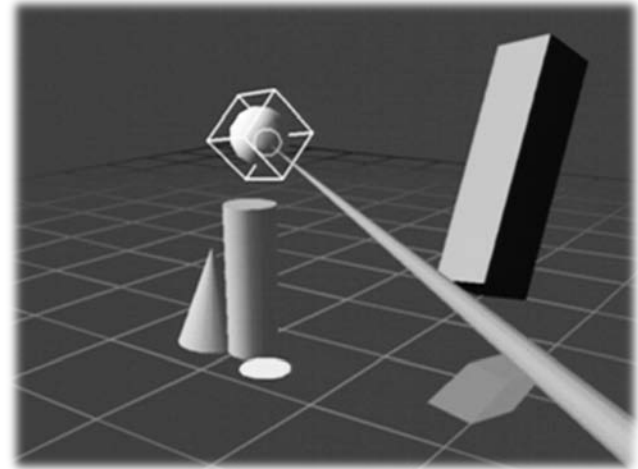
$0 < \alpha < \infty$ is fixed

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

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

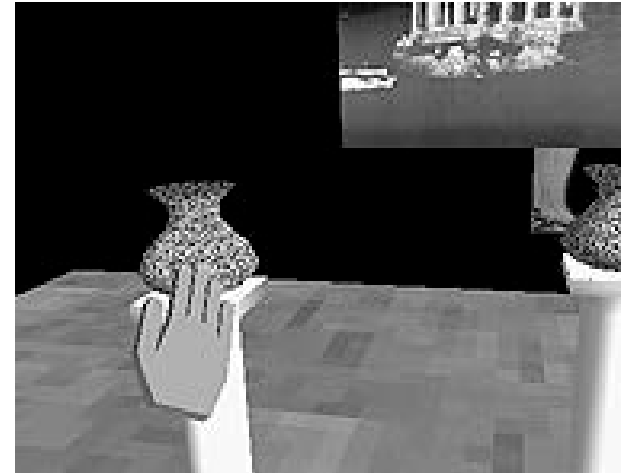
Flashlight

- 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

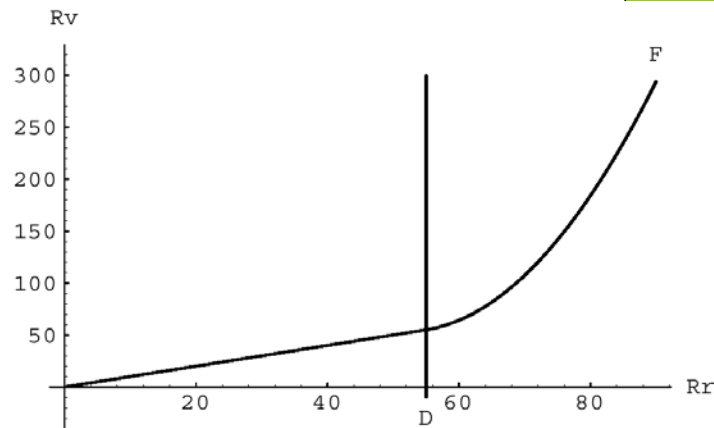
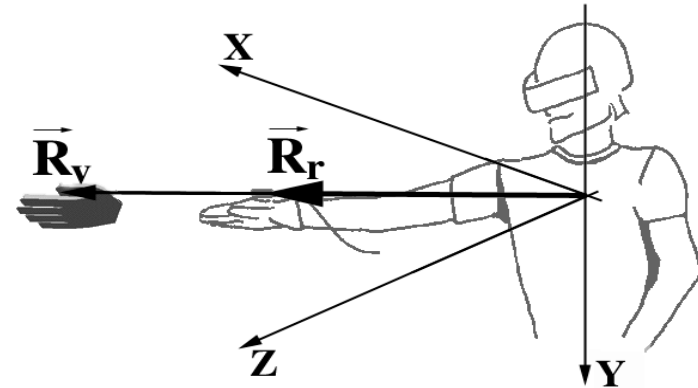
- By Ivan Poupyrev, 1996
- Arm-extension technique
- Touch objects to select, like simple virtual hand
- Non-linear mapping between physical and virtual hand position
- Requires torso position
- Local and distant regions

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

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

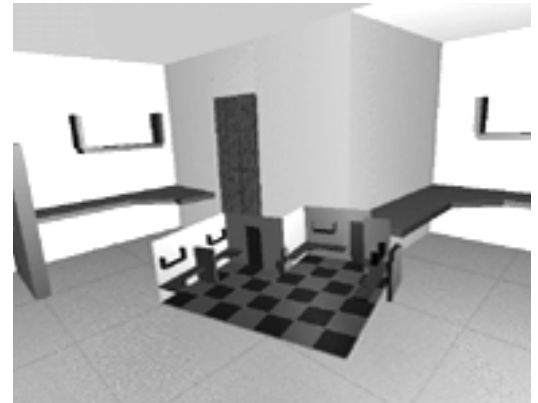
r_v = length of $\vec{\mathbf{R}}_v$

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

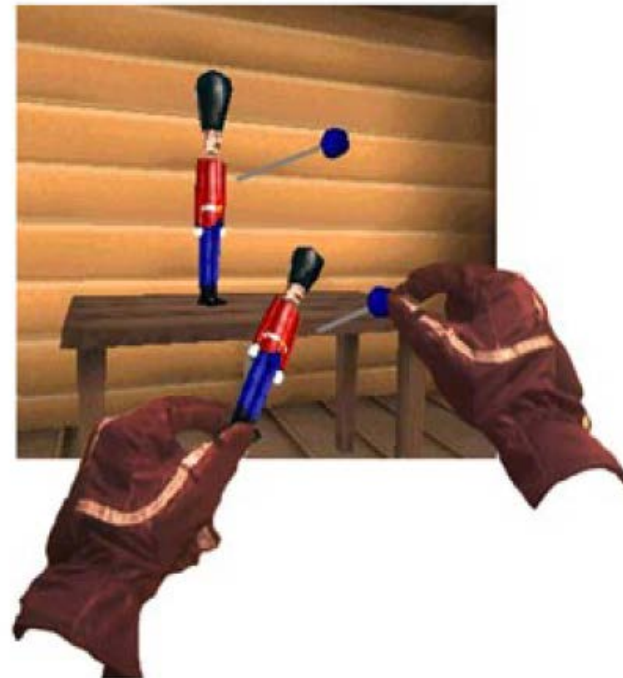
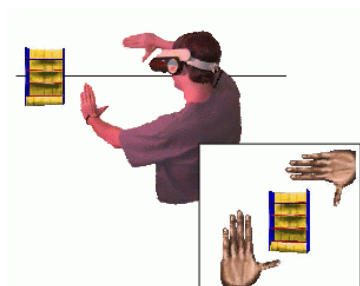


Image Plane Techniques

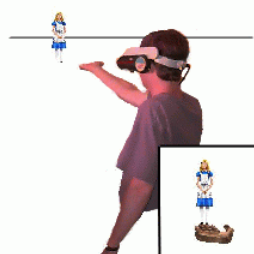
- Require only 2 DOF
 - Selection based on 2D projections
 - Use virtual image plane in front of user
 - Dependent on head/eye position



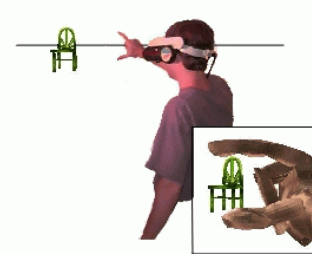
Framing



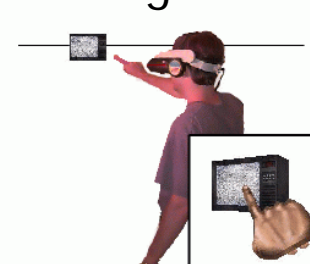
Lifting
Palms



Head-
Crusher



Sticky
Finger



Forced Perspective

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



New Interaction Techniques

- **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

