Interaction: Selection and Manipulation

CS 6334 Virtual Reality
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Some slides of this lecture are courtesy Jin Ryong Kim
Manipulation

• Complex sensorimotor relationships

• Evolution and experience

• Robot manipulation, a grand challenge

• We can make manipulation simple in VR
  • Remapping
Selection

• The task of acquiring or identifying a particular object from the entire set of objects available

• In the real world
  • Picking up one object
  • Pointing to one object
  • Indicating one object by speech
Hand-based Grasping

• Track the position and orientation of the user’s dominate hand

• Represent the user’s virtual hand as a single-point effector

Simple Virtual Hand

• Uses a strict, one-to-one mapping of a 6-DOF hand tracker to a user’s virtual hand

• Uses collisions to determine selection

• Most natural 3D manipulation technique

• Cannot select objects outside of the user’s physical reach

https://s3dit.cs.uni-potsdam.de/detail/1
Simple Virtual Hand

The Go-Go Interaction Technique

• Uses a threshold to separate near and remote interactions
• Within threshold, mapping is one to one
• Beyond threshold, a nonlinear mapping extends the virtual hand beyond the user’s physical hand

\[ R_v = F(R_r) = \begin{cases} R_r & \text{if } R_r < D \\ R_r + k(R_r - D)^2 & \text{otherwise} \end{cases} \]
The Go-Go Interaction Technique

• Can select objects outside of the user’s physical reach due to virtual hand extension

• Small objects are difficult to select beyond threshold due to nonlinear mapping

The Go-Go Interaction Technique: Non-linear Mapping for Direct Manipulation in VR.

Poupyrev et al. ACM Symposium on User Interface Software and Technology (UIST) 1996.
The Go-Go Interaction Technique

https://youtu.be/WhA8n4IxeoY
Finger-based Grasping

• Track fingers, i.e., hand pose, in the real world

• Allow users to manipulate objects with more precision

• Challenges
  • Haptic feedback
  • Mismatch in hand pose between the virtual world and the real world, e.g., fingers are not allowed to penetrate the virtual objects

GANerated Hands for Real-Time 3D Hand Tracking from Monocular RGB. Mueller et al.
Rigid-body Fingers

Figure 1: Desktop environment

22-sensor CyberGlove

Figure 3: Grasps of a static rocker arm, showing tracked hand (mesh), spring hand (solid), and force feedback vectors

Realistic Virtual Grasping. Borst and Indugula. VR’05.
Soft-body Fingers

Increasing contact area with increasing contact force

Developed hand model in lateral view while touching a virtual sphere. The deformation of finger-pads upon collision is clearly visible (right).

A Soft Hand Model for Physically-based Manipulation of Virtual Objects. Jacob and Froehlich, VR’11.
The God-Finger Method

- Simulate a contact area from a single contact point determined by collision detection
- Usable in a rigid body physics engine

The god-finger method for improving 3D interaction with virtual objects through simulation of contact area. Talvas et al. 3DUI'13
Pointing

• Allow users to select and manipulate objects beyond their physical reach by pointing at the object

• Pro: Requires less physical hand movement from the user, better selection performance

• Con: expressive 6 DOF manipulation is impossible with pointing
Pointing

• Vector-based Pointing
  • Uses a vector to determine what object is manipulated
  • Ray-casting
  • Fishing reel
  • Image-plane pointing

• Volume-based Pointing
  • Uses a volume to determine what is manipulated
  • Flashlight
  • Aperture selection
  • Sphere-casting
Ray-Casting

- Uses the forward vector of a 6-DOF input device
- Uses an infinite ray to visually represent vector
- Uses a button to select first intersected object
- Can select objects outside of the user’s physical reach due to the infinite vector
- Small or faraway objects are difficult to select
- Cannot select occluded objects
Ray-Casting
Fishing Reel

- Extends the basic concept of ray-casting
- Uses one button to push a selected object away
- Uses another button to bring a selected object closer
Image-Plane Pointing

• Projects the 3D scene on a virtual image plane located in front of the user

• The user selects and manipulates 3D objects by touching and manipulating their 2D projections

http://www.cs.cmu.edu/~stage3/publications/97/conferences/3DSymposium/HeadCrusher/
Flashlight

- Uses a cone to select objects within the volume
- Selects the object closest to the centerline
- If there’s a tie, it selects the object closest to the cone’s origin (i.e., the device)
- Requires less precision than ray-casting
- Can be difficult to use when multiple objects are present
Flashlight
Aperture Selection

- Extends the basic concept of flashlight
- Allows the user to control the spread of the cone selection volume
- Allows the user to disambiguate among multiple objects by twisting the selection volume
Aperture Selection
Sphere-Casting

• A modified version of ray-casting
• Casts a sphere onto the nearest intersected surface

Rapid and accurate 3D selection by progressive refinement. Kopper et al. 3DUI’11.
Indirect Approaches

• Allow users to manipulate virtual objects without directly interacting with them

• Example, world in miniature
Bimanual Approaches

• Allow users to manipulate objects using both hands
Hybrid Approaches

• Combine multiple techniques to provide interactions

• Hand-centered Object Manipulation Extending Ray-casting (HOMER)
  • Uses ray-casting for selection
  • Uses Go-Go-like virtual hand for manipulation
Summary

• Grasping metaphors
• Pointing metaphors
• Indirect metaphors
• Bimanual metaphors
• Hybrid metaphors
Further Reading

• Section 10.3, Virtual Reality, Steven LaValle

• Chapter 7, 3D User Interfaces: Theory and Practice, LaViola et al.