CSE 165: 3D User Interaction

Lecture #6: Selection

Instructor:
Jurgen Schulze, Ph.D.

Announcements

- Homework Assignment #2
  - Due Friday, January 23rd at 1:00pm

Tue 1/27	Eun Chul Lee	Brain-Computer Interface Systems used forVirtual Reality Control	Michael Max Hughes	Analysis of Direct Selection in Head-Mounted Display Environments	Archit Khosla	A Dual-Mode User Interface for Accessing 3D Contenton the World Wide Web
Thu 1/29	Trevor Smith	Visual feedback for virtual grasping	Zizhao Huang	Collaborative Gaming in Augmented Reality	Max Takano	Learning to be a Depth Camera for Close-Range Human Capture and Interaction
Tue 2/3	Richard Tominaga	Expressing animated performances through puppeteering	Robert Maloney	A material point method for snow simulation	Paul Sable	Mid-Air Interactions Above Stereoscopic Interactive Tables
Thu 2/5	Ching Yiu Lee	A dual-mode user interface for accessing 3D content on the world wide web	Jesus Villegas	HybridSpace: Integrating 3D Freehand Input and Stereo Viewing intoTraditional Desktop Applications	Brandon Schade	The Virtual Mitten: A Novel Interaction Paradigm for Visuo-Haptic Manipulation of Objects Using Grip Force
Tue 2/10	Daniel Salvadori	A Puppet Interface for Retrieval of Motion Capture Data	Tony Luo	Joyman: a Human-Scale Joystick for Navigating in Virtual Worlds	Sanjana Agarwal	Multiphase surface tracking with explicit contouring
Thu 2/12	Jie Sheng	Design and Evaluation of Mouse	Wes Lau	Windy trees: computing stress response for developmental tree models	Herbert Torosyan	RUIS-A toolkit for developing virtual reality applications with spatial interaction
Tue 2/17	Yangshuoshen Liu	An Evaluation of Open Source Physics Engines for Use in Virtual Reality Assembly Simulations	Eden Lin	An Evaluation of Two Simple Methods for Representing Heaviness in Immersive Virtual Environments	Stanley Mah	Digi Tap: an eyes-free VR/AR symbolic input device
Thu 2/19	Ruiqing Qiu	Interactive Tactile Experiences in Free Air	Mingshan Wang	Expressing Animated Performances through Puppeteering	David Nuernberger	3D Marking menu selection with freehand gestures
Tue 2/24	Alan Chin	Tangible and modular input device for character articulation	Hubert Hsiung	Stereoscopic Rendering of Virtual Environments withWide Field-of-Views up to 360	Zhaoyang Zeng	A multi-view application framework for hybrid reality display environments
Thu 2/26	Heng Meng	**Design and evaluation of 3D cursors and motion parallax for the exploration of desktop virtual environments**	Jimmy Nguyen	Comparing Isometric and Elastic Surfboard Interfaces forLeaning-Based Travel in 3D Virtual Environments	Saurabh Sharma	A novel 3D Carousel based on Pseudo-Haptic Feedback and GesturalInteraction for Virtual Showcasing
Tue 3/3	Erik Muntean	Ten-Dimensional Anthropomorphic Arm Control in a Human Brain-Machine Interface: Difficulties, Solutions, and Limitations (too medical?)	Azeem Ghumman	Comparison of a Two-Handed Interface to a Wand Interface and a Mouse Interface for Fundamental 3D Tasks		
Thu 3/5	Vivek Venugopal	Tapping-In-Place: Increasing the naturalness of immersive walking-in-place locomotion through novel gestural input				
Tue 3/10	Jonathan Lin	Full Body Interaction in Virtual Reality with Affordable Hardware				

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 (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

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

Technique Classification by Metaphor

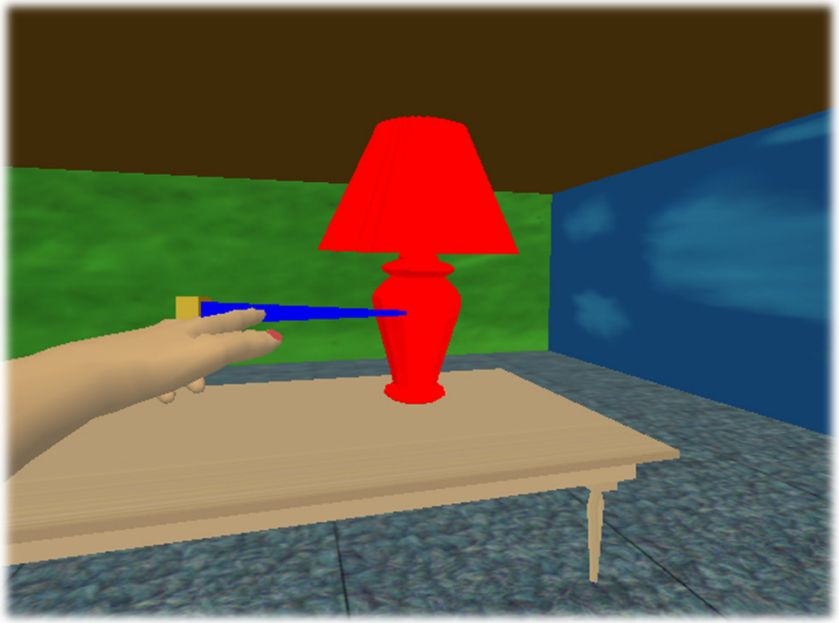
- Manipulation techniques
  - Egocentric metaphor
    - Virtual pointer metaphor
      - Ray-casting
      - Two-handed pointing
      - Flashlight
      - Image plane
    - Direct manipulation
      - "Classical" virtual hand
      - Go-Go
    - Hybrid techniques
      - HOMER
  - Exocentric metaphor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

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



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

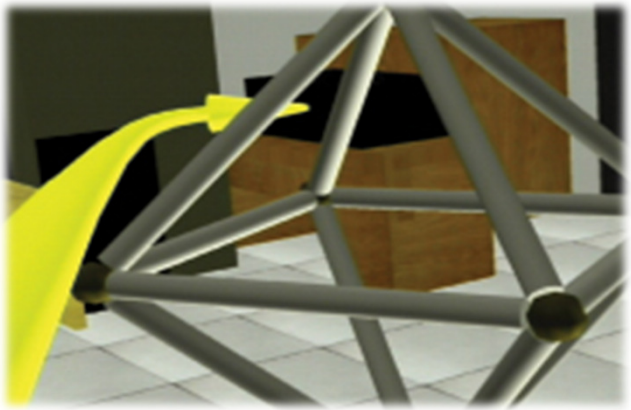
$$\mathbf{h} = 3\text{D position of virtual hand}$$

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

$$0 < \alpha < \infty \text{ determined by first object intersection}$$

Two-Handed Pointing

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



$$\mathbf{p}(\alpha) = \mathbf{h}_\mathbf{l} + \alpha \cdot (\mathbf{h}_\mathbf{r} - \mathbf{h}_\mathbf{l})$$

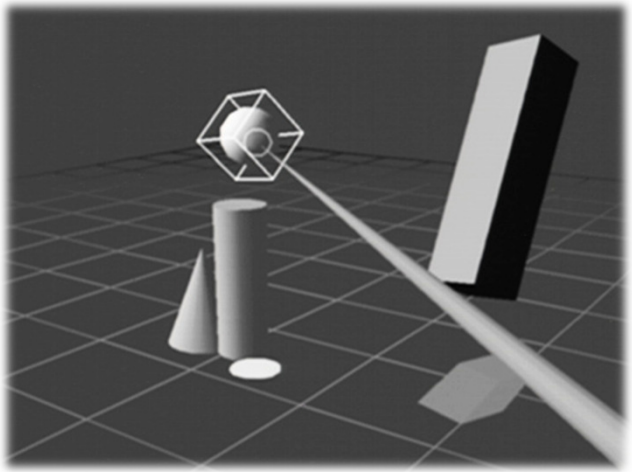
$$0 < \alpha < \infty \text{ is fixed}$$

$$\mathbf{h}_\mathbf{l} = \text{3D position of left hand}$$

$$\mathbf{h}_\mathbf{r} = \text{3D position of right hand}$$

Flashlight

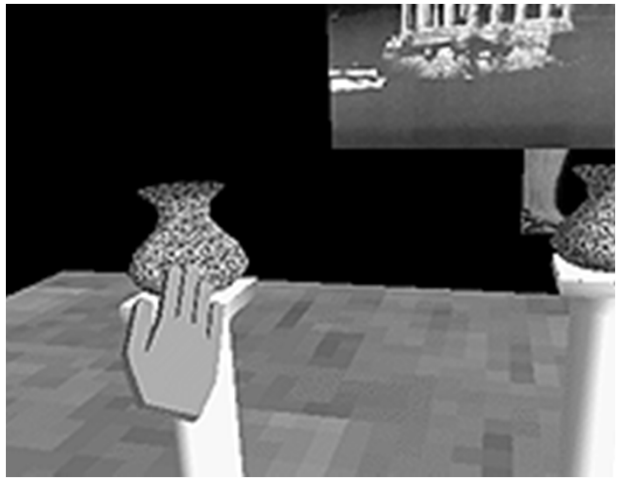
- Soft selection technique
  - Does not need precision
  - Conic selection volume
    - Tip of cone in wand
    - Cone direction determined by wand direction
    - Fixed cone size
  - If multiple objects in cone
    - Object closer to center line of cone is selected
    - If multiple objects are equally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



Selection by Dwell Time

- User points at object with any technique
  - Virtual pointer
  - Eye gaze
- Action is triggered after dwell time threshold is exceeded
- Works without physical buttons

Virtual Hand



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

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

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

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

$$\alpha = \text{fixed scaling factor}$$

Go-Go

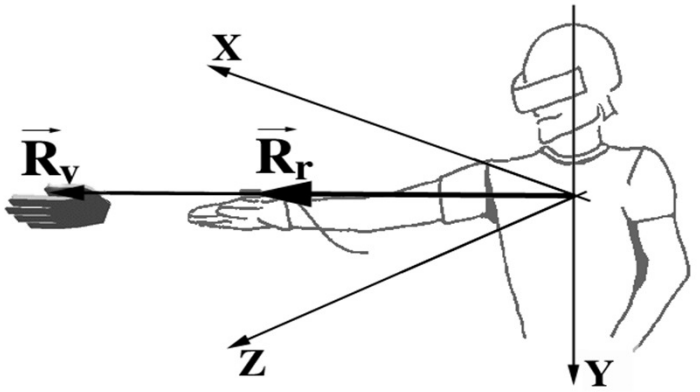
- By Poupyrev, 1996
- Arm-extension technique
- Touch objects to select, like simple virtual hand
- Non-linear mapping between physical and virtual hand position
- Requires torso position
- Local and distant regions

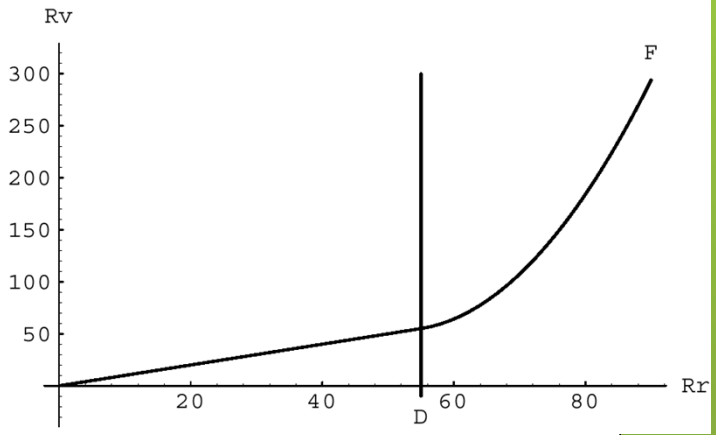
$$r_v = F(r_r) = \begin{cases} r_r & if\ r_r \le D \\ r_r + \alpha(r_r - D)^2 & otherwise \end{cases}$$

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

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

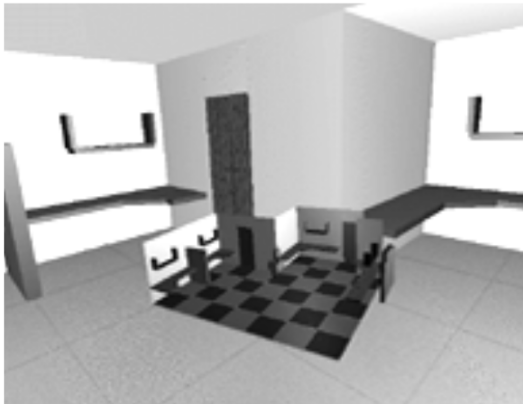
D, α are constants

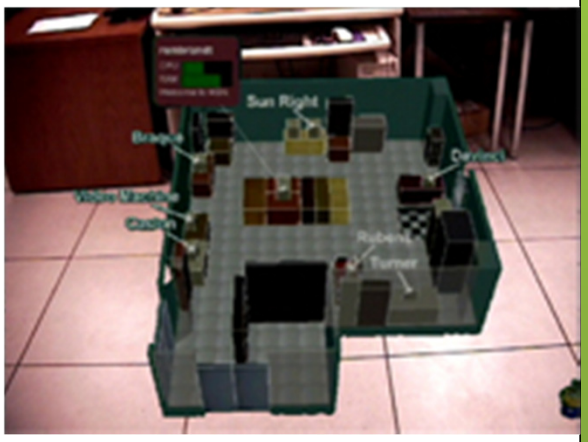




World-in-Miniature (WIM)

- 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

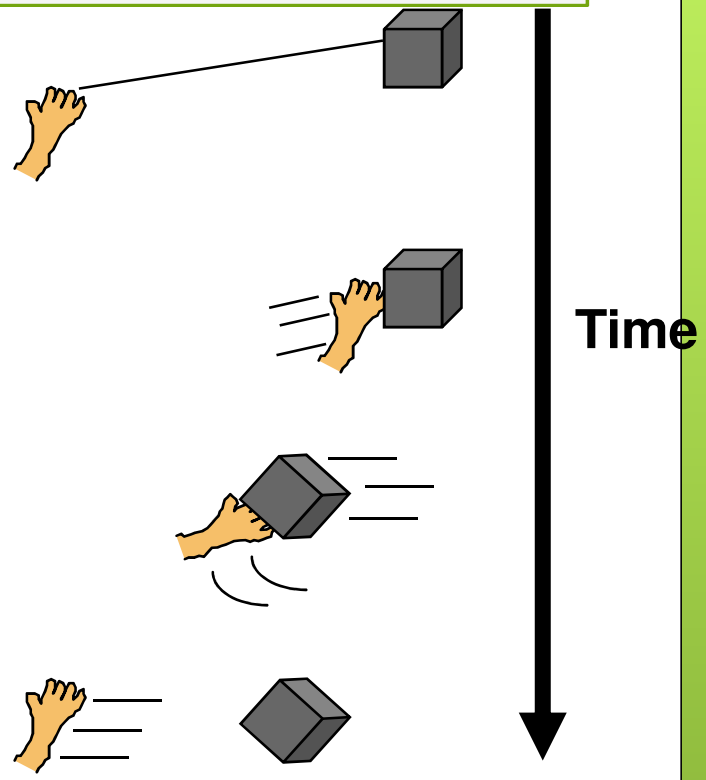




HOMER

Hand-Centered
Object
Manipulation
Extending
Ray-Casting

- By Bowman/Hodges, 1997
- Select: ray-casting
- Manipulate: hand-centered



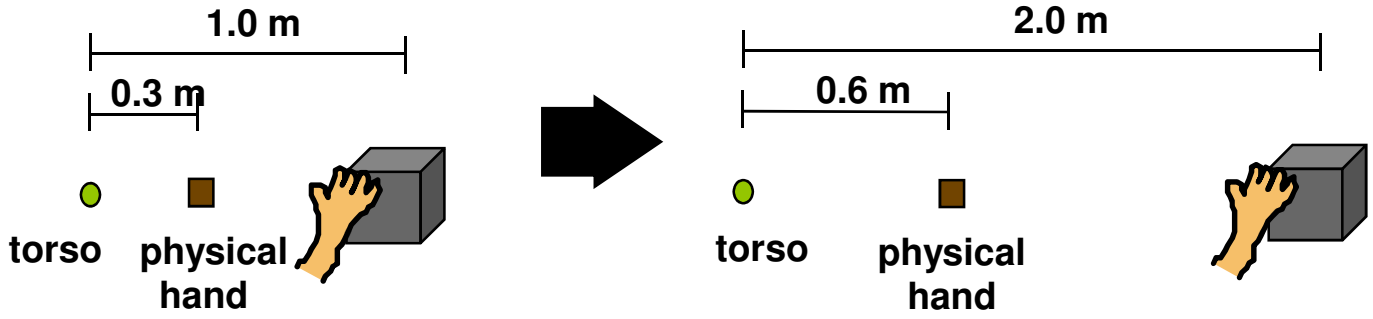
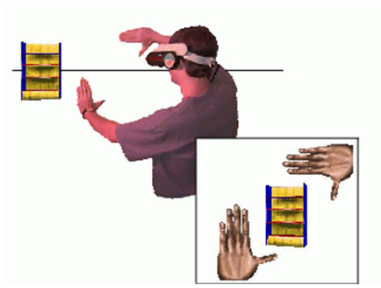


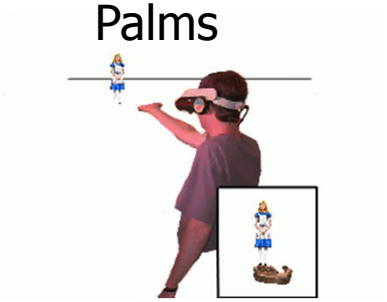
Image Plane Techniques

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

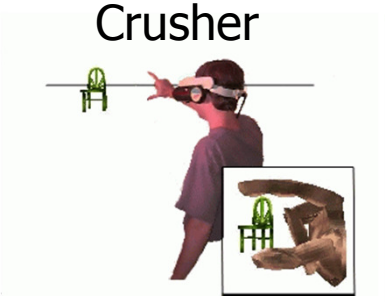
Framing



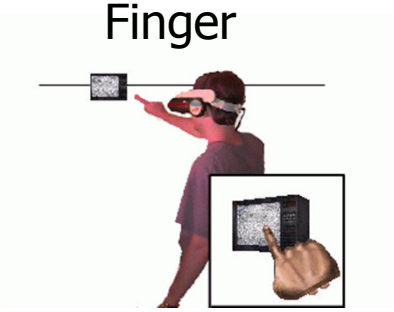
Lifting Palms



Head-Crusher

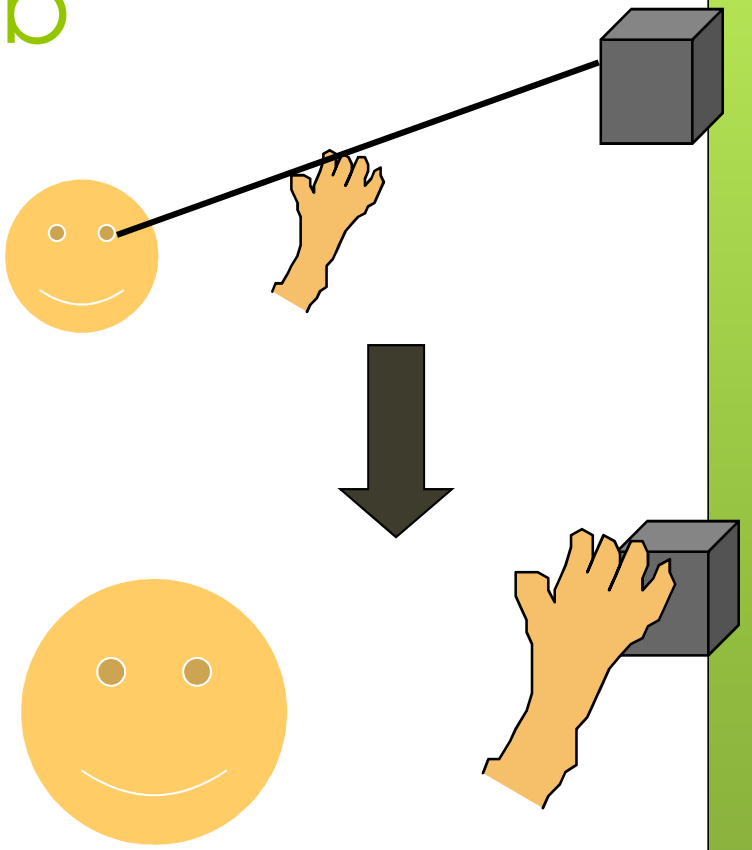


Sticky Finger



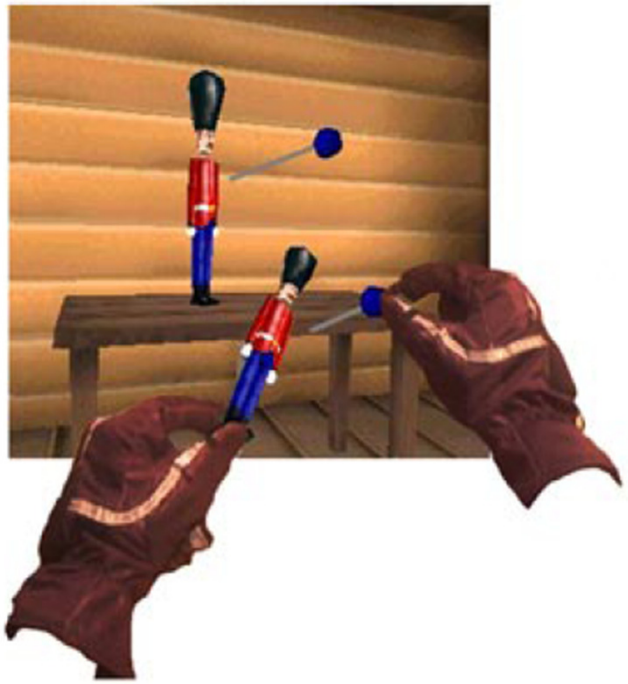
Scaled-World Grab

- By Mine et al., 1997
- Often used with occlusion
- At selection, scale world down so that virtual hand touches selected object
- User initially does not notice a change in the image, until head or hand is moved



Voodoo Dolls

- 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



Forced Perspective

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