

# 3D User Interfaces

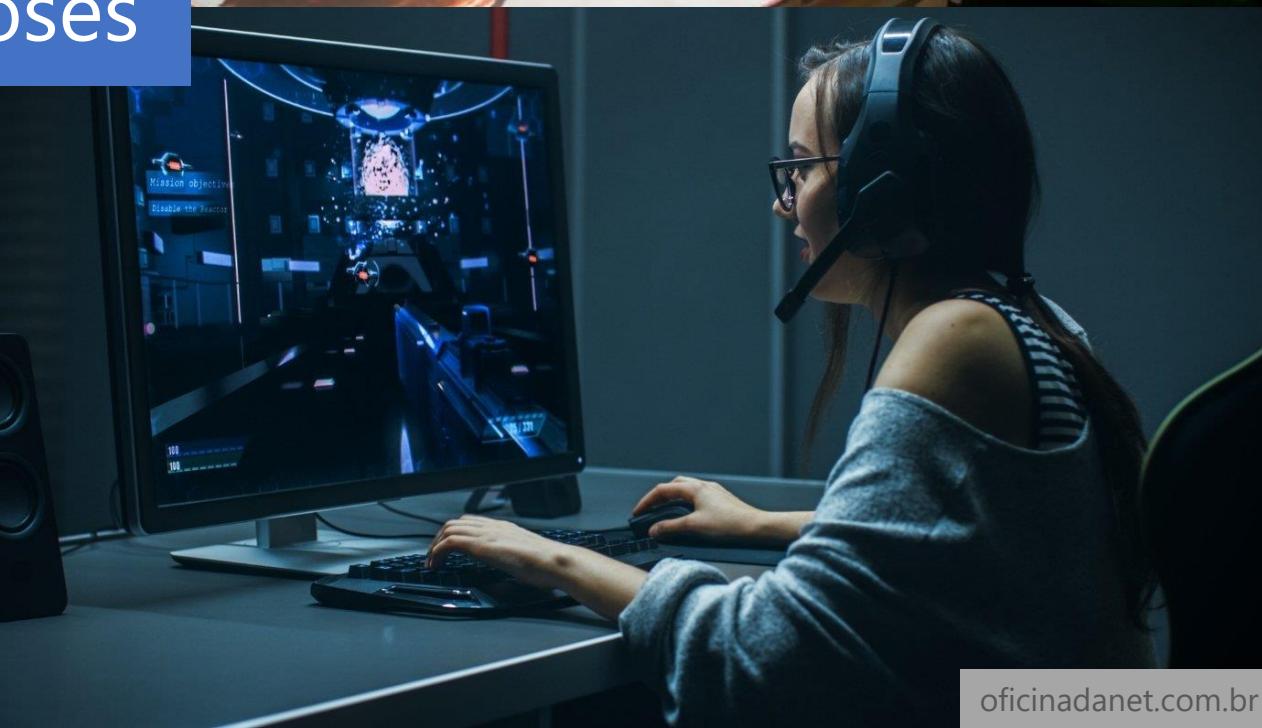
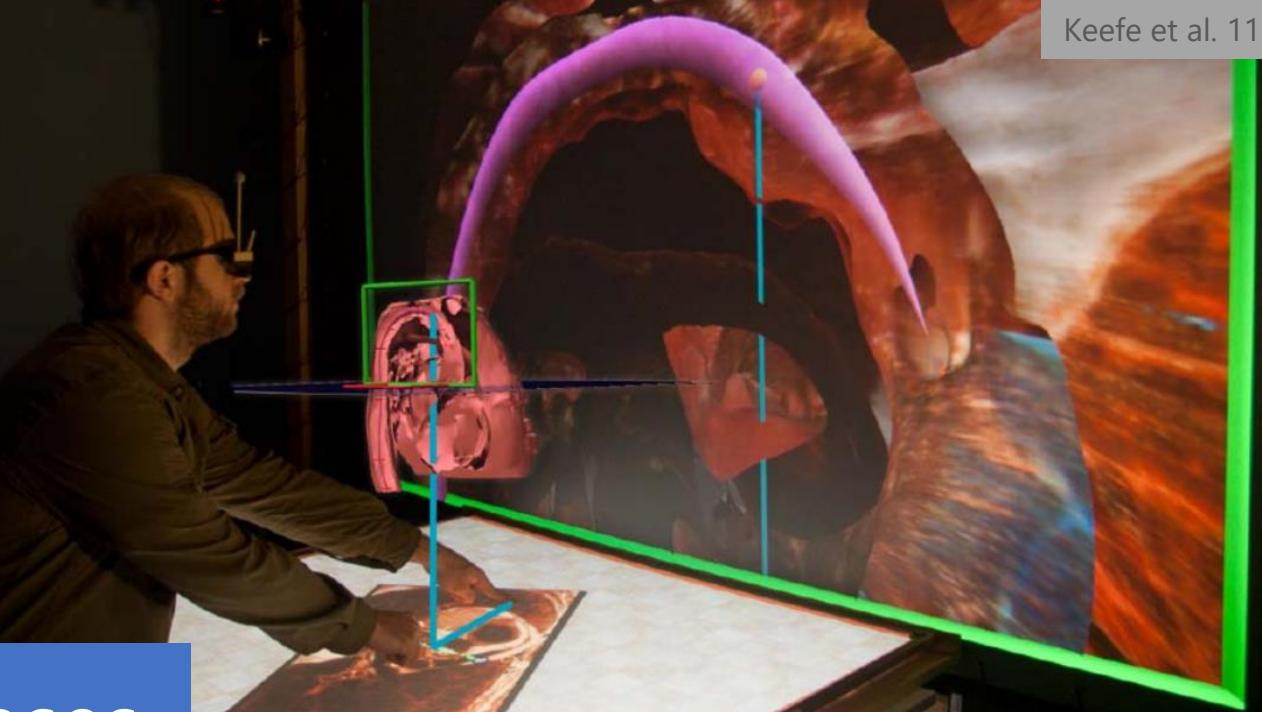
# Disclaimer

This is neither an extensive literature review nor a complete manual. That can be found in books such as "3D User Interfaces" by LaViola et al.

The main idea here is to give an overview of technological evolution and some basic concepts relevant to the development of 3DUIs.

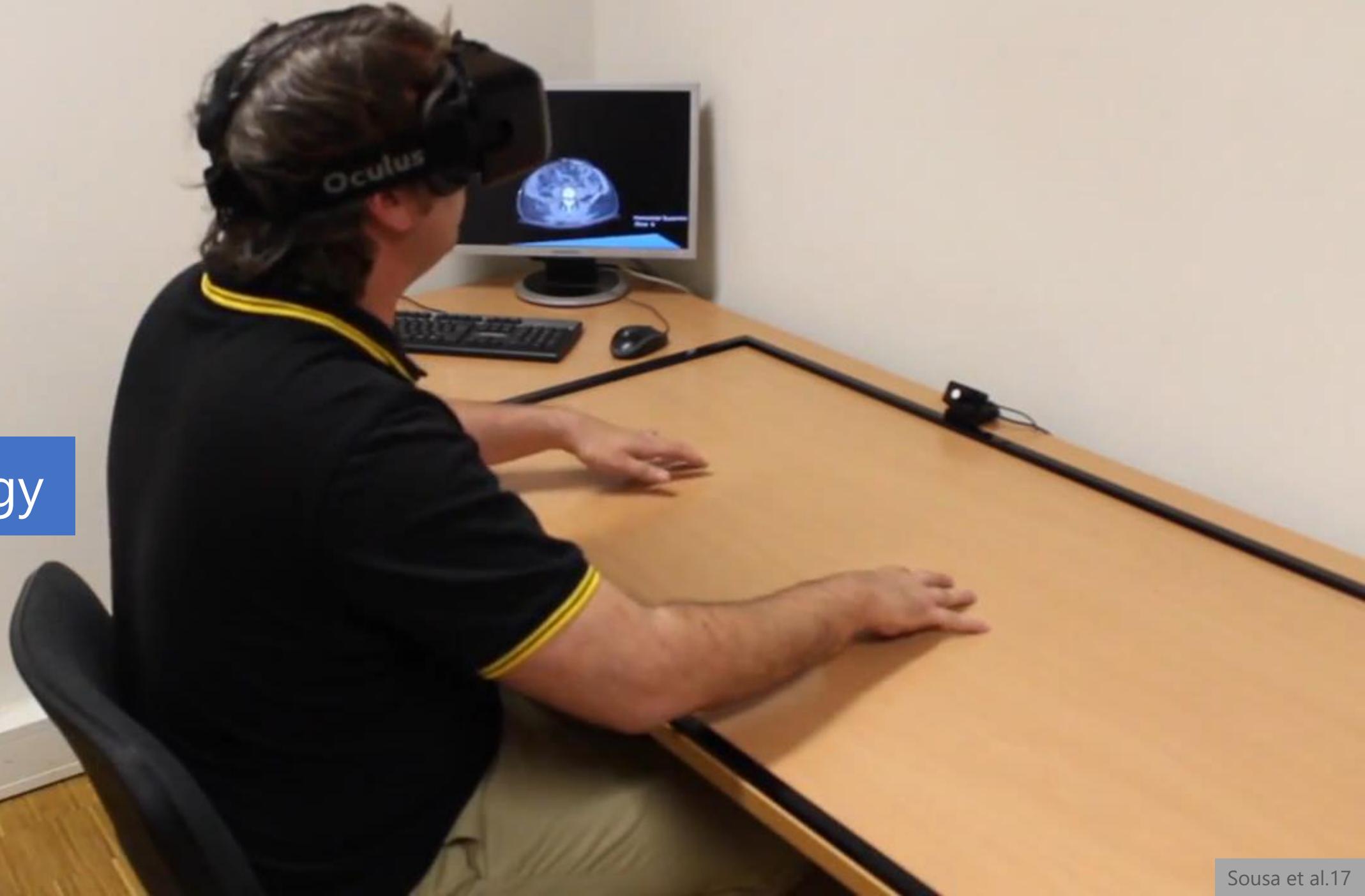
This presentation is heavily influenced by my own experience and research work. Tried to have sources for most of the content. Unfortunately, this could not be done for everything.

Suggestions for improvement are welcome.

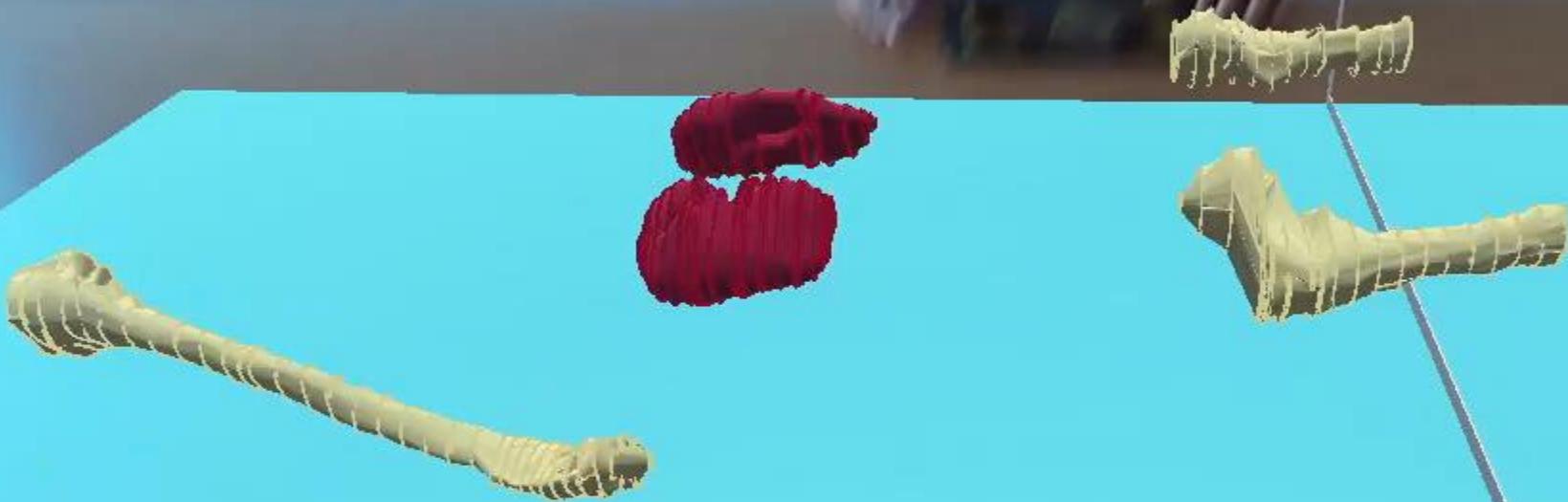


Myriad of purposes

# Radiology



# Collaborative Anatomy Learning



# What is a 3D User Interface?

# 3D Interaction





3D Real Space

474 M

3D Virtual Space

While holding **R2**, press **X** to jump and gain speed.

# 3D Real and Virtual Space



Is this a 3DUI?





Is this a 3DUI?



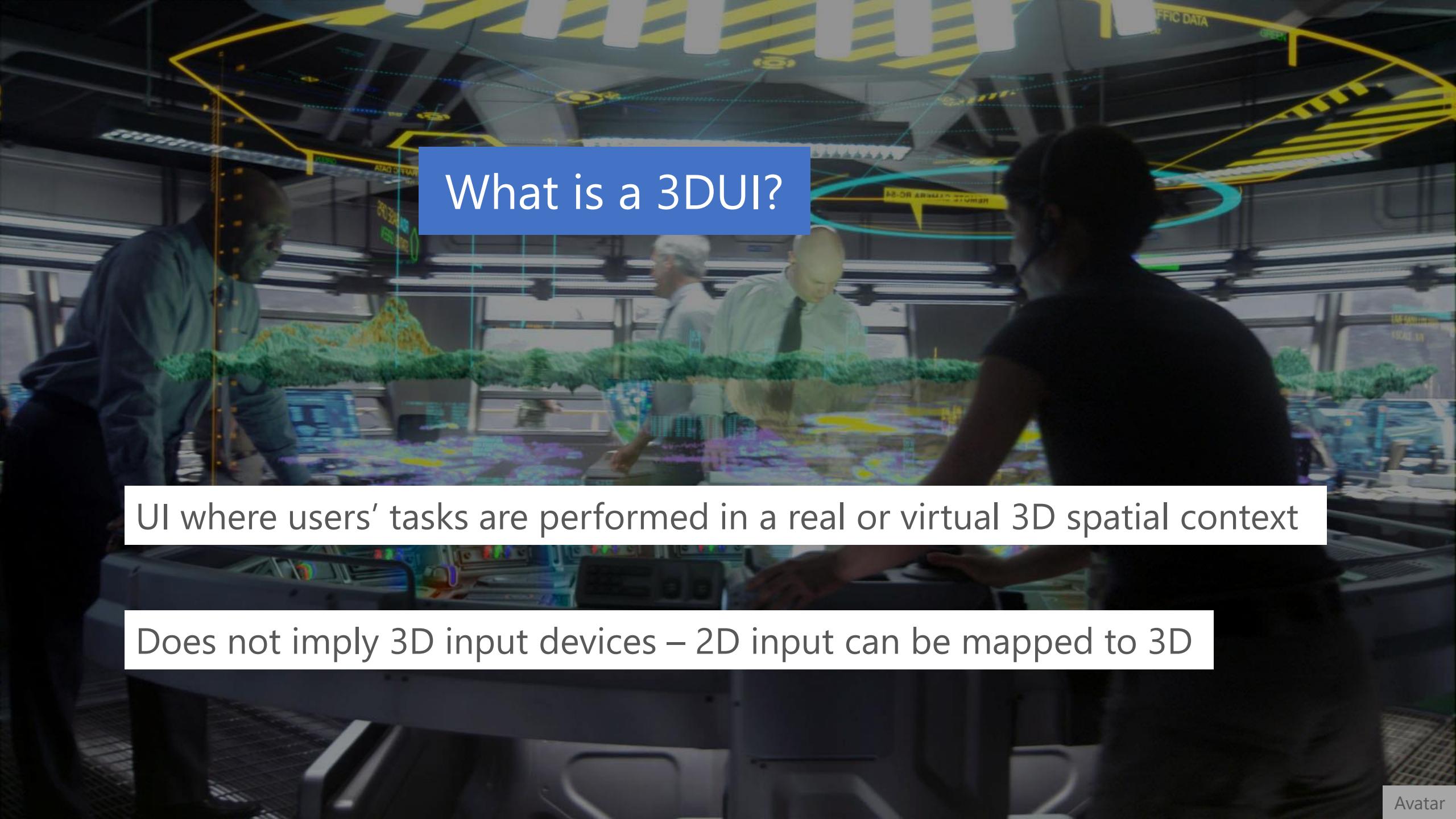
Is this a 3DUI?

Viewpoint A

Viewpoint B

Viewpoint C

Viewpoint D

A futuristic control room with a large 3D projection of a landscape and multiple operators.

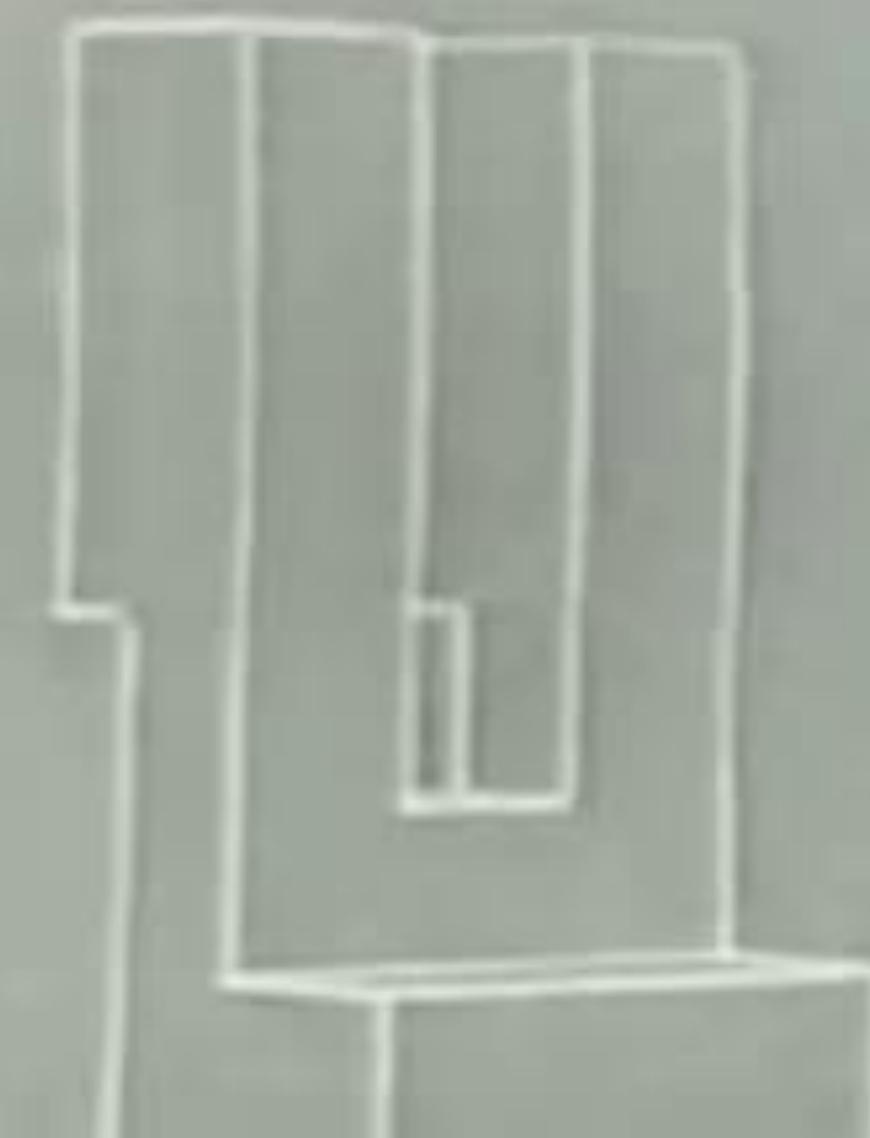
## What is a 3DUI?

UI where users' tasks are performed in a real or virtual 3D spatial context

Does not imply 3D input devices – 2D input can be mapped to 3D

(Extremely Brief)  
History of 3DUI

# Sketchpad (1963)

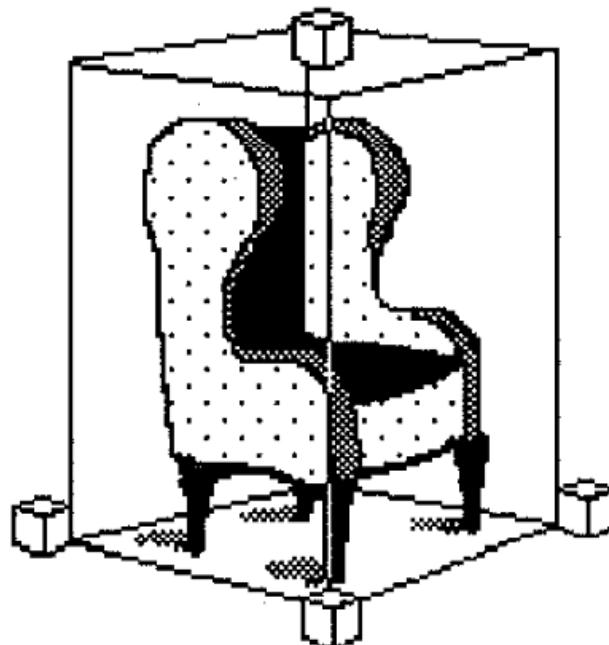




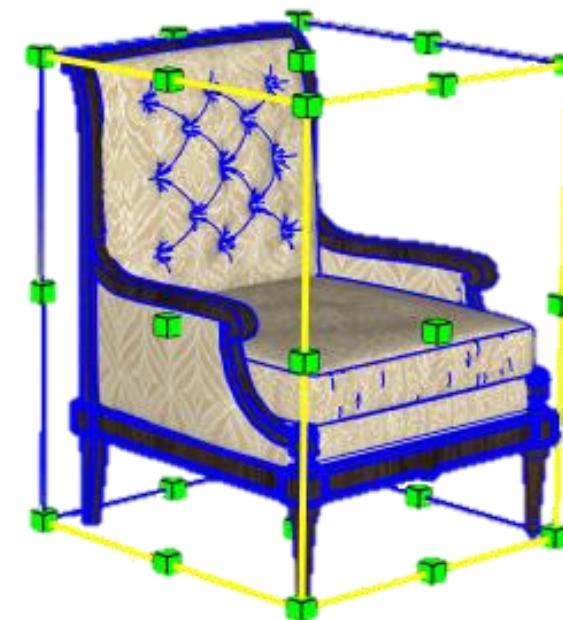
# Current 3D modelling software



## Handle box

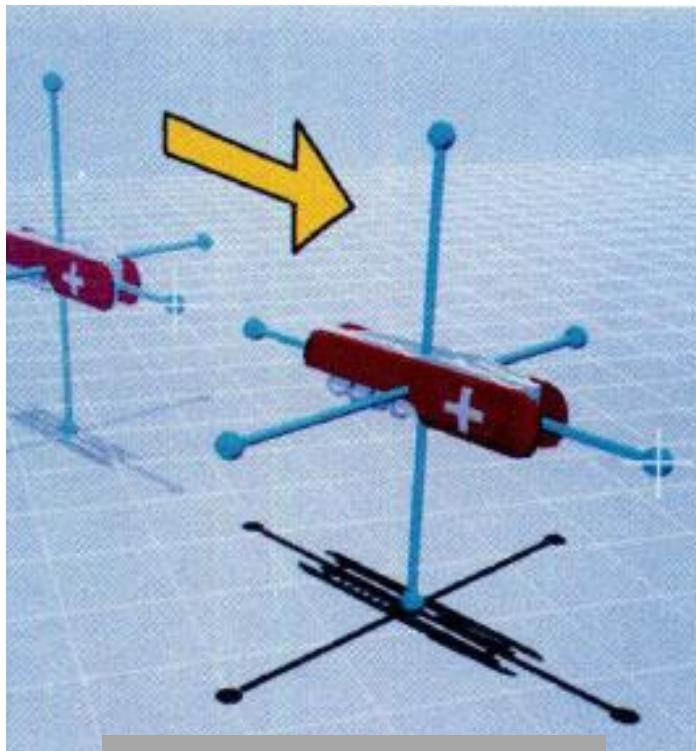


Houde 92

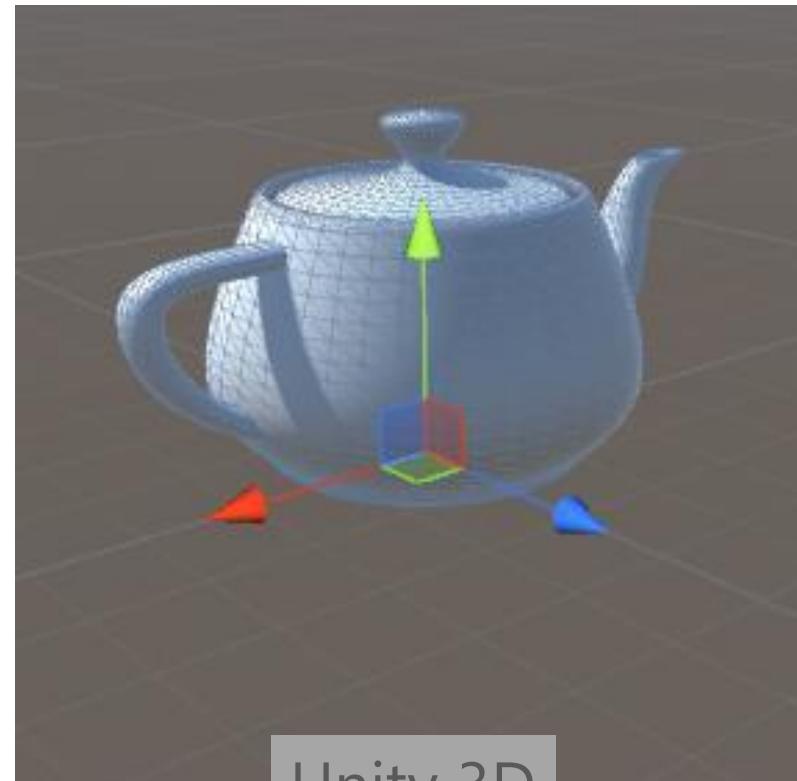


SketchUp 2016

# Virtual Handles

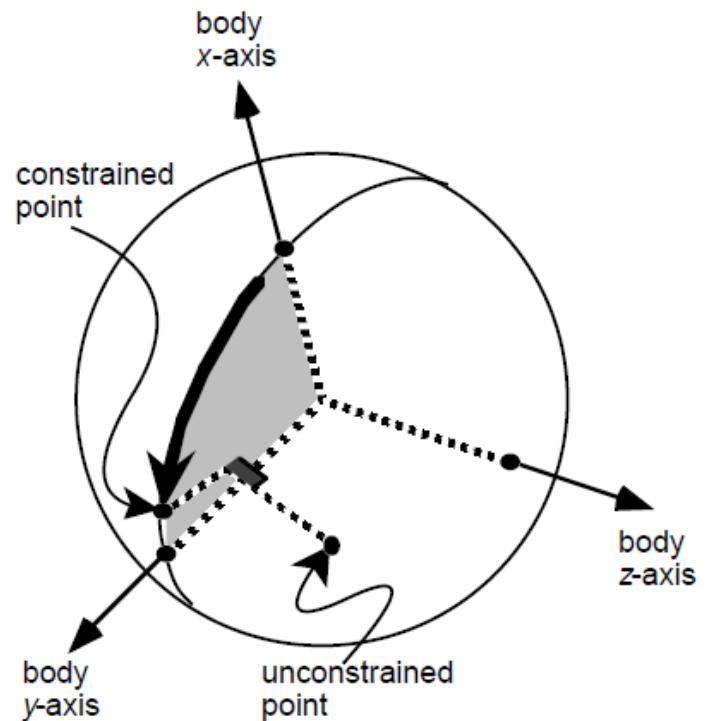


Conner et al. 92

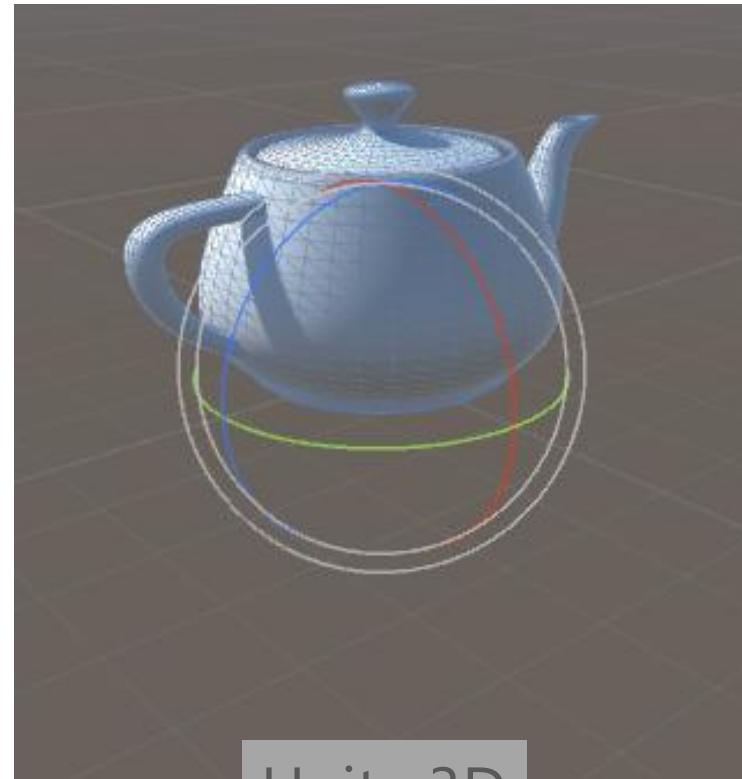


Unity 3D

# Arcball



Shoemake 92



Unity 3D

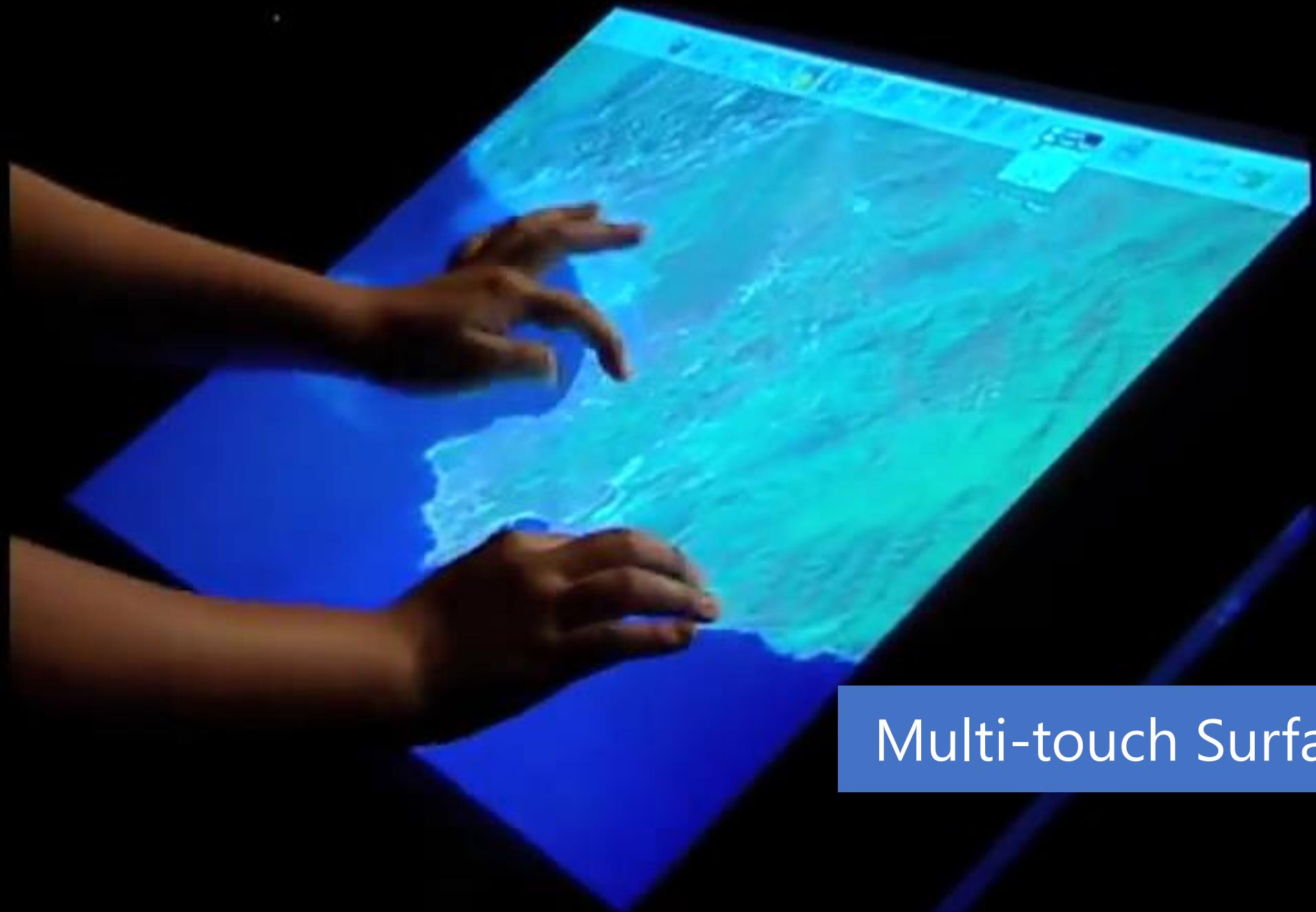


## Specific Input Devices

Spacemouse Pro



Phantom Omni



Multi-touch Surfaces

## Two Pointer Input (1997)

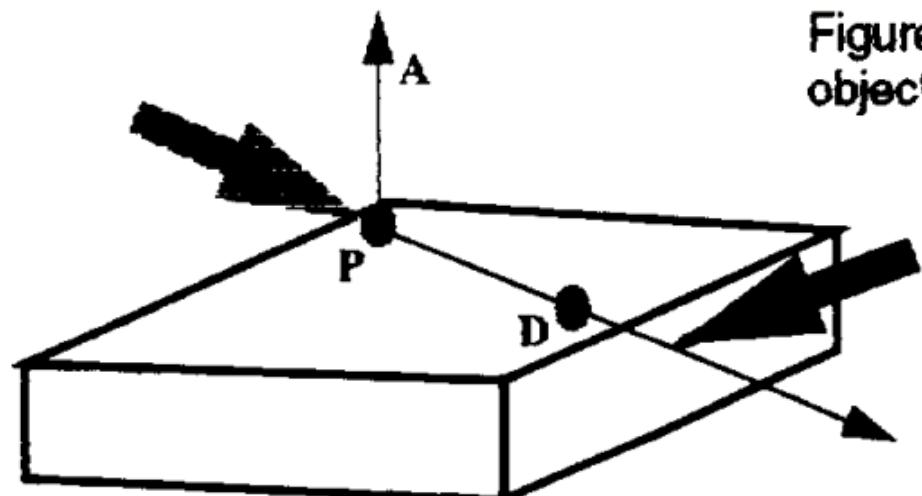


Figure 1: The DH cursor rotates the object around the vector A based at P. When the NDH cursor moves, the object translates and also rotates around the vector A so that the point D will lie along the line between the two cursors.

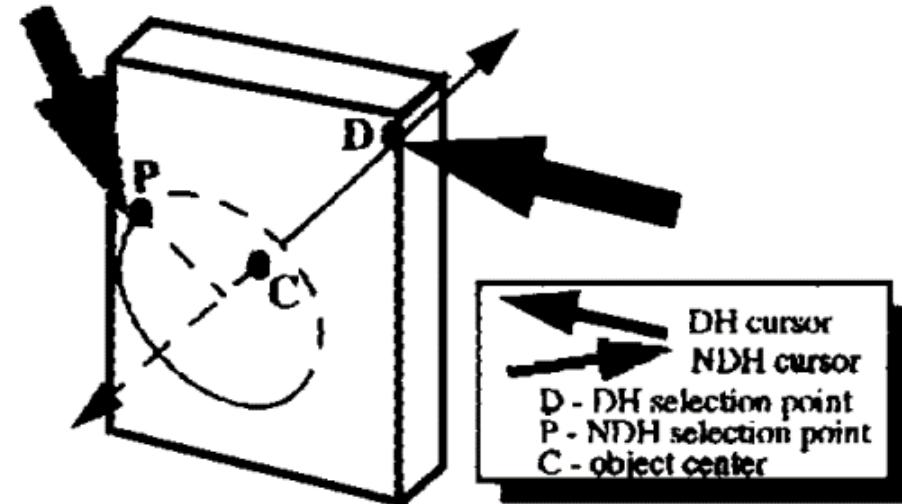
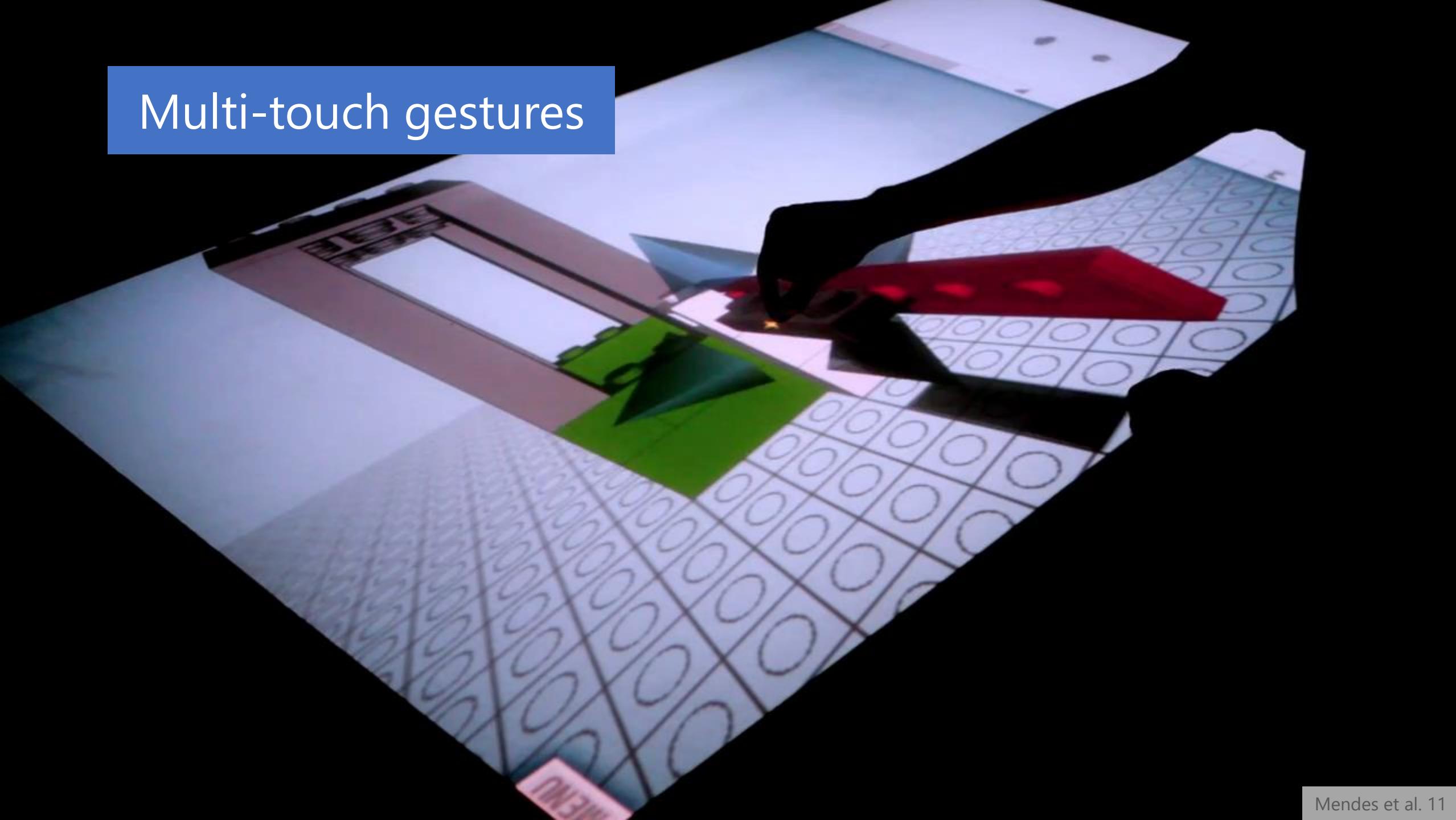
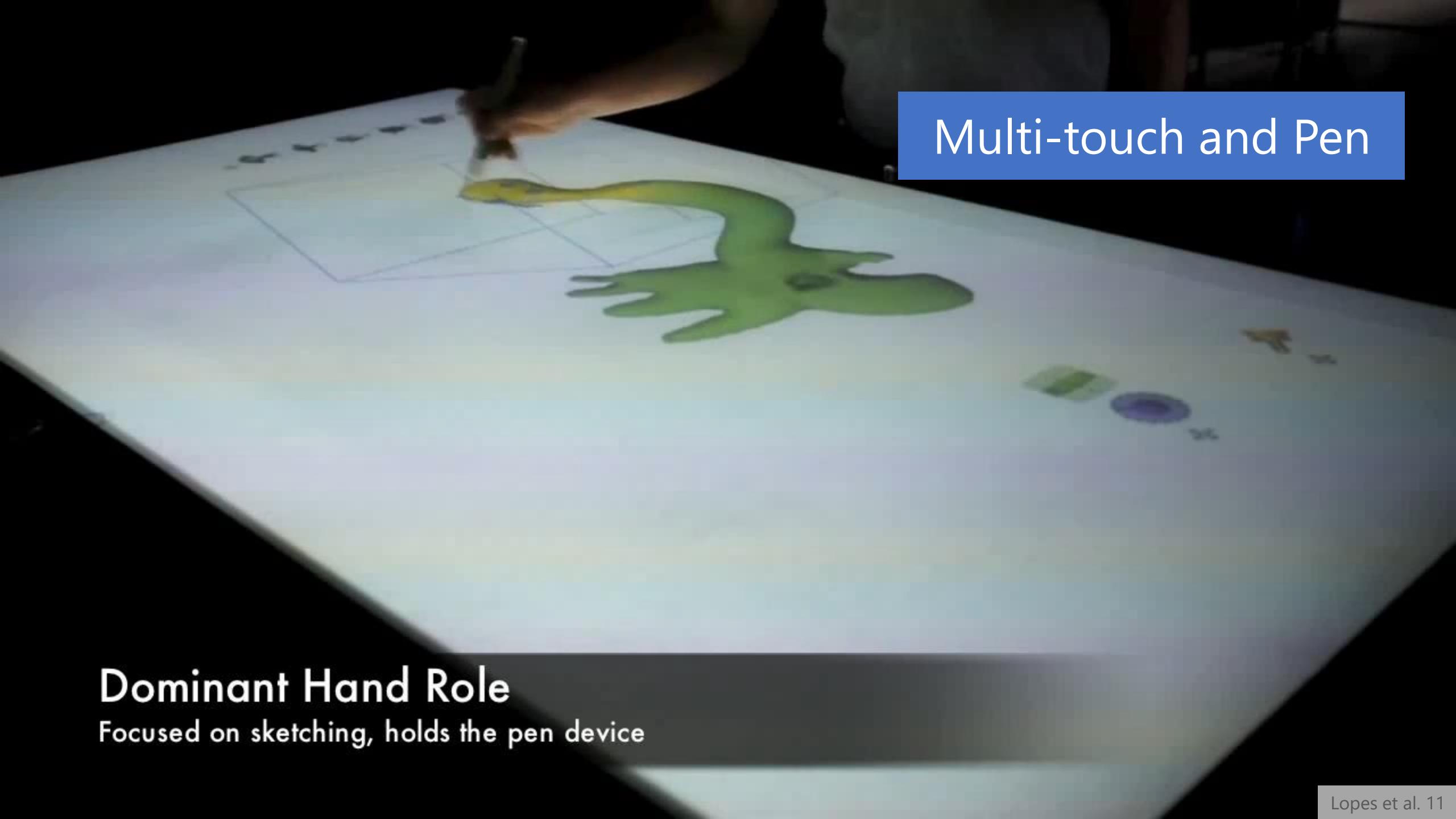


Figure 2: DH defines virtual sphere through point D. NDH rotates object around the axis CD.

## Multi-touch gestures





Multi-touch and Pen

## Dominant Hand Role

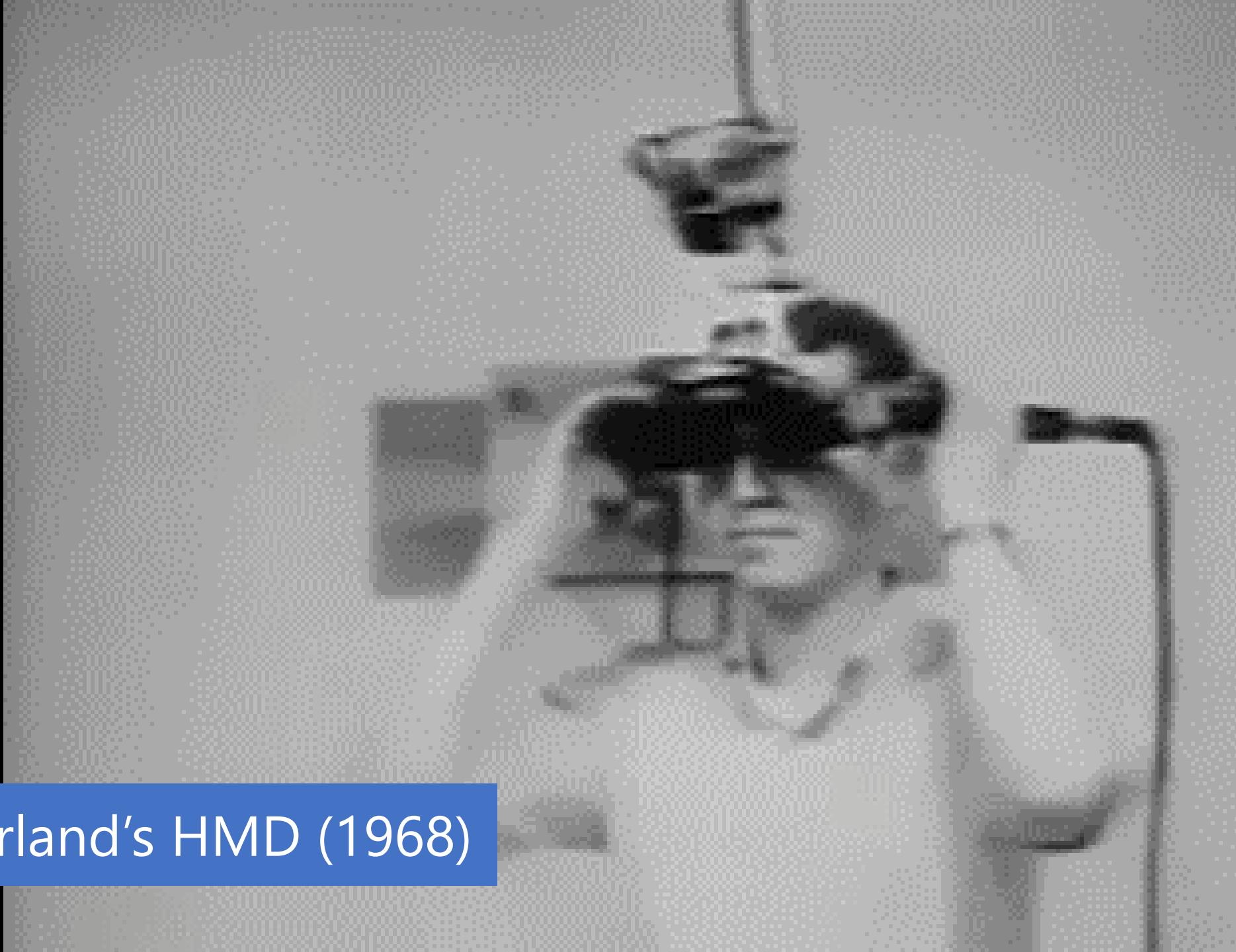
Focused on sketching, holds the pen device

## Current Multi-touch Surfaces



## Stereoscopic Screens





Sutherland's HMD (1968)



## Current HMDs

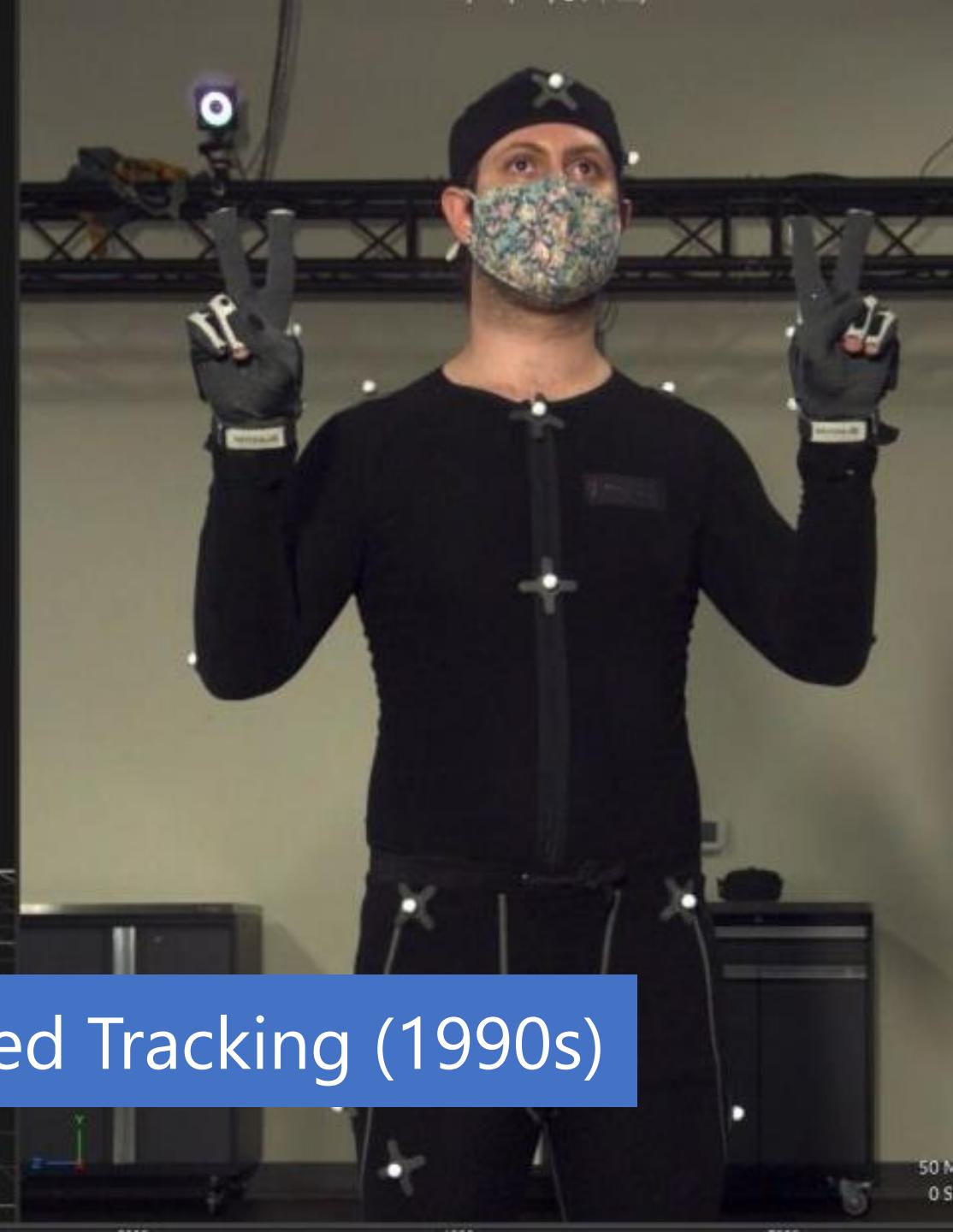


A photograph of a person standing in a CAVE (Computer Assisted Virtual Environment) system. The person is seen from the back, wearing a dark t-shirt and shorts, and is connected to a computer system by several cables. They are standing on a white floor with a grid pattern. The walls of the room are covered in a projection of a 3D landscape featuring green fields and numerous pyramids under a blue sky with clouds. The projection is perspective-correct, creating a convincing virtual environment.

CAVE (1992)

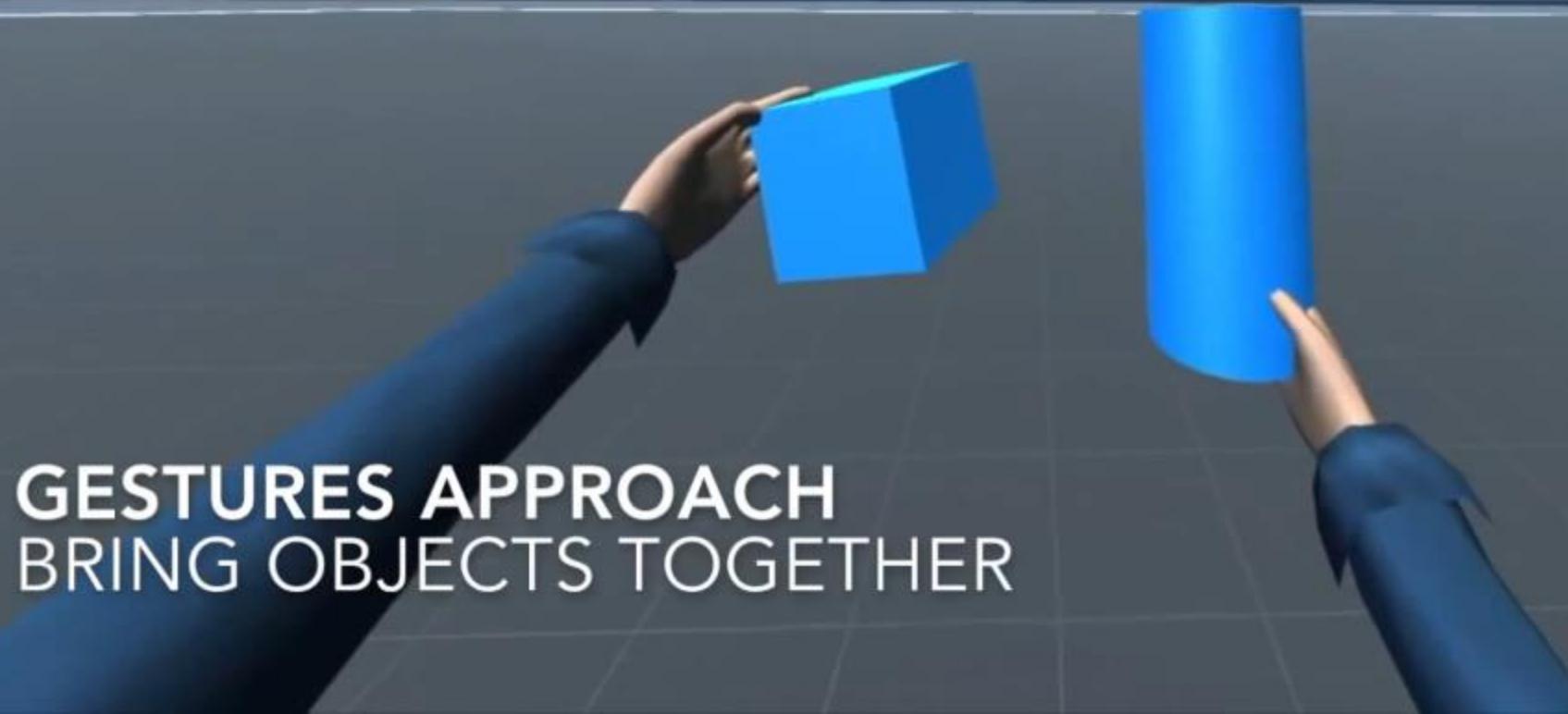


Dataglove (1987)



Marker-based Tracking (1990s)

Myo Armband (2014)



**GESTURES APPROACH**  
BRING OBJECTS TOGETHER

Orientation



Skeleton

Depth Cameras

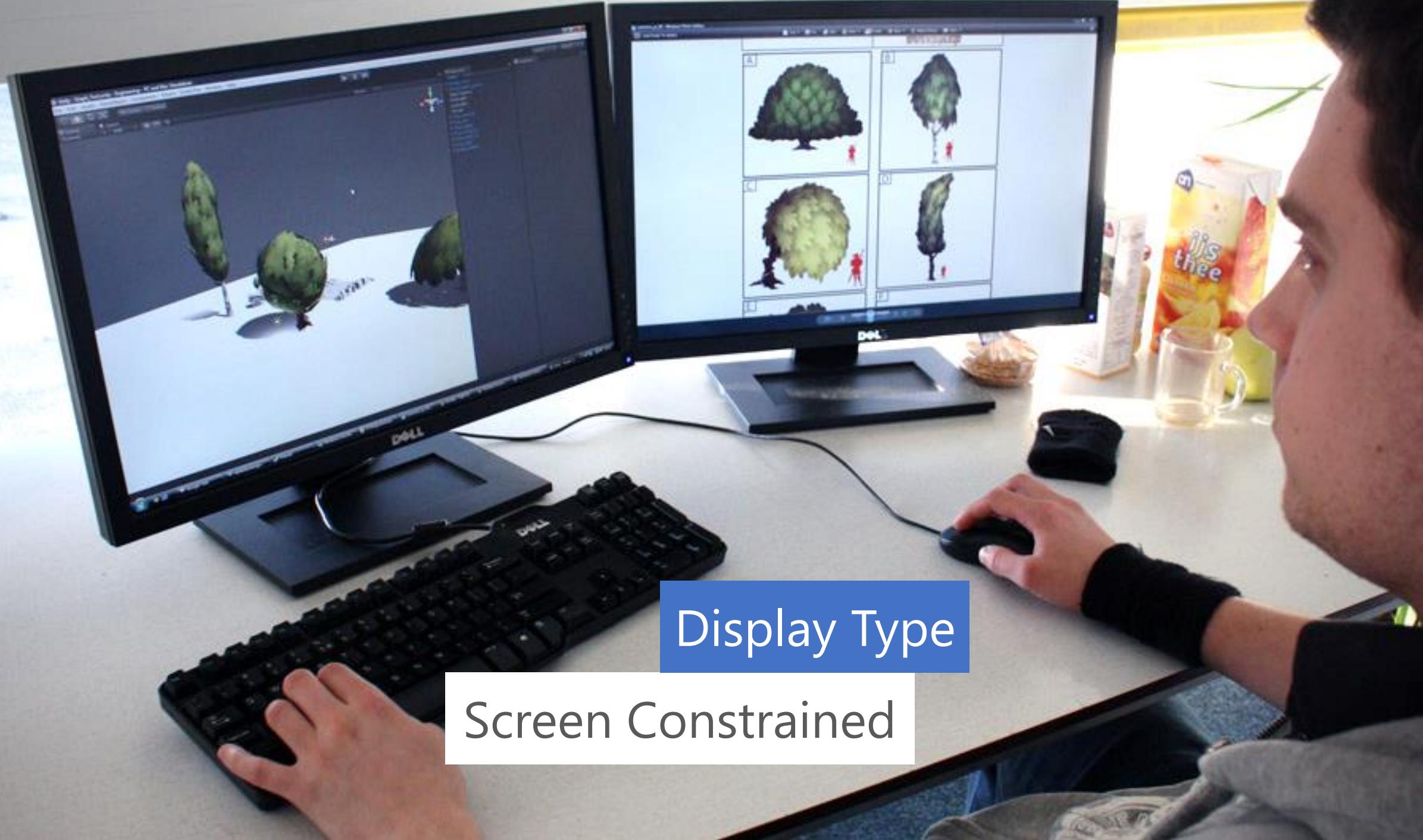
Microsoft Kinect (2010)





## Handheld Controllers

# Inputs and Outputs



Display Type

Screen Constrained

Display Type

Stereo Window





Display Type

Reality Replacement

## Multiple Input Modalities

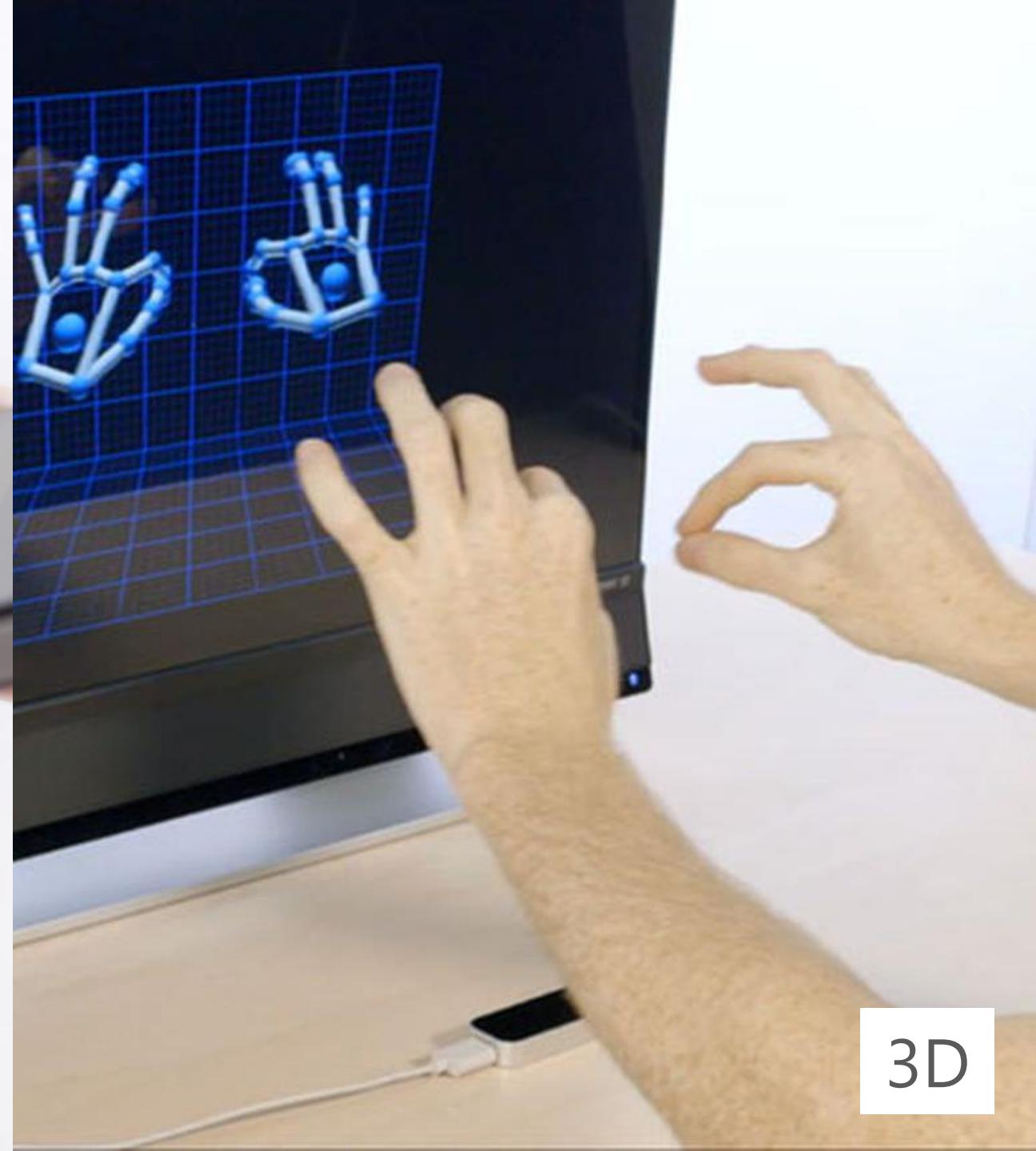


Focus on hand-based techniques

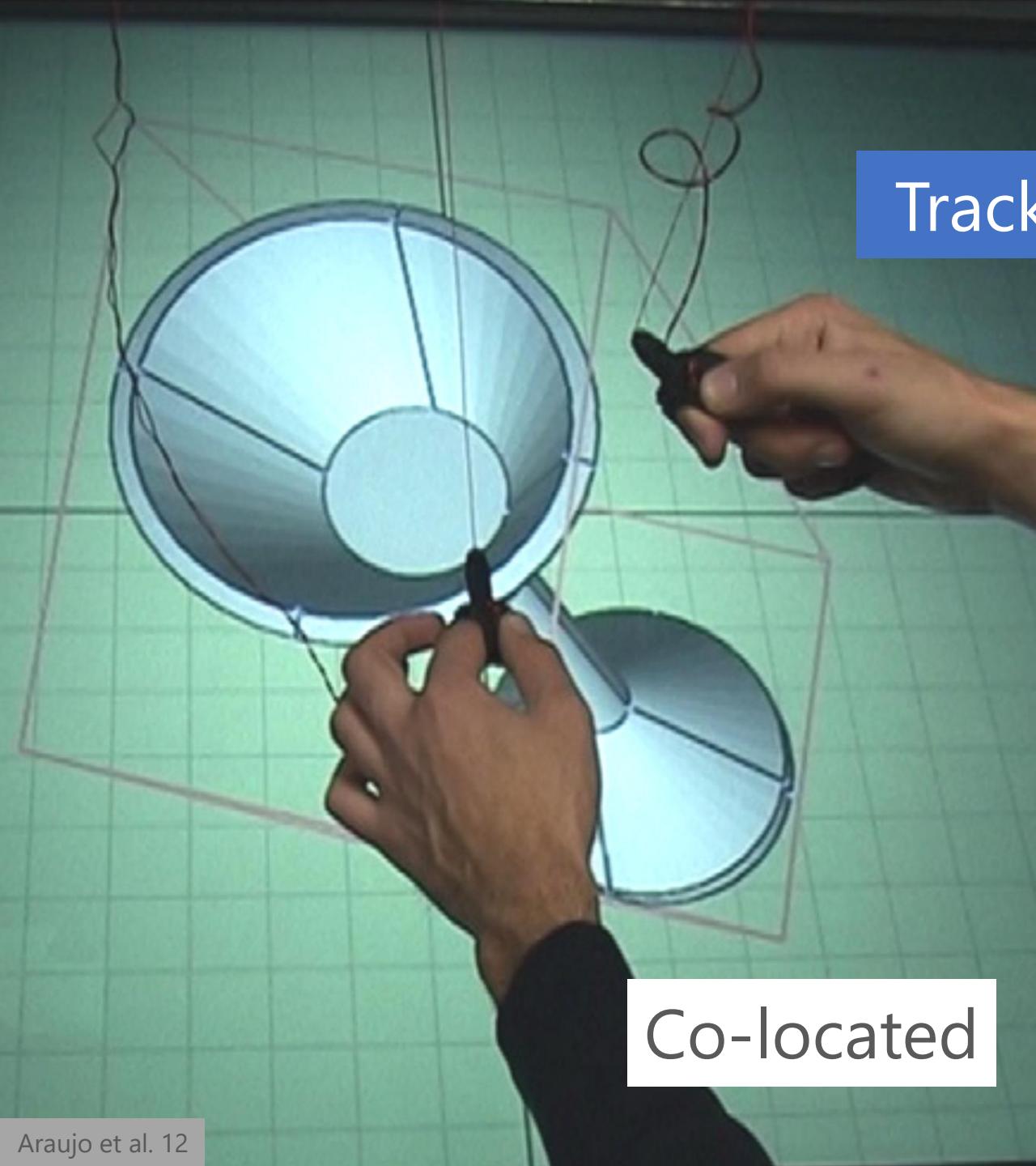
# Tracking Dimensionality



2D

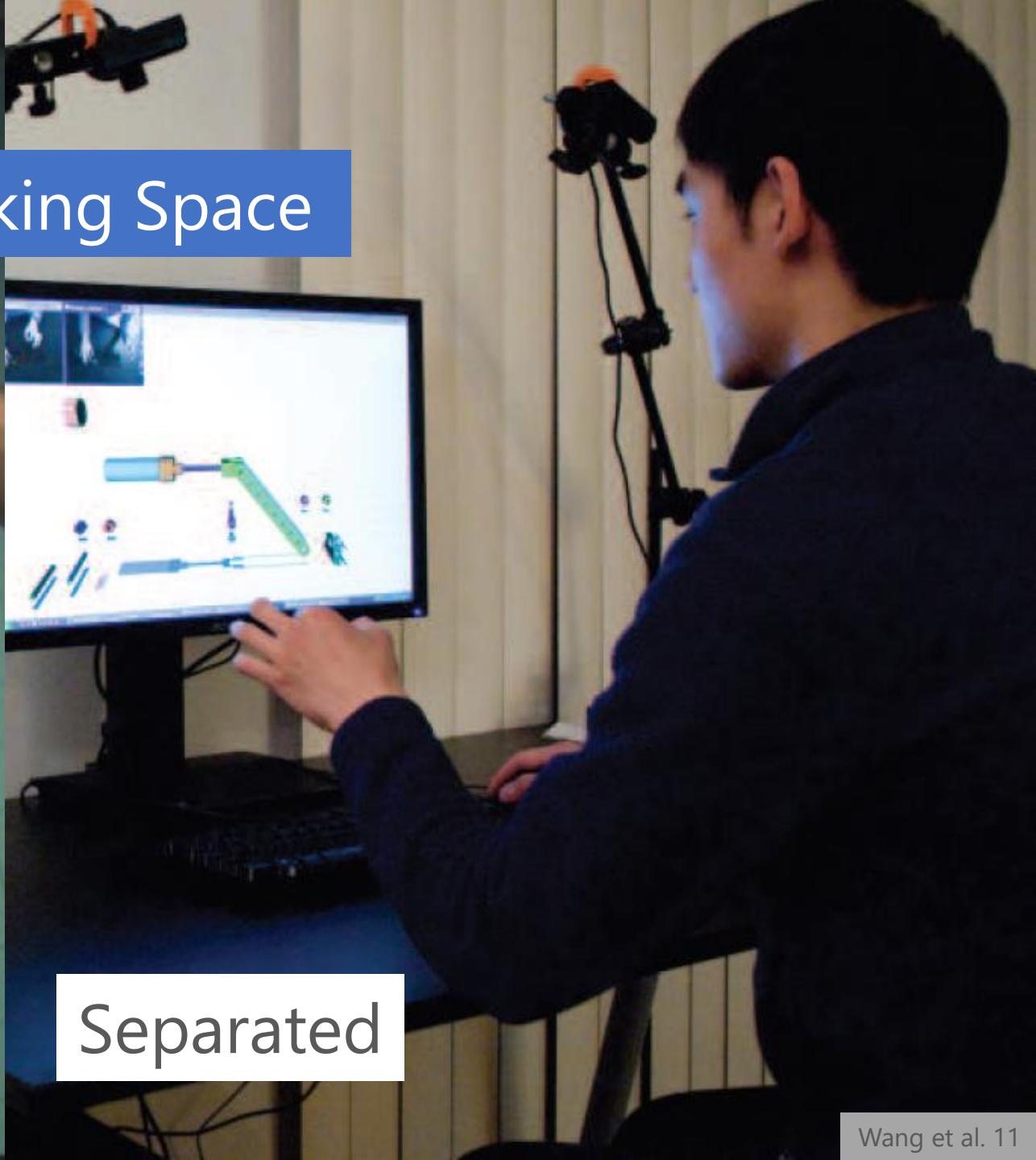


3D



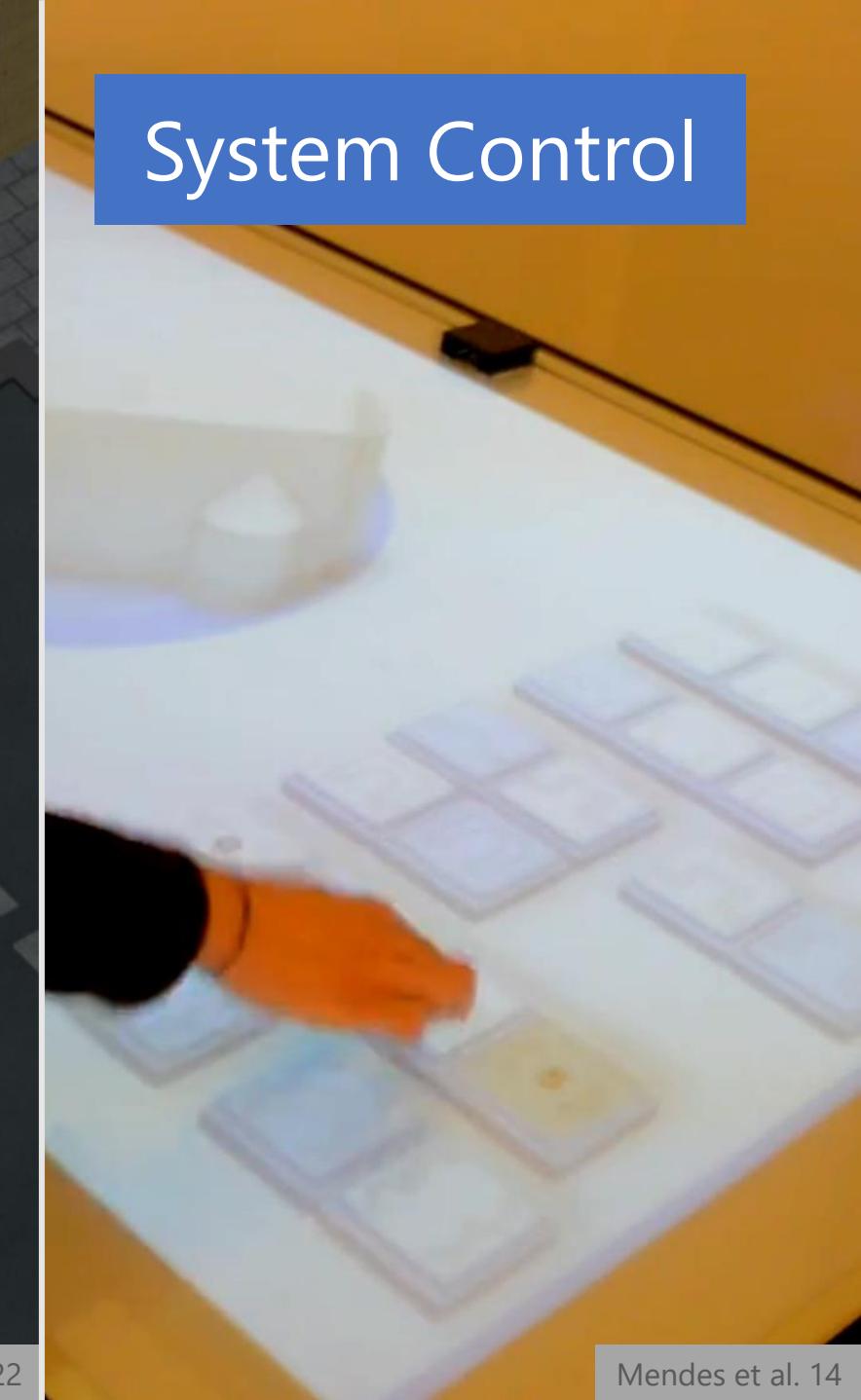
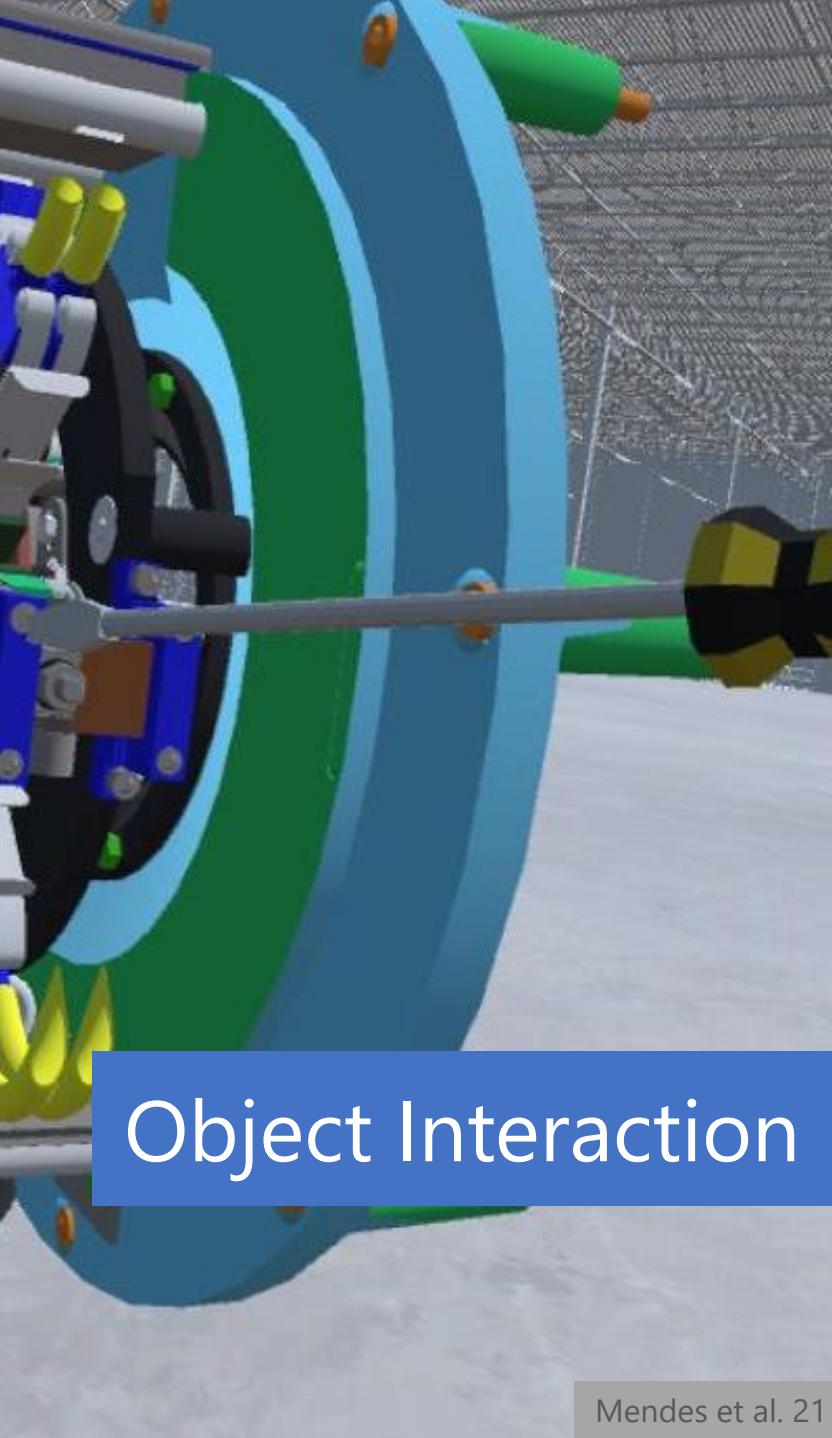
Co-located

Tracking Space



Separated

# Universal 3D Interaction Tasks



# Object Interaction



## Selection

Specifying one or more objects from a set



## Manipulation

Modifying object properties  
position, orientation, scale, shape,  
color, texture, behavior, etc.



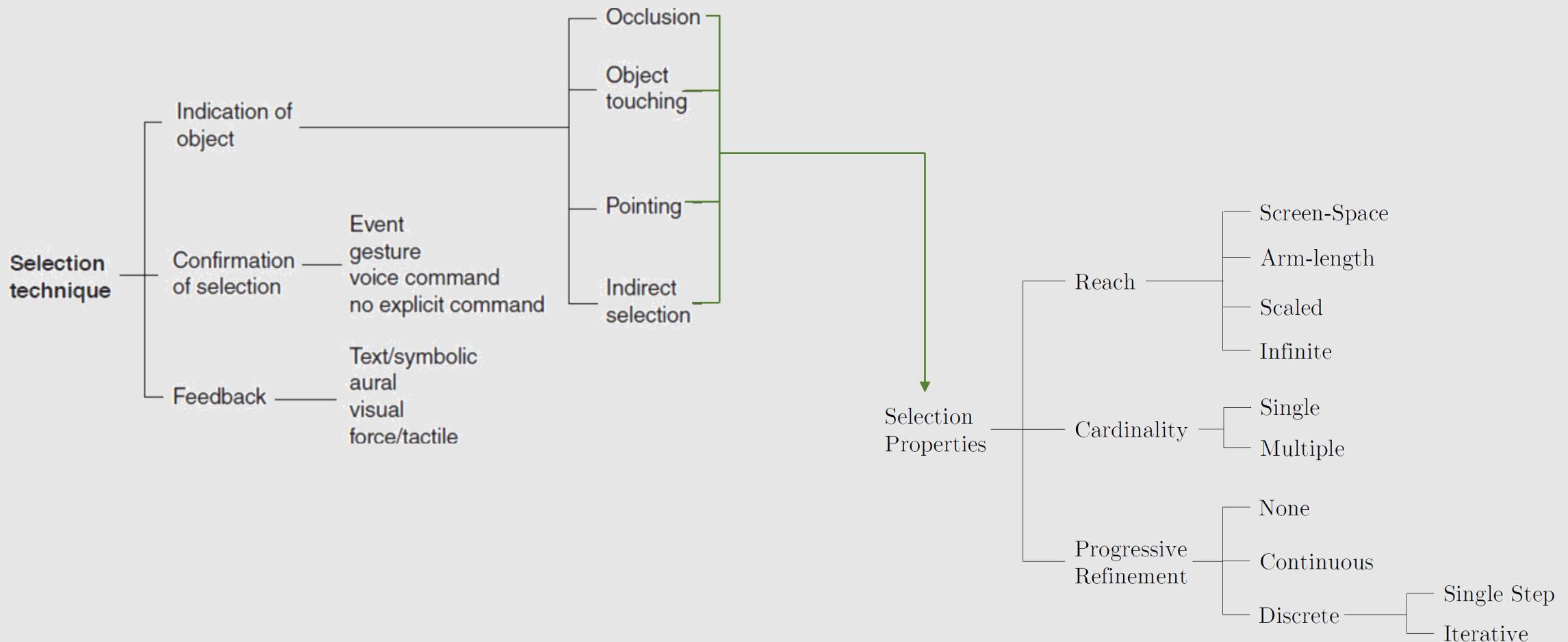
## Release

Deselecting the object

# Selection

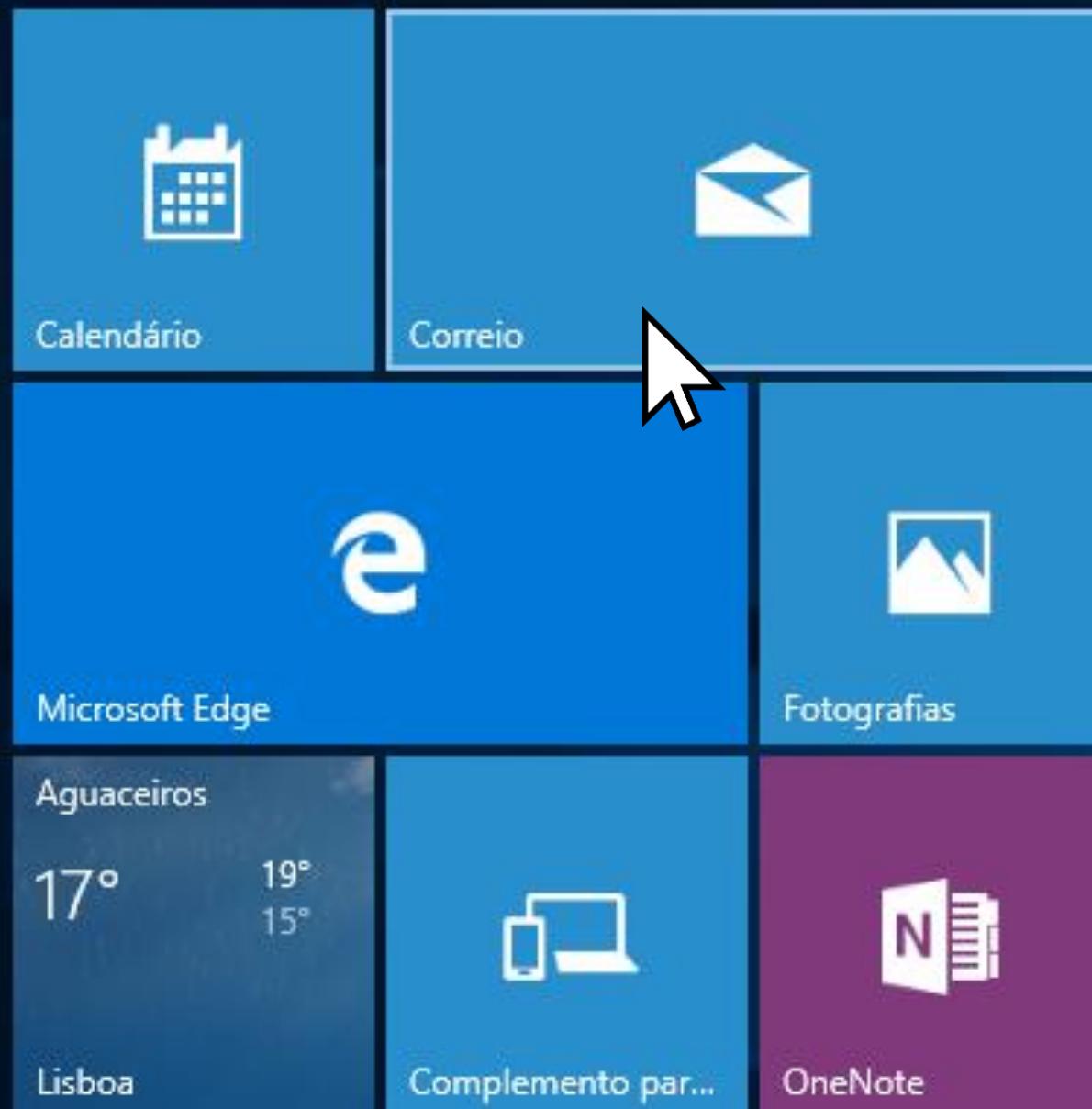


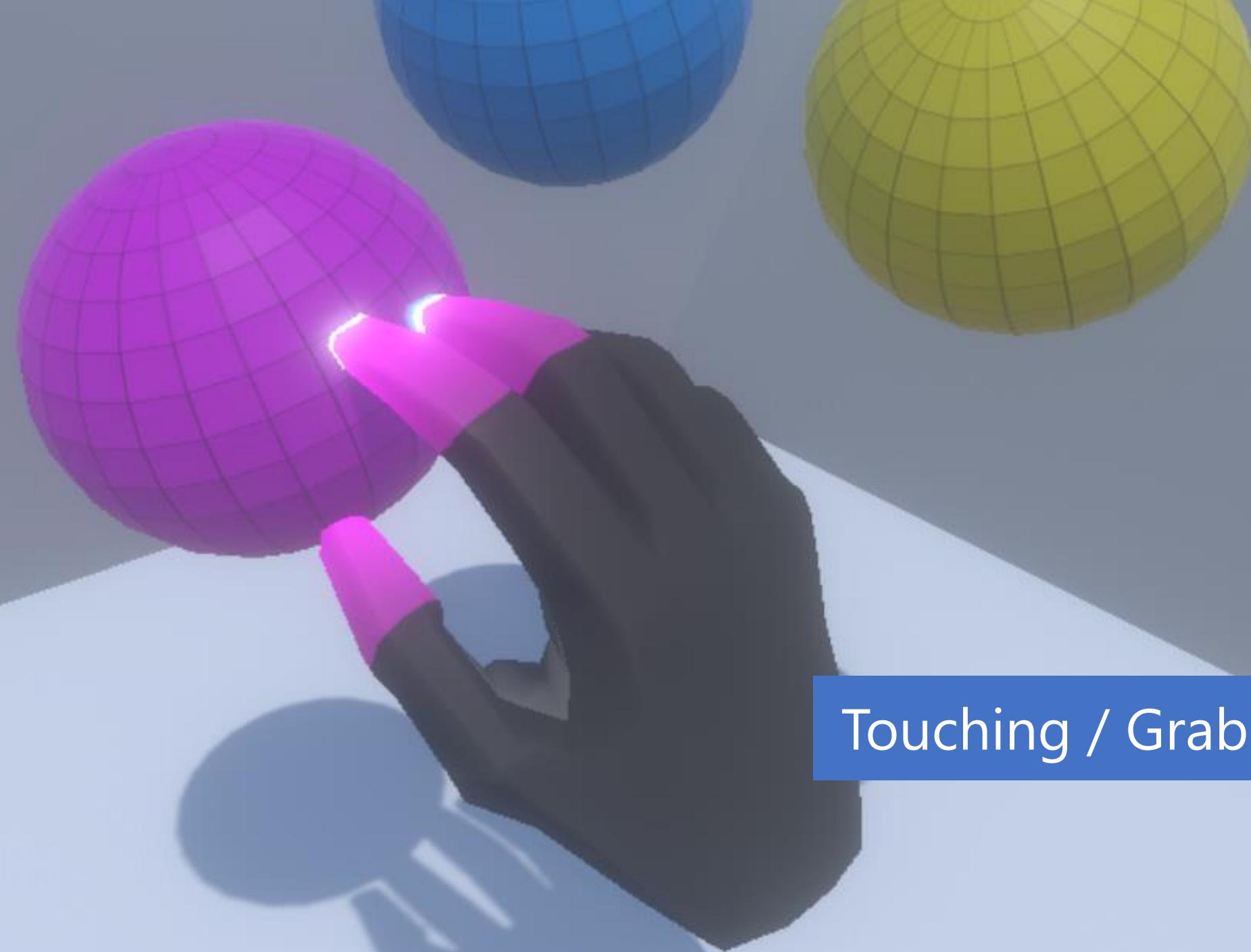
# Selection Taxonomies



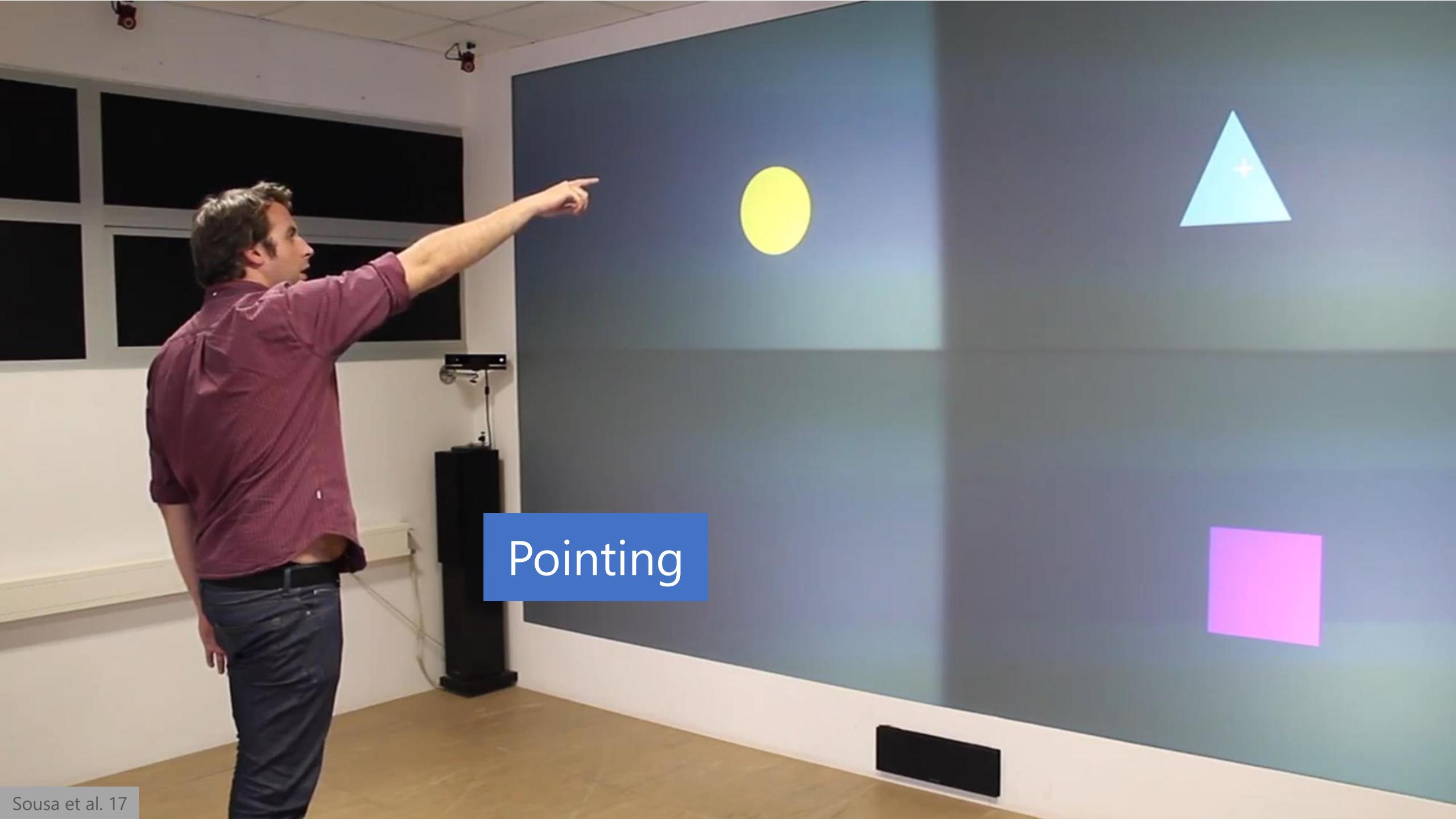
Life at a glance

# Occlusion

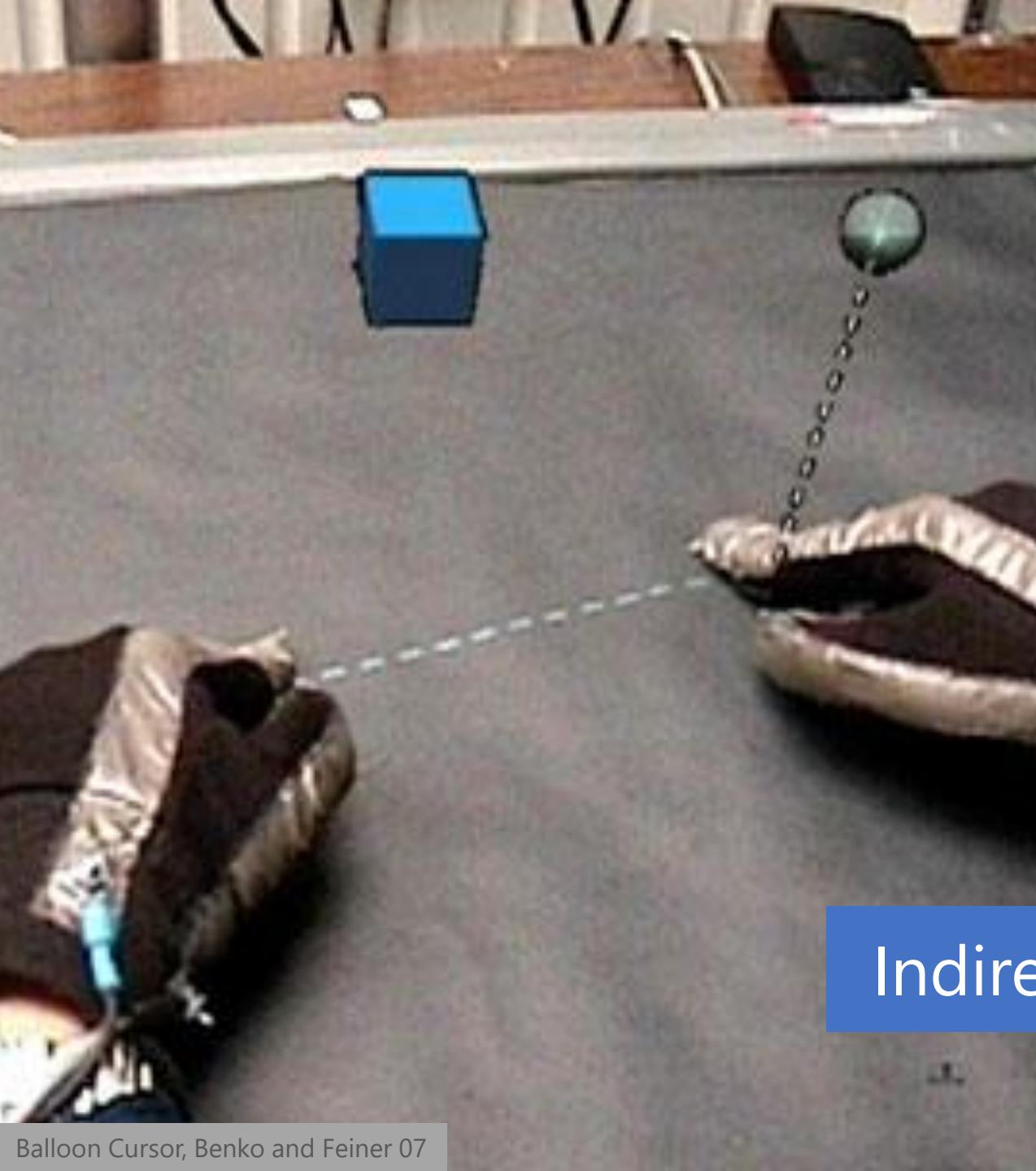




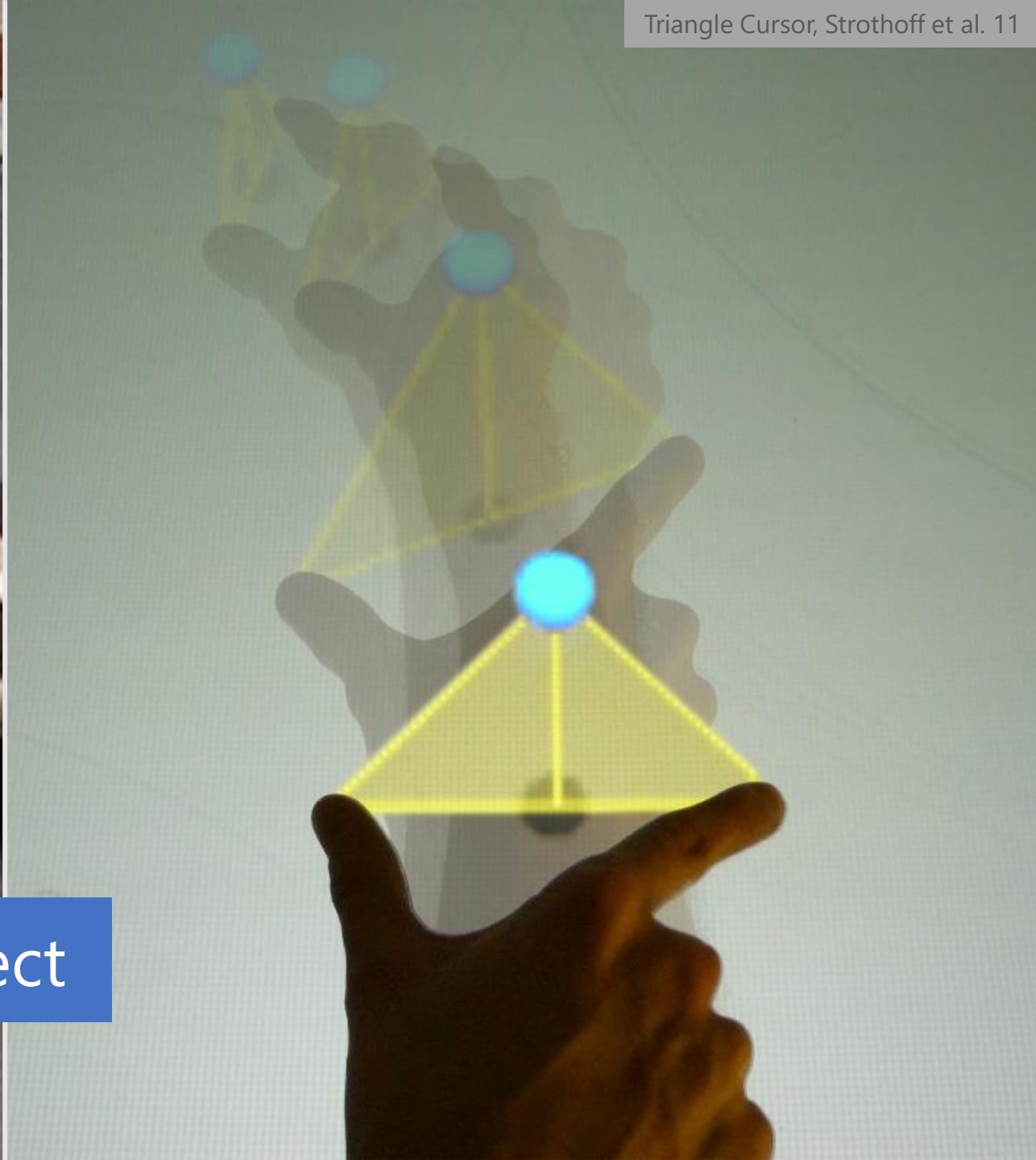
Touching / Grabbing



Pointing



Balloon Cursor, Benko and Feiner 07



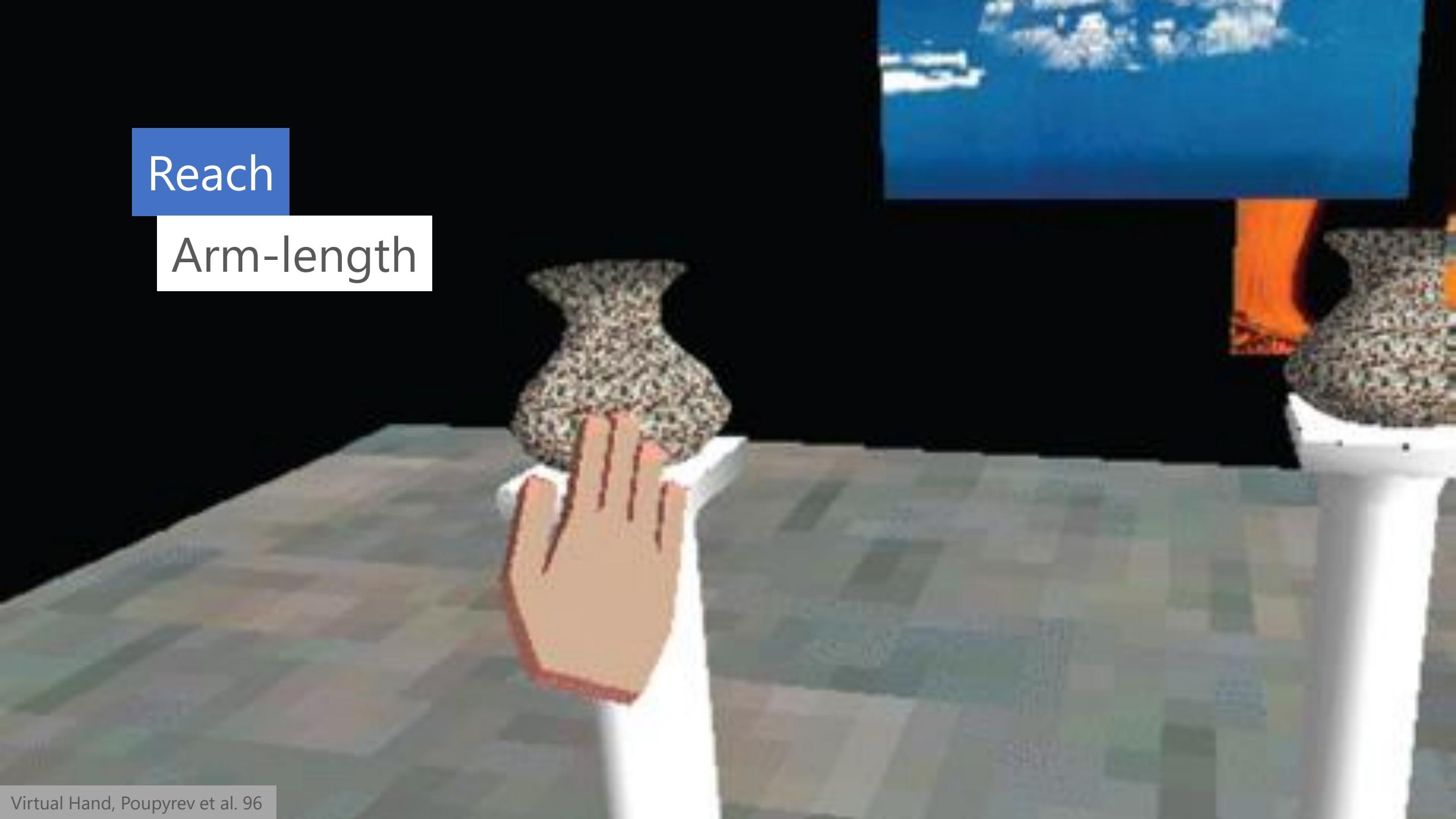


Reach

Screen-Space

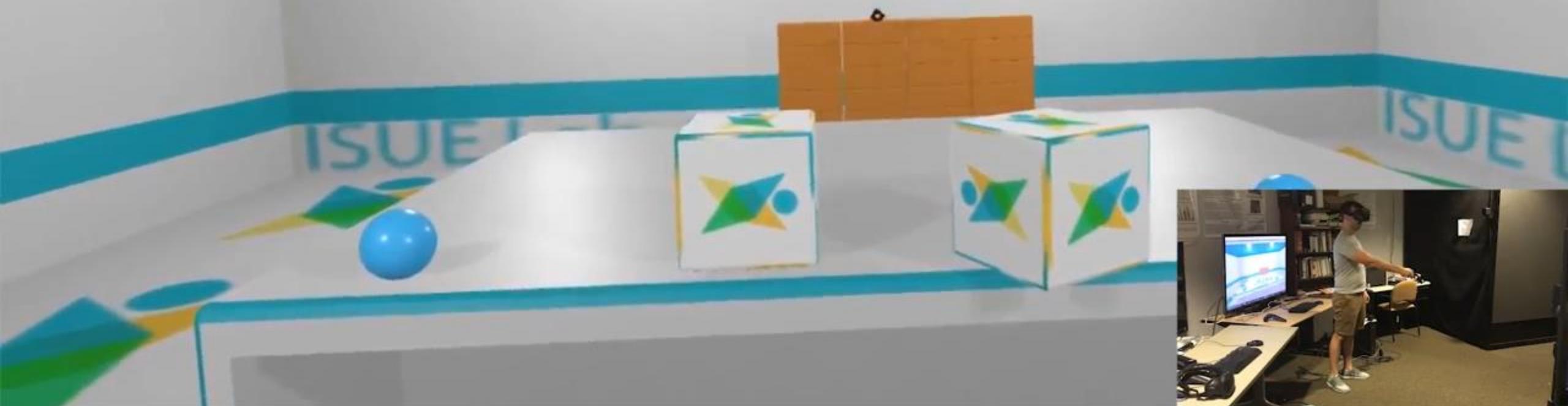
Reach

Arm-length



Reach

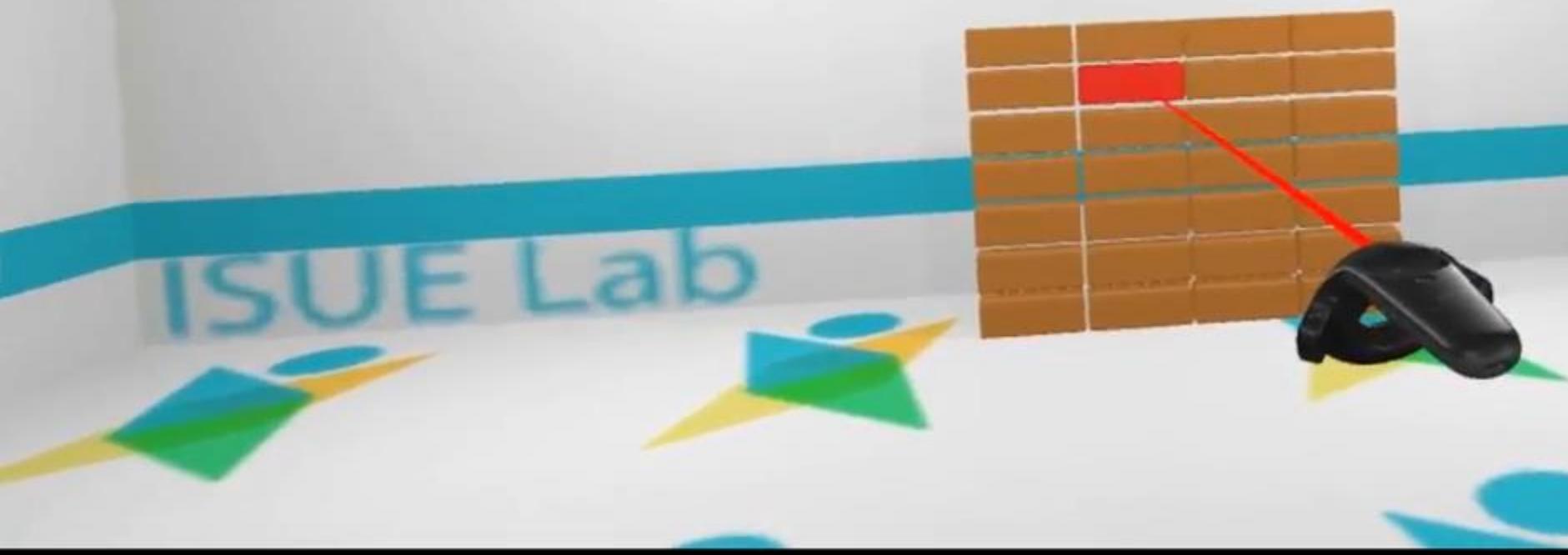
Scaled



Reach  
Infinite



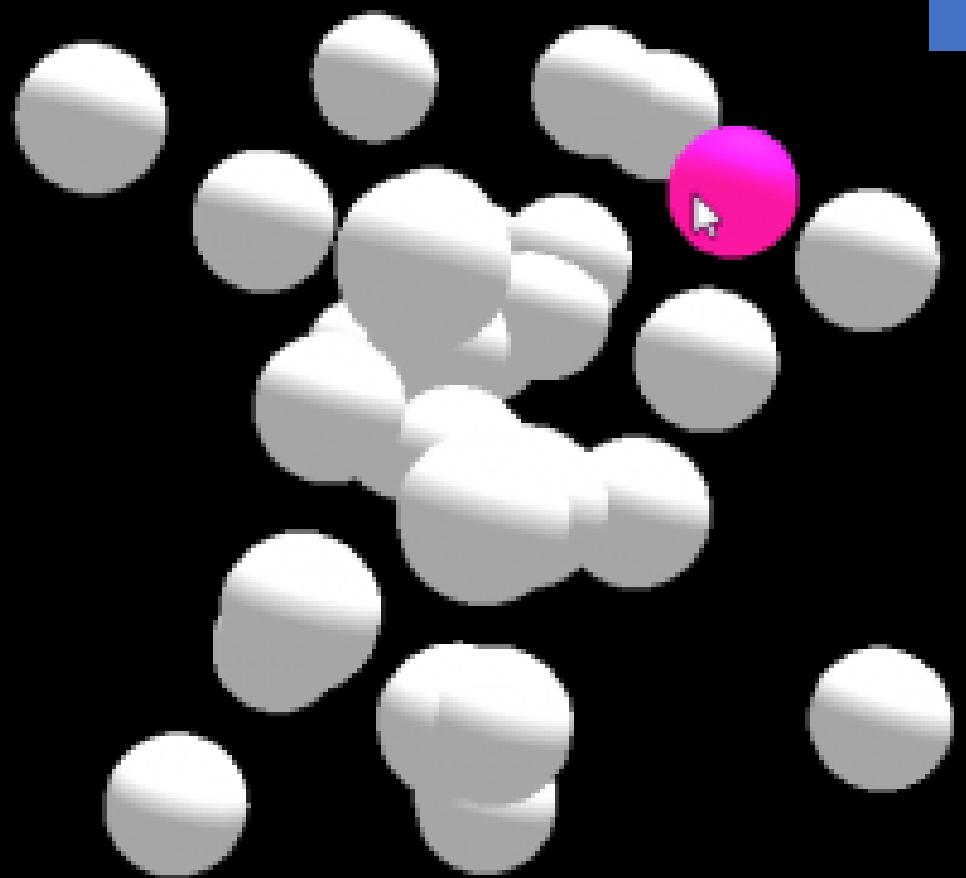
Reach  
Infinite



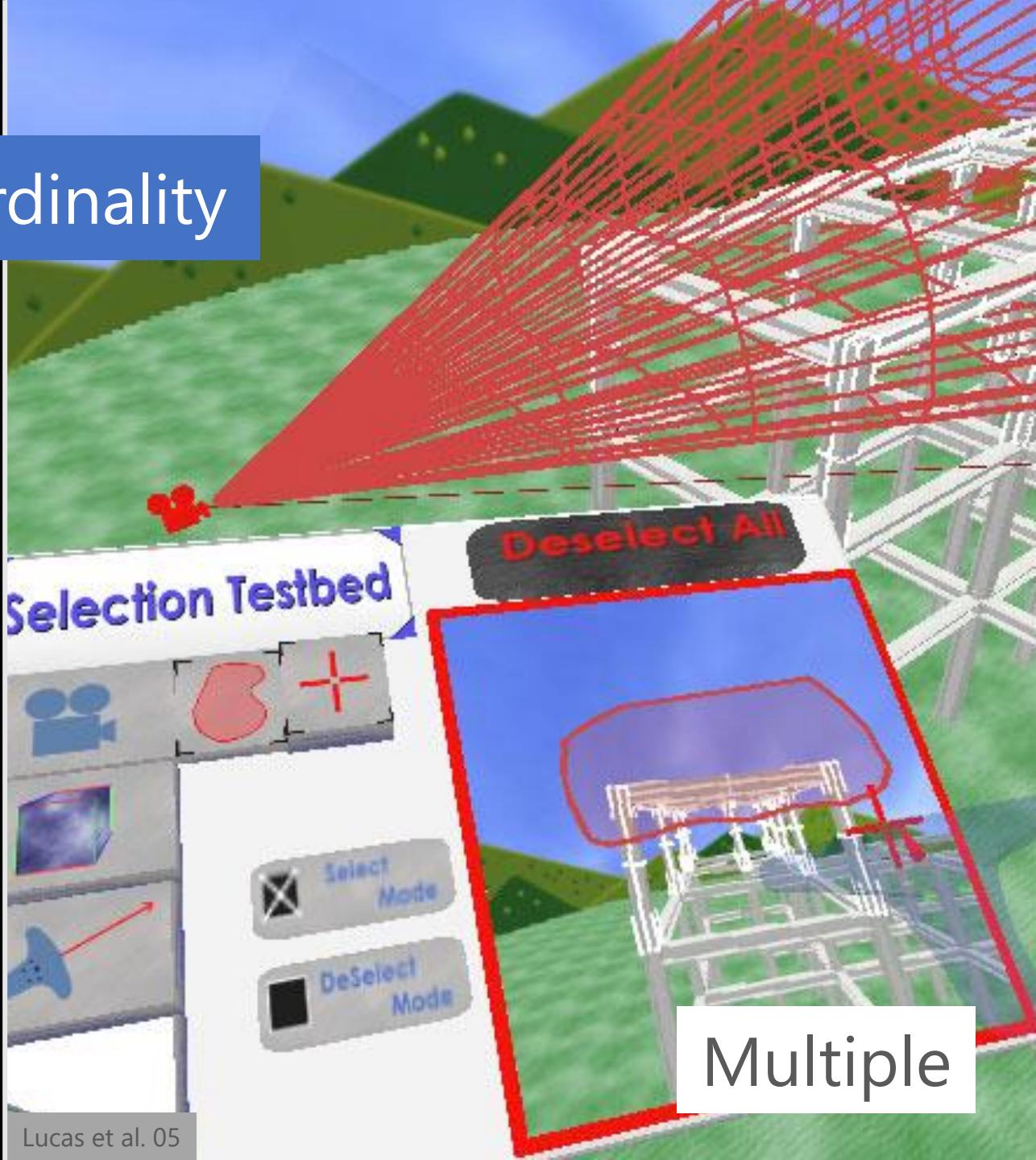


Reach  
Infinite

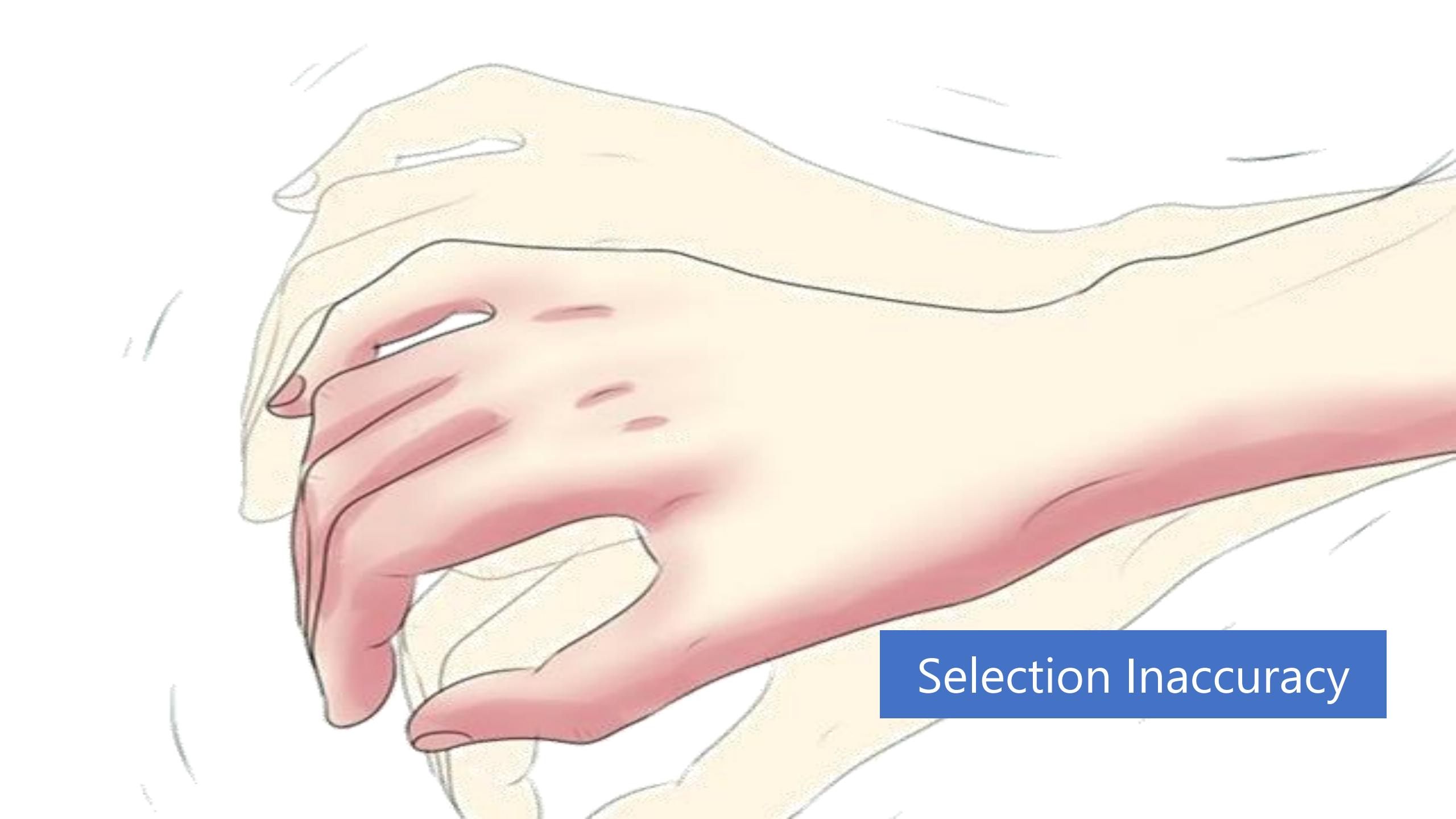
# Cardinality



Single



Multiple



Selection Inaccuracy

# Progressive Refinement

Group of interest

Desambiguation

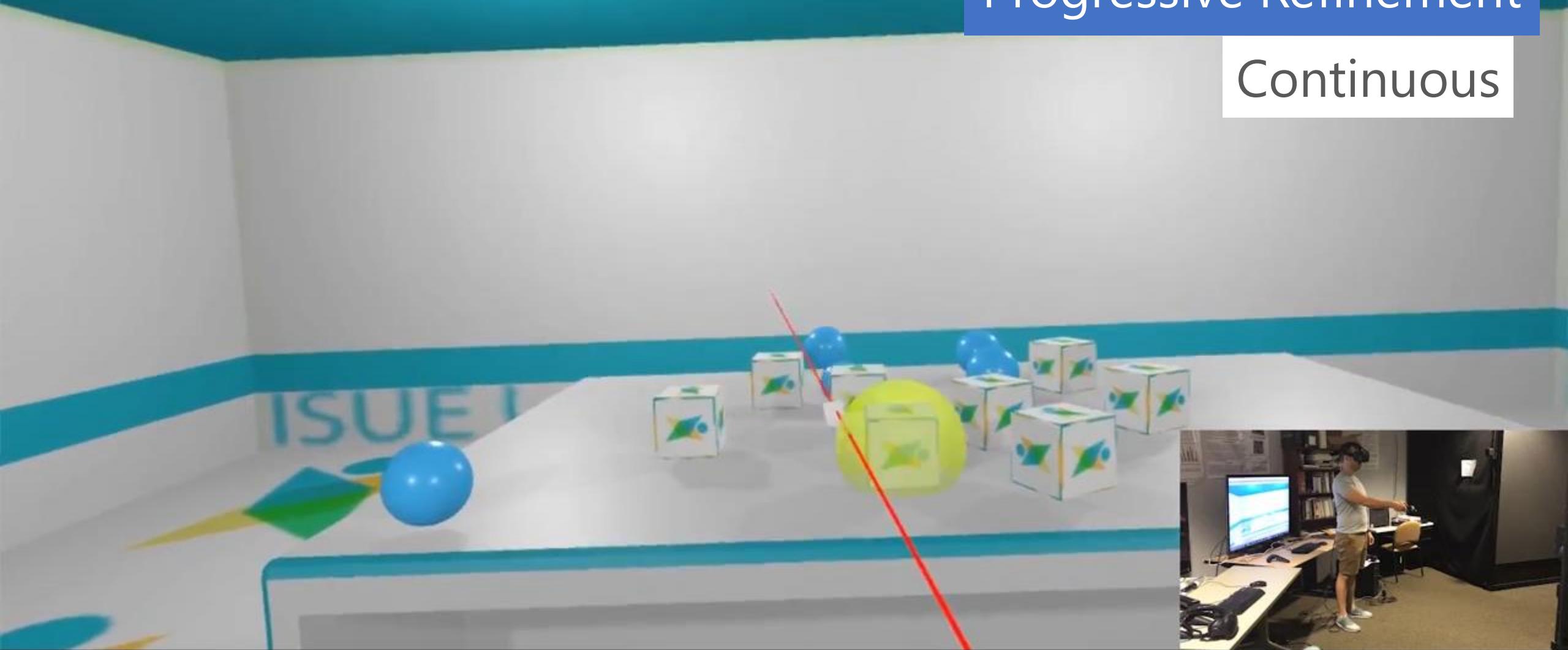
# Progressive Refinement



Continuous

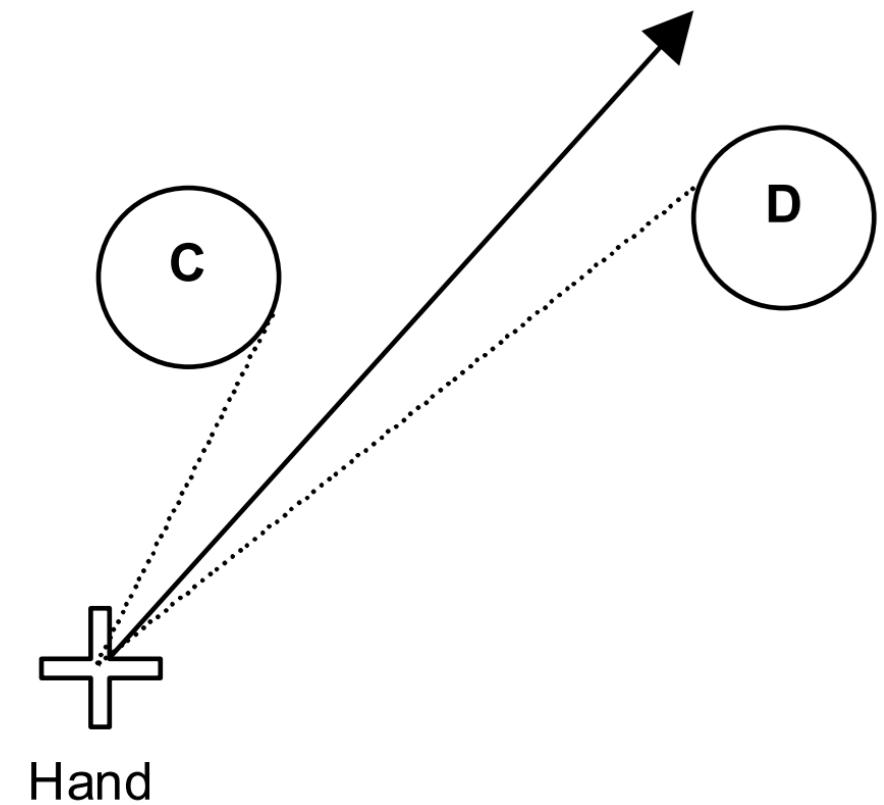
# Progressive Refinement

## Continuous



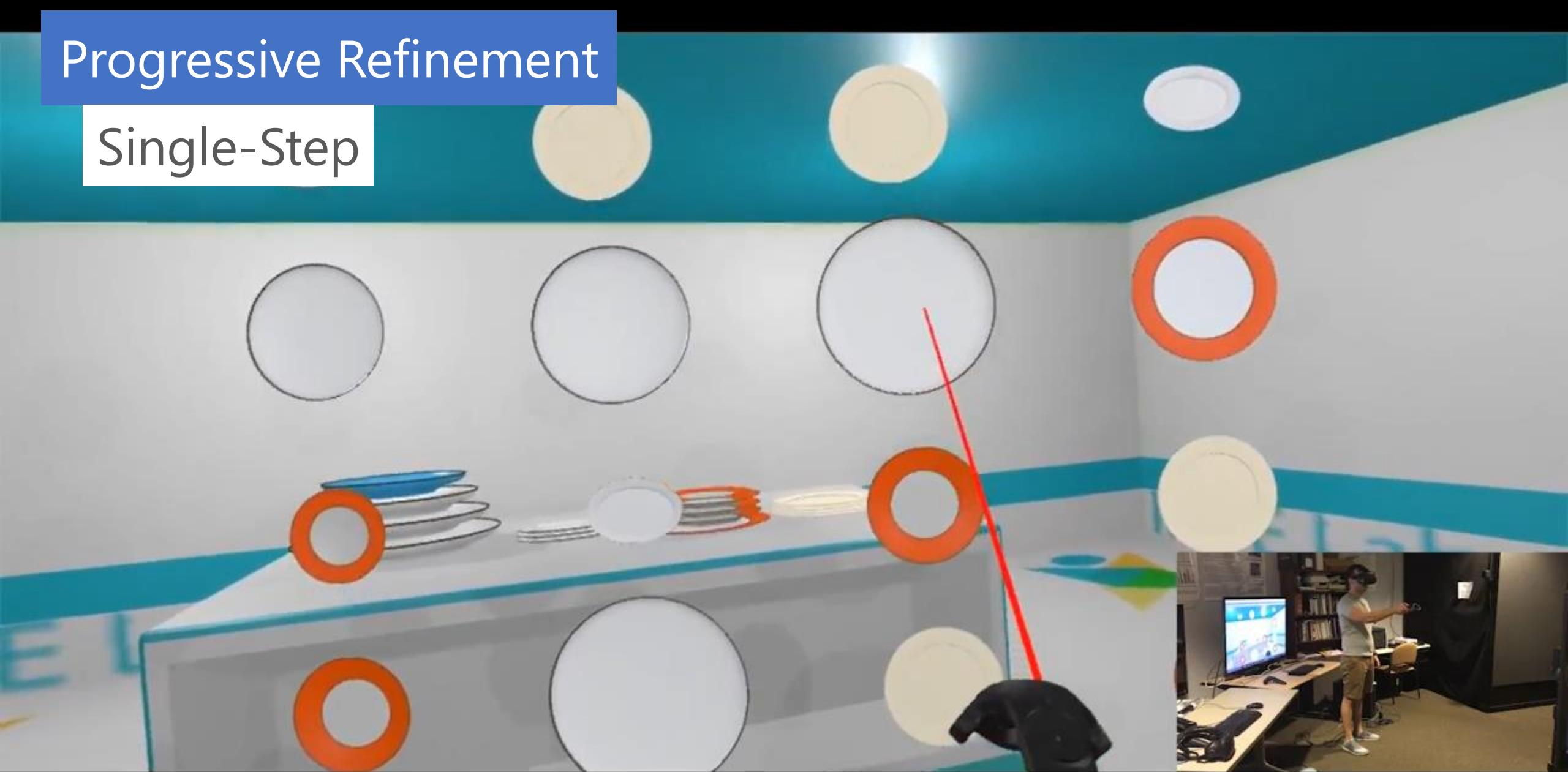
# Progressive Refinement

## Single-Step



# Progressive Refinement

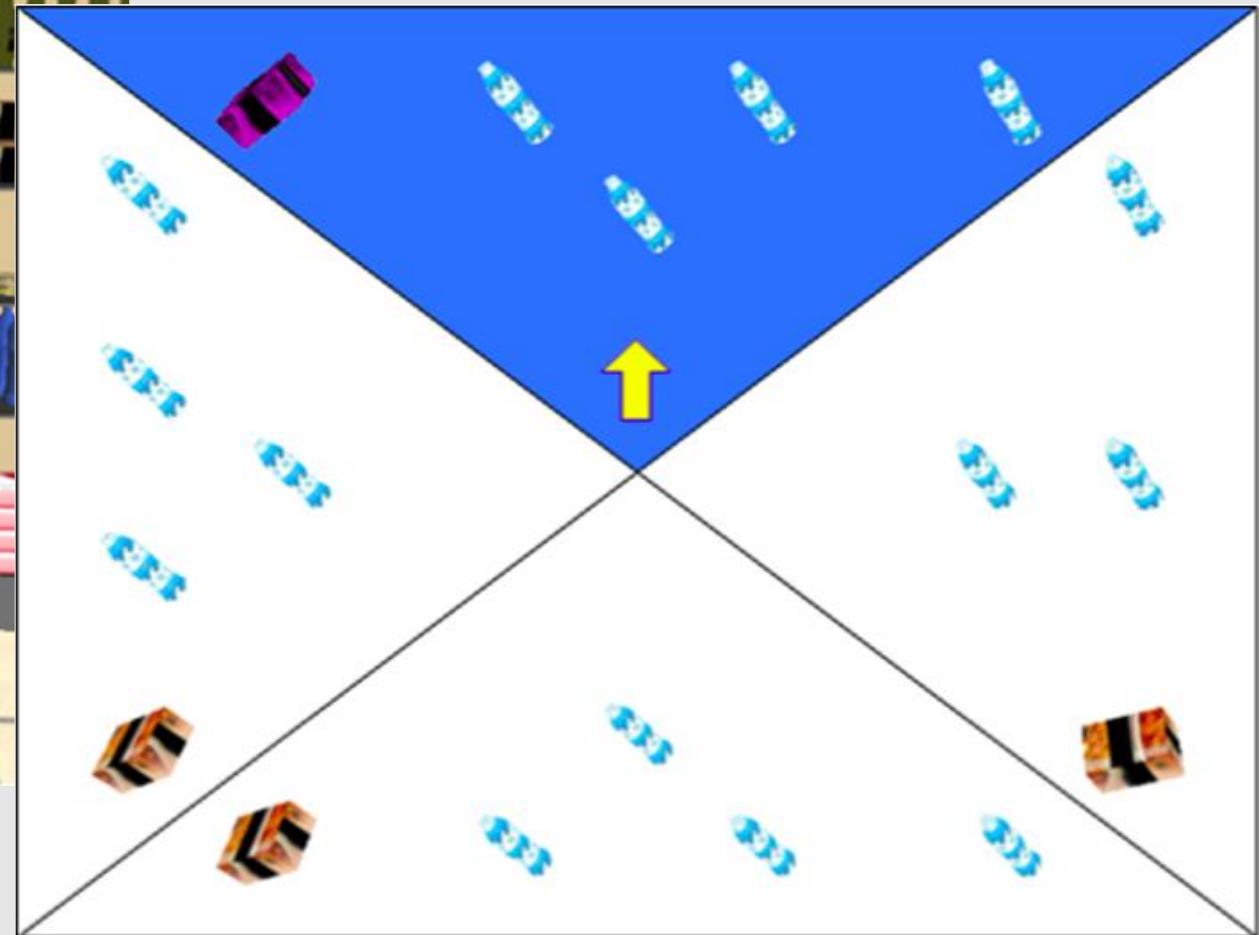
## Single-Step



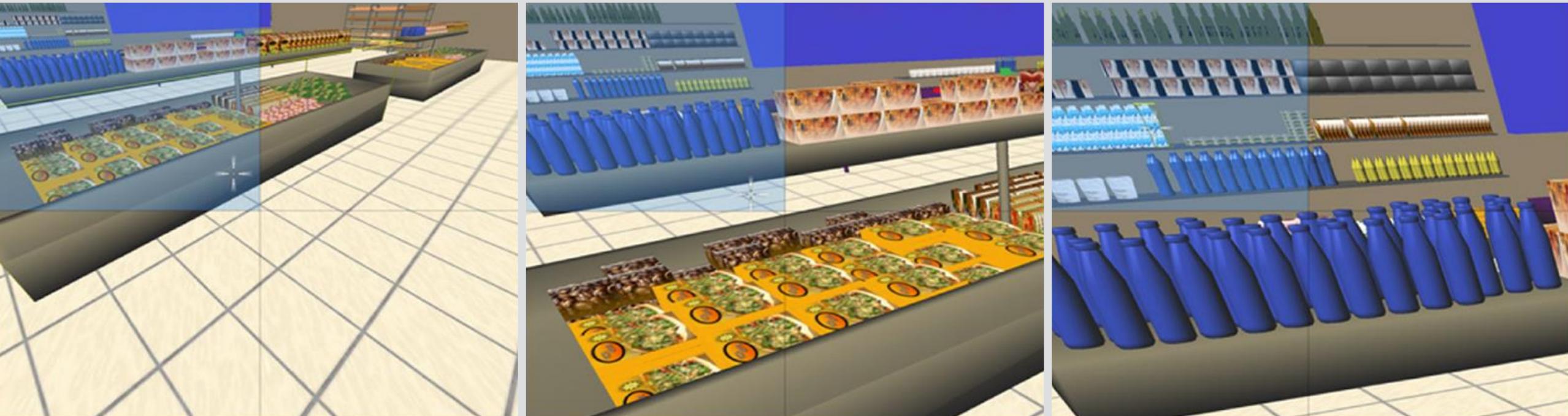
# Progressive Refinement



Iterative



# Progressive Refinement

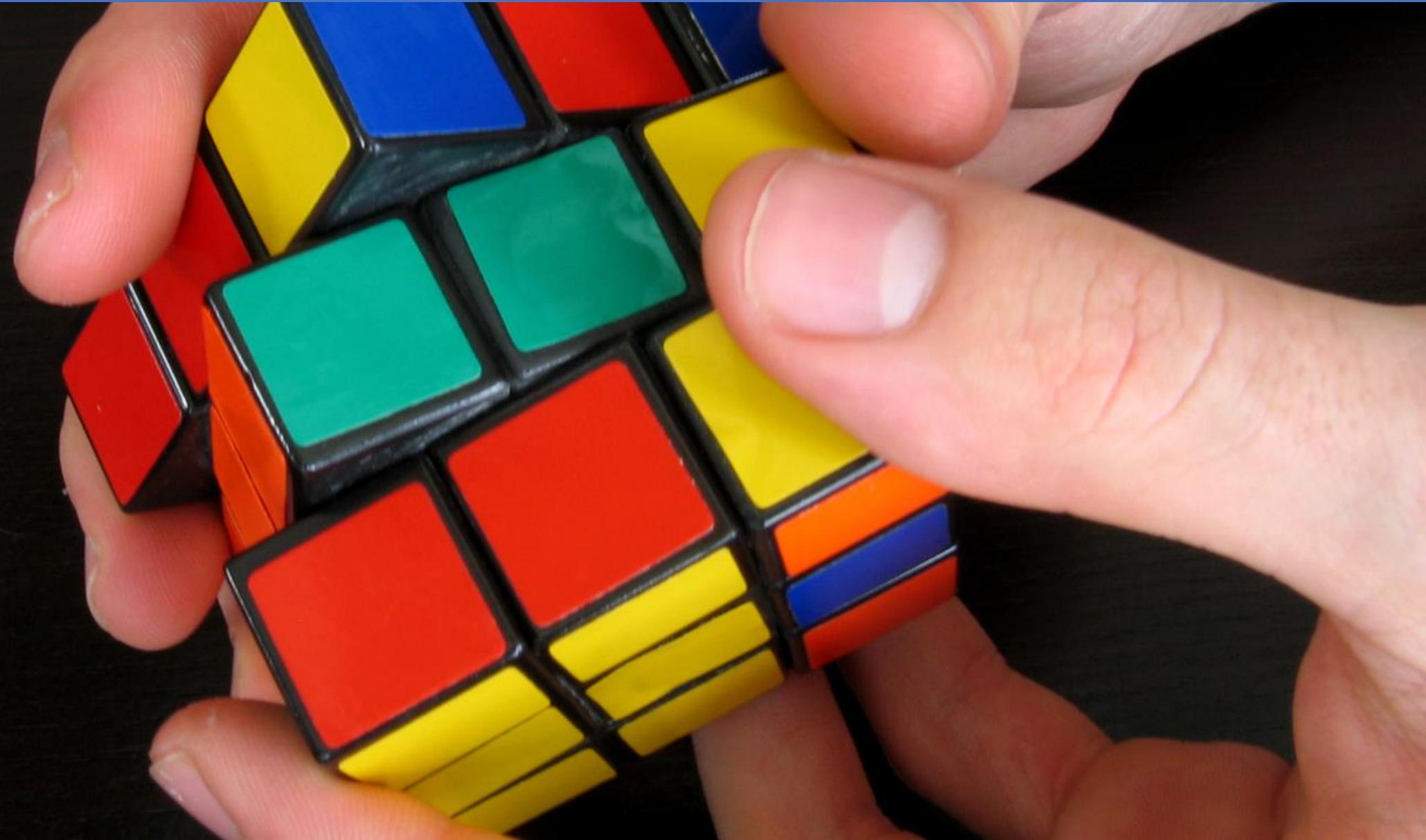


Iterative

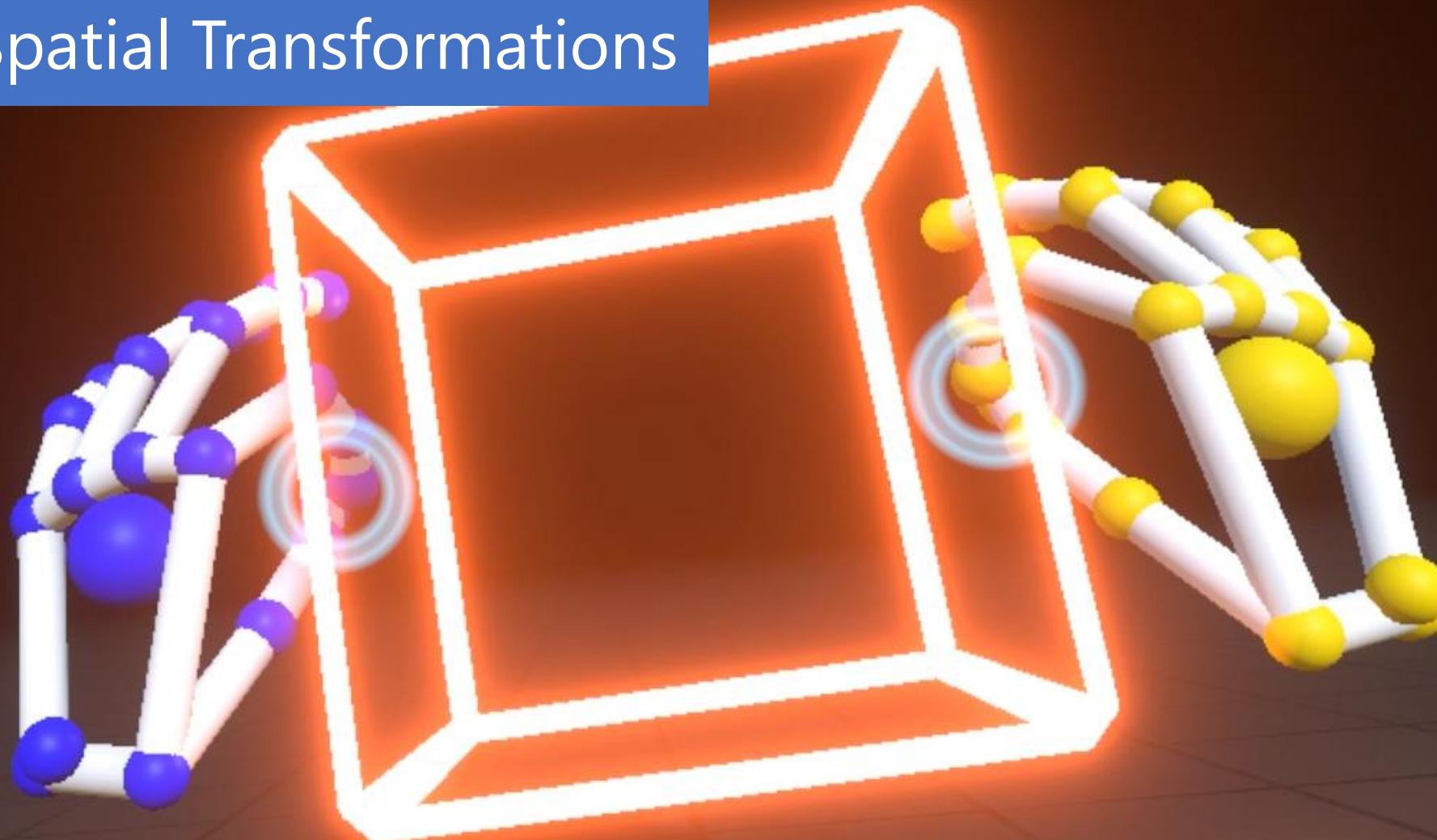


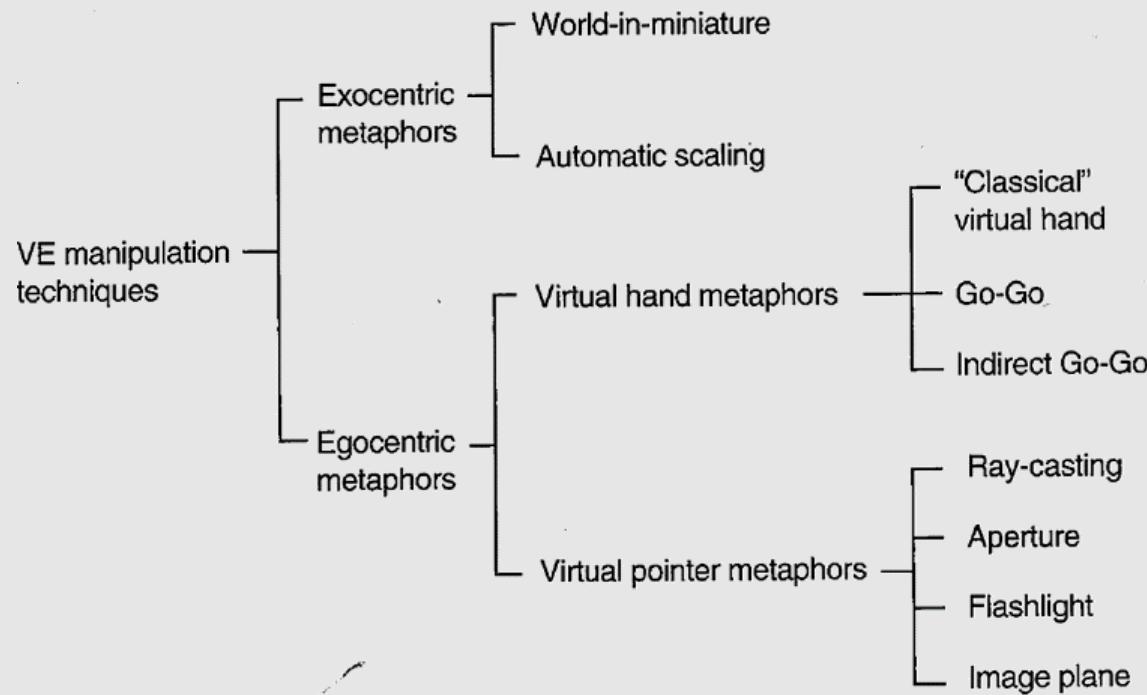
Iterative  
Progressive Refinement

# Manipulation

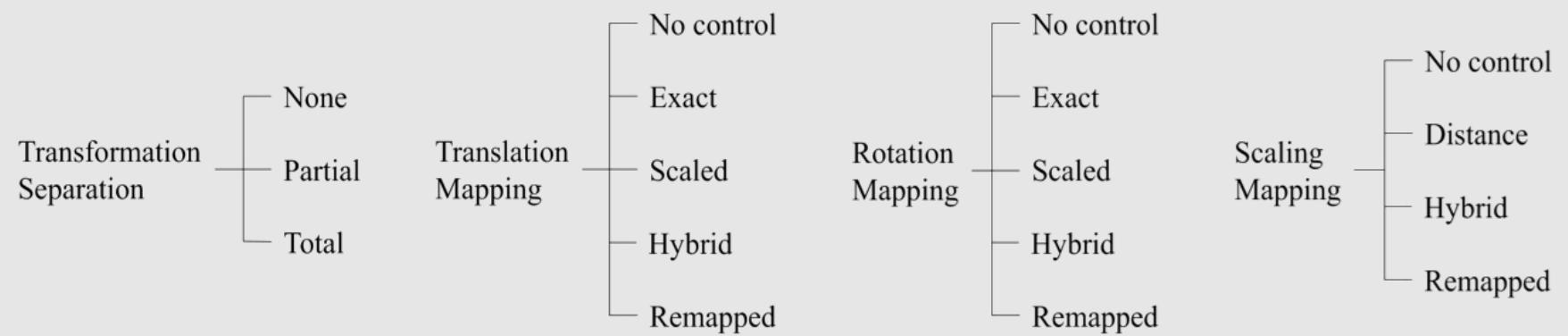


# Basic Spatial Transformations





## Manipulation Taxonomies

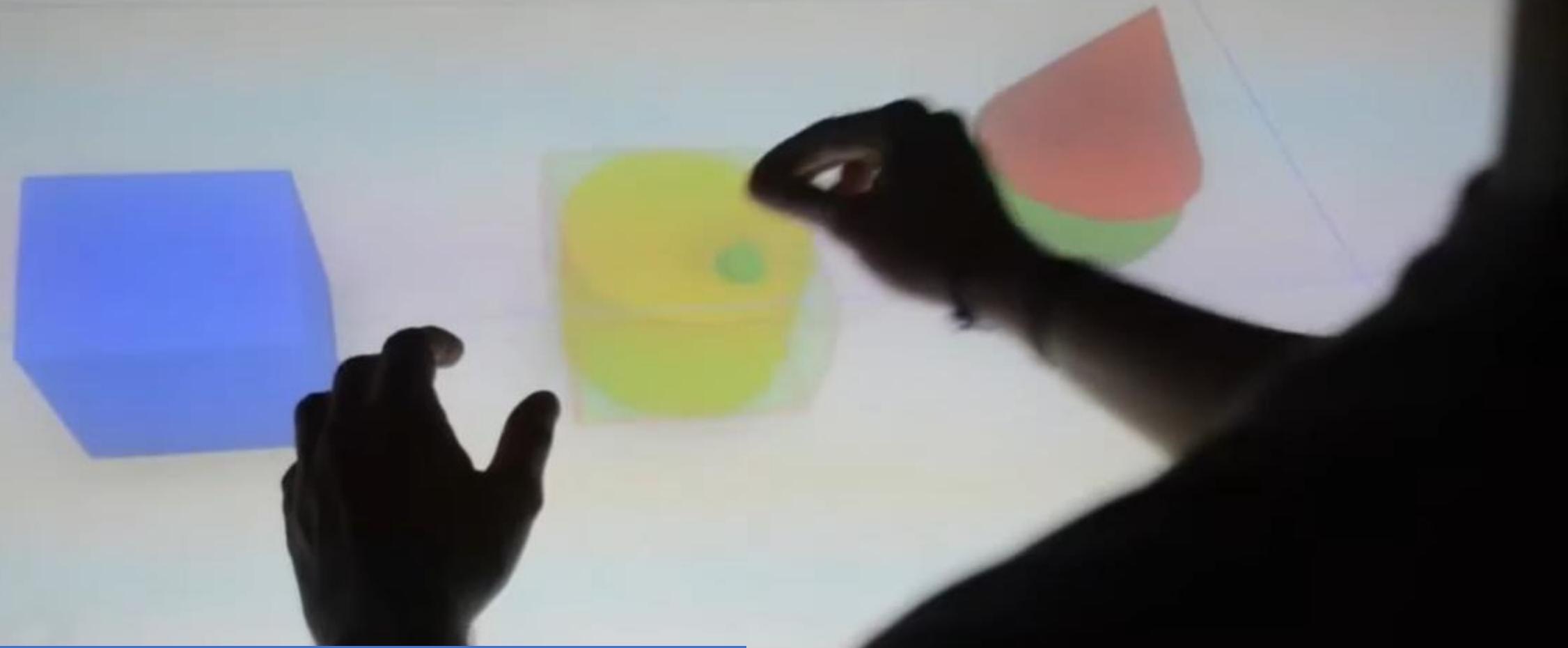




Exocentric Metaphor

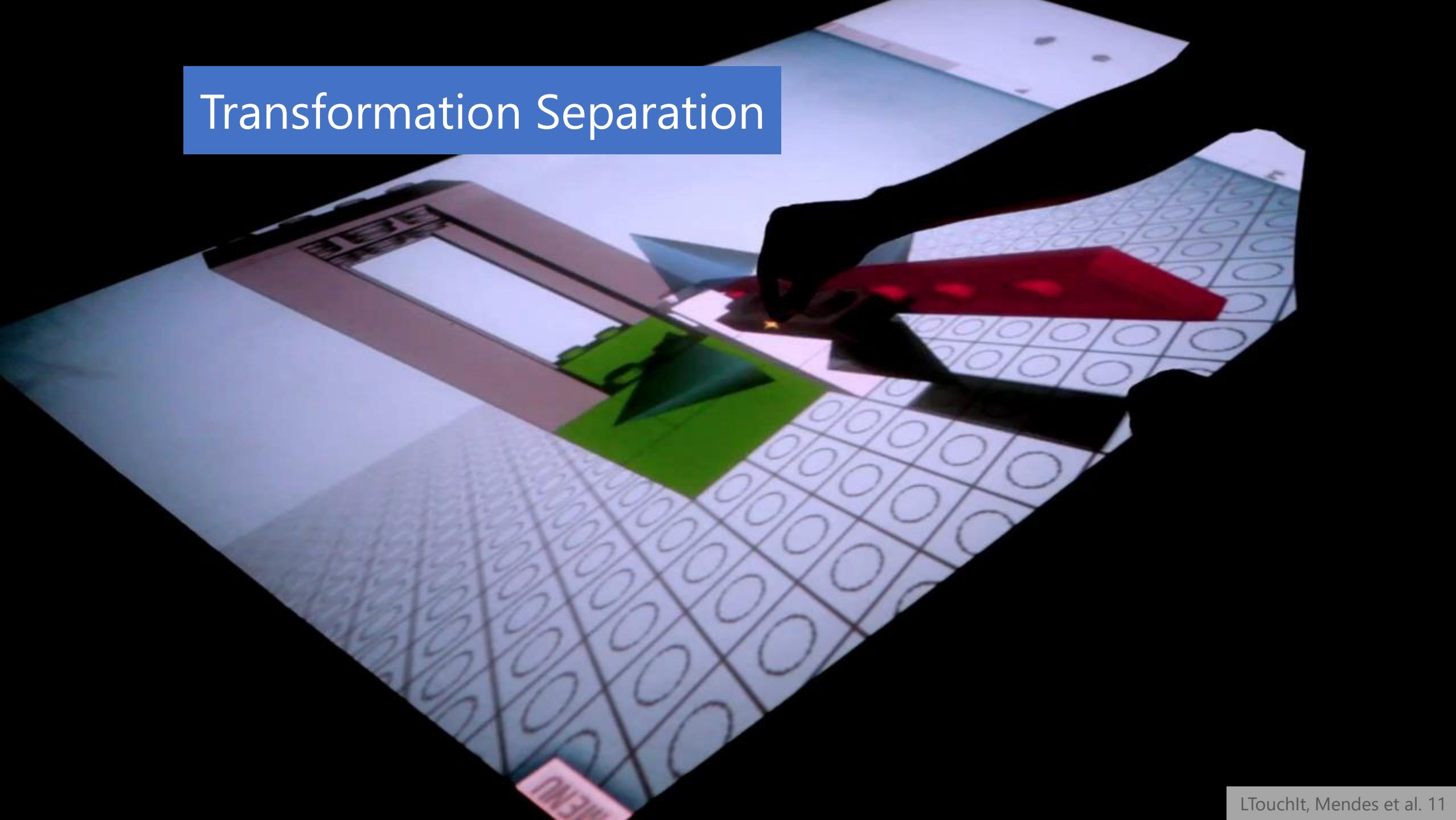


Egocentric Metaphor

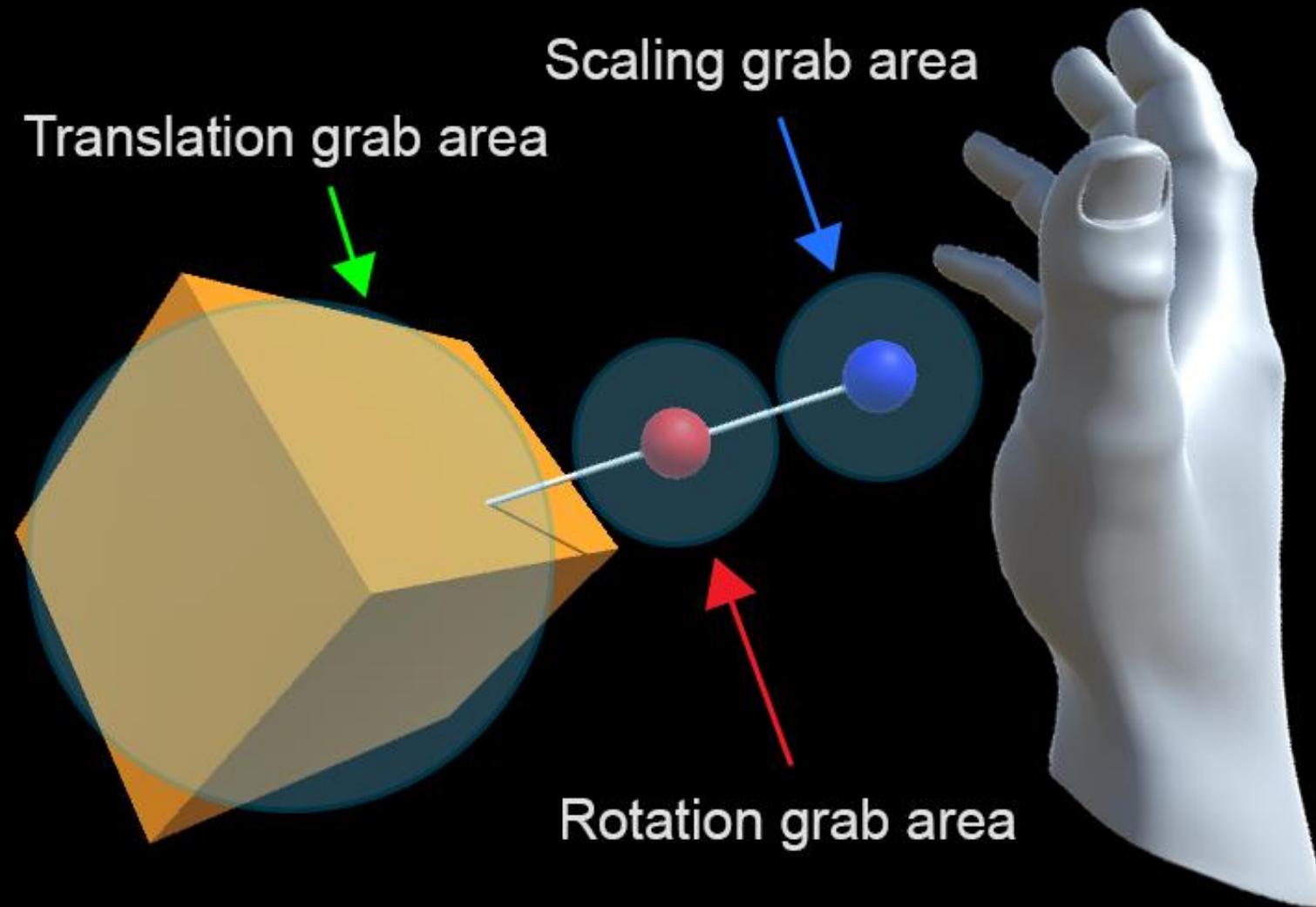


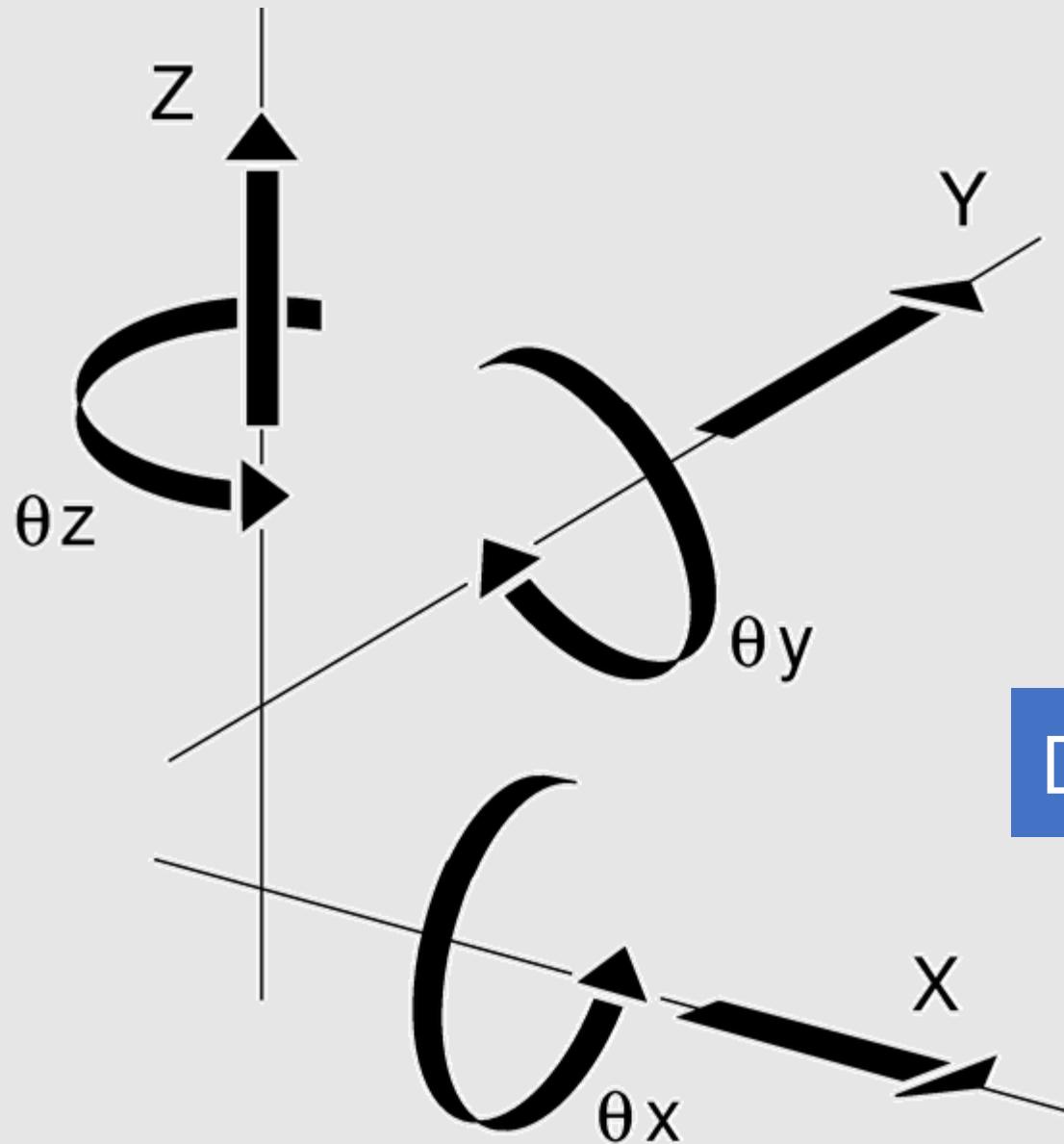
Simultaneous Transformations

# Transformation Separation



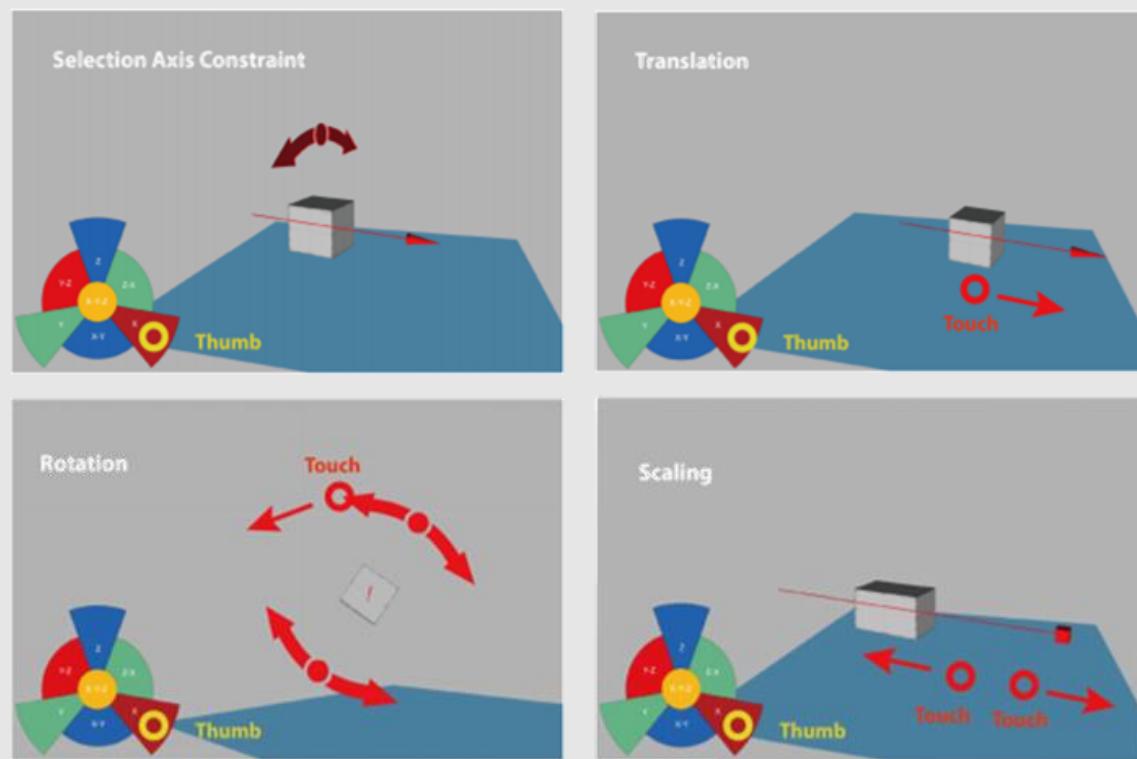
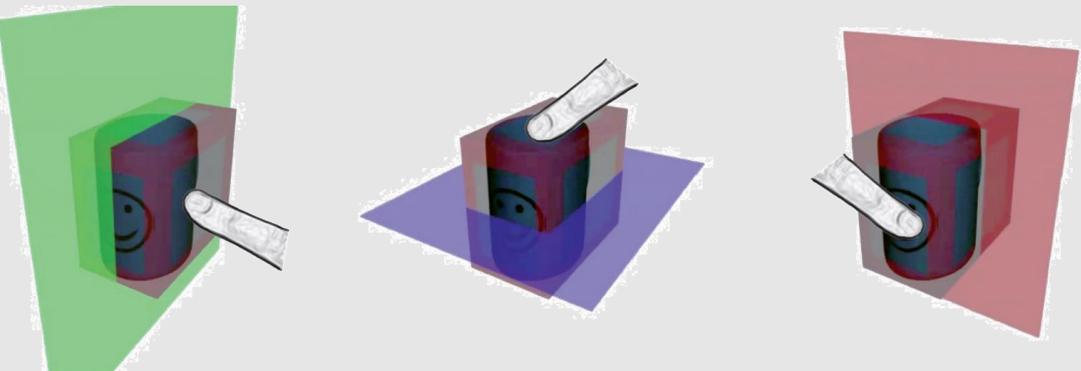
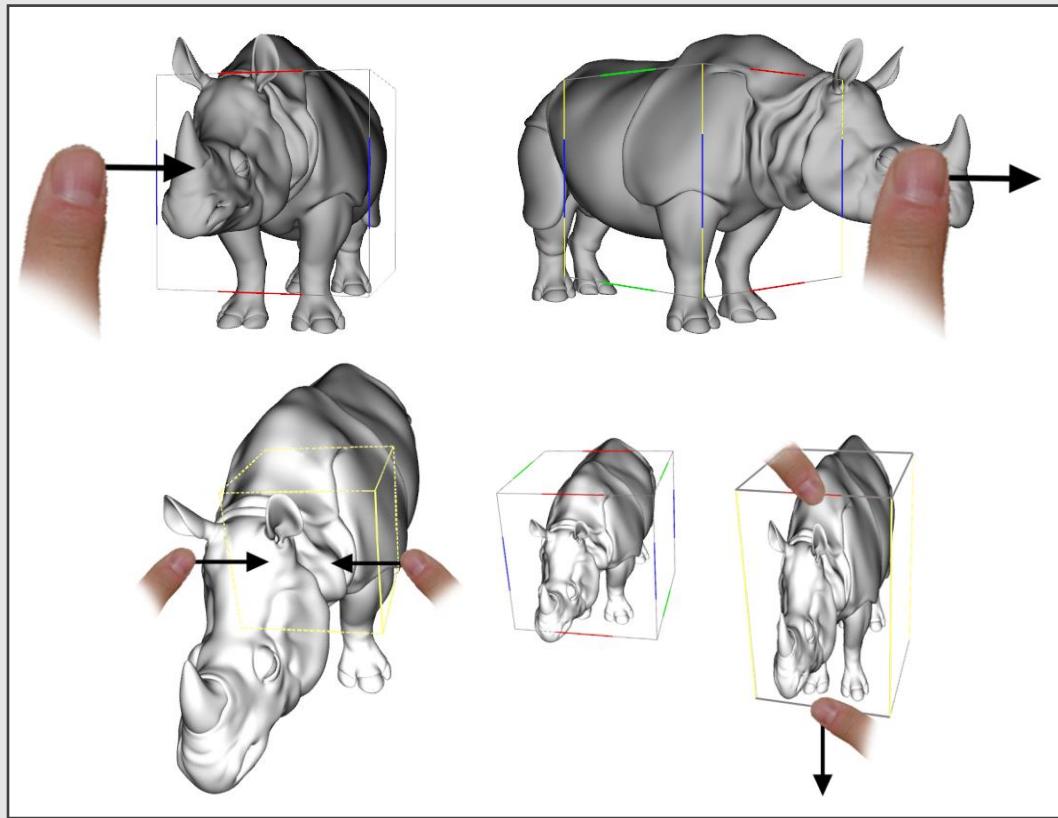
# Transformation Separation

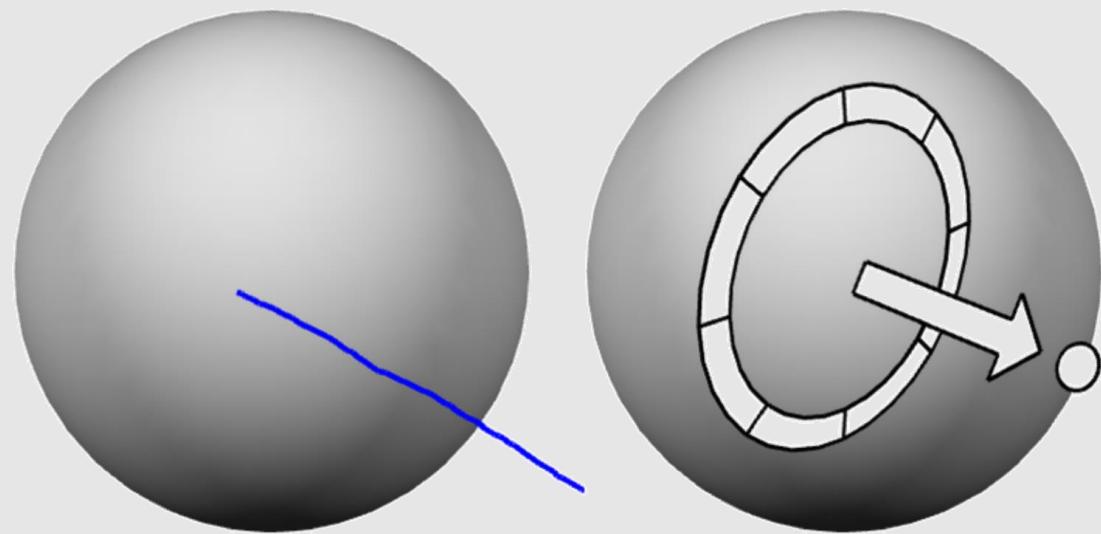




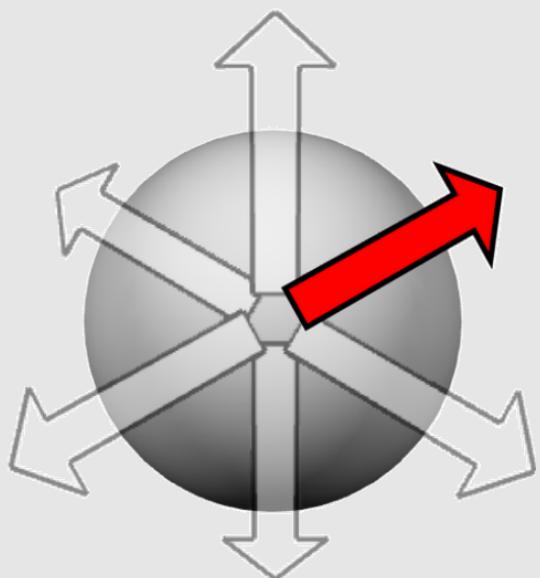
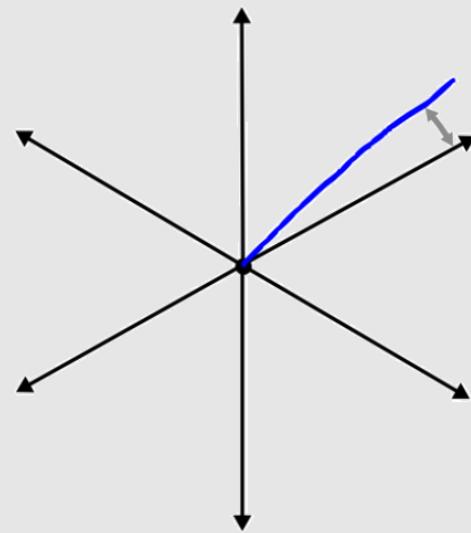
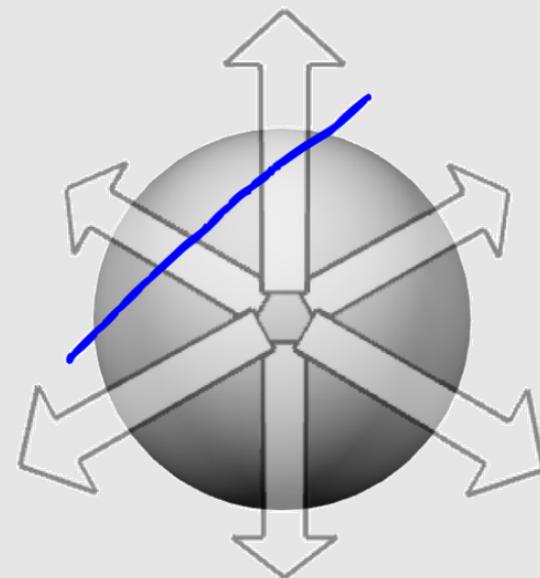
Degrees-of-freedom

# DOF Separation





Custom Axis



# Custom Axis



**Snap to candidate axes**

## Exact Mapping

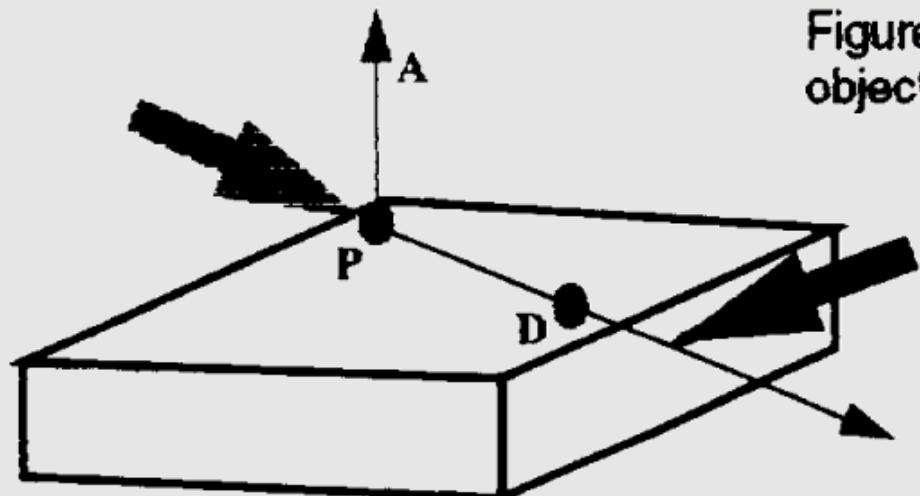


Figure 1: The DH cursor rotates the object around the vector A based at P. When the NDH cursor moves, the object translates and also rotates around the vector A so that the point D will lie along the line between the two cursors.

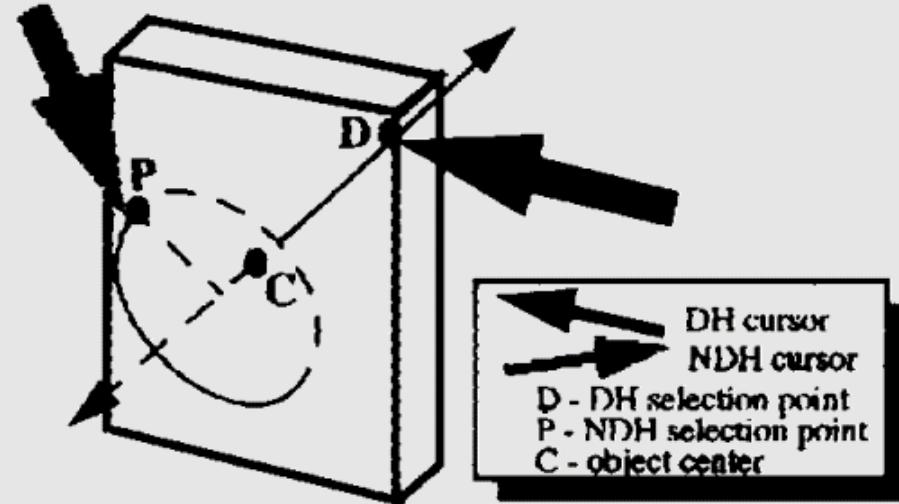
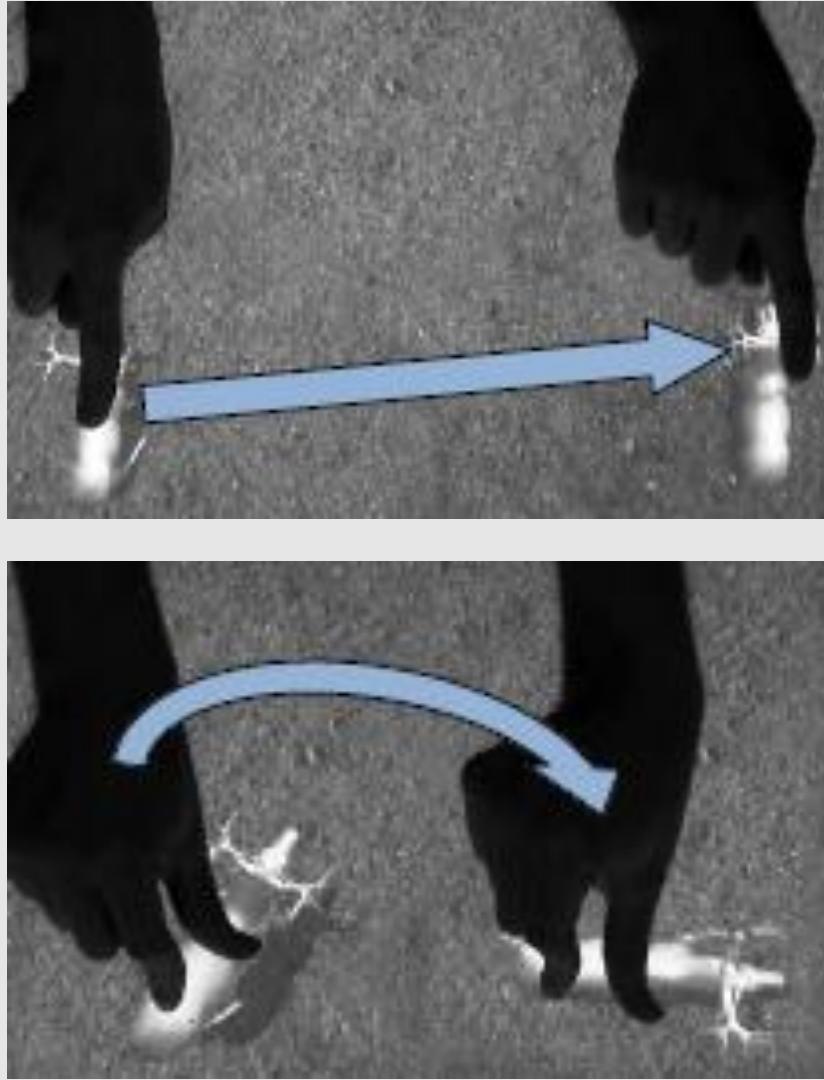
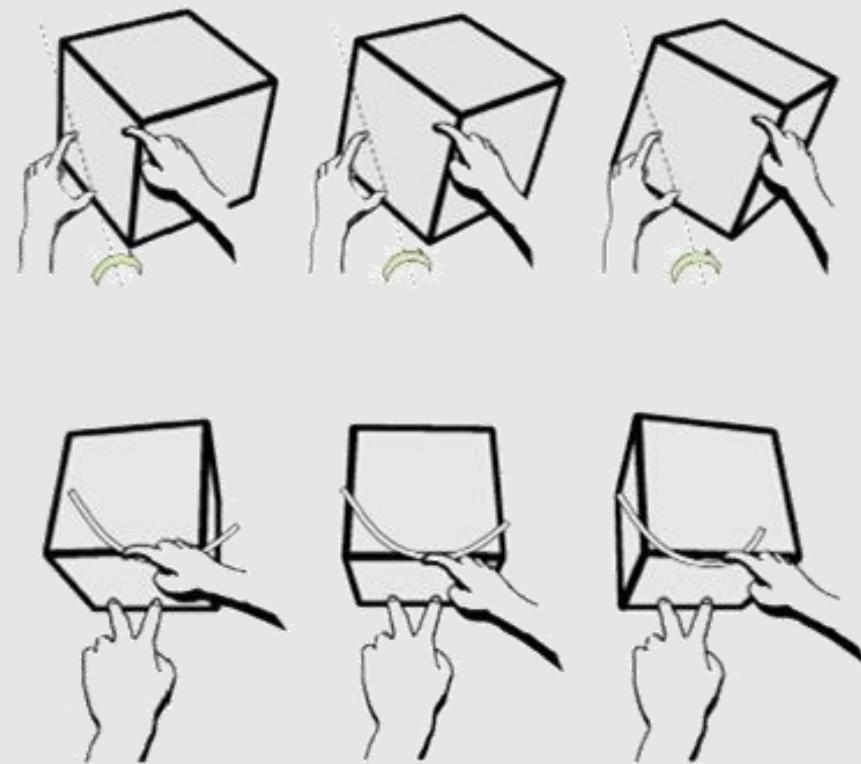


Figure 2: DH defines virtual sphere through point D. NDH rotates object around the axis CD.



## Exact Mapping

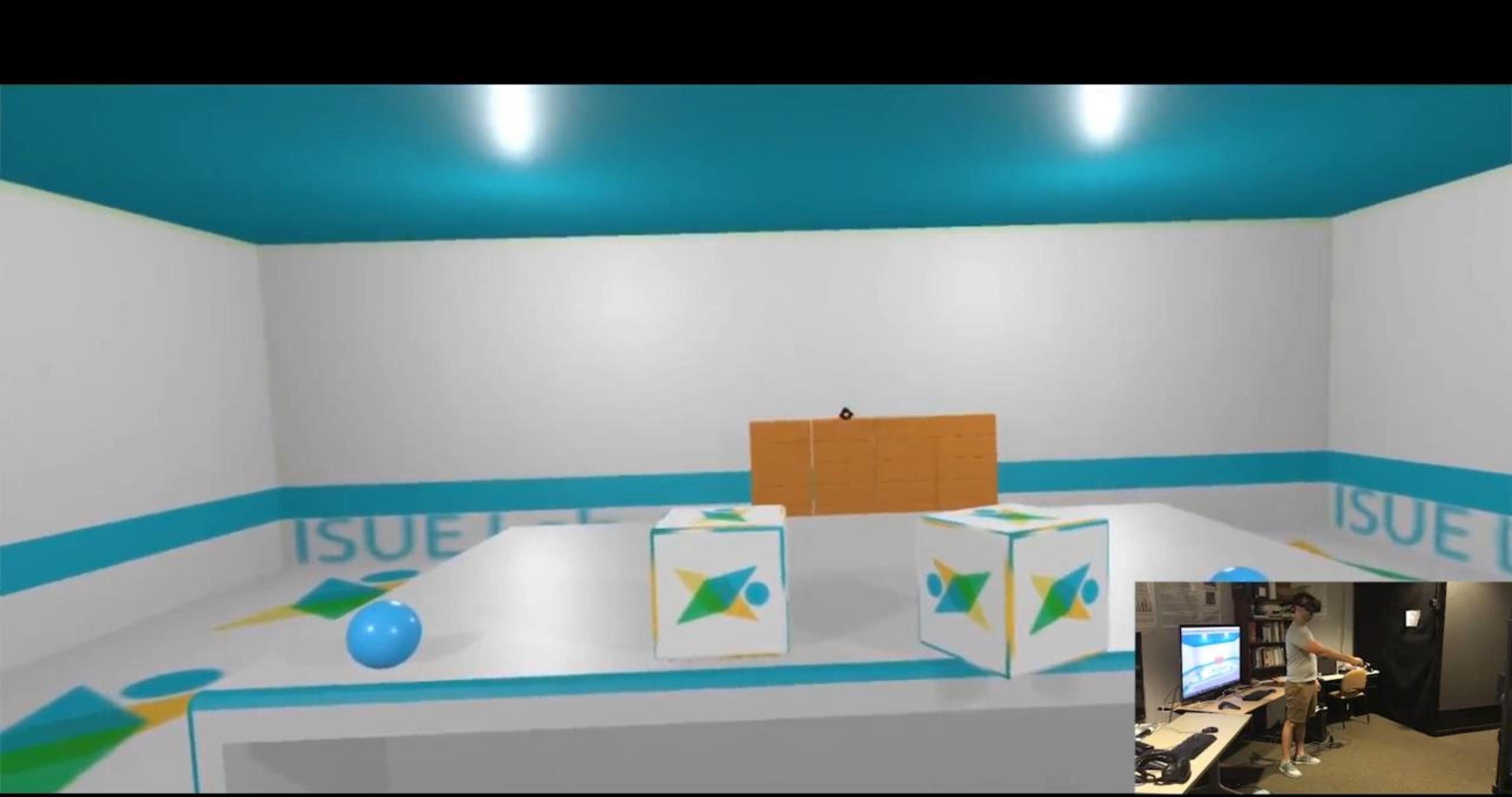




A person in a dark suit is holding a glowing red sphere in their right hand. The sphere is bright and circular, casting a soft glow. The person is standing in a dark, minimalist room with a large window in the background. The overall atmosphere is mysterious and futuristic.

Scaled Mapping

1:N





Scaled Mapping

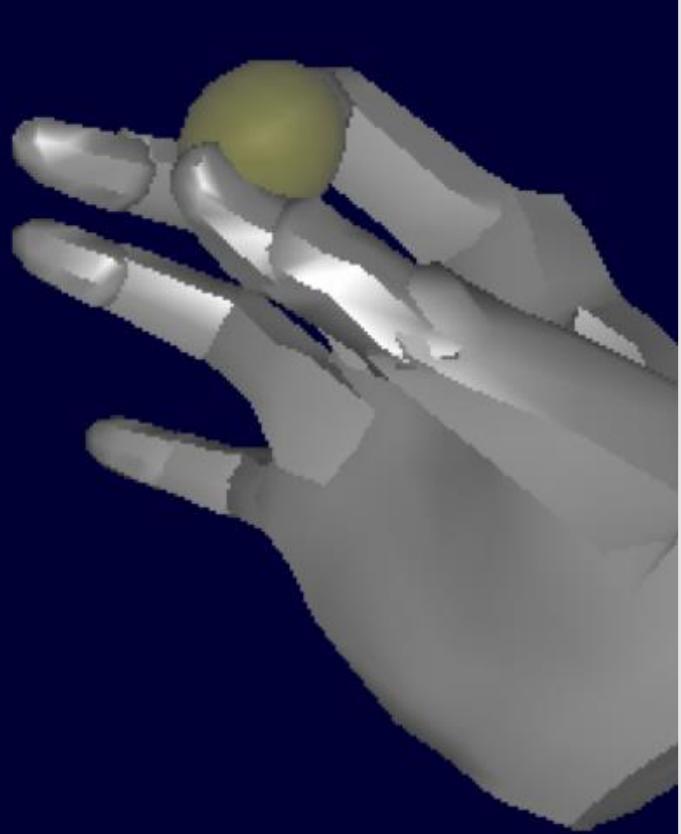
N:1



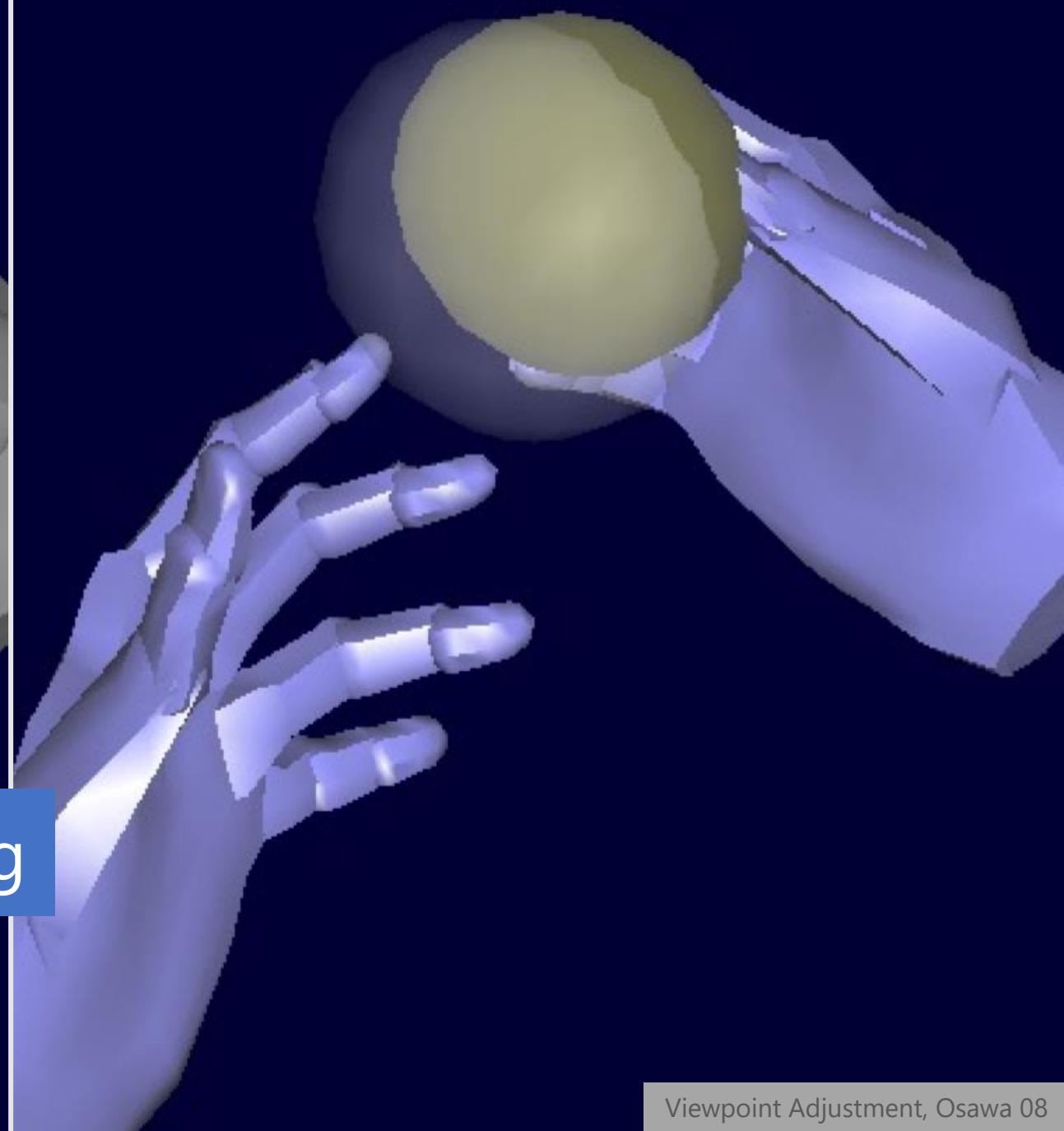
Mid-air Accuracy

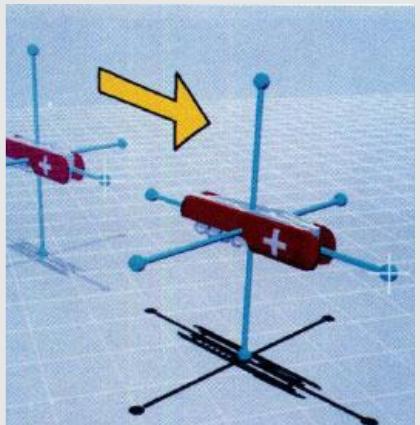
# Scaled Mapping



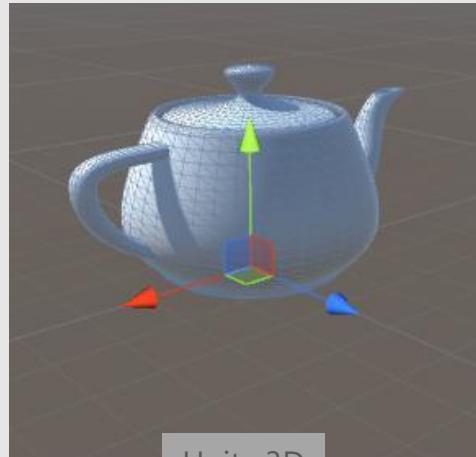


Scaled Mapping

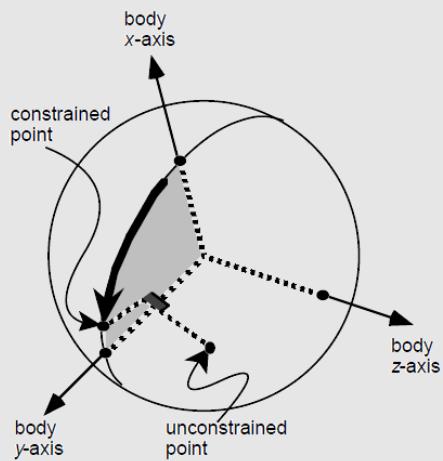




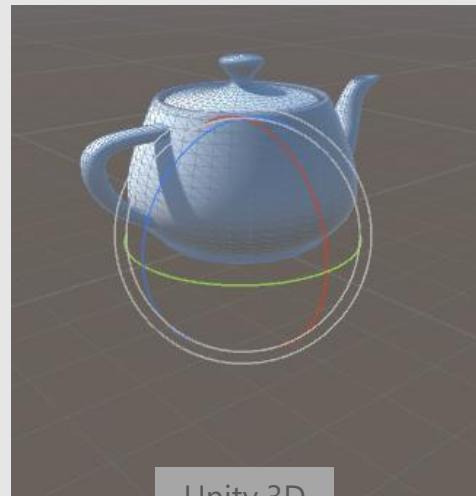
Virtual Handles, Conner et al. 92



Unity 3D

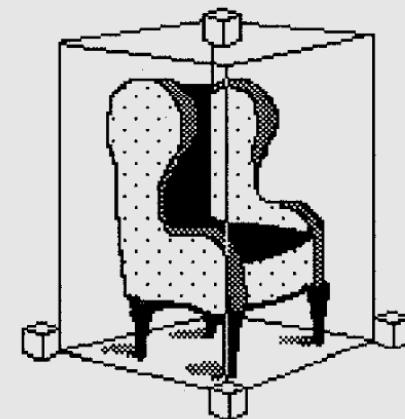


Arcball, Shoemake 92

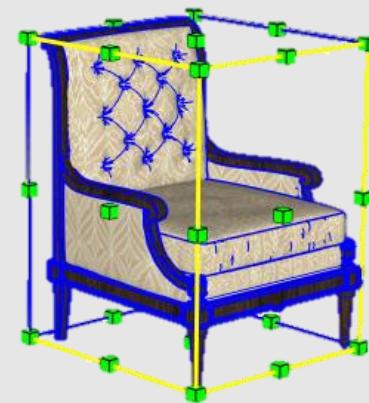


Unity 3D

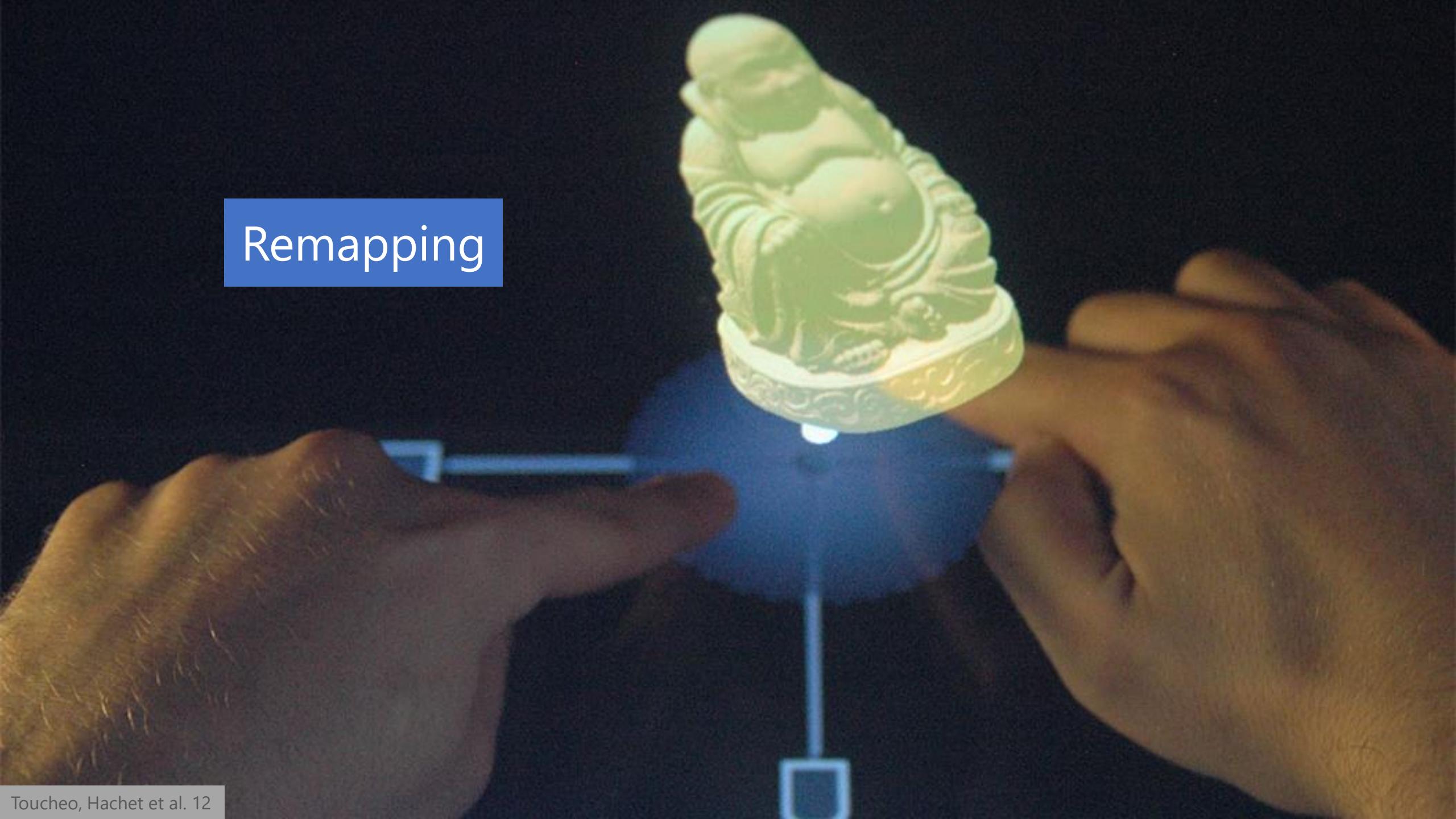
# Remapping



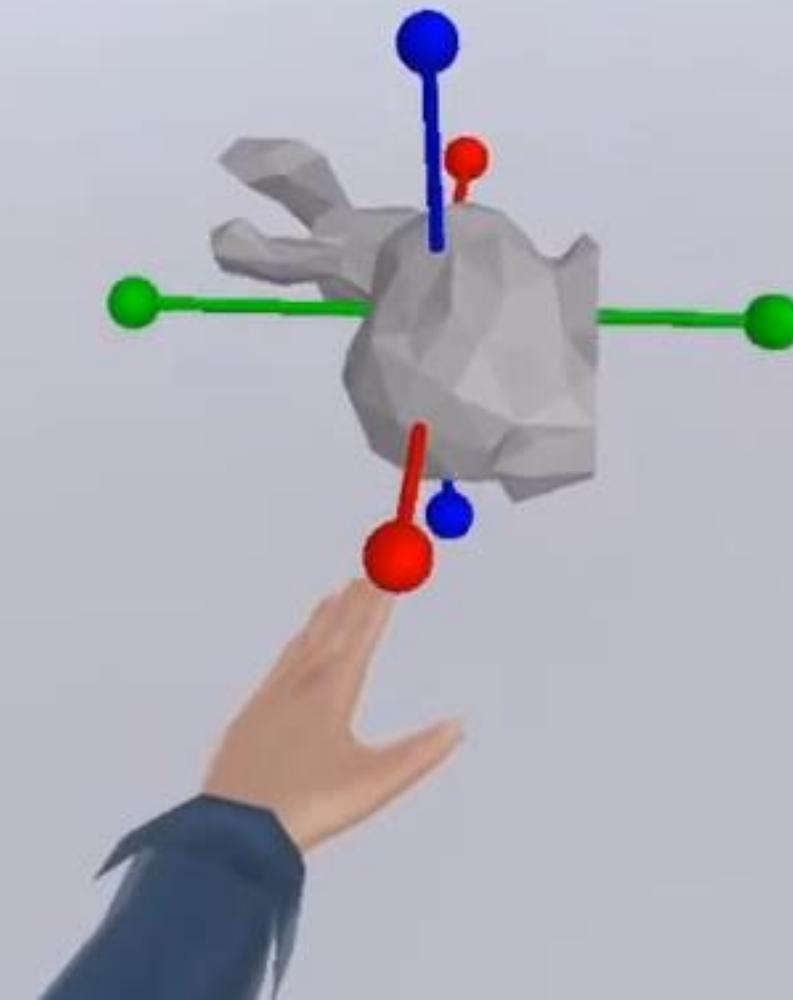
Handle box, Houde 92



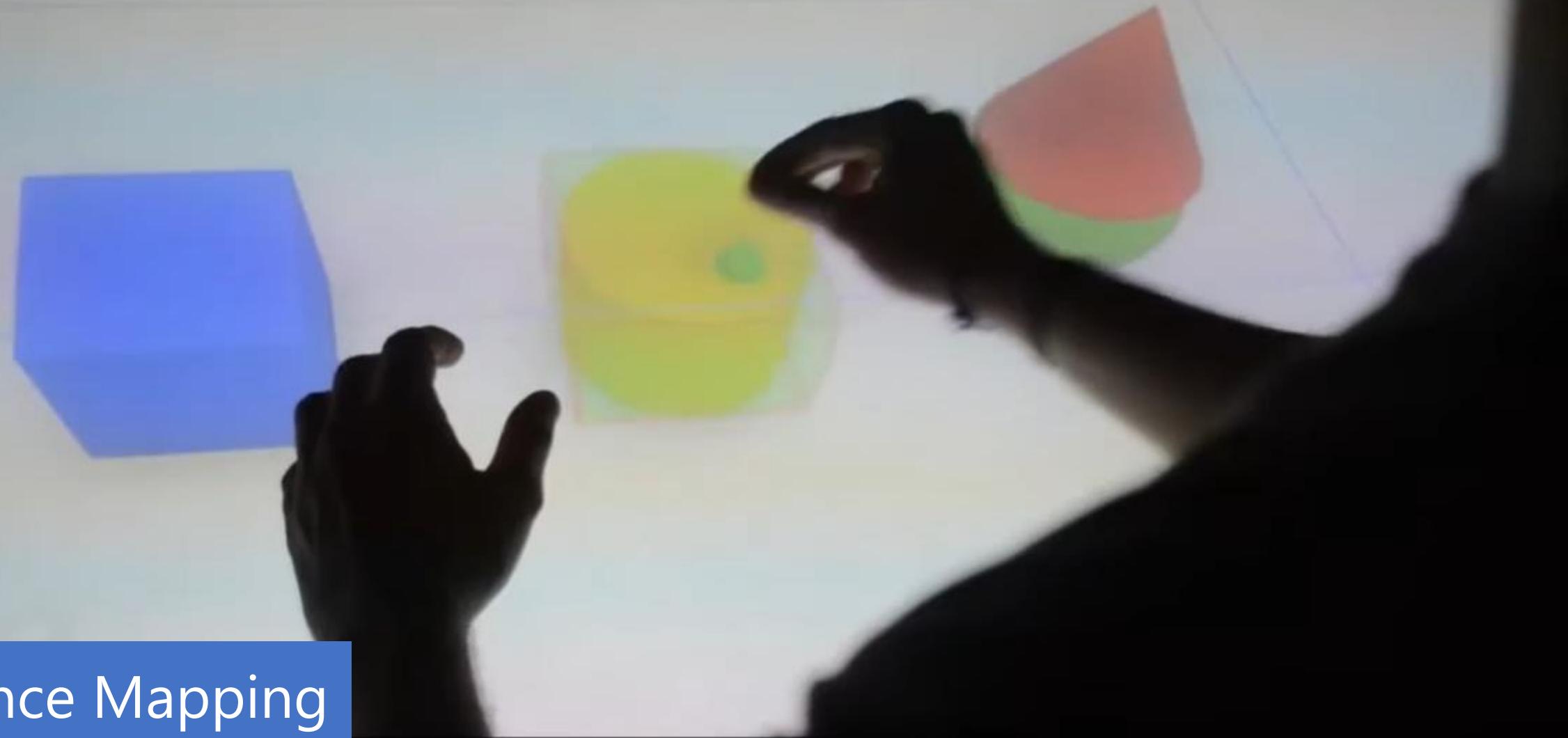
SketchUp 2016

A close-up photograph of a person's hand holding a glowing green 3D-printed model of a human brain. The brain model is highly detailed, showing gyri and sulci. It is held against a dark background. A blue line diagram is overlaid on the image, starting from the bottom center and pointing towards the brain model, illustrating a neural pathway or connection.

Remapping



Remapping



Distance Mapping

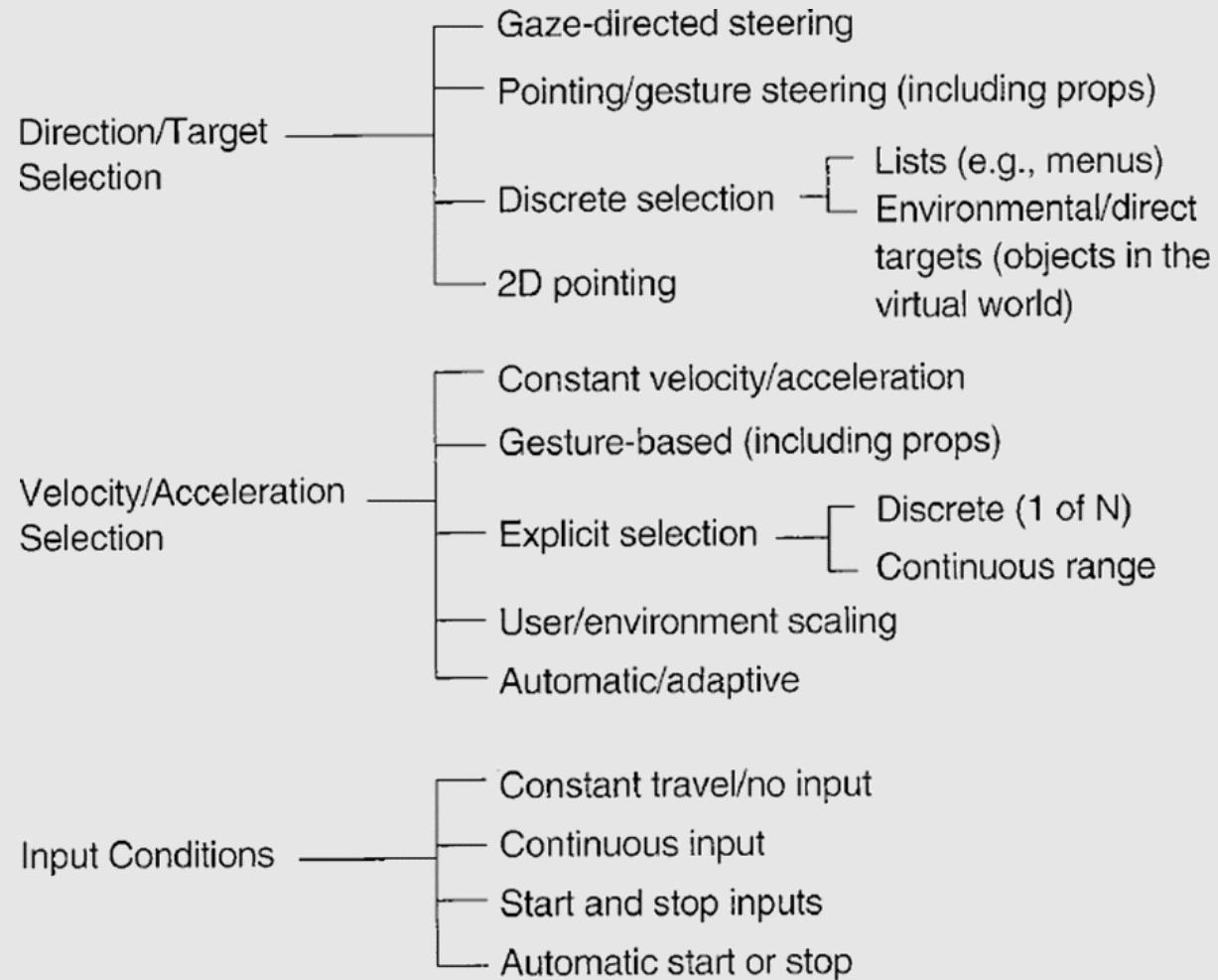
A large, dark-furred gorilla stands in a lush, green grassy field. The gorilla is facing the camera, with its head slightly tilted. It has a prominent silverback on its back and a white patch on its shoulder. The background is filled with dense green vegetation and tall grass.

Gorilla Arms

# Navigation

Navigation = Wayfinding + Travel





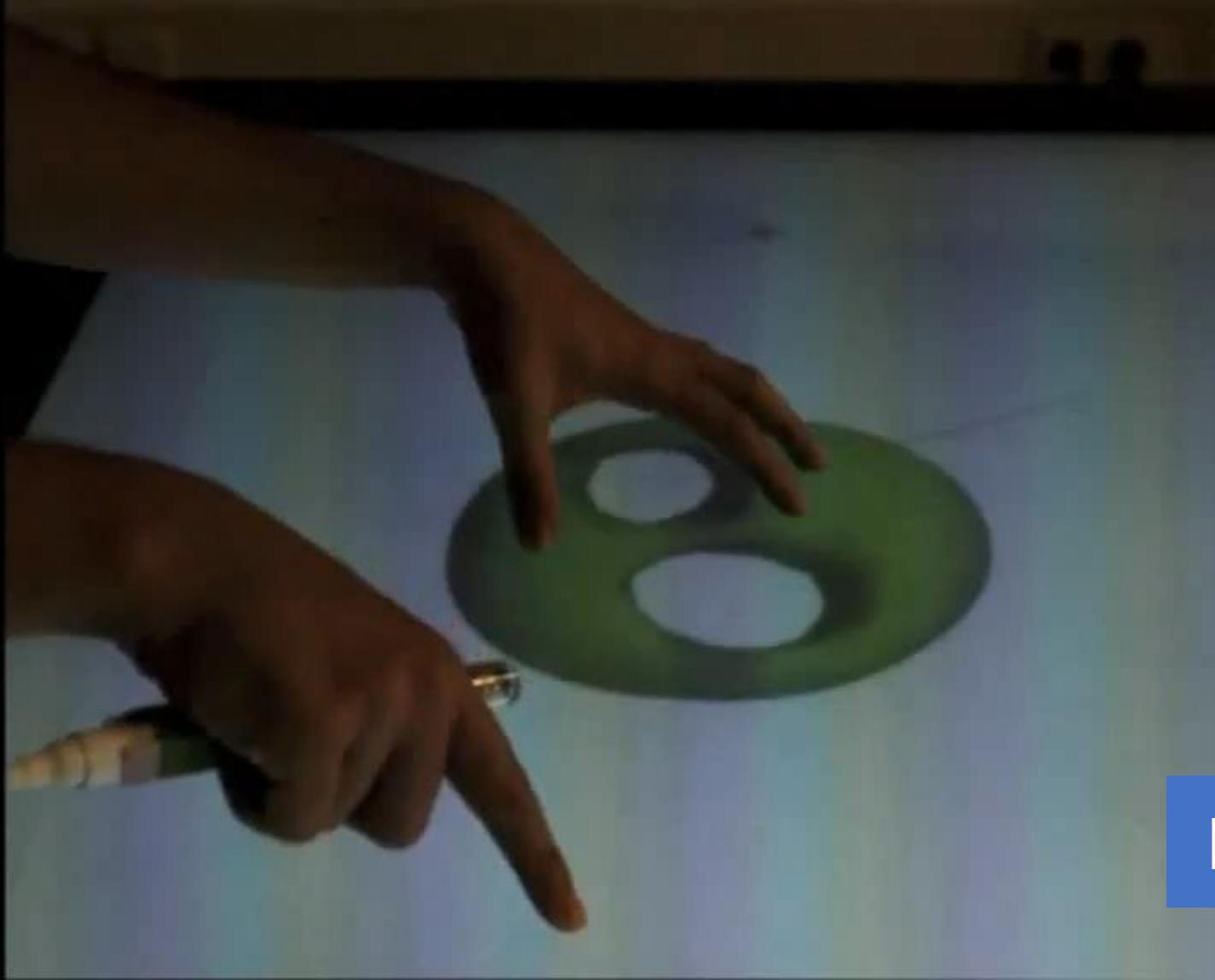
## Travel Taxonomy



Desktop



Single Touch



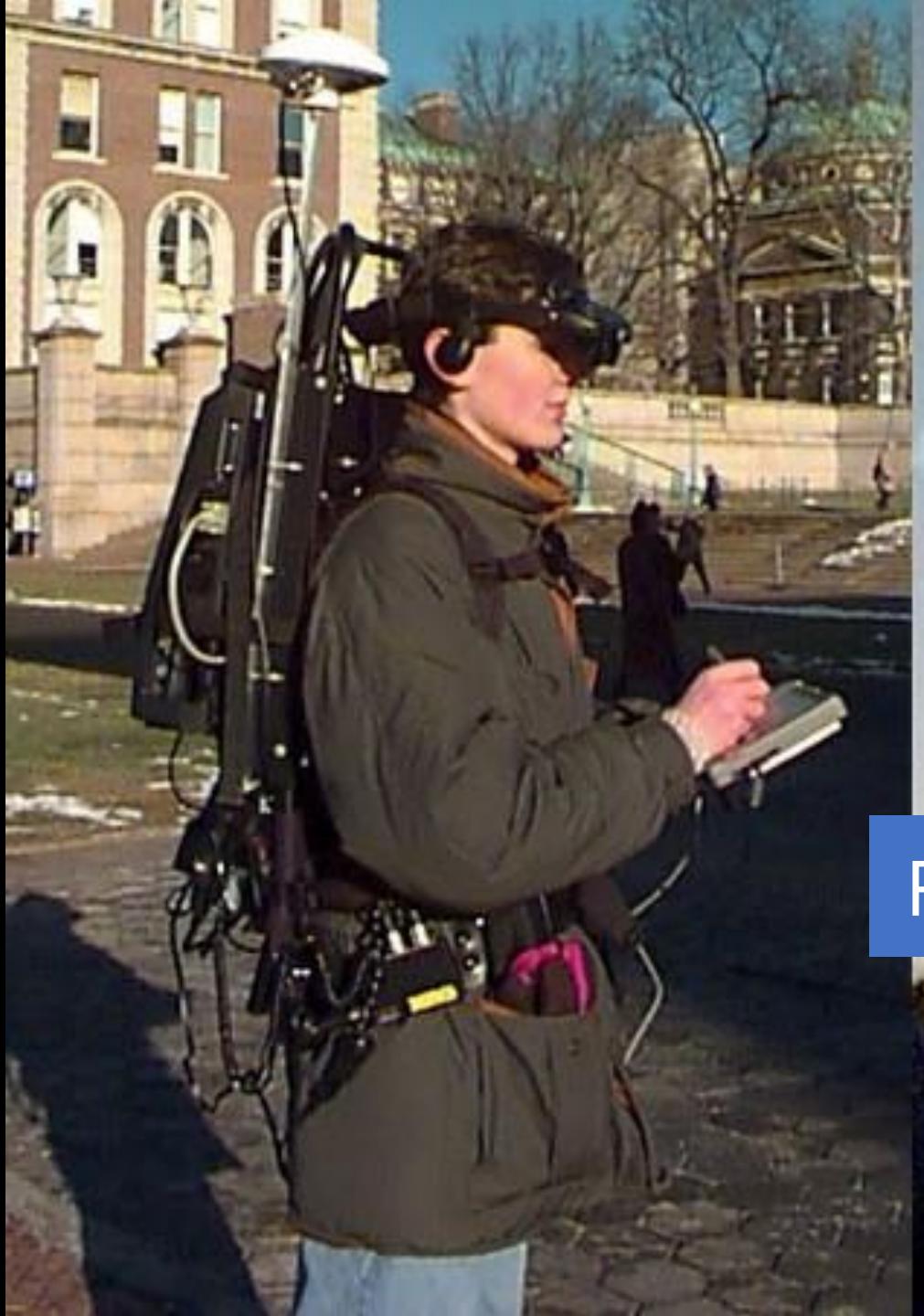
Multi-touch

## Bimanual Gestures (with or without Pen)

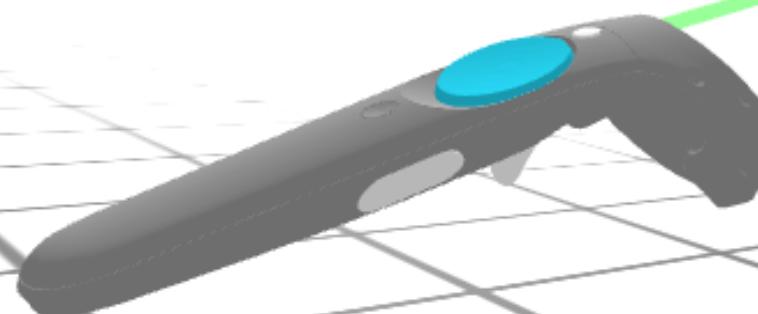
Scale (two handed) and Pan and Rotate (One or Two handed)



Multi-touch



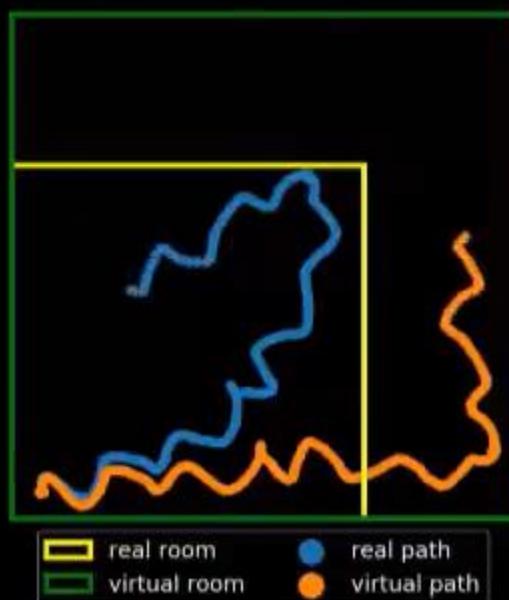
Real Walking



Teleport

# Multiscale / Flying





## Redirected Walking





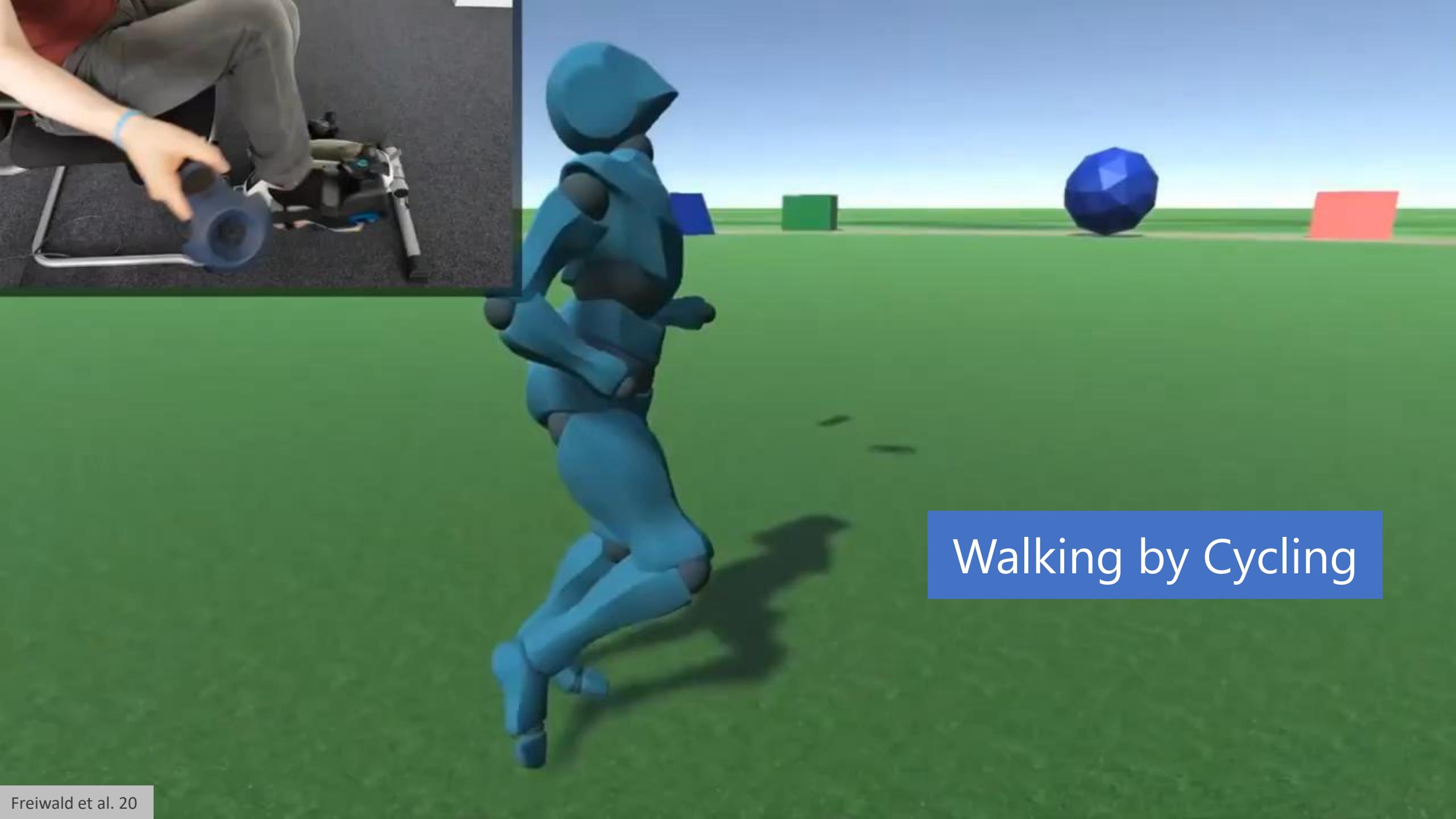
Walking in Place



Treadmills



Tilting



Walking by Cycling



Surface Dragging

Dog Paddle  
Travel technique

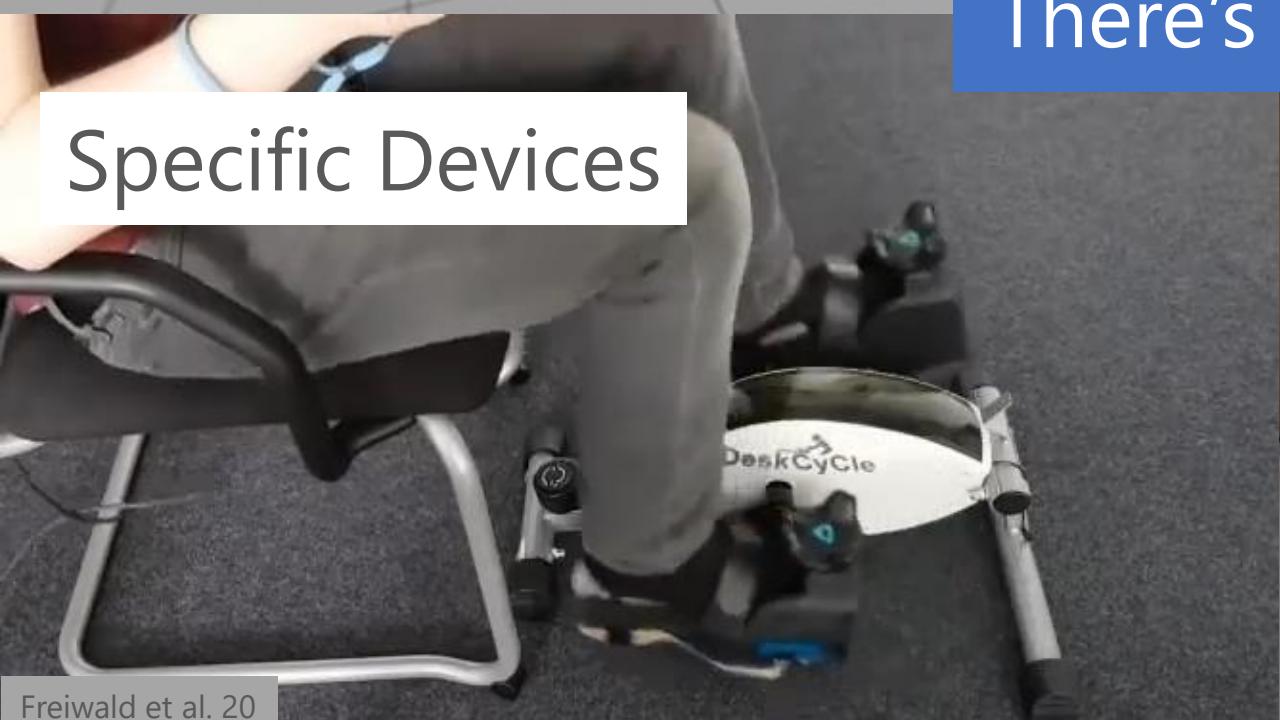


Cybersickness

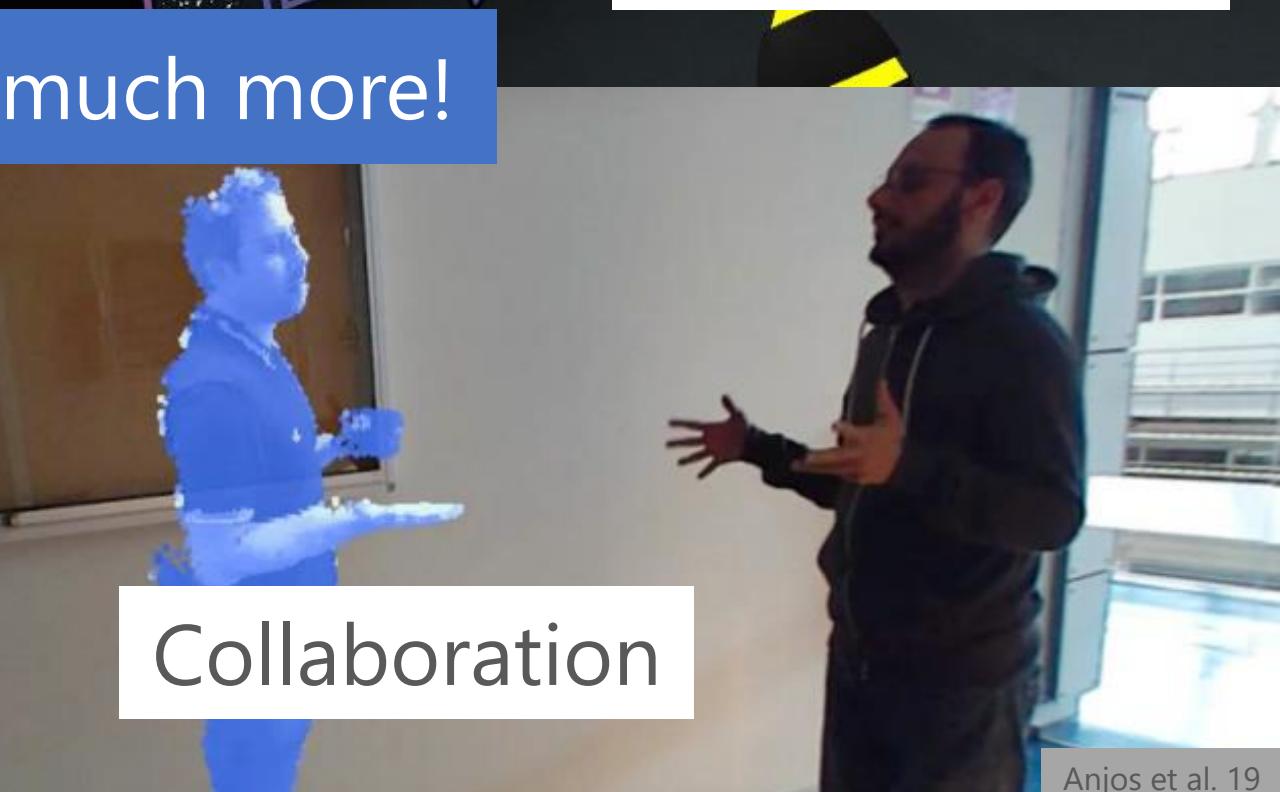
## More Techniques



There's much more!



## Specific Devices



# Questions?

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