Pointing: Image-Plane

- Like hand-eye ray casting, but
  - All interaction occurs in 2D on the projection plane
  - After selection, to support manipulation, object can be scaled/moved to
    - pick point, maintaining approximate projected size, or
    - canonical size/location,…

- “Sticky finger”
  - Object under finger is selected

- “Head crusher”
  - Object framed by tracked fingers is selected

Note: Need to designate a specific dominant eye in stereo, as with all single eye-defined pointing
**Pointing: Image-Plane**

- Like hand-eye ray casting, but
  - All interaction occurs in 2D on the projection plane
  - After selection, to support manipulation, object can be scaled/moved to
    - pick point, maintaining approximate projected size, or
    - canonical size/location,…
- “Lifting palm”
  - Object on palm is selected
- “Framing hands”
  - Object framed by hands is selected

**Note:** Need to designate a specific dominant eye in stereo, as with all single eye-defined pointing

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**Virtual Hand**

- User controls 3D “cursor” (e.g., virtual hand model) intersected with objects
- Position/orientation of body part/device are mapped to virtual hand
  - Note: Many versions of the “virtual hand” are really “virtual 3DOF/6DOF mice” (i.e., map to a single point, not a set of dexterous fingers)
- User can confirm desired object by issuing trigger event
  - E.g., voice, button, gesture,…
- Object is attached to hand for manipulation until released with additional trigger event
Virtual Hand: Basic Version

- User's hand/device position/orientation are mapped directly to virtual hand's position/orientation with linear scale

\[ p_v = \alpha p, \quad R_v = R, \quad \alpha = 1 \] in AR (typically),

where \( \alpha \) scales real to virtual world,

- \( p_v \) and \( R_v \) are virtual hand pos/ori,
- \( p \) and \( R \) are real hand/device pos/ori

Virtual Hand: Origins

- M. Krueger, Videoplace, 1970s
  
  2D projections of real 3D hands are used to interact with 2D objects. Real-time processing of thresholded video of user makes it possible to determine interesting properties useful for interaction

- L. Roberts, The Lincoln Wand, 1966
  
  Ultrasonic tracking of 3D wand tip position
Virtual Hand: Limitations

- Isomorphic
  - Intuitive, but,…
    - Can only select objects within arm’s reach
    - Must travel to select objects farther away

Virtual Hand: Go-Go

- “Classic” nonisomorphic technique
- User’s hand stretches when extended past a limit
  - Mapping function determines C-D (control–display) ratio
  - Cube represents real hand
- Typically less effective than pointing for selection, but allows uniform approach to selection and manipulation

The Go-Go Interaction Technique: … to reach farther in virtual environments

Feiner, COMS W4172, Spring 2014
Virtual Hand: Go-Go

- Determining length of virtual arm, $r_v$

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

where $r_r$ is length of $r_r$ (vector from user to real hand), real hand is at spherical coordinates $(r, \phi, \theta)$, $r_v$ is length of virtual arm, $F$ is nonlinear mapping function, $D$ and $\alpha$ are constants.

Virtual Hand: Go-Go

- Variations (Bowman & Hodges, 1997)
  - Stretch go-go
    - Distance partitioned in 3 zones. Hand
      - stretches at constant rate in far zone
      - doesn’t change in middle zone
      - retracts at constant rate in near zone
  - Indirect go-go
    - Buttons make hand stretch/retract

Gauge at right indicates zones: stretch (green), stable (violet), and retract (blue)
Virtual Hand: Silk Cursor

- An approach to precise containment selection
  - Emphasizing feedback
- “Hand” is 3D box cursor with low opacity (“silk”) faces
- Moving cursor changes number of faces through which target is seen
  - This visual cue makes it easier to position box to contain target fully

Selection Aids

World in Miniature (WIM)

- User manipulates small-scale copy of virtual world
  - Typically viewed exocentrically
  - Can also be used for travel
  - Updates are synchronized between world and WIM
  - Larger worlds can use selective display of WIM subset, with scaling and scrolling

- Need to avoid occlusion by walls
  - Hack: Model only interior wall surfaces for room and use backface culling to suppress when seen from outside
Combining Selection Techniques

- When one technique is insufficient, combine techniques
  - Choice
    - User chooses among alternative techniques
      - E.g., through menu, different selection gestures,…
  - Integration
    - System switches among techniques automatically based on task
      - E.g., switch between selection and manipulation, based on selection and release triggers

Integrated: HOMER (Hand-centered Object Manipulation Extending Ray-casting)

- Selection with pointing (ray-casting) switches to
- Manipulation with virtual hand automatically moved and attached to object
  \[ r_v = \alpha_o r_r, \quad \alpha_h = \frac{D_o}{D_n}, \]

  where \( \alpha_h \) is a scaling factor defined at time of selection, \( D_o \) is distance to object, \( D_n = r_r \) at time of selection
- Hand returns when object is dropped
- Distance at which object can be placed depends on \( \alpha_h \)
  - Asymmetric: Easier for moving far object near, than near object far!
**Integrated: HOMER** *(Hand-centered Object Manipulation Extending Ray-casting)*

- Variations
  - *Indirect HOMER*
    - Buttons are used to translate virtual hand (like *indirect go-go*)

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**Integrated: Scaled-World Grab**

- *Selection* with image-plane technique causes temporary *scaling* of entire world around viewpoint by $\alpha_s$, so object can be manipulated relative to world with virtual hand
  \[
  \alpha_s = \frac{D_v}{D_o},
  \]
  where $D_v$ is distance from virtual viewpoint to virtual hand, $D_o$ is distance from virtual viewpoint to object at time of selection
- User *might* notice no or little change, depending on locations of other objects, use of stereo
- World rescaled when released
- Near–far asymmetry of manipulation because of scaling

Note: Object and world maintain relative spatial relationships (unlike image-plane pointing, in which only object is temporarily moved)

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M. Mine, F. Brooks, & C. Sequin, 1997
**Integrated: Voodoo Dolls**

- Requires two 6DOF-tracked hands
- Select object with image-plane technique
  - System creates *doll* (copy) of object in hand
  - Releasing a doll destroys it
- Doll in dominant (D) hand
  - Controls object's position/orientation when both hands hold dolls

J. Pierce, B. Stearns, and R. Pausch, 1999

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**Integrated: Voodoo Dolls**

- Doll in nondominant (ND) hand
  - Scaled to constant length (e.g., .5m) along longest dimension
    - D doll is scaled proportionally relative to ND doll
  - Acts as reference frame for doll in D hand
    - Transformation of D doll relative to ND doll is applied to D doll’s object
  - Does *not* transform its object
  - Spawns new dolls that can be selected (and manipulated) by D hand
    - Spawned dolls represent all descendants of ND doll in scene graph hierarchy, and other objects within set radius of ND doll
    - Context can also be determined using two hands as “framing hands” or by specifying the radius explicitly
  - Dolls can be transferred between hands

J. Pierce, B. Stearns, and R. Pausch, 1999
Integrated: Voodoo Dolls

- Seamless interaction at multiple scales
  - But, note problem if ND doll is scaled up, making D doll too large
- Can manipulate occluded objects
  - D hand can grab a spawned occluded doll in ND doll context
- Can move ND doll into more comfortable position for D hand interaction
- Can “freeze” (relative to user’s hands) doll of moving object by making it an ND doll
  - But, first need to grab moving object

Pierce & Pausch, 1999

Integrated: Voodoo Dolls

- Problem
  - Hard to move D doll to position away from other objects, since ND doll is created by picking an object (and D doll moves relative to ND doll)
- Extension (Pierce & Pausch 2002)
  - Selecting point on “ground” creates temporary object (represented as multi-colored cube) that can be an ND doll

Pierce & Pausch 2002