CSE 165: 3D User Interaction

Lecture #4: Selection

Announcements

- Video presentation scheduling due Sunday
- Project 1 due next Friday at 2pm

Selection and Manipulation

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 (<u>position</u>, <u>orientation</u>, 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

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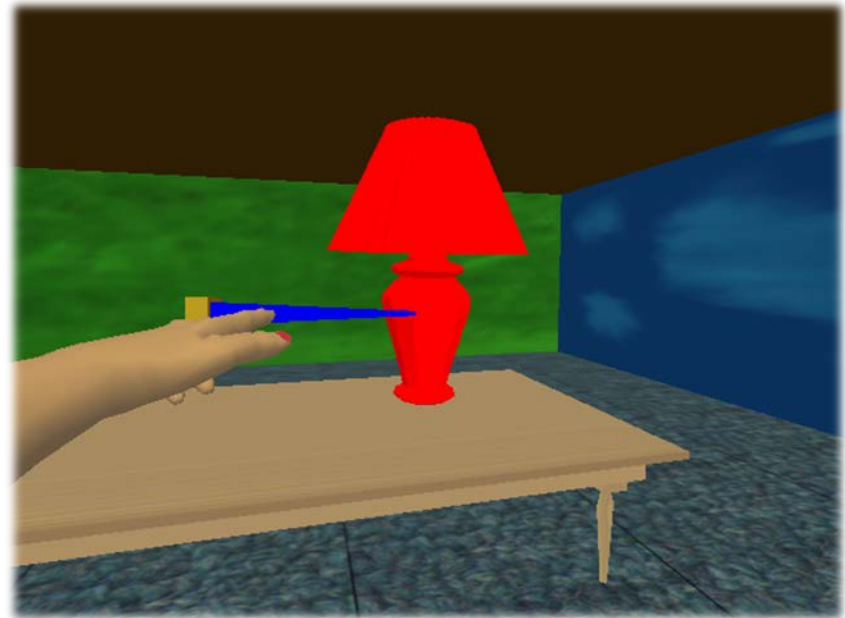
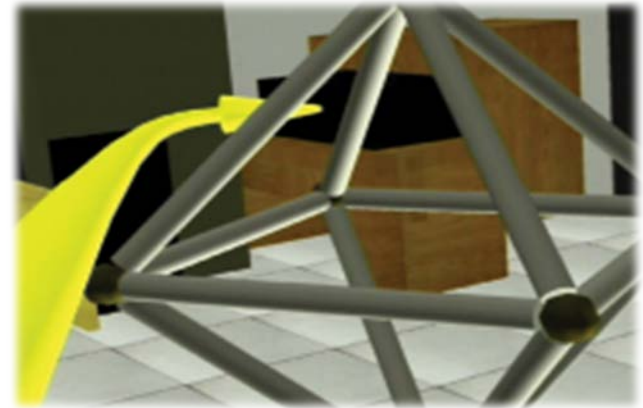$$\mathbf{p}(\alpha) = \mathbf{h} + \alpha \cdot \vec{\mathbf{p}}$$

$\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

$$\mathbf{p}(\alpha) = \mathbf{h_l} + \alpha \cdot (\mathbf{h_r} - \mathbf{h_l})$$

$$0 < \alpha < \infty \text{ is fixed}$$

$$\mathbf{h_l} = 3\text{D position of left hand}$$

$$\mathbf{h_r} = 3\text{D position of right hand}$$

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
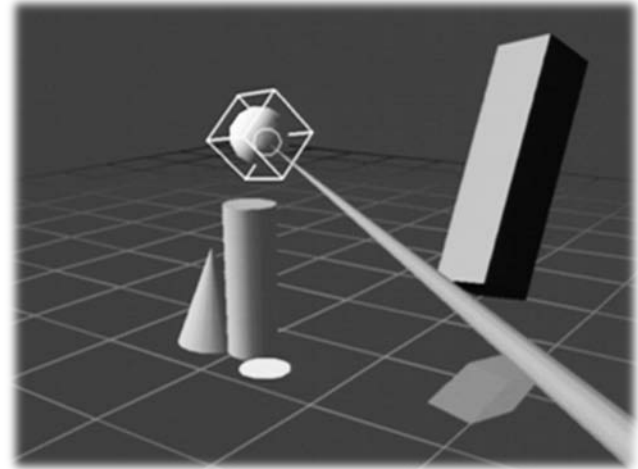
Virtual Hand

o Select and manipulate directly with hand
o Hand represented as 3D cursor
o Intersection between cursor and object indicates selection
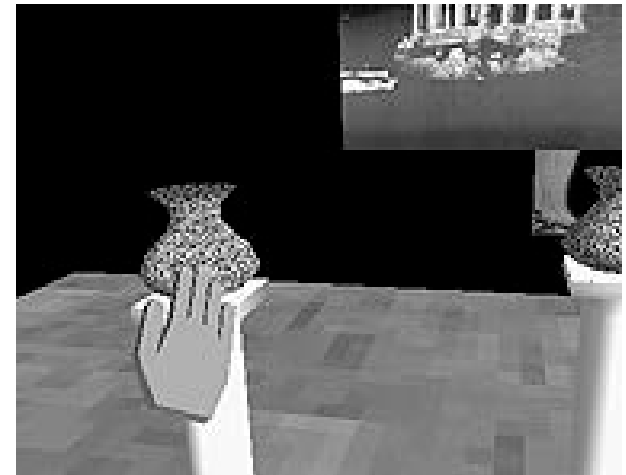
$$\mathbf{p_v} = \alpha \cdot \mathbf{p_r}, \mathbf{R_v} = \mathbf{R_r}$$

$\mathbf{p_r}, \mathbf{R_r} = \text{position and orientation of real hand}$

$\mathbf{p_v}, \mathbf{R_v} = \text{position and orientation of hand in VE}$
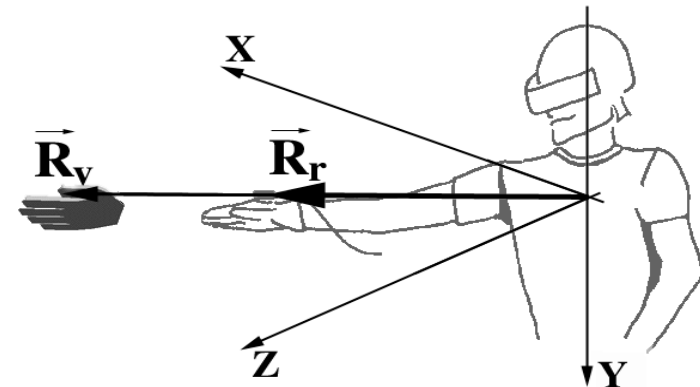
$\alpha = \text{fixed scaling factor}$

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

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

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

$r_v = $ length of $\vec{\mathbf{R}}_\mathbf{v}$

D, α are constants
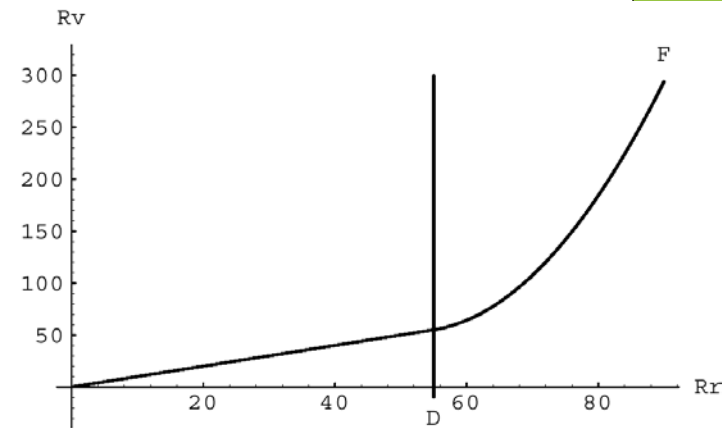
World-in-Miniature (WIM)

- By Stoakley, 1995
- "Dollhouse" world held in user's hand
- Miniature objects can be manipulated directly
- Moving miniature objects affects full-scale objects
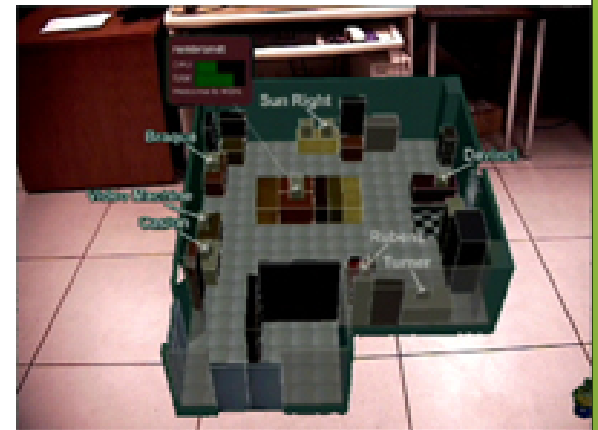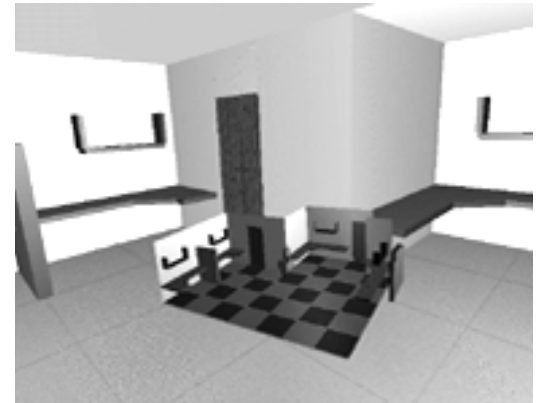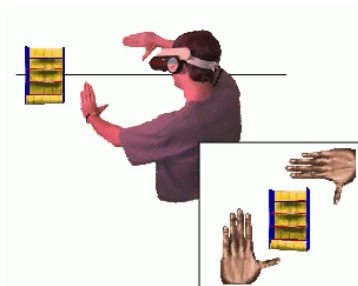- Can also be used for navigation
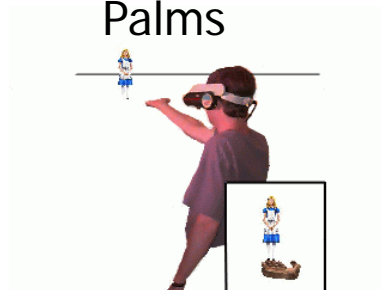
Image Plane Techniques

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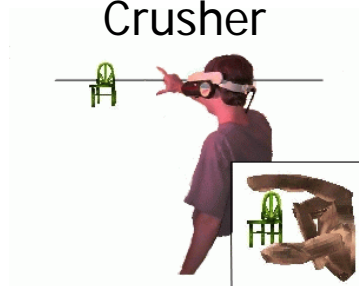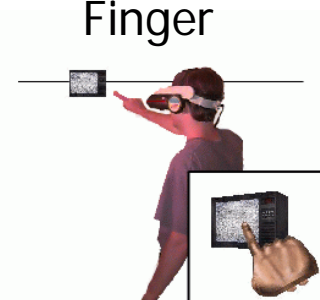   - Dependent on head/eye position

| Framing | Lifting Palms | Head-Crusher | Sticky Finger |

Forced Perspective

- Museum of Simulation Technology
  - http://www.youtube.com/watch?v=HOfll06X16c

Left Click
to grab/release

And when you put it down…

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
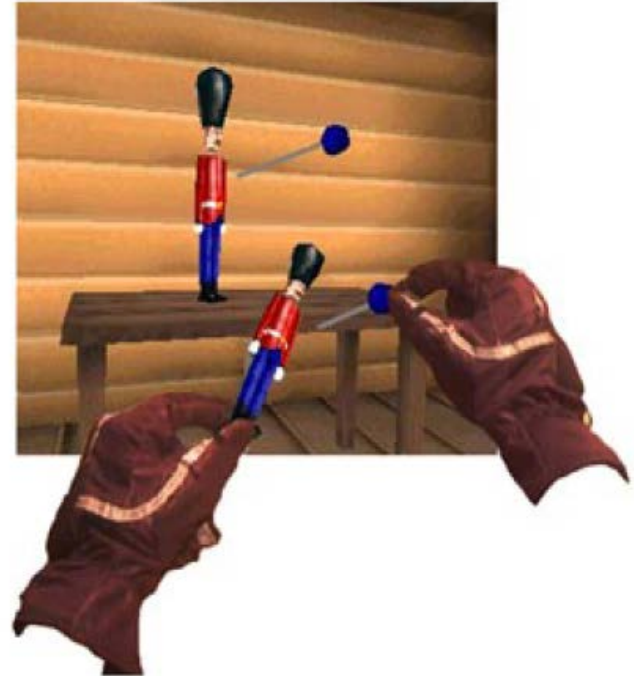
Technique Classification by Metaphor

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