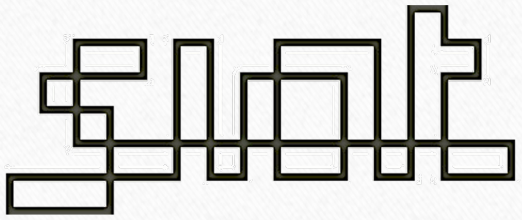
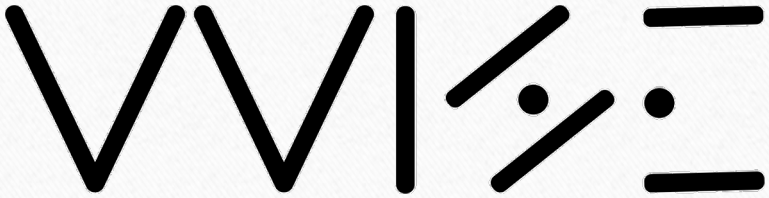


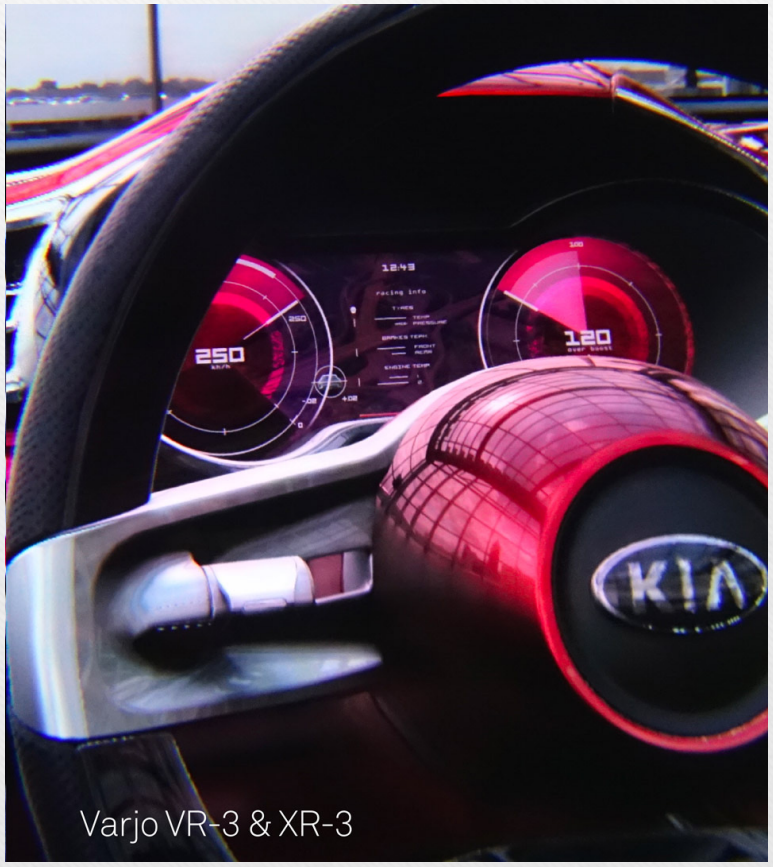
SCHOOL OF INTERACTIVE
ARTS + TECHNOLOGY



Towards Professional VR & AR Systems

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

VR & AR Works!



Varjo VR-3 & XR-3

My Vision: Professional VR/AR Systems

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

My Vision: Professional VR/AR Systems

- Use VR/AR to solve hard(er) real-world problems
  - Design & Engineering
    - Objects, structures, infrastructure, medical, biological, …
  - Training
    - Skill-transfer to real world tasks
    - Spatial skills

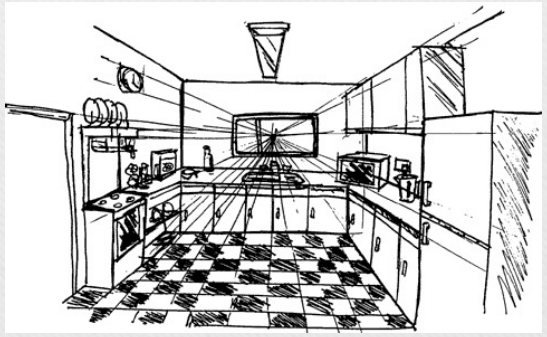
How to Get There?

- 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

Usability Guidelines (2D)

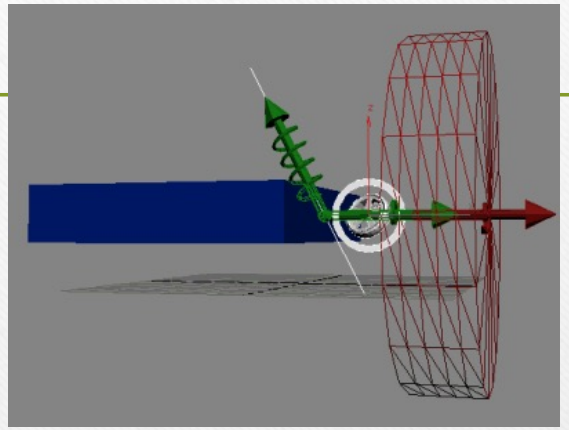
- Scott Klemmer's take on Nielsen's Guidelines

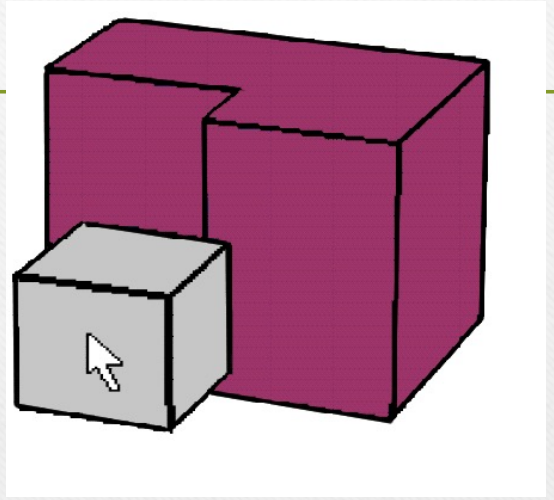
Usability Guidelines (3D)

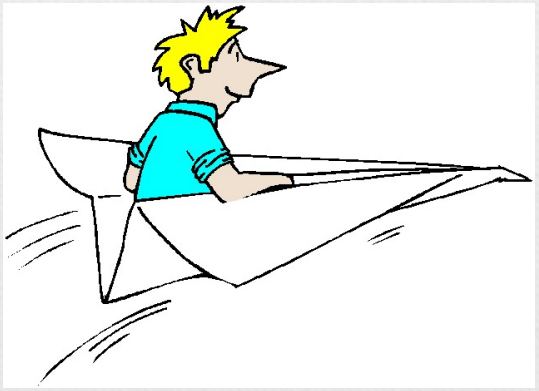


[with C. Wingrave, Dagstuhl08]

Usability Guidelines (3D)







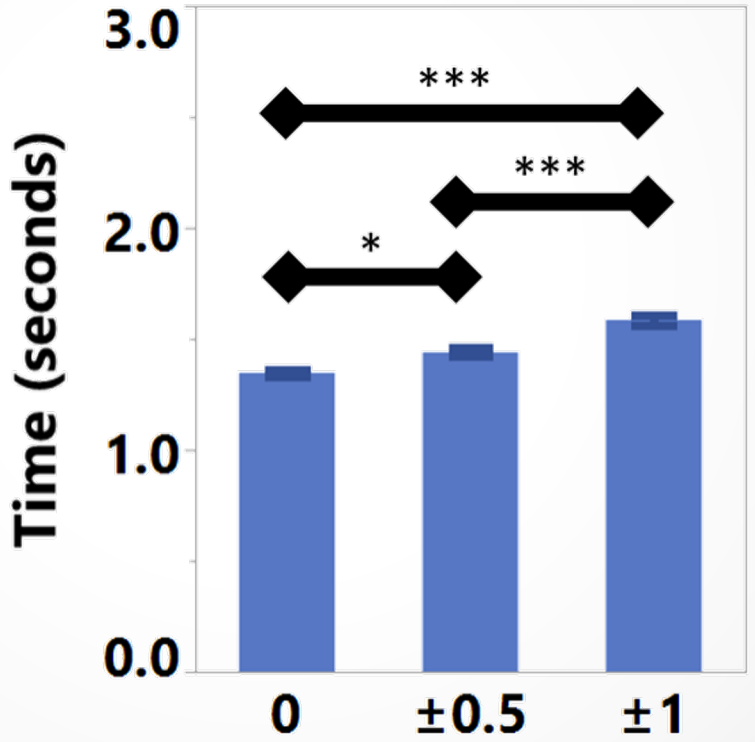
[with C. Wingrave, Dagstuhl08]

Some Real-World Challenges for VR & AR

- Precise Interfaces
- Ergonomic Interfaces
- Reliable Interfaces
- The Depth Dimension
- Spatial Skills
- Dense Virtual Content
- Multiscale Environments

Precise Interfaces

- Need
  - Simulation, CAD, Engineering
- Jitter does not help



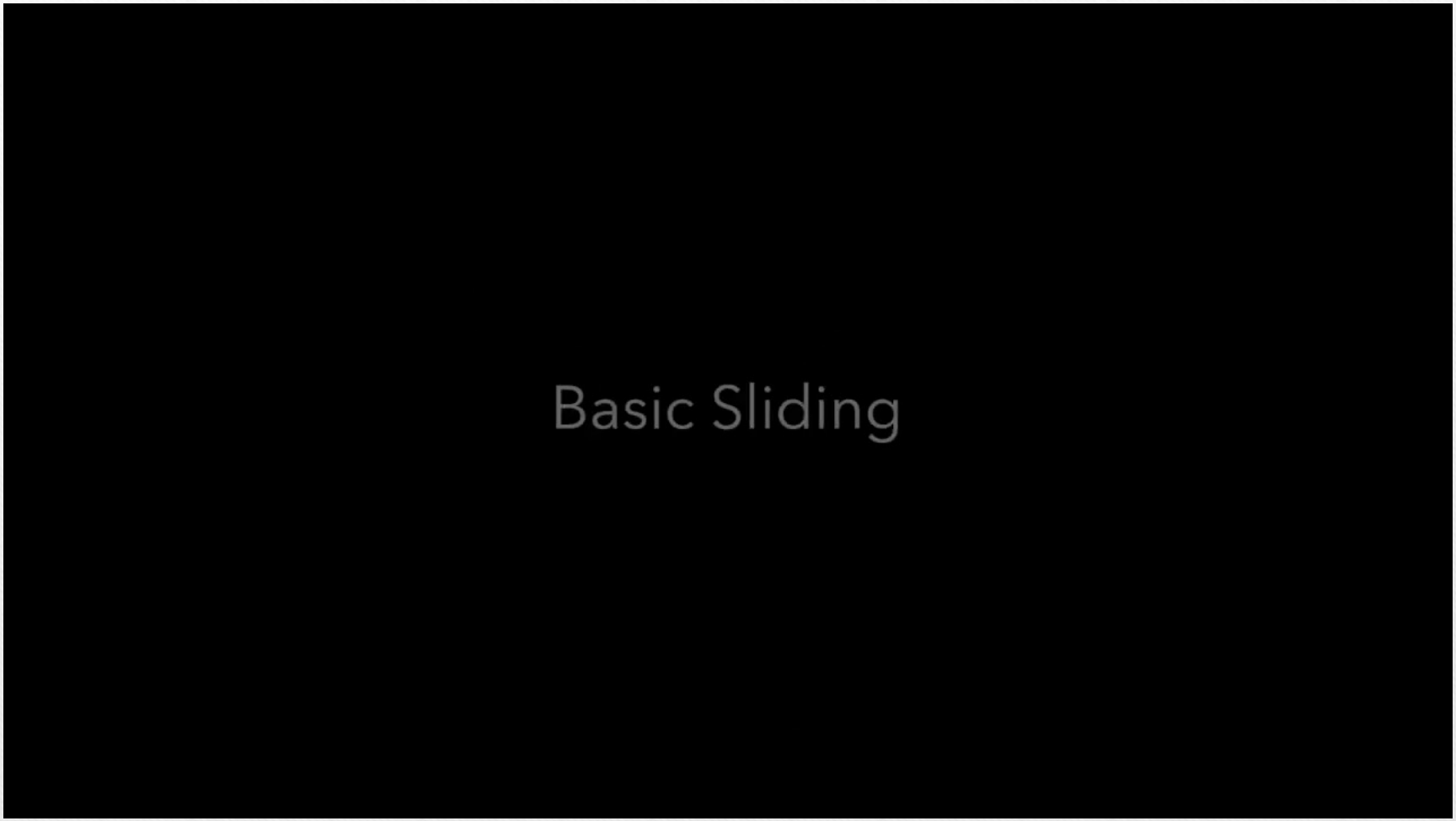
[Batmaz FTC '20]

Pen Input

[Pham VRST '19, Batmaz NIDIT '20]

[J. Sun SUI '16]

Sliding (Desktop)

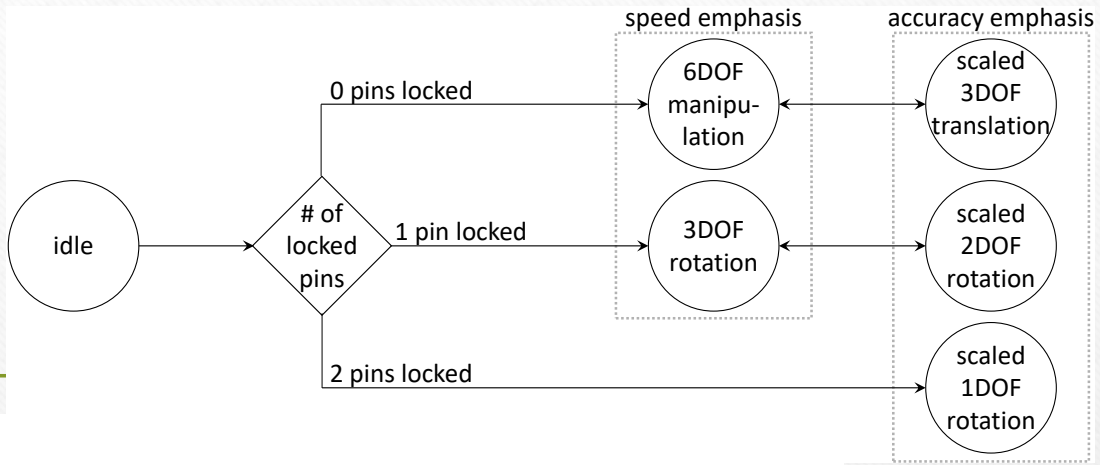


[J. Sun VRST '19]

Sliding (VR)

[Gloumeau TVCG '20]

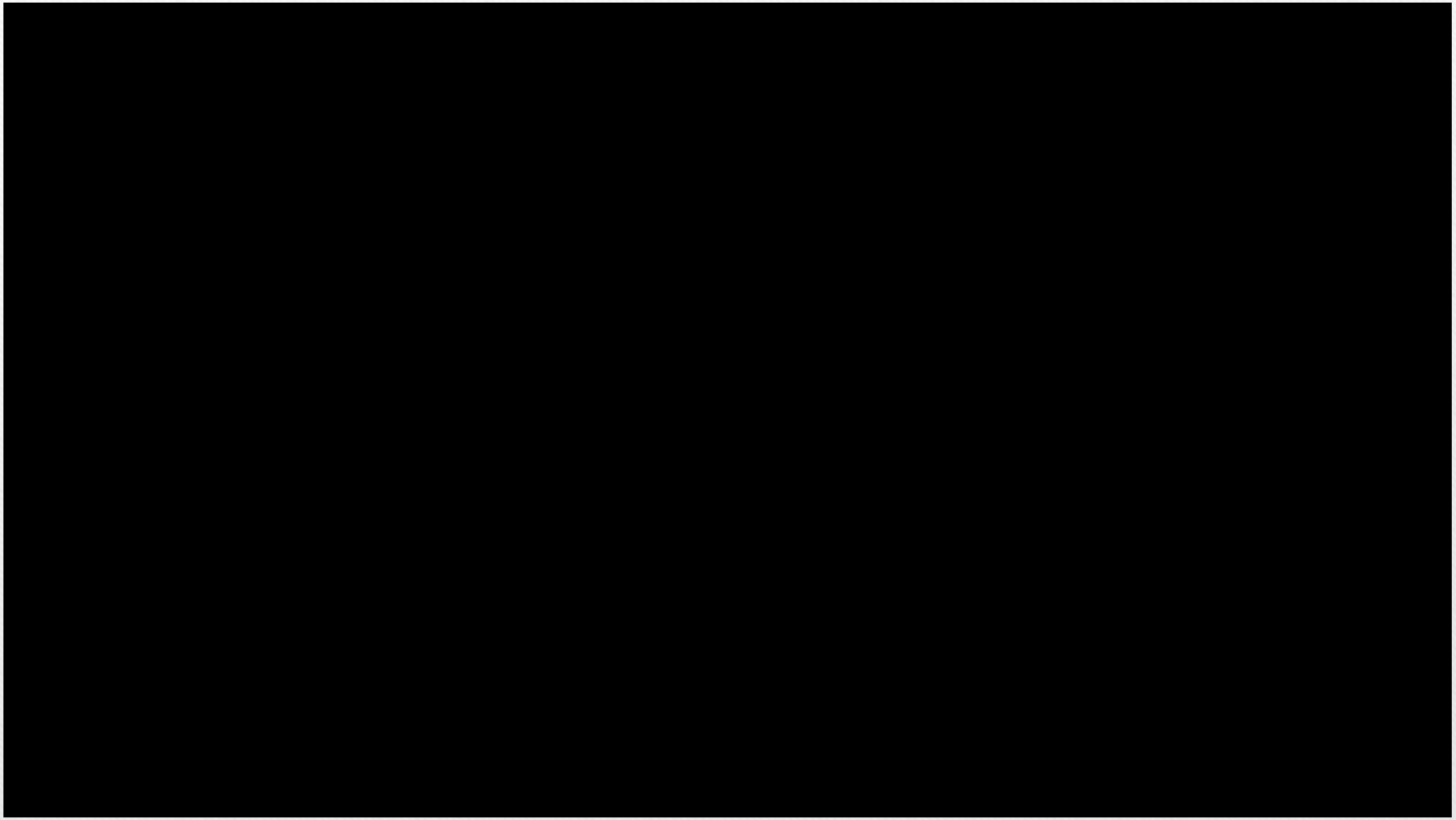
Pin'N'Pivot



PinNPivot

P. Christopher Gloumeau, Wolfgang Stuerzlinger and JungHyun Han

Plane, Ray, and Point



Open Challenges

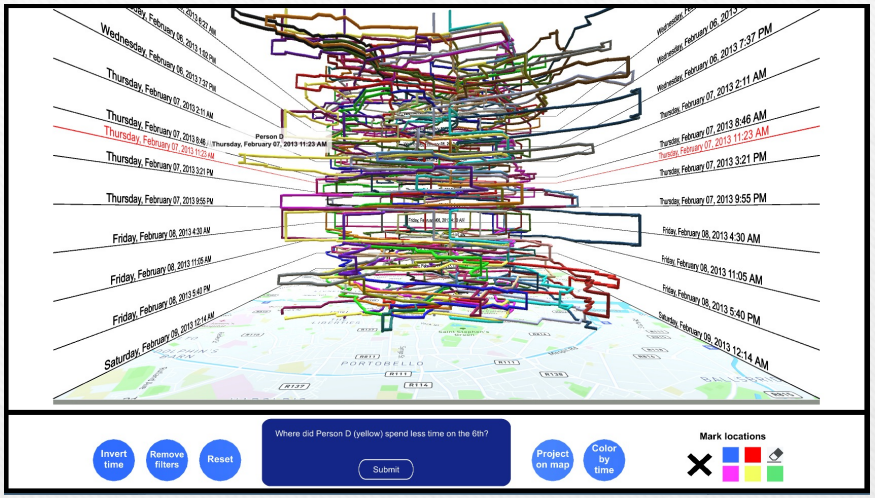
- Engineering requirements
  - Precise measurements
    - 19.375 m
  - Match real world
    - Tracking

Ergonomic Interfaces

- How long will users stand?
  - Support seated interaction
- Virtual hand vs ray-casting?

[Wagner VR/TVCG '19]

Immersive Analytics of STC Seated Desktop vs. VR



[Wagner TVCG '21]

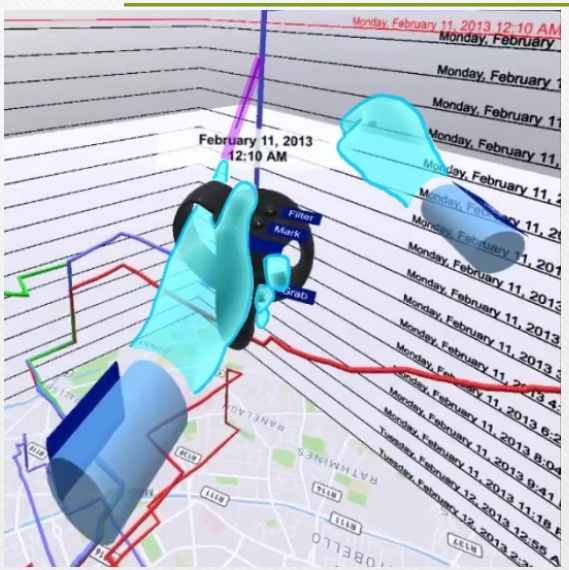
Ego vs Exocentric, Walking vs Flying Navigate or Move Data or Both?

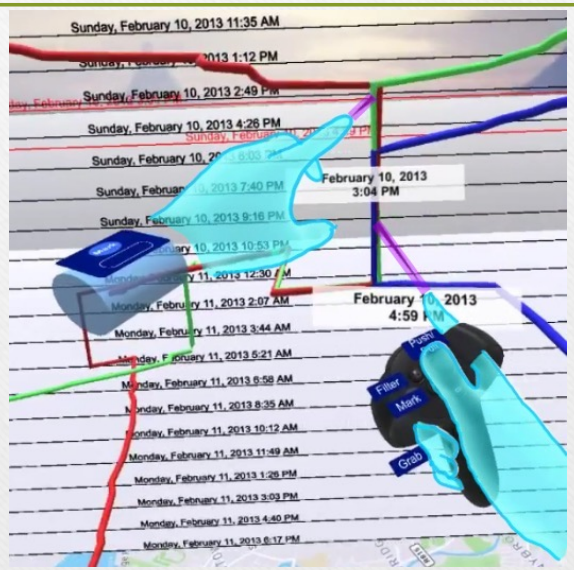
The Effect of Exploration Mode and Frame of Reference in Immersive Analytics

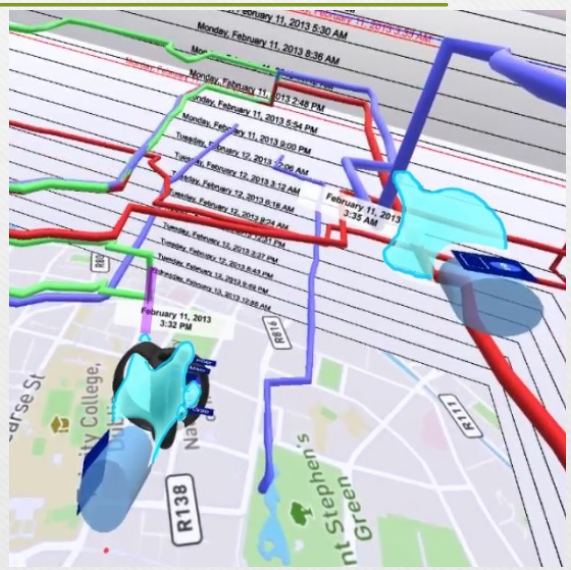
Jorge Wagner, Wolfgang Stuerzlinger, Luciana Nedel

[Wagner VR/TVCG '21]

Virtual Hand vs Ray-Casting







HawKEY

- 77+ WPM while standing
- Video when looking down

[Pham VRST '19]

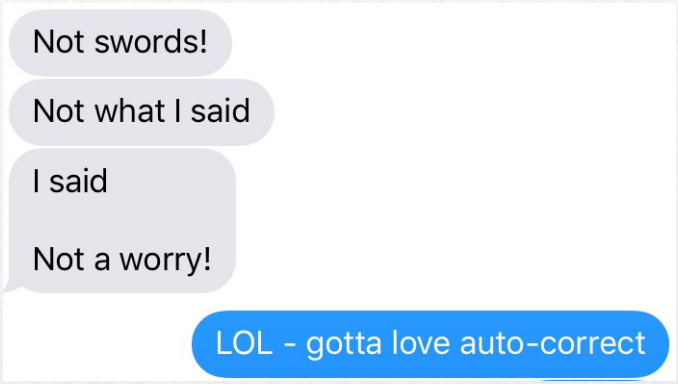
Open Challenges

- Using a headset for 8 hours a day?
- Transitions between desktop & VR/AR

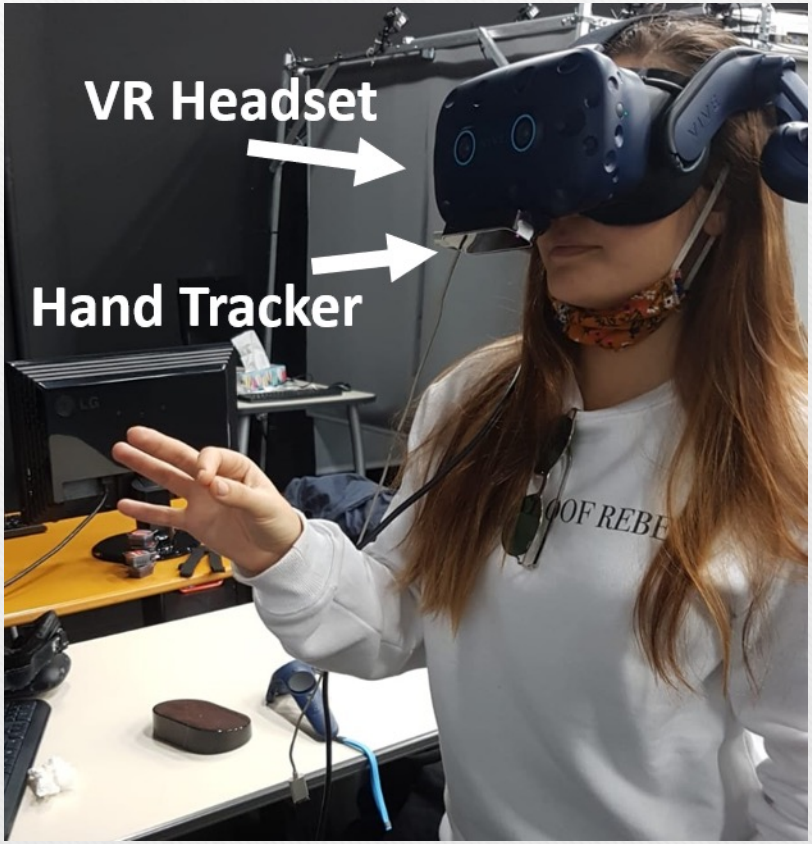
Reliable Interfaces

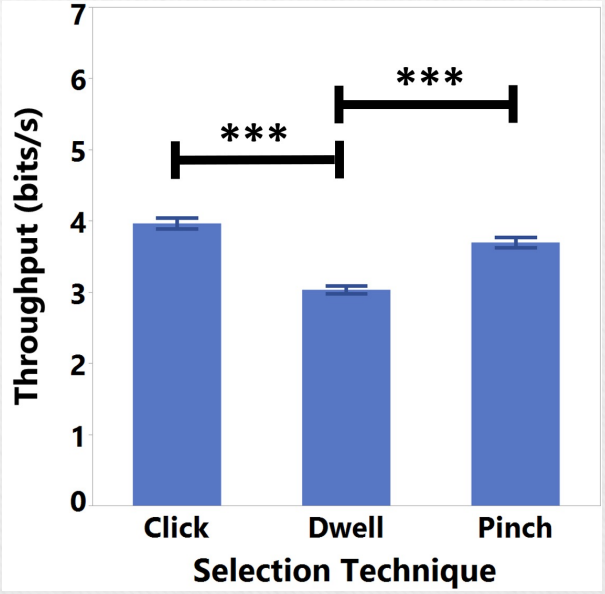
- The ***cost*** of errors
  - Regardless if system or user
- Need
  - Everyone
- Some Technologies fail occasionally
  - Recognition
    - Pinch “away” from camera
  - Eye tracking
  - Tracking glitches

Assistive/Recognition Technologies



Selection for Eye-Tracking





[Mutasim ETRA '21]

Adaptation?

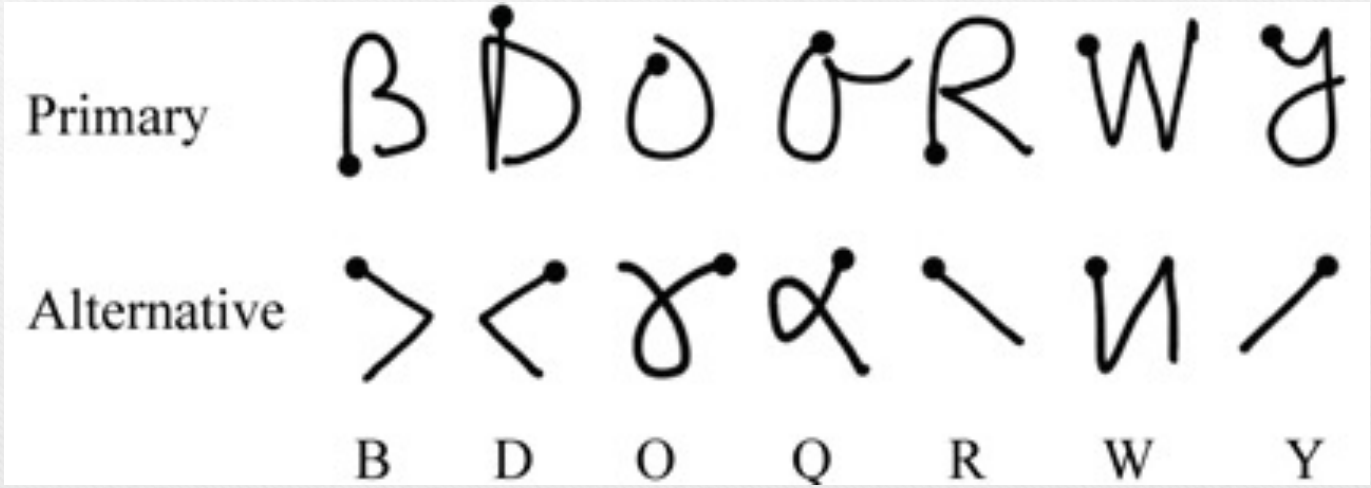
- Errors can happen (system or user)
  - And *errors on errors*
  - There is a ***cost*** to errors
- Humans could adapt
  - BUT …

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

Gesture Study

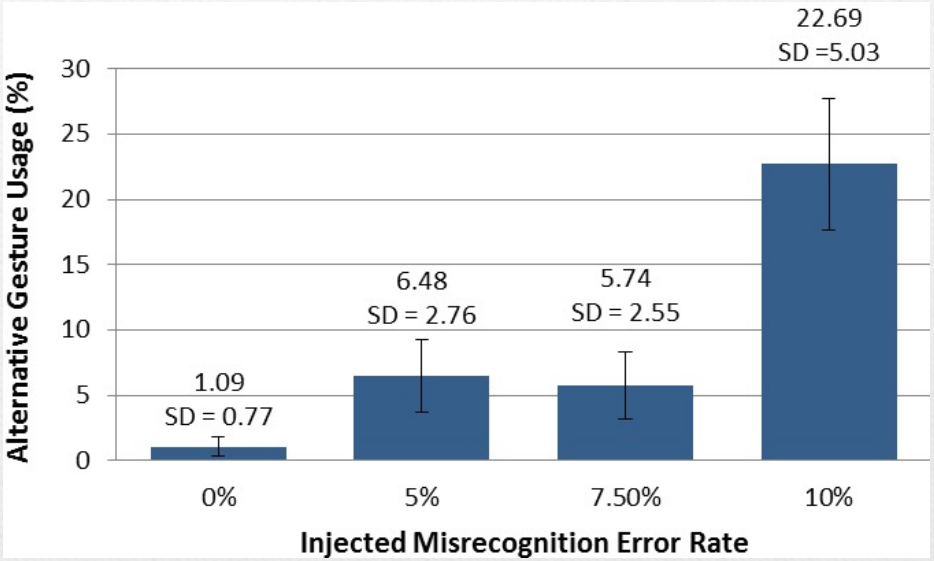
- Graffiti ≈ Unistrokes [Castellucci, MacKenzie 2008]
  - Method switch will not compromise performance



[Arif GI '14]

Alternative Method Usage

- Significant effect of misrecognition rate



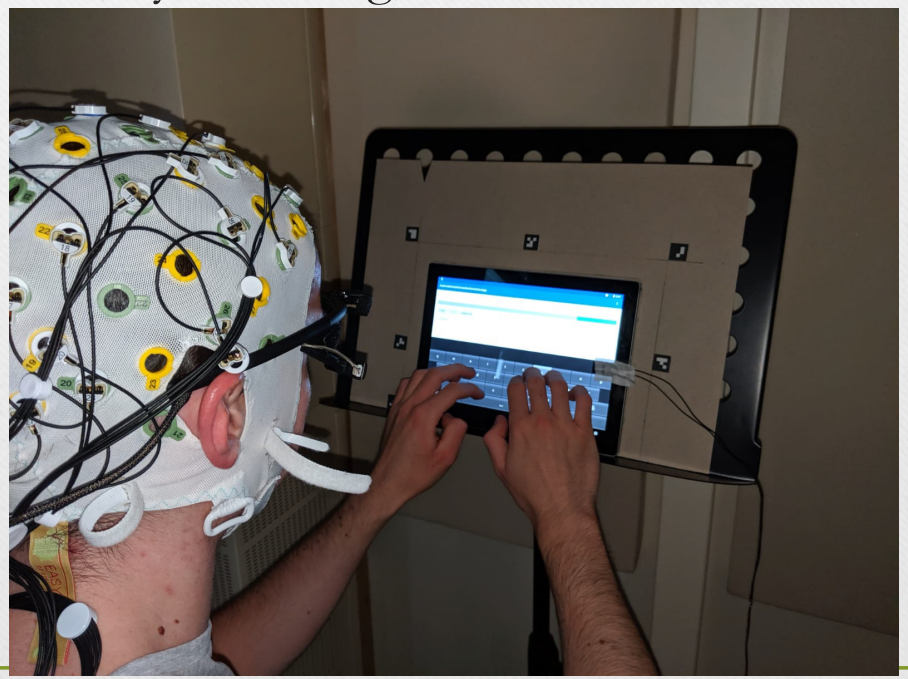
- 0, 5-7.5% and 10% significantly different

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?

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%



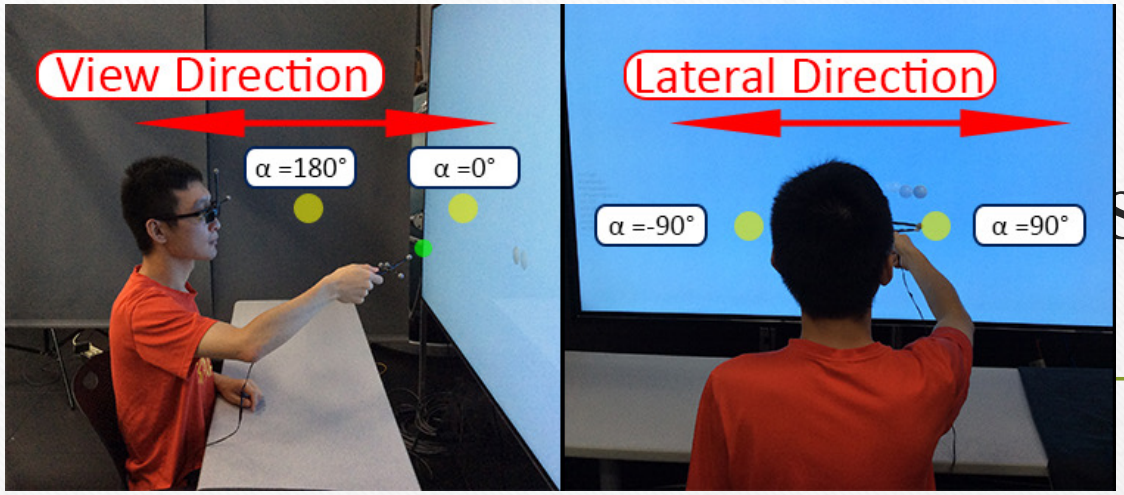
[Putze ICMI '17]
[Putze CHI '20]

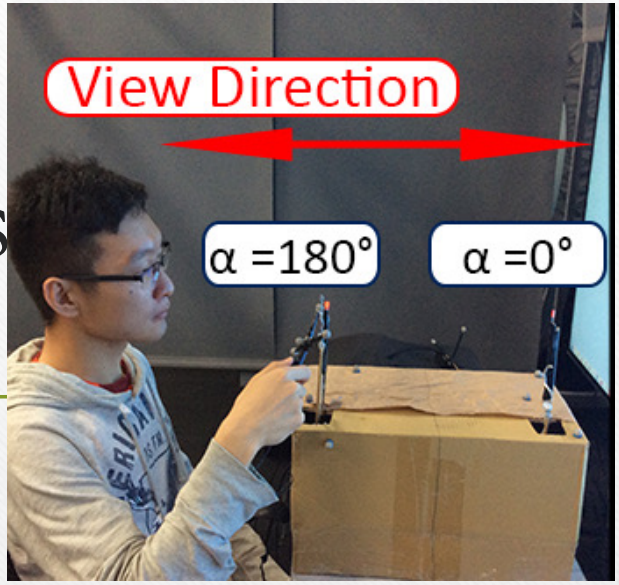
Open Challenges

- Reliability a big challenge in terms of usability
  - Tracking systems
  - Recognition systems
  - …

The Depth Dimension

- Need
  - Anyone who needs more than 2D





[Barrera CHI '19][Batmaz VR '19]

[Batmaz CHI ’22 conditionally accepted]

Multi-focal Display

Open Challenges

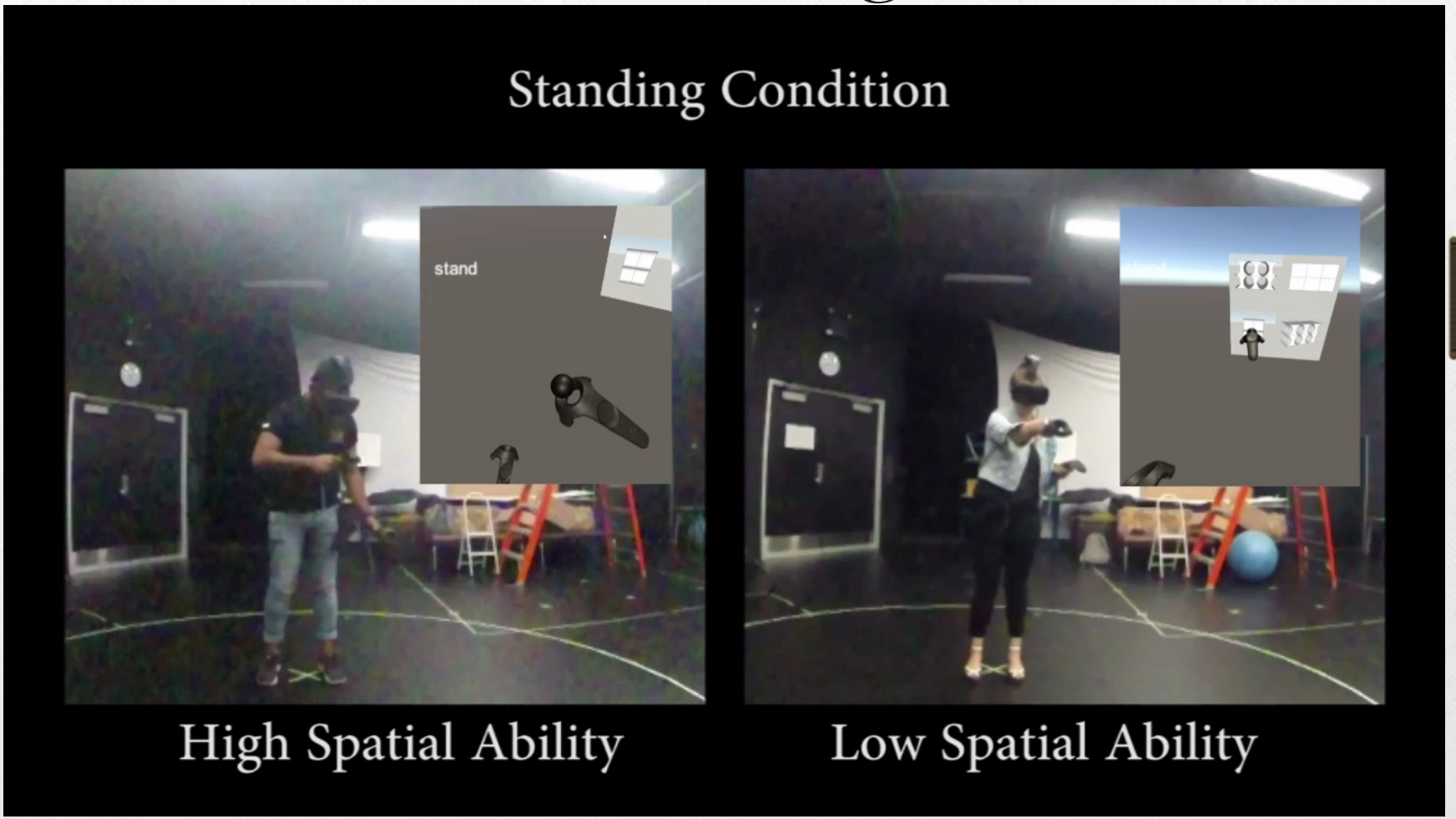
- Build headsets that afford multi-focal displays
- Study interaction in multi-focal displays more
  - Between focal planes

Spatial Skills

- Need
  - Anyone creating/editing content in VR
  - Creative industry, engineering

[Barrera C&C '19]

Sketching



[Chidambaram DIS '21]

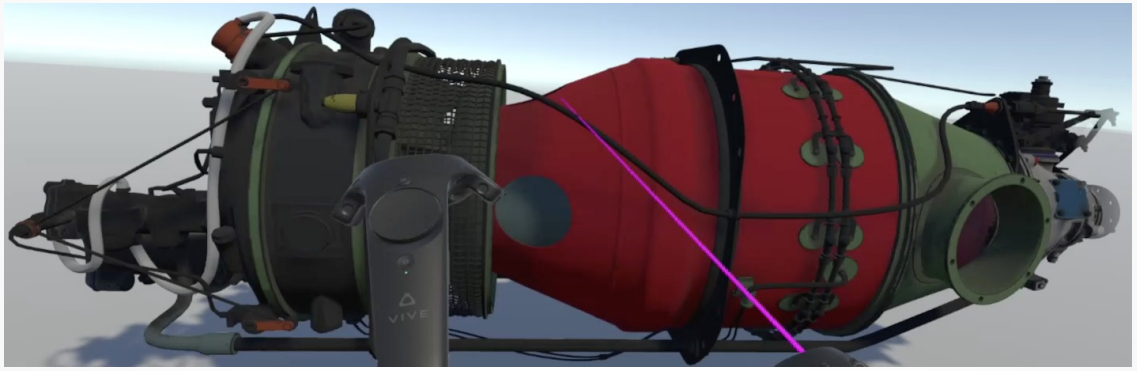
ProcessAR: Spatial Skills Training

Open Challenges

- How to detect if user could benefit from help
  - Including users with weak or no stereo vision
- How to help users with spatial perception

Dense Virtual Content

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



- Volume visualization

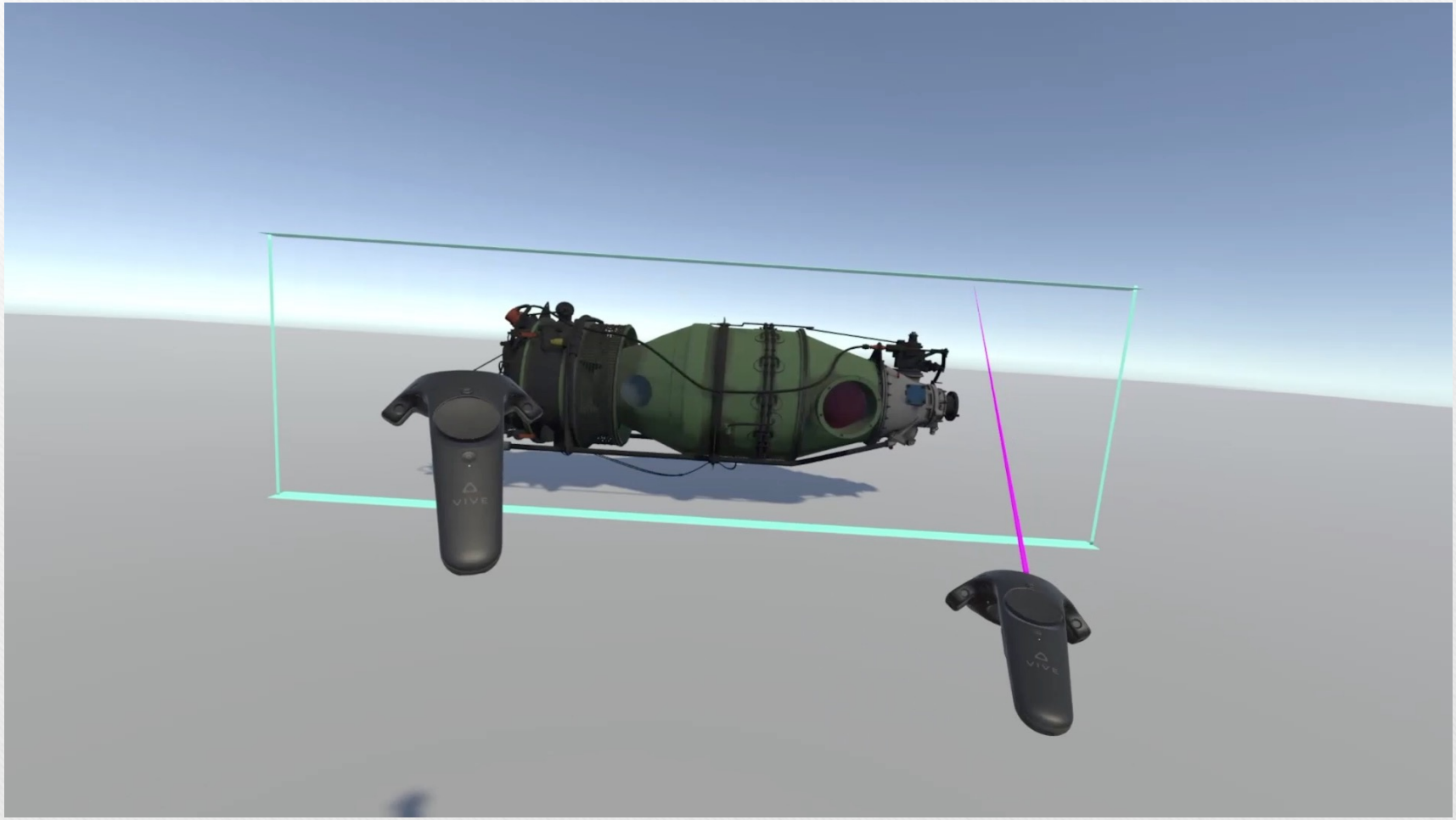
[J. Sun SUI '16]

Depth-Pop

[J. Sun GI '19]

Occluded Objects – Desktop

Occluded Objects – VR



Open Challenges

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

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

Open Challenges

- Computationally efficient multi-scale navigation
- Multi-scale content creation

Thanks!

- Students
  - Aunnoy Mutasim
  - Jong-In Lee
  - Morteza Malekmakan
- Past Students & Postdocs
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  - A. Ufuk Batmaz @ Kadir Has
  - Rob Teather @ Carleton
  - Ahmed S. Arif @ UCMerced
  - Junwei Sun
  - Duc-Minh Pham
- Collaborators
  - K. Ramani @ Purdue
  - J. Han @ Korea
  - D. Wigdor @ Toronto
  - F. Putze @ Bremen
  - P. Asente @ Adobe
  - N. Vinson @ NRC