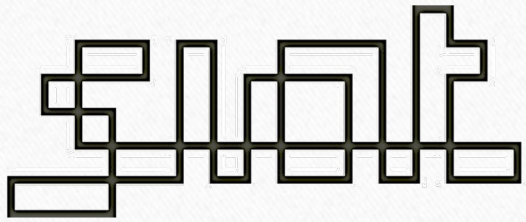
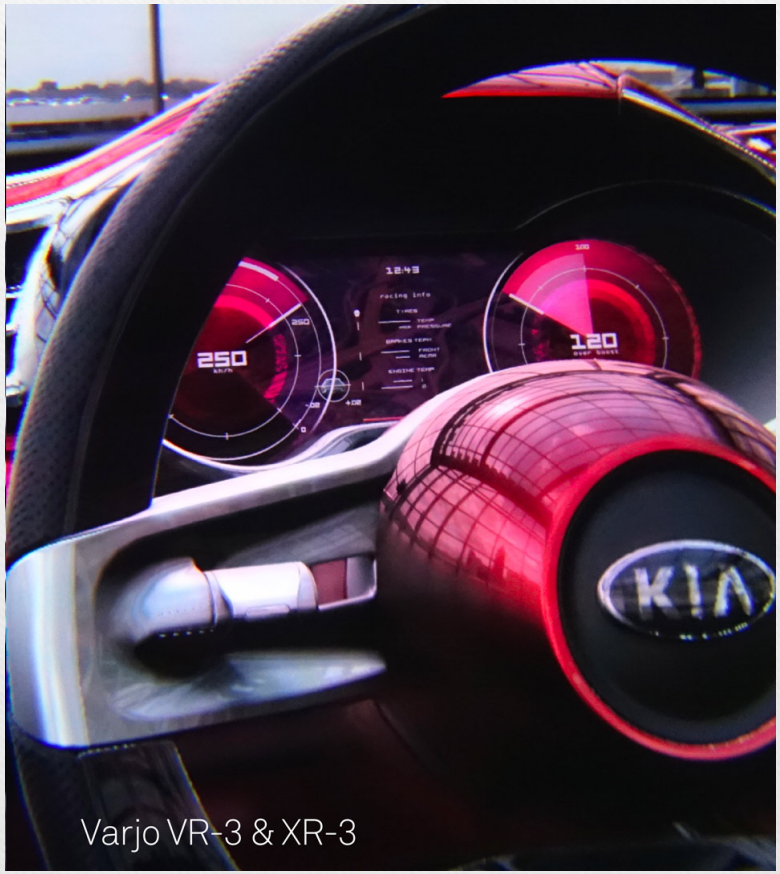


SCHOOL OF INTERACTIVE
ARTS + TECHNOLOGY

Why are we not working in XR every day (with 3D)?

Wolfgang Stuerzlinger, http://vvise.iat.sfu.ca

VR/AR/XR Works!



Varjo VR-3 & XR-3

But few fully interactive XR Systems used regularly

- Beyond VR for games & entertainment
  - Many companies in that space
- Beyond VR for training
  - Many companies in that space

My Vision: Professional VR/AR/XR Systems

- Use XR to solve hard(er) real-world problems
  - Design & Engineering
    - Build objects, vehicles, buildings, infrastructure, …
  - Medical applications
    - Plan medical procedures (brain surgery)
    - Train skills to transfer to real-world tasks
  - Simulation

How to Get There?

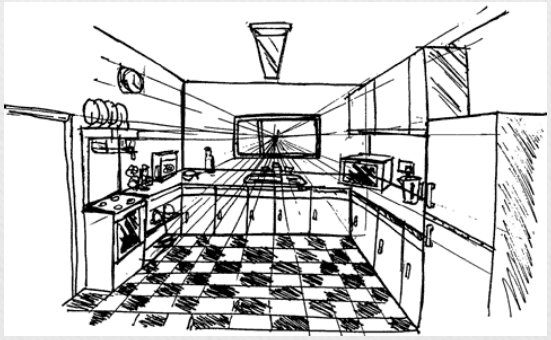
- Address real-world obstacles
  - Faced by practitioners, companies, end-users, …
- Knowledge of human capabilities, skills & limitations
- Observe users
  - User studies
    - Non-VR/AR-savvy participants
- Listening to people outside of VR/AR/XR

Usability Guidelines (2D)

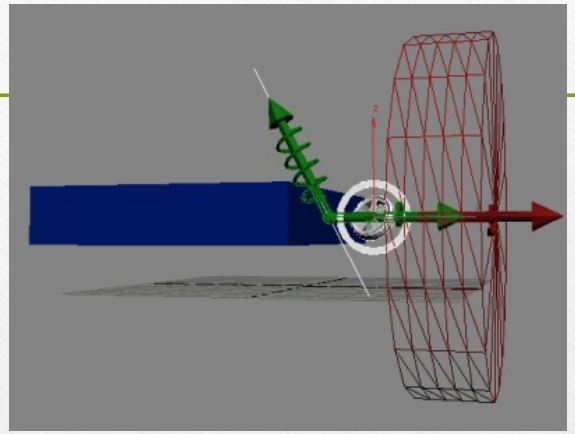
- Scott Klemmer's take on Nielsen's Guidelines

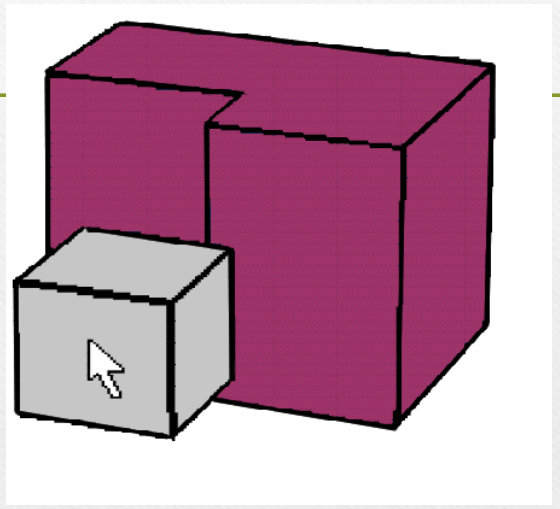
[with C. Wingrave, Dagstuhl08]

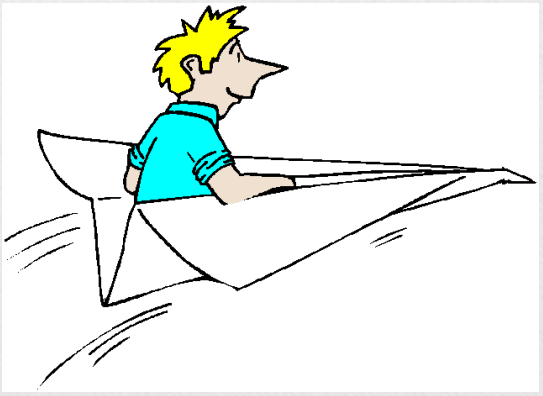
Usability Guidelines (3D)



Usability Guidelines (3D)





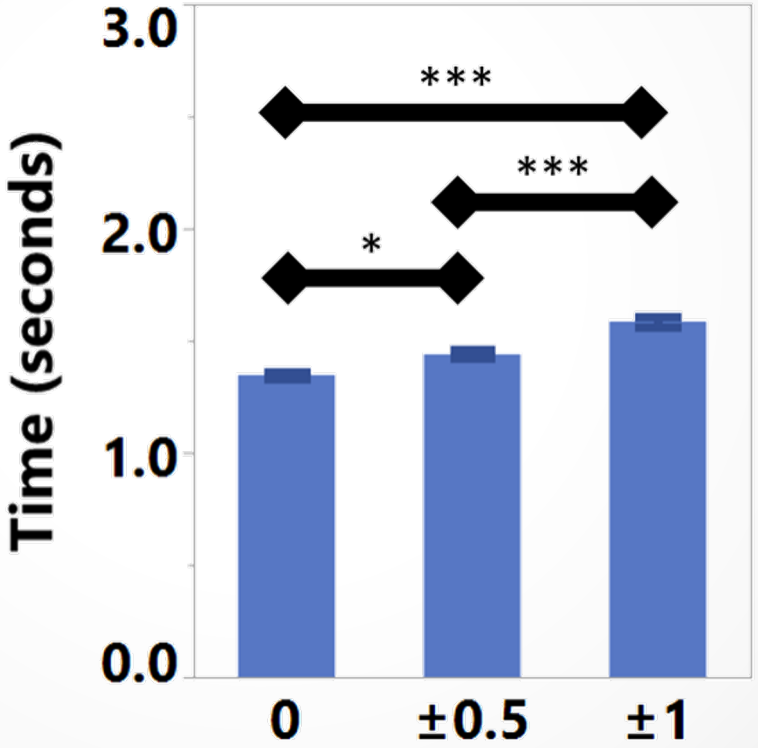


Some Real-World Challenges for VR & AR

- Precise Interaction
- Efficent Interaction Methods
- Reliable Interfaces
- The Depth Dimension
- Spatial Skills
- Dense Virtual Content
- Multiscale Environments

Precise Interfaces

- Need
  - Simulation, CAD, Engineering, Medical planning, …
- Jitter does not help



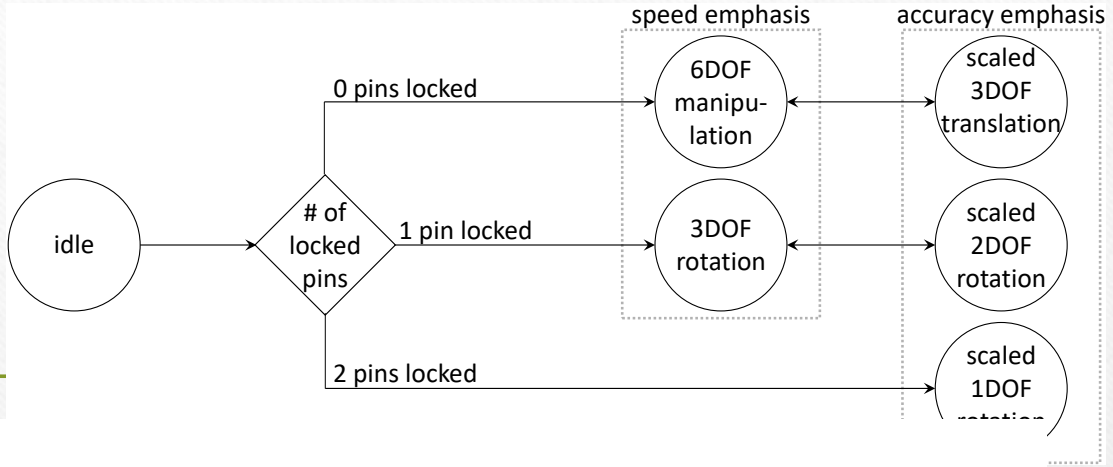
[Batmaz FTC '20]

[Pham VRST '19, Batmaz NIDIT '20]

Pen Input

[Gloumeau TVCG '20]

Pin'N'Pivot

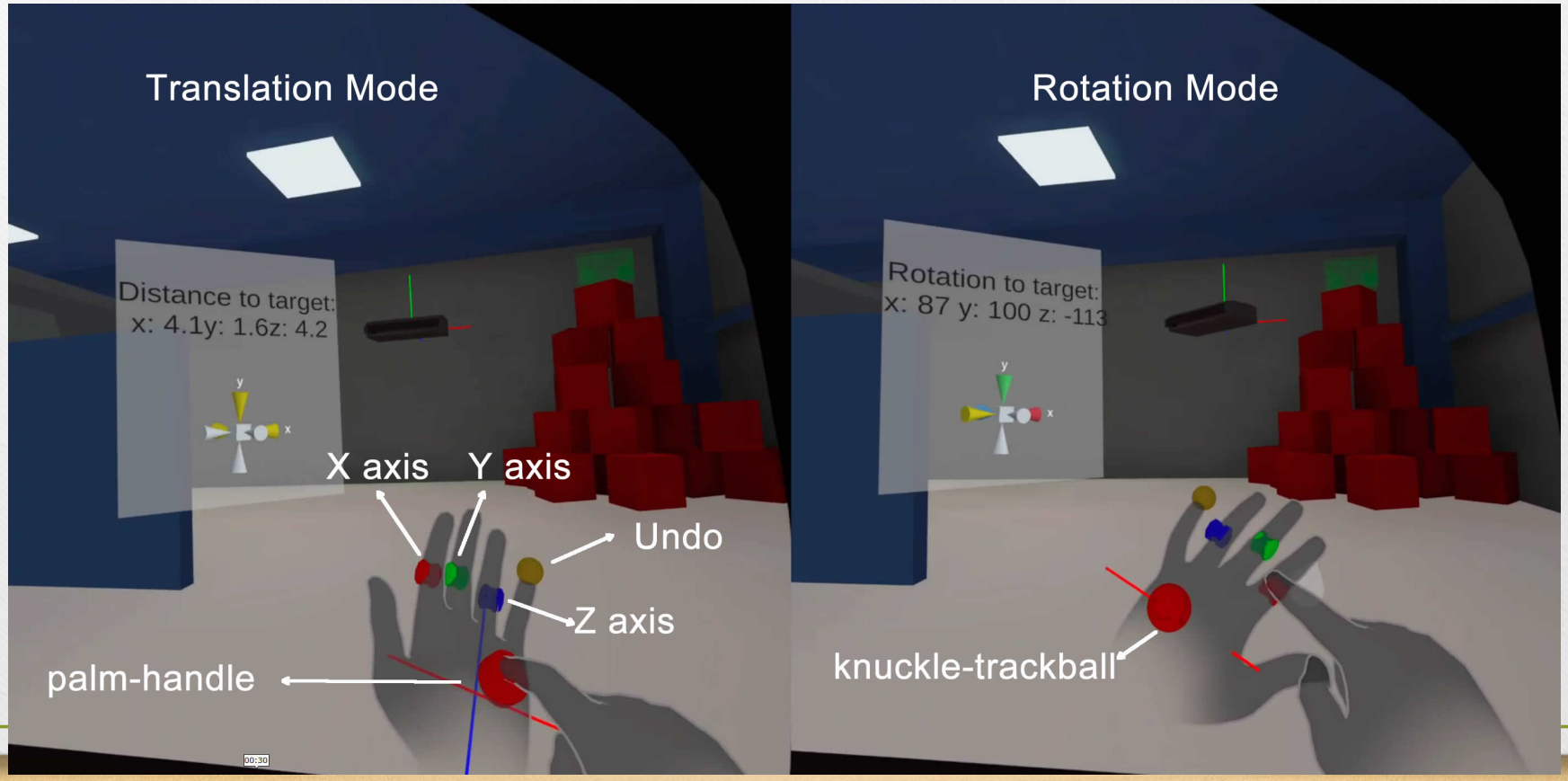


PinNPivot

P. Christopher Gloumeau, Wolfgang Stuerzlinger and JungHyun Han

[Zhao NIDIT '25]

More precise barehand interaction: THFP



Open Challenges

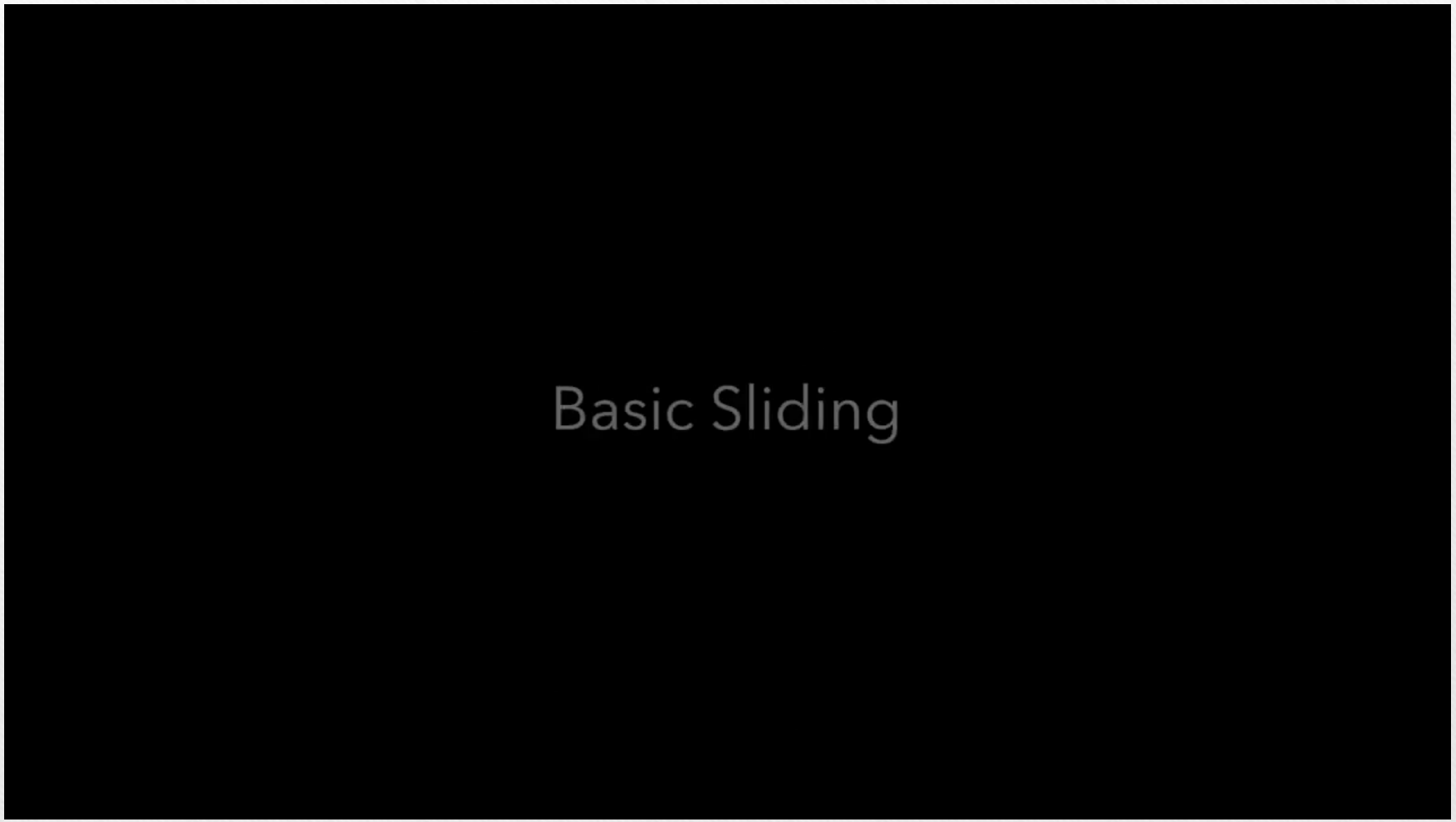
- Engineering requirements
  - Use precise values
    - 4.375 m for car length
    - 57.32 degrees for angle of surgical tool
  - Match real world
    - AR Tracking of an object

Efficient Interaction Methods

- 2D vs 3D interaction?
- Virtual hand vs ray-casting?

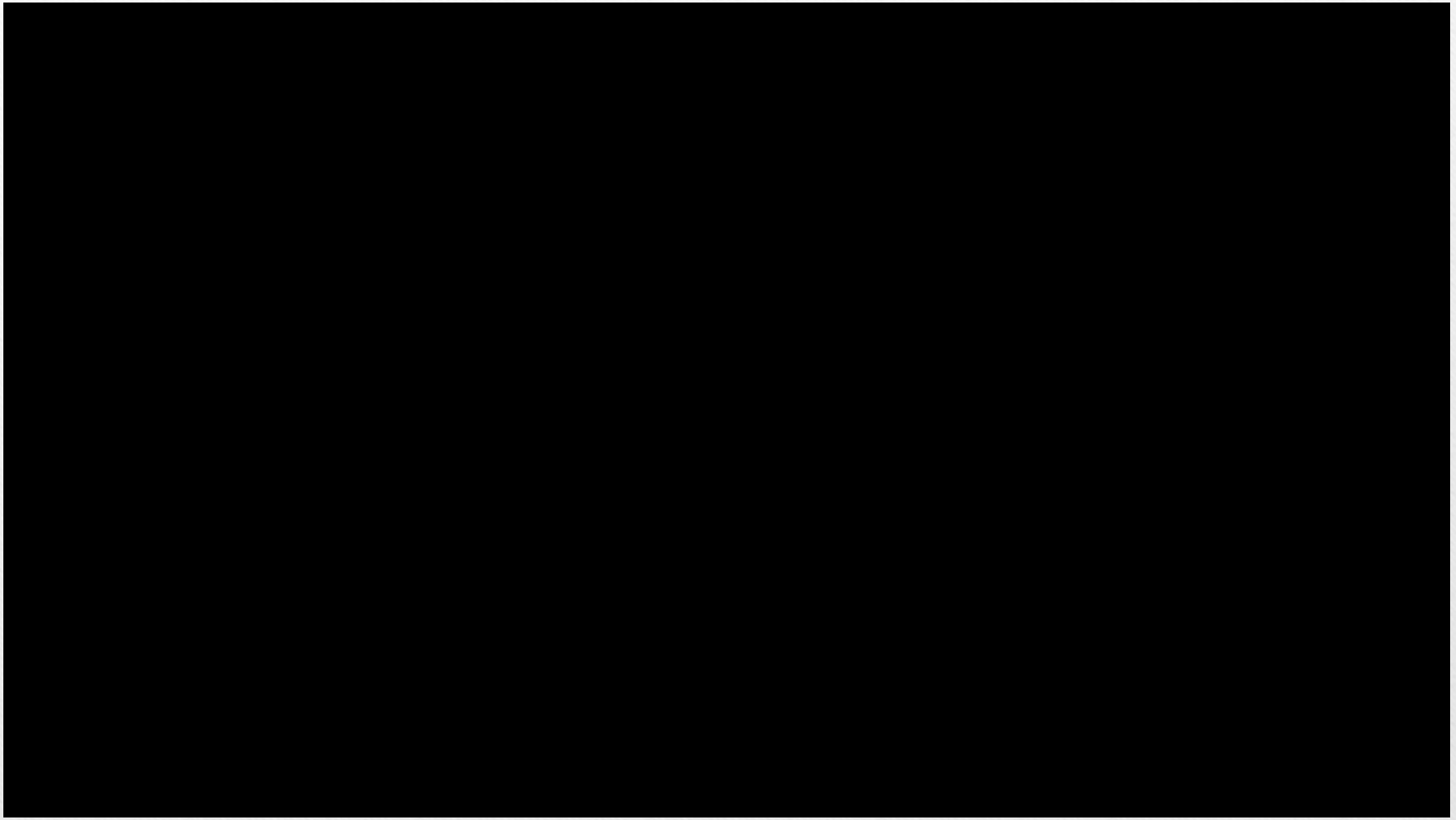
[J. Sun SUI '16]

Sliding - Desktop



[J. Sun VRST ‘19]

Sliding - VR



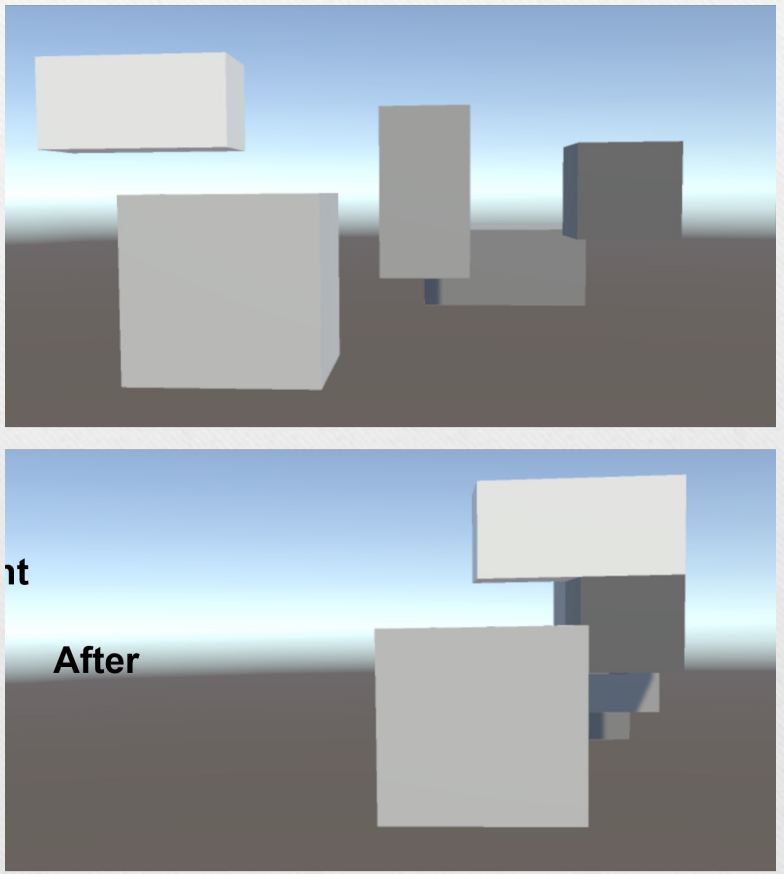
[D. Hayatpur UIST '19]

Plane, Ray, and Point

[Shi SUI '23]

Object Alignment Methods

- Example: Align right
  - Avoiding collisions

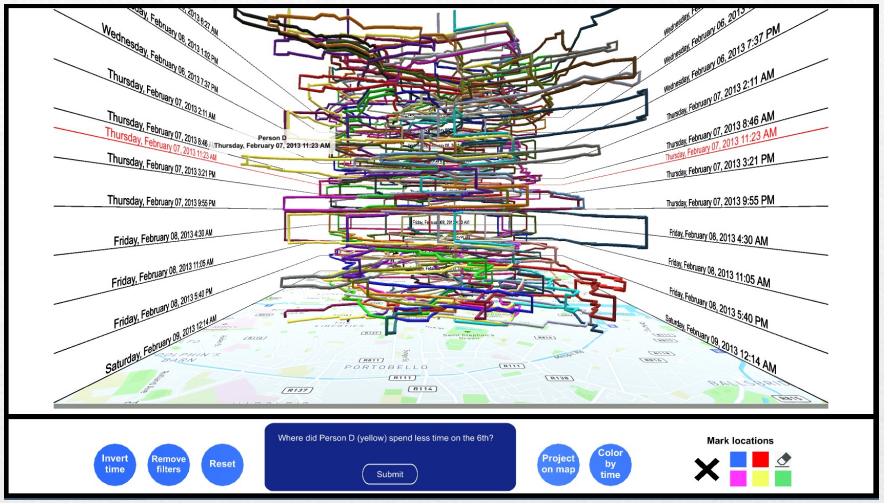


[Gemici ISMAR ‘24]

Object Speed Control

[Wagner VR/TVCG '19]

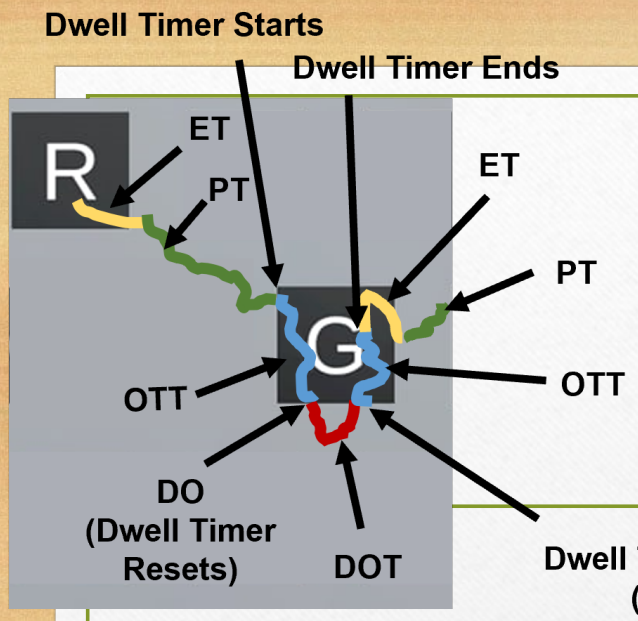
Immersive Analytics of STC Seated Desktop vs. VR



[Pham VRST '19]

HawKEY

- 77+ WPM while standing
- Video when looking down



[Mutasim CHI '25]

Multi-Threshold Dwell

Last Phrase WPM: 18.2

THE UNION WILL GO ON STRIKE

THE UNION WIL_

4°

1.5°

Dwell Timer Animation

Q W E R T Y U I O P

1.5°

1°

3° A S D F G H J K L 4°

3° Z X C V B N M <-

Gaze Cursor

First Selection:	300 ms	200 ms	100 ms	450 ms
Successive Selections:	500 ms	500 ms	500 ms	450 ms

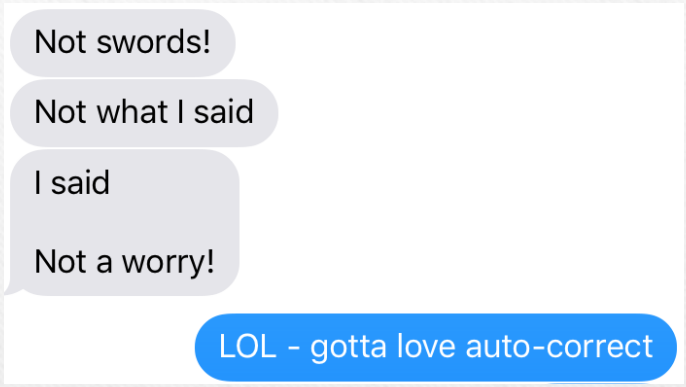
Open Challenges

- Can we match desktop performance?
- Transitions between desktop & XR
  - Input device/modality?
- Using a headset for 8 hours a day?

Reliable Interfaces

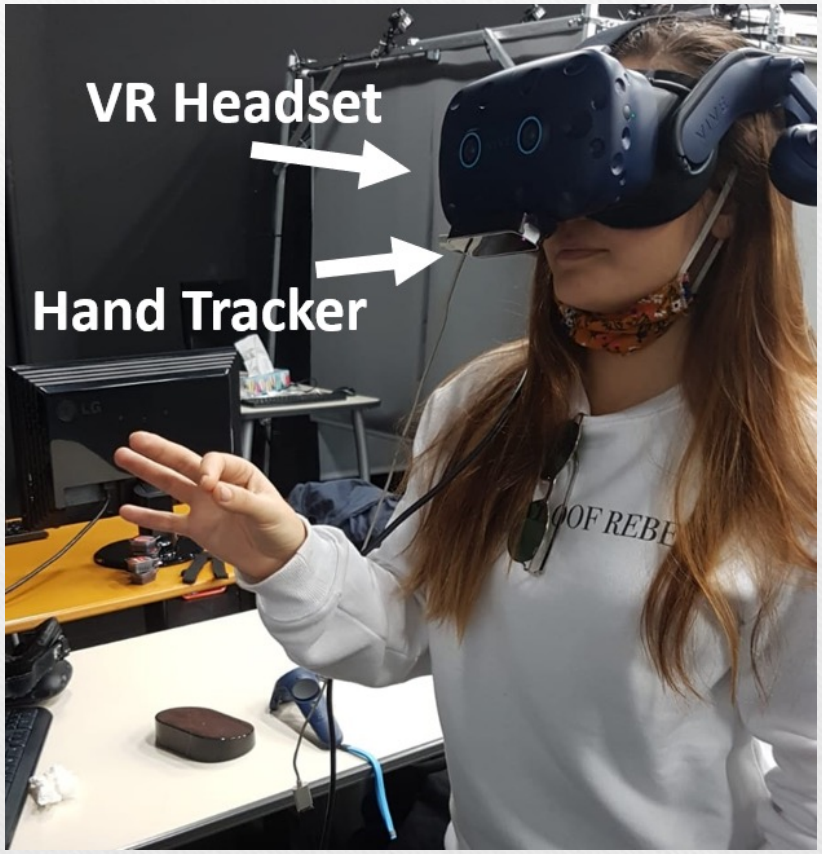
- Errors have a ***cost***
  - For fixing them
  - Regardless if system or user
- Need
  - Everyone
- Some technologies fail occasionally
  - Recognition
    - Pinch “away” from camera
    - Voice
  - Tracking glitches
  - AI/LLM

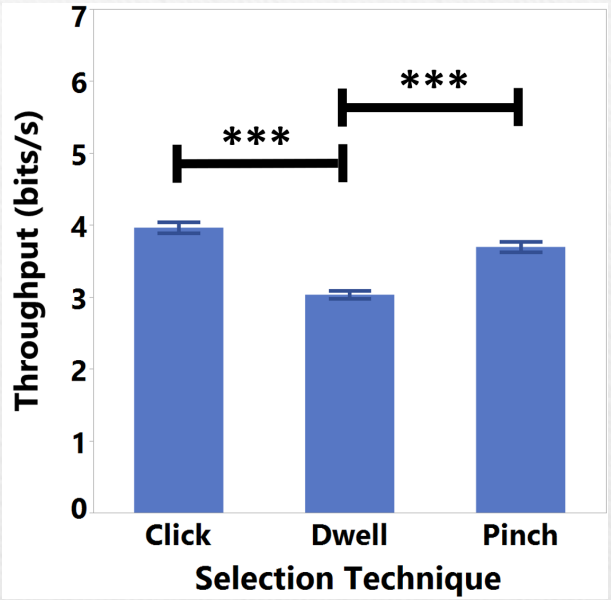
Assistive/Recognition Technologies



[Mutasim ETRA '21]

Selection for Eye-Tracking





Adaptation?

- Errors can happen (system or user)
  - And *errors on errors on* …
  - Errors have a ***cost***
    - To fix them
- Humans could be more careful or adapt
  - BUT …

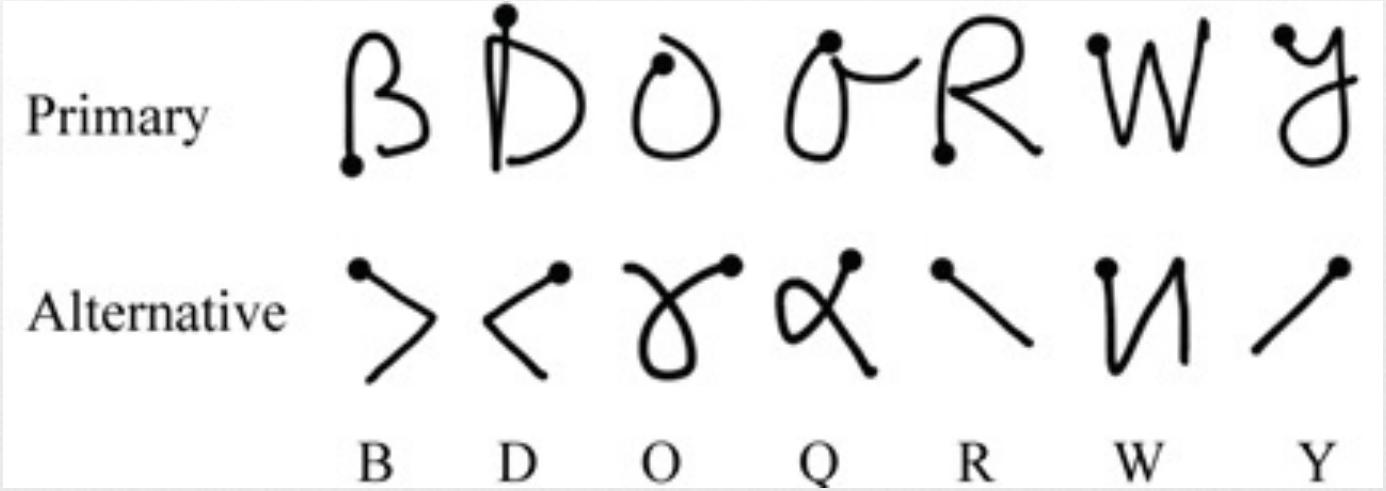
Adaptation: Core problem

- Technology not always predictable
  - Recognition/tracking tech sensitive to ”random” variations
  - Changes due to updates/upgrades/…
- People don’t generally understand underlying systems
- System appears to be random
  - So **cannot** predict if & when will fail
  - Cannot adapt to failures

[Arif GI '14]

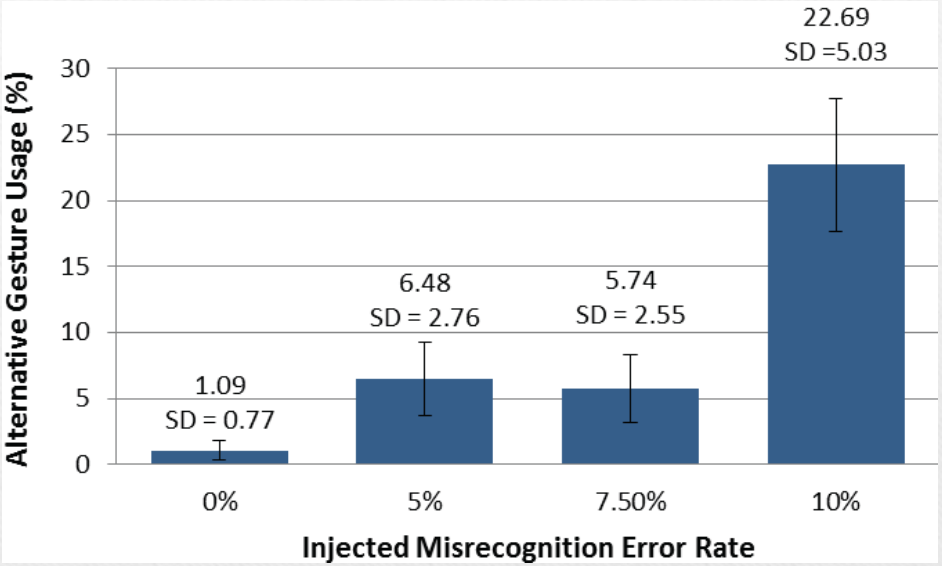
Gesture Study

- Graffiti ≈ Unistrokes [Castellucci, MacKenzie 2008]
  - Method switch will not compromise performance



Alternative Method Usage

- Significant effect of misrecognition rate



- 0, 5-7.5% and 10% significantly different

Further Thoughts

- Some adaptation for 0% as well
- Half did not identify all 3 faulty letters

  - Or did not spend effort to learn
  - Different cognitive strategies / personalities?

[Putze ICMI '17 & CHI '20]

Eye-Tracking & EEG to Detect Autocorrect Errors

- Auto-correction errors can be detected!
  - Combination of EEG, eye-tracking, & context features
- Accuracy 83%
  F1-score 67%

Open Challenges

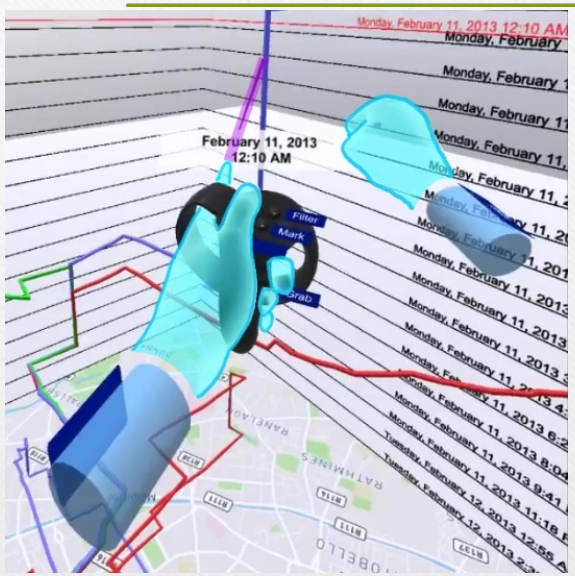
- Reliability a big challenge for usability
  - Tracking systems
  - Recognition systems
  - …

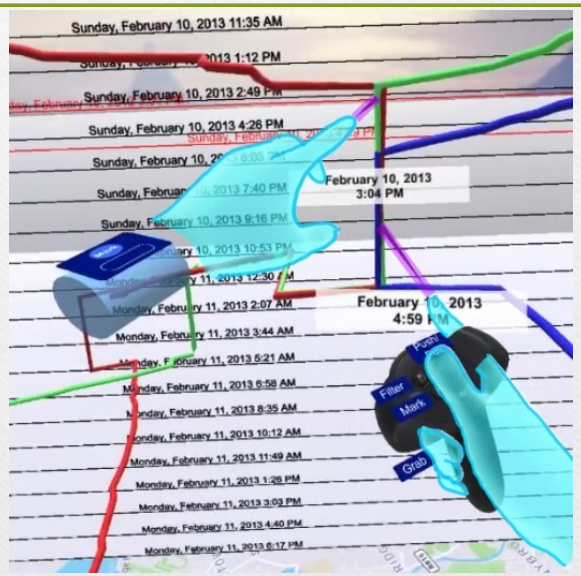
The Depth Dimension

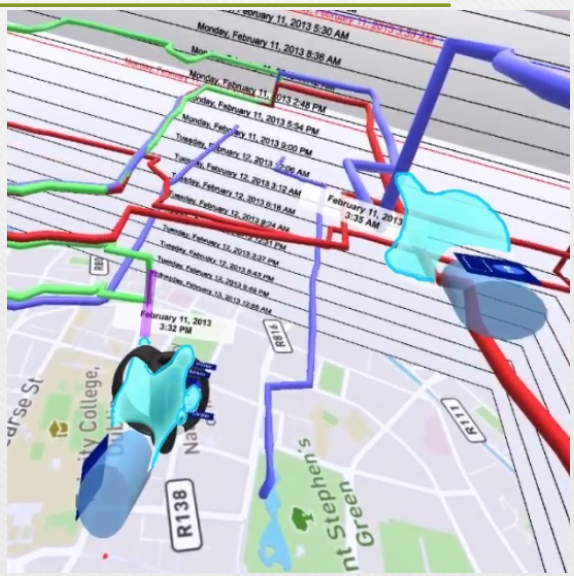
- Need
  - Anyone who needs more than 2D

[Wagner VR/TVCG '21]

Virtual Hand vs Ray-Casting

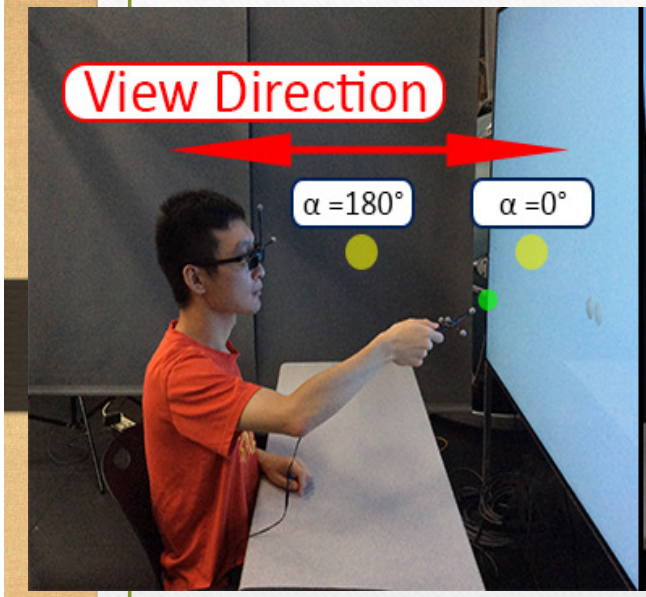


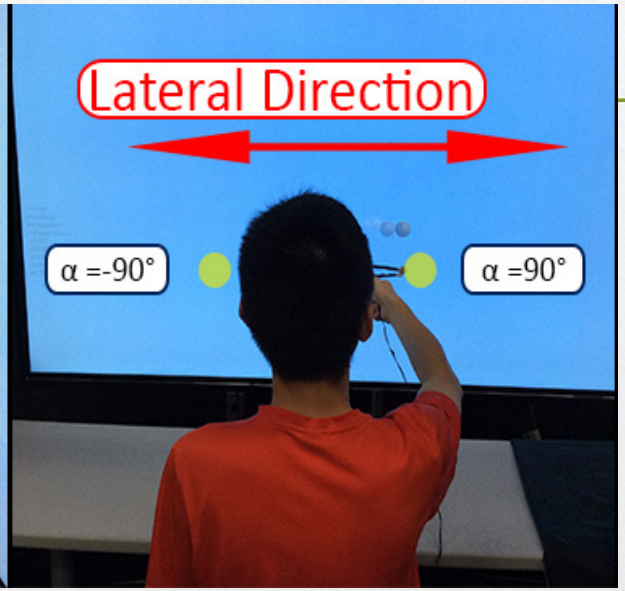


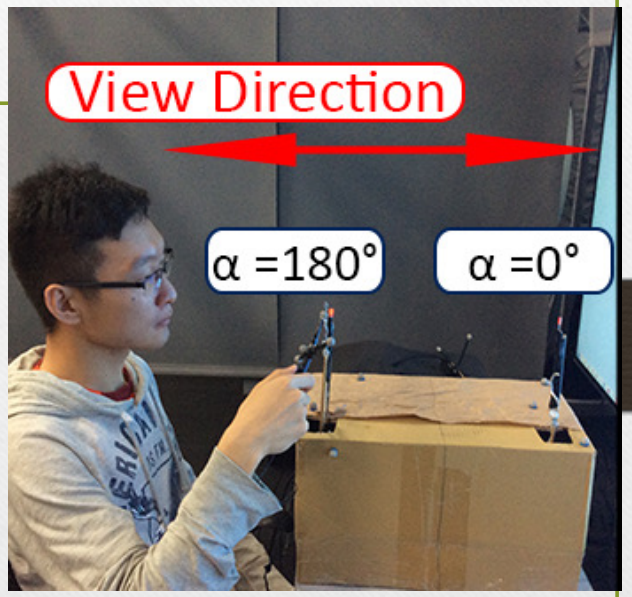


[Barrera CHI ’19 & Batmaz VR ‘19]

(Visual) Depth Dimension



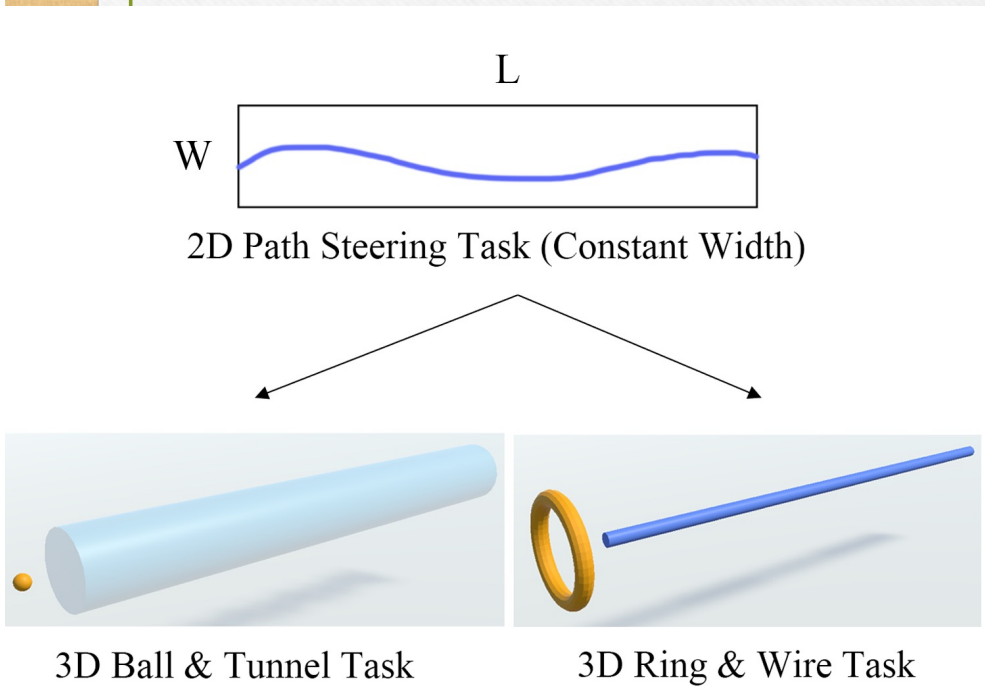




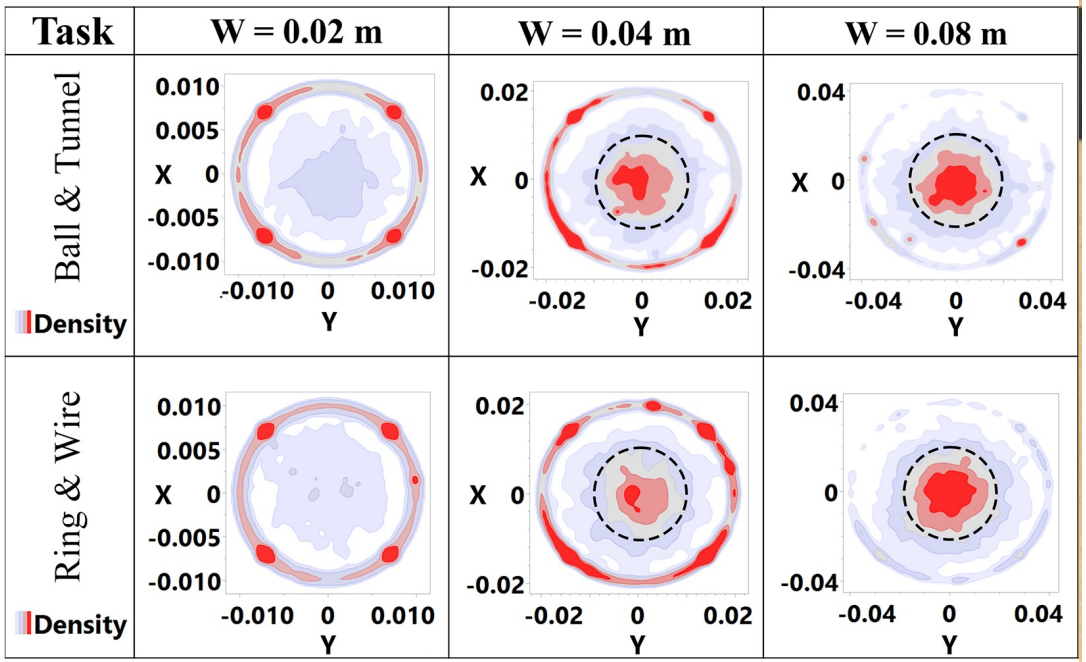
[Amini VRST '25]

Steering: Tunnels vs Wires

- Depth dimension matters



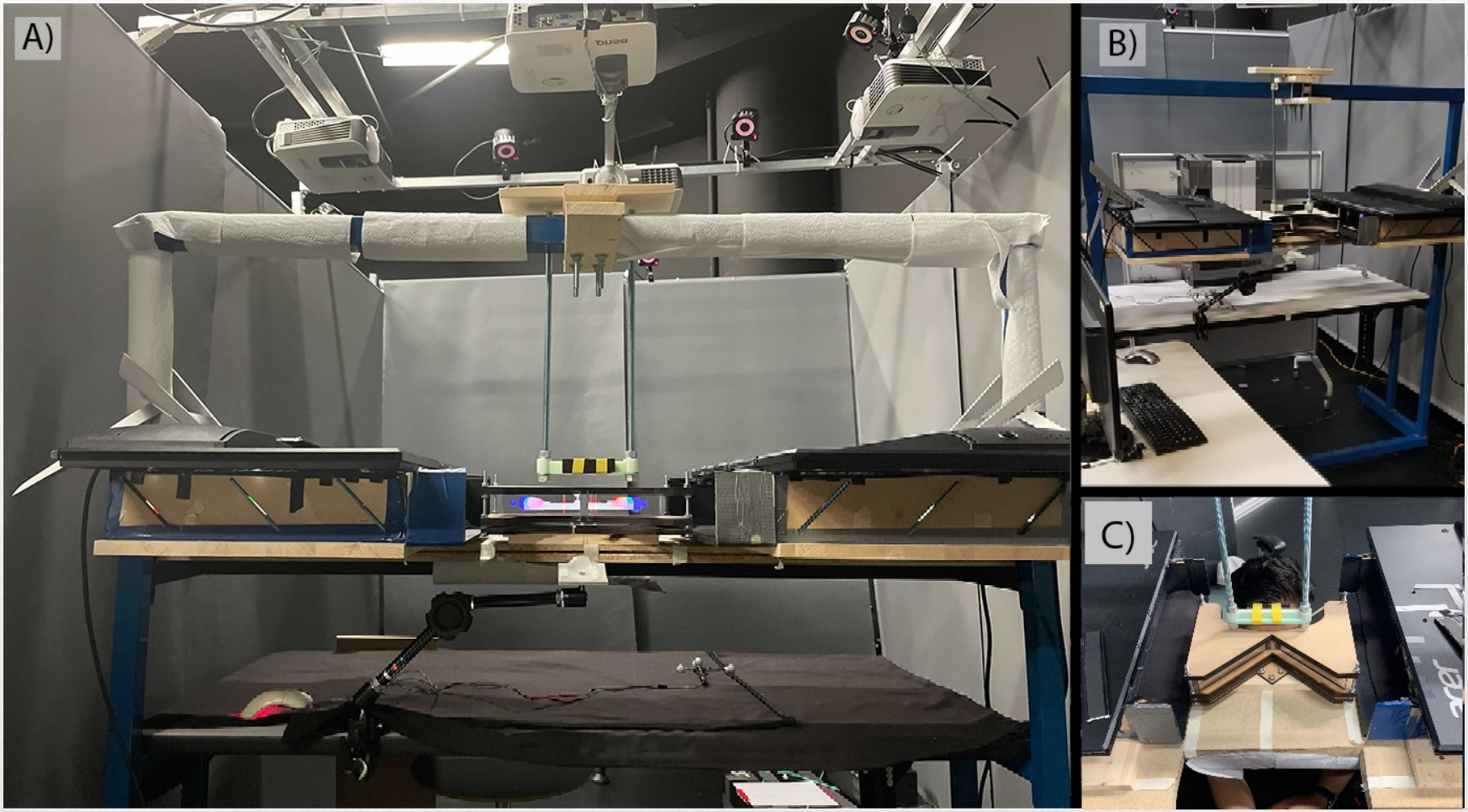
(a)



(b)

[Batmaz CHI ’22]

Multi-focal Display



Open Challenges

- Need headsets that afford better depth cues
  - Multi-focal
- Study interaction in multi-focal displays
  - Between focal planes

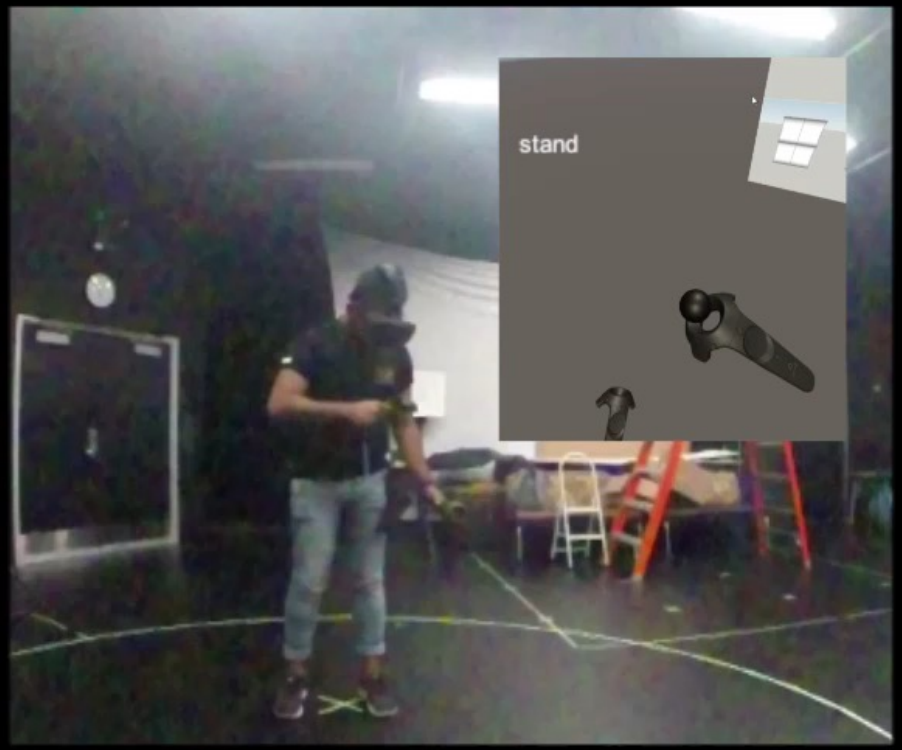
Spatial Skills

- Need
  - Creating/editing content in VR
  - Creative industry, engineering

[Barrera C&C '19]

Sketching

Standing Condition



High Spatial Ability

Low Spatial Ability

[Chidambaram DIS ’21 & ISMAR ‘22]

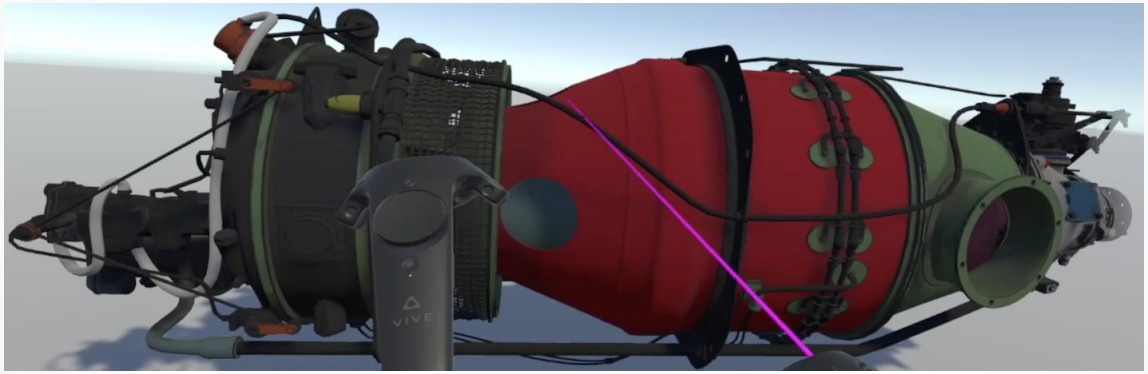
ProcessAR/EditAR : Spatial Skill Training

Open Challenges

- How to help users with spatial perception
  - Including users with weak or no stereo vision
- Detect if user could benefit from help
  - Encourage them to move?

Dense Virtual Content

- Need
  - Training, maintenance, simulation, large-scale engineering, urban planning, …
- Aircraft engine

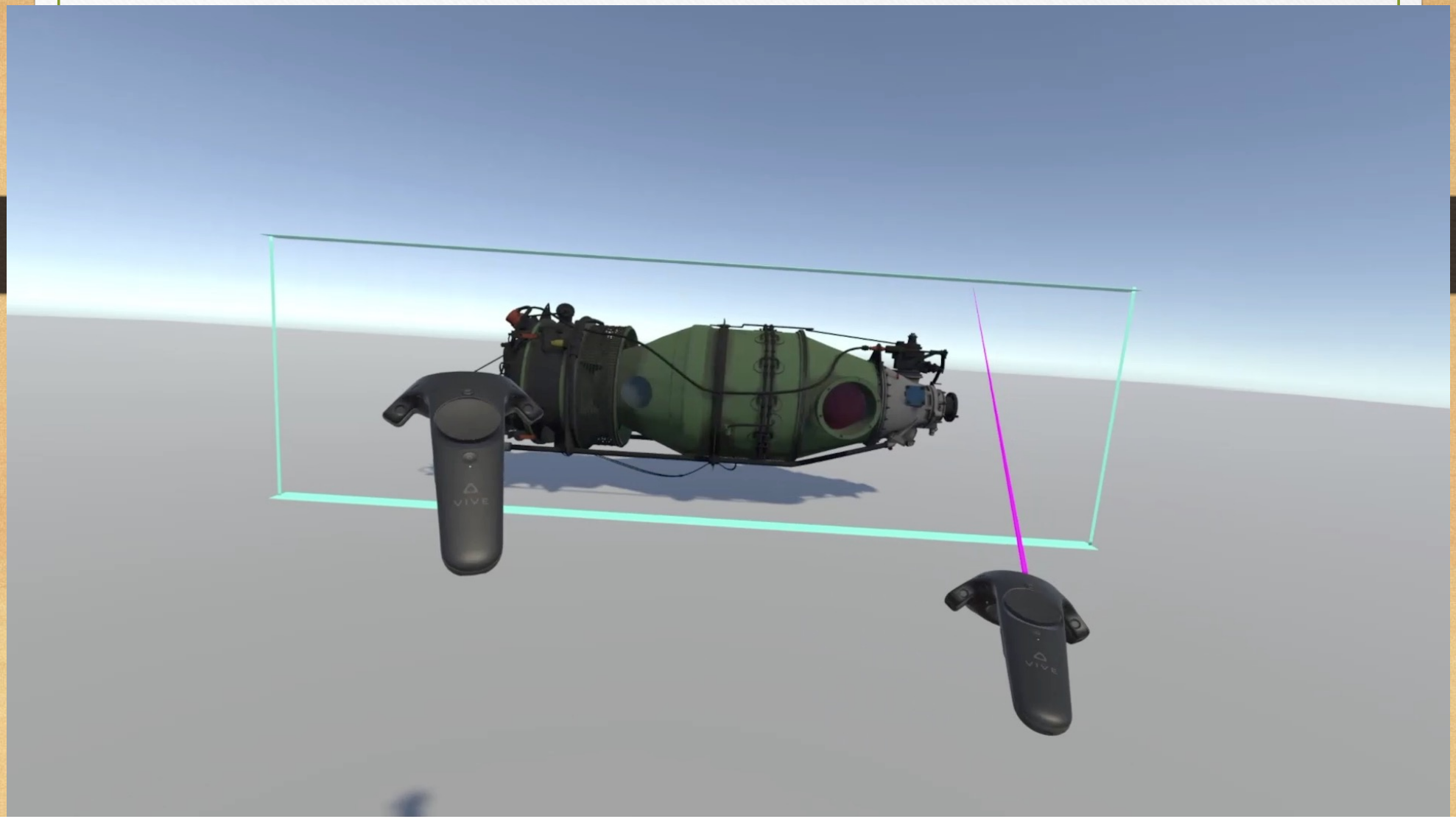


- Volume visualization

[J. Sun SUI '16]

Depth-Pop

Occluded Objects – VR



Open Challenges

- Efficient interaction with complex real-world models
- X-ray is challenging
  - Hard to see in which layer one interacts
  - Transparency is challenging!

Multi-scale Virtual Content

- Need
  - Anyone with large datasets
    - A country/continent
  - Games work very creatively with scale
- The ***cost*** of navigation

[Lee VRST '20]

Multiscale Navigation

Evaluating Automatic Parameter Control Methods for Locomotion in Multiscale Virtual Environments

Jong-In Lee, Paul Asente, Byungmoon Kim, Yeojin Kim, Wolfgang Stuerzlinger

Open Challenges

- Efficient multi-scale navigation
- Multi-scale content manipulation/creation

Thanks!

- Students
  - Aunnoy Mutasim
  - Morteza Malekmakan
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  - Jorge Wagner @ Apple
  - Mayra Barrera @ Calgary
  - A. Ufuk Batmaz @ Concordia
  - Rob Teather @ Carleton
  - Ahmed S. Arif @ UCMerced
  - Junwei Sun @ Huawei
  - Duc-Minh Pham @ Amazon
- Collaborators
  - K. Ramani @ Purdue
  - J. Han @ Korea
  - D. Wigdor @ UToronto
  - F. Putze @ Bremen
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