CSE 165: 3D User Interaction

Lecture #5: Selection

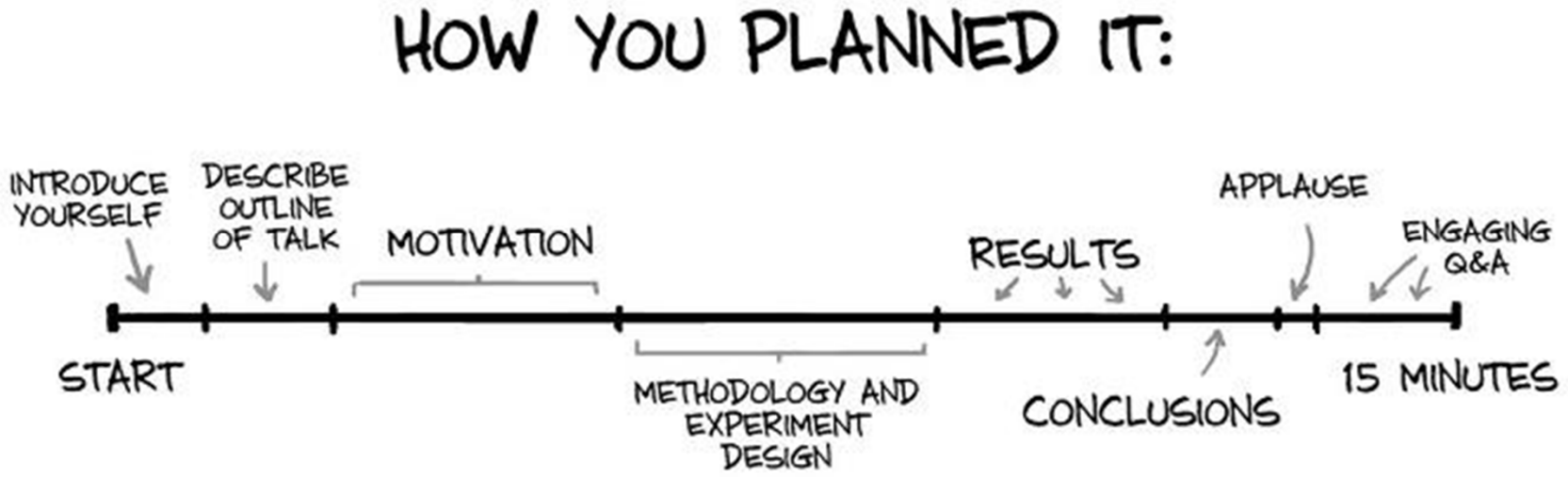
Announcements

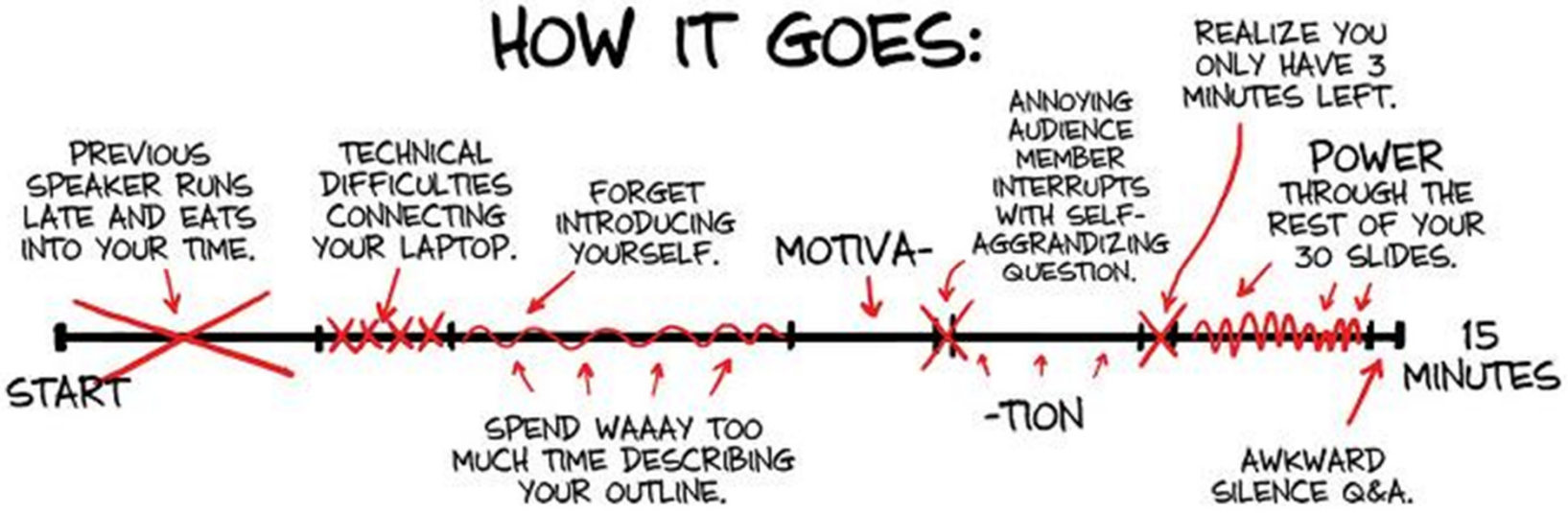
- Homework Assignment #2
  - To be discussed tomorrow at 1pm in WLH 2205
  - Due next Friday at 2pm
  - To be presented in CSE lab 220
- Paper presentations schedule is complete
  - First presentation this Thursday

Date	Name 1	Paper Title 1	Name 2	Paper Title 2	Name 3	Paper Title 3
Tue 1/19						
Thu 1/21	Anish Kannan	Perceiving mass in mixed reality through pseudo-haptic rendering of Newton's third law				
Tue 1/26	Naiwen Chang	The Mind-Mirror: See Your Brain in Action in Your Head Using EEG and Augmented Reality (IEEE VR 2014)	Phillip Hodgson	The Virtual Mitten: A novel interaction paradigm for visuo-haptic manipulation of objects using grip force	Sainan Liu	Extended Depth-of-Field Projector by Fast Focal Sweep Projection (2015 ACM SIGGRAPH)
Thu 1/28						
Tue 2/2	Jan Groot	Tapping-In-Place: Increasing the naturalness of immersive walking-in-place locomotion through novel gestural input (2013 IEEE Symposium on 3DUI)	Jeffrey Johnson	Head-Mounted Display with Mid-Air Tactile Feedback (2015 VRST)	Ahmed Elhosseiny	**Facial Performance Sensing Head-Mounted Display (2015 ACM SIGGRAPH)**
Thu 2/4	Sammy-phat Chi Hoang	IDS: The intent driven selection method for natural user interfaces (2015 IEEE Symposium on 3DUI)	Justin Vu	Comparing the performance of natural, semi-natural, and non-natural locomotion techniques in virtual reality (2015 IEEE Symposium on 3DUI)	Ben Martin	Shop-i: Gaze based Interaction in the Physical World for In-Store Social Shopping Experience
Tue 2/9	Hoang Tran	Punching Ducks for Post-Stroke Neurorehabilitation: System Design and Initial Exploratory Feasibility Study (2013 IEE Symposium on 3DUI)	Jonathan Mao	Visual feedback for virtual grasping (2014 IEEE Symposium on 3DUI)	Sylvia Li	An Affordable Solution for Binocular Eye Tracking and Calibration in Head-mounted Displays (ACM SIGGRAPH 2015)
Thu 2/11	Roger Lewis	Rendering volumetric haptic shapes in mid-air using ultrasound (2014 ACM SIGGRAPH)	Sean Mahbod	Is the user trained? Assessing performance and cognitive resource demands in the Virtusphere (2013 IEEE Symposium on 3DUI)		
Tue 2/16	Yasin Ahmed	Evaluating stereo vision and user tracking in mixed reality tasks (2015 IEE Symposium on 3DUI)	John Leyson	Finger-based manipulation in immersive spaces and the real world (2015 IEEE Symposium on 3DUI)	Aram Sarafian	High-Quality Hair Modeling from A Single Portrait Photo (ACM SIGGRAPH Asia 2015)
Thu 2/18	Jonathan Mui	TurkDeck: Physical Virtual Reality Based on People (UIST '15: Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology)	Tianxiang Liu	Mobile User Interfaces for Efficient Verification of Holograms		
Tue 2/23	Yumei Jin	LazyNav: 3D ground navigation with non-critical body parts	Payam Shahidi	An evaluation of two simple methods for representing heaviness in immersive virtual environments		
Thu 2/25	Kai Wang	Evaluation of 3D virtual cursor offset techniques for navigation tasks in a multi-display virtual environment	Yang Zhou	LazyNav: 3D ground navigation with non-critical body parts (2015 IEEE Symposium on 3DUI)	Jordan Miller	Turbulent motions cannot shake VR
Tue 3/1	Dennis Bykkov	JackIn head: immersive visual telepresence system with omnidirectional wearable camera for remote collaboration (VRST '15 Proceedings of the 21st ACM Symposium on Virtual Reality Software and Technology)	Kirill Rudenko	Analysis of Direct Selection in Head-Mounted Display Environments(2014 IEEE Symposium on 3DUI)		
Thu 3/3	Samuel Whang	Procedural Generation of Dungeons	Stephanie King	User-Centered BCI Videogame Design	Douglas King	**A comparison of different methods for reducing the unintended positional drift accompanying walking-in-place locomotion**
Tue 3/8	Jessica Tran	LazyNav: 3D Ground Navigation with Non-Critical Body Parts	Fred Greene	3D Touch: A Wearable 3D input Device for 3D Applications (2015 IEEE VR)		
Thu 3/10						

Paper Presentation

- Paper Stats
  - Title
  - Authors
  - Institute
  - Conference/Journal
  - Year
- Outline
- Related Work
- Methodology
- Results
- Conclusions
- Q&A


HOW YOU PLANNED IT:
INTRODUCE YOURSELF
DESCRIBE OUTLINE OF TALK
MOTIVATION
METHODOLOGY AND EXPERIMENT DESIGN
RESULTS
CONCLUSIONS
APPLAUSE
ENGAGING Q&A
START
15 MINUTES

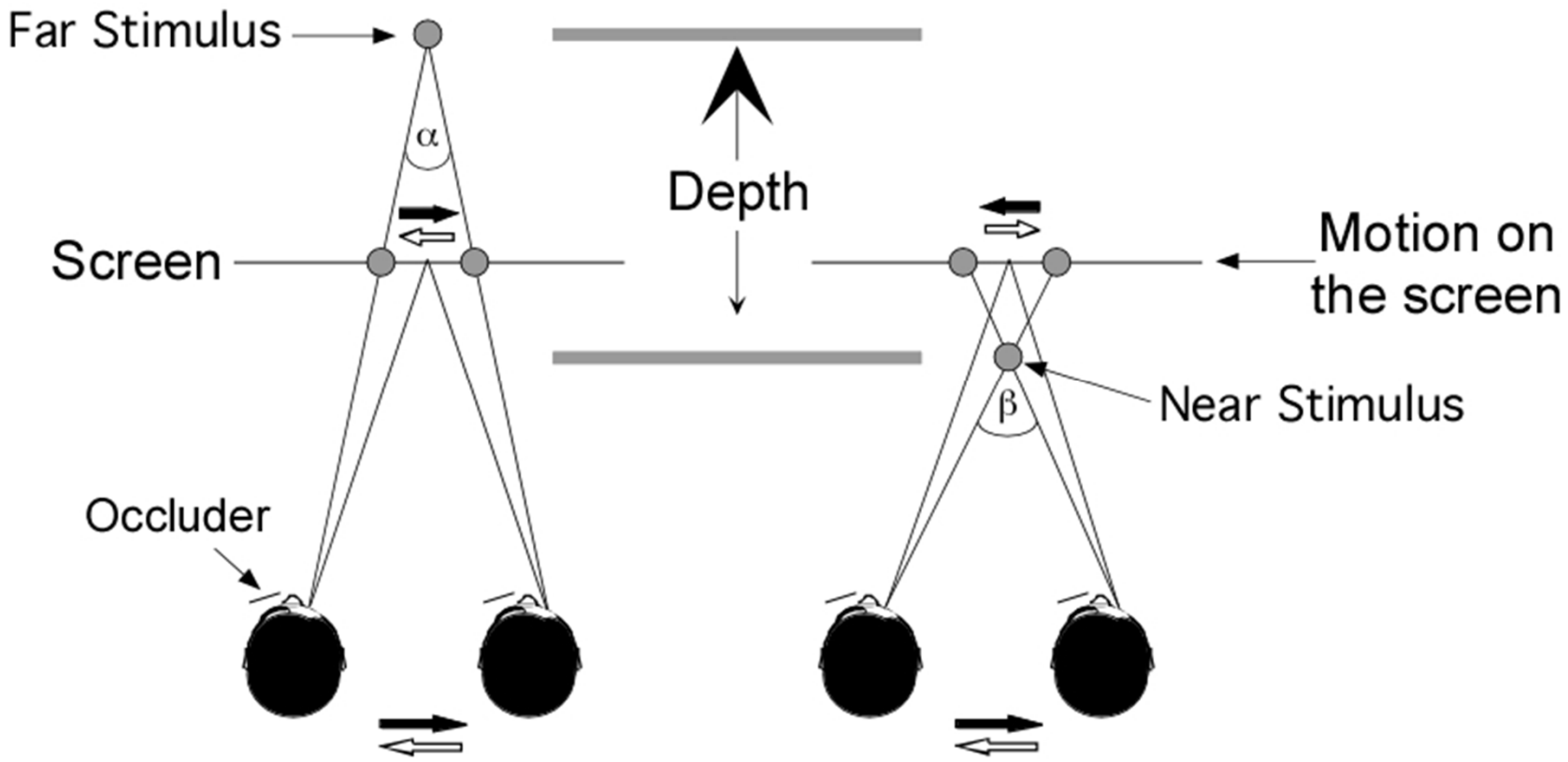

HOW IT GOES:
PREVIOUS SPEAKER RUNS LATE AND EATS INTO YOUR TIME.
TECHNICAL DIFFICULTIES CONNECTING YOUR LAPTOP.
FORGET INTRODUCING YOURSELF.
MOTIVA-
ANNOYING AUDIENCE MEMBER INTERRUPTS WITH SELF-AGGRANDIZING QUESTION.
REALIZE YOU ONLY HAVE 3 MINUTES LEFT.
POWER THROUGH THE REST OF YOUR 30 SLIDES.
START
SPEND WAAAY TOO MUCH TIME DESCRIBING YOUR OUTLINE.
-TION
AWKWARD SILENCE Q&A.
15 MINUTES

3D Viewing Aids

Overview

- Motion Parallax: move camera
  - For example, oscillate camera between two horizontally offset points.
- Draw 3D grid with fine lines.
- Draw a ground plane and shadows, light source above the scene.
- Monocular depth cues.

Motion Parallax



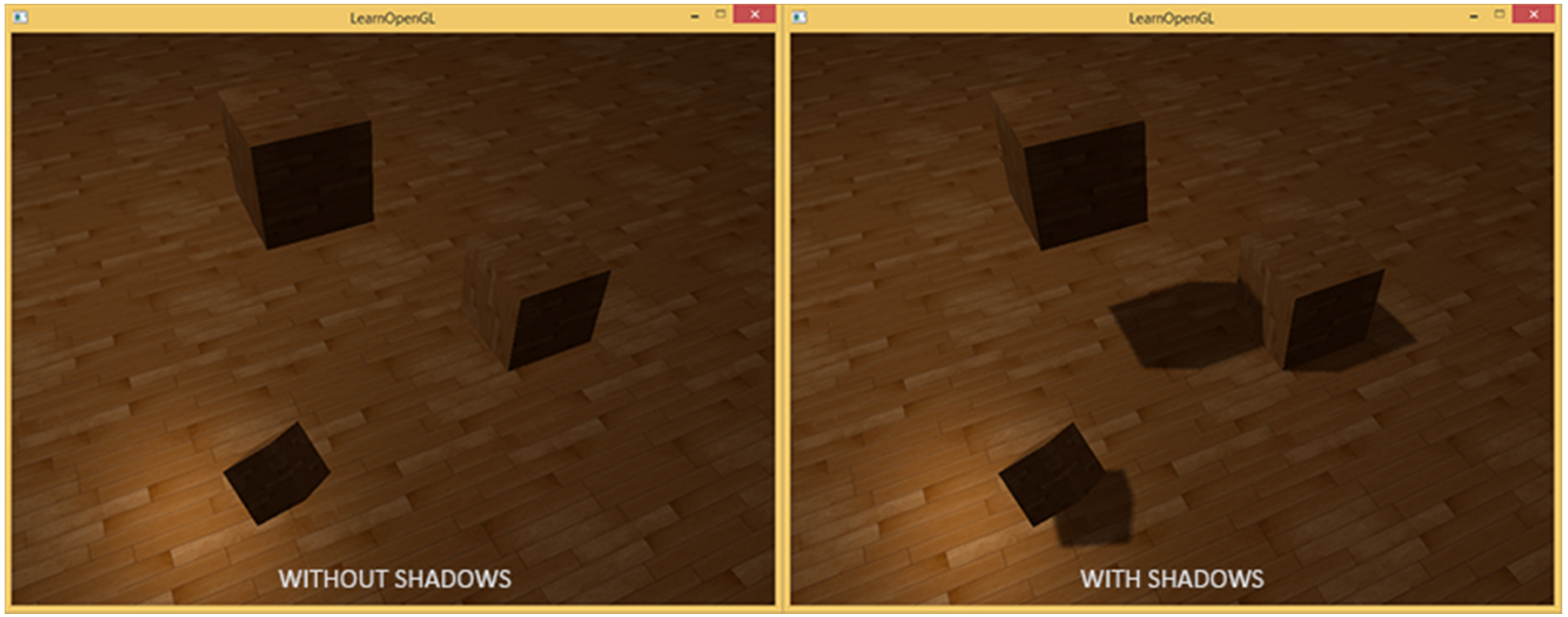
http://www.yorku.ca/hono/parallax_demo/definition_magnitude.html

3D Line Grid

- Occlusion of data by grid lines reveals depth
- Regular grid with known cell size allows size estimation
- Thin lines: if too thick there might be too much occlusion by the lines

http://www.mymodernmet.com/profiles/blogs/numen-for-use-string-prototype

Shadows

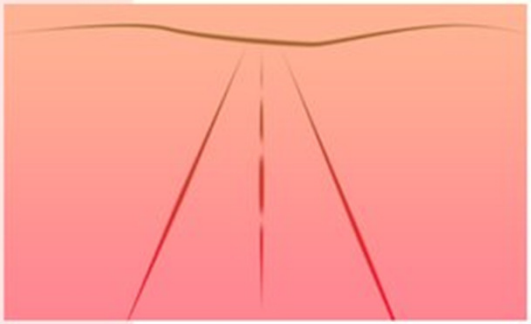


http://learnopengl.com/#!Advanced-Lighting/Shadows/Shadow-Mapping

linear perspective

involving parallel lines

Linear perspective is a depth cue that utilizes the fact that lines converge in the distance. That is, **parallel lines** will get "closer together" or **narrower** as they appear **farther** from the viewer. A common illustration of this cue is that of a road or path.



interposition

involving overlapping objects

Interposition involves objects that appear to be coming **inbetween** the viewer and another object. If an object is interfering with, or **overlapping** the sight of the second object, it is percieved as **closer** than the second to the viewer.

height in plane

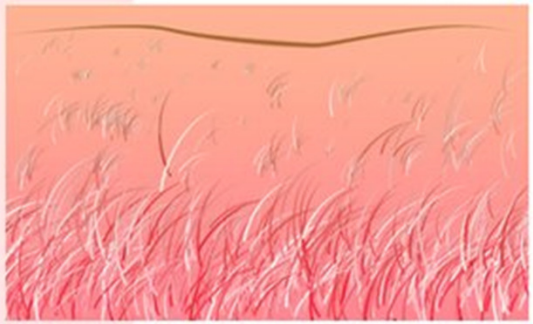
involving separate high and low in the visual field

In a picture, objects that are **further** from the viewer appear **higher** in the visual field. Likewise, **lower** objects suggest that they are **closer** to the viewer. This concept is called **height in plane**.

texture gradients

involving coarse and fine textures

Details are too small to see when they are far away. This idea is known as **texture gradient**. Therefore, areas closer to the viewer will look **coarser**, and areas farther away will have a **finer** texture.



relative size

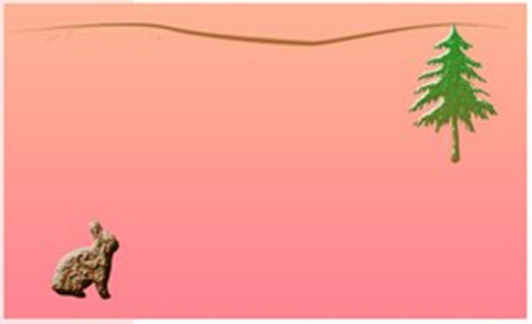
involving separate objects expected to be the same size

Closer objects appear **larger** than objects further away. Therefore, if two objects are expected to be the same size, then the larger object will appear closer. This is called **relative size**.

light and shadow

involving patterns of light and dark

Patterns of **light** and **dark** can create the illusion of a **three dimensional** figure. This concept can be useful in judging distance.



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

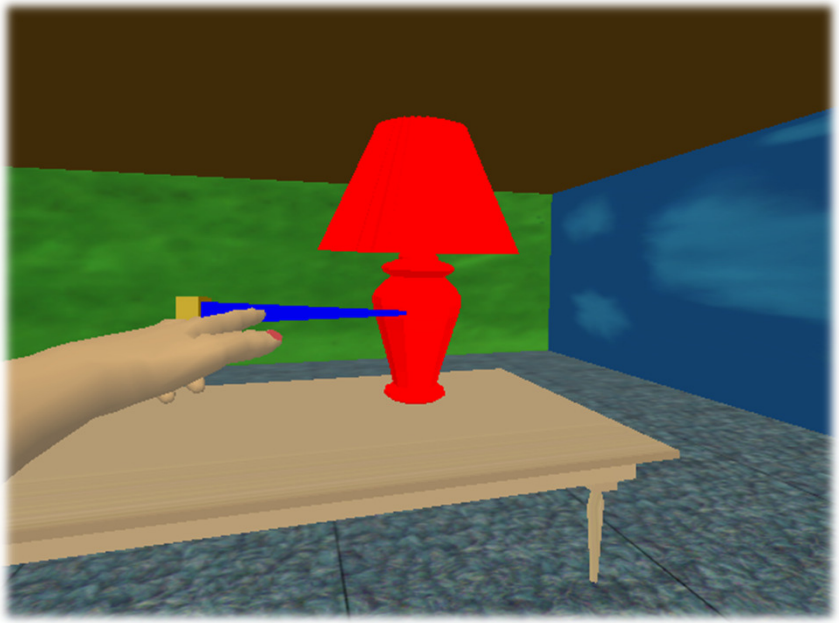
- Manipulation techniques
  - Egocentric metaphor
    - Virtual pointer metaphor
      - Ray-casting
      - Two-handed pointing
      - Flashlight
      - Image plane
    - Direct manipulation
      - "Classical" virtual hand
      - Go-Go
  - Exocentric metaphor
    - World-in-miniature
    - Scaled-world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



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

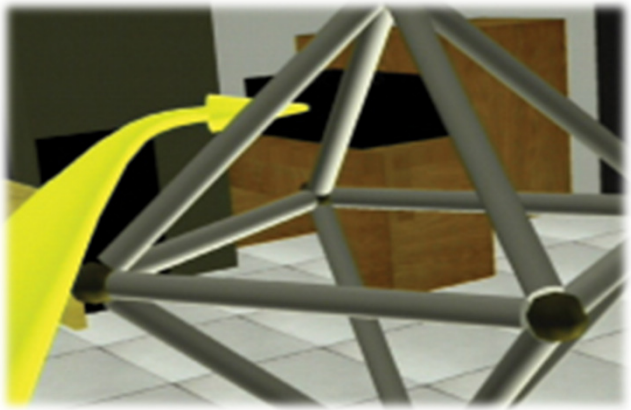
$$\mathbf{h} = \text{3D position of virtual hand}$$

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

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

Two-Handed Pointing

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



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

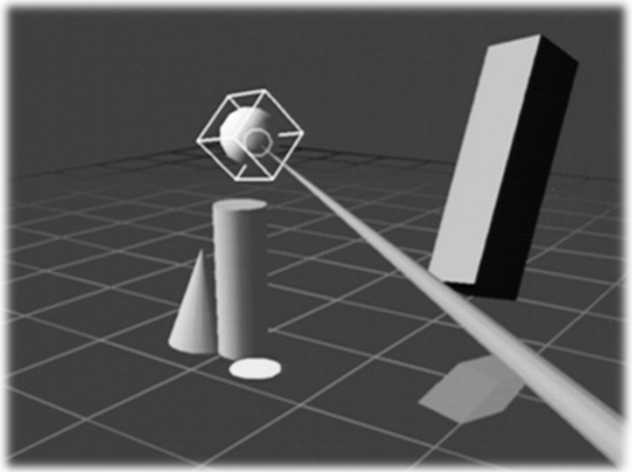
$$0 < \alpha < \infty \text{ is fixed}$$

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

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

Flashlight

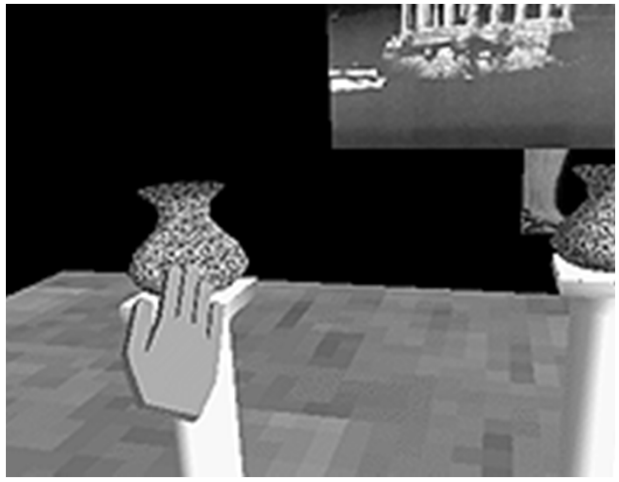
- Soft selection technique
  - Does not need precision
  - Conic selection volume
    - Tip of cone in wand
    - Cone direction determined by wand direction
    - Fixed cone size
  - If multiple objects in cone
    - Object closer to center line of cone is selected
    - If multiple objects are equally 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
- Frequently used in controller-less VR: Google Cardboard, Samsung Gear VR

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

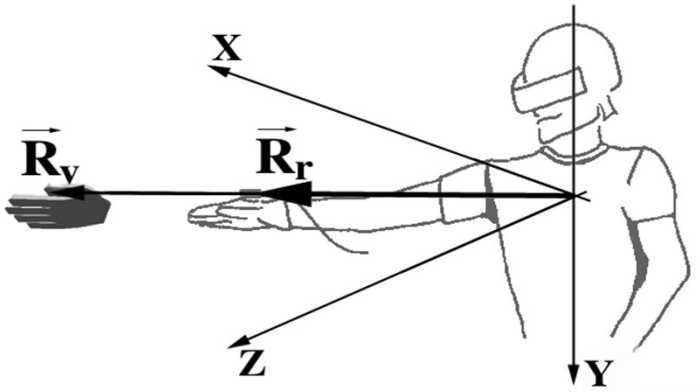
- By Poupyrev, 1996
- Arm-extension technique
- Touch objects to select, like simple virtual hand
- Non-linear mapping between physical and virtual hand position
- Requires torso position
- Local and distant regions

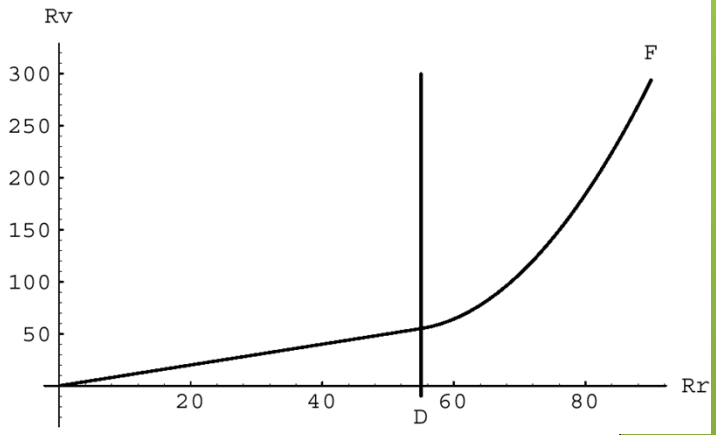
$$r_v = F(r_r) = \begin{cases} r_r & if\ r_r \le D \\ r_r + \alpha(r_r - D)^2 & otherwise \end{cases}$$

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

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

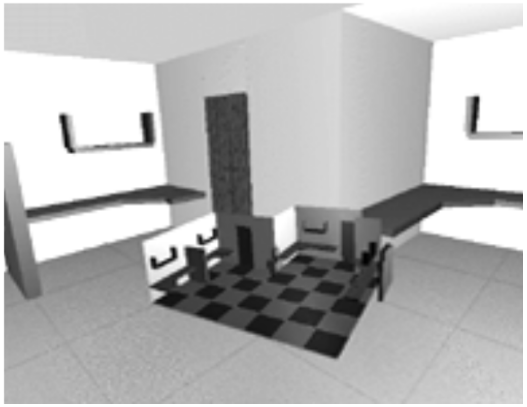
D, α are constants





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



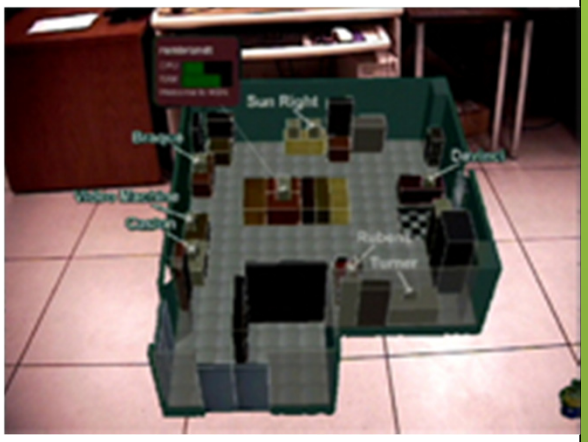
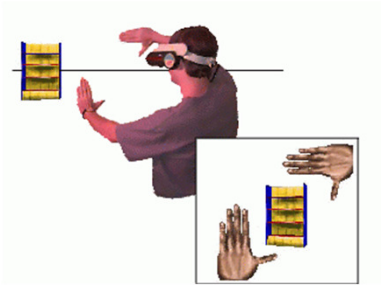


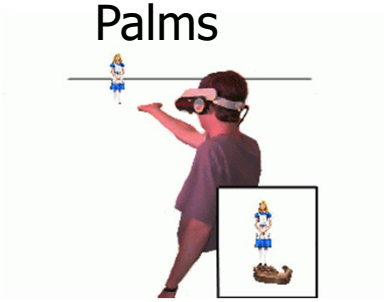
Image Plane Techniques

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

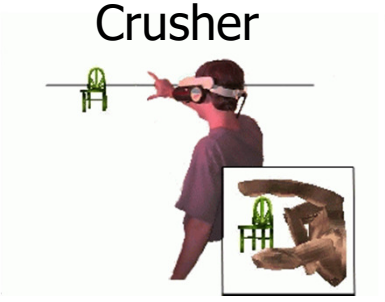
Framing



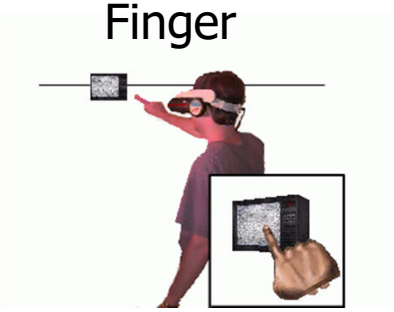
Lifting Palms



Head-Crusher

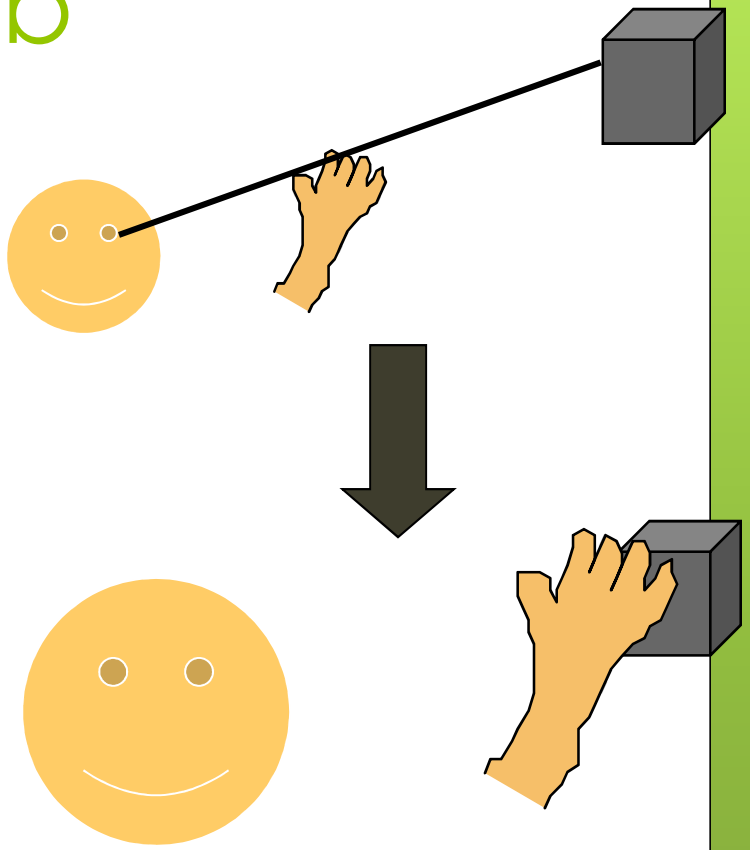


Sticky Finger



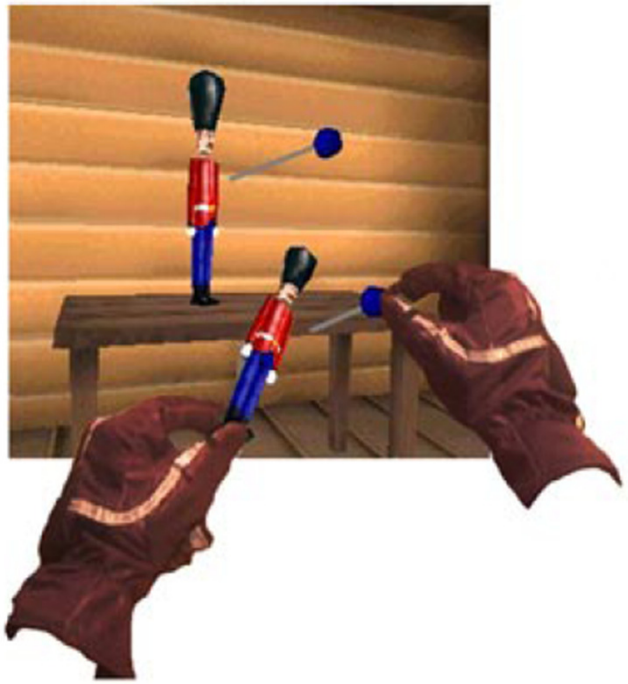
Scaled-World Grab

- 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



Related: Forced Perspective

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