Interactive Tools and Techniques in Virtual Environment

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WIMP

Metaphor WIMP - Windows, Icons, Menus, Pointers
(would not exist without CG !)

WIMP supposes that a human interacts with a computer.

However,

human wants to interact with a real world.

But …
real and digital worlds are separated.

Q: ***Are we limited by traditional interfaces in a way of using computers ?***


SONY
SONY
FD Trinitron

Interaction in 3D space

Basic terms and definitions

3D interaction

Human-Computer Interaction in which the user's tasks are performed directly in a 3D spatial context

3D user interface (3D UI)

A UI that involves 3D interaction

Technological areas for 3D UIs

virtual environment (VE)

A synthetic, spatial (usually 3D) world seen from a first-person point of view. The view in a VE is under the real-time control of the user.

virtual reality (VR)

Synonymous with VE, but it is associated with unrealistic hype generated by the media.

Technological areas for 3D UIs

augmented reality (AR)

A real-world environment that is enhanced (augmented) with synthetic objects or information.

mixed reality (MR)

A continuum including both VEs and AR. Distinguishes the level of "virtuality" (from "purely virtual" to "purely physical"

ubiquitous computing

The notion that the computing devices and infrastructure may be mobile or scattered throughout the real environment.

3D interaction - application areas

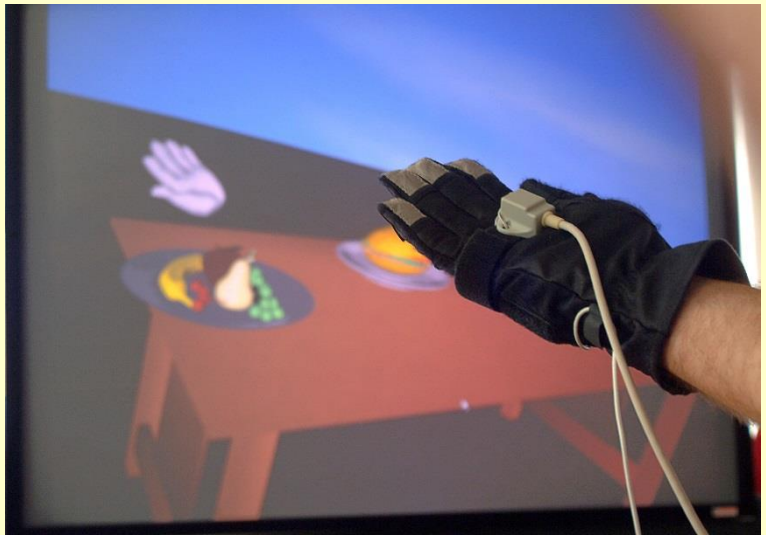
Design and prototyping
"new architecture in real-world context"

Psychiatric treatment
"exposure therapy"

Scientific visualization
"insight and navigation through the data"

Heritage/tourism
"living history"

Collaborative work
"medicine, … "



3D technologies

3D realistic rendering

- shape, global light & shadows, stereo & holograms

3D positioning

- 3DOF, 6DOF tracking

3D image/shape acquisition

- cameras, scanners, etc.

3D/6D force feedback

eyes, head, voice, hands, feet, gestures, ...

3D Interaction Techniques

Interaction techniques for universal tasks

Interaction techniques for complex or composite tasks

3D interaction techniques using 2D devices

3D UI widgets

Higher level approaches for 3D UI design

Hybrid interaction techniques

– combination of existing techniques

Two-handed interaction

– using both hands in a complementary way

Multimodal interaction

– using many different input and output "modalities" (gestures plus voice input, …)

3D interaction aids

– hand held tablet, doll, wheel, transparent interfaces,…

Black Magic Wand

3D UI design strategies

real-world metaphors helping to guide the user

applying **principles of** aesthetics and visual **design**

basing UI design on **formal taxonomies** and guidelines

"magic" to go **beyond the limitation**s of the real world

intentionally violating assumptions about the real world in the virtual world

Why Manipulation?

From the moment we are born we learn to manipulate things around us using our hands and by adulthood we get to the point where we do not need any conscious attention to perform extremely complex manipulation.

The areas of the human brain that allow us to control hands are highly developed, occupying a major portion of the human motor cortex.

Why Manipulation?

Hand manipulation is the major method of interaction in virtual worlds.

While voice, gaze and movement of other body parts are also used, direct hand manipulation remains **the most natural and efficient input** method for humans in 3D user interfaces.

Design of 3D manipulation techniques is difficult !

3D Manipulation Task

Canonical 3D manipulation tasks are

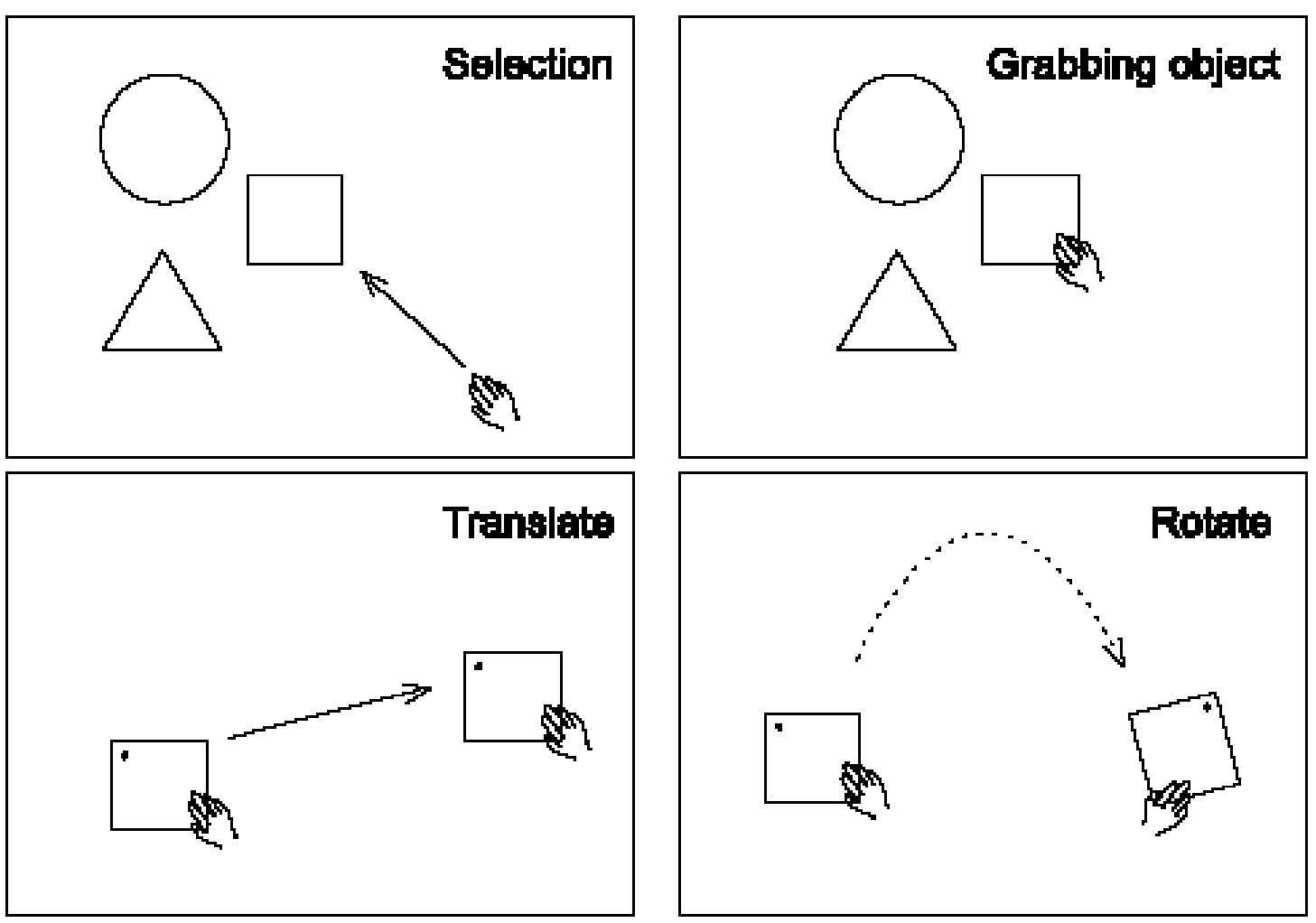
select, position and rotate

Variables that affect manipulation

- distance to object, object size, required translation distance, amount of rotation, objects density, and others

Design of manipulation techniques depends on interaction tasks and variables

Selection and manipulation



Basic 3D tasks

task	parameters
selection	distance and direction to the goal, density of objects close to the goal, number of selected objects, occlusion of goal
positioning	distance and direction to the initial position, distance and direction to the final position, precision of placement
rotation	distance to the goal, initial and final orientation, amount of rotation, precision of rotation

Classification of selection techniques (task decomposition)

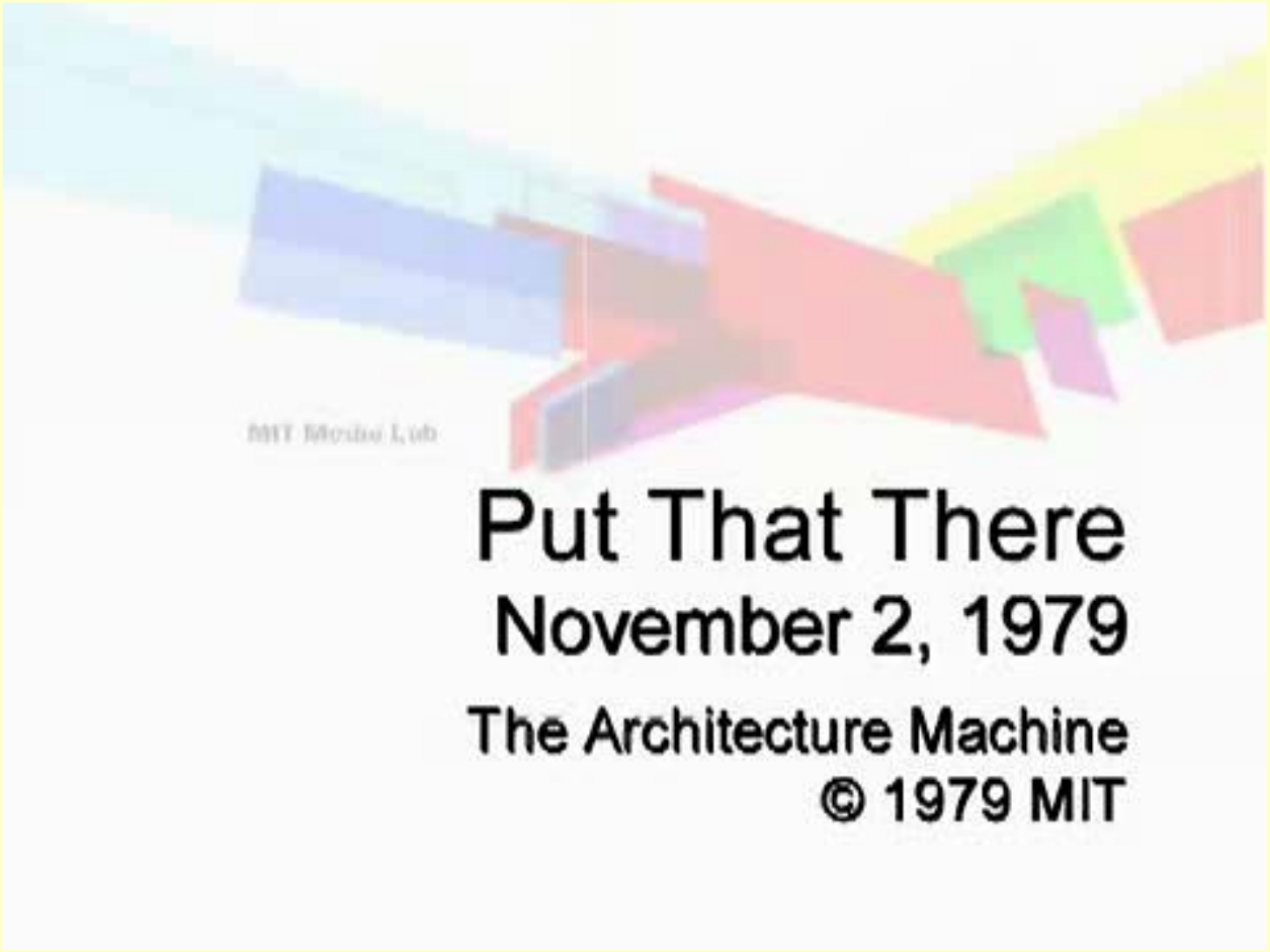
- Indication of object
  - occlusion
  - object touching
  - pointing
  - indirect selection
- Confirmation of selection
  - event
  - gesture
  - voice command
  - no explicit command
- Feedback
  - text/symbolic
  - aural
  - visual
  - force/tactile

Classification of manipulation techniques by metaphor

- Exocentric metaphors
  - World-in-miniature
  - Automatic scaling
- Egocentric metaphors
  - *Virtual hand metaphors*
  - classical virtual hand
  - Go-Go
  - Indirect Go-Go
  - *Virtual pointer metaphors*
  - Ray casting
  - Aperture
  - Flashlight
  - Image plane

Avatar and exocentric view

First trials …



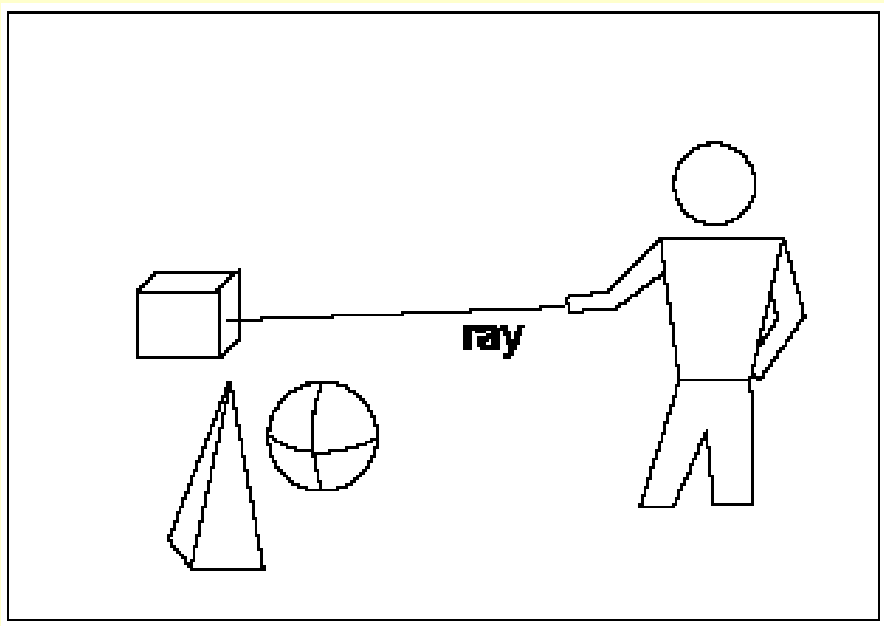
Interact. Techniques - Virtual hand and pointer

The *virtual hand* and *virtual pointer* (ray-casting, laser ray) are the most basic techniques for 3D manipulation in VEs.

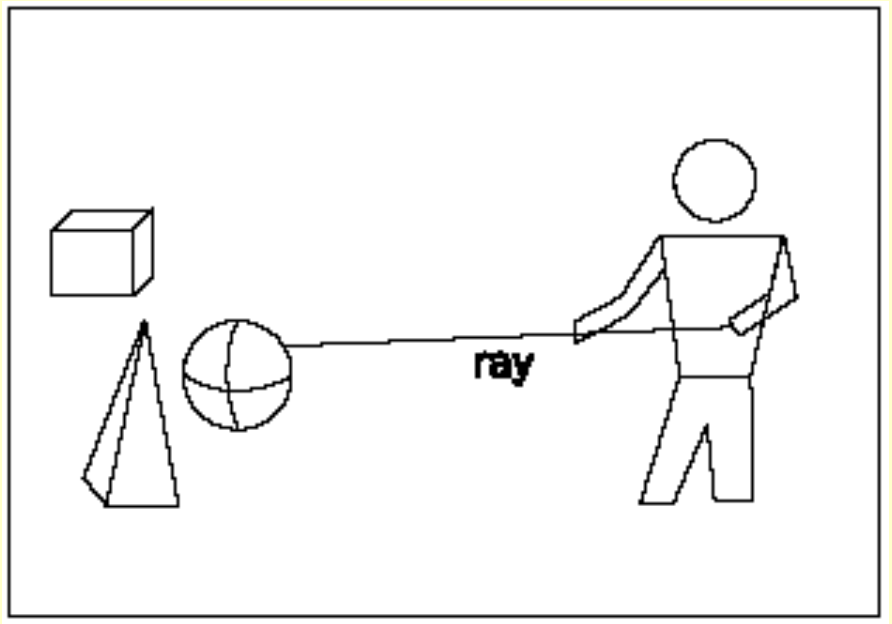
The ***virtual hand* technique** is a direct mapping of the user hand motion into the affected motions in a virtual environment, typically linearly scaled to establish the correspondence between the device and environment coordinate systems.

- The user is provided with a virtual "hand" - a 3D cursor, often shaped like a human hand, whose movements correspond to the movements of the tracker worn on the hand or held in the user's fingers.
- To select an object, the user simply intersects the virtual hand with the target, and presses a trigger (or issues a voice command or a hand gesture) to pick it up.

Ray casting



one-hand pointing



two-hand pointing

Ray casting - video

Interact. Techniques - Virtual hand and pointer

The virtual hand technique is rather intuitive; one problem is that only those objects that are within the area of reach can be picked up, and this significantly limits the technique's applicability.

The motivation behind the ***ray-casting* technique** was to allow the user to select and manipulate objects beyond the area of normal reach.

The user points at objects with a virtual ray emanating from a virtual hand and then objects intersecting with the virtual ray can be selected, attached, and manipulated.

Interact. Techniques - Virtual hand and pointer

Object manipulation can be efficiently accomplished only in radial movements around the user (perpendicular to the ray direction) and rotations only around the ray axis.

Full 6DOF manipulation with ray-casting is **impossible**.

Natural constraints limit the user manipulations degrees of freedom.

Interaction Techniques

Advantages

"Simple" virtual Hand

The most natural

Ray-casting

Objects can be selected at any distance (in theory)

Natural, requires little effort

Disadvantages

"Simple" virtual Hand

Limited area of manipulation

Ray-casting

Ineffective for selection of small and far away objects

Ineffective for object positioning and rotation

Interaction Techniques

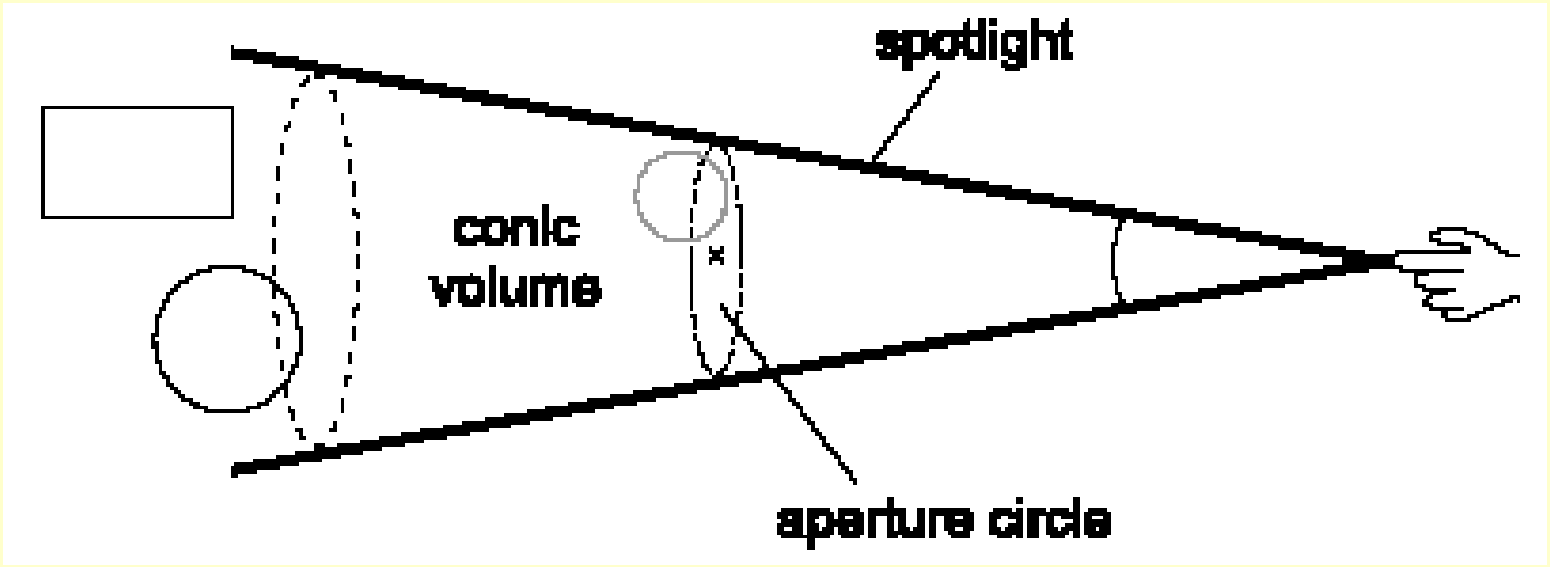
Improvements in ray-casting: Spotlight and Aperture techniques

The *spotlight* or *flashlight* technique (Liang, et al. 1994) uses a conic selection volume

easily select small objects no matter how far they are

requires techniques for further disambiguation of the target objects

Spotlight with Aperture technique



Interaction Techniques

Advantages

Spotlight

Easier selection of small objects at any distance

Aperture (Forsberg, (1996)

Interactive and intuitive object disambiguation

Selection is 2D

Disadvantages

Spotlight (Liang, 1994)

Several objects fall into spotlight

Inefficient positioning/rotation

Aperture

Inefficient positioning/rotation

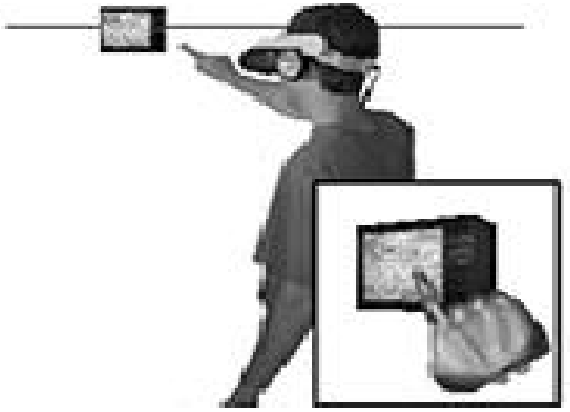
Fishing reel

method of controlling distances via a *fishing reel*.

- after selecting an object, the user can reel it back and forth
- fishing reel lets the user control the distance, but it separates the manipulation's degrees of freedom
- ray direction is controlled by the 6DOF movements of the user's hand, while distance is controlled by a separate controller
- requires an extra input device for the control of the ray length.

The Image Plane techniques

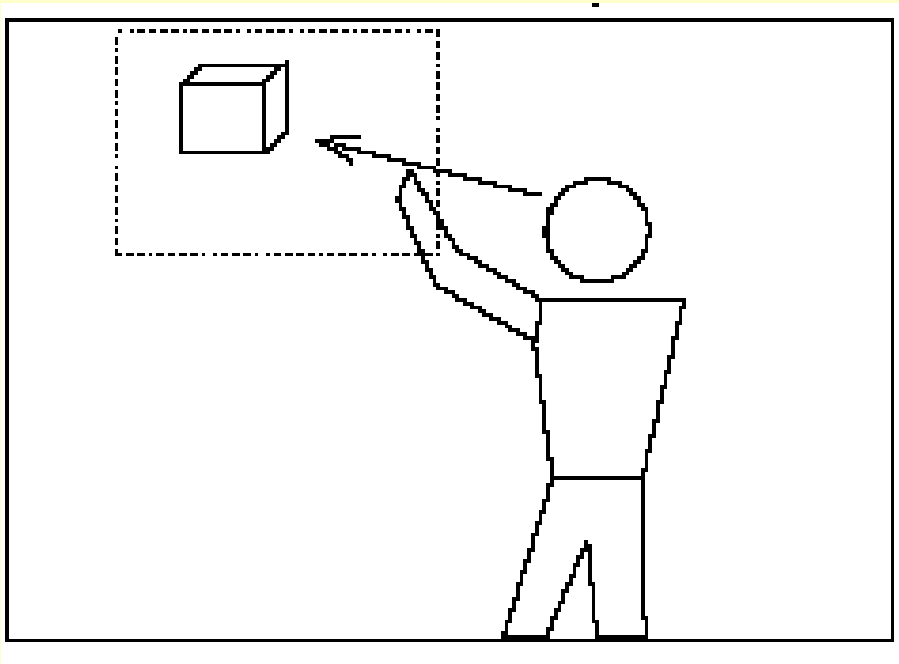
The techniques allow the user to select and manipulate objects by interacting with their 2D projections on an image plane in front of the user: the user selects objects by simply touching their projection on an image plane.



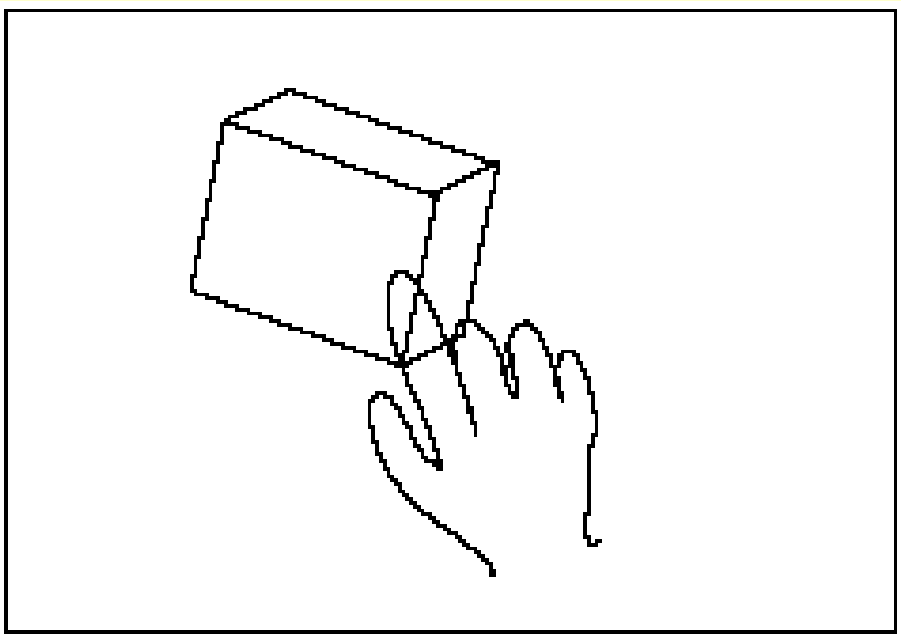
Sticky finger (Pierce, et al. 1997)

The Image Plane techniques

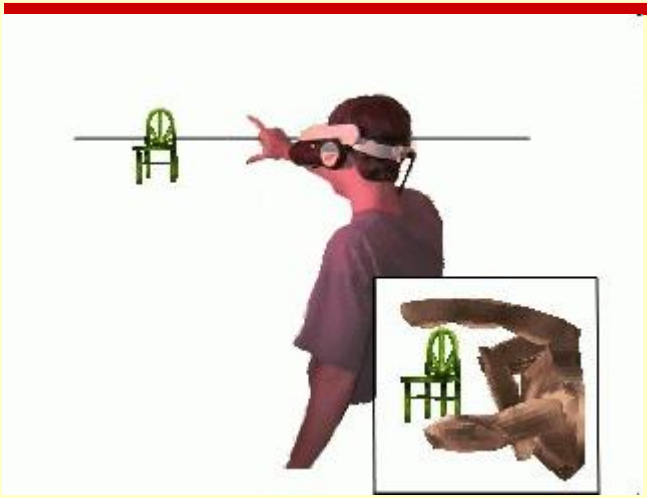
3rd person's view



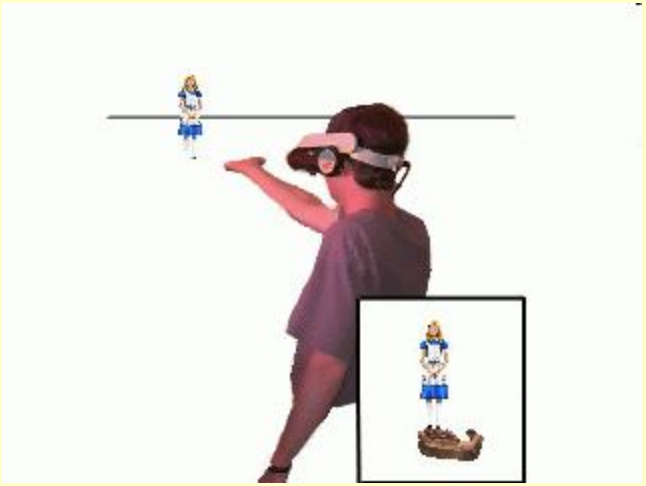
user's view



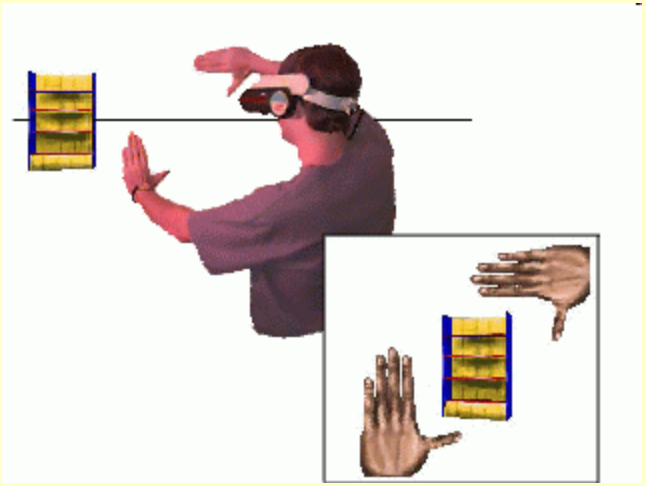
The Image Plane techniques



head crusher

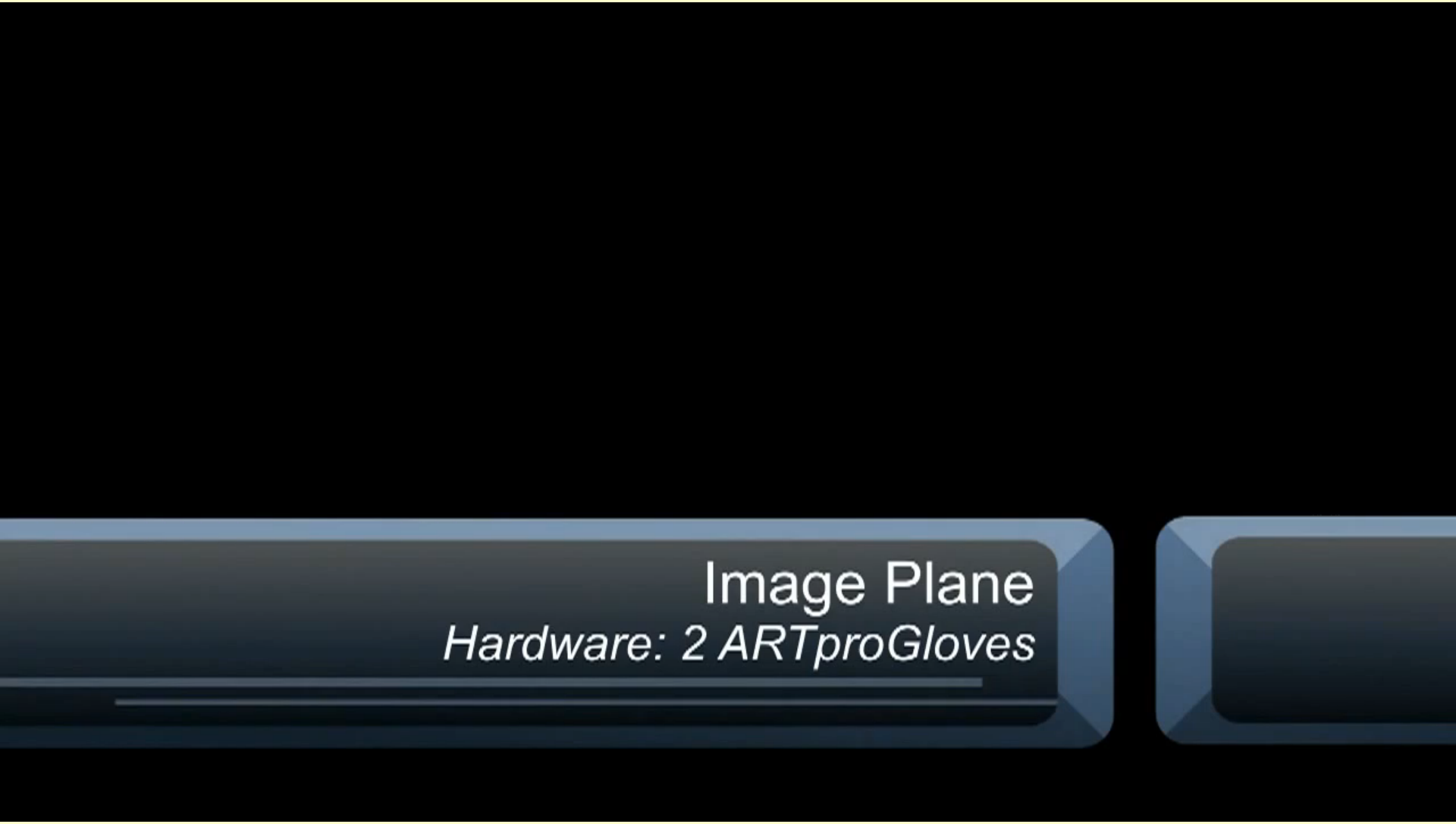


lifting palm



framing hands

The Image Plane technique



Interaction Techniques

Advantages

Image plane (Pierce, 1997)

Easy, intuitive selection

Ray-casting with "fishing reel" (Bowman, 1997)

Distance control to ray-casting

Disadvantages

Image plane

Remote object manipulation impossible

Ray-casting with "fishing reel"

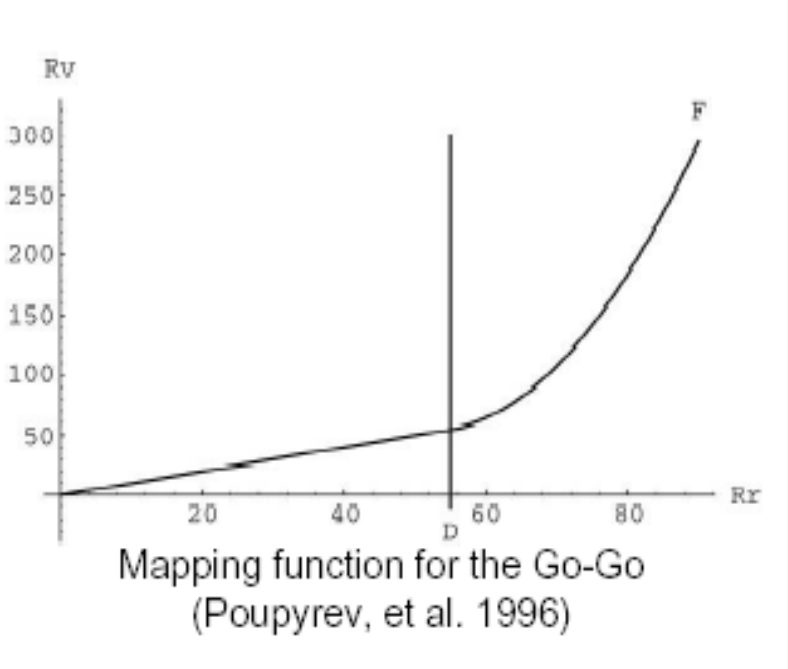
Extra control device separates manipulation degree of freedom

Rotation is still difficult

The Go-Go technique

Different mapping to achieve a different control-display gain between real and virtual hands

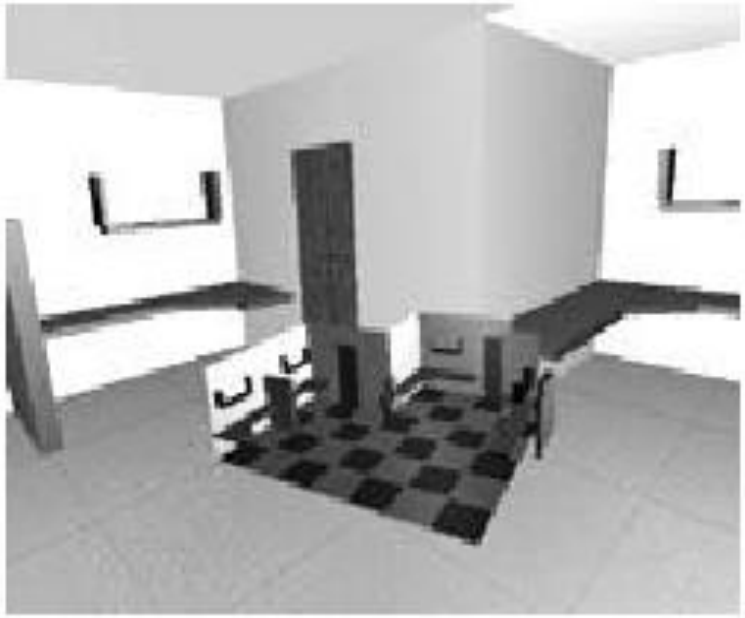
Go-Go technique allows direct seamless 6DOF object manipulation both close to the user and at-a-distance.



Mapping function for the Go-Go (Poupyrev, et al. 1996)

World-in-Miniature, WIM

An alternative to extending the length of the user arm is to scale the entire world and bring it within the user reach.



World-in-Miniature
(Stoakley, et al. 1995)

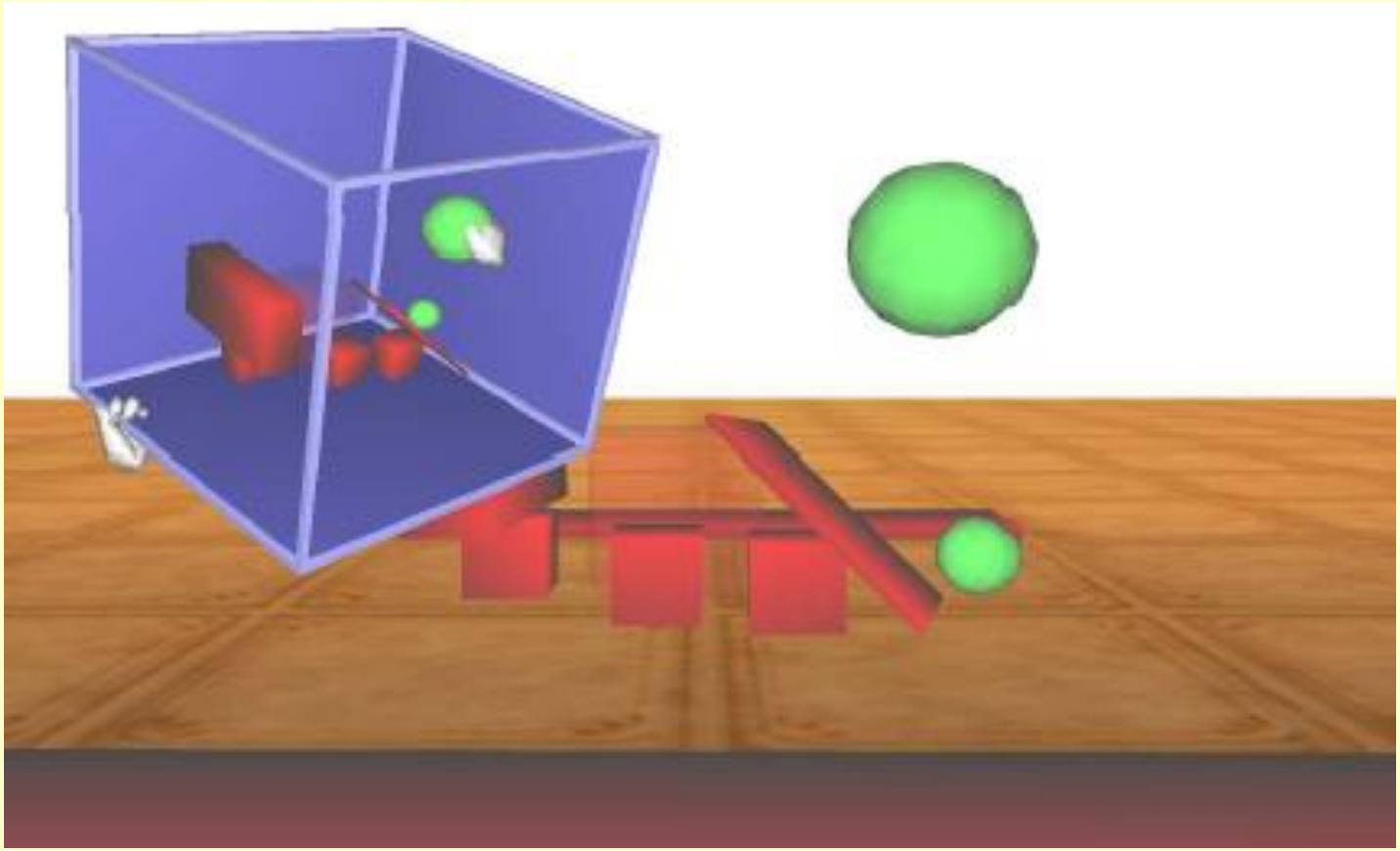
World-in-Miniature

The user can indirectly manipulate virtual objects by interacting with their representations in the WIM.

Easy object manipulation both within and outside of the area of user reach.

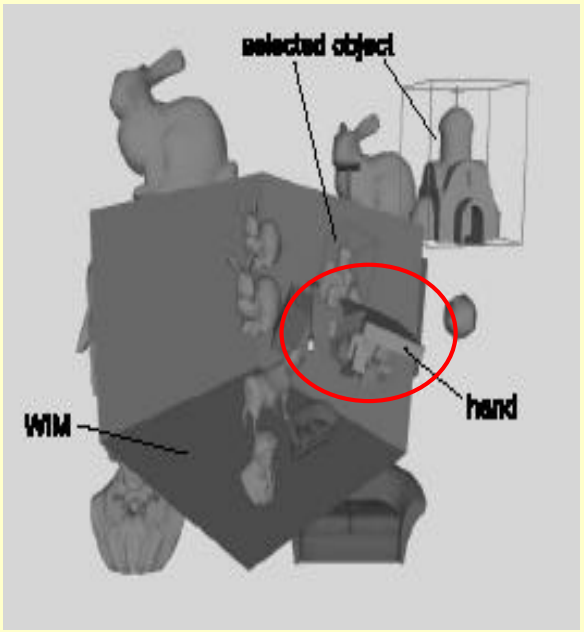
It can combine navigation with manipulation since the user can easily move his or her own representation on the WIM.

WIM metaphore

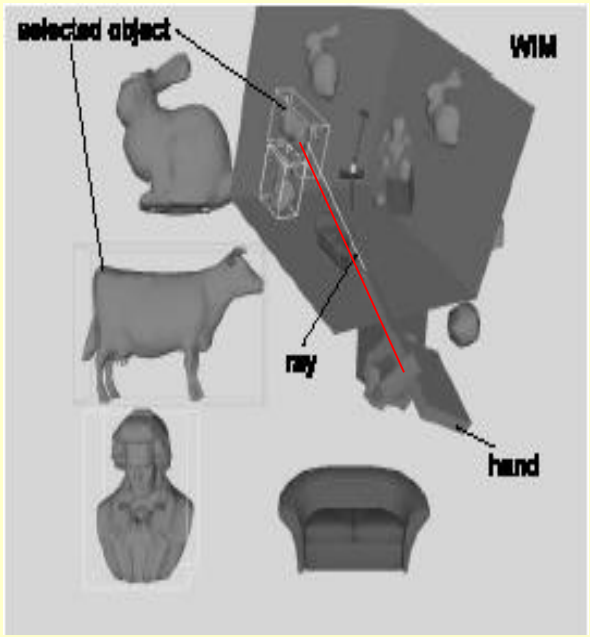


WIM - video

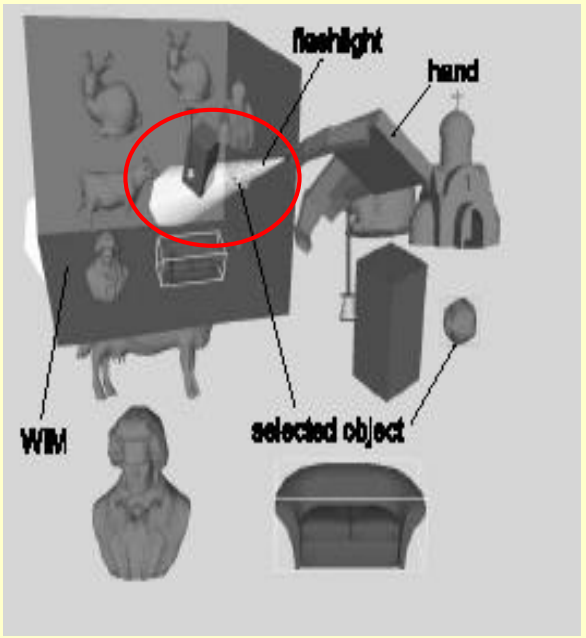
Selection in WIM



classical
virt.hand



ray casting



light cone

WIM and raycasting

Interaction Techniques

Advantages

Go-Go

Seamless 6DOF manipulation in a large range of distances

Intuitive and enjoyable

World-in-Miniature

Allows 6DOF manipulation and any distance

Disadvantages

Go-Go

Manipulation range is still limited

Overshoot with large distances

World-in-Miniature

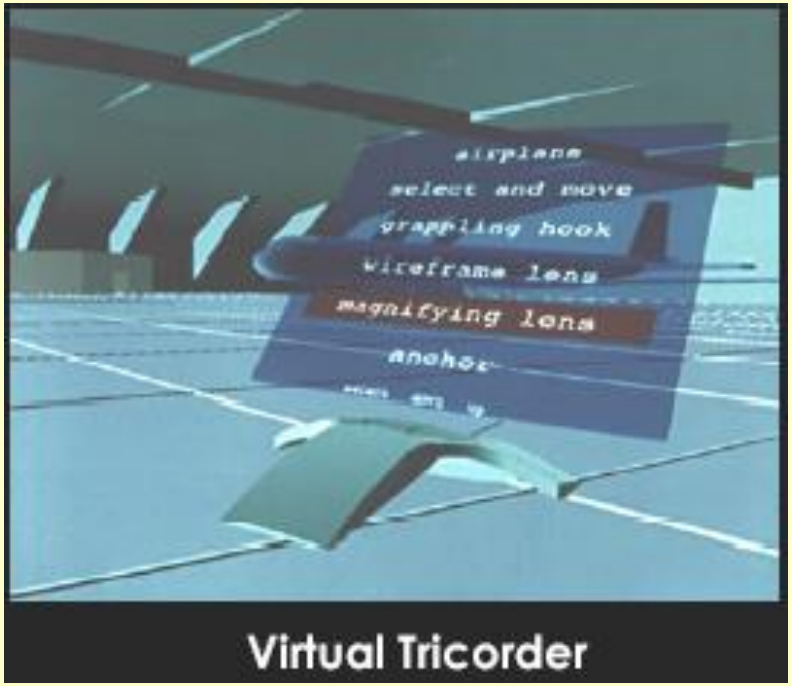
Difficult to precisely manipulate

small objects

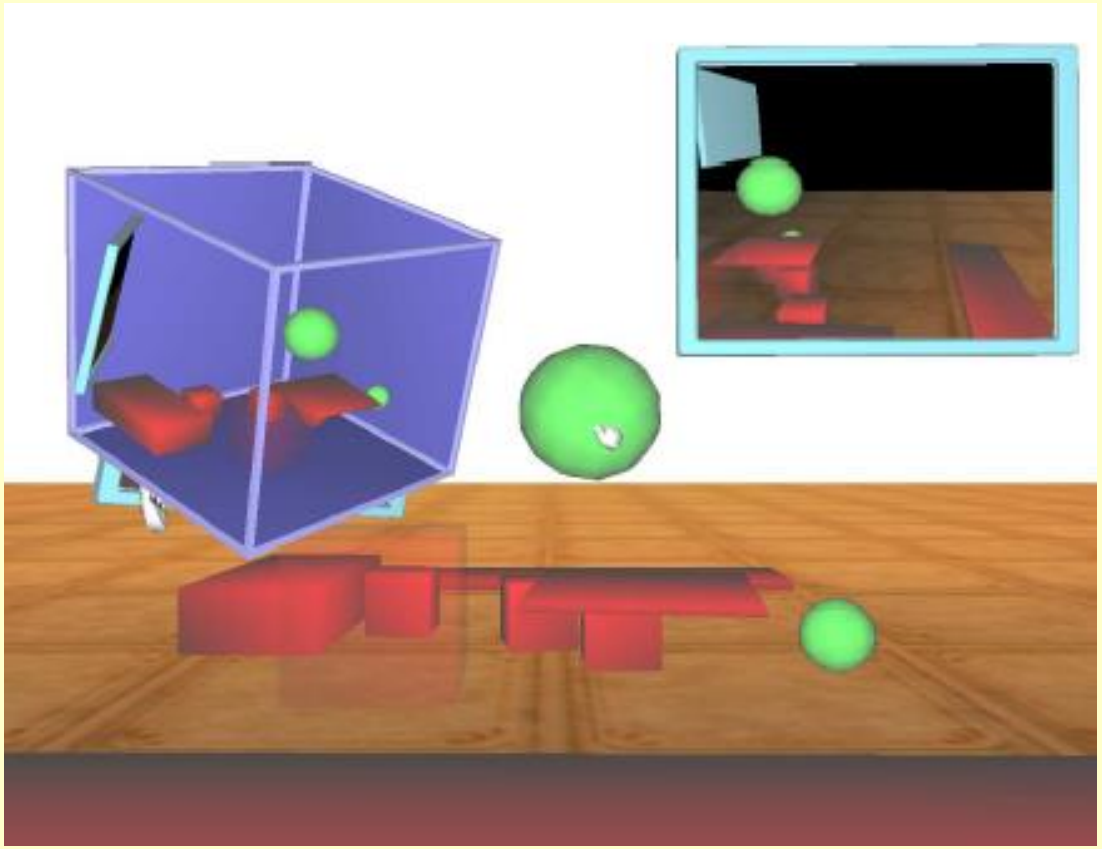
Technique Combination/Examples

Hybrid techniques

- HOMER (Bowman, 1997)
- World-scale grab (Mine, 1997)
- Voodoo Dolls (Pierce, 1999)

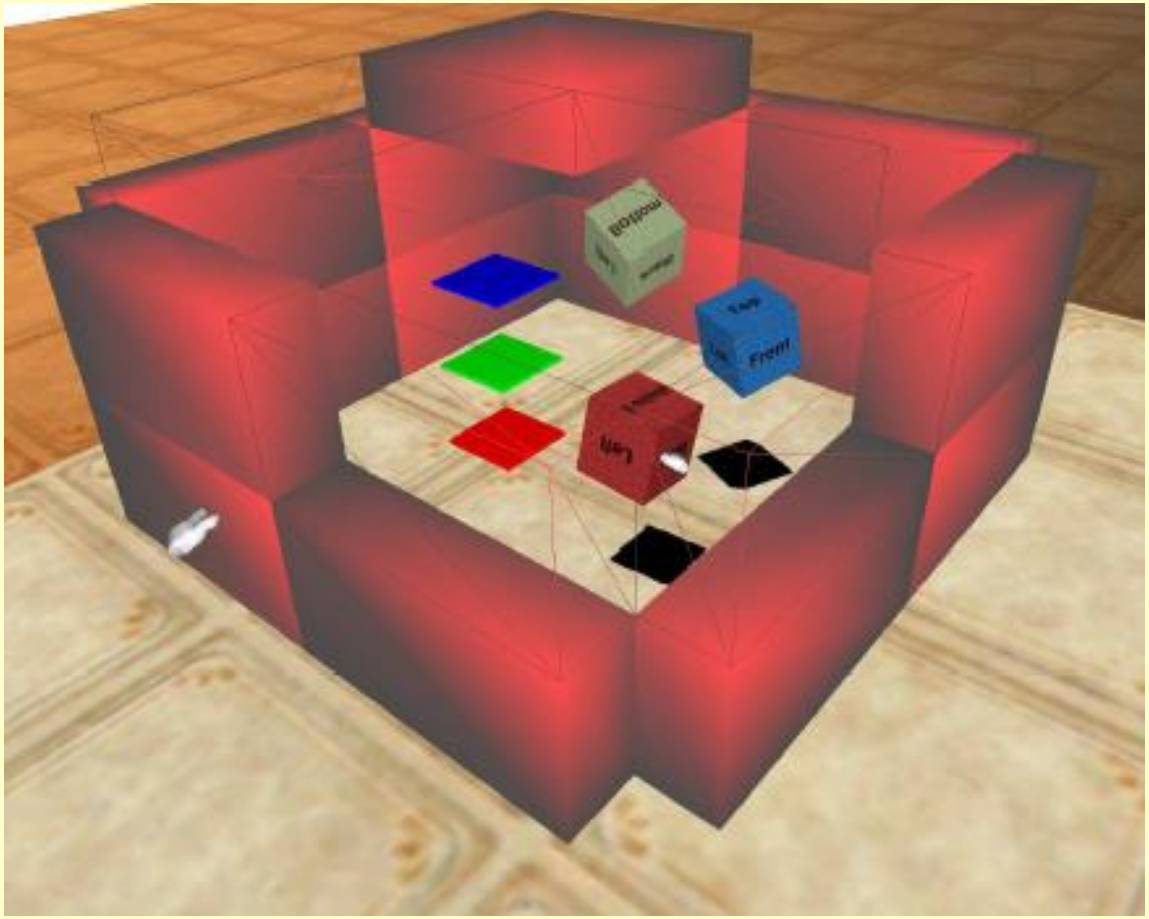


Tools combined



WIM and Mirror with the auxiliary display

Objects behind obstacles



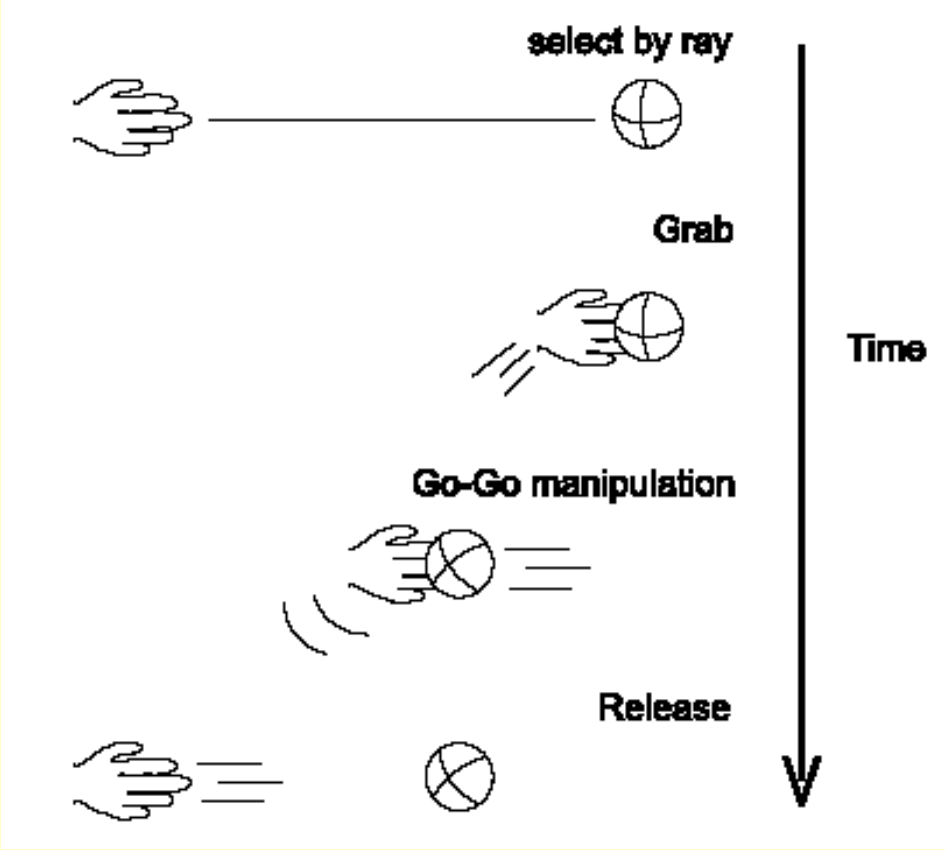
HOMER

HOMER (Bowman et al., 1997) –

Hand-centered Object Manipulation Extending Ray-casting technique.

The user selects an object using ray-casting and after that, instead having the object attached to the ray, the user's virtual hand instantly moves to the object and attaches to it.

Hand manipulation technique



HOMER (hand centered object manipulation extending ray casting)

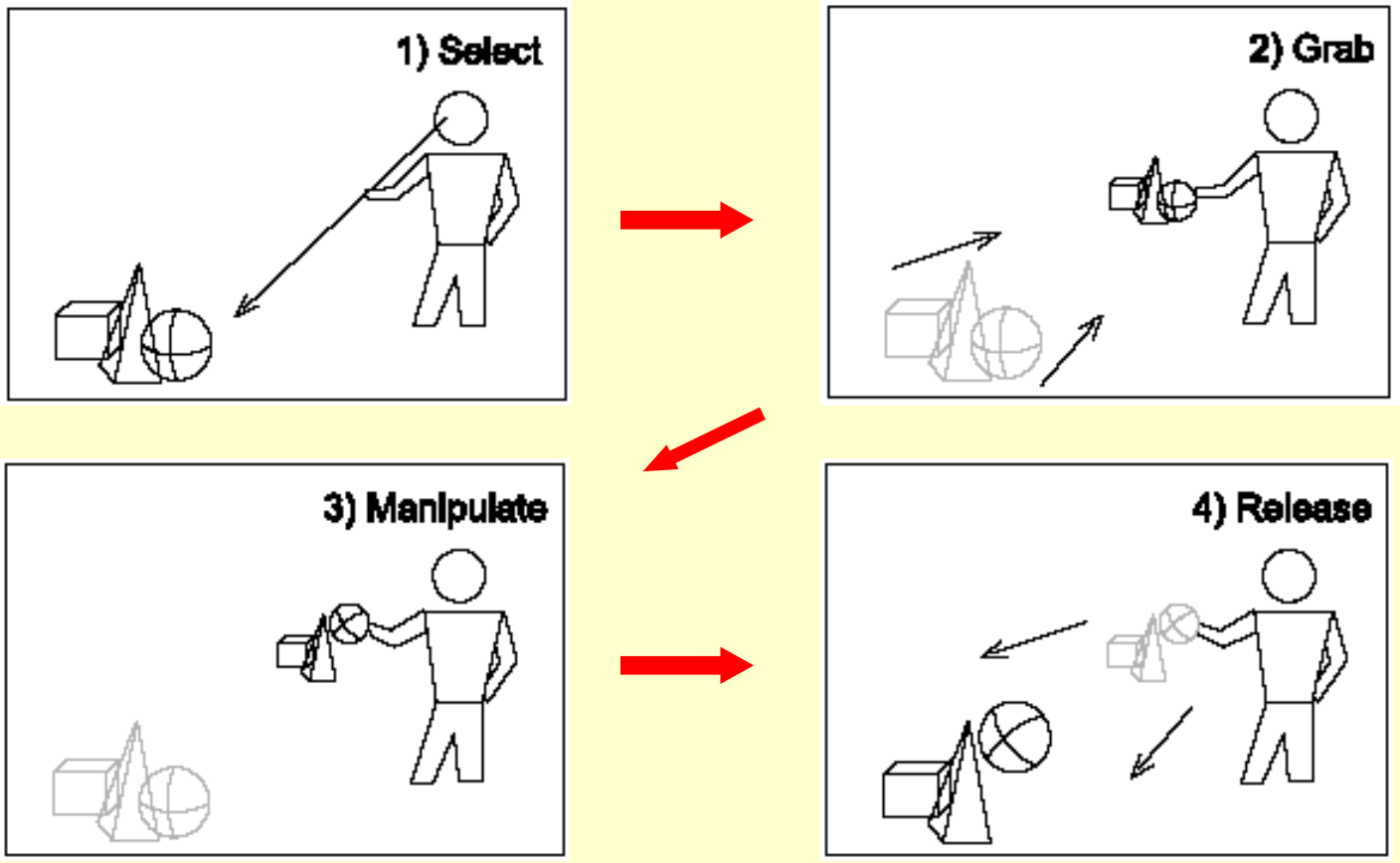
Scaled-world grab

User first selects an object using an image-plane technique

After selection the technique scales down the whole virtual environment, so that objects are brought within the user reach and are manipulated using the simple virtual hand.

The scaling coefficient is calculated so that the *visual size* of objects in the environment remains unchanged.

Automatic scaling



Hybrid Techniques

Advantages

HOMER (Bowman et al., 1997)

Scaled-world grab (Mine et al., 1997)

Easy selection: ray-casting or image plane

6DOF Manipulation on a wide range of distances

Mine: manipulation within normal area of reach

Disadvantages

HOMER

Scaled-world grab

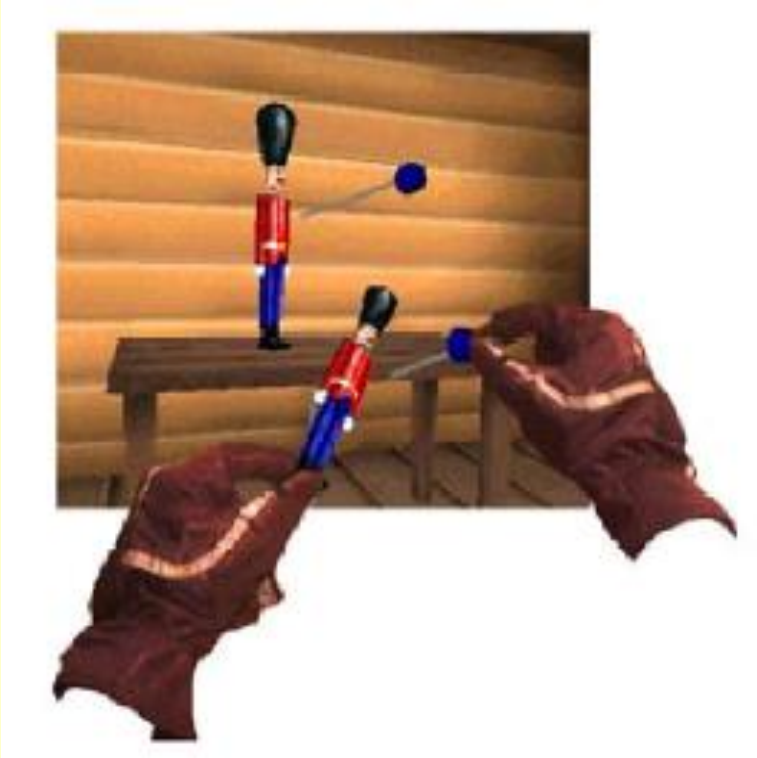
Moving objects from within reach to far is problematic

Inconsistency in mappings between physical and virtual hands movements

Voodoo Dolls

Two-handed interaction technique for manipulating objects at a distance in immersive virtual environments.

It aims to provide an easy method of interacting with objects of widely varying sizes and at different distances.



Voodoo Dolls

To start object manipulation the user dynamically creates dolls: temporary, miniature, hand-held copies of objects.

The manipulated virtual objects can be at any distance, size and state of occlusion.

The user can interactively specify a frame of reference for manipulation. The doll in the non-dominant hand represents a stationary frame of reference, and the corresponding virtual object does not move when the user moves this doll.

Voodoo Dolls

The doll that in the dominant hand represents a manipulated object; the corresponding virtual object moves to the same position and orientation relative to the virtual object represented by the doll in non-dominant hand.

Voodoo Doll scales down/up dolls to a convenient size, thus overcoming one of the limitations of the WIM technique.

It separates the selection mode from the manipulation mode: the user first selects an objects by using an Image Plane technique, then the technique switches to the manipulation mode, and switches back to the selection mode when the dolls are released.

Hybrid Techniques (II)

Advantages

Voodoo Dolls (Pierce et al., 1999)

Manipulation on large range of distances and scales

One-to-one mapping in object manipulation

Manipulation of animated, moving objects

Disadvantages

Voodoo Dolls

More complex than all other techniques

Requires use of pinch gloves

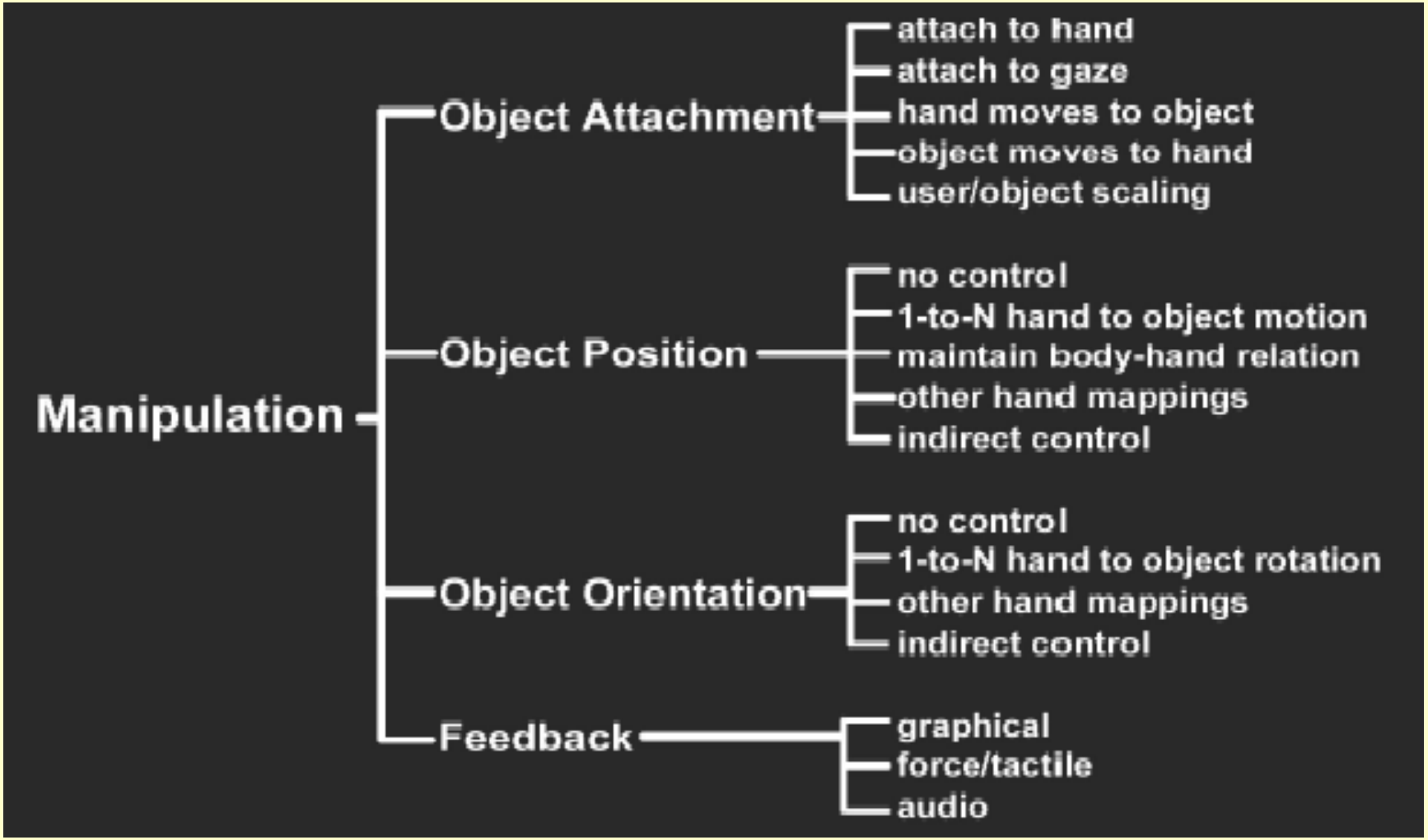
Component-based taxonomy of techniques

For example, in a manipulation task, the object can be positioned, rotated, and the feedback should be provided, etc.

Instead of classifying the techniques as a whole, we only classify components that accomplish these subtasks within techniques.

As a result, theoretically, any technique can be constructed out of these components simply by picking the appropriate components and putting them together.

Classification: By Component



Conclusions and further work

- Further evaluations of techniques
- Techniques for new input/output devices
- Re-evaluation of today's techniques for new input/output devices
- Techniques integration
- Multiple modalities
- Techniques for complex tasks
- Standards and guidelines