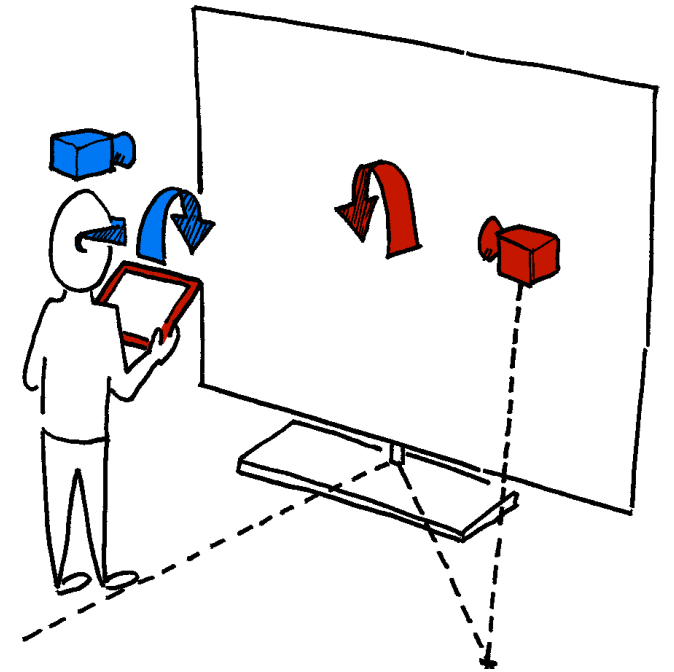


Towards an Understanding of Mobile Touch Navigation in a Stereoscopic Viewing Environment for 3D Data Exploration

David López, Lora Oehlberg,
Candemir Doger, and Tobias Isenberg



3D Data Visualization: Stereoscopy/VR



[image: Univ. Groningen]

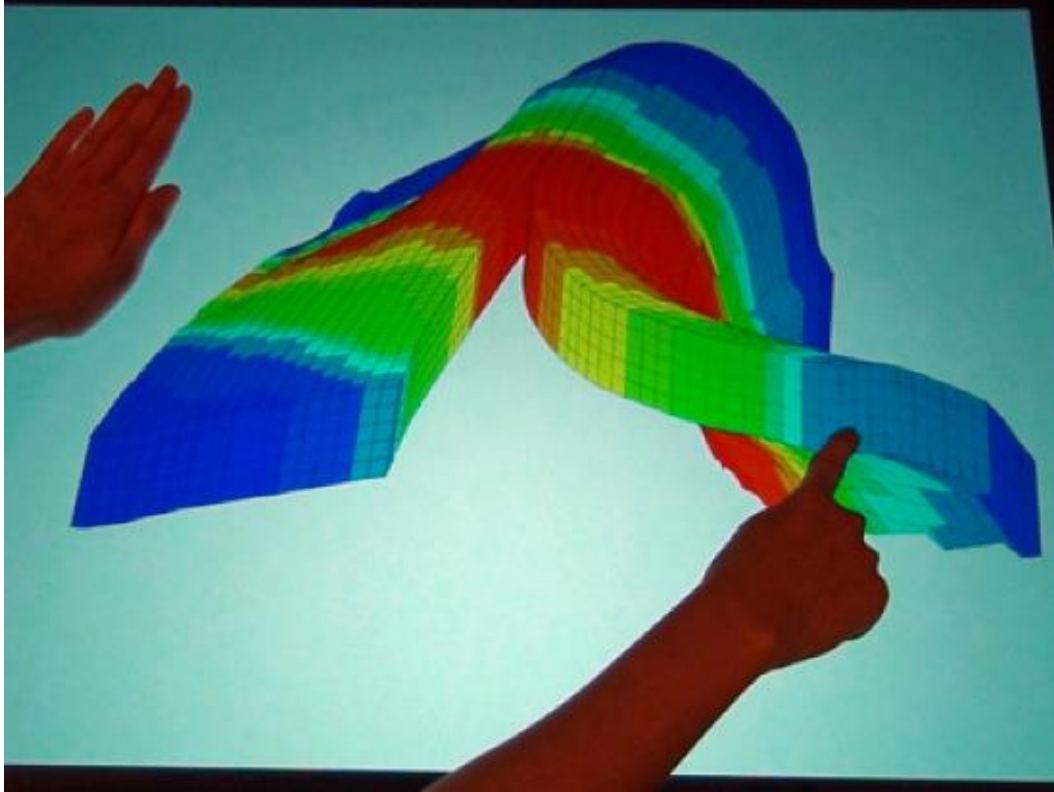
3D Data Visualization: Stereoscopy/VR



[image: Univ. Groningen]

→ visual immersion

Touch-Based 3D Data Exploration



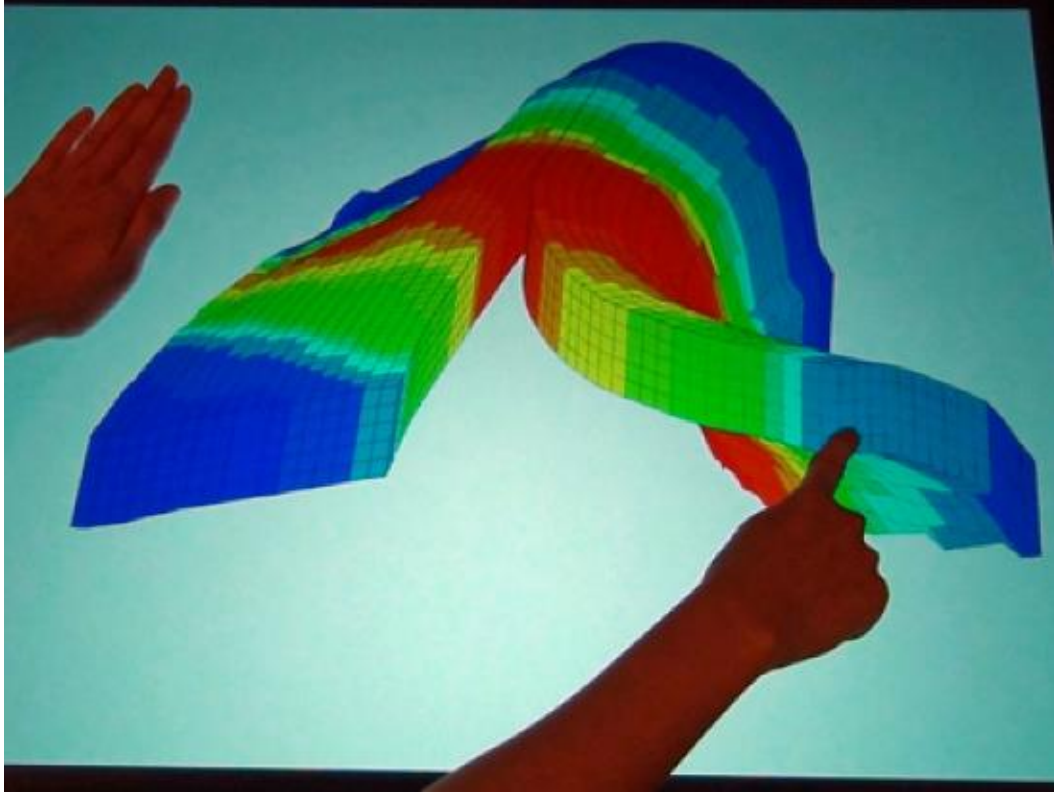
[Sultanum et al. 2010/2011]



[Lundström et al., 2011]



Touch-Based 3D Data Exploration



[Sultanum et al. 2010/2011]



[Lundström et al., 2011]

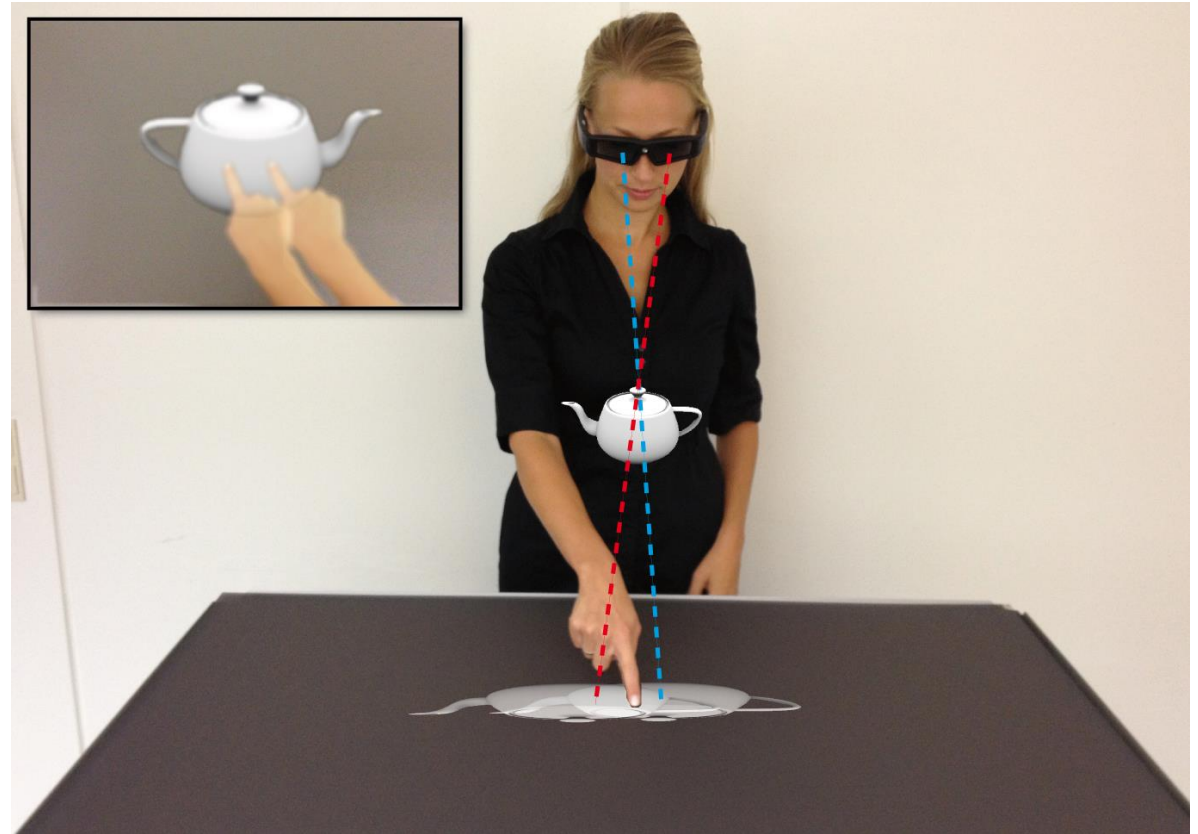
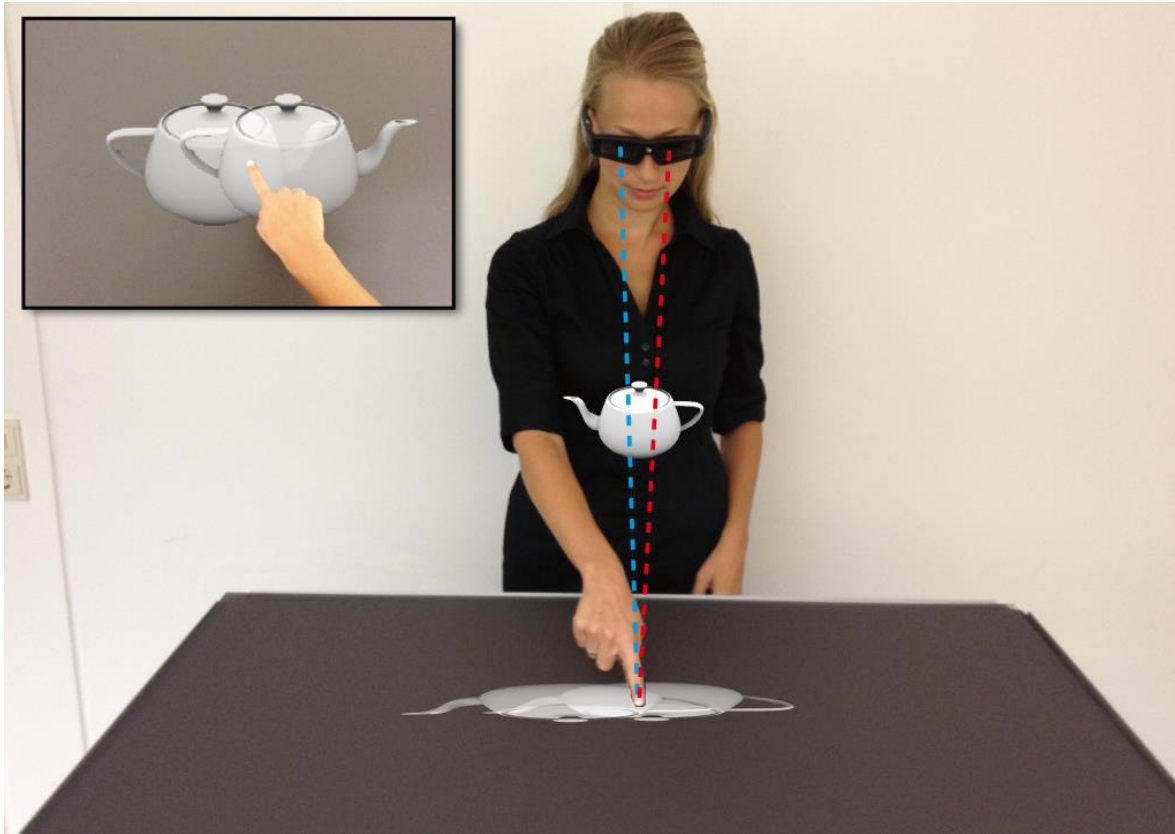
→ immersion from interaction

Touch-based Navigation & Stereo?



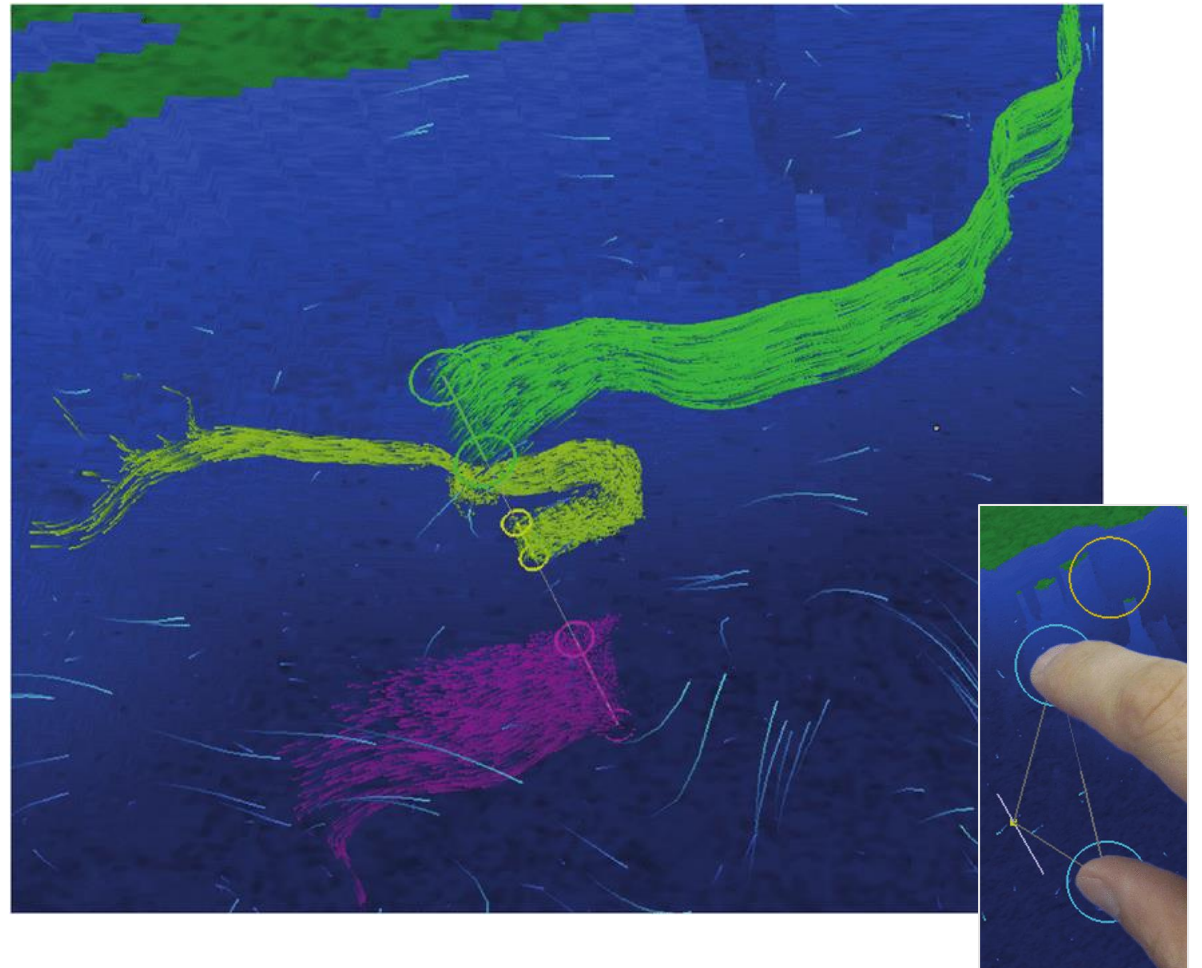
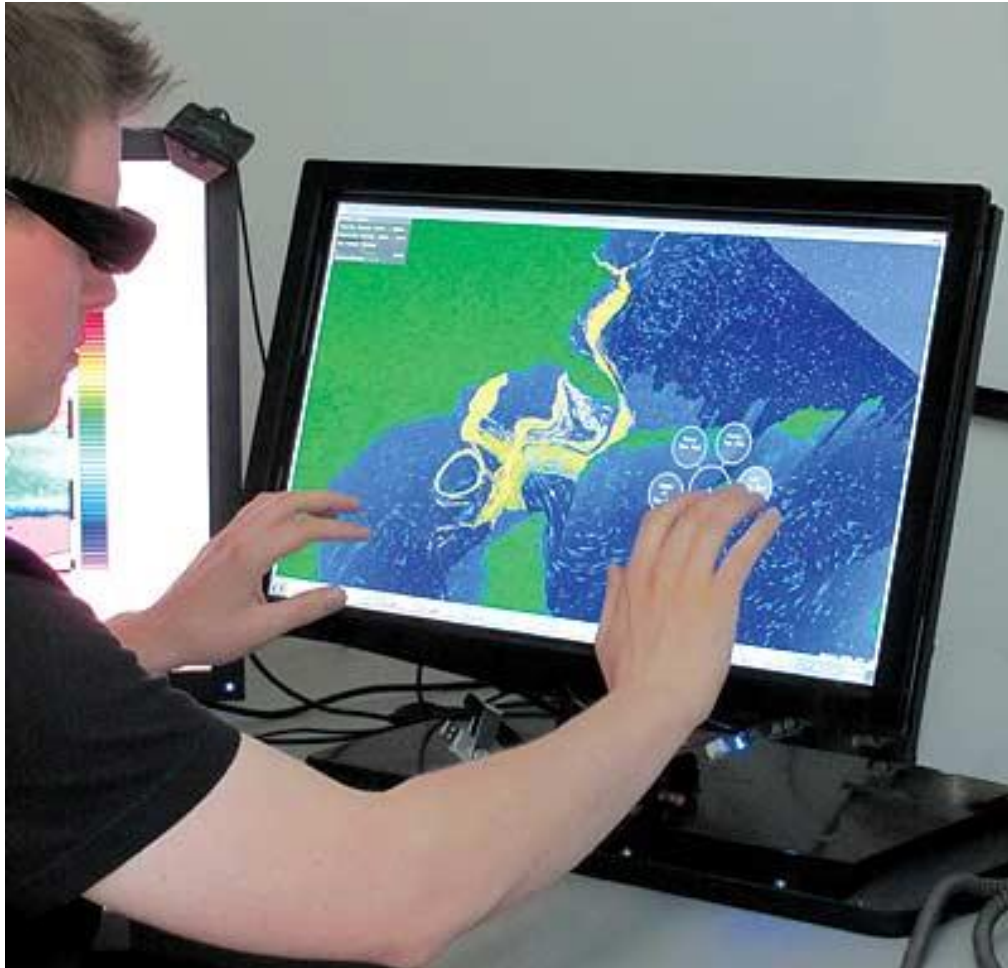
[Bruder et al. 2013]

Touch-based Navigation & Stereo?



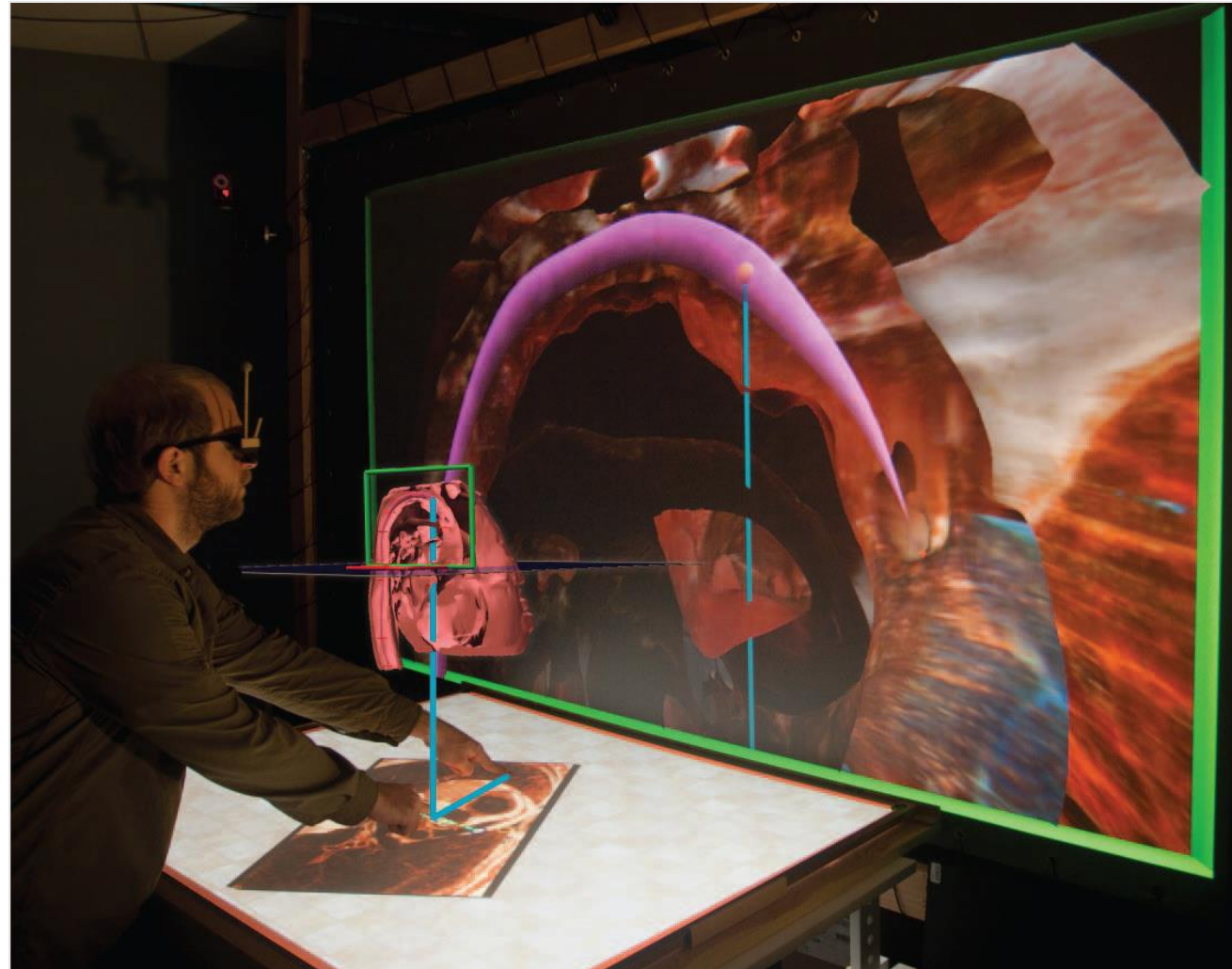
[Bruder et al. 2013]

Touch Navigation + Stereo View – Shallow 3D



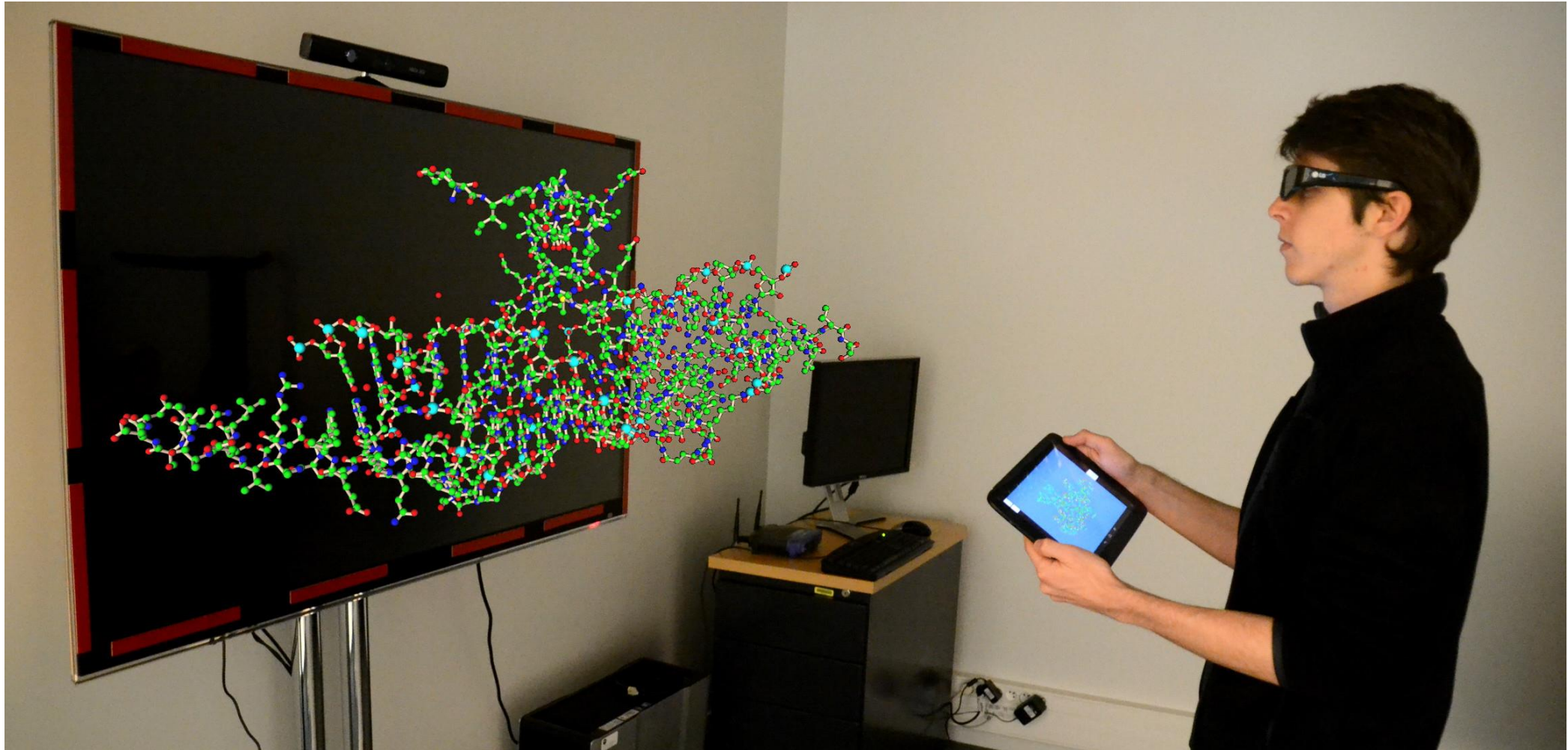
[Burtkiewicz & Ware, 2011]

Touch Navigation + Stereo View – SliceWIM

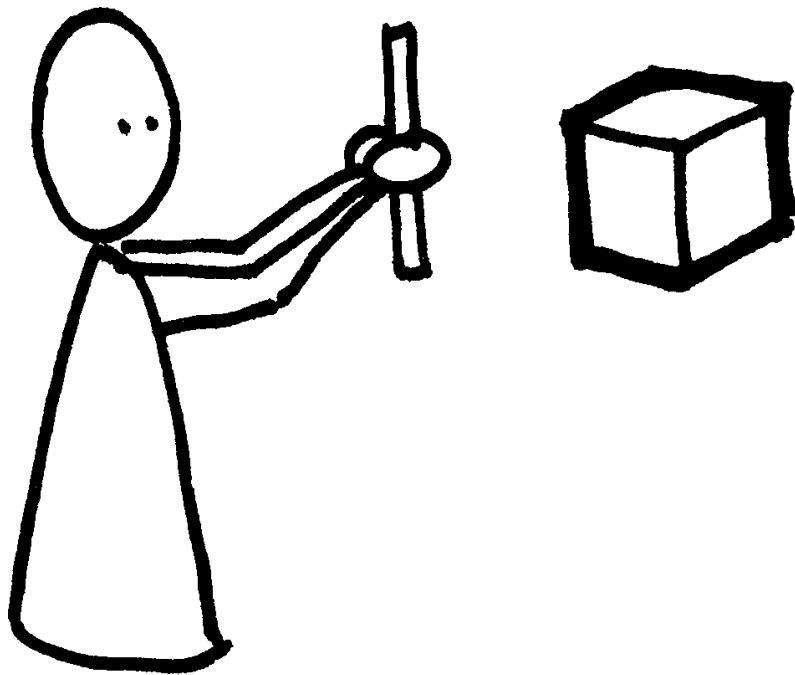


[Coffey et al. 2011/2012]

Mobile Touch Navigation + Stereo View



Mobile Touch Navigation + Stereo View



metaphor (video) camera, taking pictures

goal set correct view

tablet camera $\approx$ (VR) viewer cam
 $\approx$ viewer

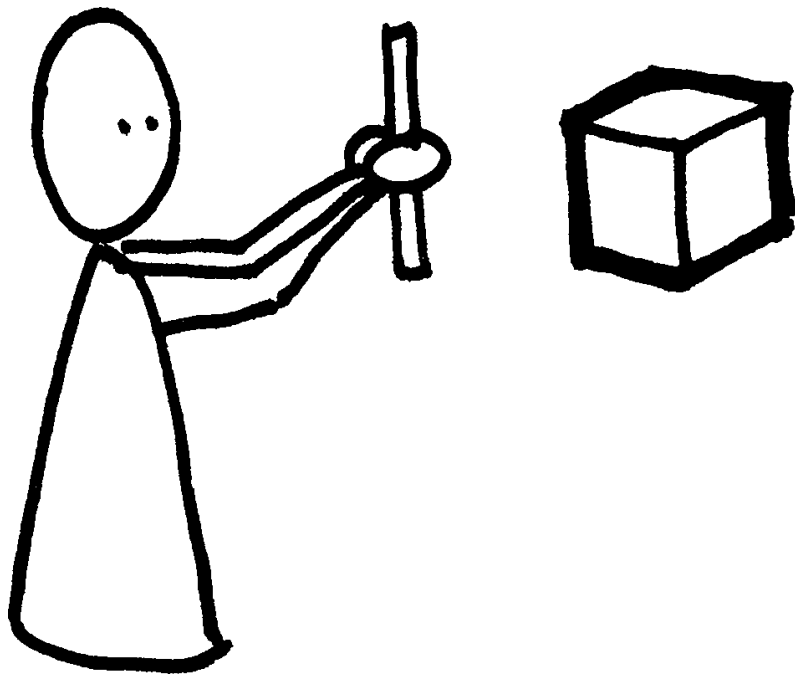
tablet position = tablet cam
 $\approx$ viewer cam

interaction focus tablet

mapping clarity clear

tablet handling **awkward**

Mobile Touch Navigation + Stereo View



metaphor (video) camera, taking pictures

goal set correct view

tablet camera $\approx$ (VR) viewer cam
 $\approx$ viewer

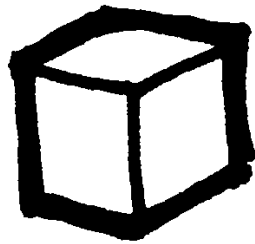
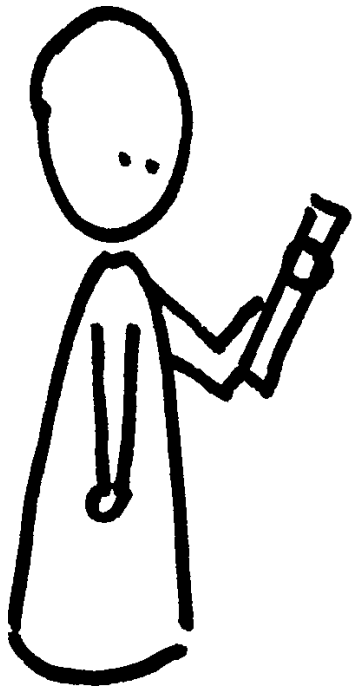
tablet position = tablet cam
 $\approx$ viewer cam

interaction focus tablet

mapping clarity clear

tablet handling **awkward**

Mobile Touch Navigation + Stereo View



metaphor

still camera, after pictures

goal

controllable, stable interaction

tablet camera

≈ (VR) viewer cam

≈ viewer

tablet position

lower than tablet/viewer cams,
only 1 rotation

interaction focus

tablet or stereo view

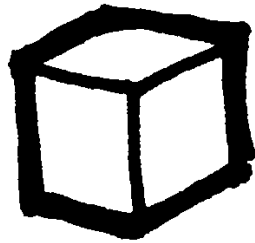
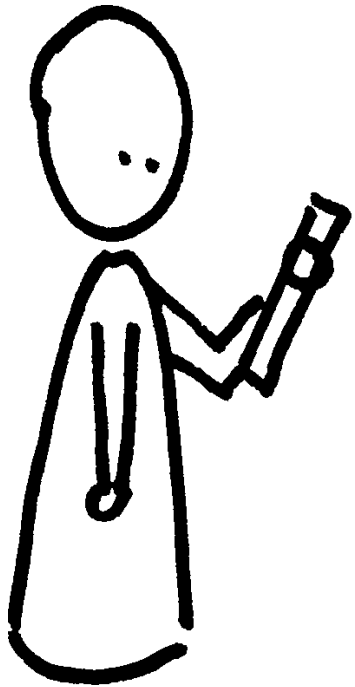
mapping clarity

clear

tablet handling

easy

Mobile Touch Navigation + Stereo View



metaphor

still camera, after pictures

goal

controllable, stable interaction

tablet camera

≈ (VR) viewer cam

≈ viewer

tablet position

lower than tablet/viewer cams,
only 1 rotation

interaction focus

tablet or stereo view

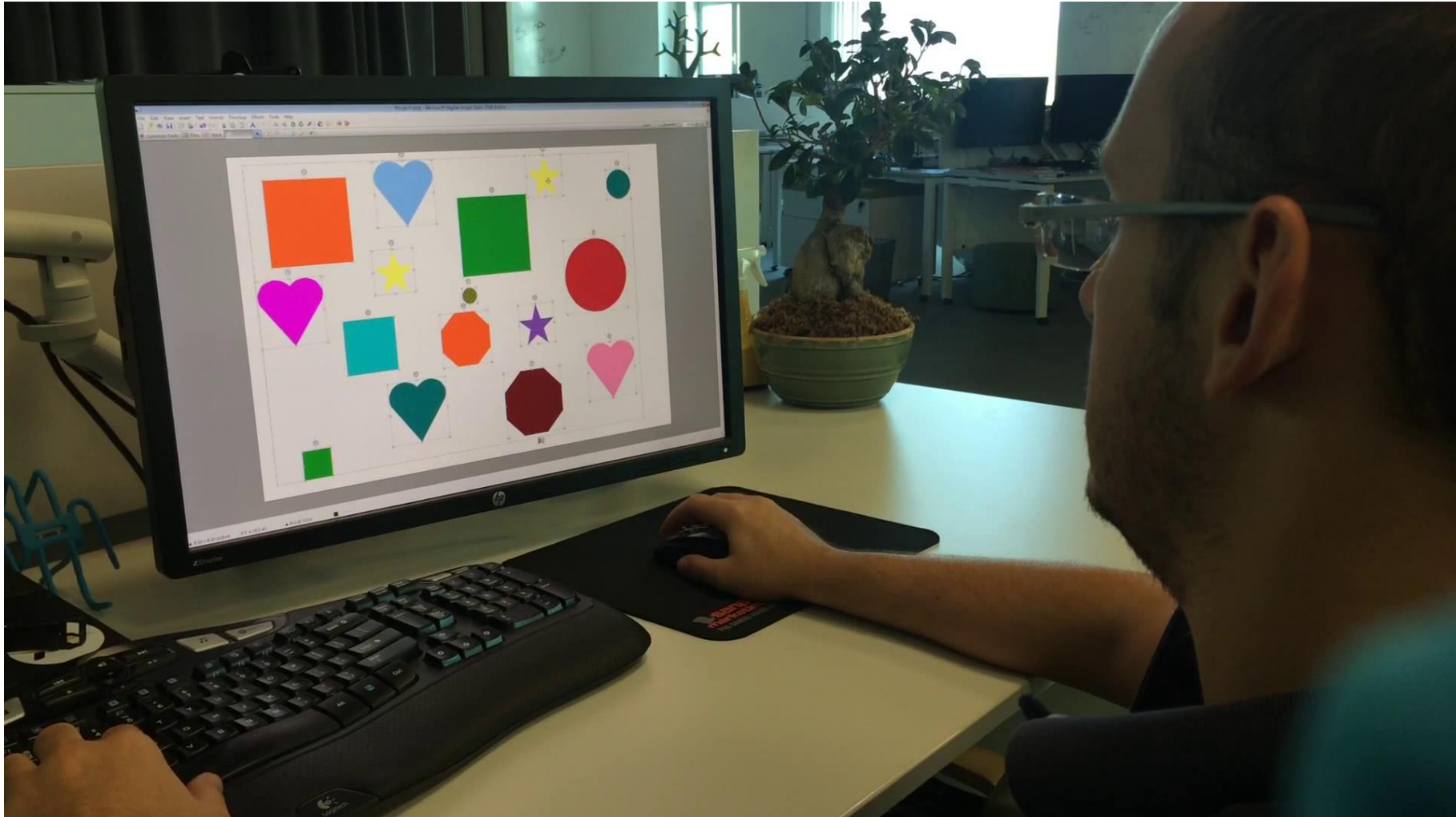
mapping clarity

clear

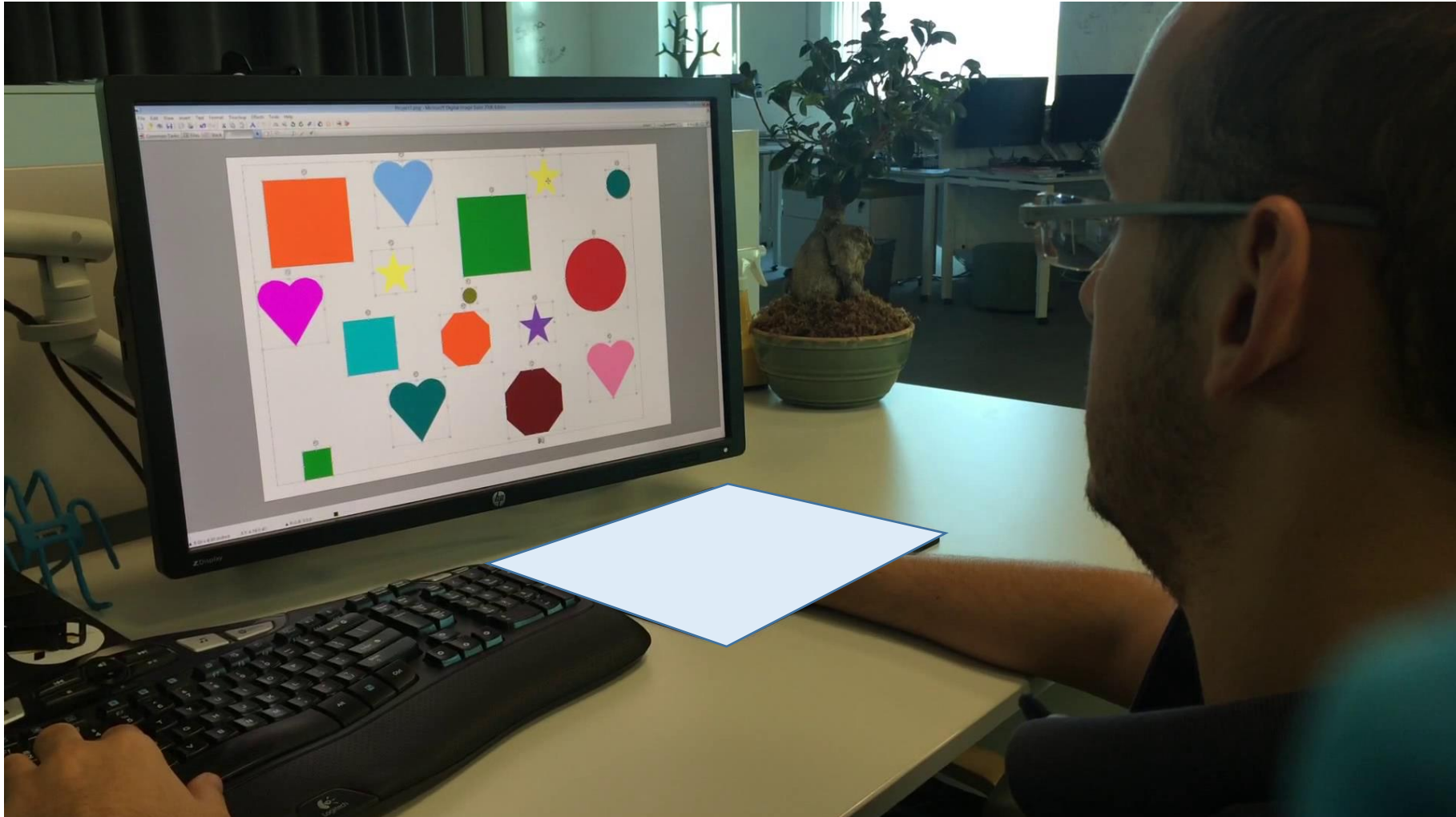
tablet handling

easy

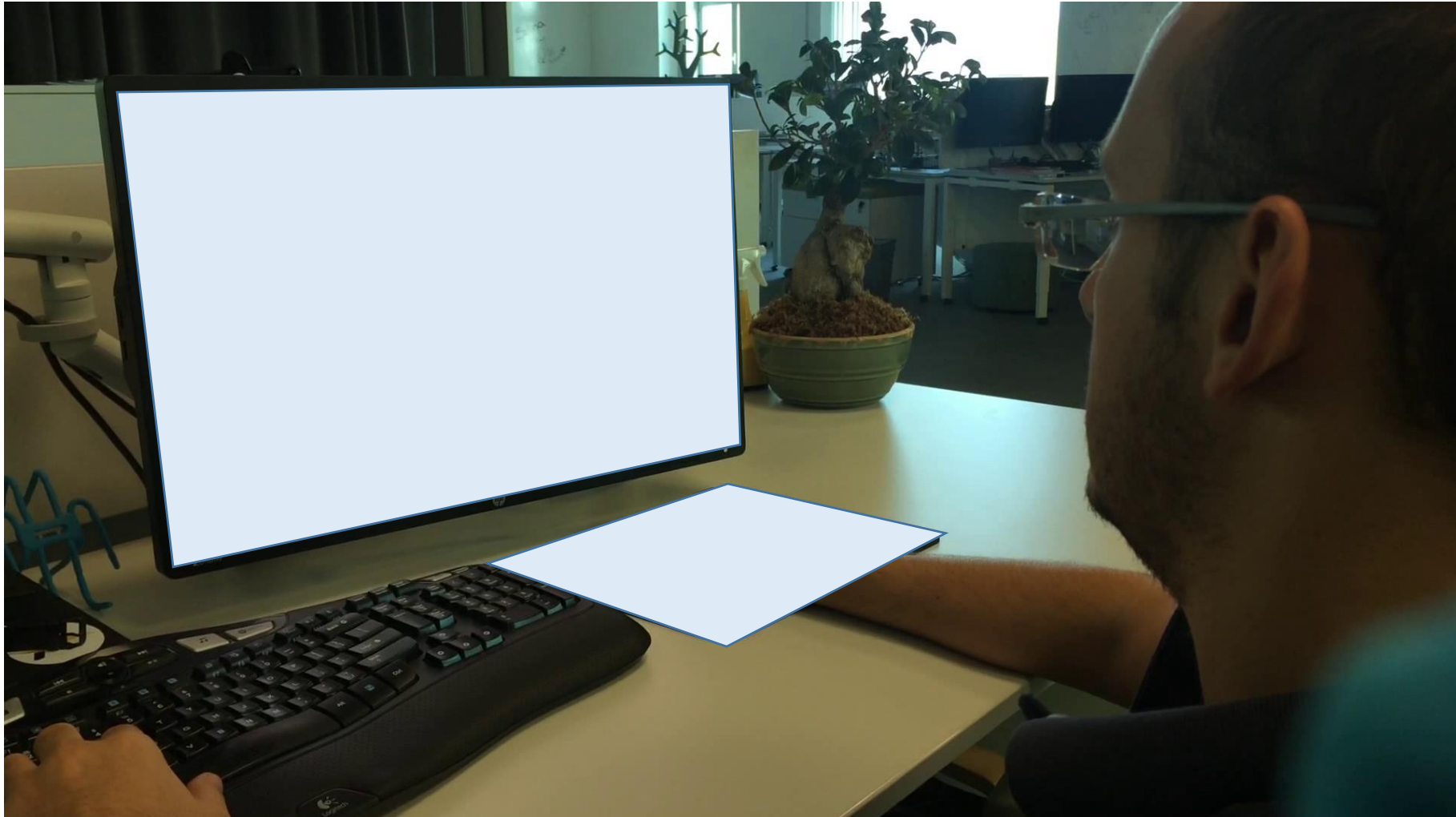
Why does this still work?



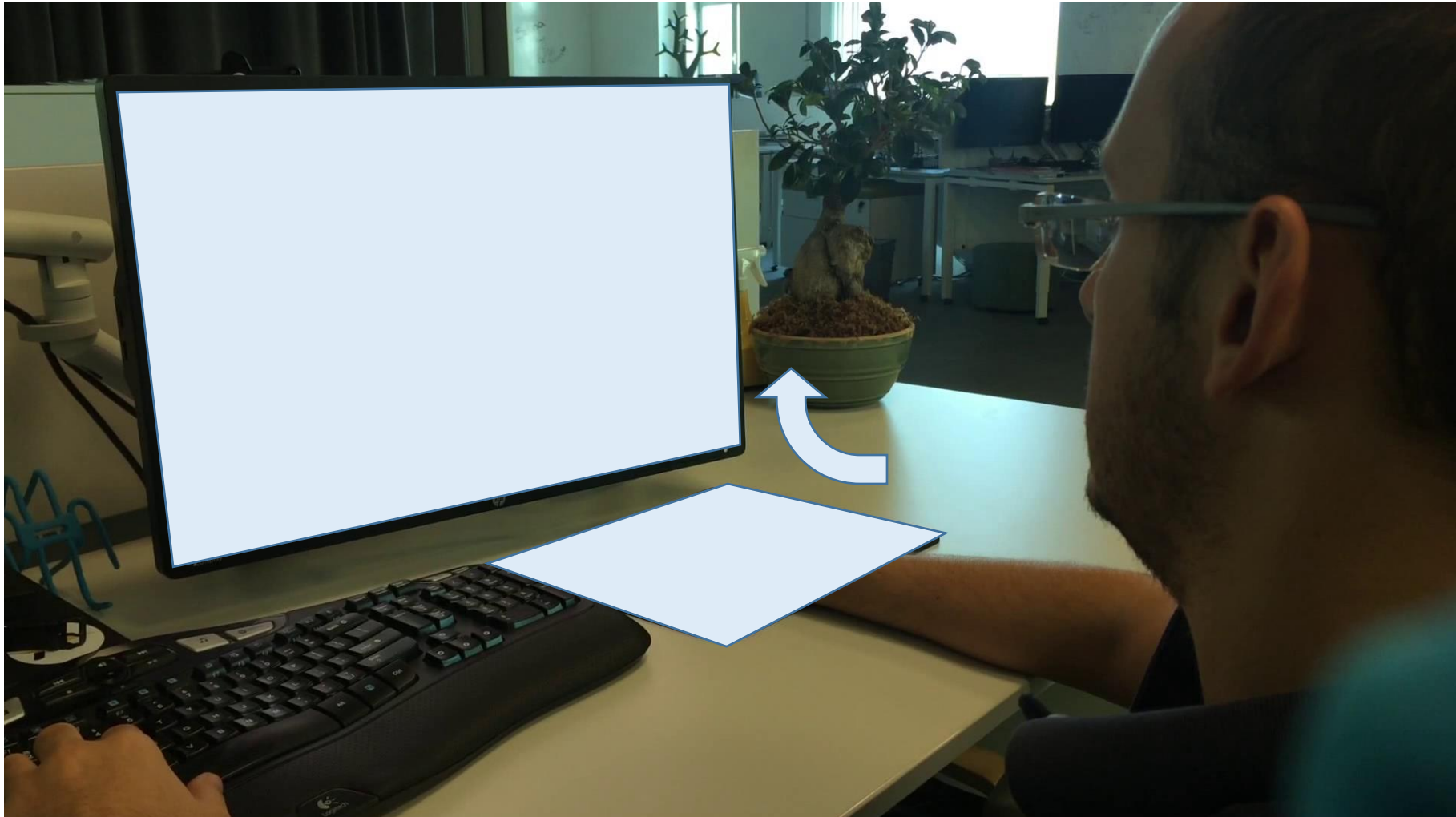
Why does this still work?



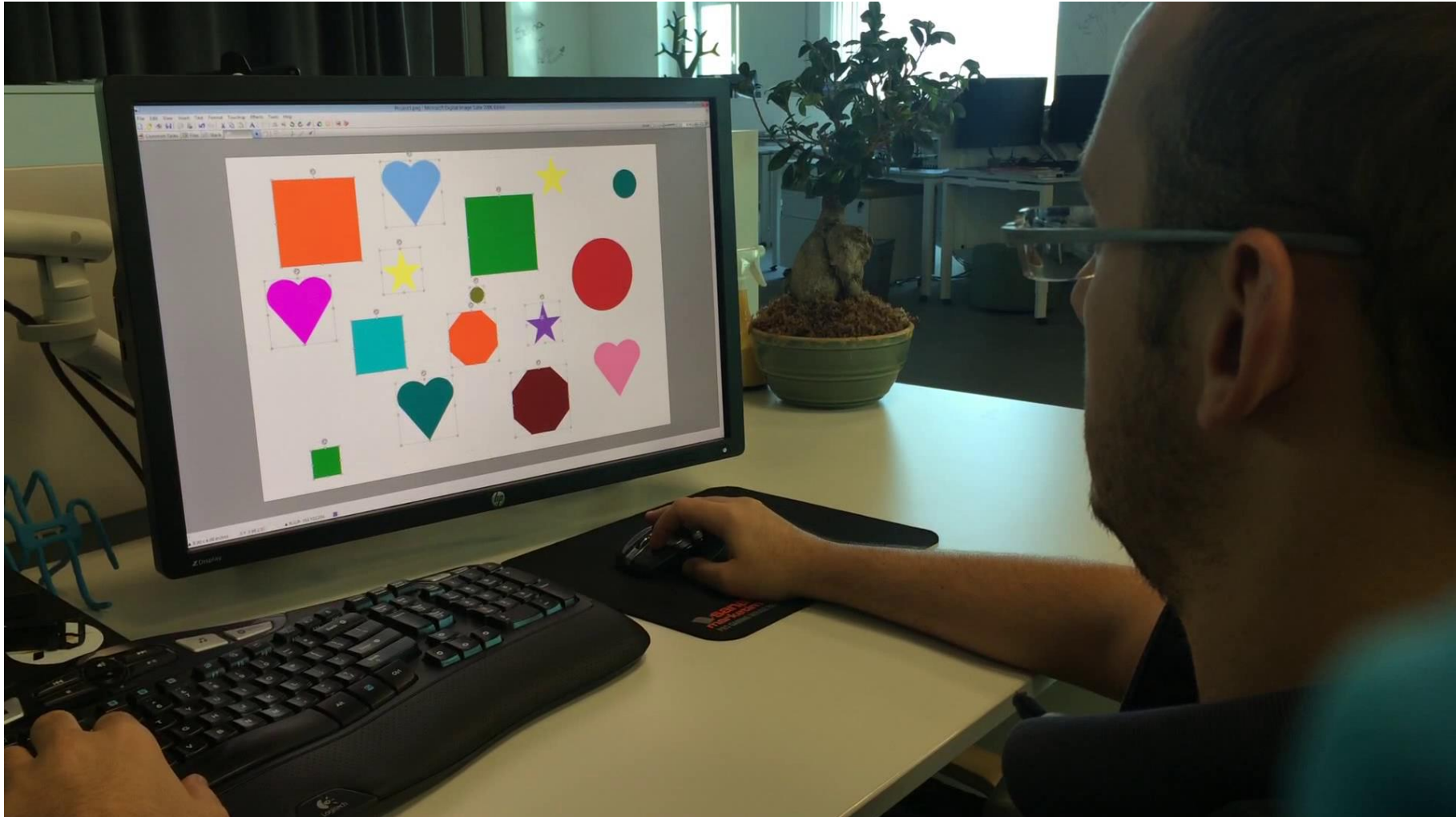
Why does this still work?



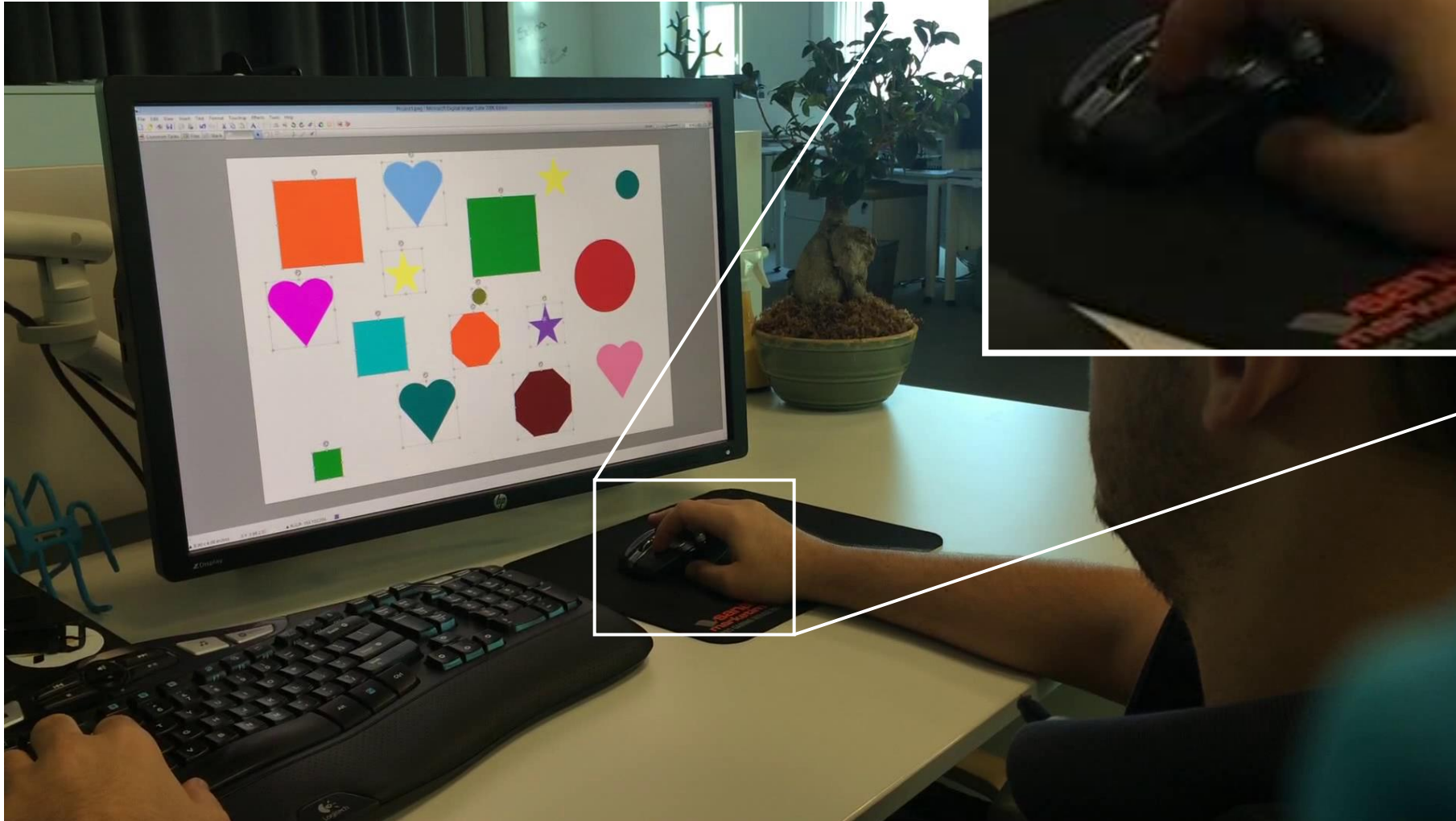
Why does this still work?



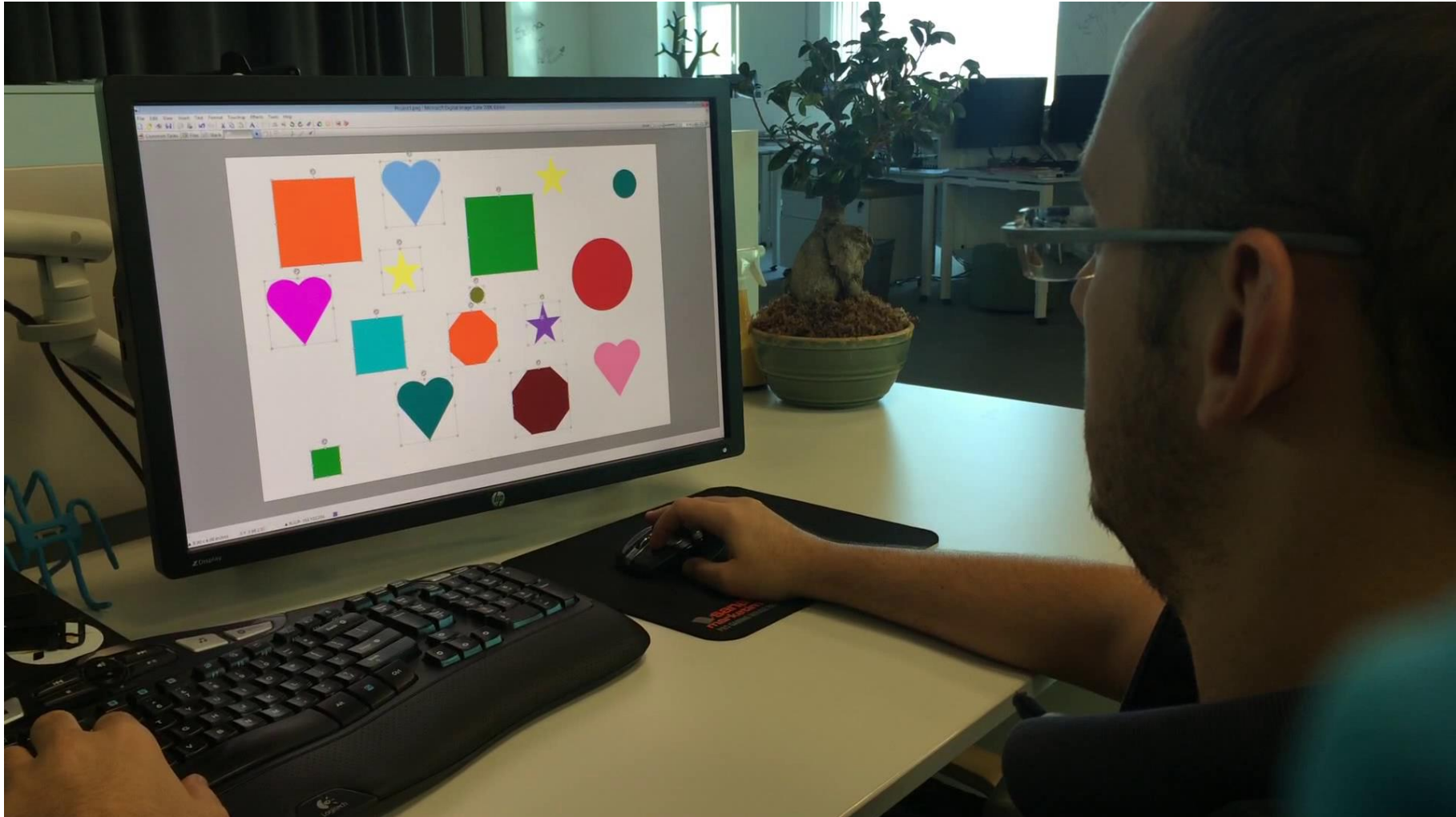
Why does this still work?



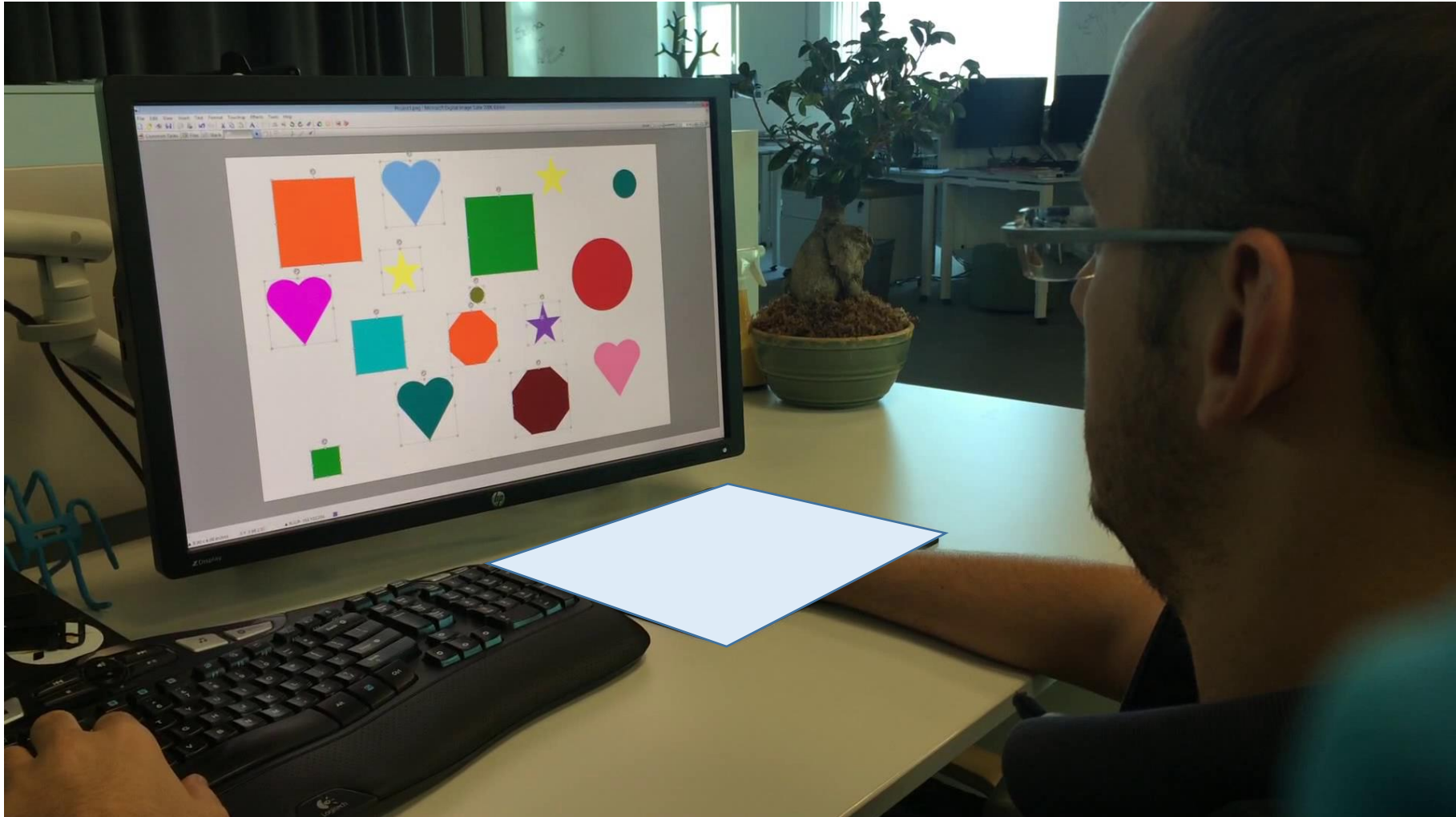
Why does this still work?



Why does this still work?



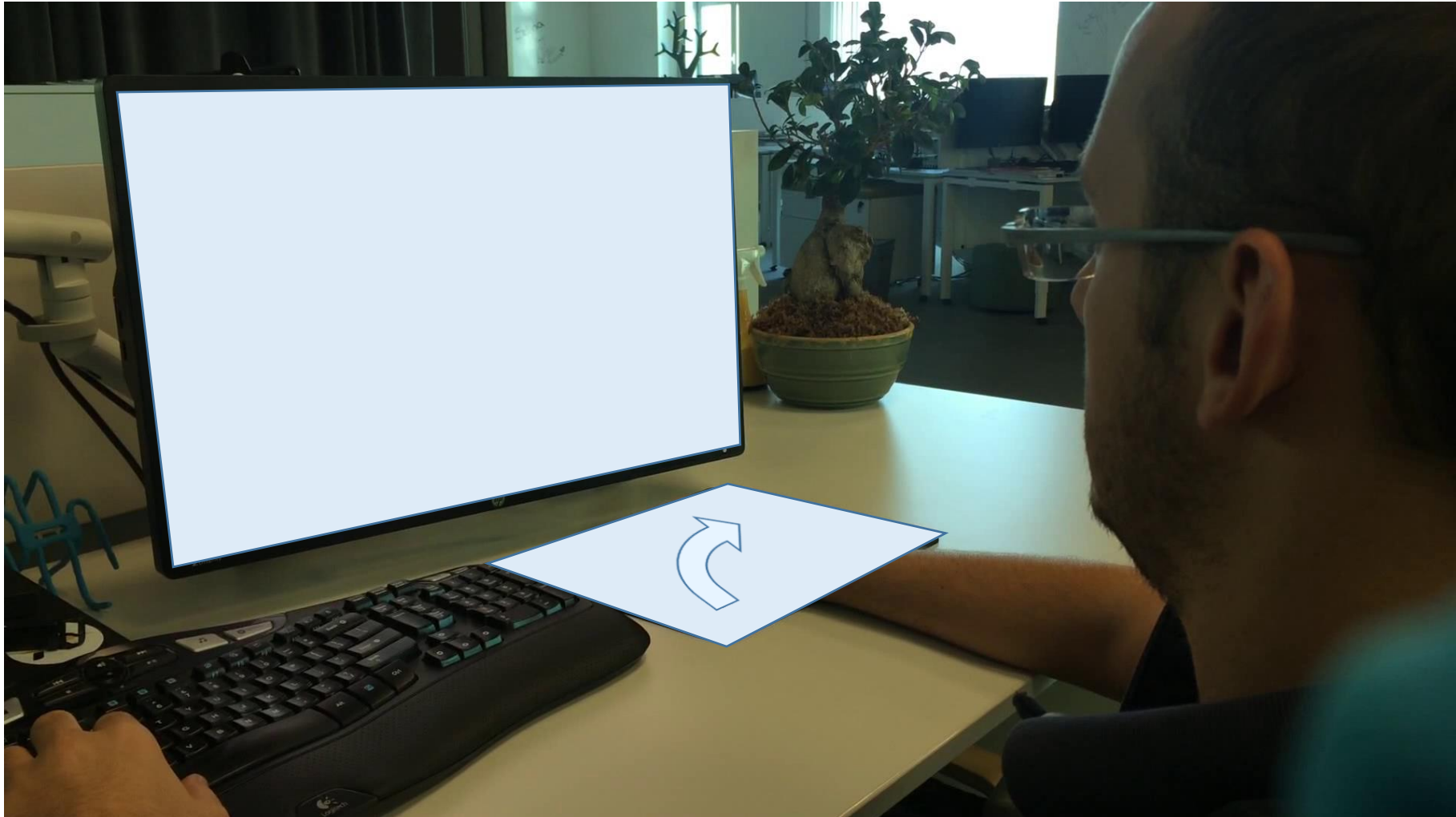
Why does this still work?



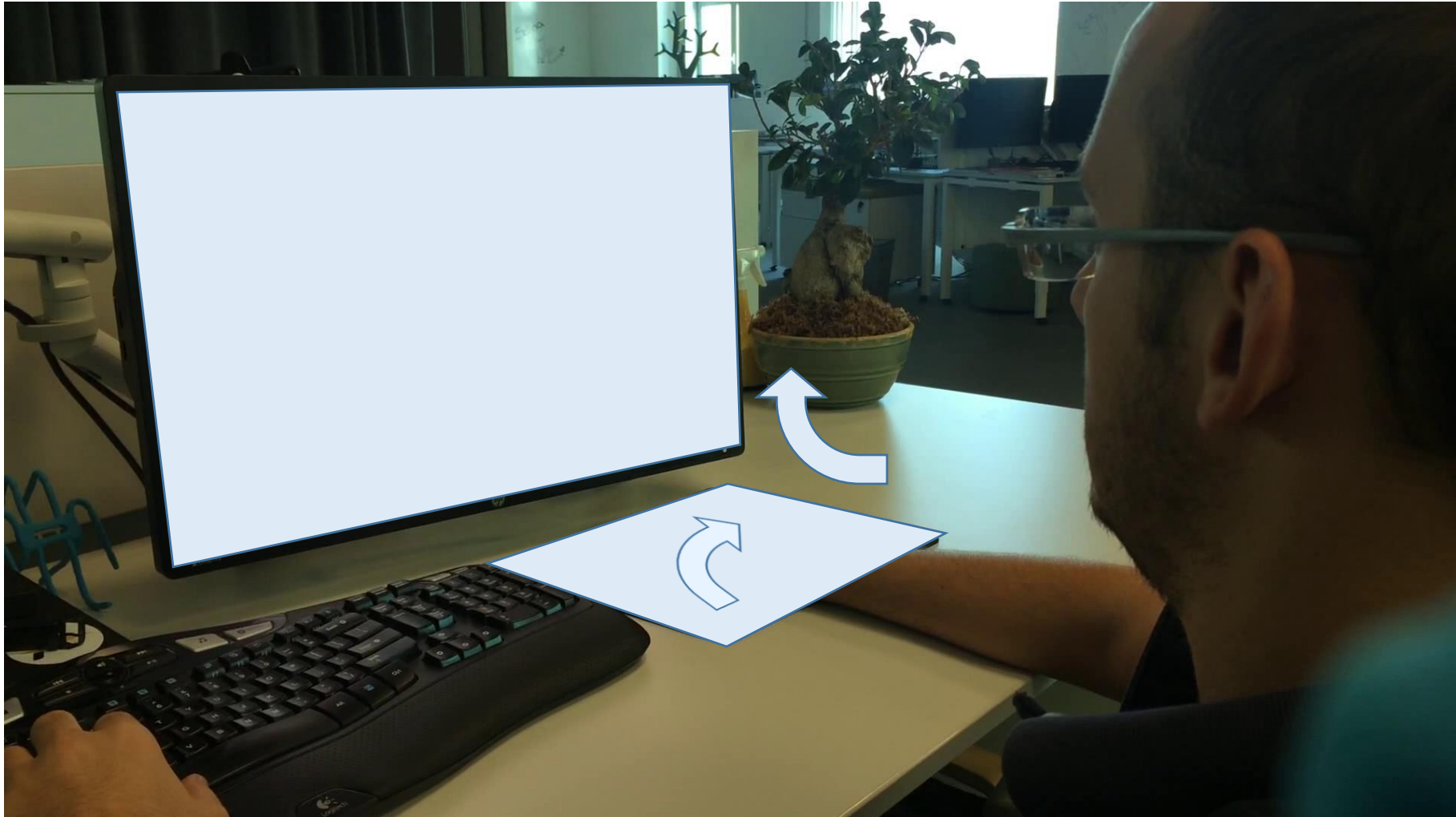
Why does this still work?



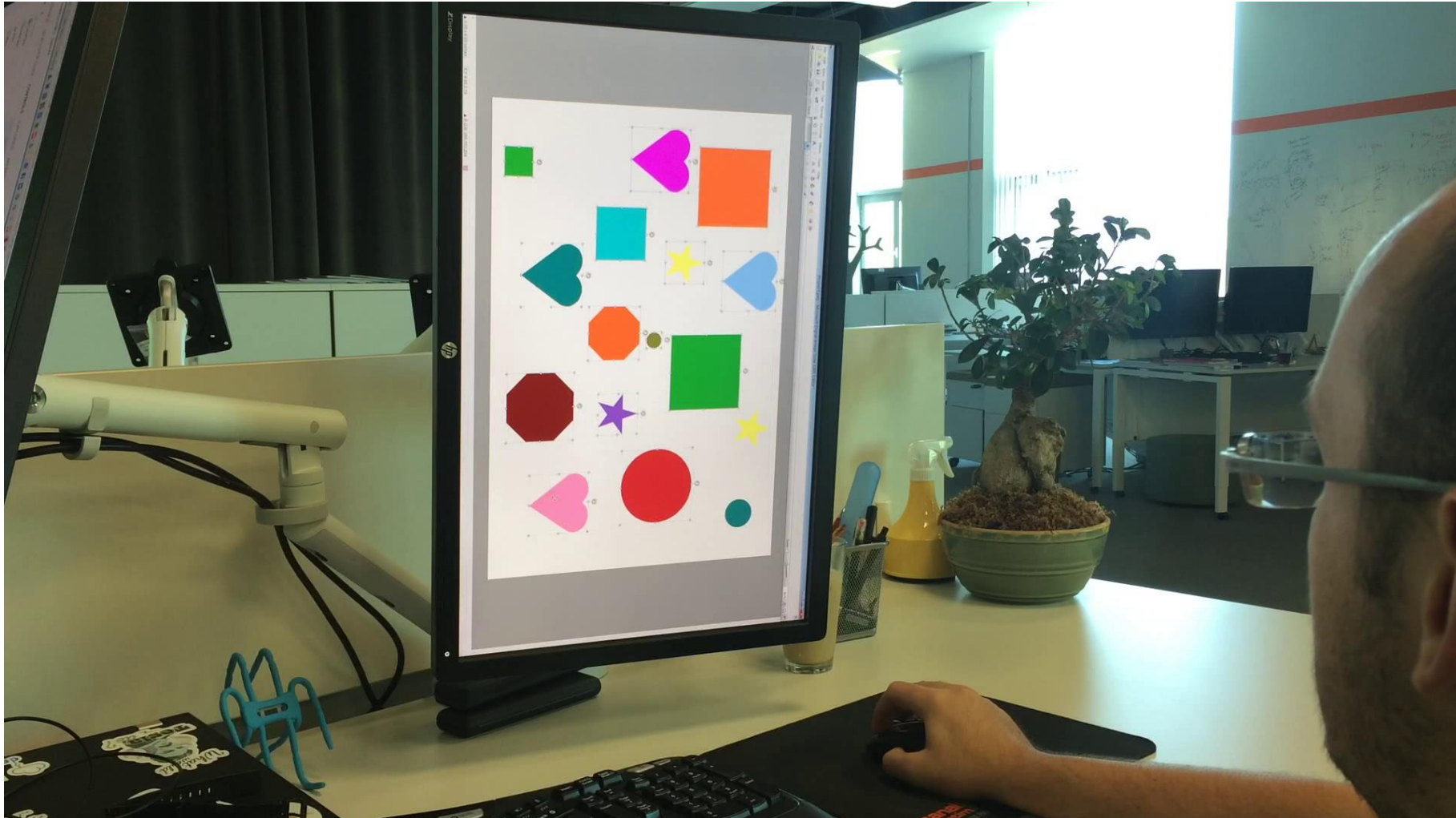
Why does this still work?



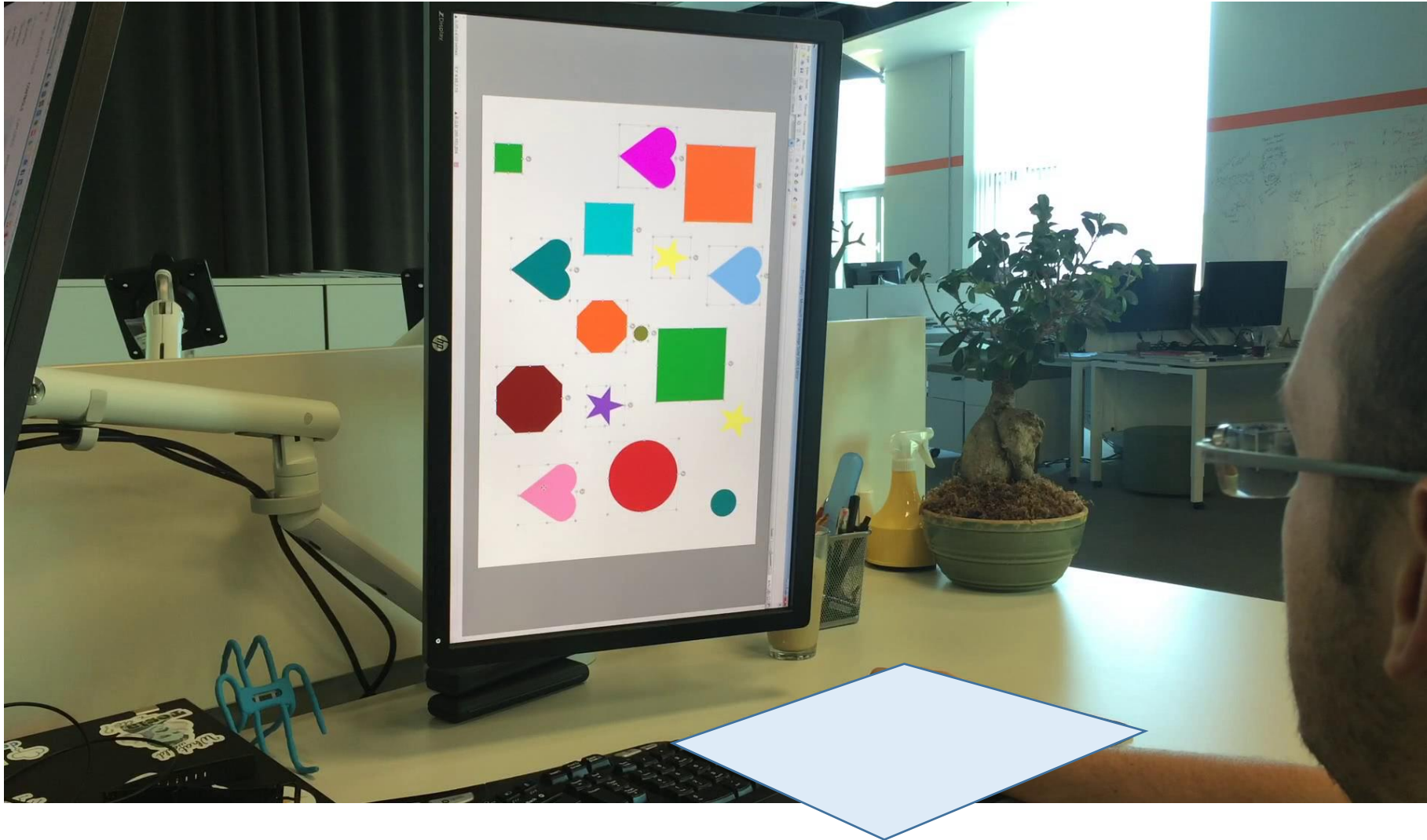
Why does this still work?



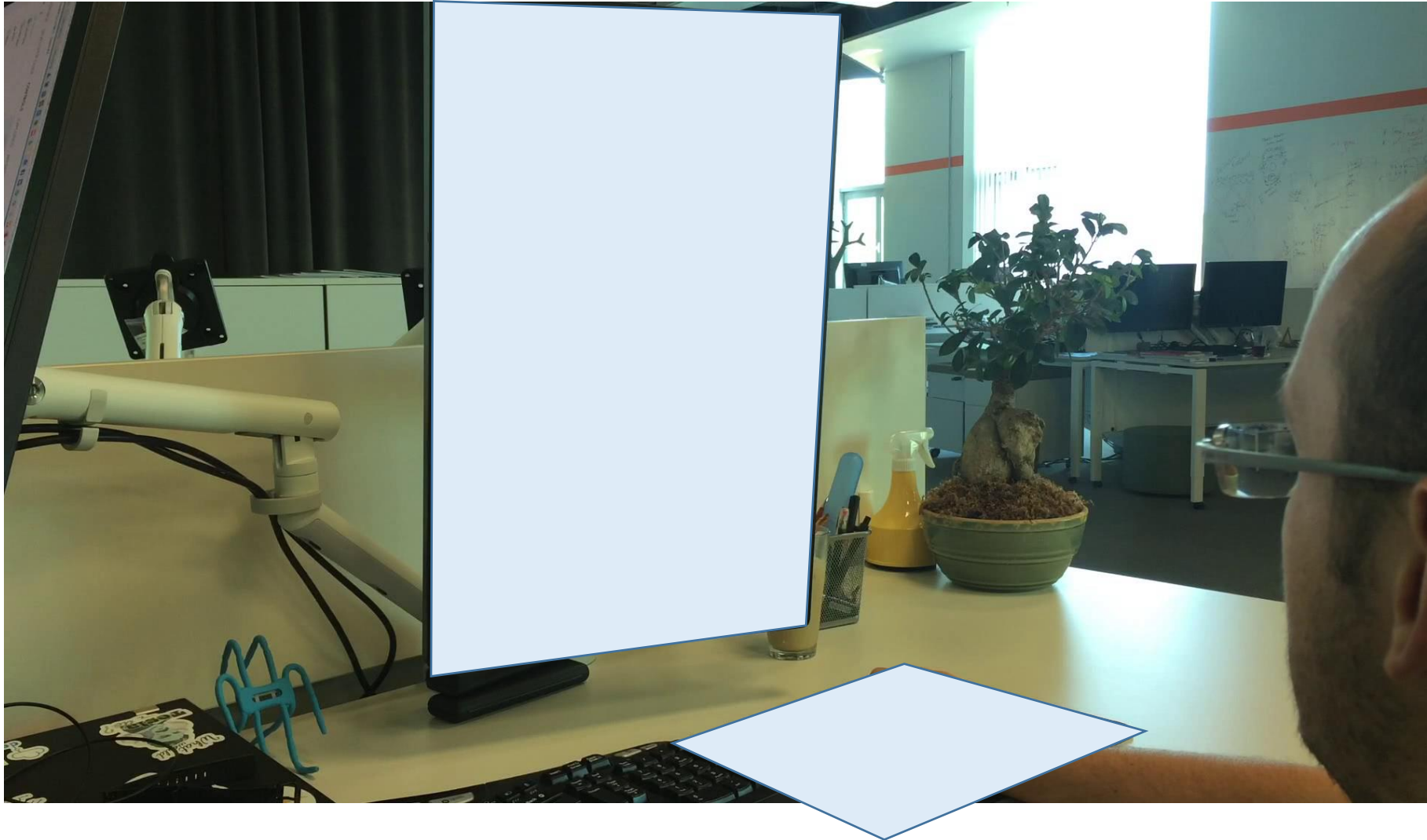
Why does this still work?



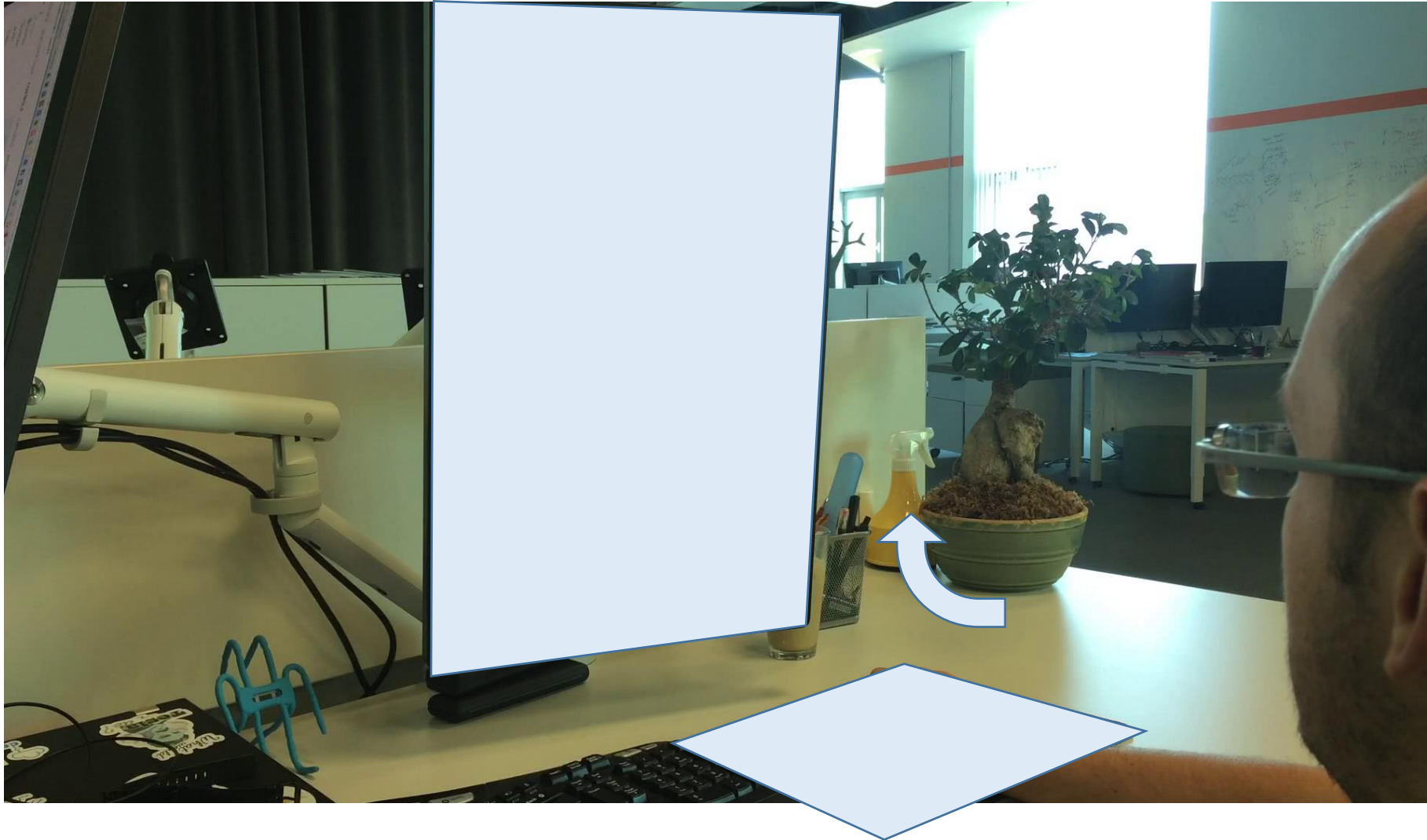
Why does this still work?



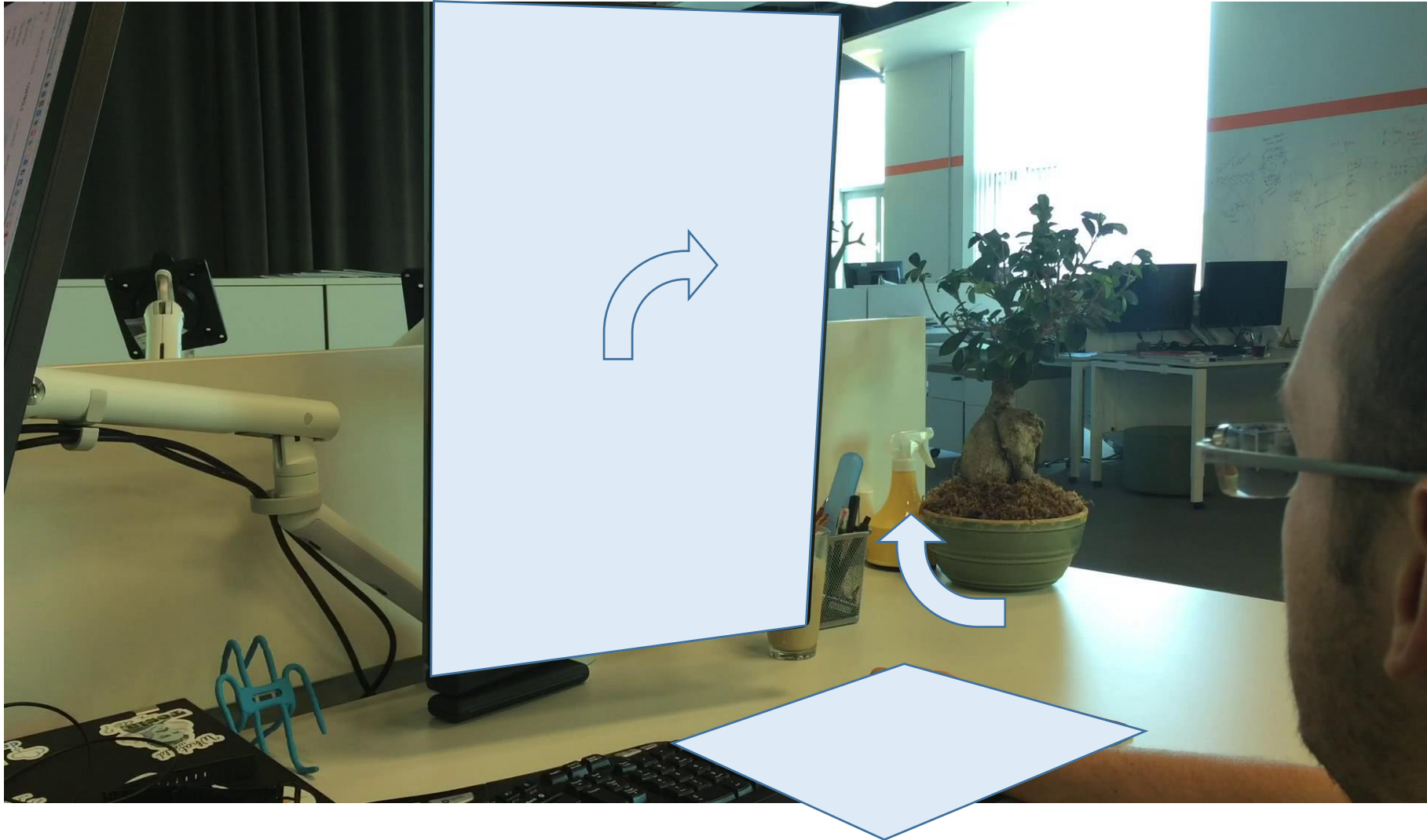
Why does this still work?



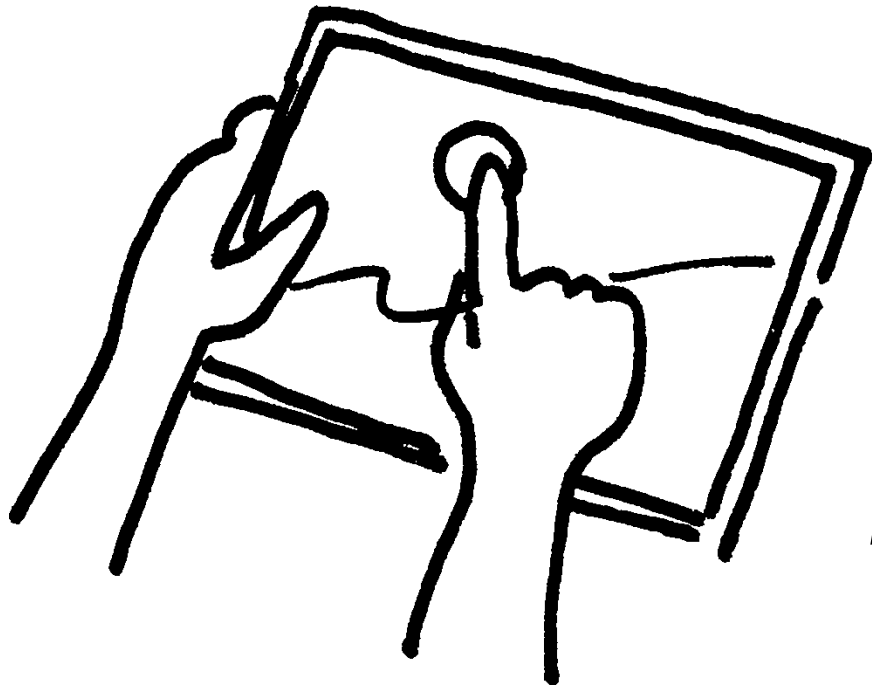
Why does this still work?



Why does this still work?



Mobile Touch Navigation + Stereo View



metaphor

still camera, touch interaction

goal

controllable, stable navigation

tablet camera

≈ (VR) viewer cam

≈ viewer

tablet position

lower than tablet/viewer cams,

only 1 rotation

interaction focus

tablet or stereo view

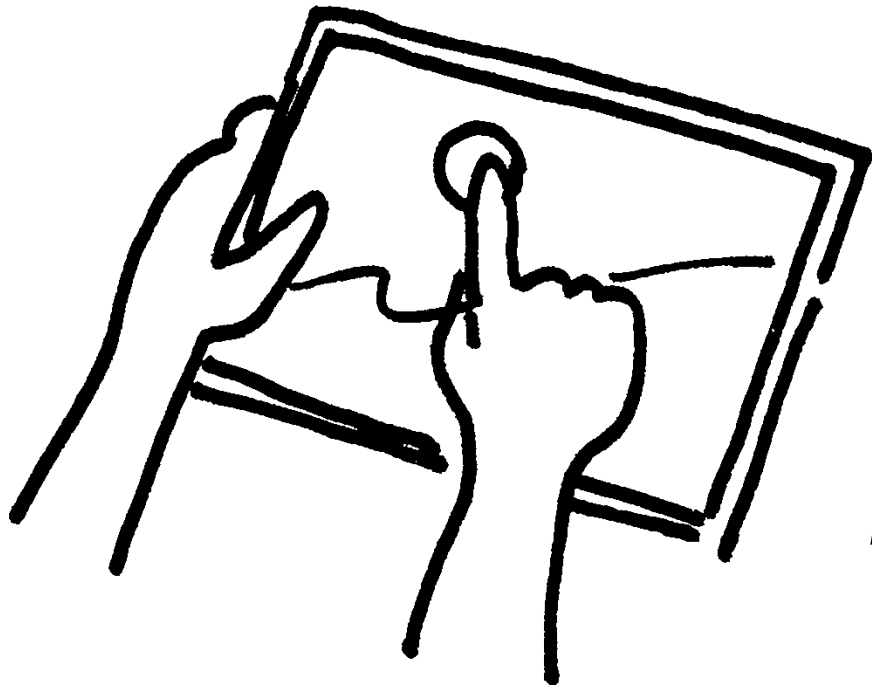
mapping clarity

clear

tablet handling

easy

Mobile Touch Navigation + Stereo View



metaphor still camera, touch interaction

goal **controllable, stable navigation**

tablet camera $\approx$ (VR) viewer cam
 $\approx$ viewer

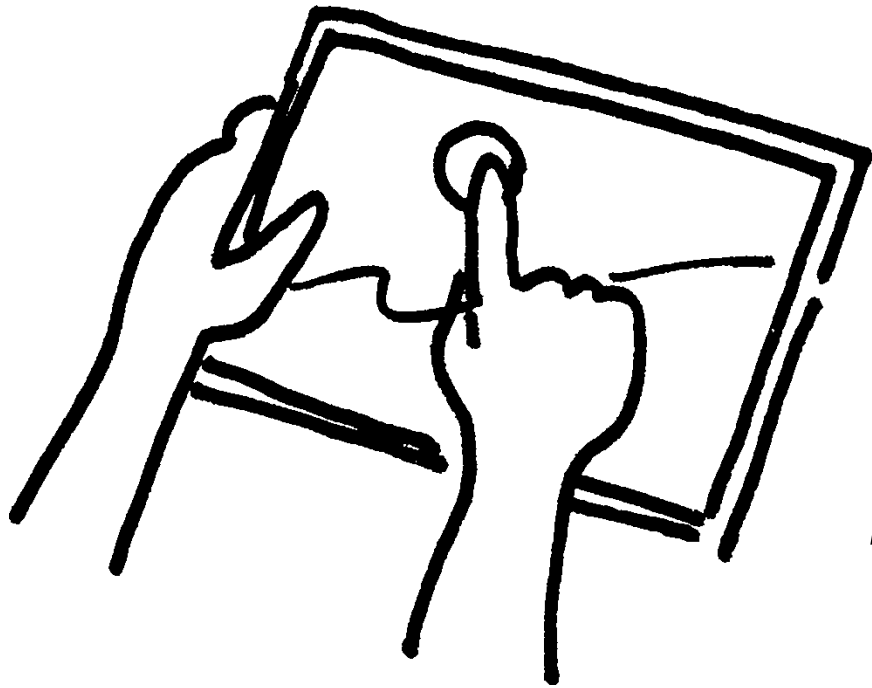
tablet position lower than tablet/viewer cams,
only 1 rotation

interaction focus tablet or stereo view

mapping clarity clear

tablet handling easy

Mobile Touch Navigation + Stereo View



metaphor still camera, touch interaction

goal **controllable, stable navigation**

tablet camera $\approx$ (VR) viewer cam
 $\approx$ viewer

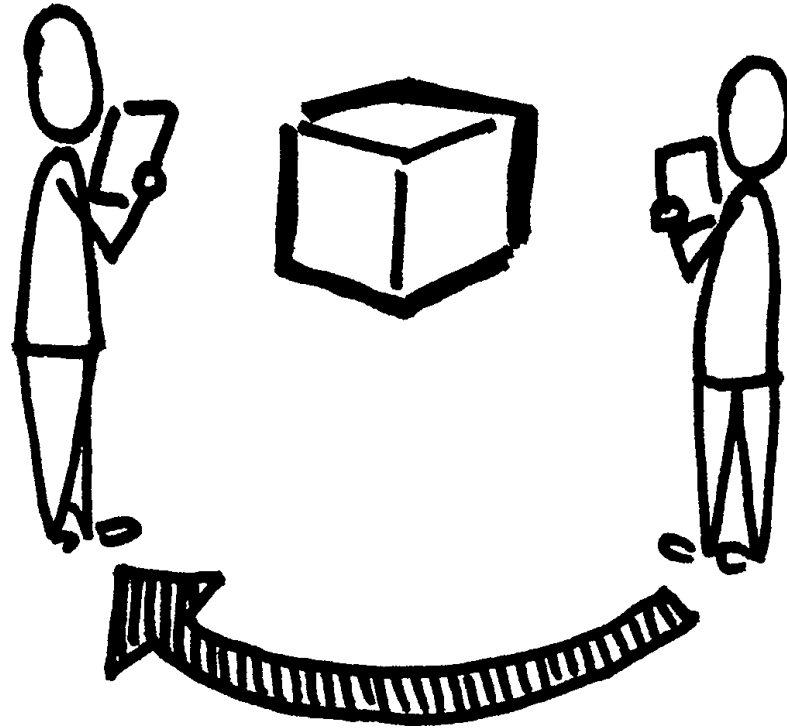
tablet position lower than tablet/viewer cams,
only 1 rotation

interaction focus tablet or stereo view

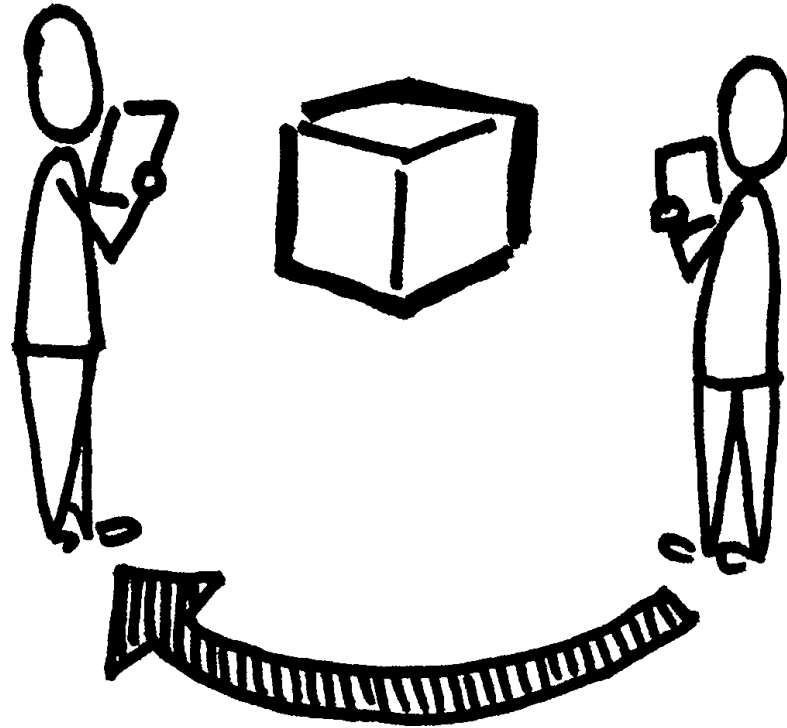
mapping clarity clear

tablet handling easy

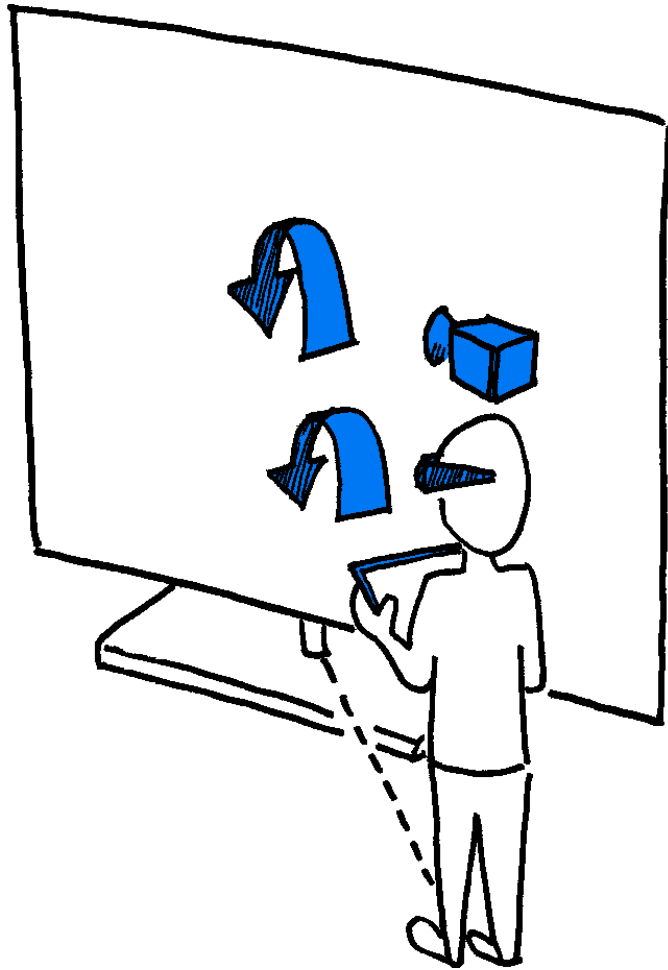
Mobile Touch Navigation + Stereo View



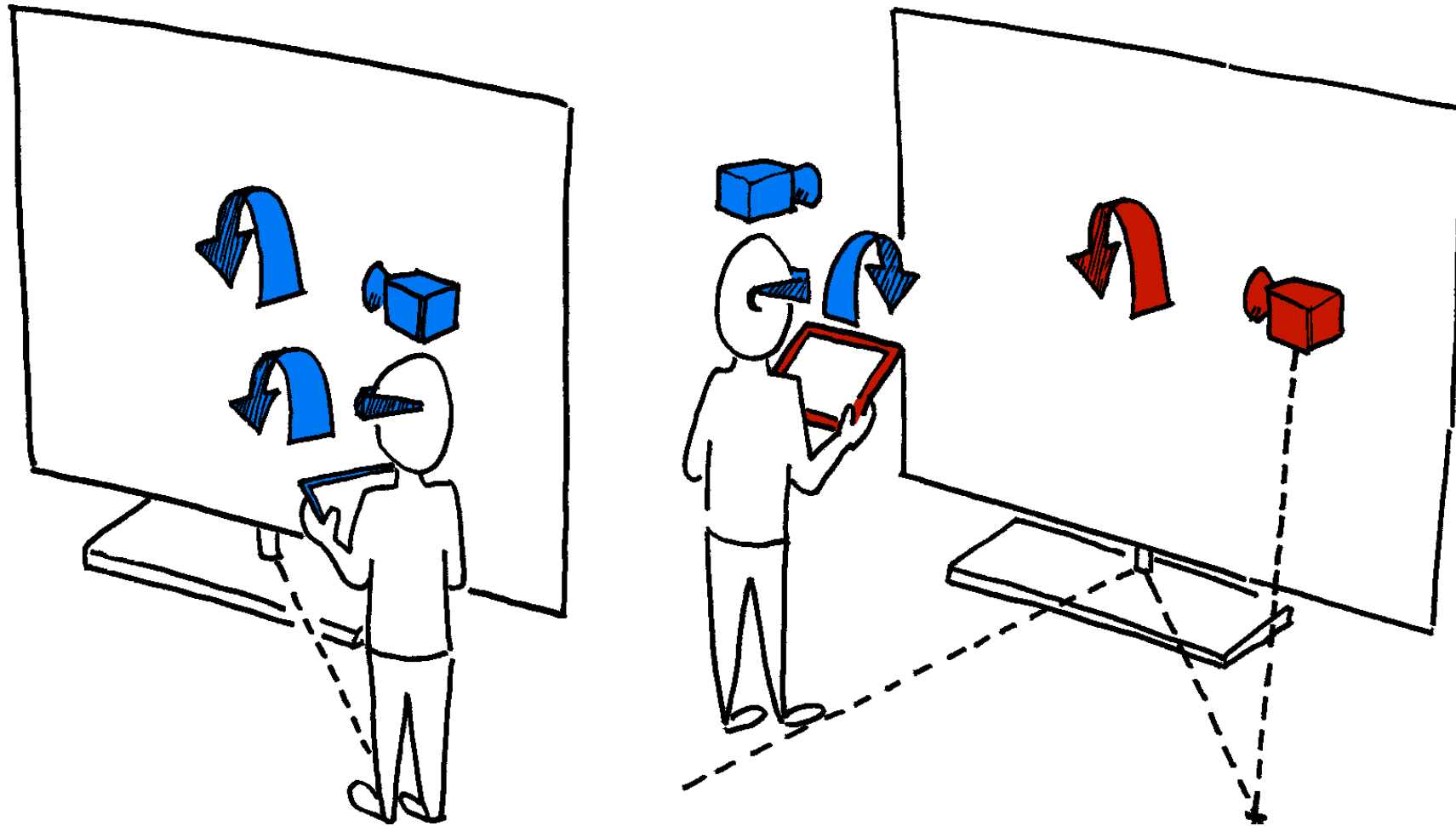
Mobile Touch Navigation + Stereo View



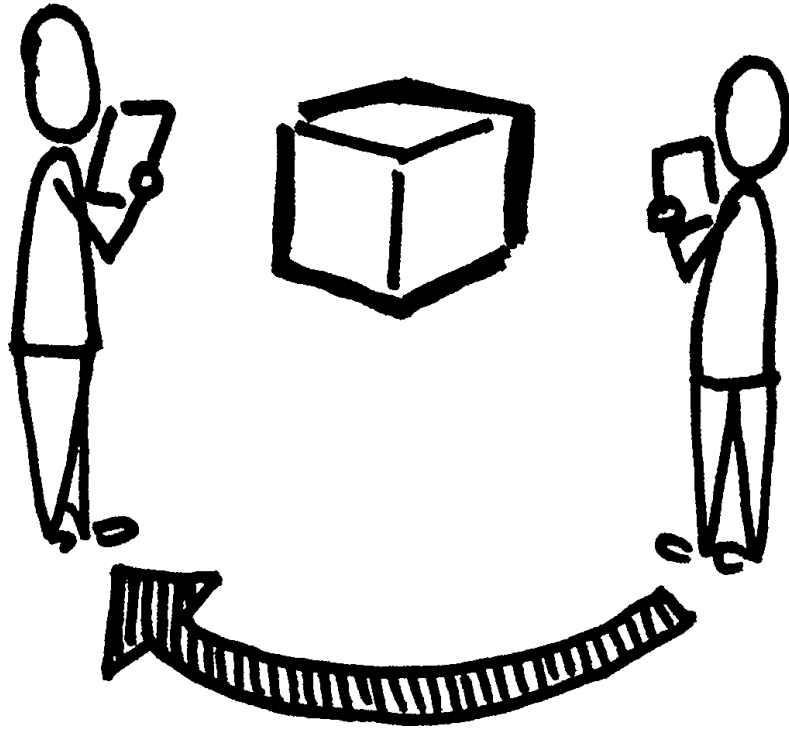
Mobile Touch Navigation + Stereo View



Mobile Touch Navigation + Stereo View



Mobile Touch Navigation + Stereo View



metaphor

still camera, viewer moves

goal

different view in 3D VR data space

tablet camera

≠ (VR) viewer cam
≠ viewer

tablet position

lower than tablet/viewer cams,
2 rotations

interaction focus

tablet or stereo view

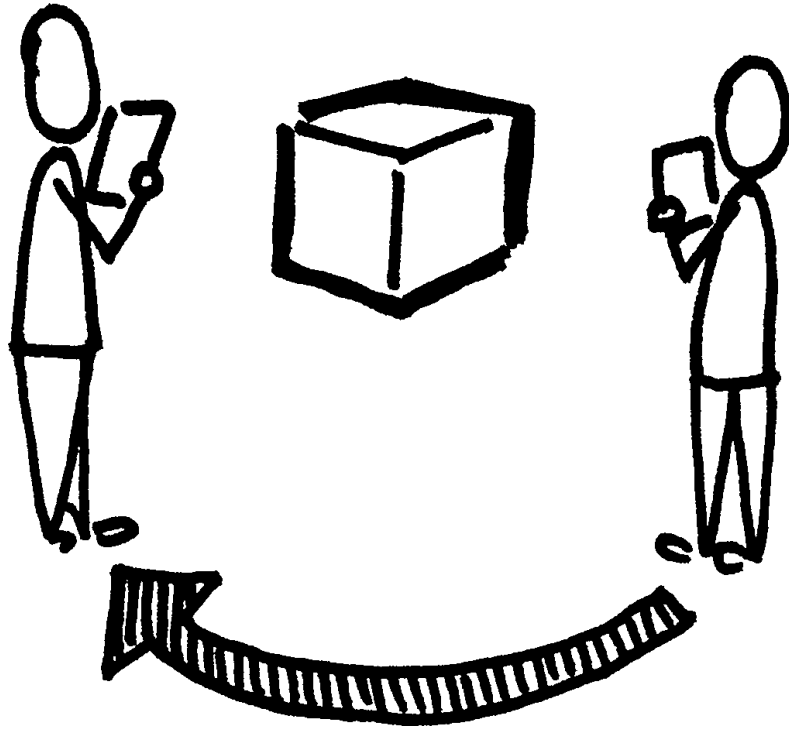
mapping clarity

unclear

tablet handling

easy

Mobile Touch Navigation + Stereo View



metaphor

still camera, viewer moves

goal

different view in 3D VR data space

tablet camera

≠ (VR) viewer cam
≠ viewer

tablet position

lower than tablet/viewer cams,
2 rotations

interaction focus

tablet or stereo view

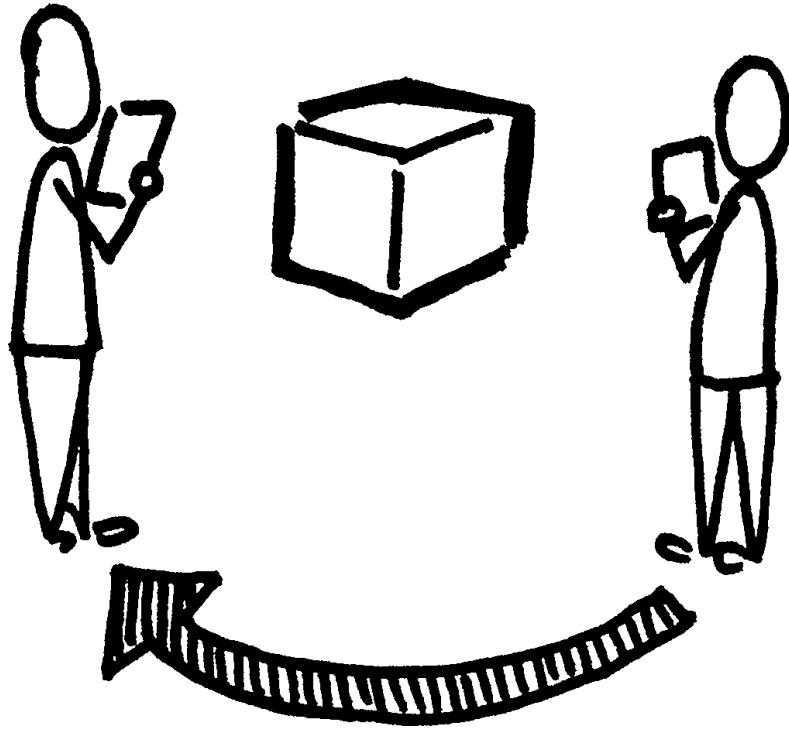
mapping clarity

unclear

tablet handling

easy

Mobile Touch Navigation + Stereo View



metaphor

still camera, viewer moves

goal

different view in 3D VR data space

tablet camera

≠ (VR) viewer cam
≠ viewer

tablet position

lower than tablet/viewer cams,

2 rotations

interaction focus

tablet or stereo view

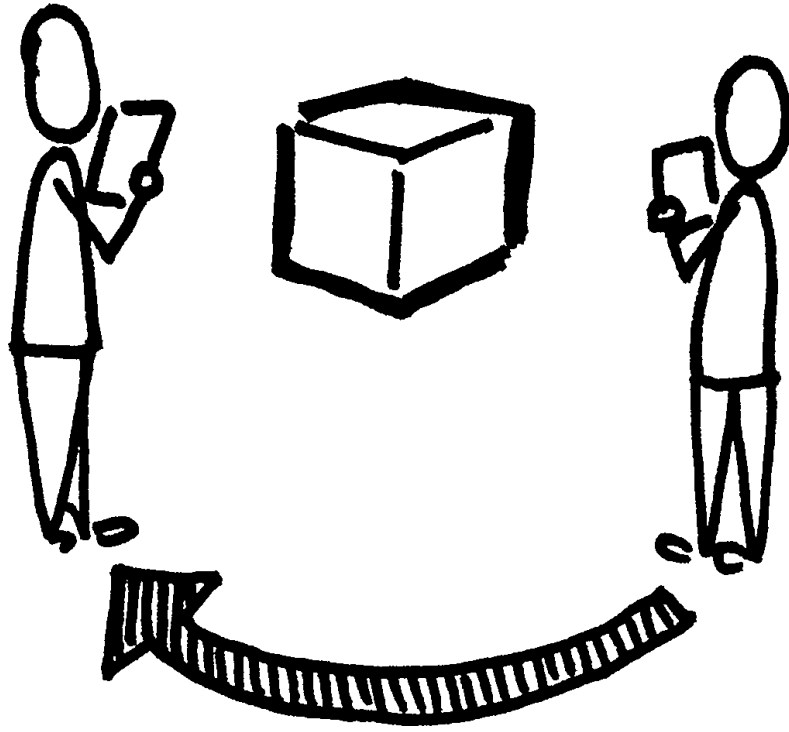
mapping clarity

unclear

tablet handling

easy

Mobile Touch Navigation + Stereo View



metaphor

still camera, viewer moves

goal

different view in 3D VR data space

tablet camera

≠ (VR) viewer cam
≠ viewer

tablet position

lower than tablet/viewer cams,

2 rotations

interaction focus

tablet or stereo view

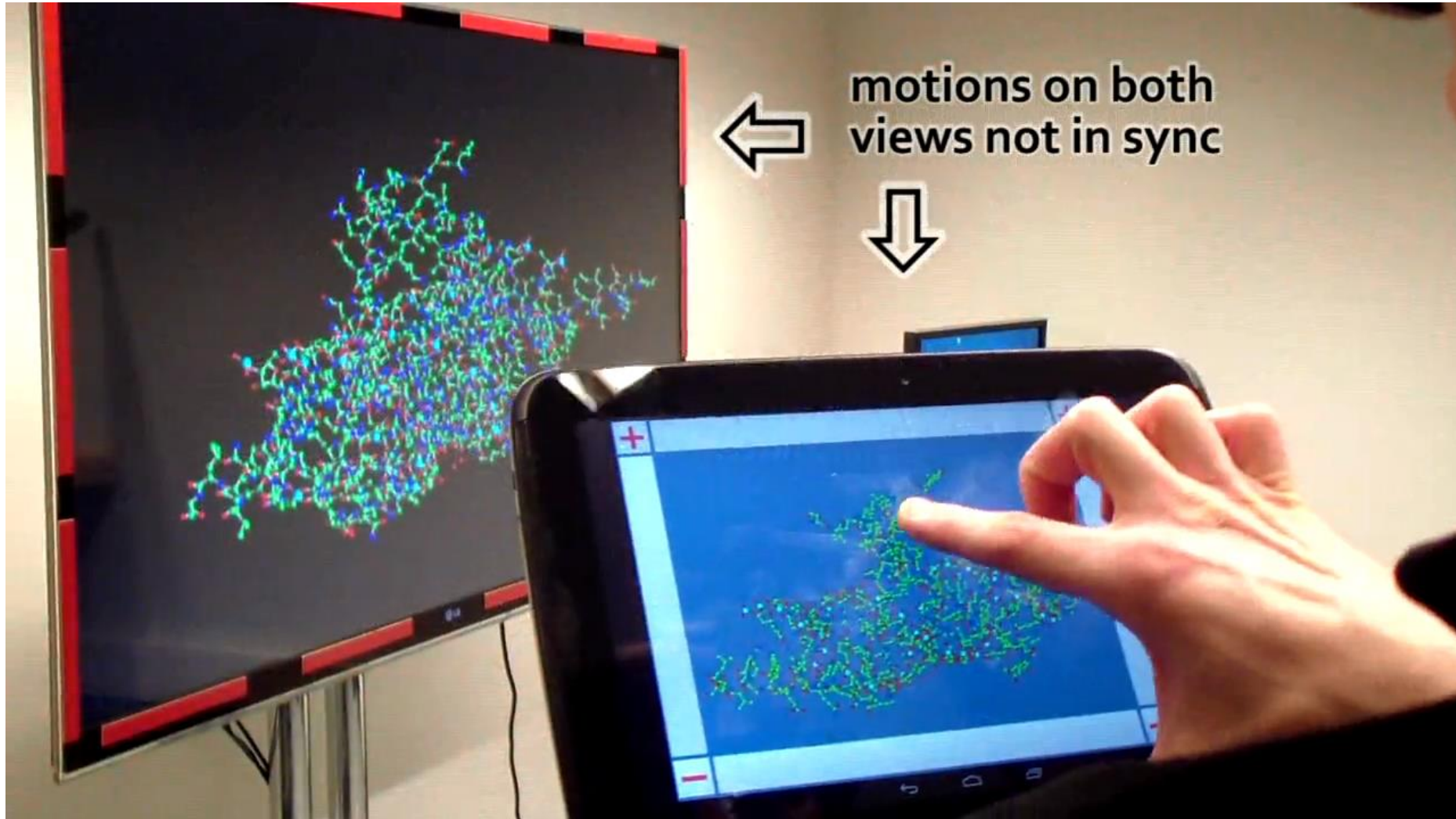
mapping clarity

unclear

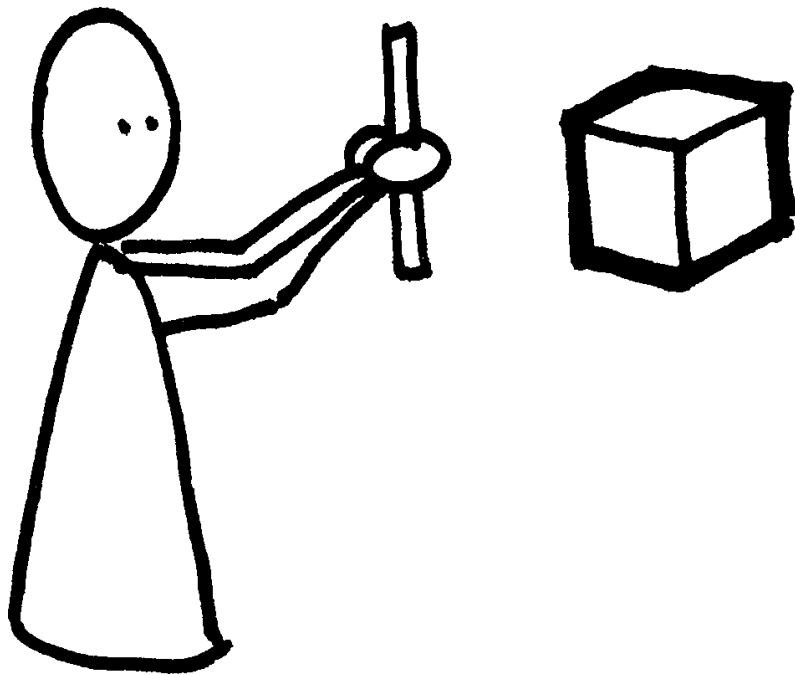
tablet handling

easy

Mobile Touch Navigation + Stereo View



Mobile Touch Navigation + Stereo View



metaphor (video) camera, taking pictures

goal set correct view

tablet camera $\approx$ (VR) viewer cam
 $\approx$ viewer

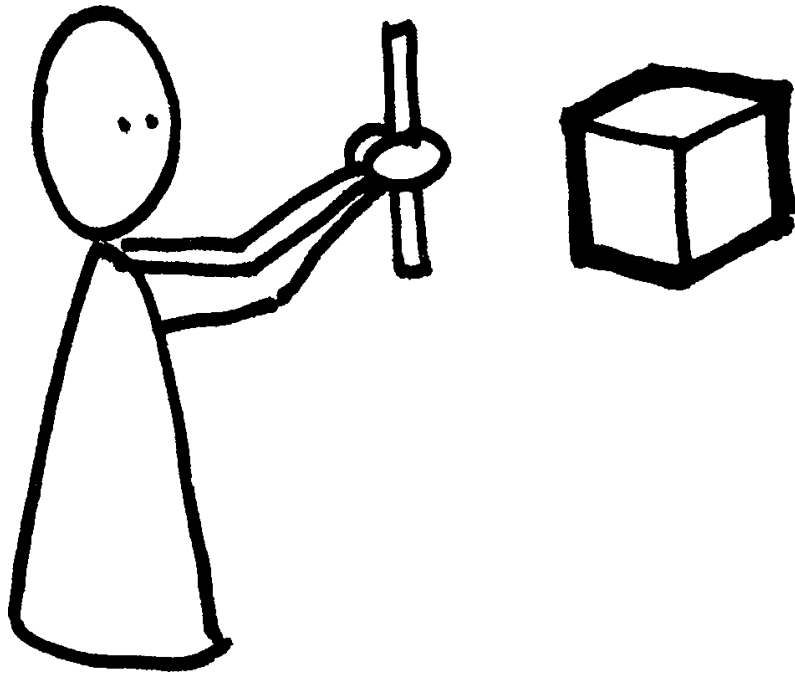
tablet position = tablet cam
 $\approx$ viewer cam

interaction focus tablet

mapping clarity clear

tablet handling **awkward**

Mobile Touch Navigation + Stereo View



metaphor (video) camera, taking pictures

goal set correct view

tablet camera $\approx$ (VR) viewer cam
 $\approx$ viewer

tablet position = tablet cam
 $\approx$ viewer cam

interaction focus tablet

mapping clarity clear

tablet handling **awkward**

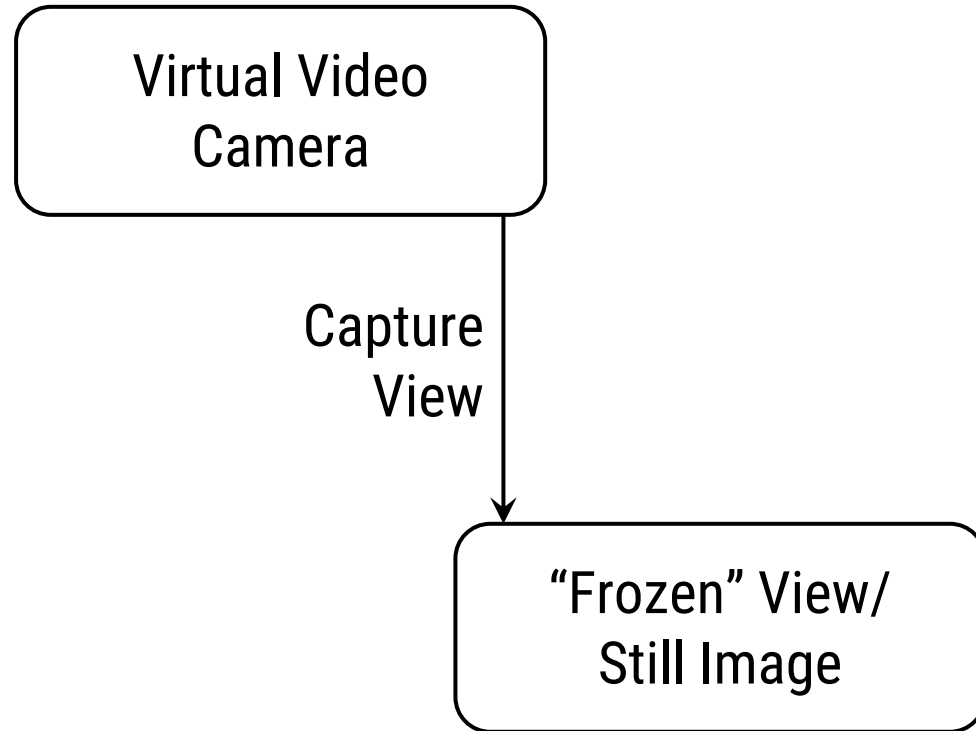
Resulting Interaction Workflow



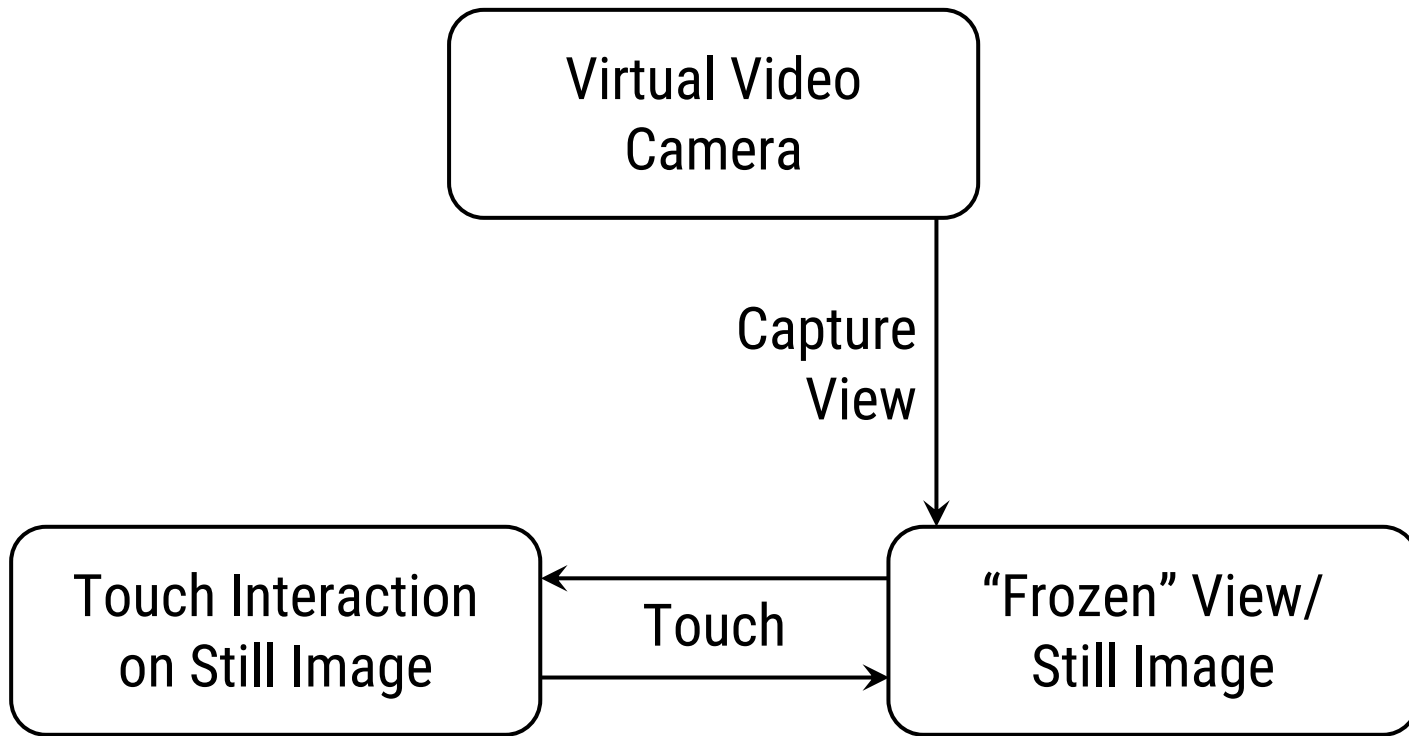
```
graph TD; A[Virtual Video Camera];
```

Virtual Video
Camera

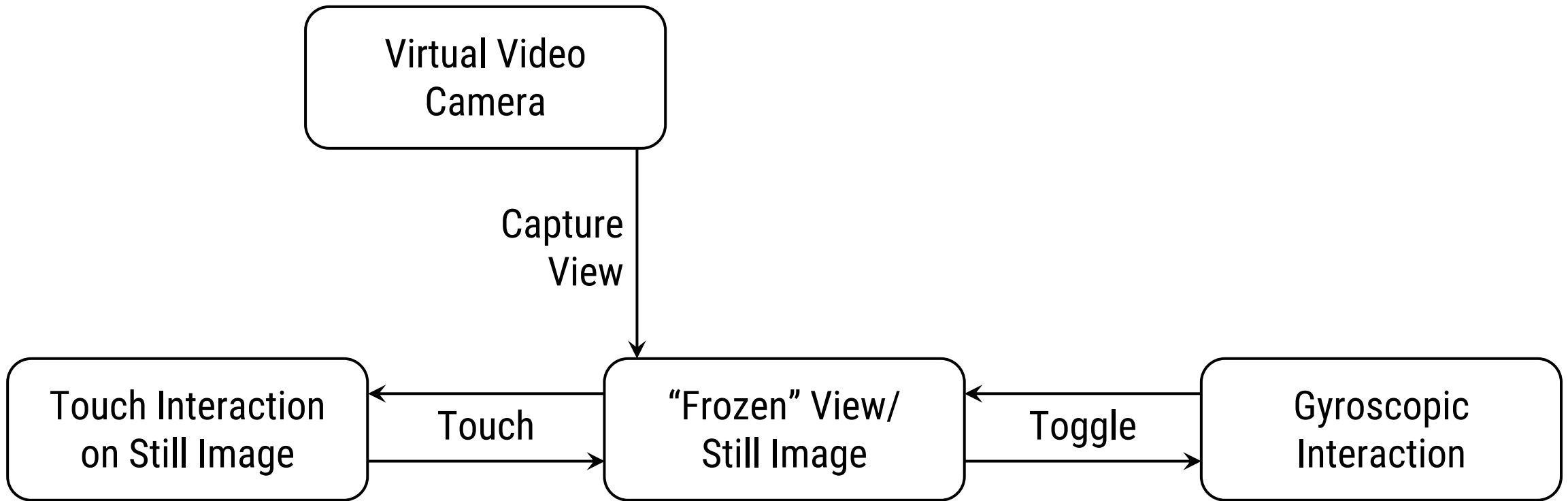
Resulting Interaction Workflow



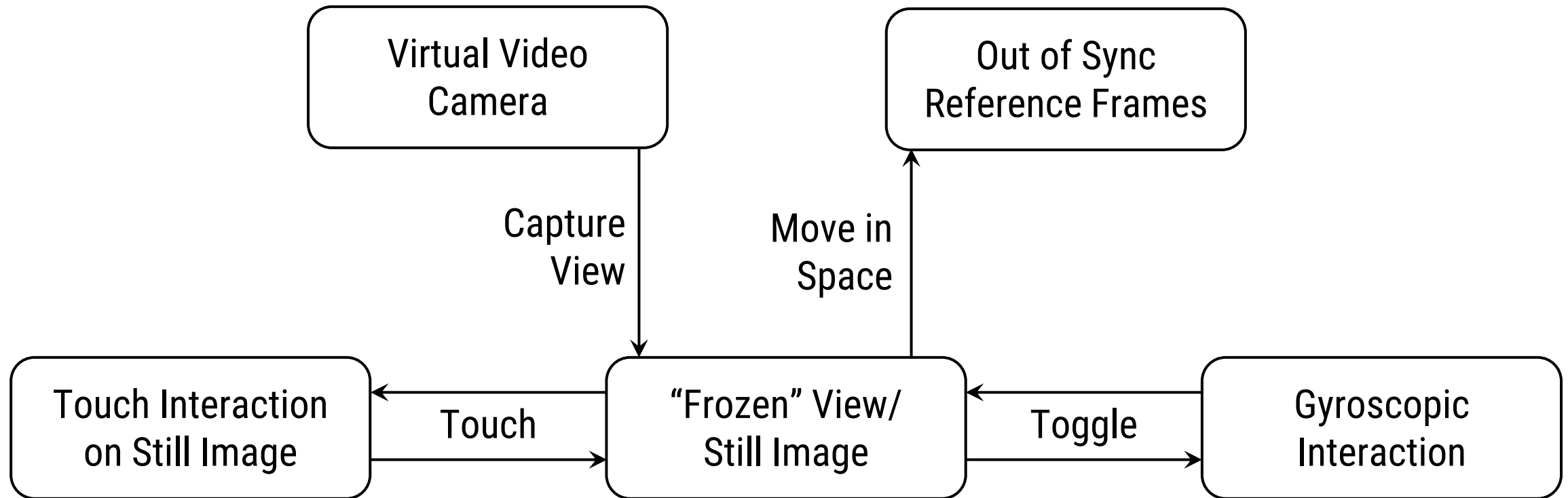
Resulting Interaction Workflow



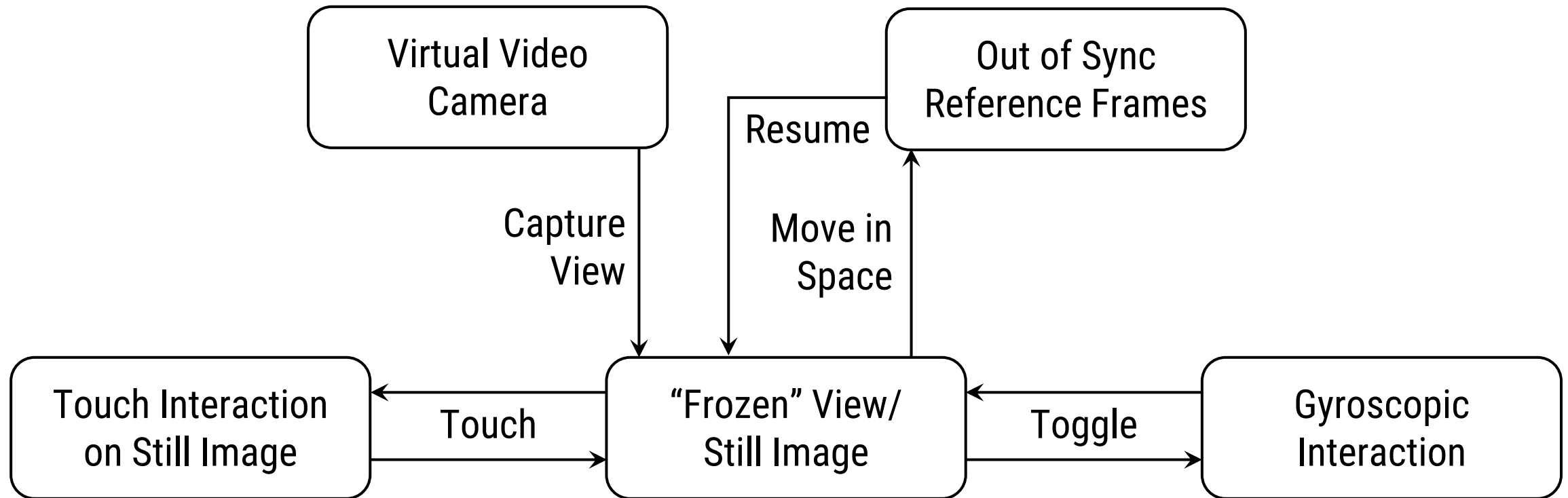
Resulting Interaction Workflow



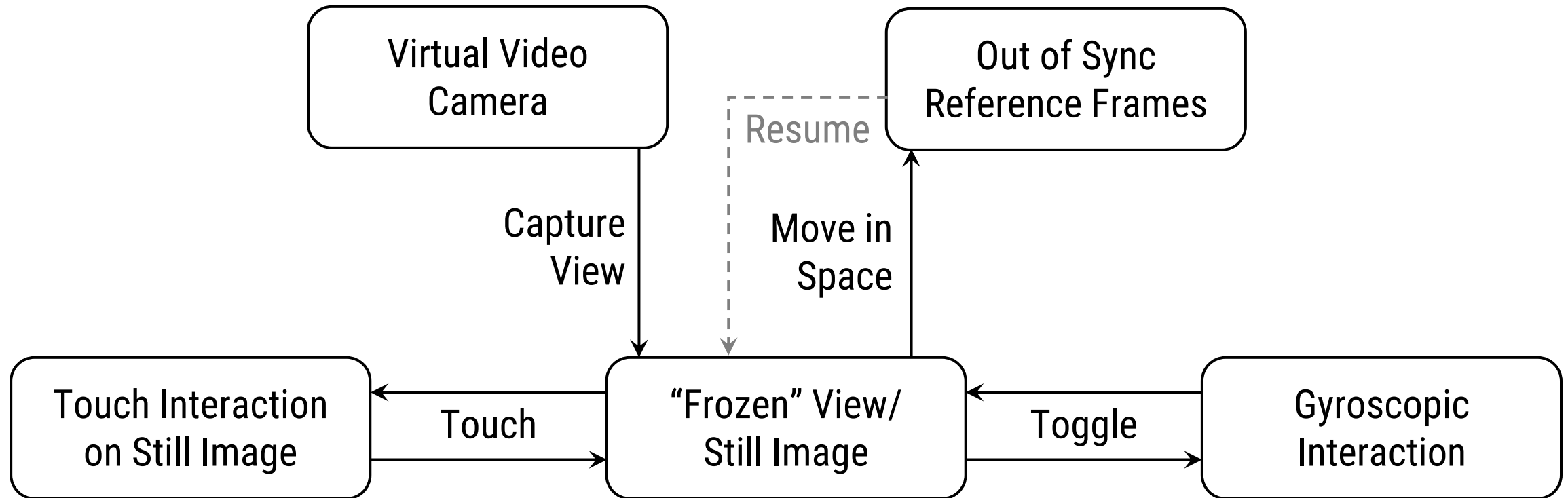
Resulting Interaction Workflow



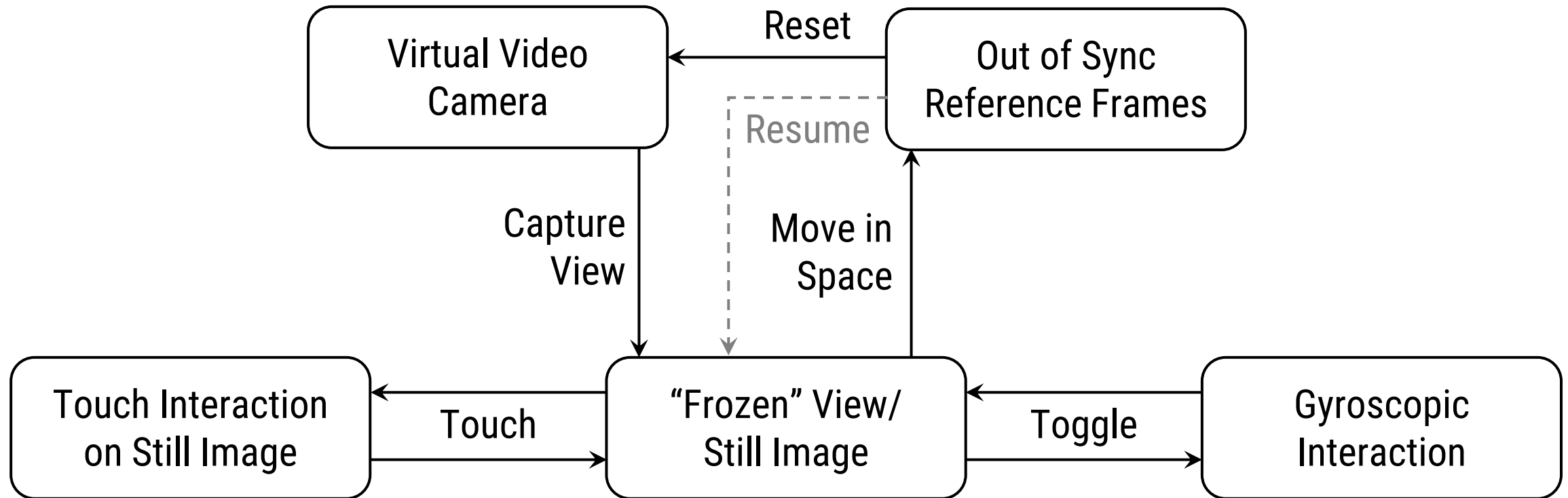
Resulting Interaction Workflow



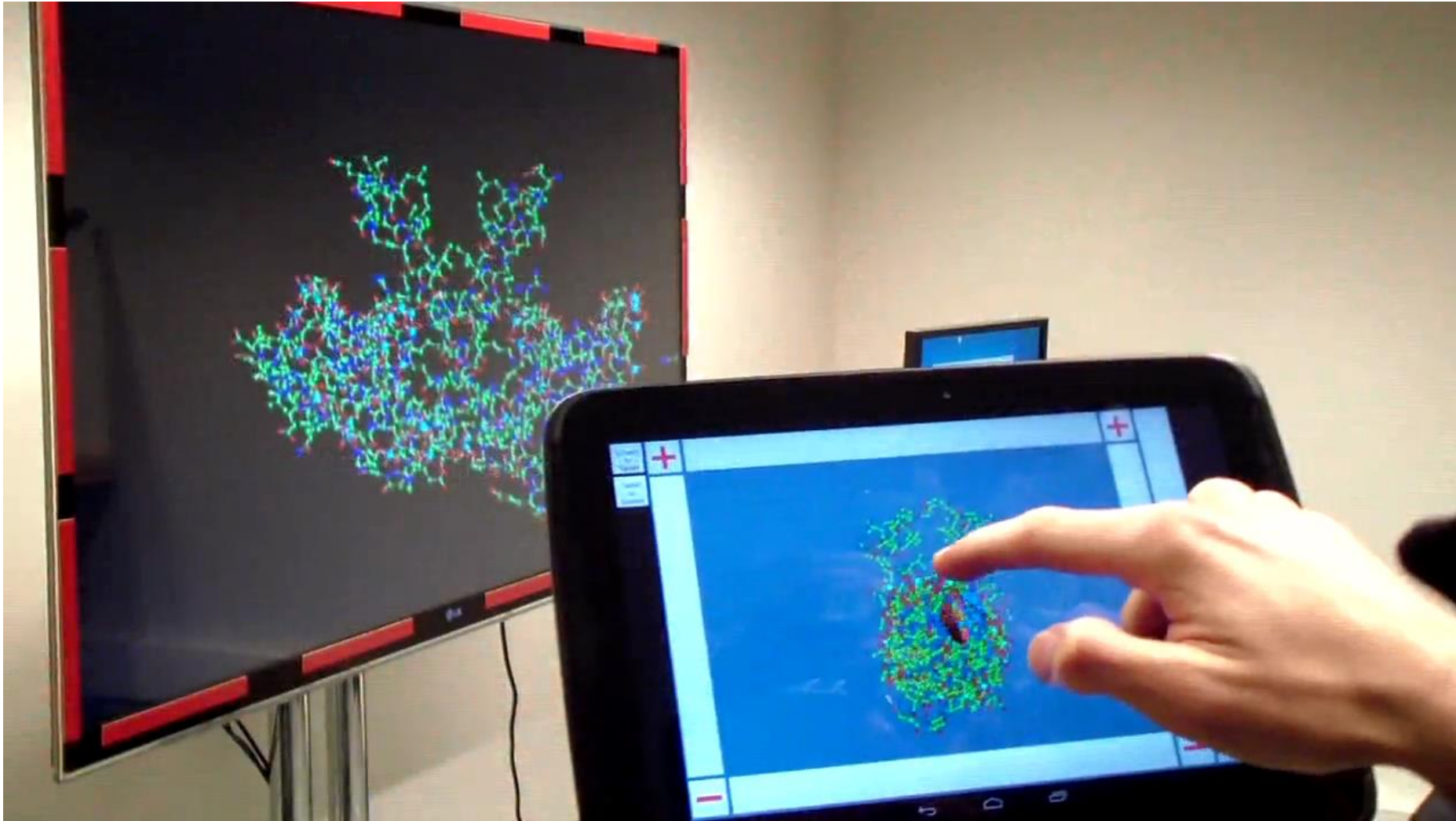
Resulting Interaction Workflow



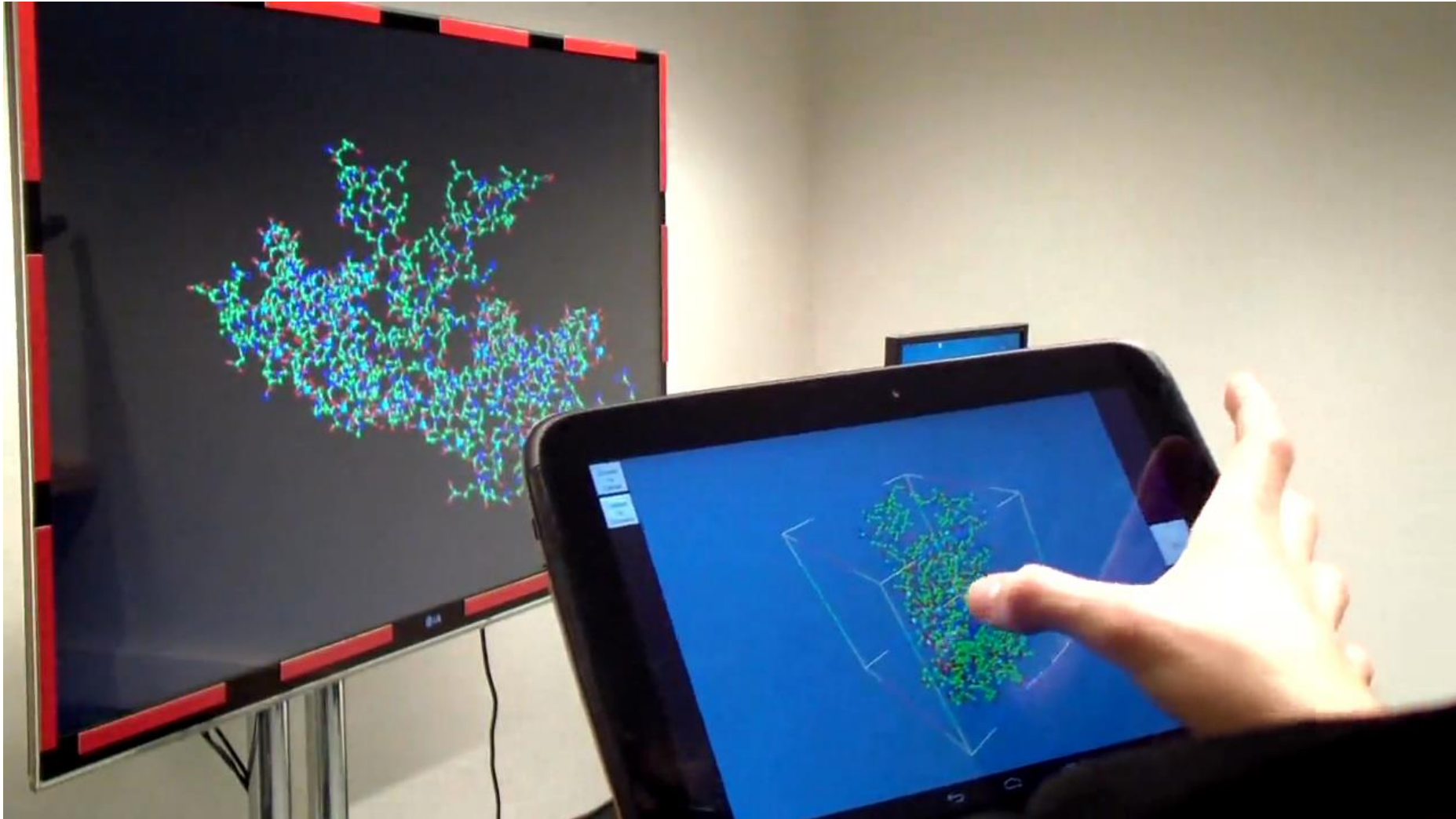
Resulting Interaction Workflow



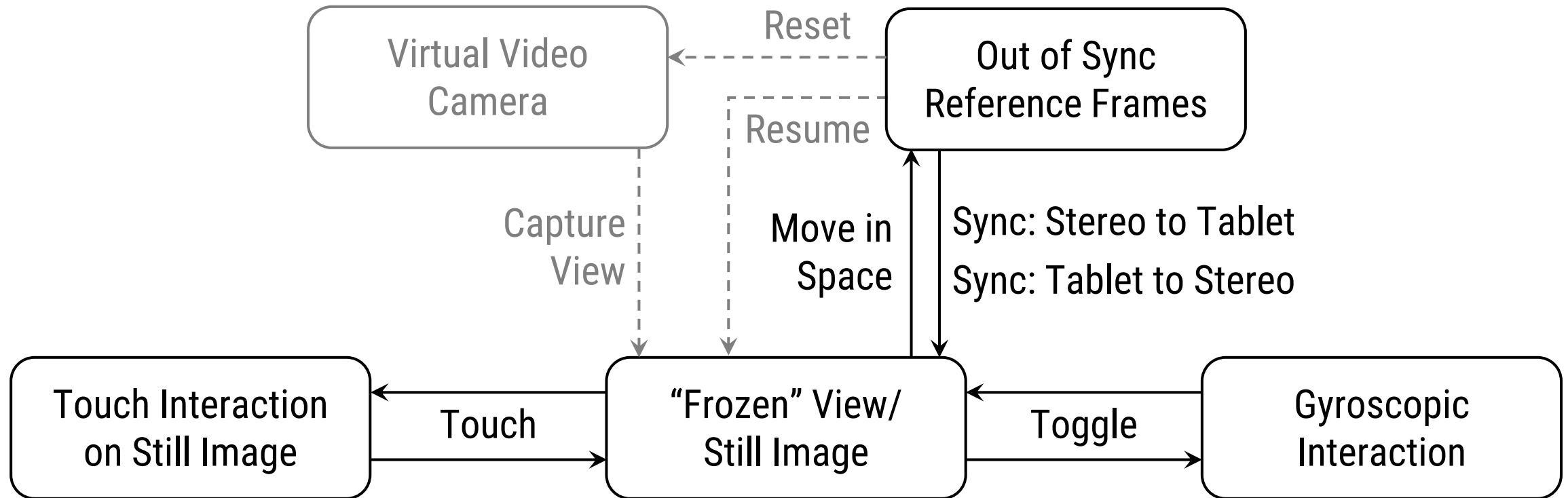
Synchronization: Tablet to Stereo Screen



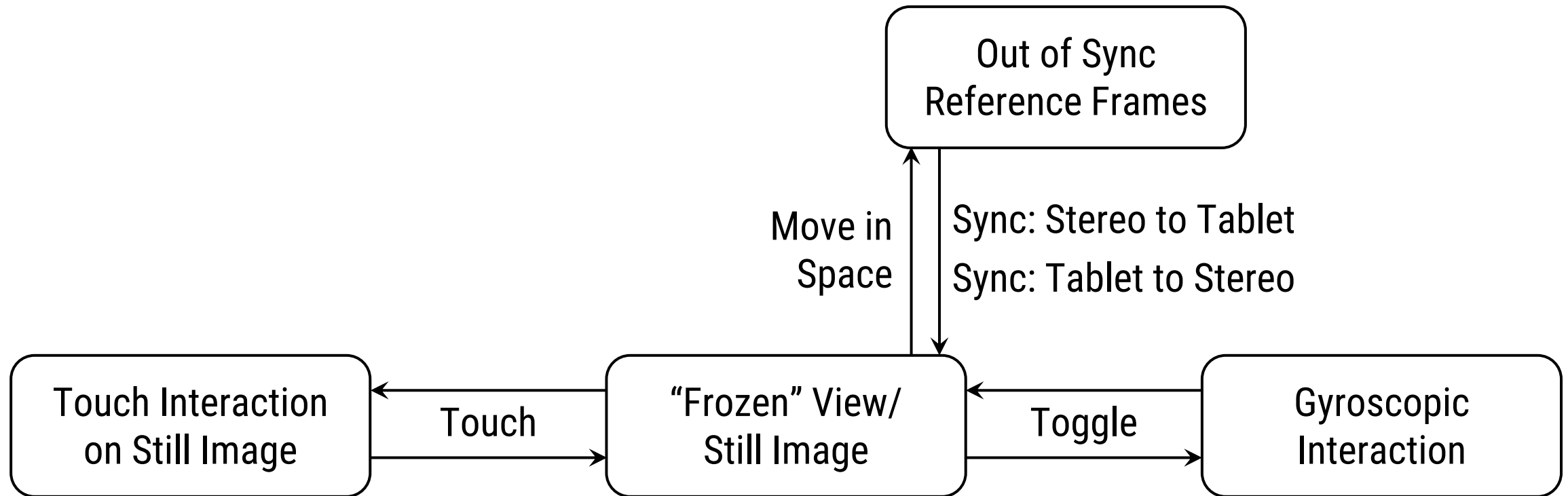
Synchronization: Stereo Screen to Tablet



Final Interaction Workflow

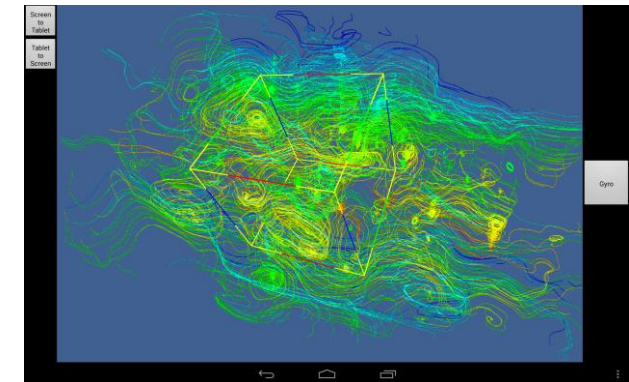
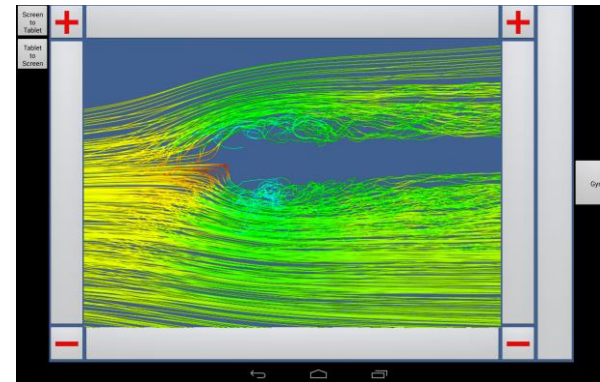
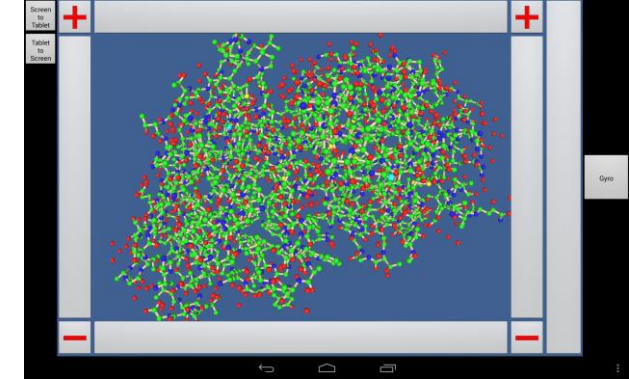
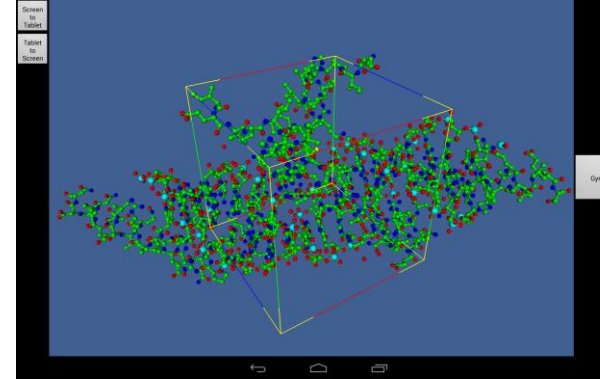


Final Interaction Workflow



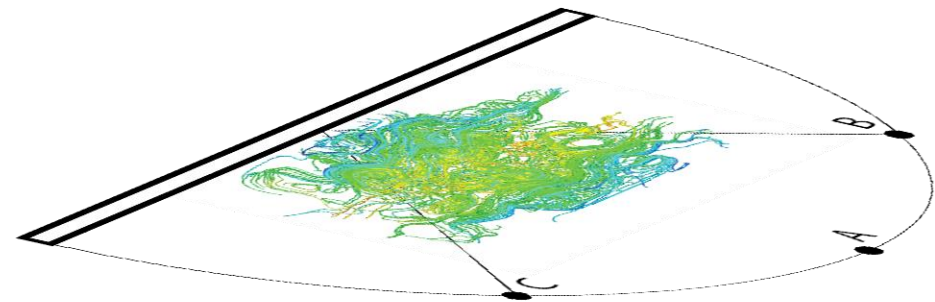
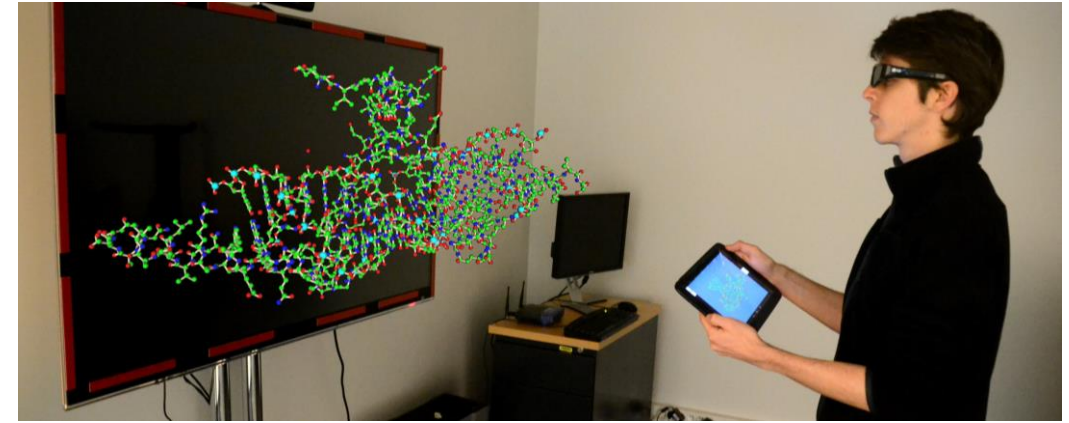
Observational Study with Experts

- 8 participants (2f, 6m)
 - 2 types of experts: structural biology & fluid mechanics
 - median 9.5 years experience
- 2 interfaces: tBox & FI3D
- 2 datasets per domain
- both counter-balanced
- logging and video-capture

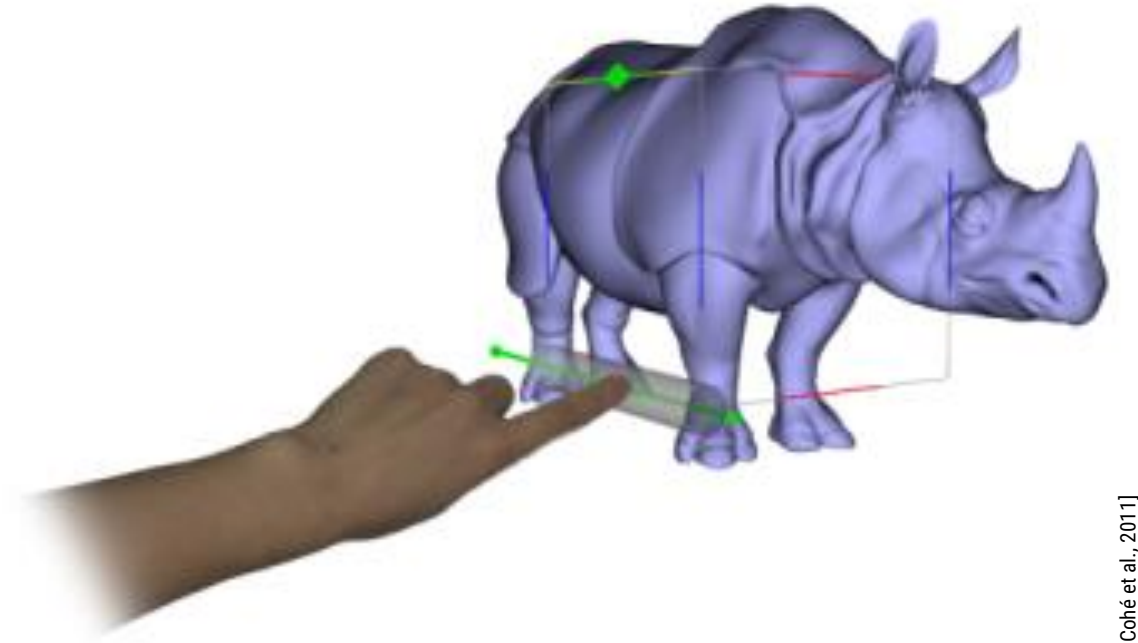
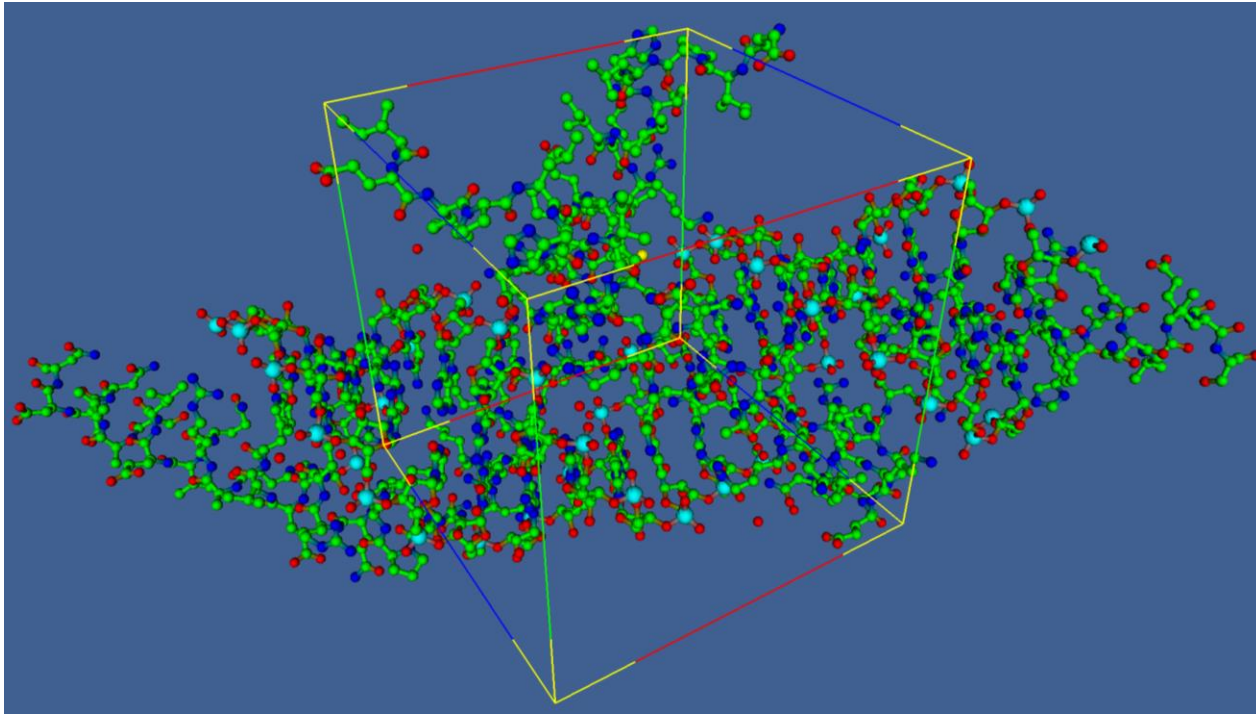


Observational Study with Experts

- 8 participants (2f, 6m)
 - 2 types of experts: structural biology & fluid mechanics
 - median 9.5 years experience
- 2 interfaces: tBox & FI3D
- 2 datasets per domain
- both counter-balanced
- logging and video-capture

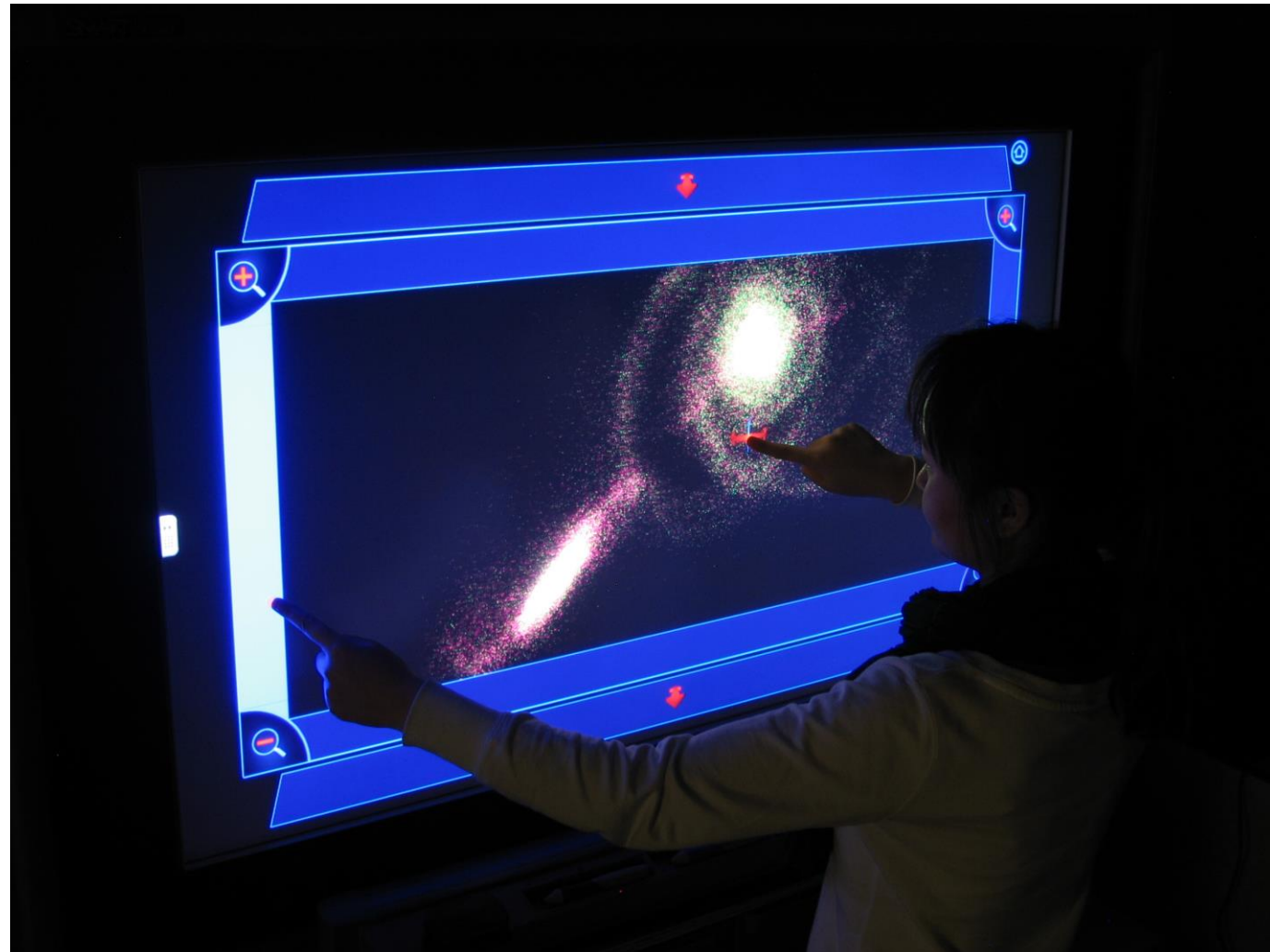


Touch-Based 3D Navigation: tBox



[Cohé et al., 2011]

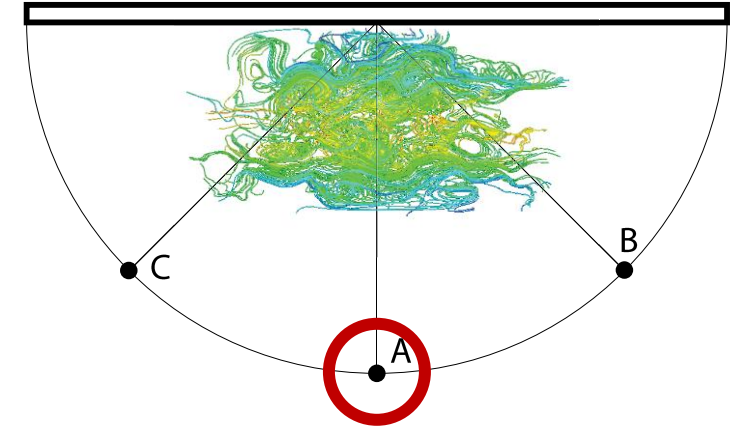
Touch-Based 3D Navigation: FI3D



[Yu et al. 2010]

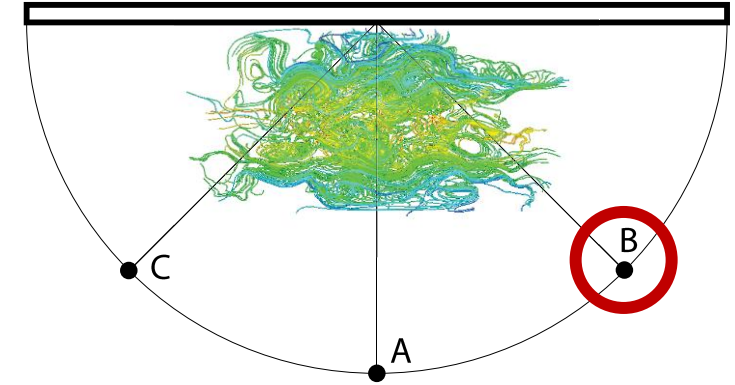
Study Procedure

- start at A
 - training in interface (tBox or FI3D)
 - find view that is particularly interesting (view 1)



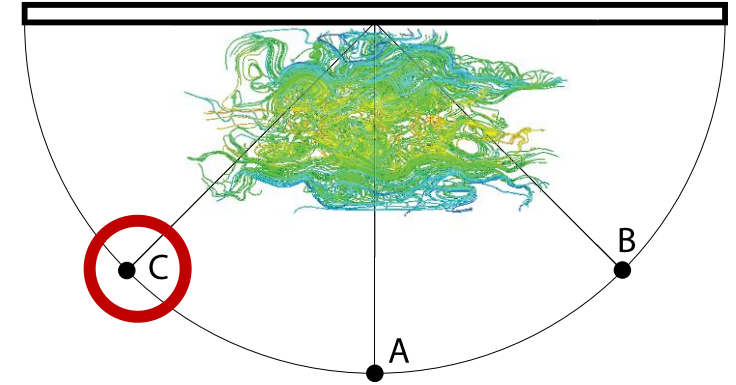
Study Procedure

- start at A
 - training in interface (tBox or FI3D)
 - find view that is particularly interesting (view 1)
- move to B
 - data static in space, stereo view changed for new perspective
 - task: reproduce view 1 from point B → difficulties due to out of sync
 - discussion of out of sync issues, introduction of synchronization techniques and adding respective elements to interface
 - expected interaction: *tablet to stereo* synchronization



Study Procedure

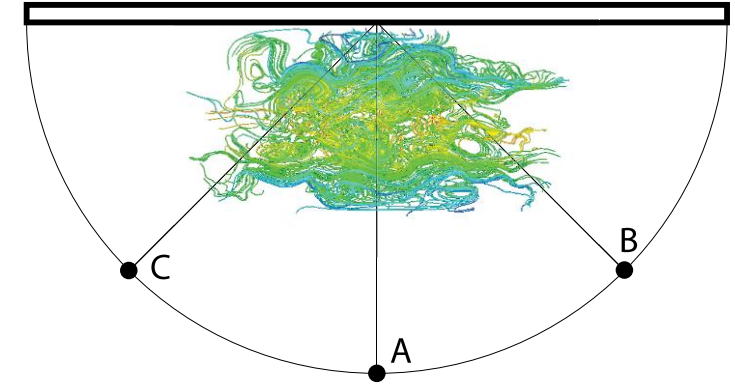
- move to C
 - even stronger interaction out-of-sync effect
 - task: manipulate data such that a person at point A would see view 1
 - discussion of difficulties
 - expected interaction: stereo to tablet, then additional interactions



Study Procedure

- move to C
 - even stronger interaction out-of-sync effect
 - task: manipulate data such that a person at point A would see view 1
 - discussion of difficulties
 - expected interaction: stereo to tablet, then additional interactions
- repetition of these steps with second dataset, but with all interface elements enabled

questionnaire about study experience,
semi-structured interview



Results & Observations (Highlights)

- switching between tablet and stereo views: no problems
- resolving reference frame issues:
 - 1st iteration B: 4 identified problems, 4 focused on stereo screen
 C: 3 tablet→stereo 2 stereo→tablet 3 no sync
 - 2nd iteration B: 5 tablet→stereo 0 stereo→tablet 3 no sync
 C: 3 tablet→stereo 3 stereo→tablet 2 no sync
- all participants
 - considered sync to be important
 - appreciated both tablet and stereo views

Results & Observations (Highlights)

- tBox
 - preferred by 2 participants
 - perceived to be more precise (seen both as positive and as negative)
 - perceived implied order of operations
 - clearer interaction focus
- FI3D
 - preferred by 6 participants
 - perceived to be better for free exploration, but less precise
 - no implied order of operations
- **each useful for different purposes/interaction goals**

Conclusion

- interaction related to AR: but in visualization data is virtual
- stable reference frame essential for tablet-based 3D interface
- explanation of when relaxed interaction works, and when not
 - different frames of reference to consider
 - awkward interaction can be avoided
 - if one moves to far from initial view, sync is necessary
- extension of existing work on two-surface data exploration
- plenty of exciting future work on two-surface interfaces

Thanks

David López, Lora Oehlberg, Candemir Doger, and Tobias Isenberg:
*Towards an Understanding of Mobile Touch Navigation
in a Stereoscopic Viewing Environment for 3D Data Exploration.*
IEEE Transactions on Visualization and Computer Graphics, 22, 2016.
To appear.
DOI: 10.1109/TVCG.2015.2440233
URL: <http://tobias.isenberg.cc/VideosAndDemos/Lopez2016TUM>

