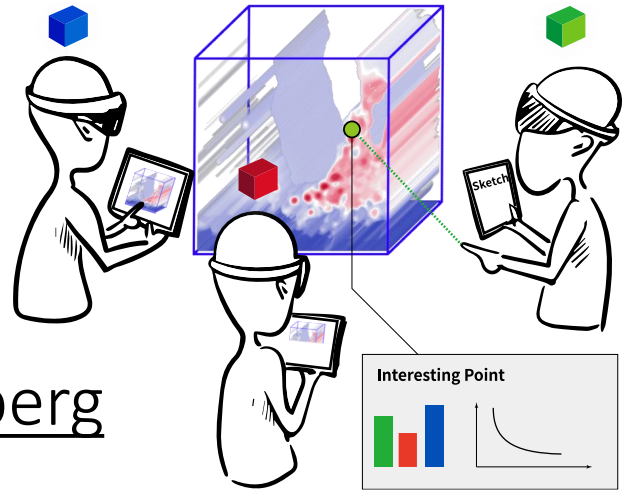
université PARIS-SACLAY

LISN LABORATOIRE INTERDISCIPLINAIRE DES SCIENCES DU NUMÉRIQUE

informatics mathematics Inria

Aviz

Collaborative Data Exploration and Discussion with Augmented Reality Support

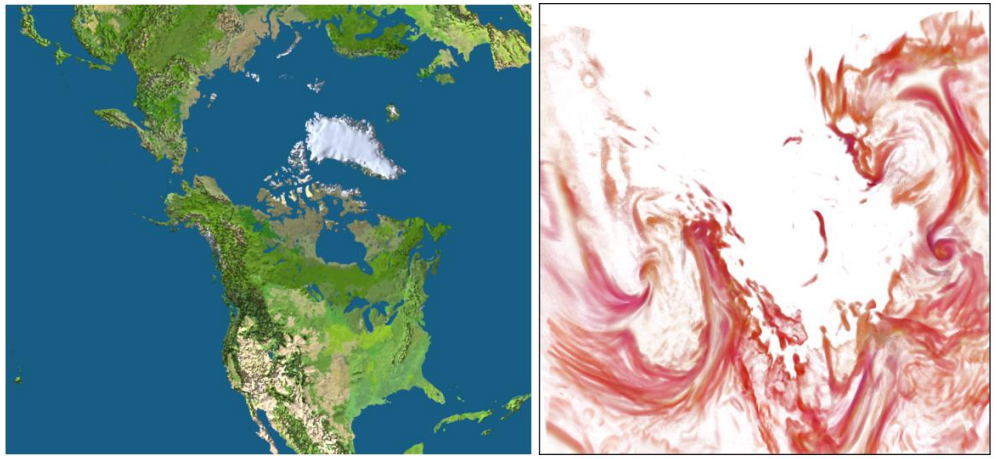


Mickaël Sereno, supervised by Tobias Isenberg

What are Data Visualization and Data Exploration?

Visual Analytics

Kniss et al., "**Gaussian transfer functions for multi-field volume visualization**," 2003



Context Map

Extract Air Mass Front

Variables: temperature, humidity, wind speed

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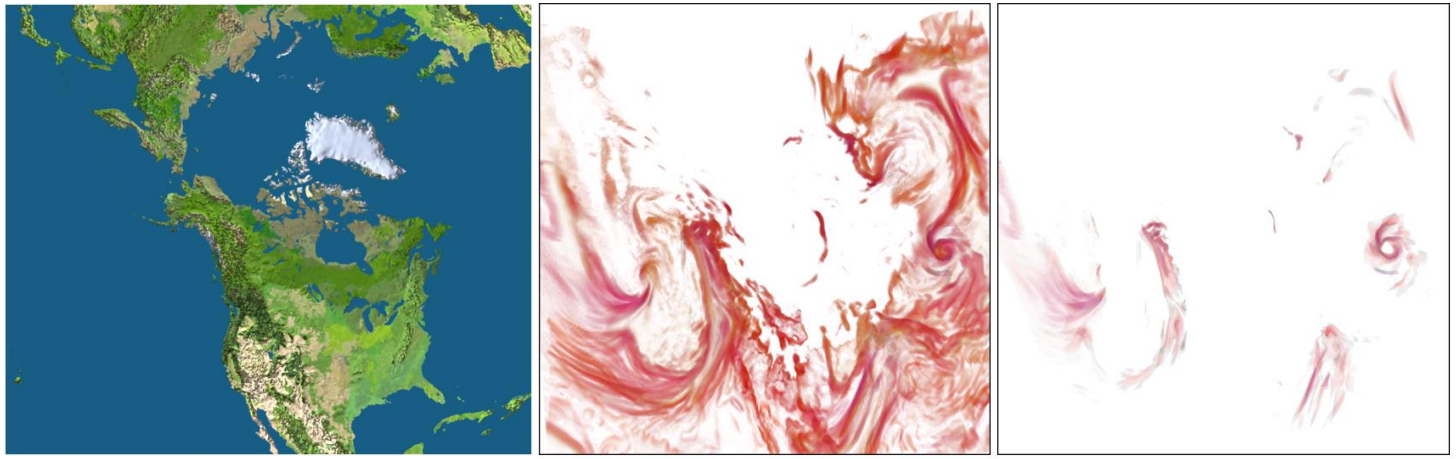

Context Map | Extract Air Mass Front | Extract Air Mass Front Of Strong Wind

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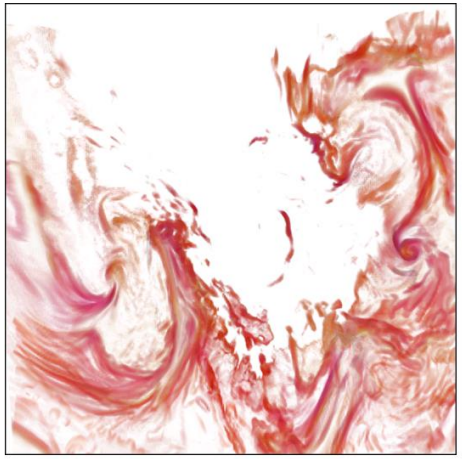


Extract Air Mass Front

Extract Air Mass Front
Of Strong Wind

Variables: temperature, humidity, wind speed

Immersive Analytics

What is Augmented Reality (AR)?

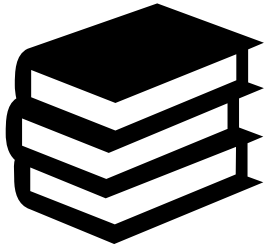
Merge virtual and real

Microsoft

Pokémon Go

Piper et al., “**Illuminating Clay: A 3-D Tangible Interface for Landscape Analysis”,** 2002

How to start this PhD?
Reading Surveys and Summaries



- N(AR-CSCW) = ε

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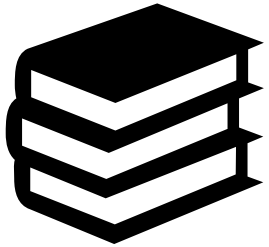

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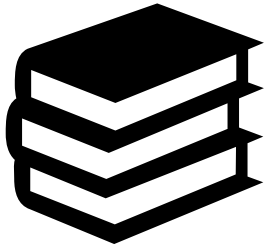

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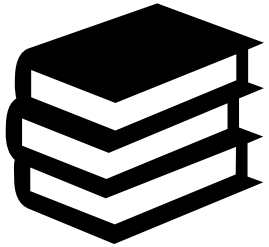

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- Past surveys either:
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  - Do not consider the technological breakthrough of 2016

Microsoft

At the Beginning, a Survey (TVCG 2020)

Mickaël Sereno, Lonni Besançon, Xiyao Wang, Michael McGuffin, Tobias Isenberg

- Focus on technological aspects

At the Beginning, a Survey (TVCG 2020)

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- Focus on technological aspects

- Discuss about Immersive Analytics

At the Beginning, a Survey (TVCG 2020)
Background and Taxonomy

68 

- Space and Time
  - Co-Located vs. Remote
  - Synchronous vs. Asynchronous

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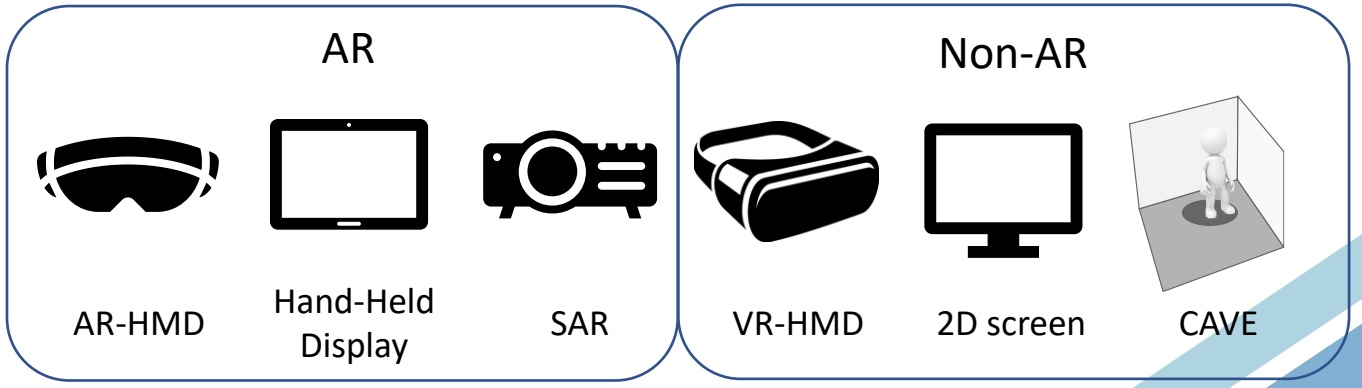

Collaborative Immersive Analytics

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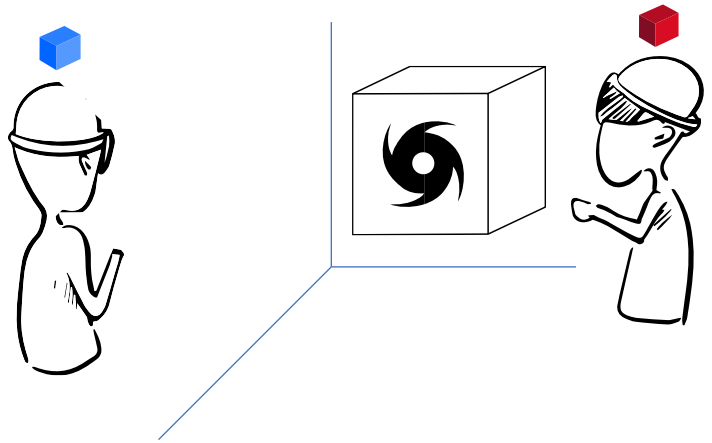
Before 2016: Not enough computing power

Head-Mounted Displays as AR devices

RQ: *What are the benefits and limitations of AR-HMDs for collaborative 3D data exploration?*



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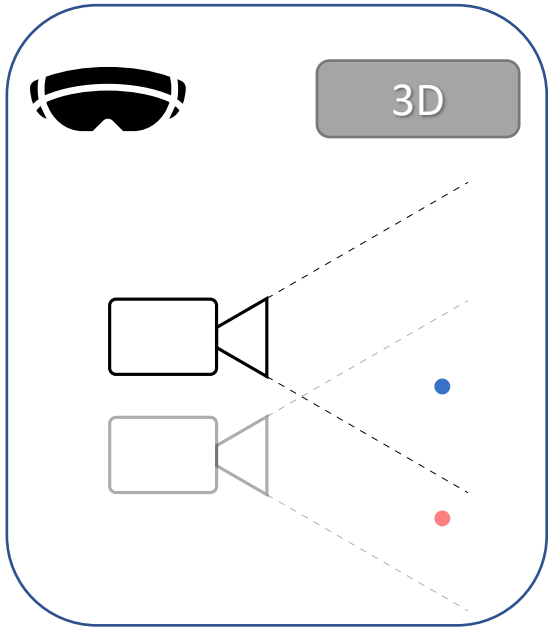

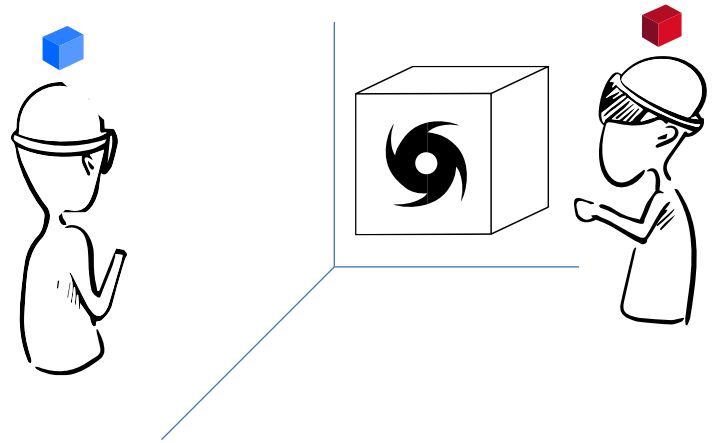

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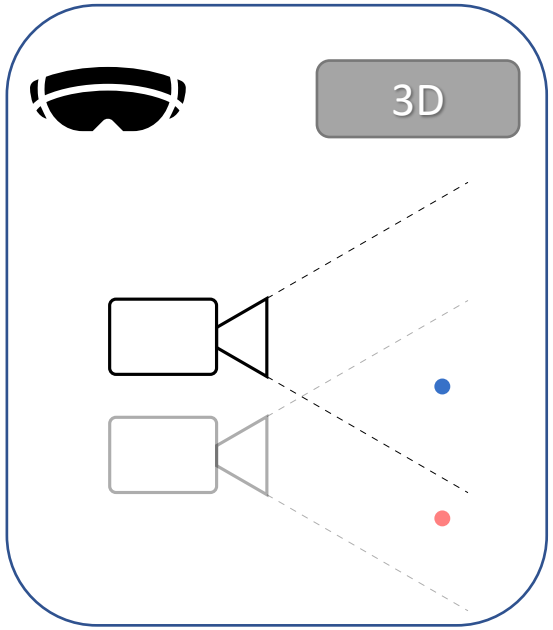

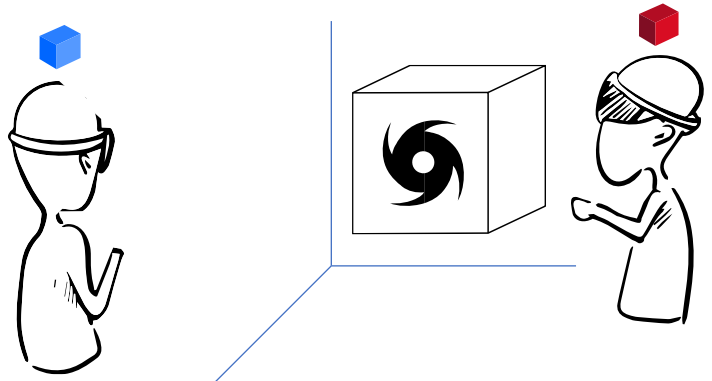

Visualization
Interaction
Collaborative

Physical Space

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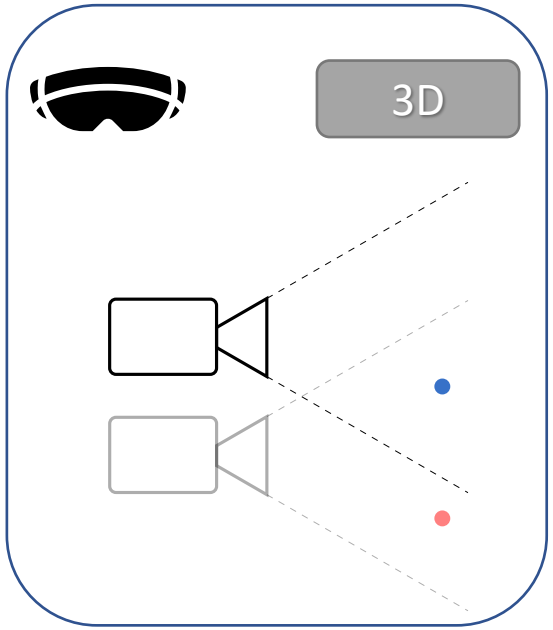

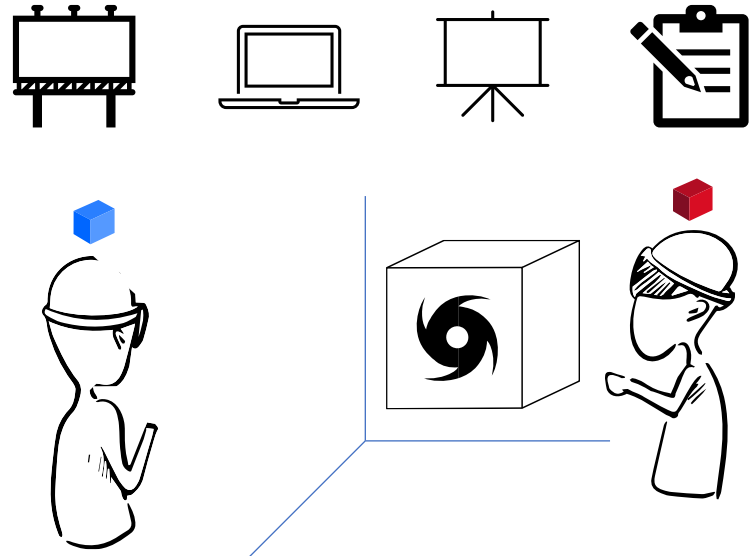

Visualization
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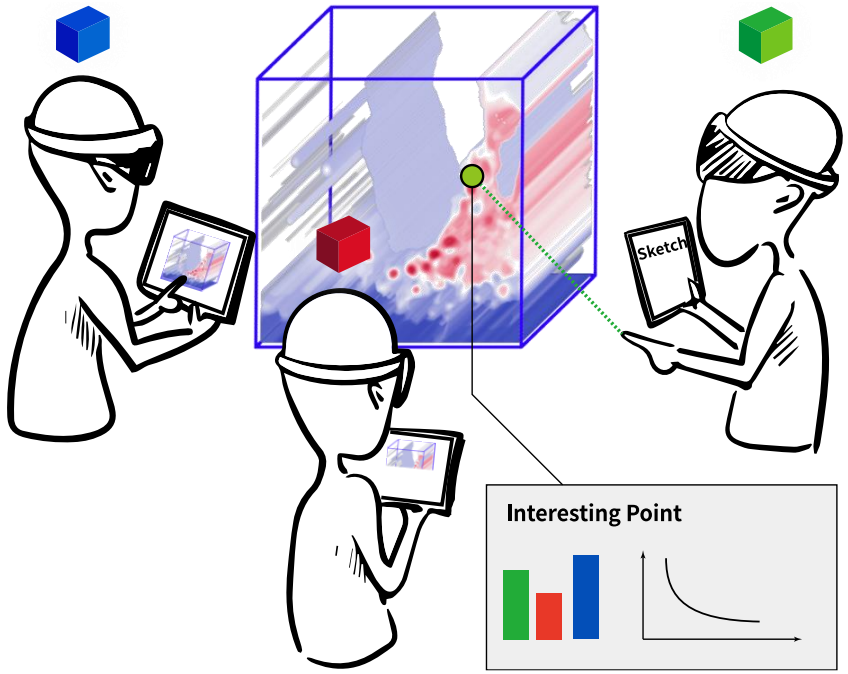
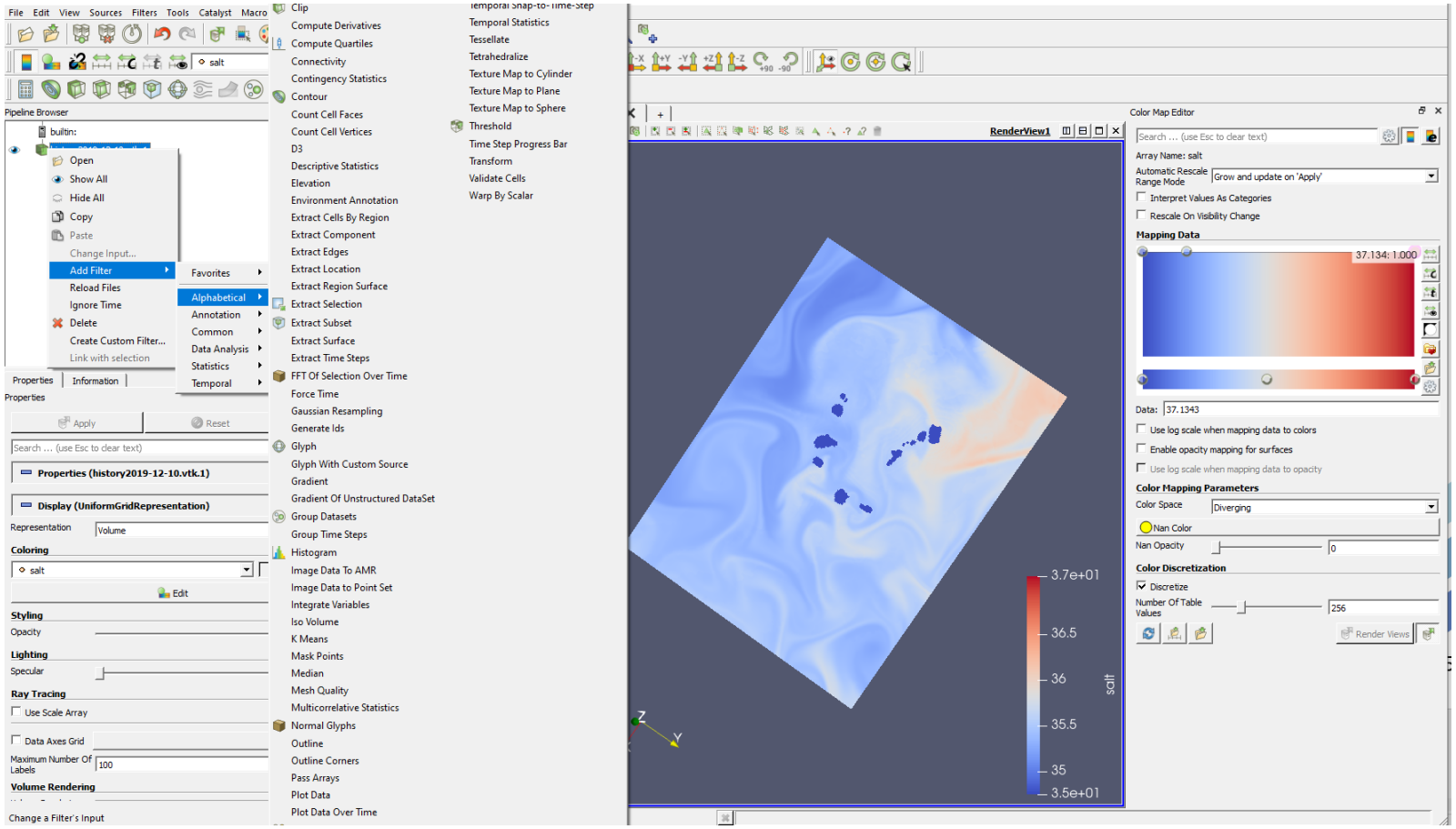
Physical Space

Collaborative **Co-Located 3D** Data Exploration and Discussion with Augmented Reality **Head-Mounted Displays** Support.



Headsets and Interactions

*The need of **NUMEROUS** exploratory tools*



ParaView, Kitware

Headsets and Interactions

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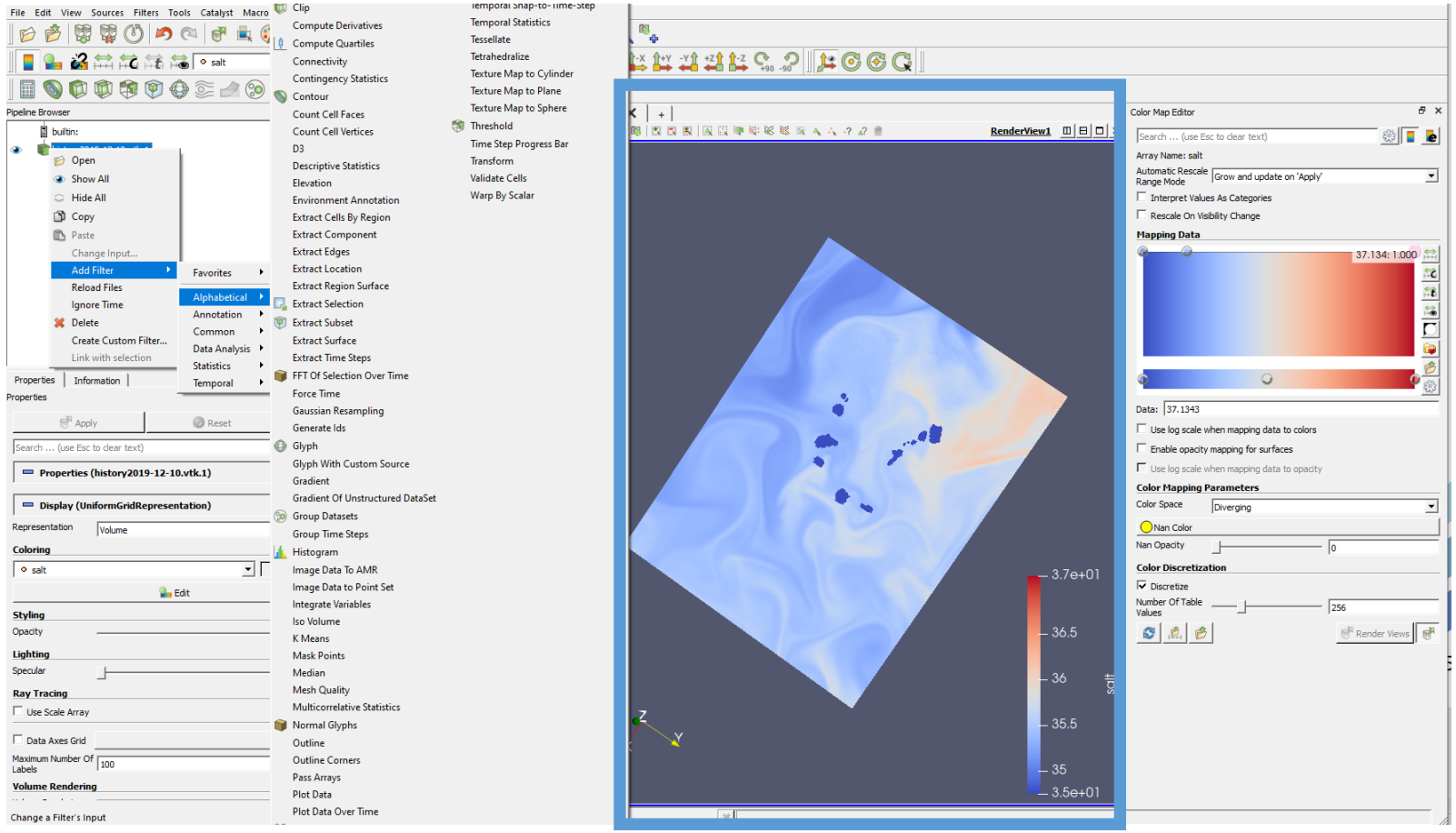

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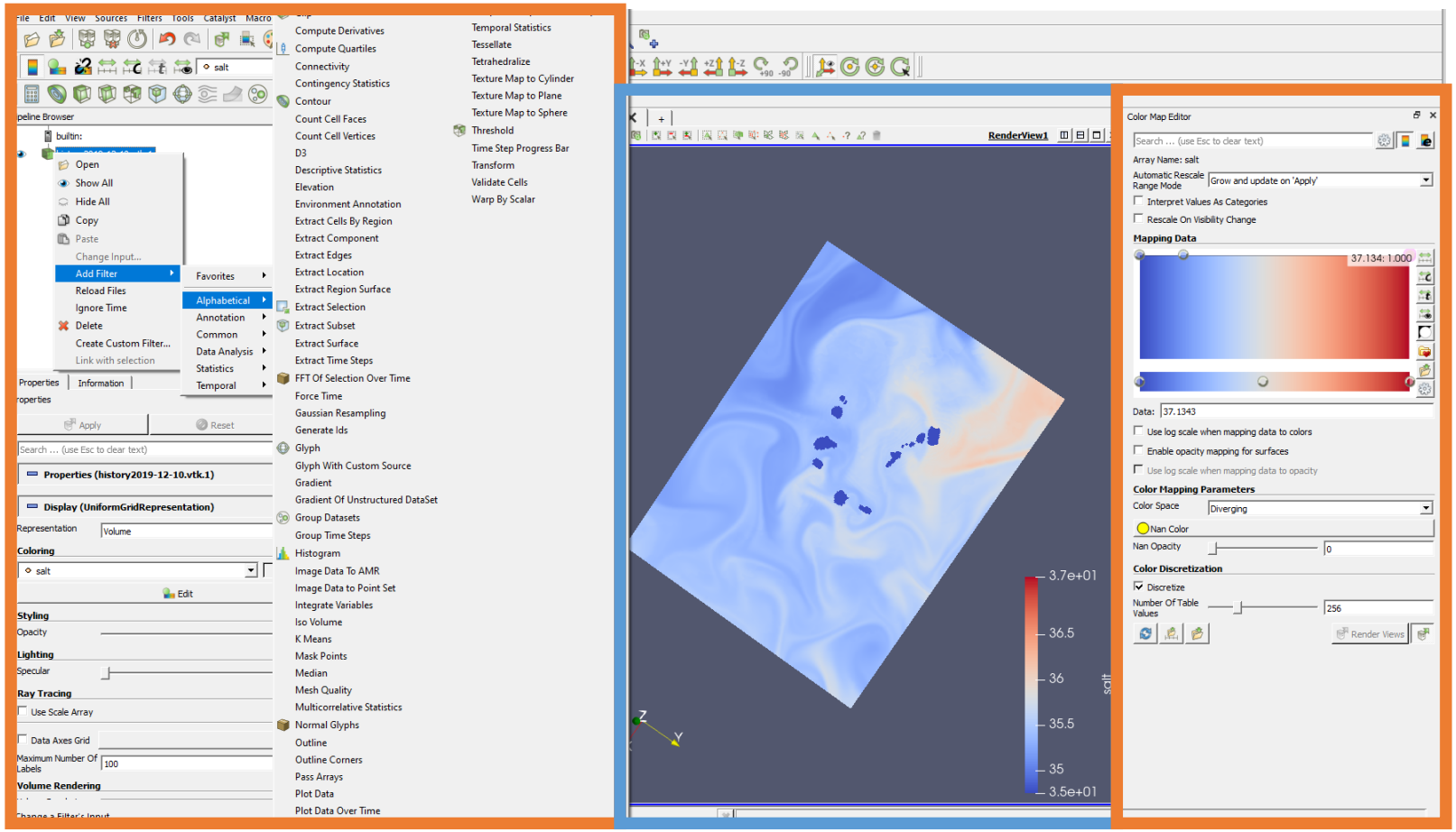


ParaView, Kitware

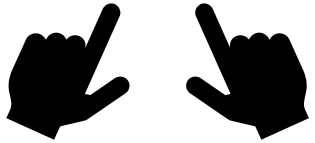
Head-Mounted Displays and Interactions
The available interfaces

Speech

Confusing
Discrete Interaction

Gaze

Limited
Continuous interaction



Mid-air gestures

Tiring (Gorilla Arm effect)

Head-Mounted Displays and Interactions
Hybrid Environment

Survey: 

10 standalone

29 hybrid

Head-Mounted Displays and Interactions
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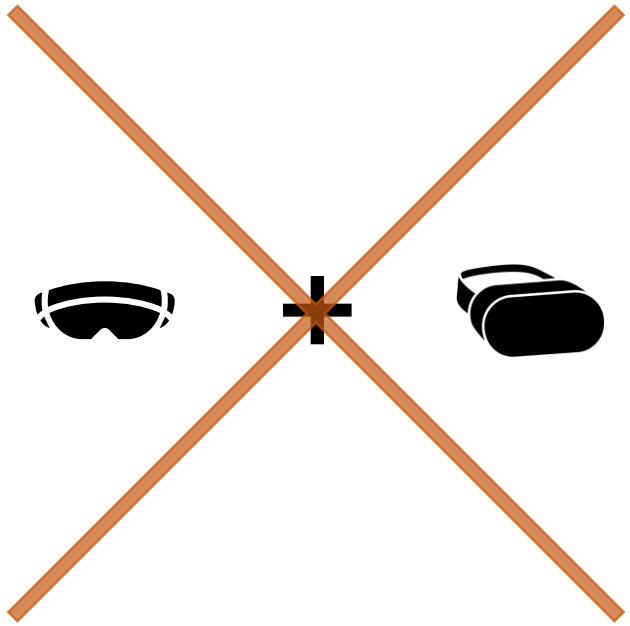
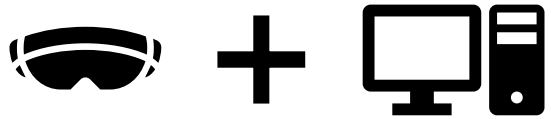


Breaks
Collaborative Space

Head-Mounted Displays and Interaction
Hybrid Environment



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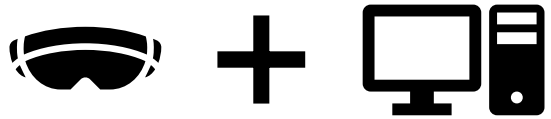

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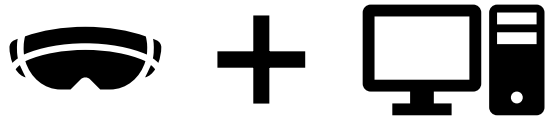
Benefits

- Keyboard
- Computing Power

Head-Mounted Displays and Interaction
Hybrid Environment



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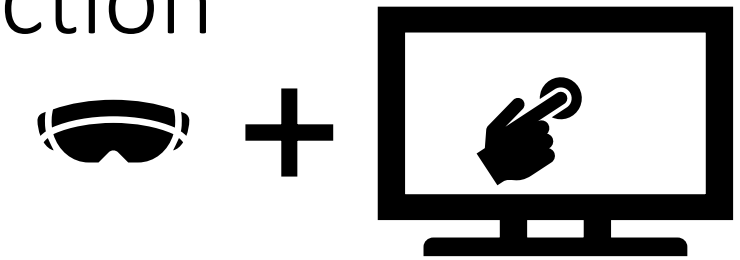
Benefits

- Keyboard
- Computing Power

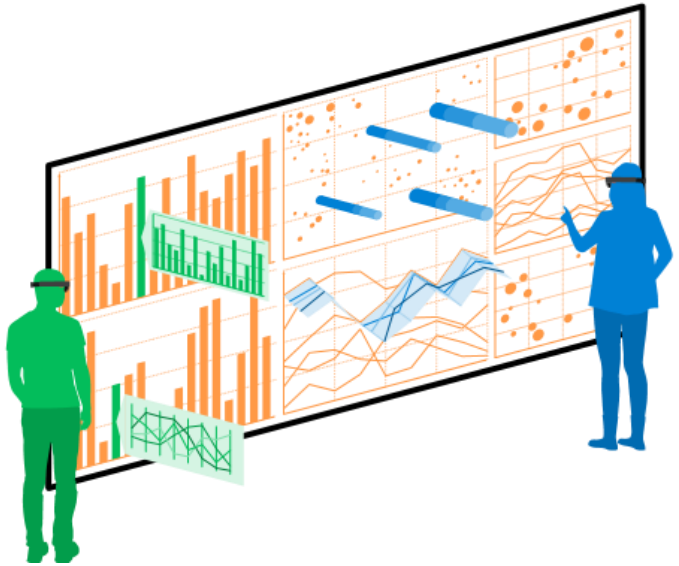
Limitations

- No collaborative space
- Not mobile

Head-Mounted Displays and Interaction
Hybrid Environment



Reipschlager et al., "**Personal augmented reality for information visualization on large interactive displays**," 2020



Head-Mounted Displays and Interaction
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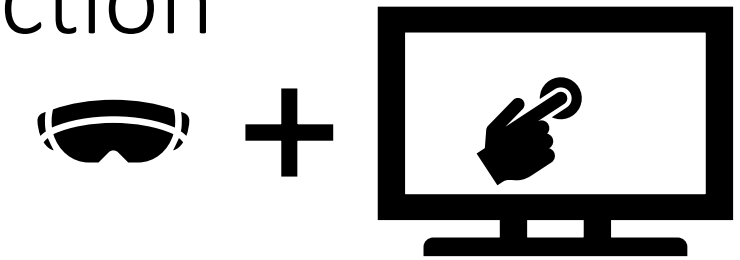

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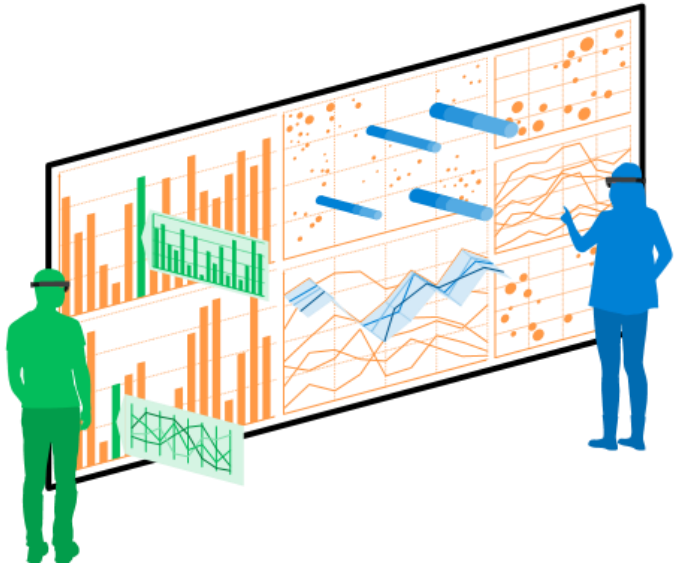
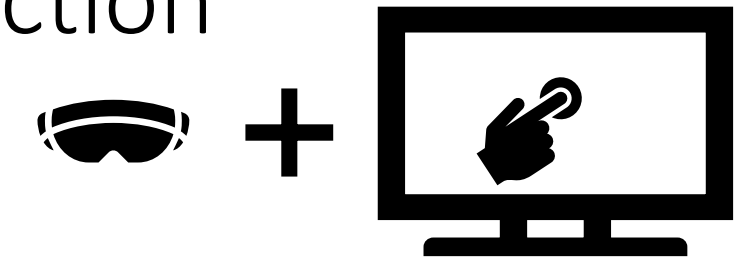


Benefits

- Touch input
- Large workspace
- Public 2D screen
- Require only one additional device

Head-Mounted Displays and Interaction
Hybrid Environment



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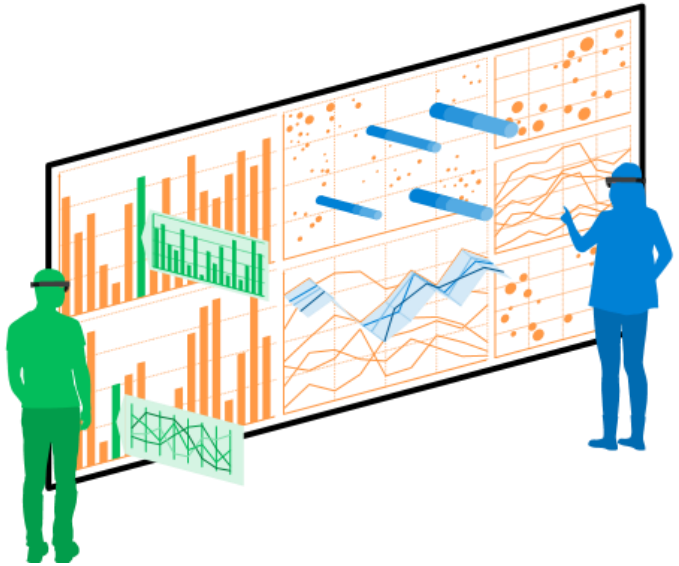


<u>Benefits</u>

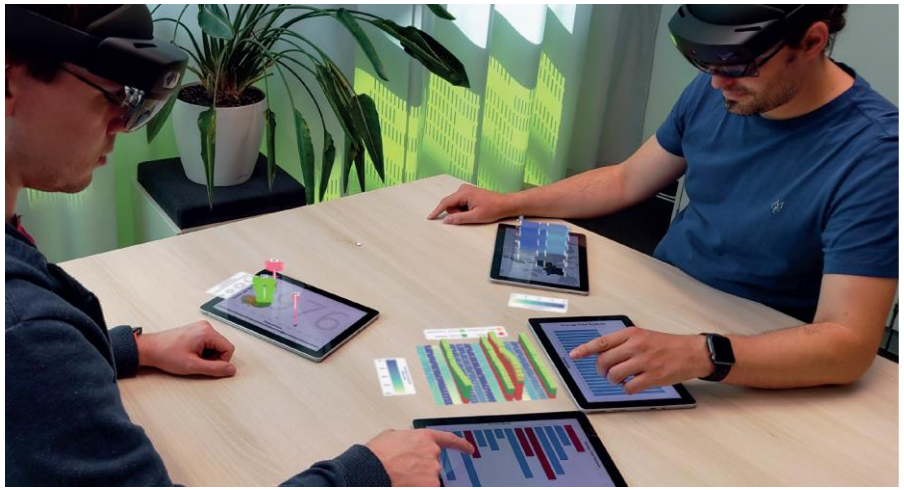
- Touch input
- Large workspace
- Public 2D screen
- Require only one additional device

<u>Limitations</u>

- Expensive, static
- Tradeoff between **size** and **personal interactive space**
- Keyboard
- Require movements

Head-Mounted Displays and Interaction
Hybrid Environment

Büschel et al., "**MIRIA: A Mixed Reality Toolkit for the In-Situ Visualization and Analysis of Spatio-Temporal Interaction Data**," 2021



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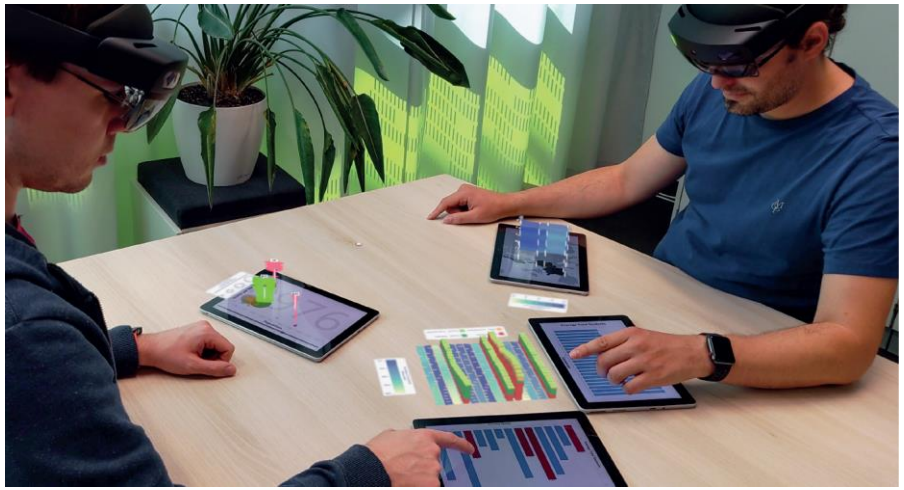

Benefits

- Touch input
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- Mobility
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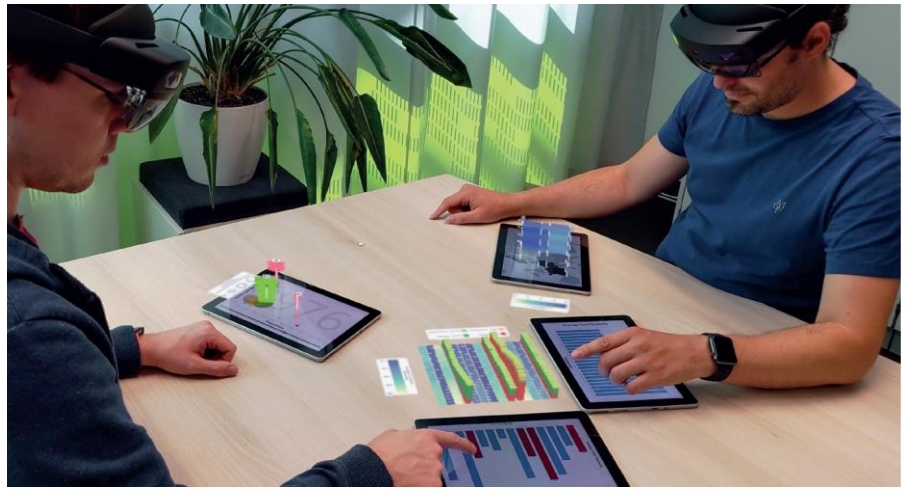

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Limitations

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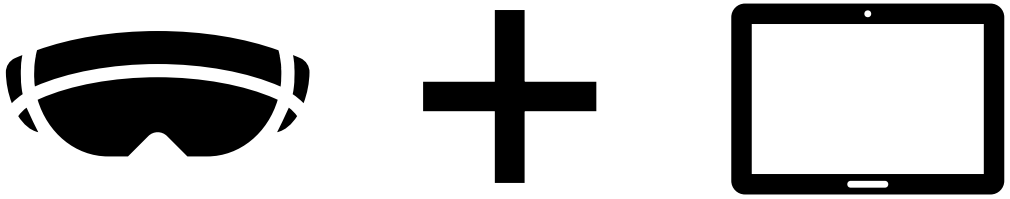
- Keyboard
- Public space

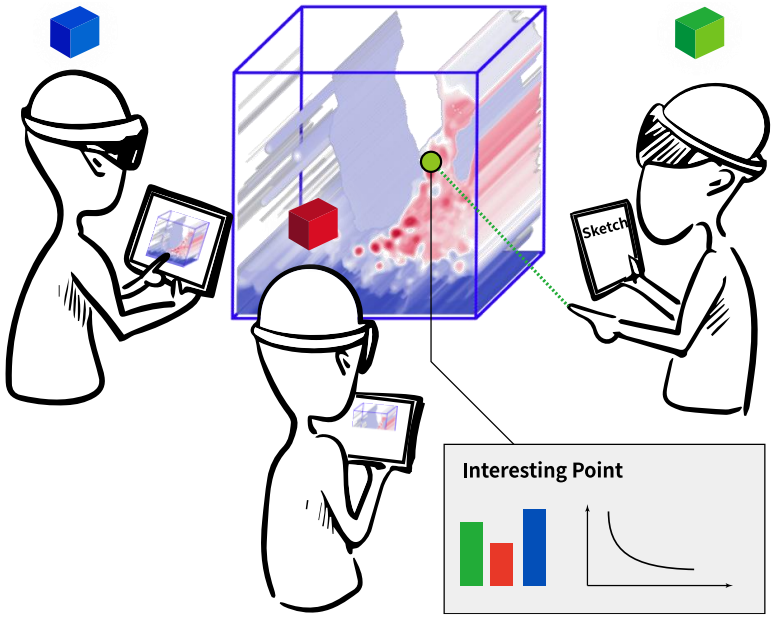
Head-Mounted Displays and Interaction
Hybrid Environment



But Collaboration First

Headsets +Tablets

RQ1: *How complementary can multi-touch tablets and AR-HMDs be to collaboratively explore 3D data?*



Scenarios

- Data pre-processed (scripting)
- For collaboration
- 3D visualizations are the focus

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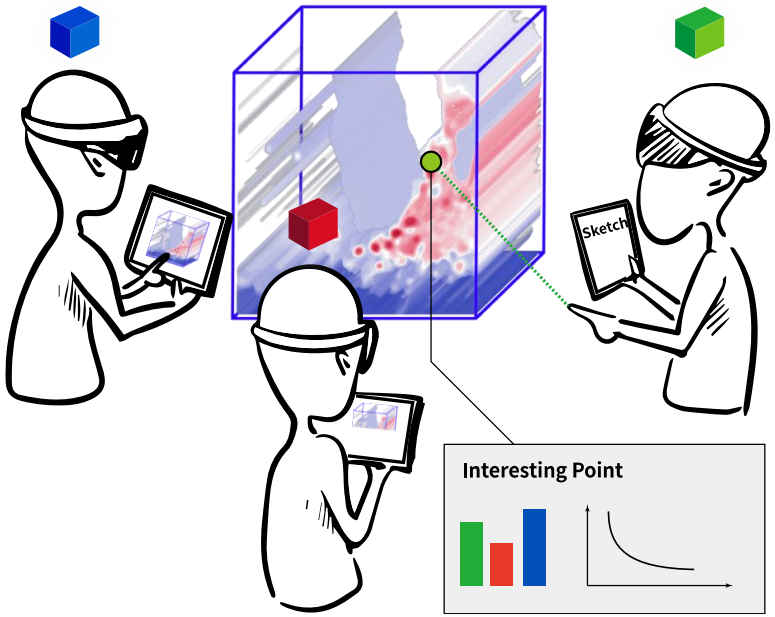

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Computing power

What Research Axis?
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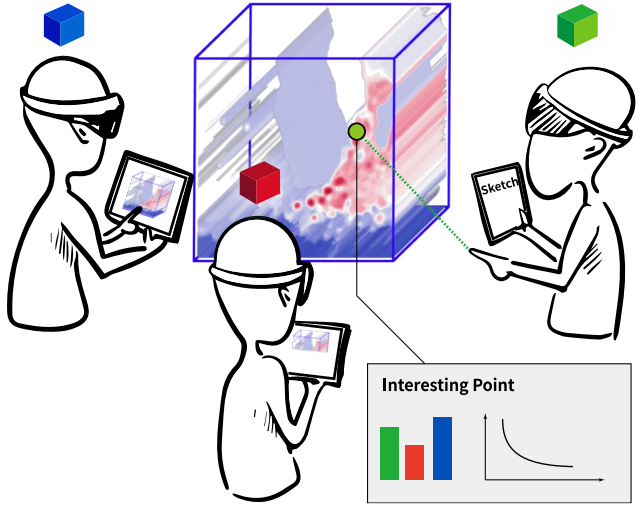

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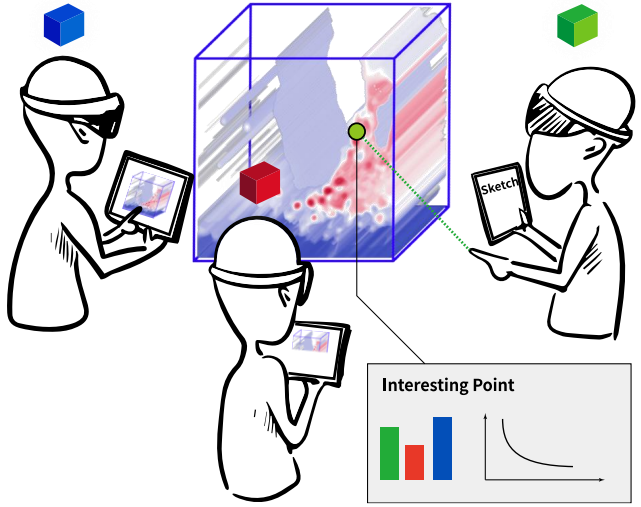

- Interaction
- Visualization

What Research Axis?
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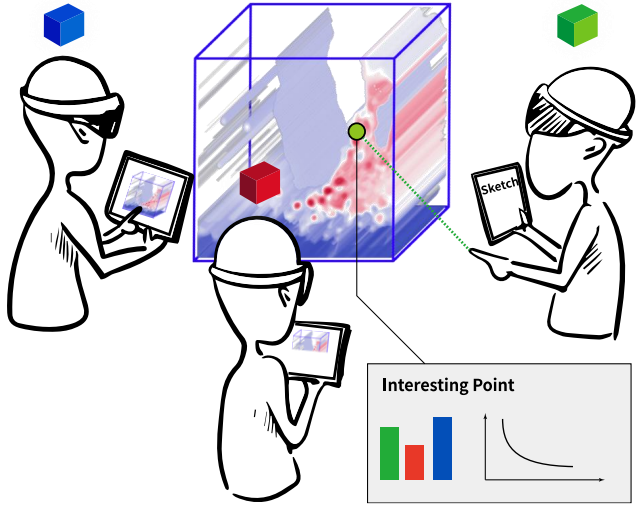
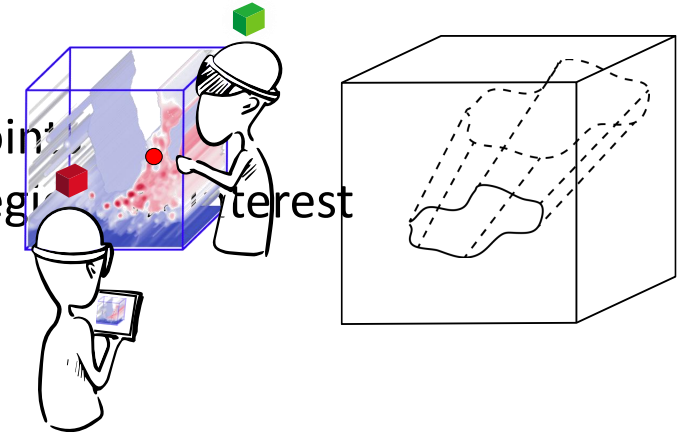


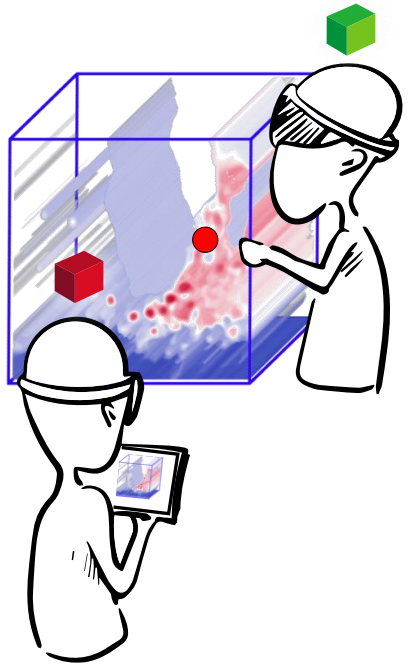
- Interaction
  - Specifying Point
  - Specifying Region of Interest



- Visualization

Specifying Points (Springer Virtual Reality, 2021)

Mickaël Sereno, L. Besançon, T. Isenberg



- Anchor virtual objects

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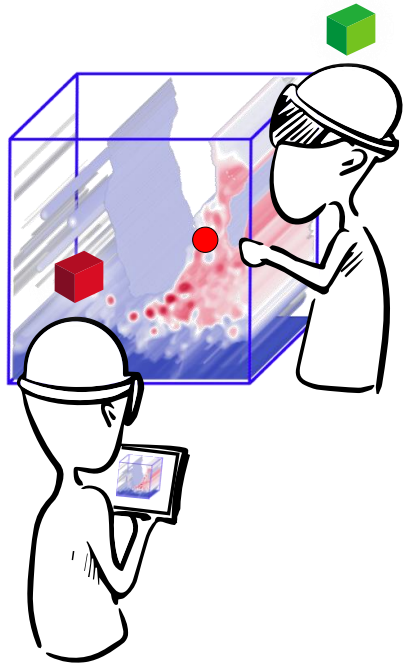

- Anchor virtual objects
- Probe data

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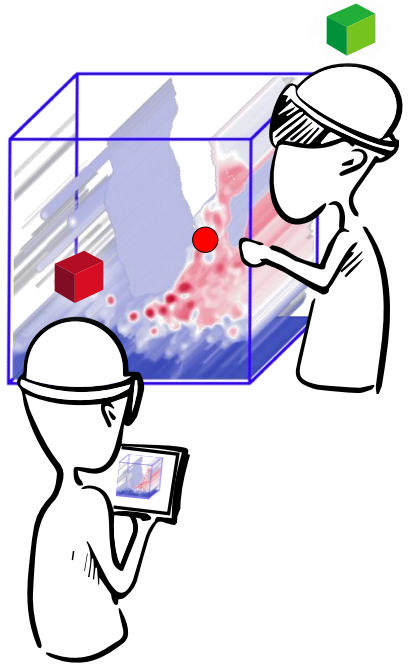
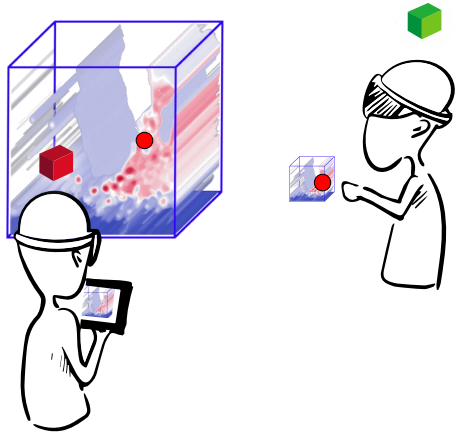
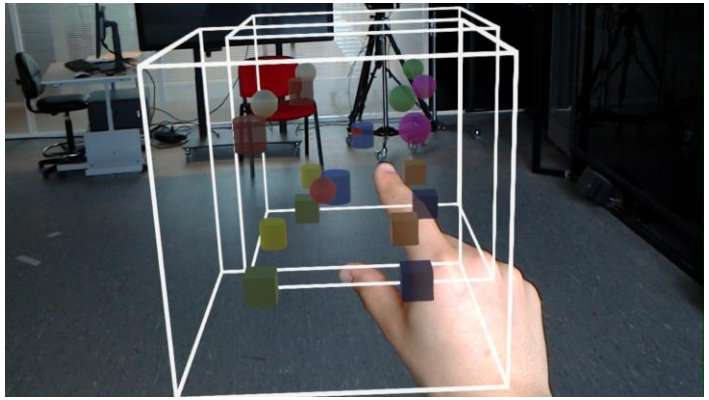


- Anchor virtual objects
- Probe data
- Show a point

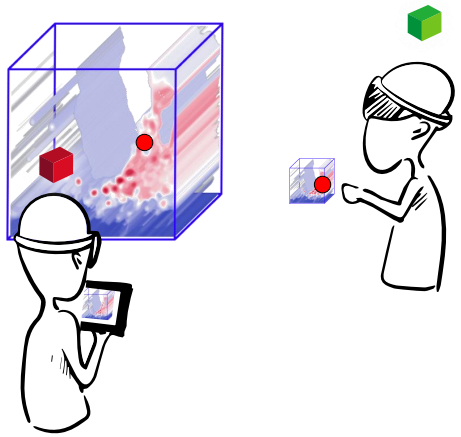
Specifying Points: The Techniques

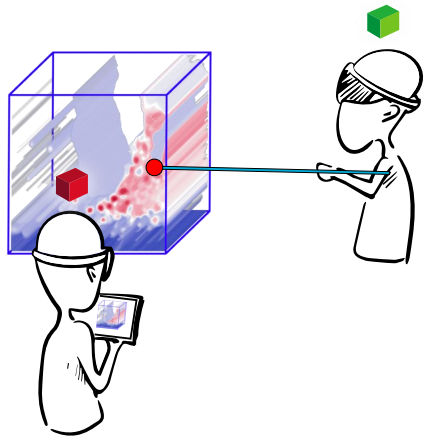


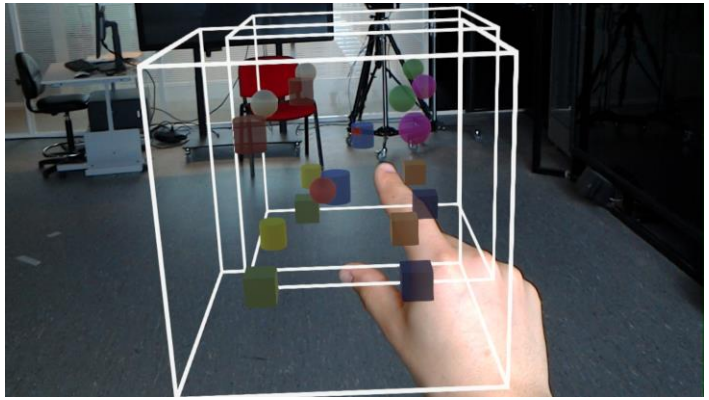


WIM

Specifying Points: The Techniques







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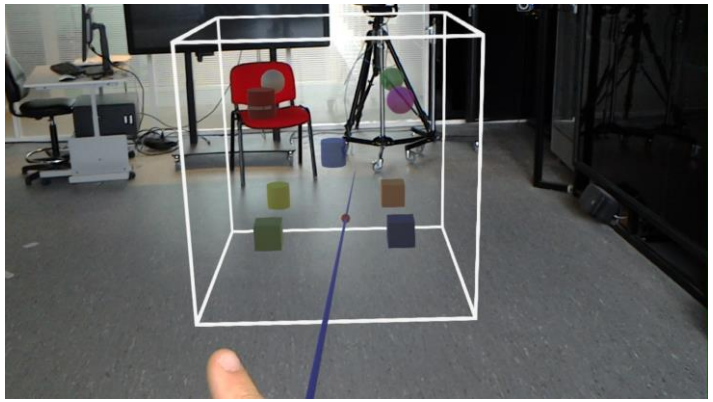
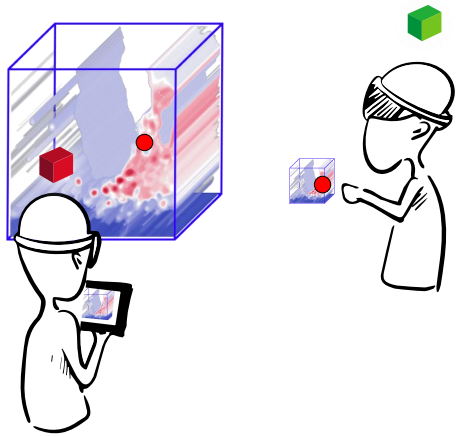
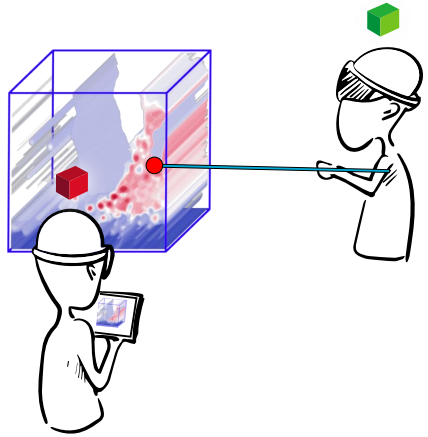
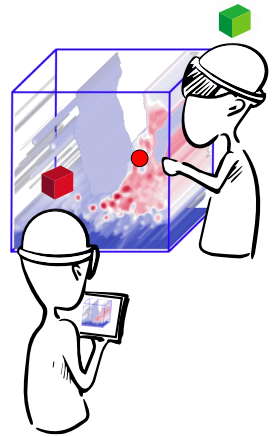


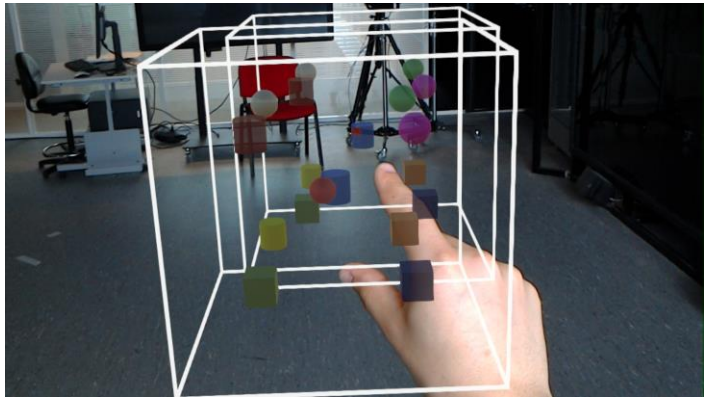
Go-Go

Specifying Points: The Techniques

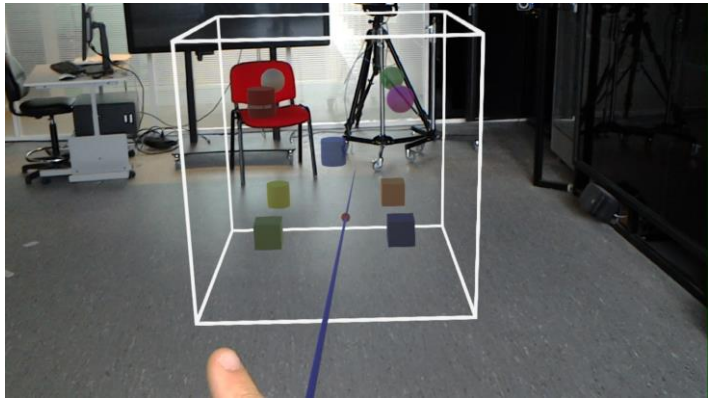




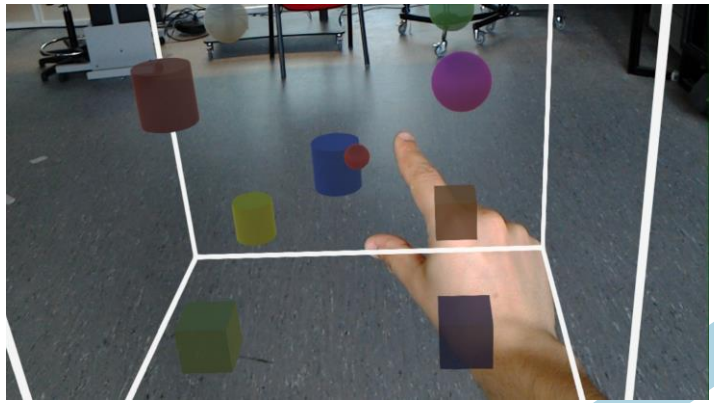




WIM



Go-Go

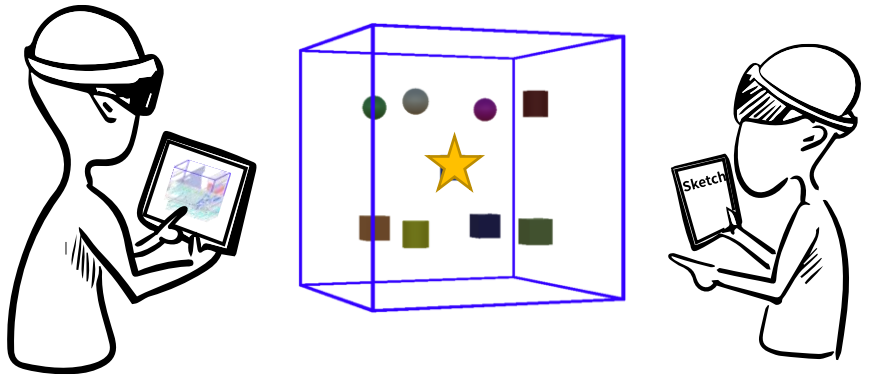


Manual

Specifying Points: Tasks

12 pairs (= 24) of Participants. Within-subject.

- Collaborative “Guiding” Tasks



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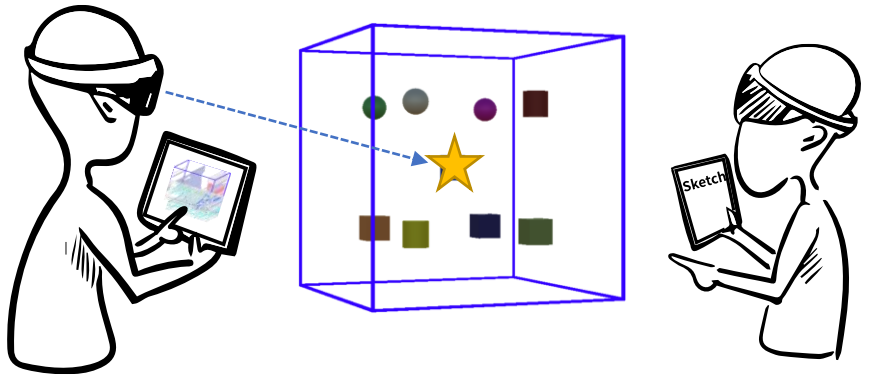

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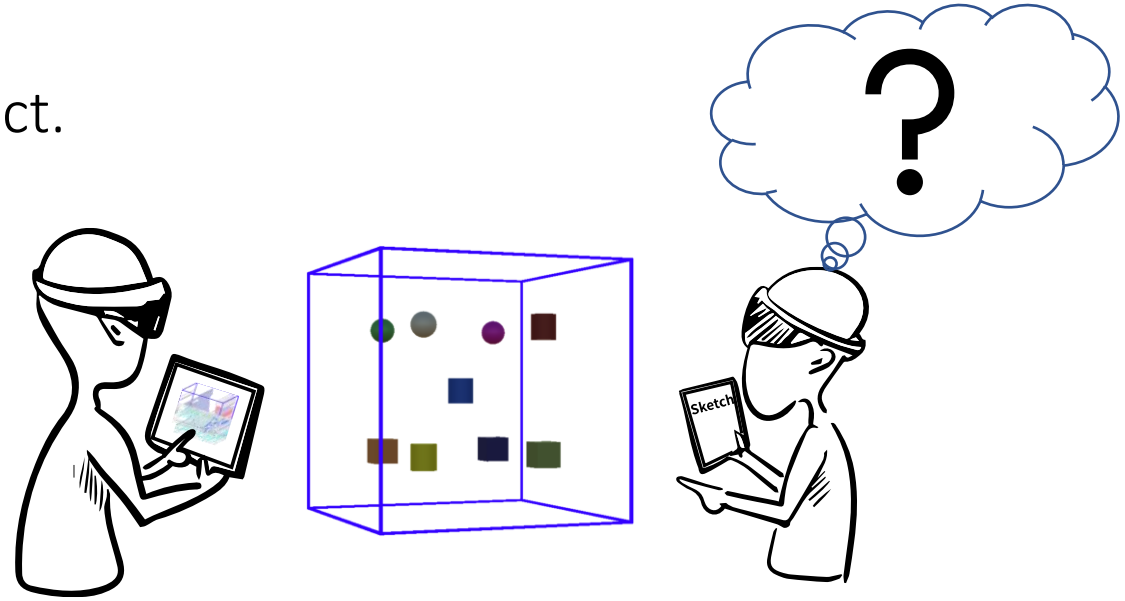

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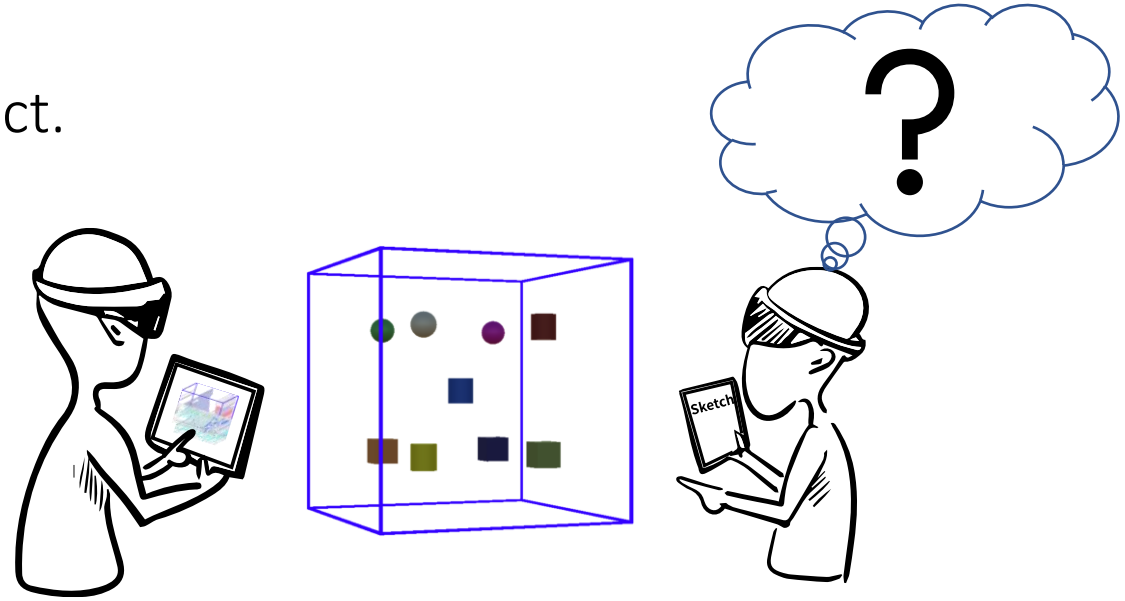
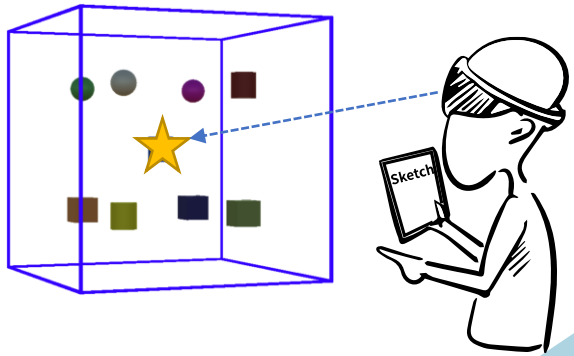


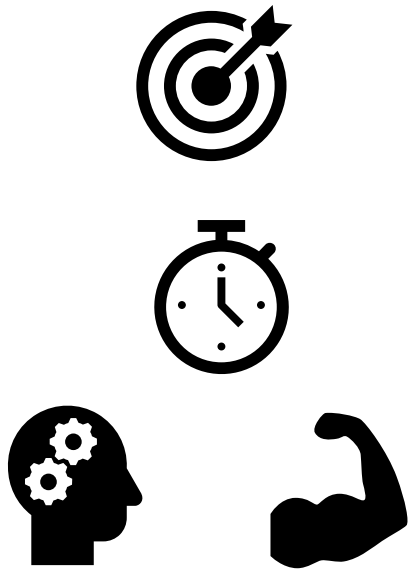
- Solo Tasks



Specifying Points: Measures

Dependent Variables

- Accuracy
- Speed
- Workload



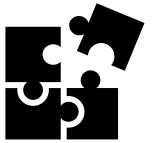
Specifying Points: Measures

Dependent Variables

- Accuracy
- Speed
- Workload

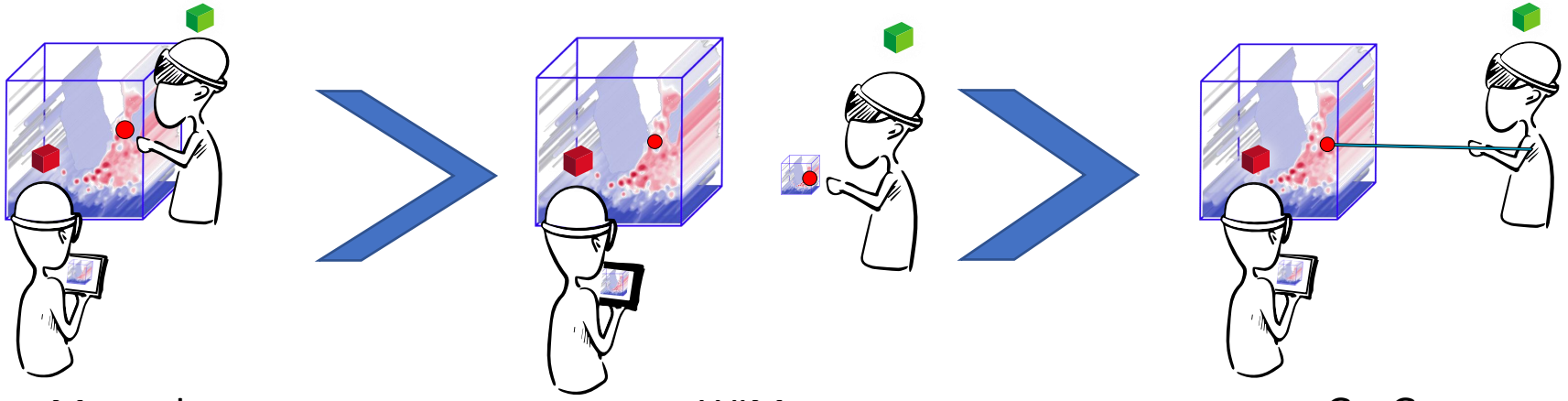


- Co-Presence
- Understanding
- Behavior


Specifying Points: Results

- 



Specifying Points: Results

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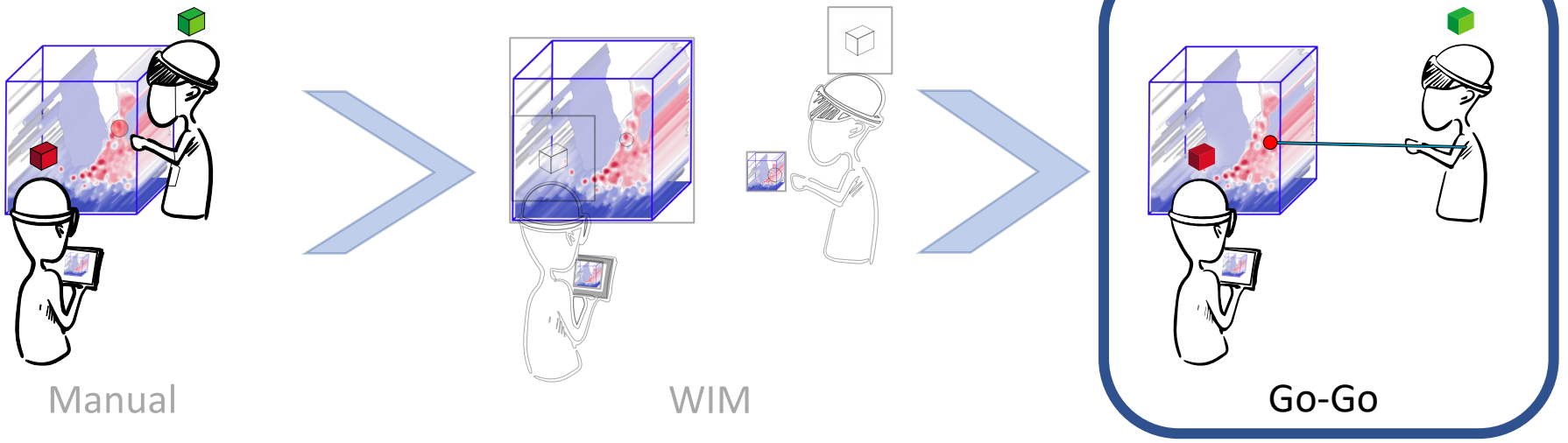

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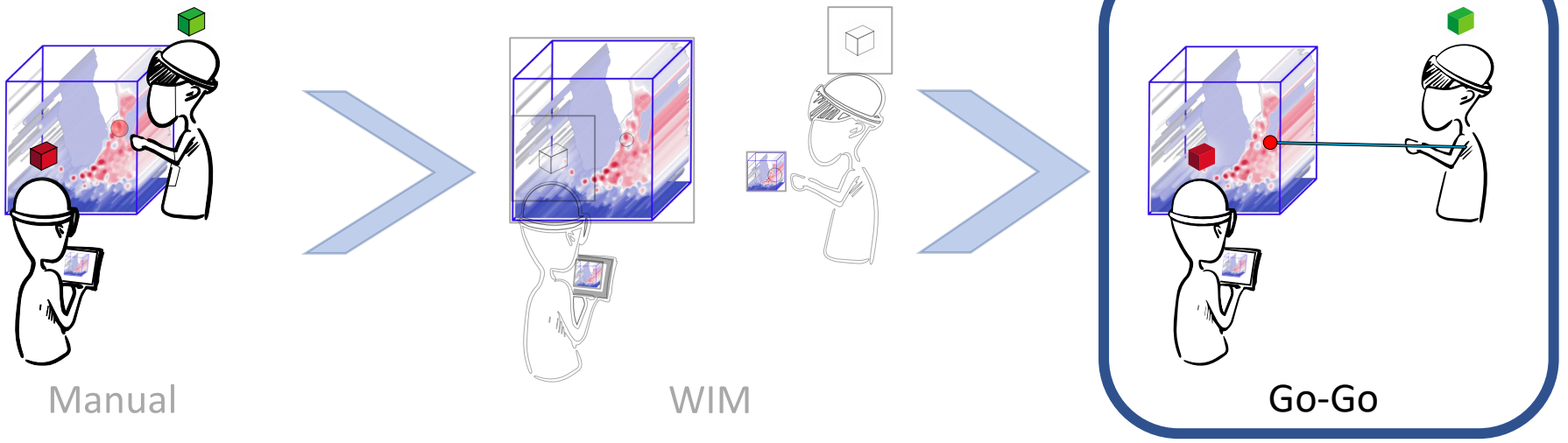
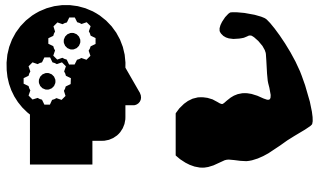
Go-Go is the slowest (solo tasks)

Specifying Points: Results

- 



-  Go-Go is the slowest (solo tasks)

-  Go-Go is the most tiring, difficult, and stressful

Specifying Points: Results

Co-Presence, Understanding, and Preference (95% Confidence Intervals).

Co-Presence.

Weak evidence that Manual feels more “together” than WIM.

Specifying Points: Results

Co-Presence, Understanding, and Preference (95% Confidence Intervals).

Co-Presence.
Weak evidence that Manual feels more “together” than WIM.

Message Understanding.
Weak evidence that Manual is more understandable than Go-Go.

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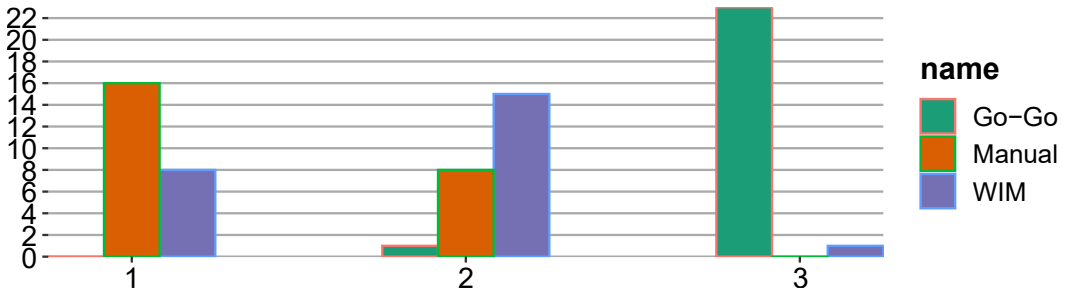
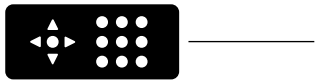


Preferences.
Manual is the most preferred, Go-Go is the least preferred.

Specifying Points: Conclusions

GO-GO

- Good Directional Cues
- Requires higher motor skills
- Depth perception issue

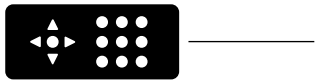


Teaching

Specifying Points: Conclusions

GO-GO

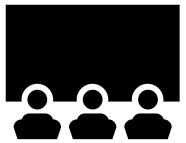
- Good Directional Cues
- Requires higher motor skills
- Depth perception issue



Teaching

Manual

- Most preferred
- But tracking conflict



Together

One-User

Specifying Points: Conclusions

GO-GO

- Good Directional Cues
- Requires higher motor skills
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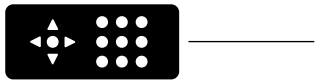

Teaching

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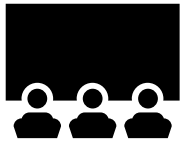
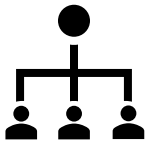


Together

One-User

WIM

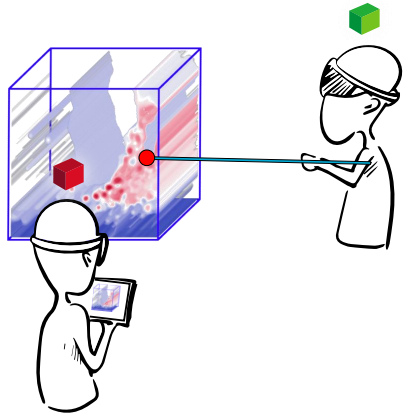
- Two “references” → confusion
  - Able to guide from Main Window



Parallel Work

Next Project:

Specifying Points → Specifying Regions

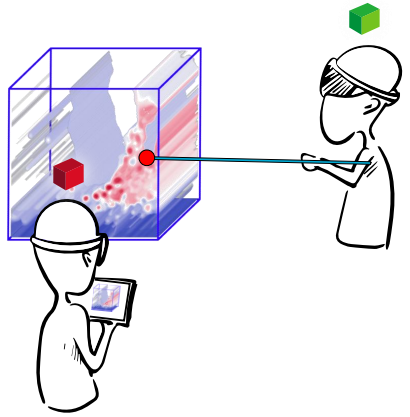


Points: -Extensive literature in VR
-“Simple”

N users

Next Project:

Specifying Points → Specifying Regions



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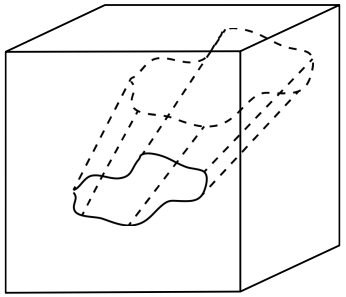
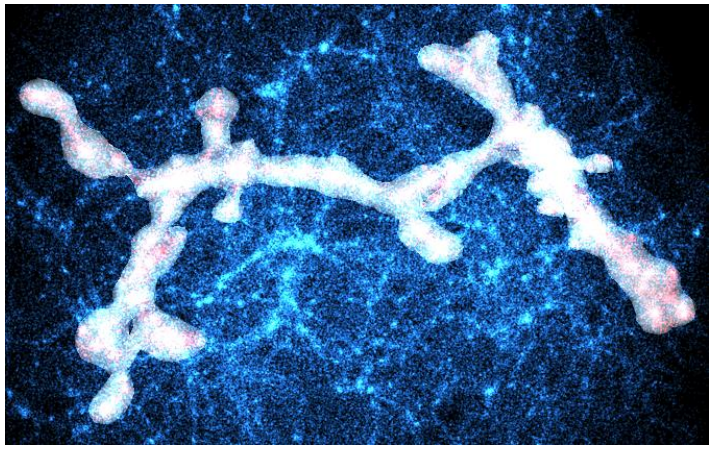


Regions: -Less studied
-“Complex”

One user

Specifying Regions
A general technique

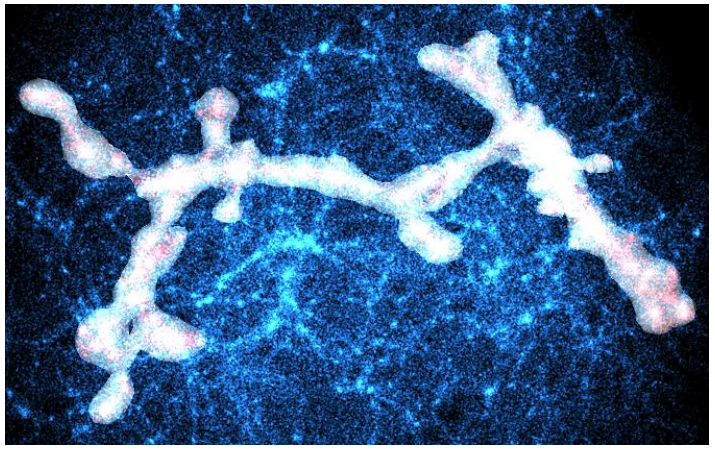
Cloud points



Yu et al., "**CAST: Effective and efficient user interaction for context-aware selection in 3D particle clouds**," 2016

Specifying Regions
A general technique

Cloud points



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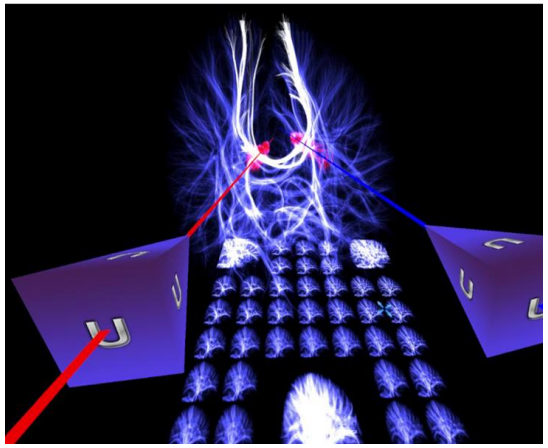
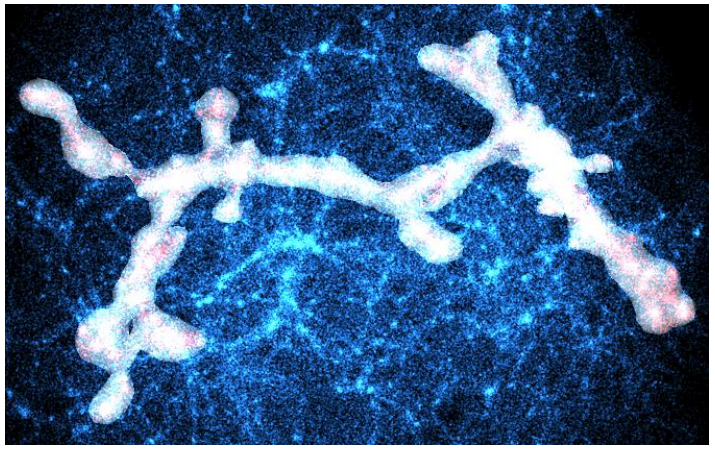
Paths



Hurter et al., "**FiberClay: Sculpting three dimensional trajectories to reveal structural insights**," 2019

Specifying Regions
A general technique

Cloud points



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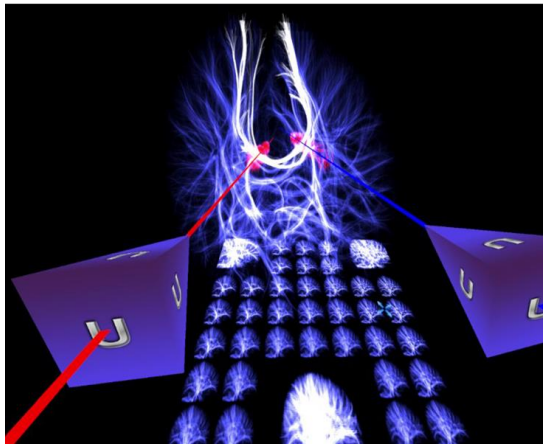

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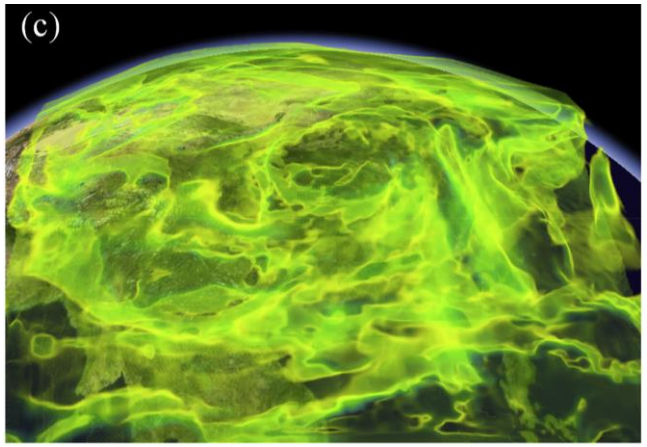
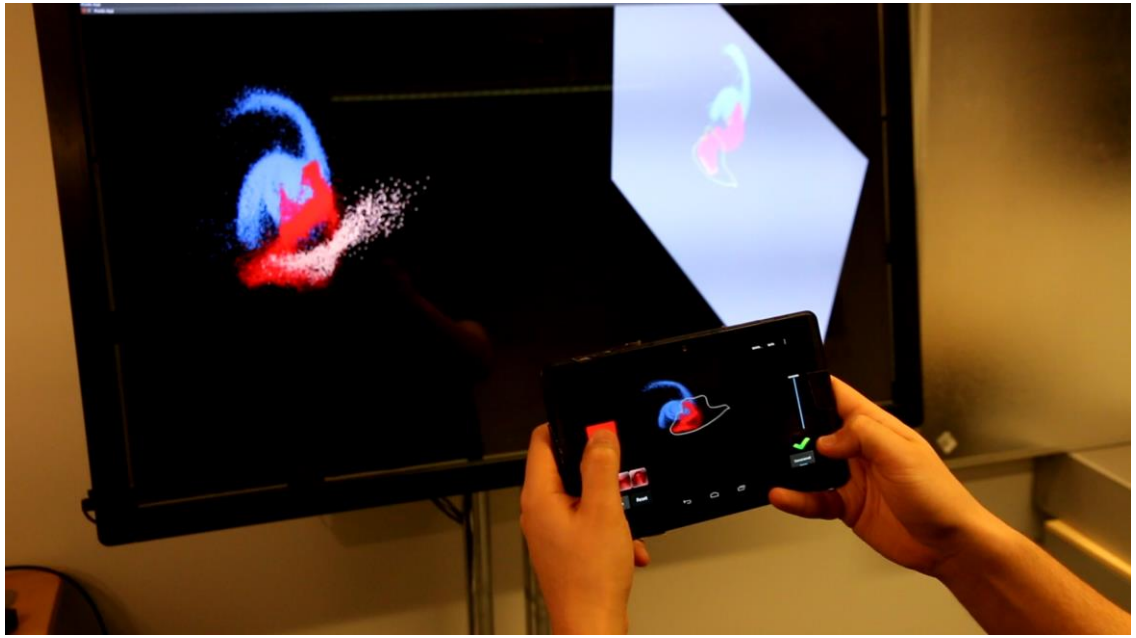
Scalar field



Zhang et al., "**An efficient dynamic volume rendering for large-scale meteorological data in a virtual globe**," 2019

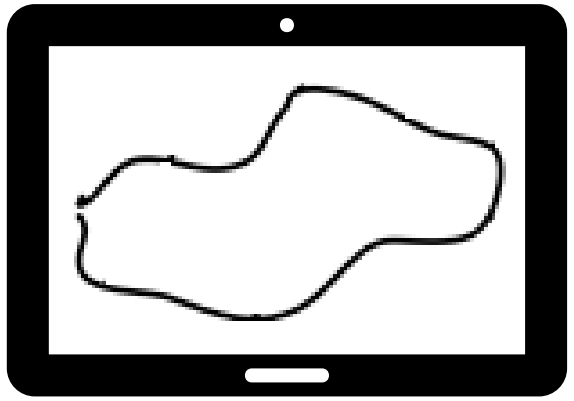
The Original Tangible Brush (2019)

Back in Time…. **Tangible Brush**

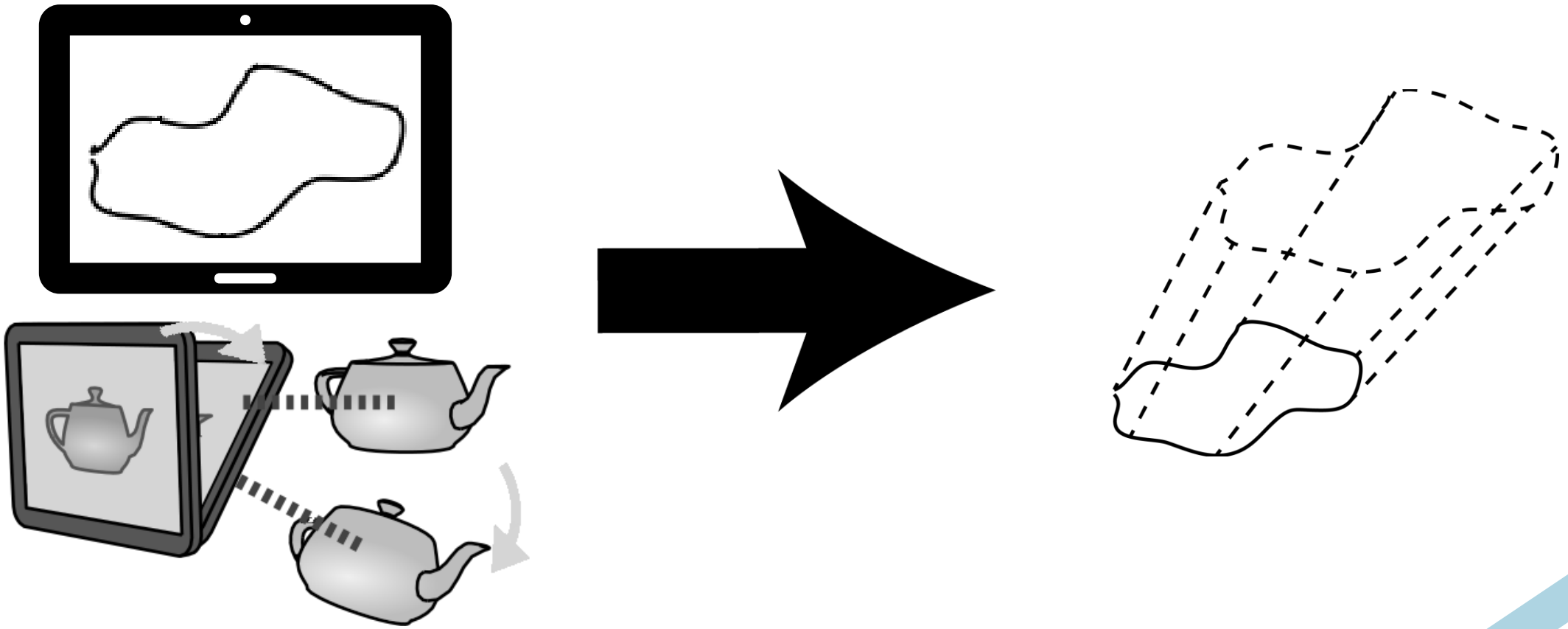


L. Besançon, **Mickael Sereno**, M. Ammi, L. Yu, T. Isenberg, ‘‘**Hybrid Touch/Tangible Spatial 3D Data Selection’’**, 2019

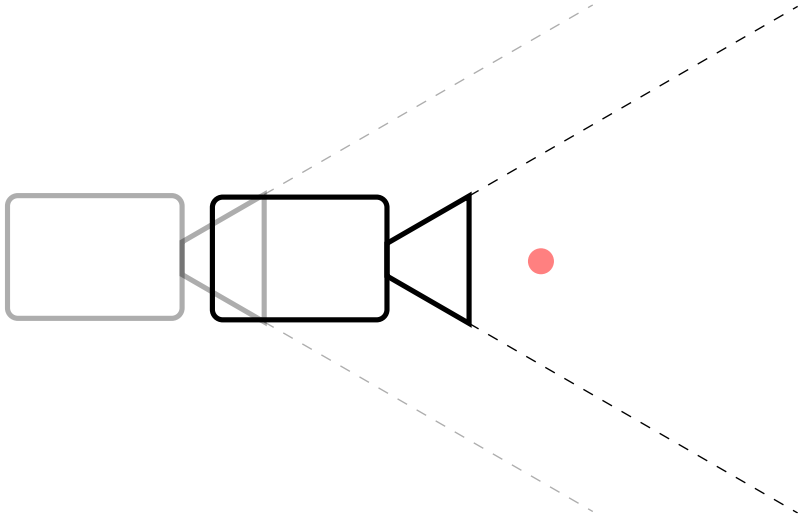
Tangible Brush, Principles



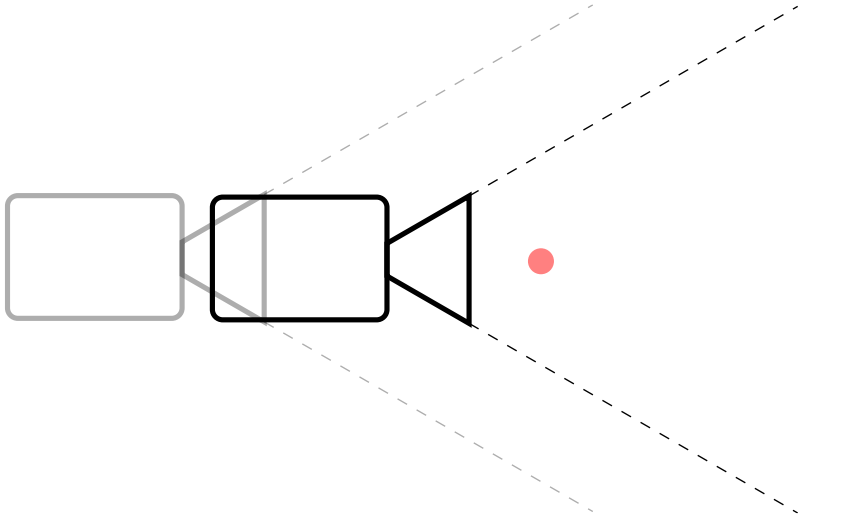
Tangible Brush, Principles



Tangible Brush, **Perspective** vs. Orthographic



Tangible Brush, **Perspective** vs. Orthographic 



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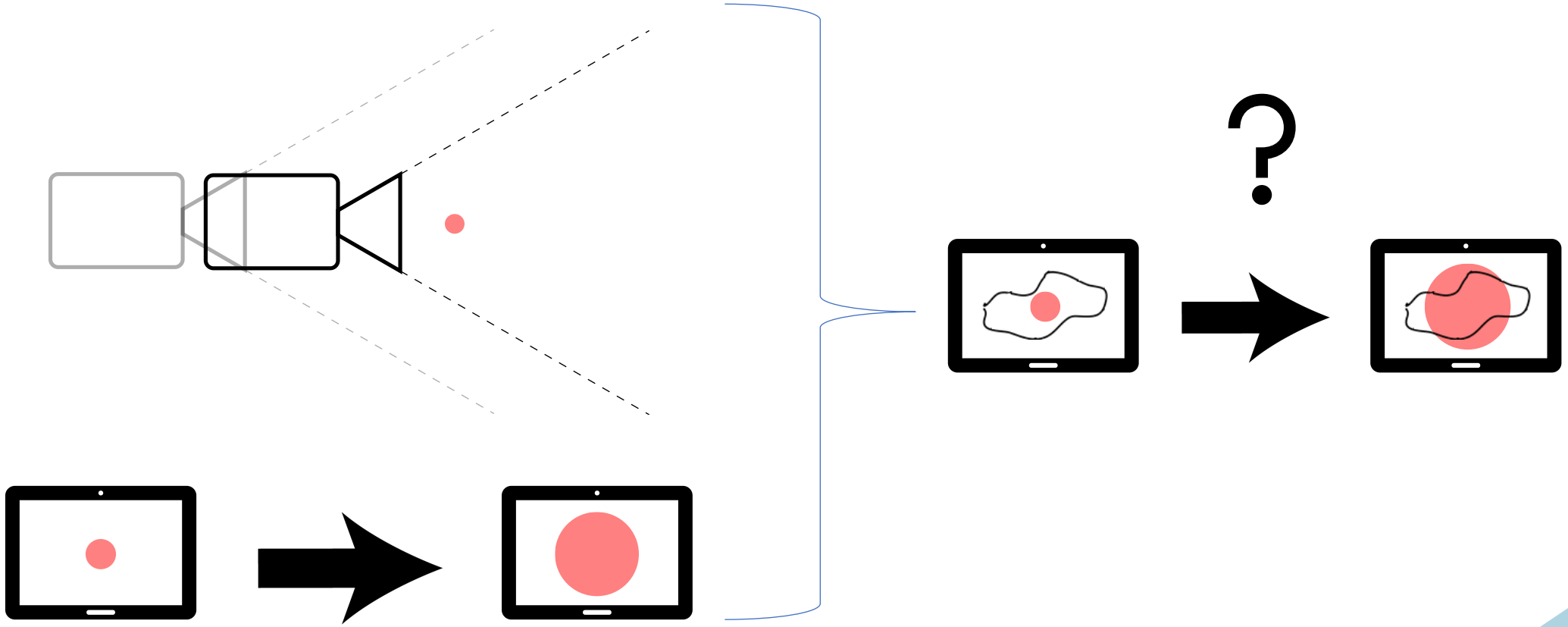
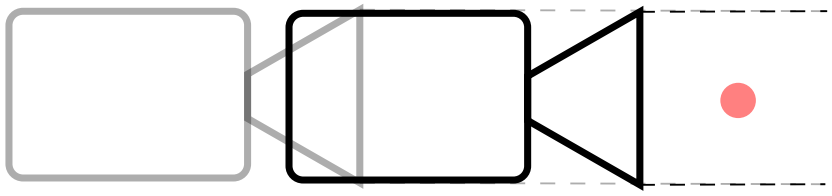


Tangible Brush, Perspective vs. **Orthographic**



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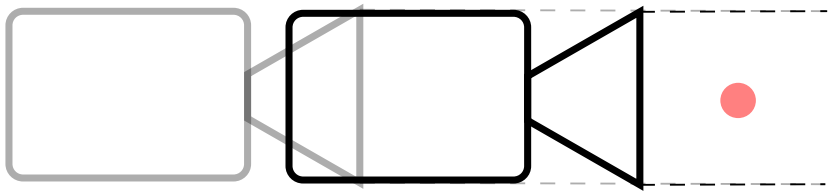

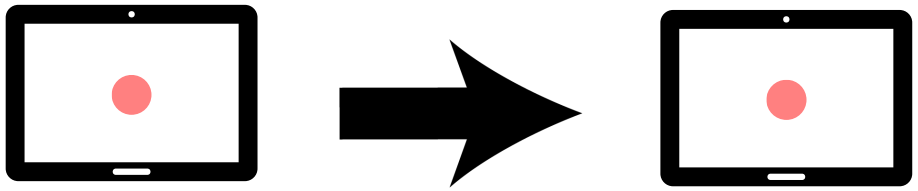

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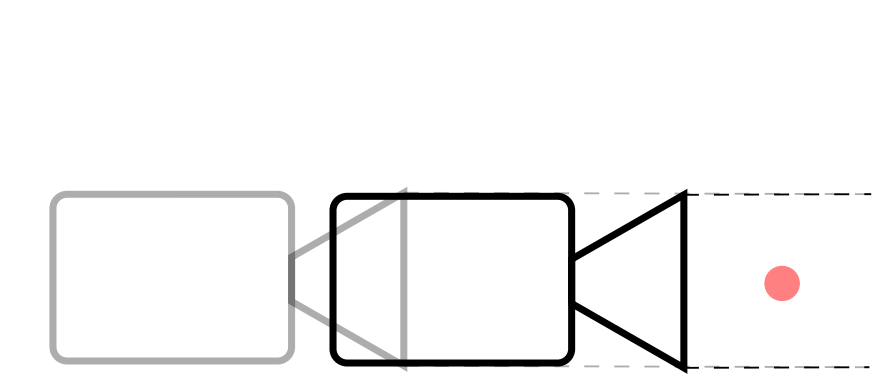
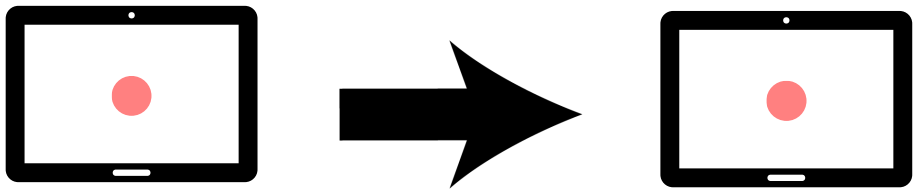
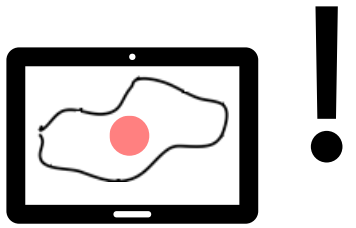
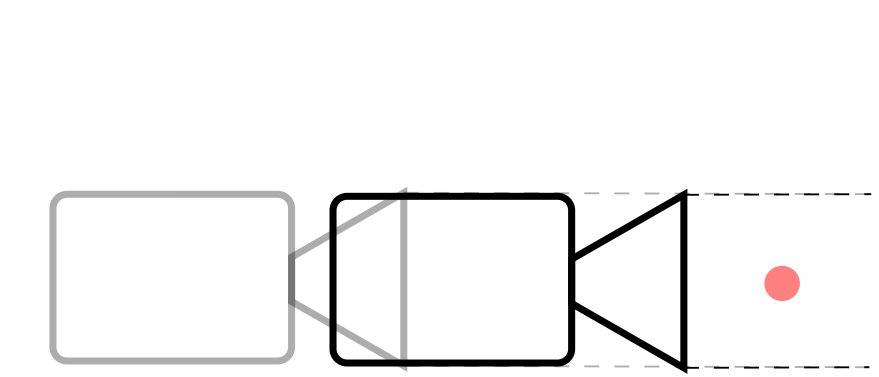
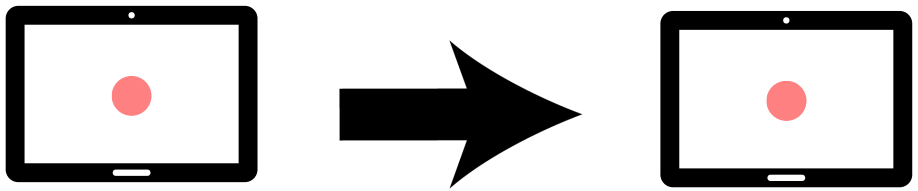


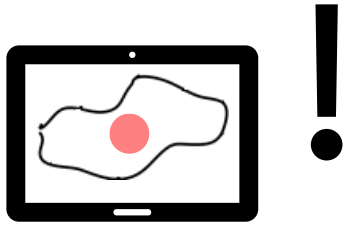




Tangible Brush, Perspective vs. **Orthographic**

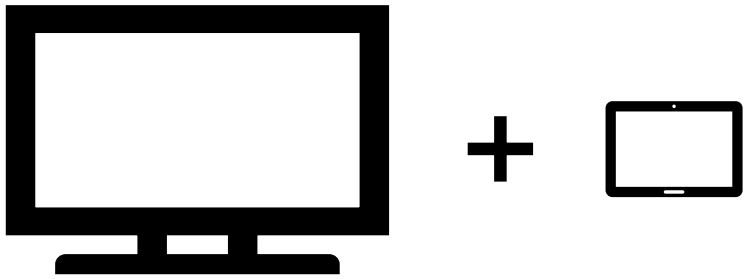






3D

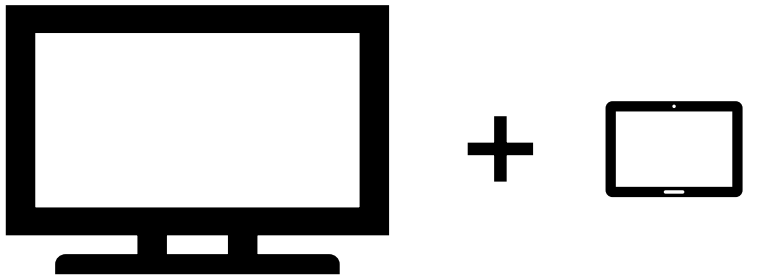
Tangible Brush, Two Screens



Perspective

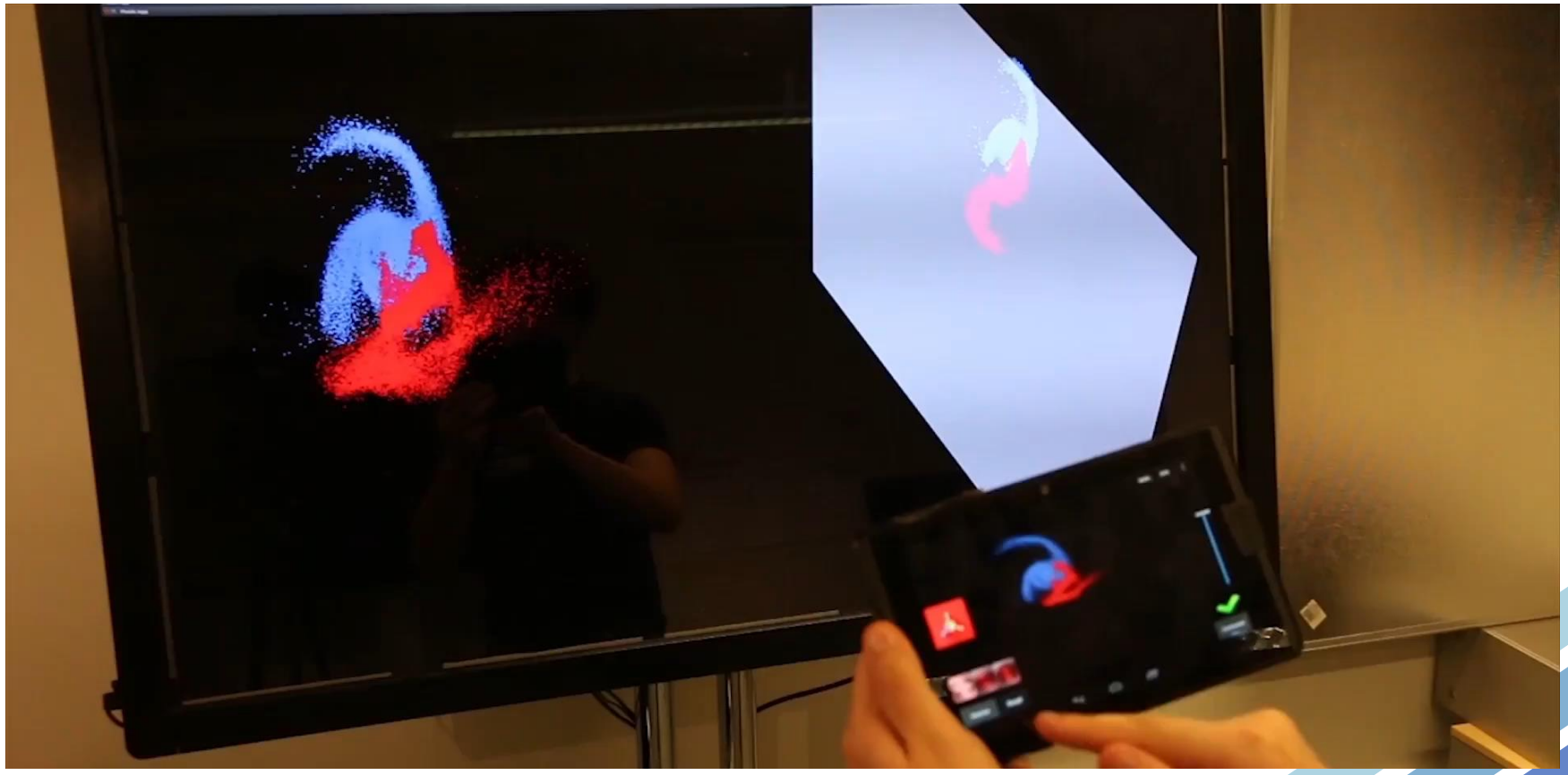
Orthographics

Tangible Brush, Two Screens



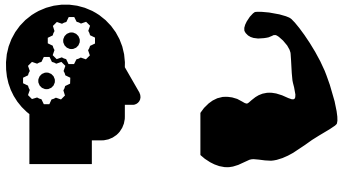
Perspective

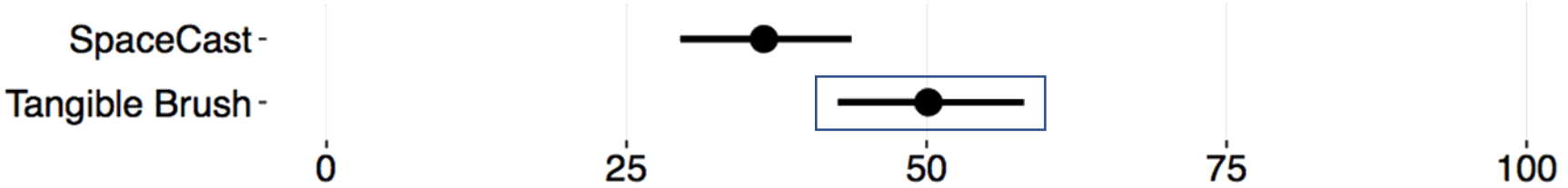
Orthographics



Tangible Brush, **Accurate BUT Mentally Demanding**

MCC score. **Tangible Brush more accurate**

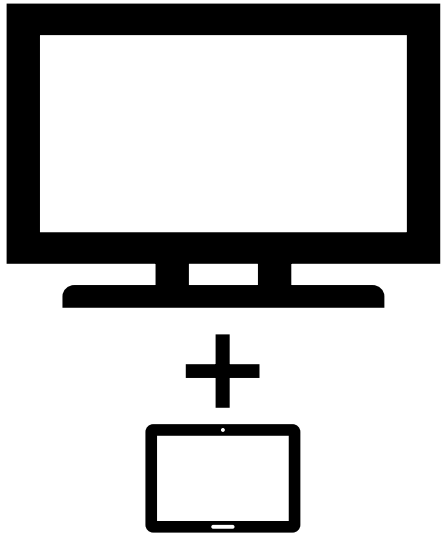




Total Workload. **Tangible Brush more demanding**

Specifying Regions – From 2D to 3D

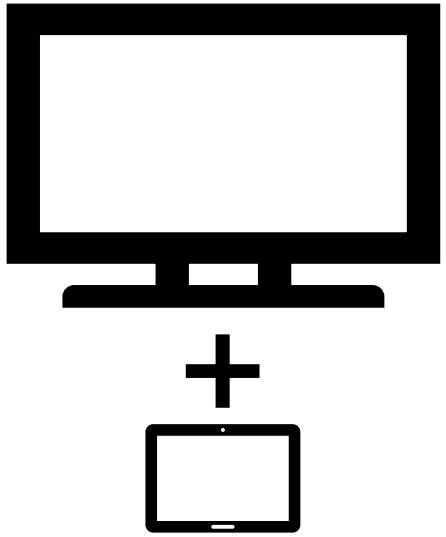
***Mickaël Sereno**, S. Gosset, L. Besançon, T. Isenberg*



Decoupled

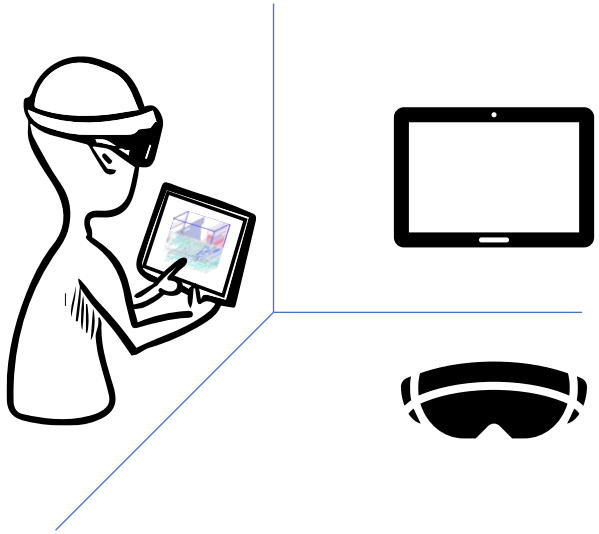
Specifying Regions – From 2D to 3D

Mickaël Sereno, S. Gosset, L. Besançon, T. Isenberg



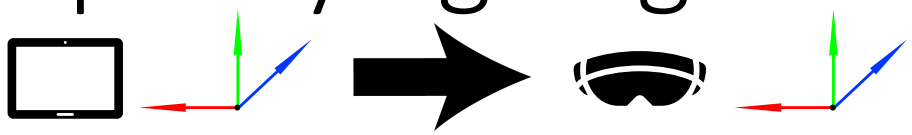
Decoupled

Stéphane Gosset, Intern

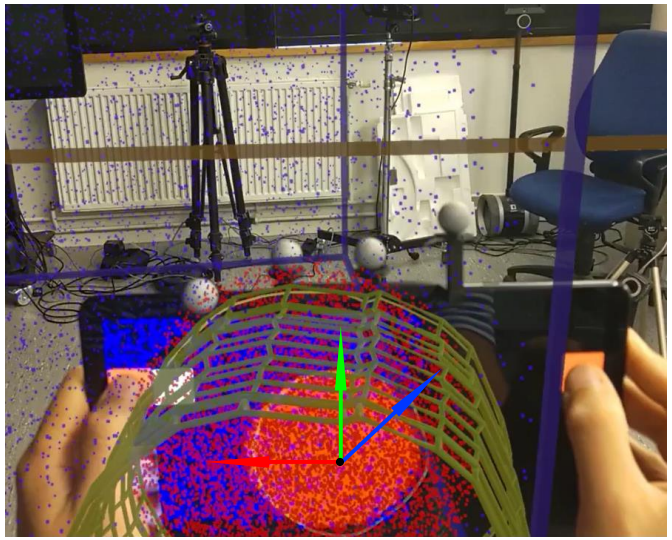


Coupled

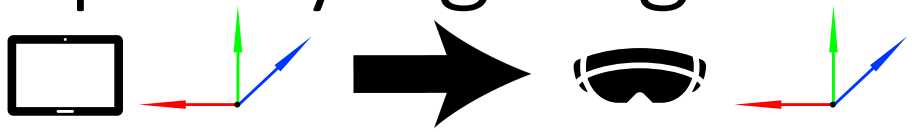
Specifying Regions – Mappings



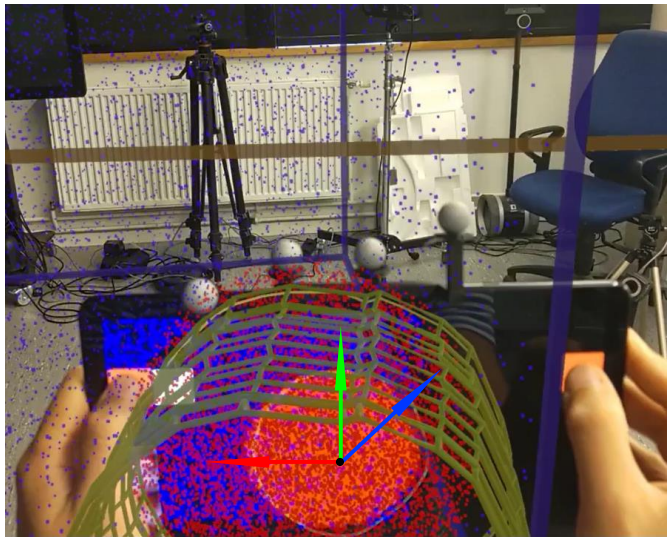
Naïve Approach



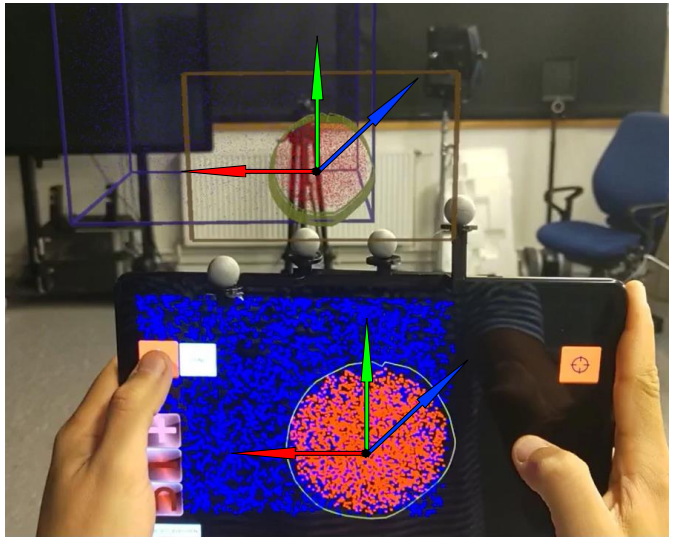
Specifying Regions – Mappings



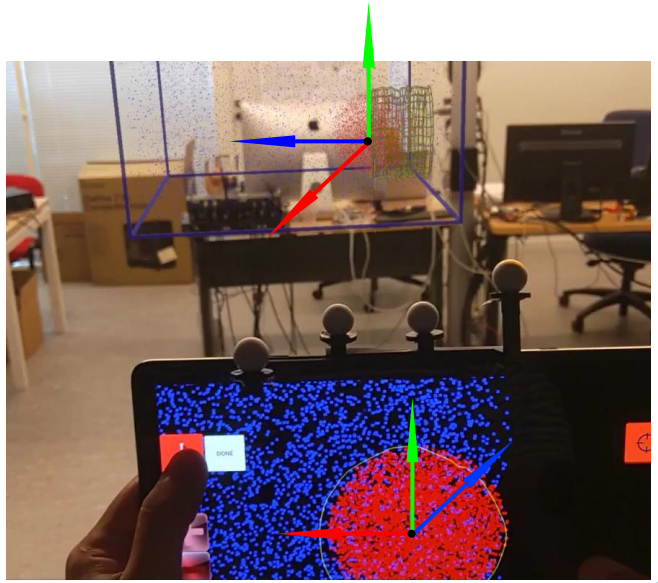
Naïve Approach



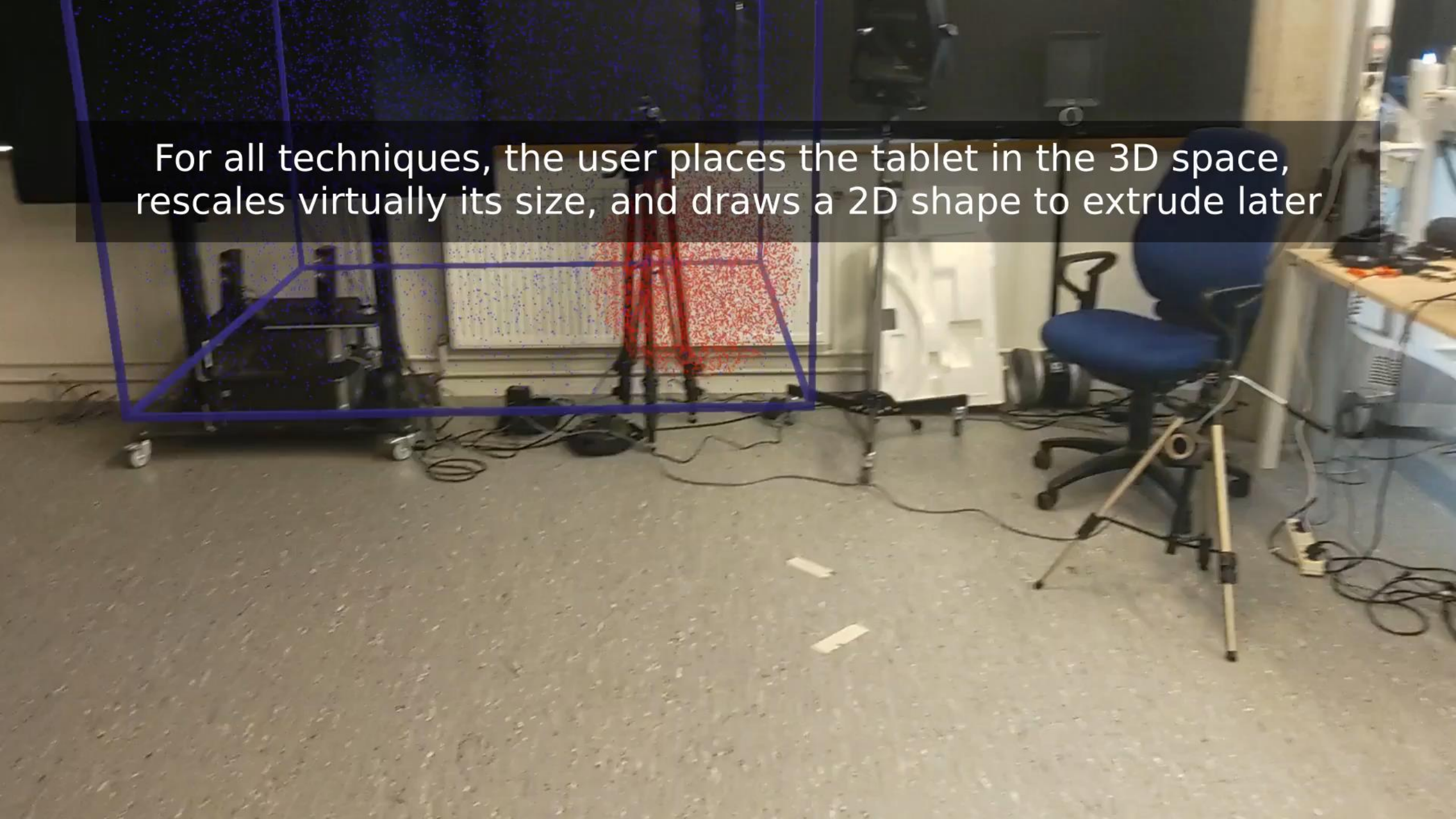
Relative-Aligned



Relative-Full

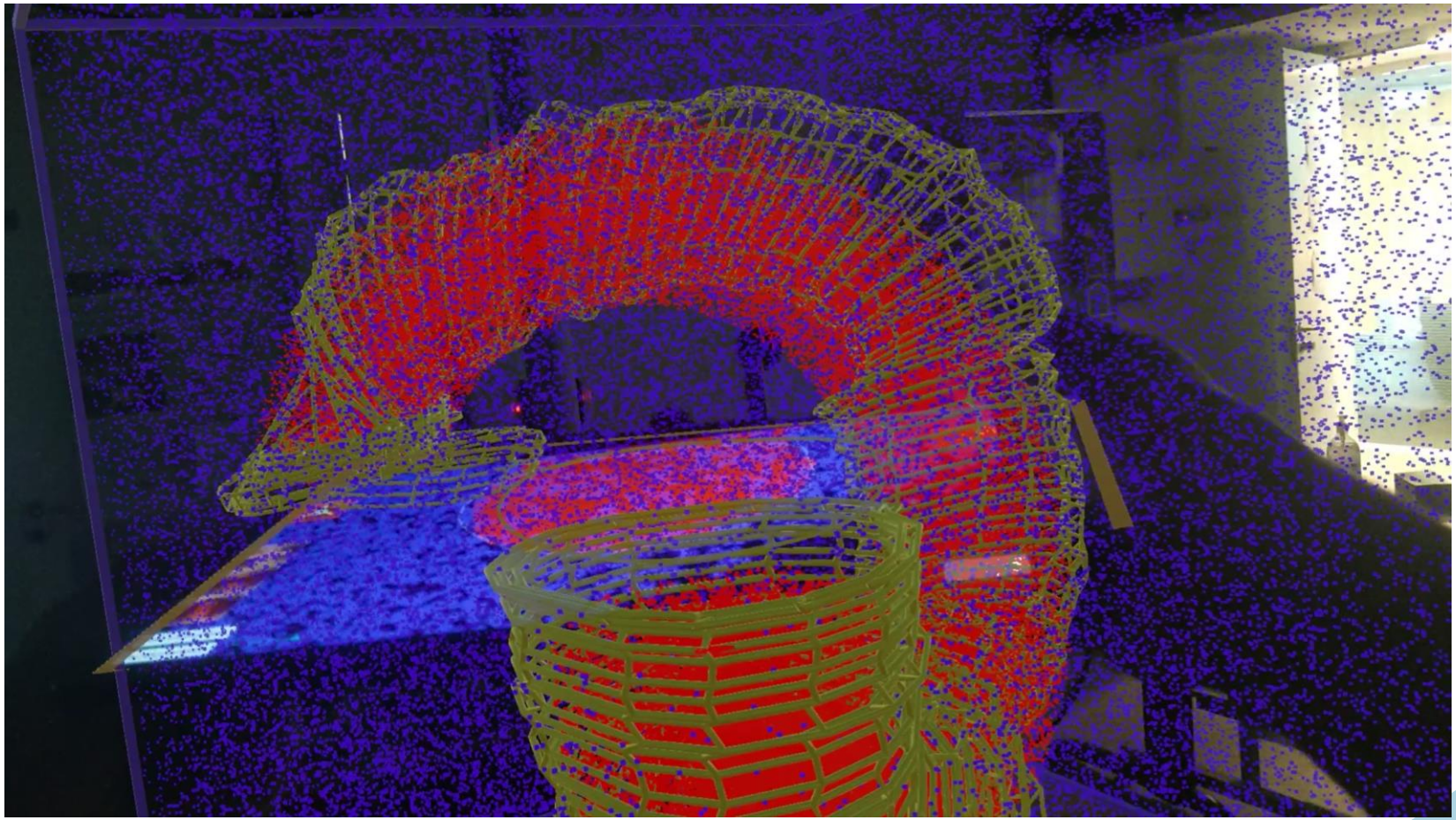


Relative Mappings

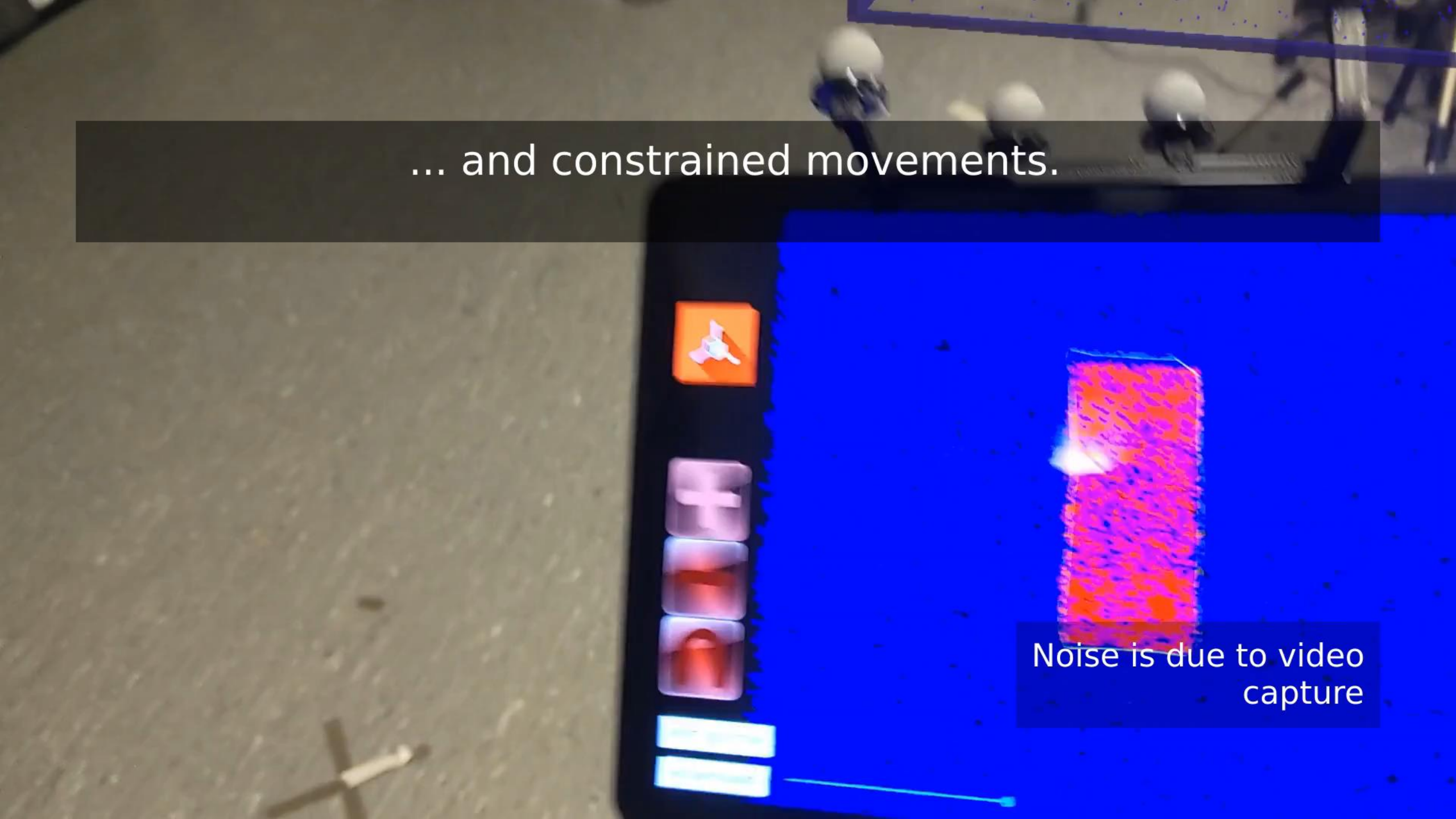

For all techniques, the user places the tablet in the 3D space,
rescales virtually its size, and draws a 2D shape to extrude later


Users can use unconstrained movements…

Specifying Regions – Unconstrained



... and constrained movements.

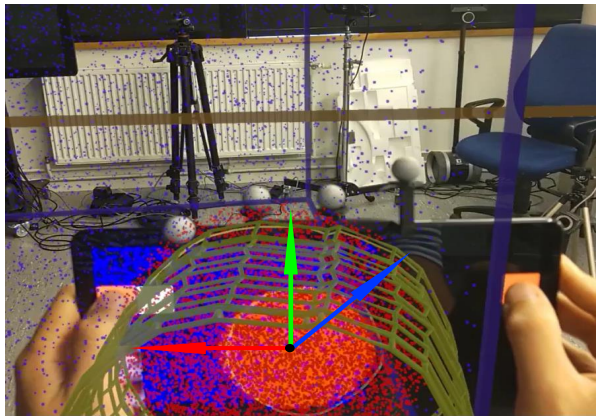


Noise is due to video capture

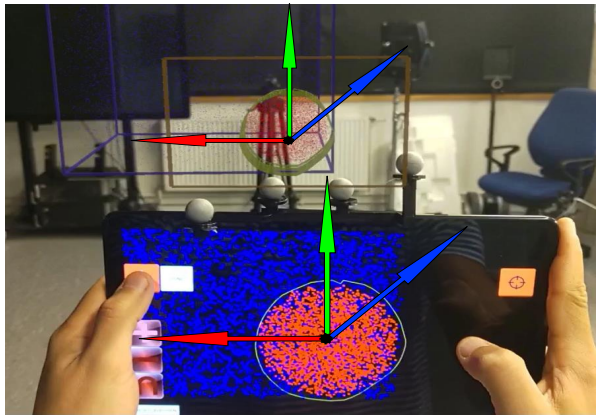
Specifying Regions – User Study

3 mappings

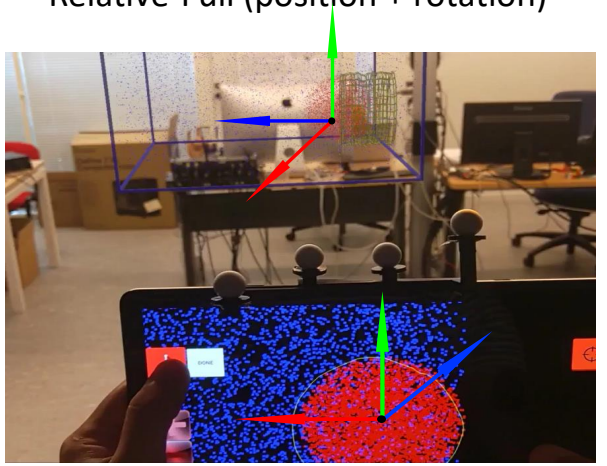
Naïve Approach



Relative-Aligned (position)

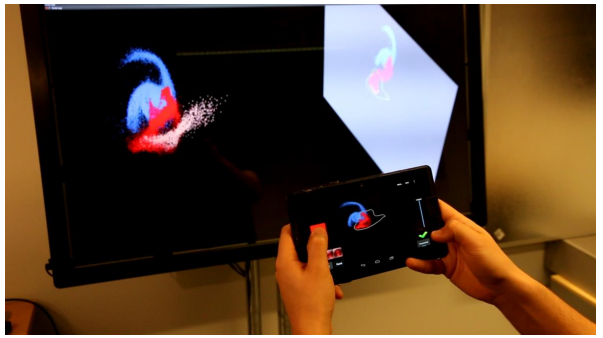


Relative-Full (position + rotation)

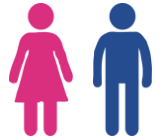


Relative Mappings

1 mapping



Specifying Regions – Two User Experiments

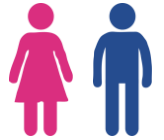


2 X 18

Within-Subject. Select Red, do not select Blue

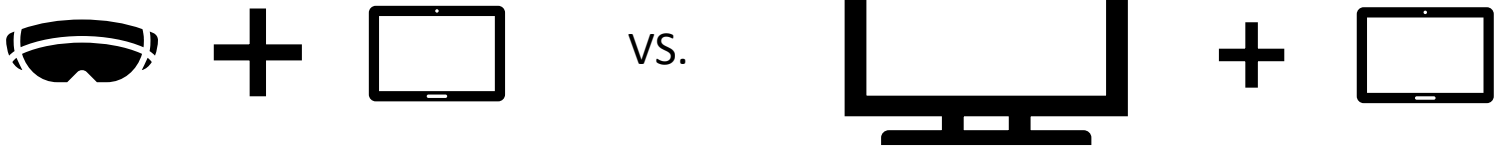
- AR alone

Specifying Regions – Two User Experiments

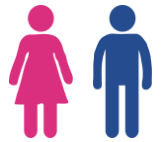


2 X 18

Within-Subject. Select Red, do not select Blue

- AR alone 
- “Best” AR vs. 2D 

Specifying Regions – Two User Experiments

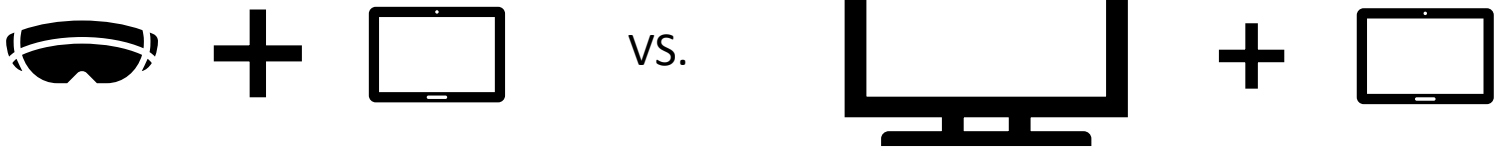


2 X 18

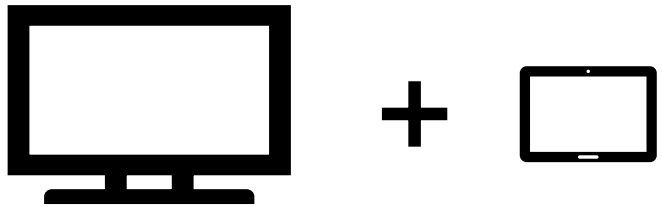
Within-Subject. Select Red, do not select Blue

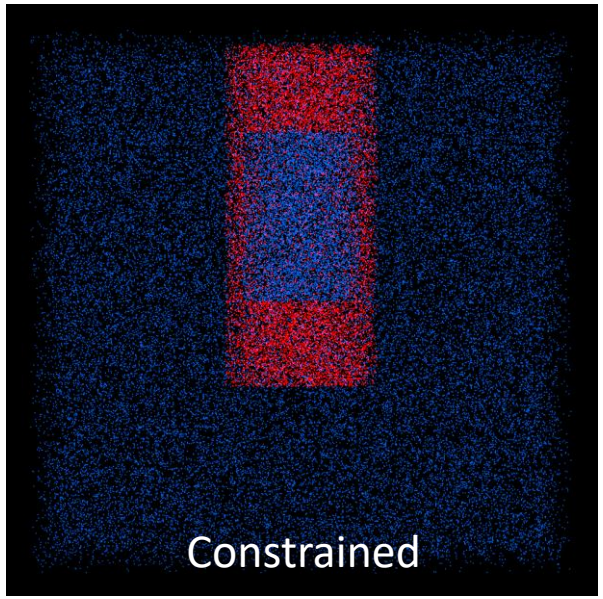
- AR alone

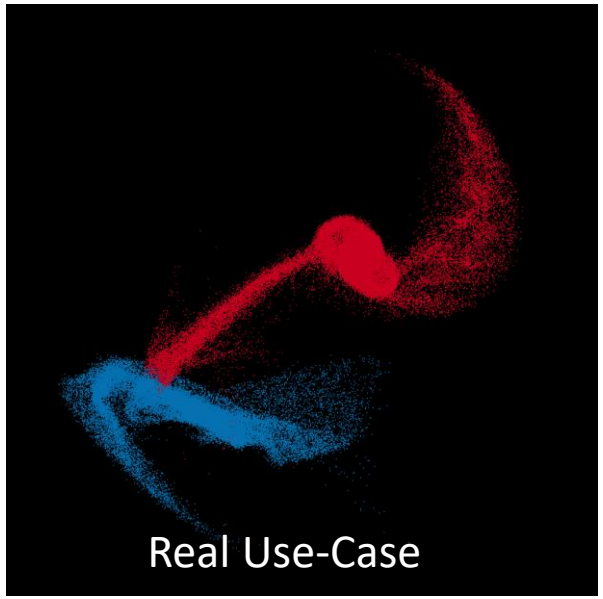
- “Best” AR vs. 2D

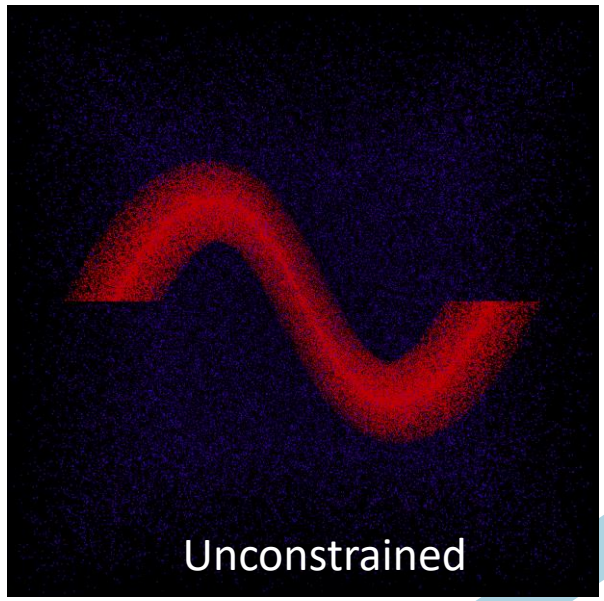


VS.







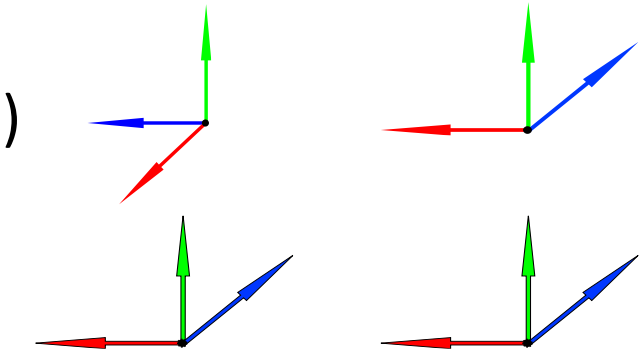


Specifying Regions – Experiment (AR)

- Relative-Full: most accurate (But small size-effect)

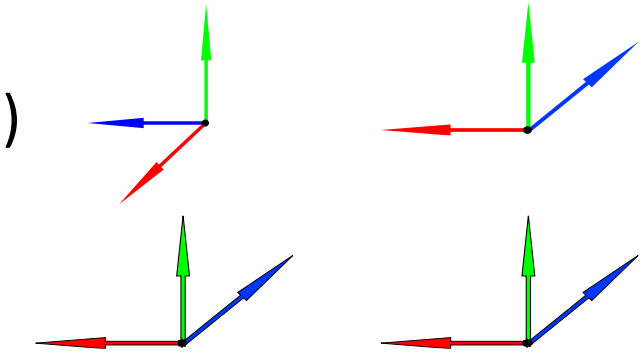
Specifying Regions – Experiment (AR)

- Relative-Full: most accurate (But small size-effect)
- Relative-Aligned: required lowest effort



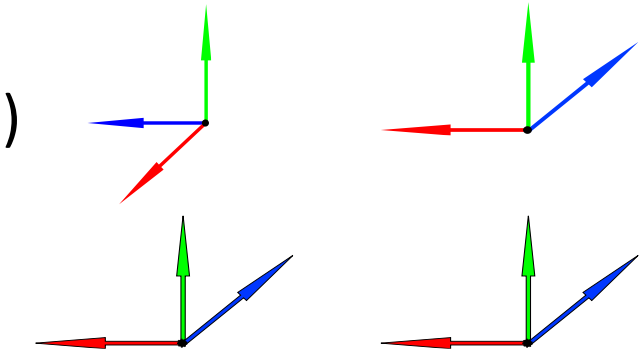
Specifying Regions – Experiment (AR)

- Relative-Full: most accurate (But small size-effect)
- Relative-Aligned: required lowest effort
- Relative-Aligned: Preferred

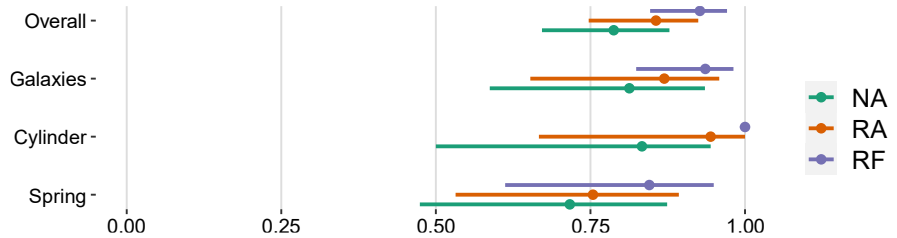


Specifying Regions – Experiment (AR)

- Relative-Full: most accurate (But small size-effect)
- Relative-Aligned: required lowest effort
- Relative-Aligned: Preferred
- Main Focus:



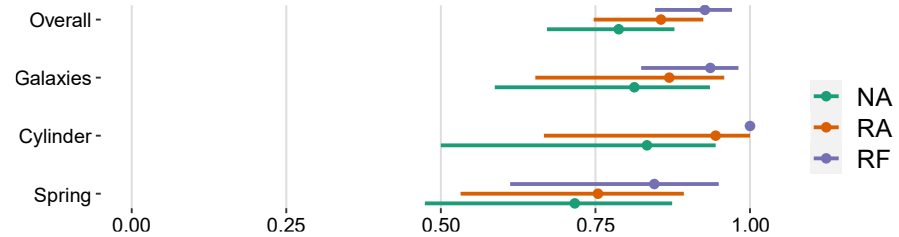
Specifying Regions – Experiment (AR)



Constraint/Total operations.

RF calls for more constrained movements (pair-wise analysis).

Specifying Regions – Experiment (AR)



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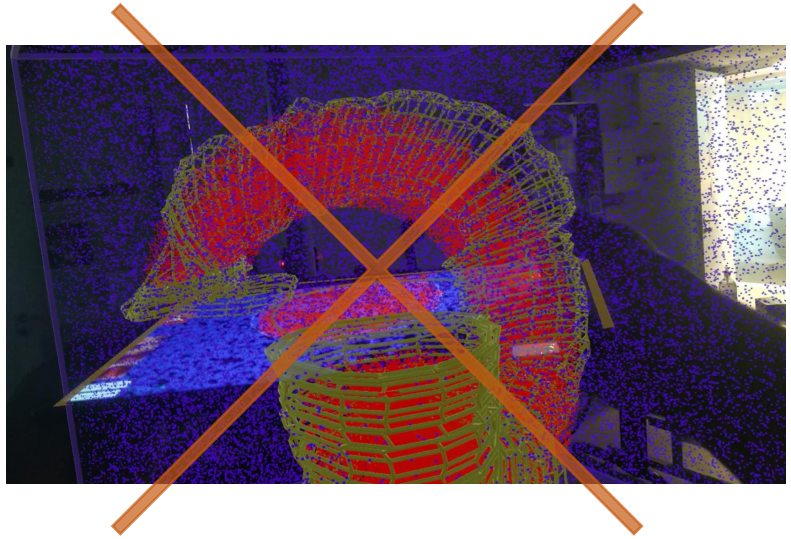
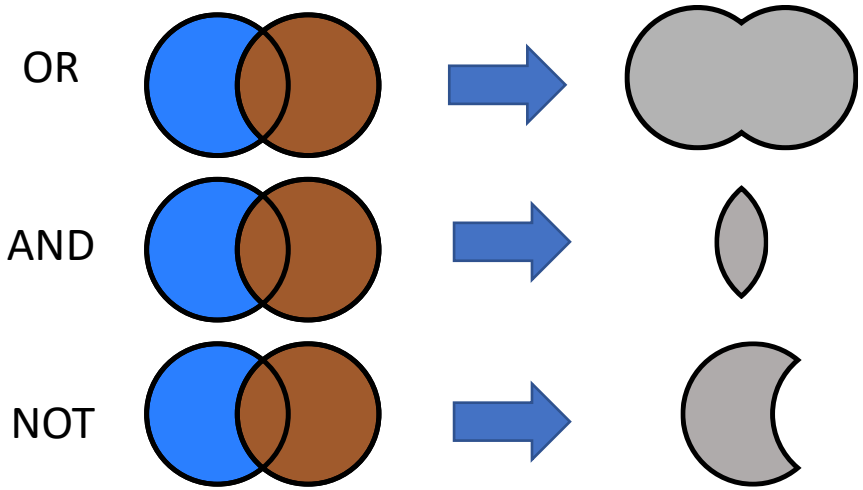
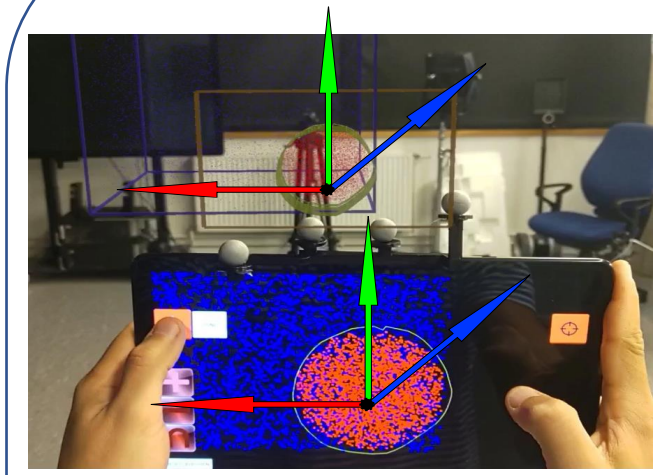


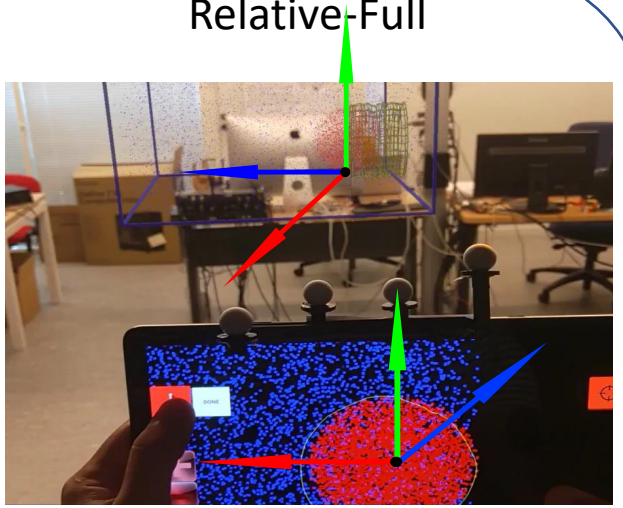


Specifying Regions – AR – Overall

Relative-Aligned

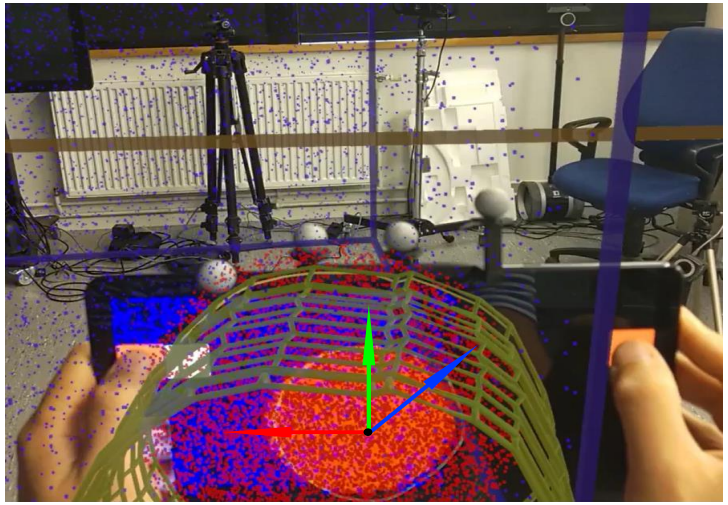


Relative-Full



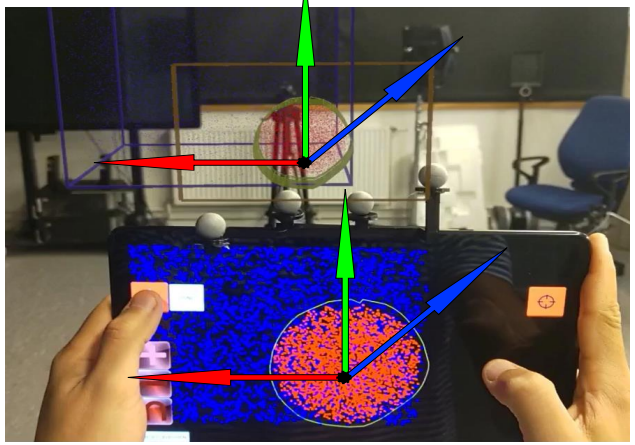
Relative Mappings

Naïve Approach

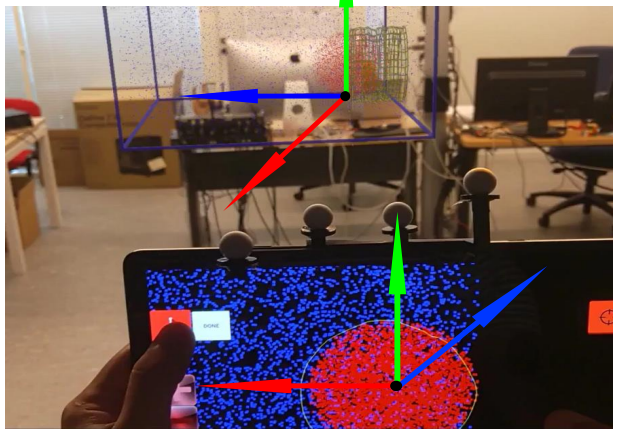


Specifying Regions – AR – Overall

Relative-Aligned

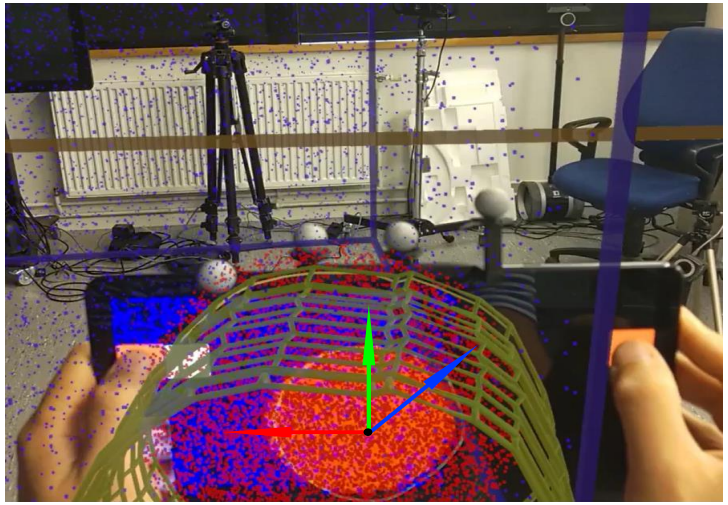


Relative-Full

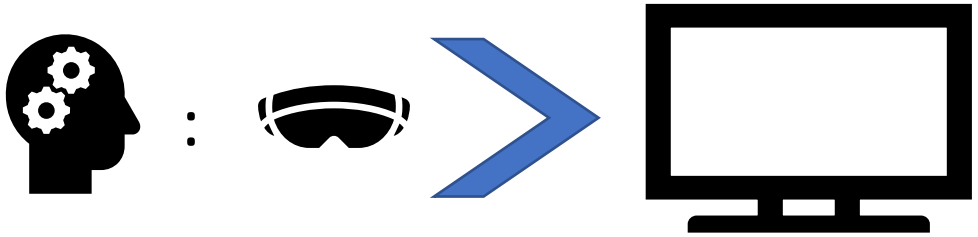


Relative Mappings

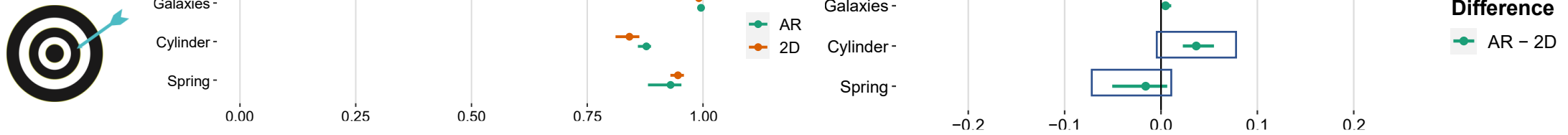
Naïve Approach



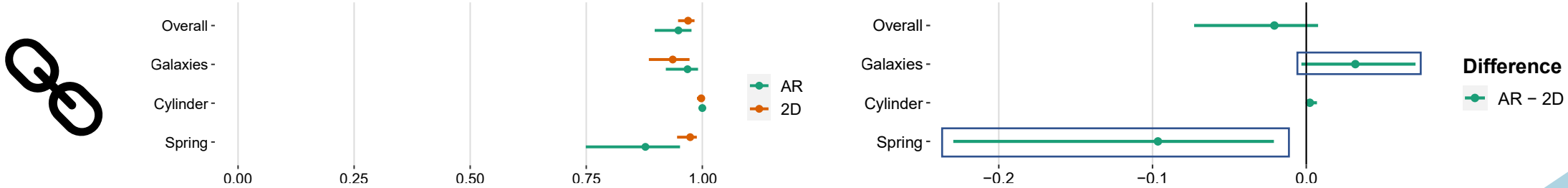
Specifying Regions – Experiment (AR vs. 2D)

-  : Similar
- 

Specifying Regions – Experiment (AR vs. 2D)

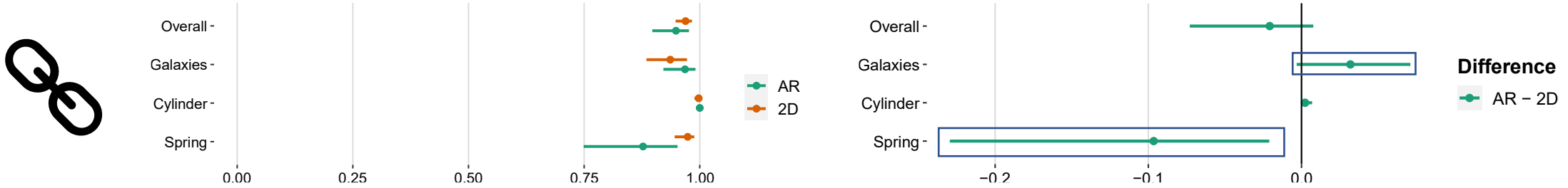


MCC score. Different results.



Constraint/Total operations.
Participants understood better the 3D visualizations in AR.

Specifying Regions – Experiment (AR vs. 2D)



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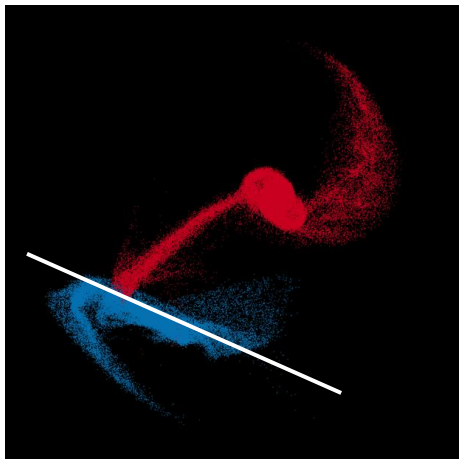
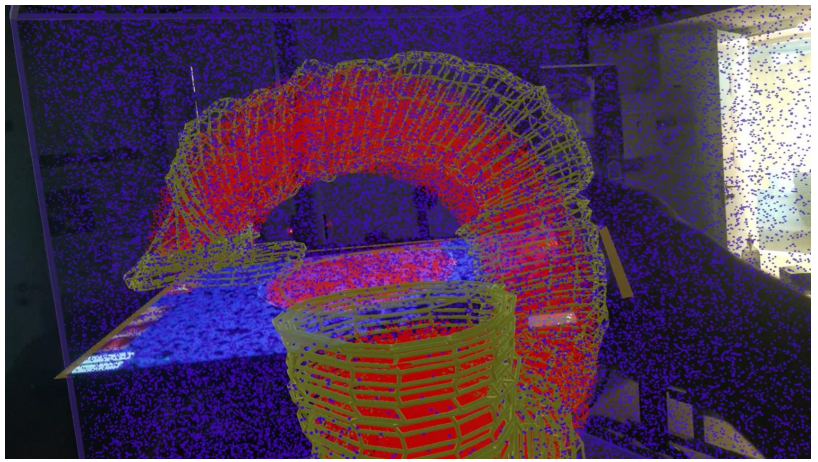
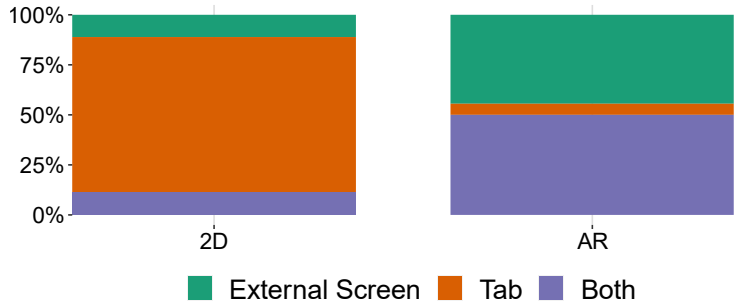




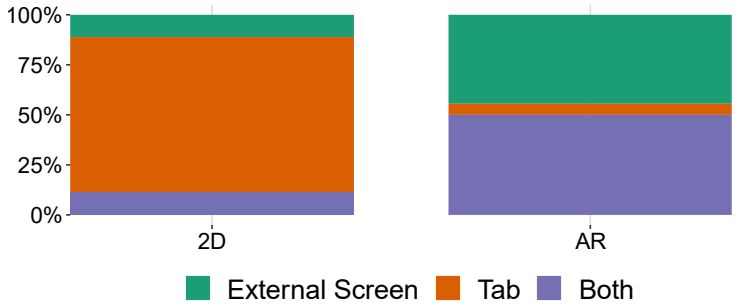
Specifying Regions – Experiment (AR vs. 2D)



Participants' focus.

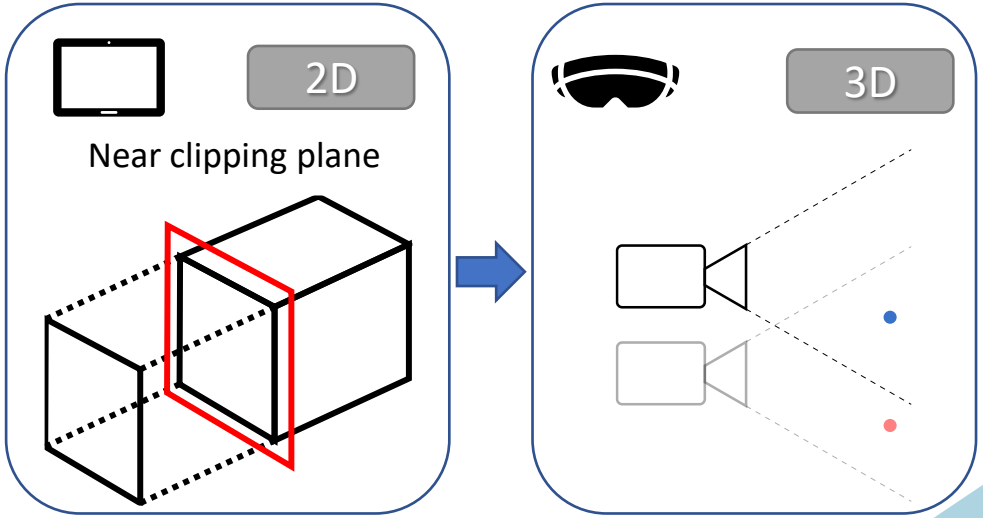
Switch from the Tablet to the AR view

Specifying Regions – Experiment (AR vs. 2D)

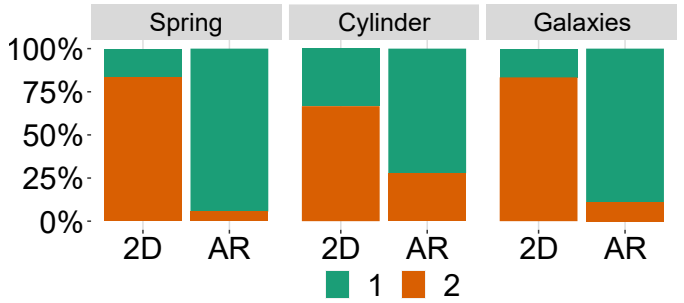


Participants' focus.

Switch from the Tablet to the AR view

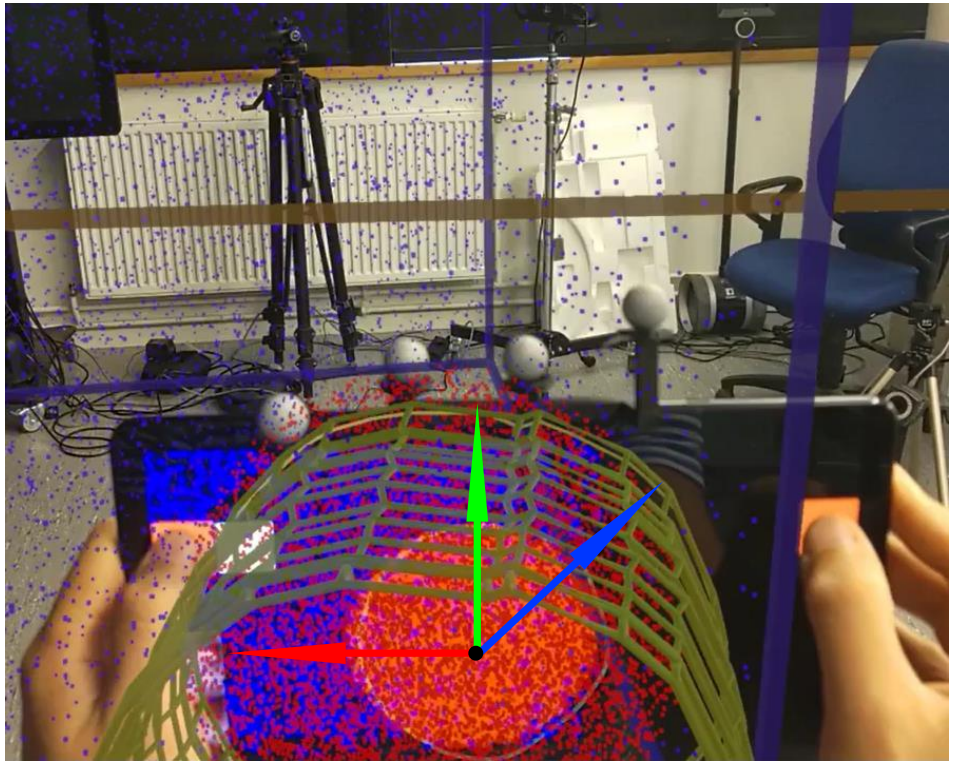


Specifying Regions – Experiment (AR vs. 2D)



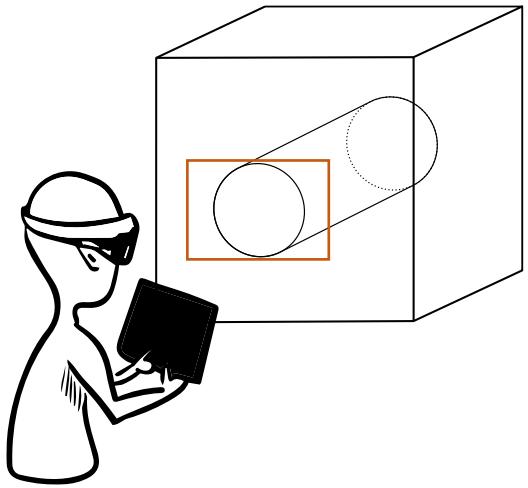
Participants' ranking. 1 is best.
Participants largely preferred AR over 2D.

Specifying Regions – Behaviors (Naïve Approach)

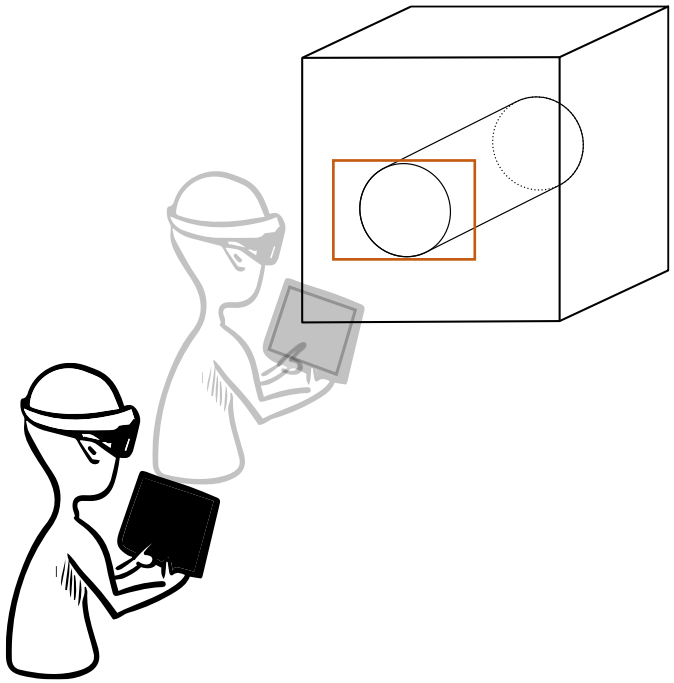


- Conflict between tablet and HMD
- Lack of Scene-overview

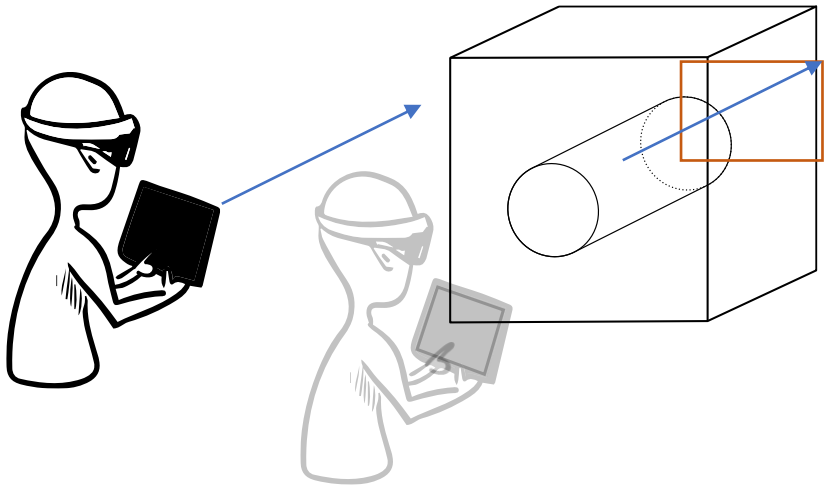
Specifying Regions – Behaviors (Relative-Aligned)



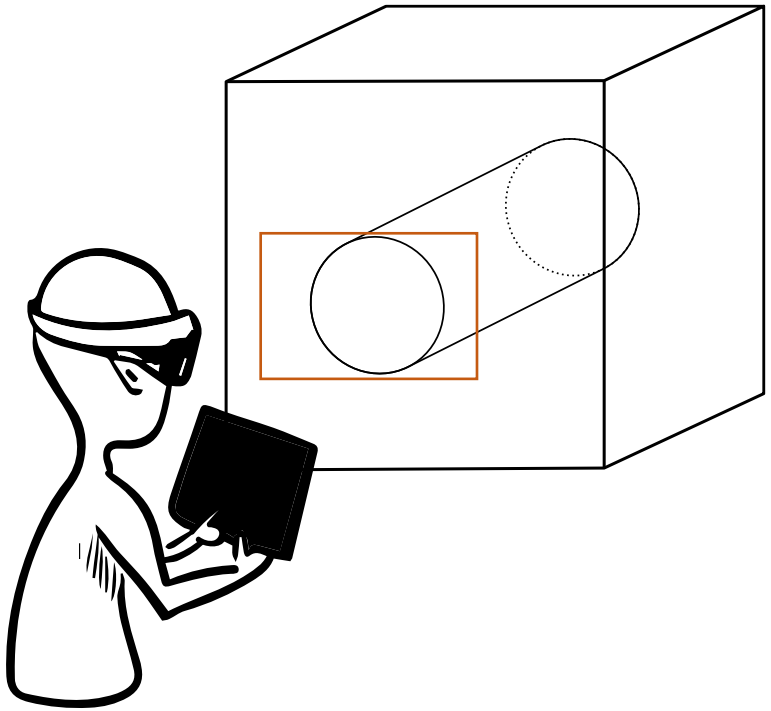
Specifying Regions – Behaviors (Relative-Aligned)

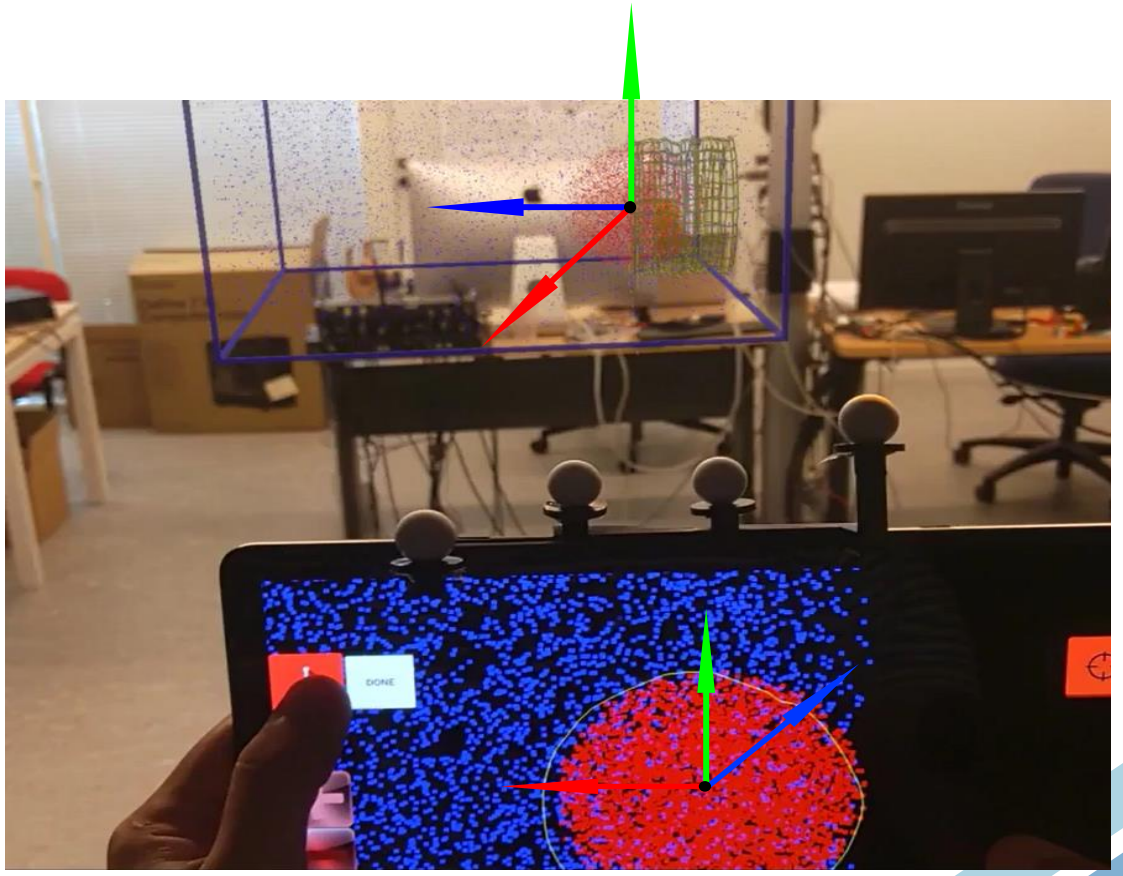


Specifying Regions – Behaviors (Relative-Aligned)

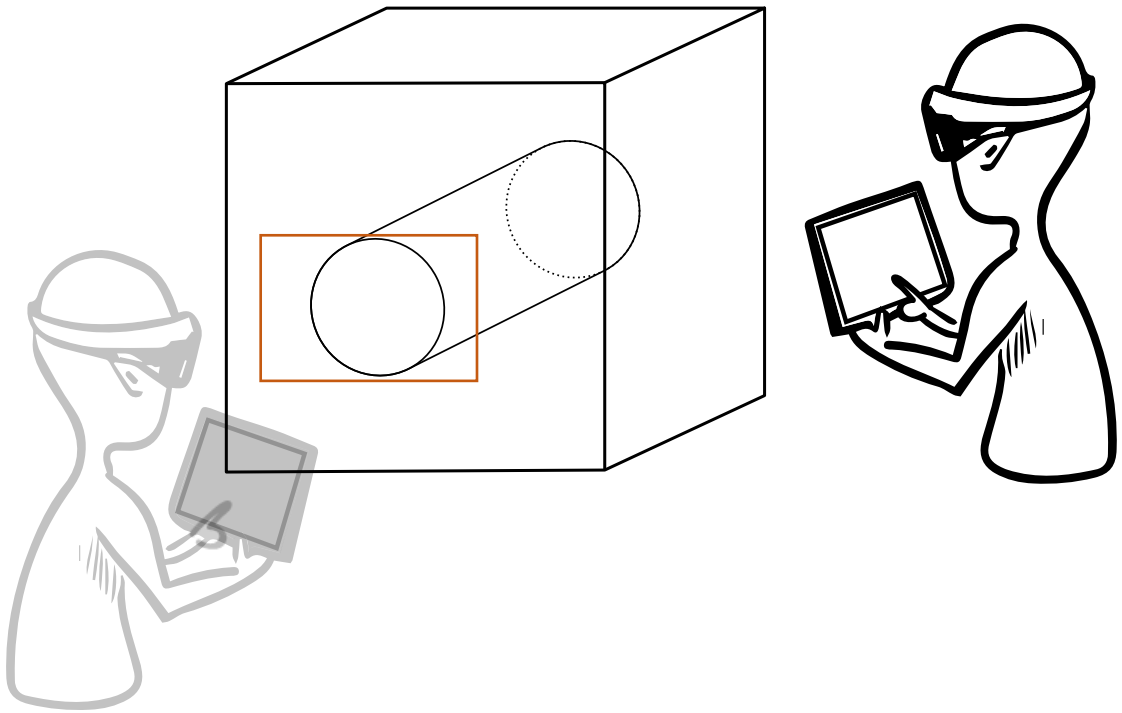


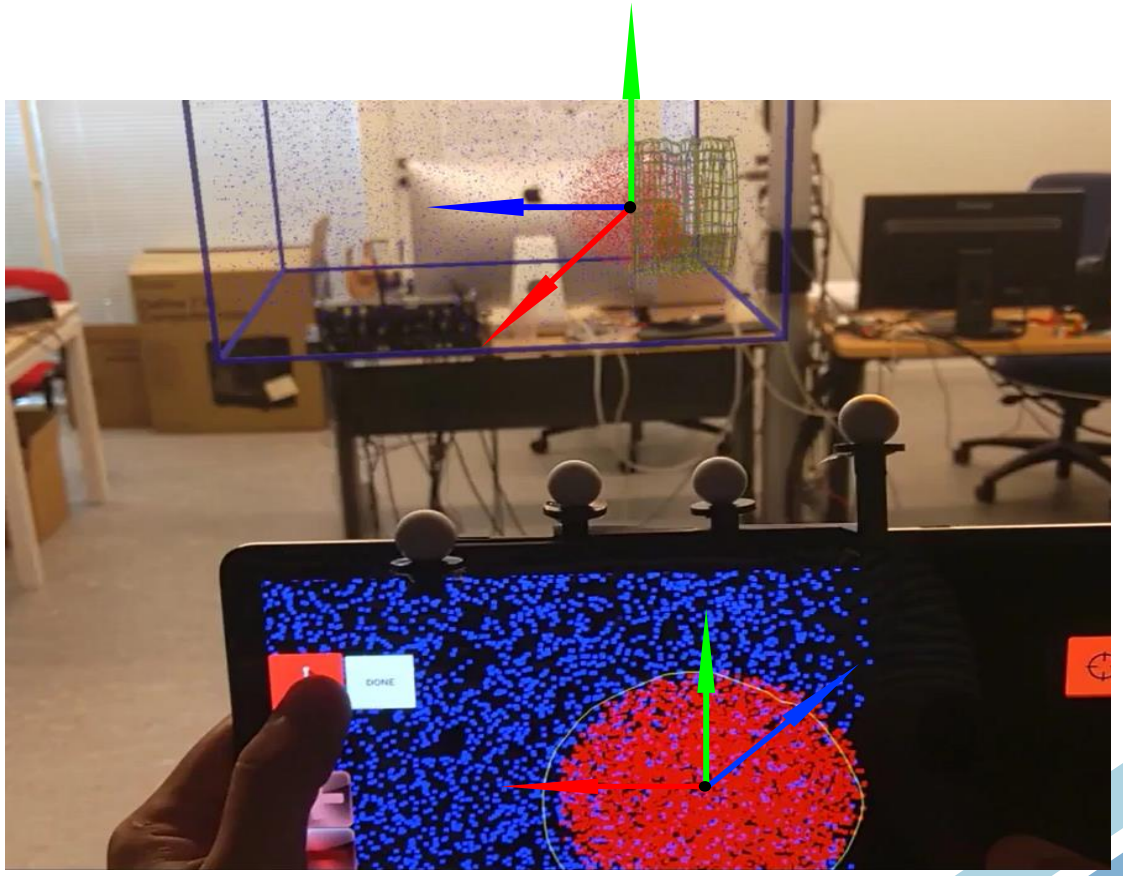
Specifying Regions – Behaviors (Relative-Full)



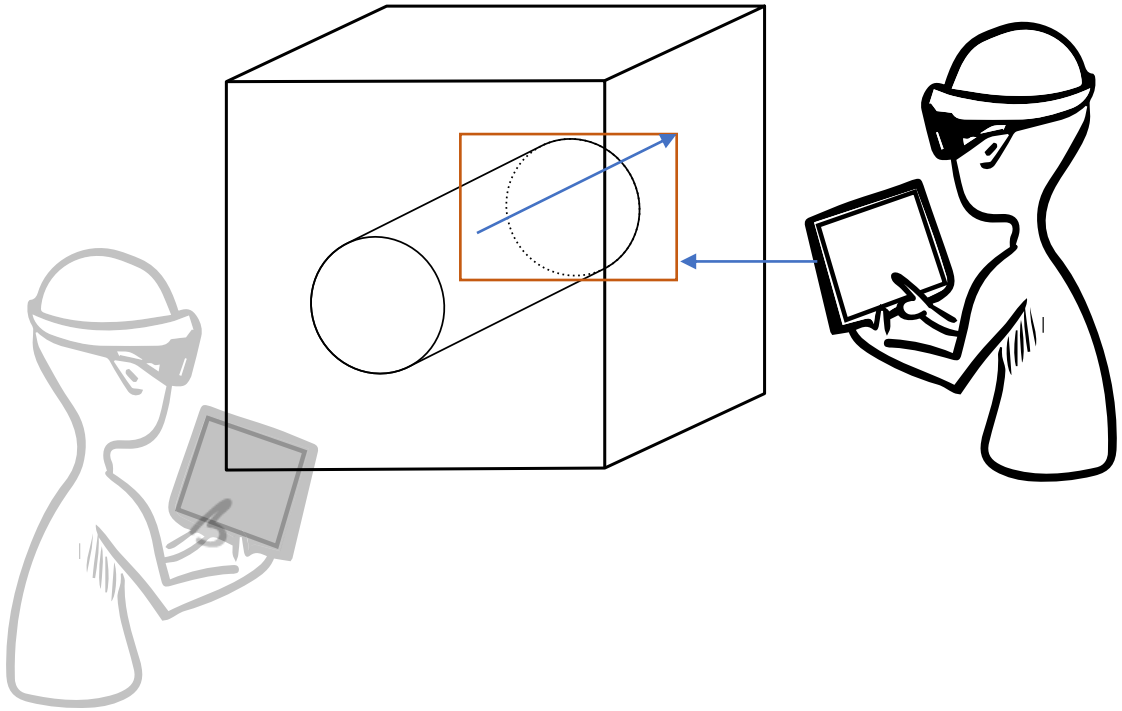


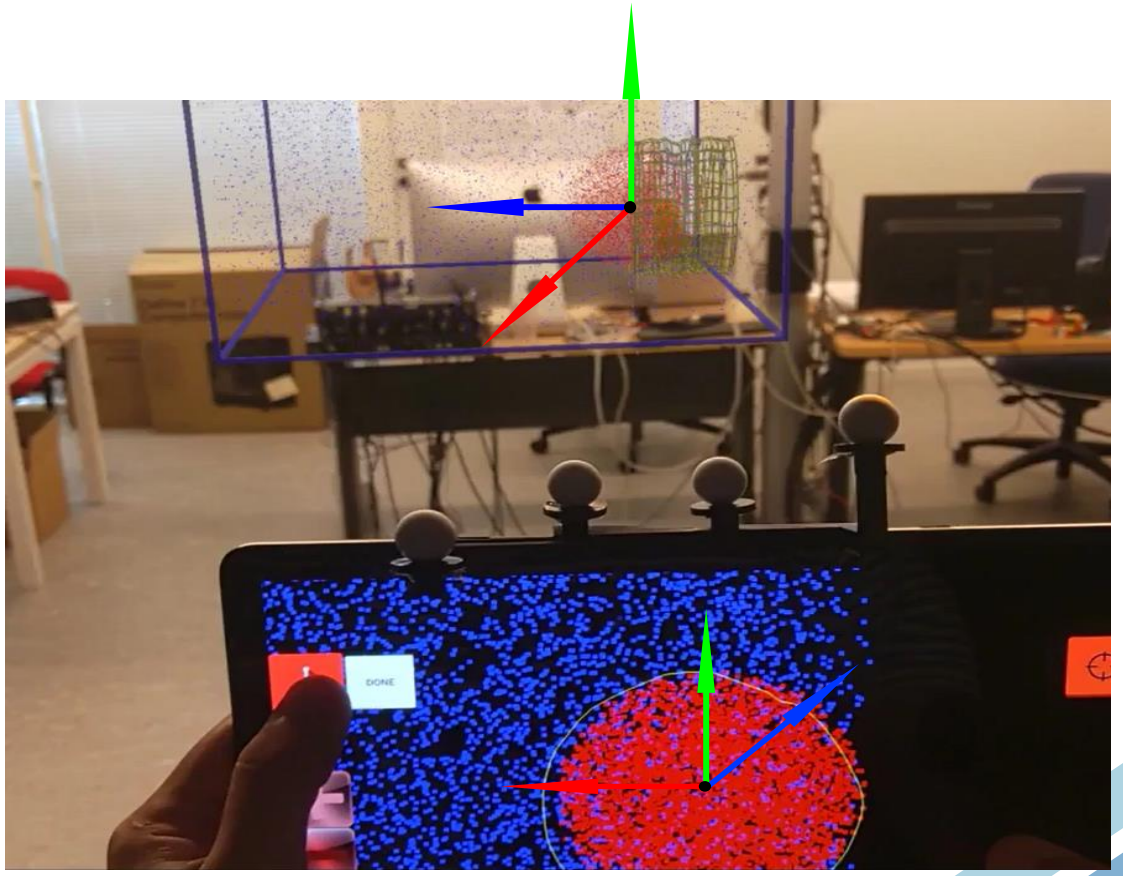
Specifying Regions – Behaviors (Relative-Full)





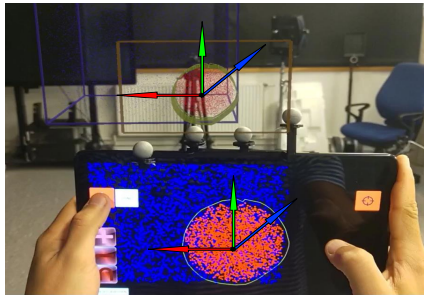
Specifying Regions – Behaviors (Relative-Full)



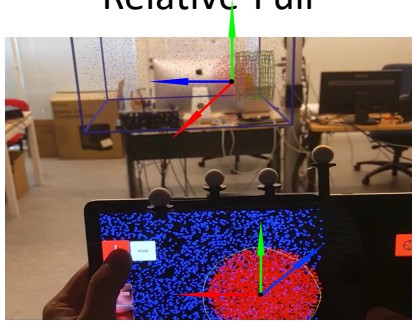


Specifying Regions – Overall

- Relative-Aligned

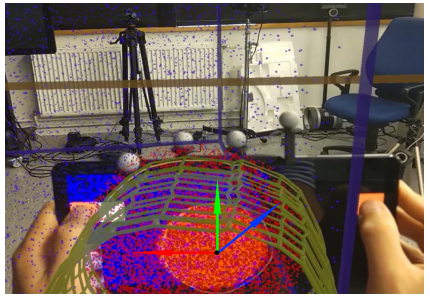


Relative-Full



Relative Mappings

Naïve Approach



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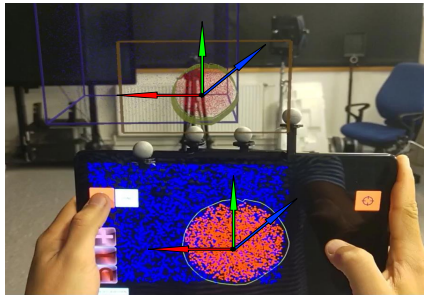
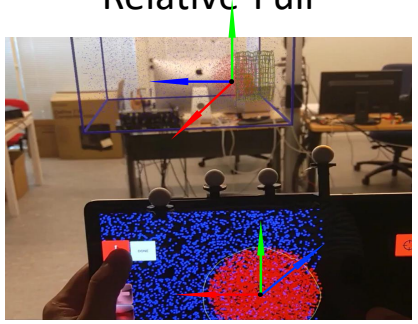
Specifying Regions – Overall

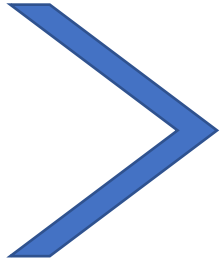
- Relative-Aligned



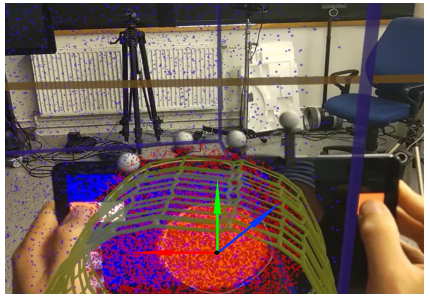
Relative-Full



Relative Mappings



Naïve Approach



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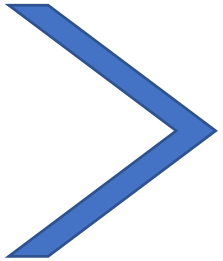
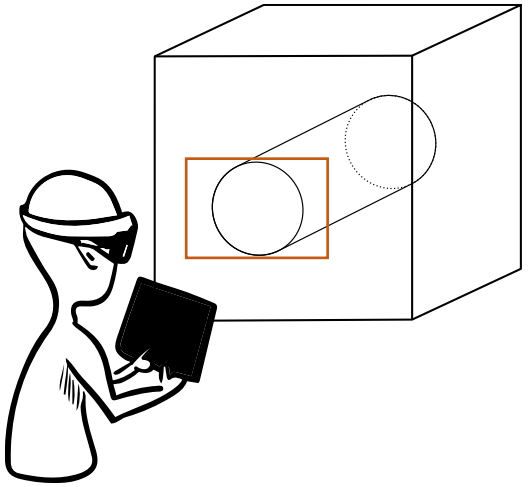


- Workload
- Preference

Specifying Regions – Future Work

- Test for different rotations (RF)
  - 45°
  - 90°
  - 180°



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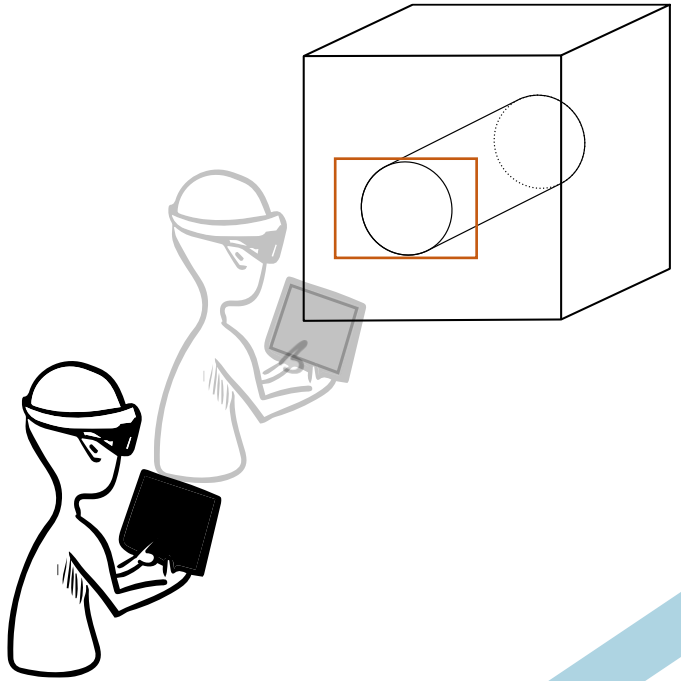

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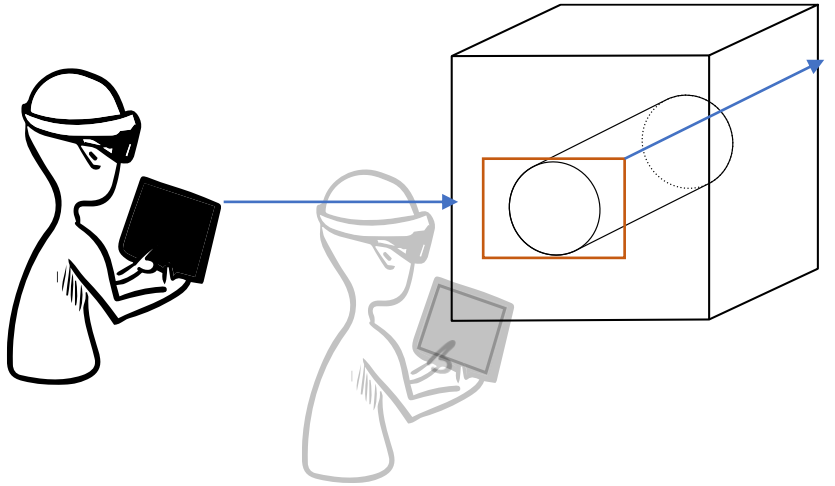
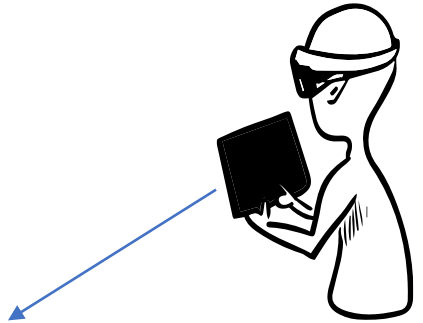


Specifying Regions – Future Work



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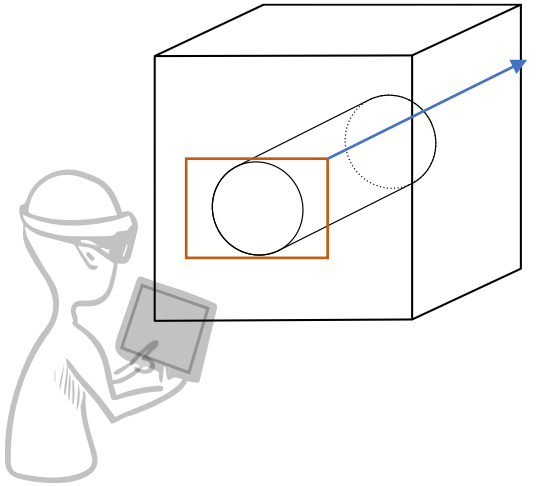
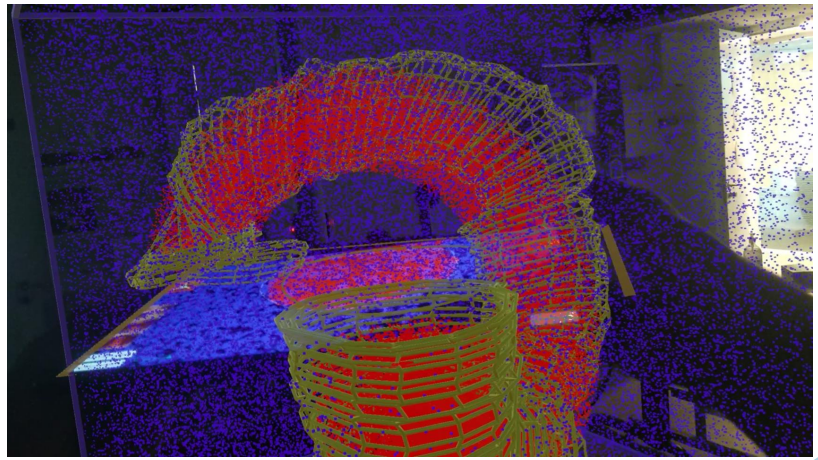


Specifying Regions – Future Work

- Test for different rotations (RF)
  - 45°
  - 90°
  - 180°

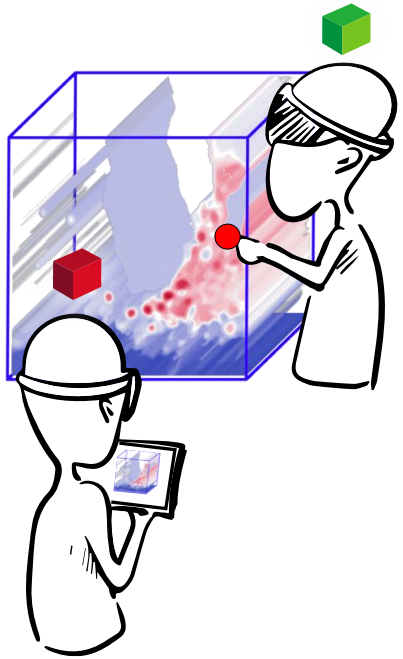
- Test the human's ability to handle multiple degrees of freedom
  - By studying trained users?



Direct vs. Indirect Interactions

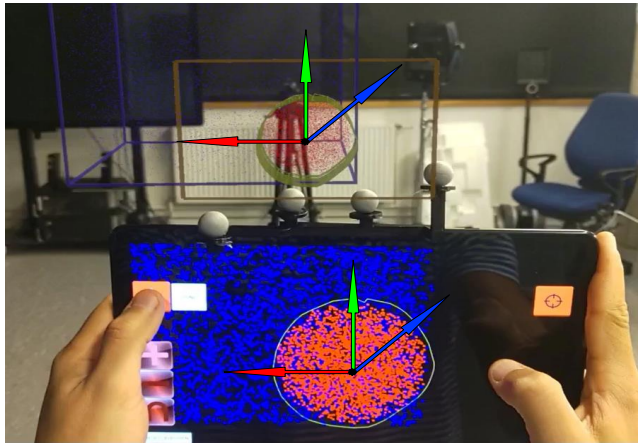
RQ4: *As a side effect of those studies, what are the main benefits and limitations of direct interaction mappings compared to remote ones?*

Points: Direct

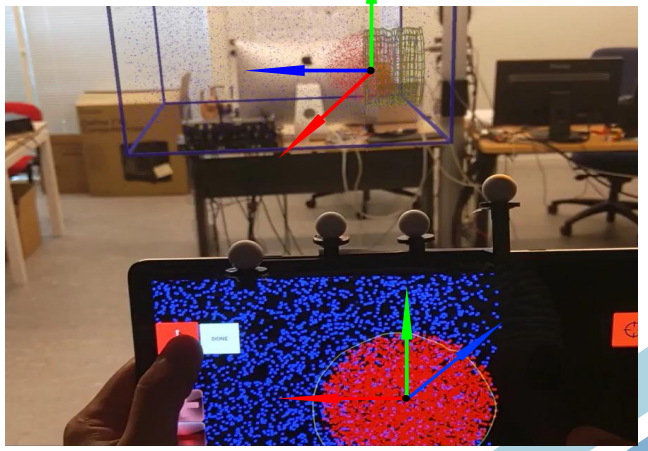


Regions: Indirect

Relative-Aligned



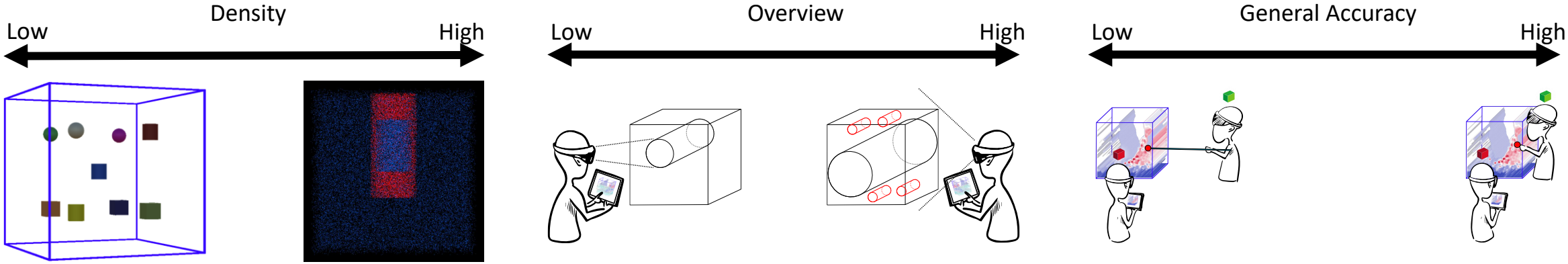
Relative-Full



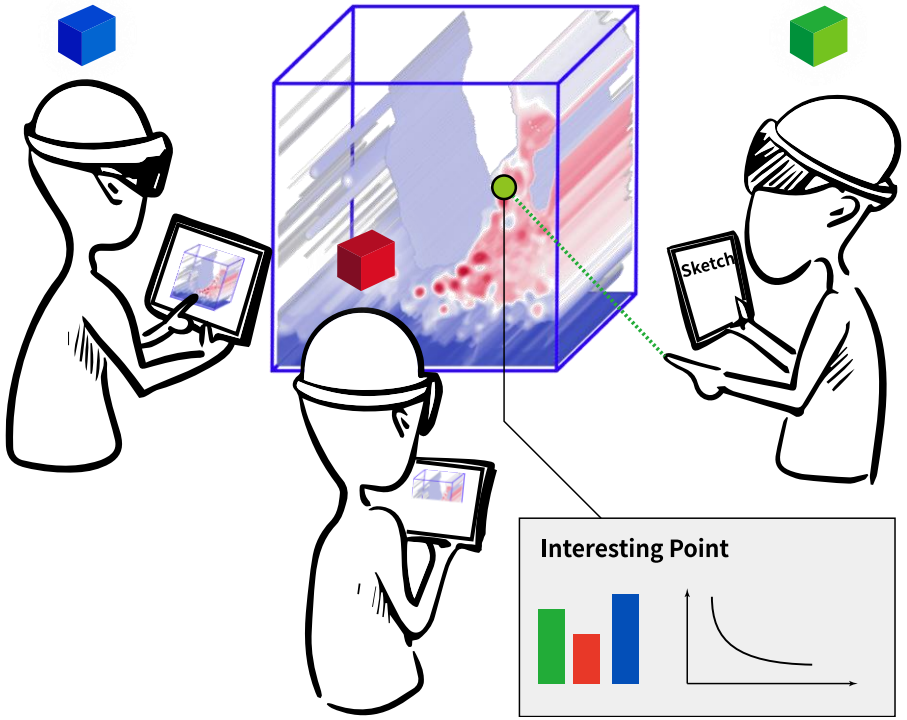
Relative Mappings

Direct vs. Indirect Interactions

Users' preference and general performance

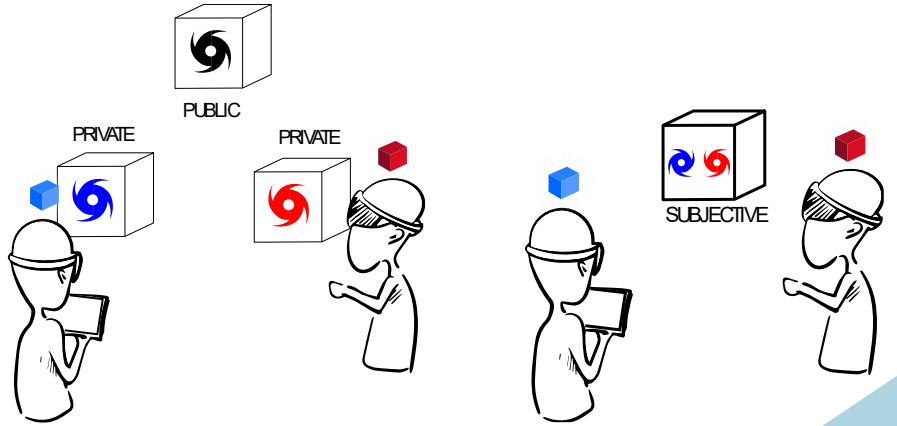


Interactions + **Visualization**

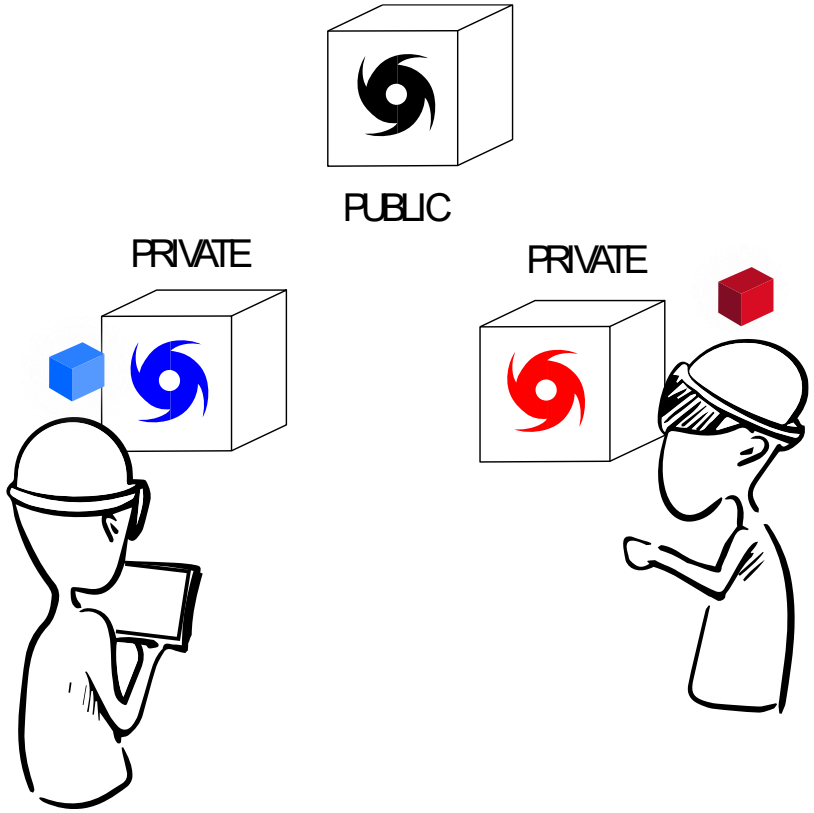


- Interactions
  - Specifying points
  - Specifying Regions

- Visualization
  - Private / Public / Subjective Space

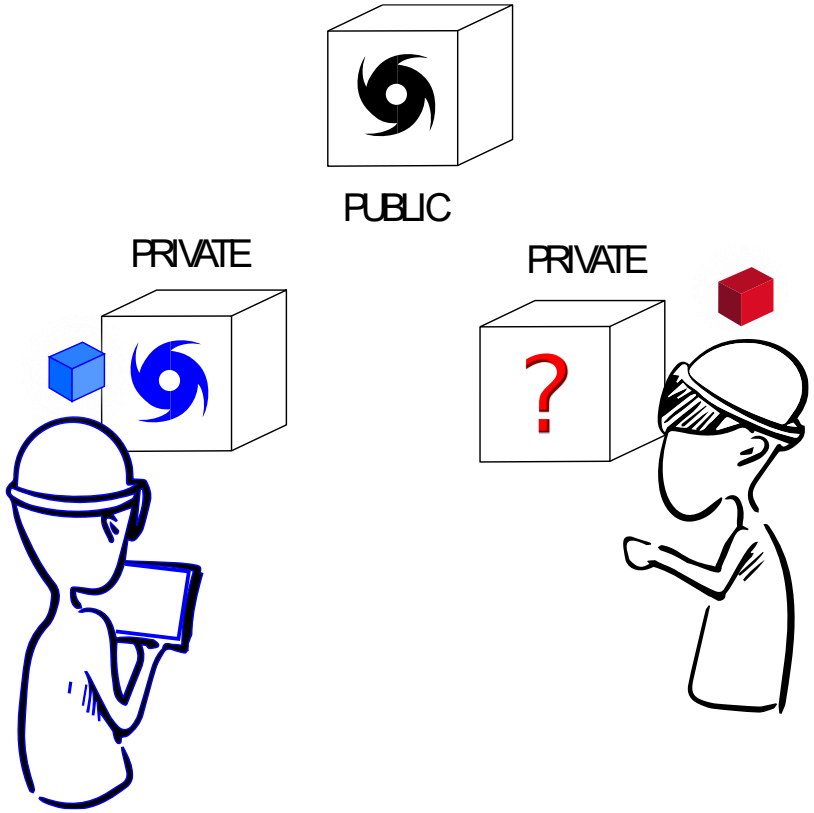


Private Views in Augmented Reality



Mickaël Sereno - AVIZ

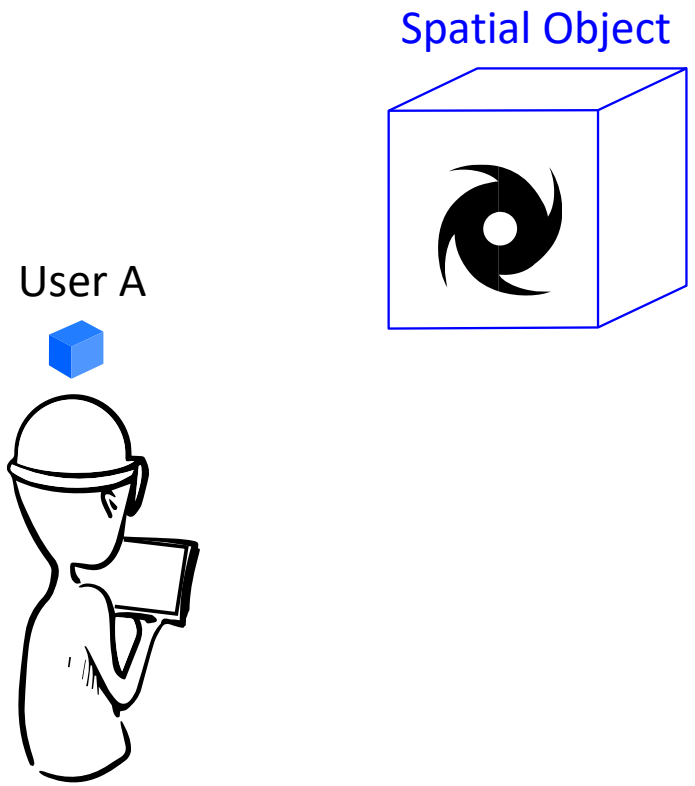
Private Views in Augmented Reality



Mickaël Sereno - AVIZ

An Initial Subjective View – Definition and Problem

RQ5: *What are the subjective views advantages and disadvantages? Which interaction techniques and visualizations support users?*



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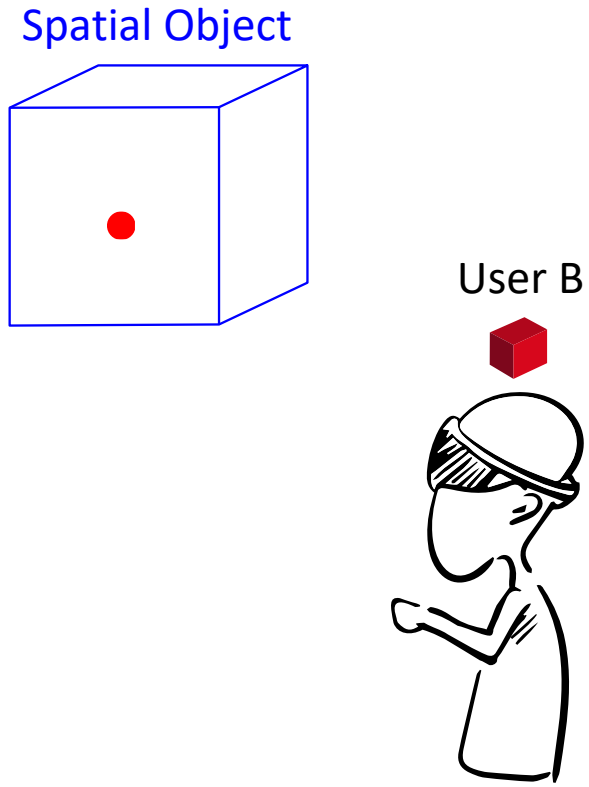

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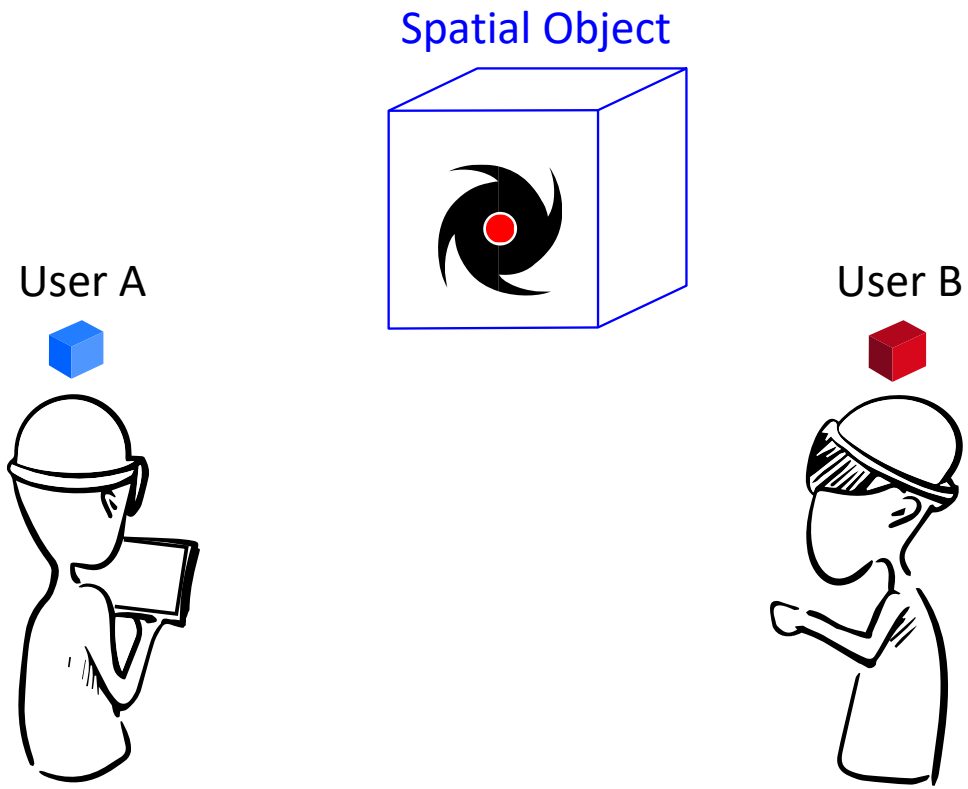

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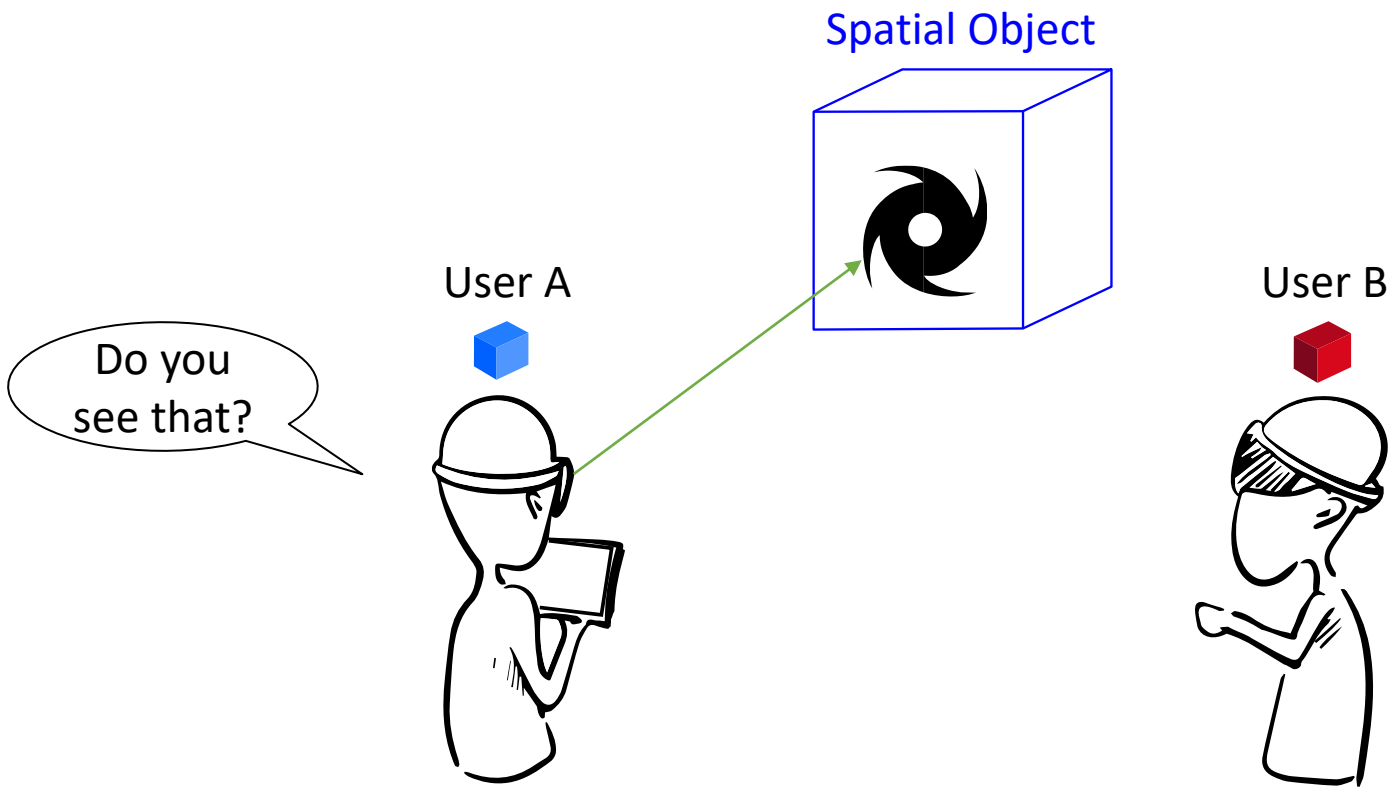

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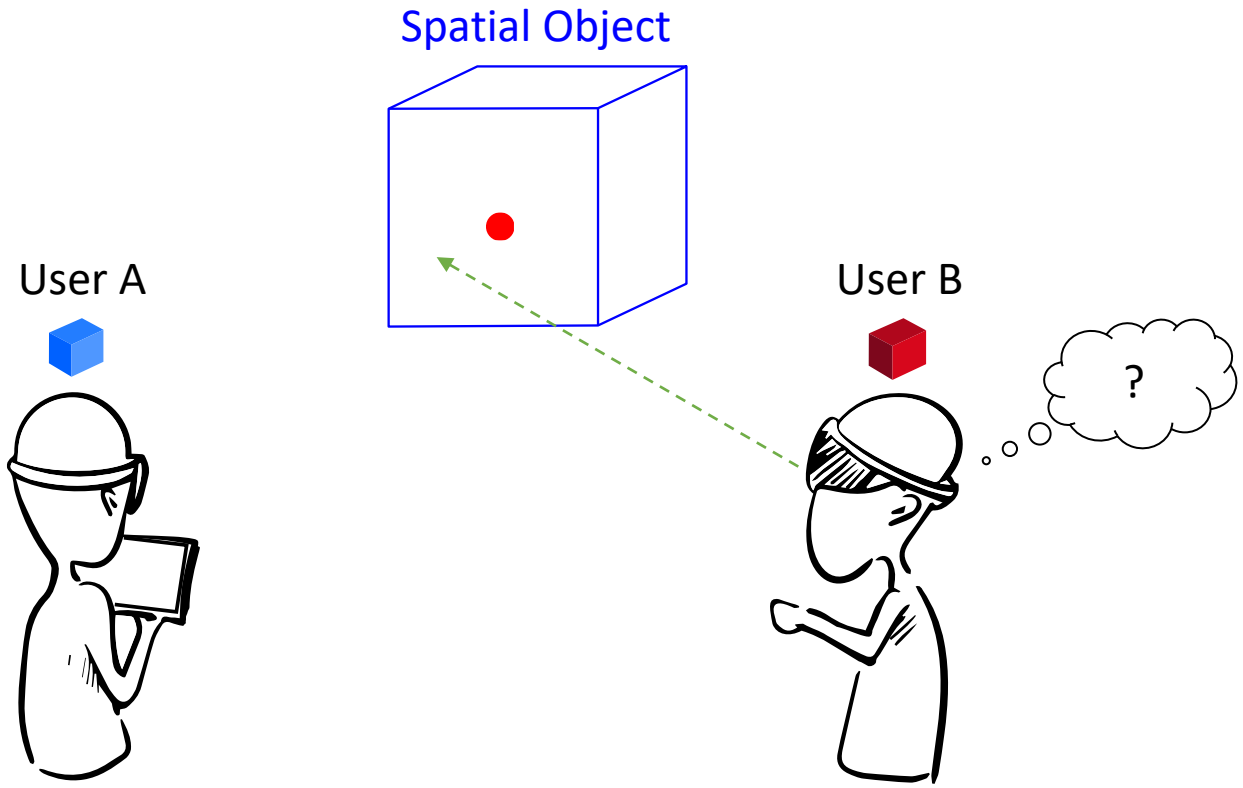
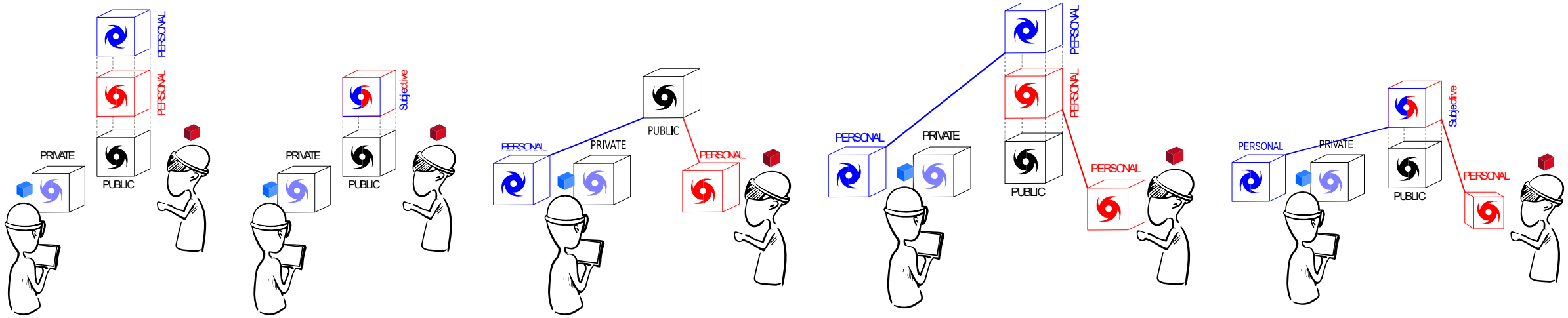
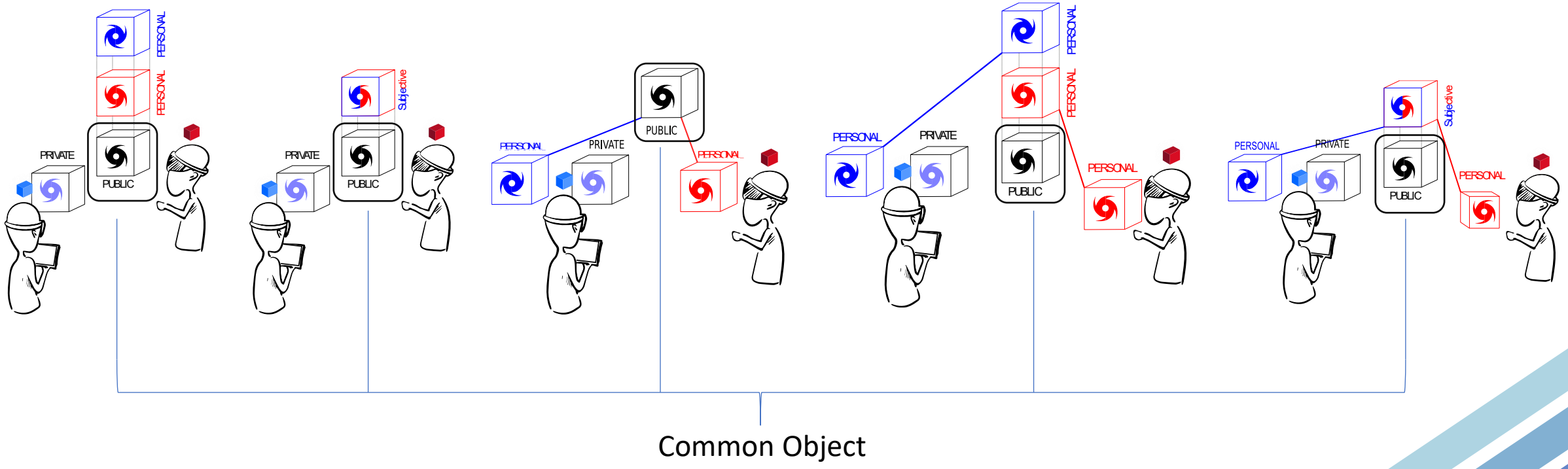


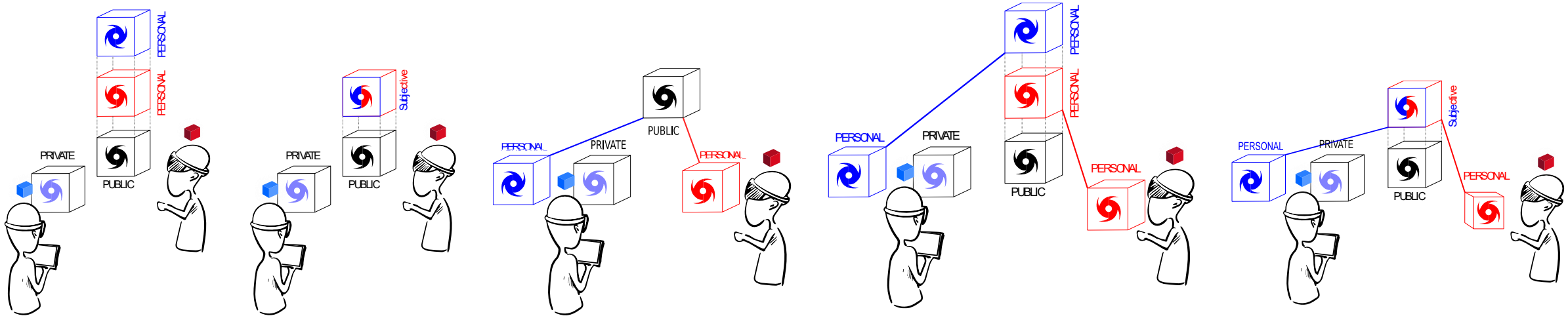
Visualization Context – Initial Designs



Visualization Context – Initial Designs



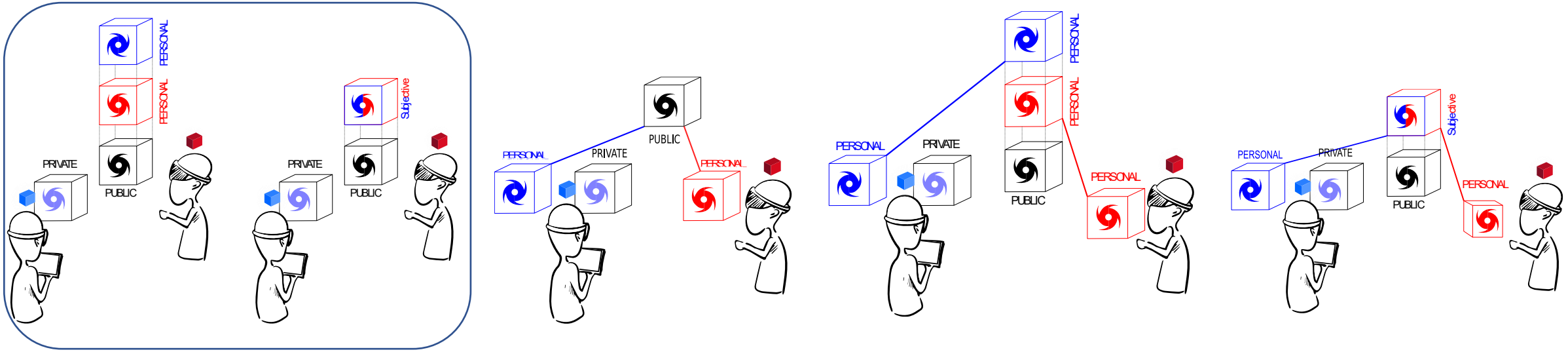
Visualization Context – Initial Designs



Visualization Context – Initial Designs

Layout Stacking

Dissociated Associated

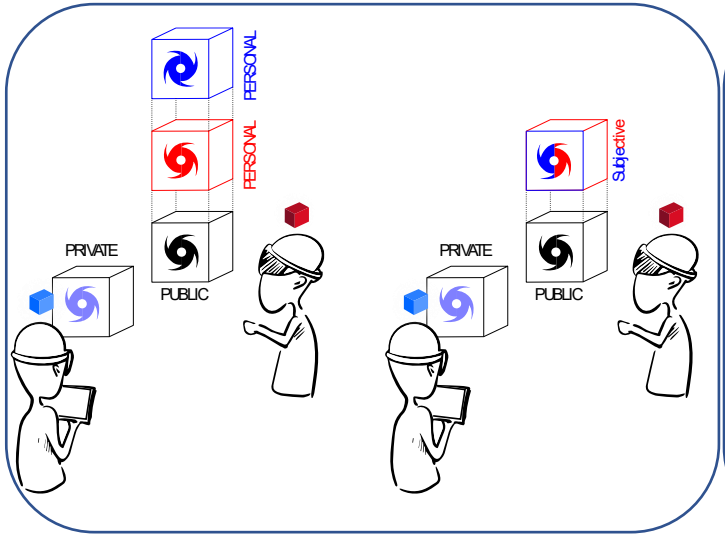


Visualization Context – Initial Designs

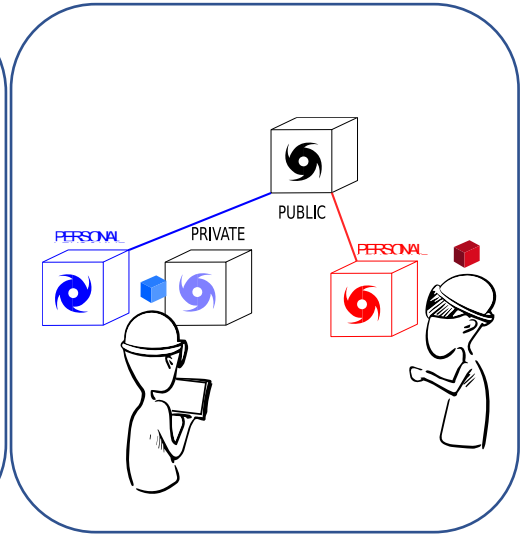
Layout Stacking

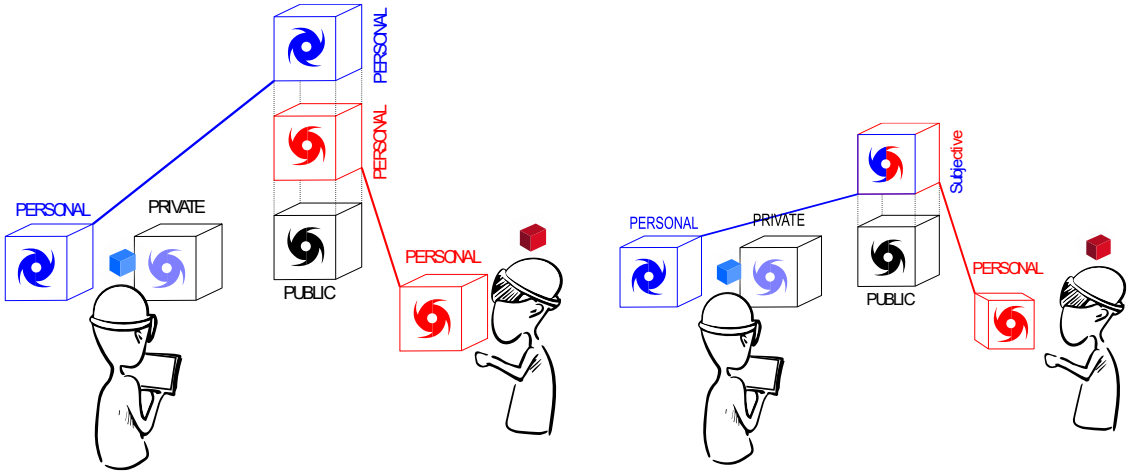
Dissociated

Associated



Linked View

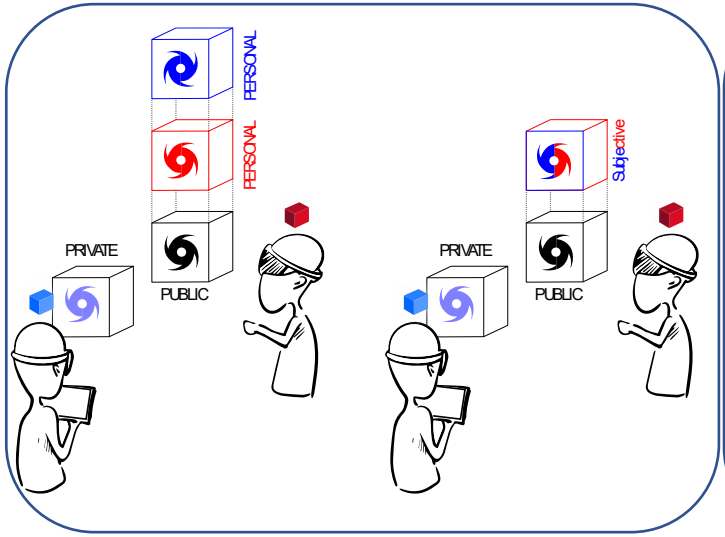




Visualization Context – Initial Designs

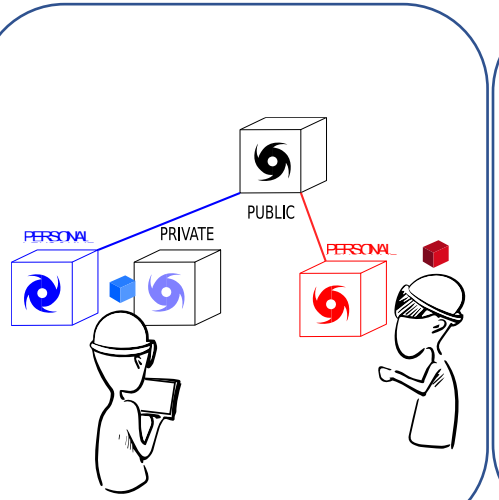
Layout Stacking

Dissociated



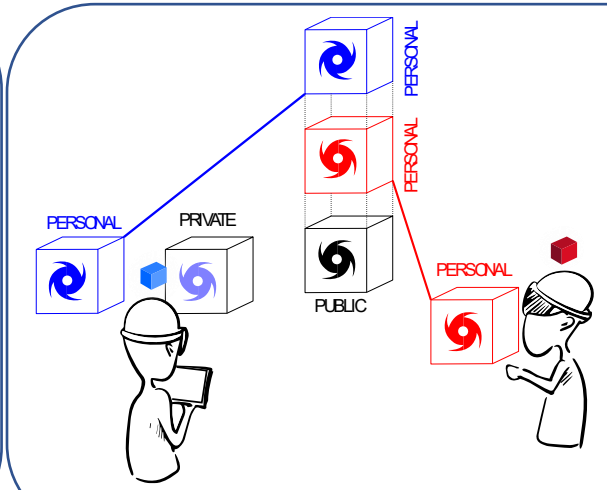
Associated

Linked View

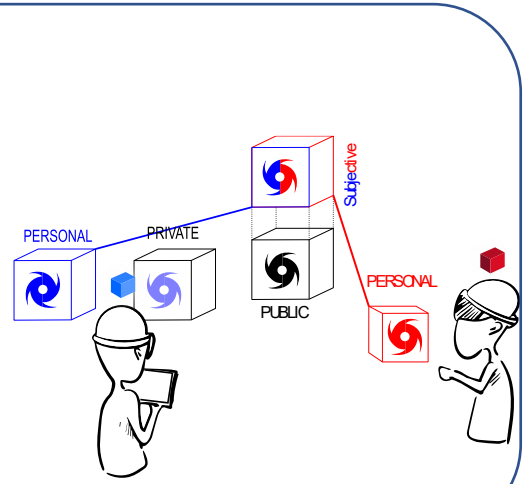


Layout Stacking + Linked View

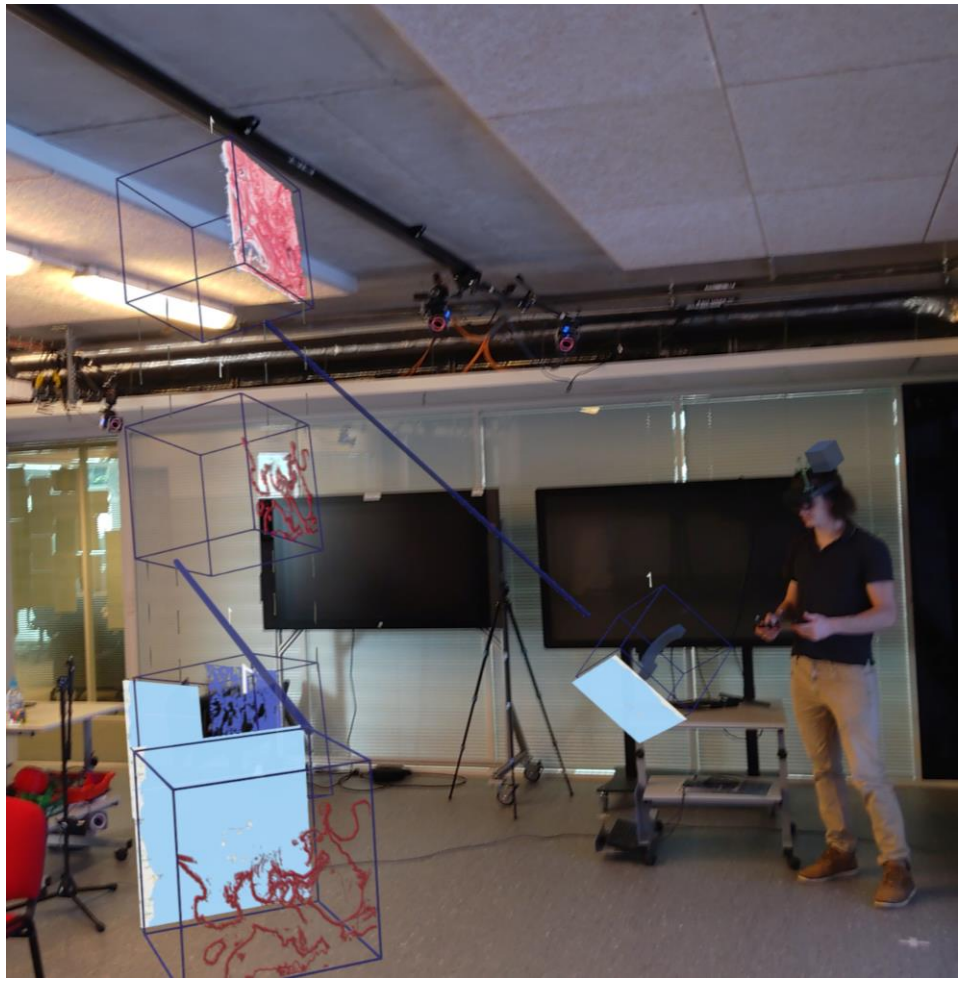
Dissociated



Associated



Subjective Views – Examples



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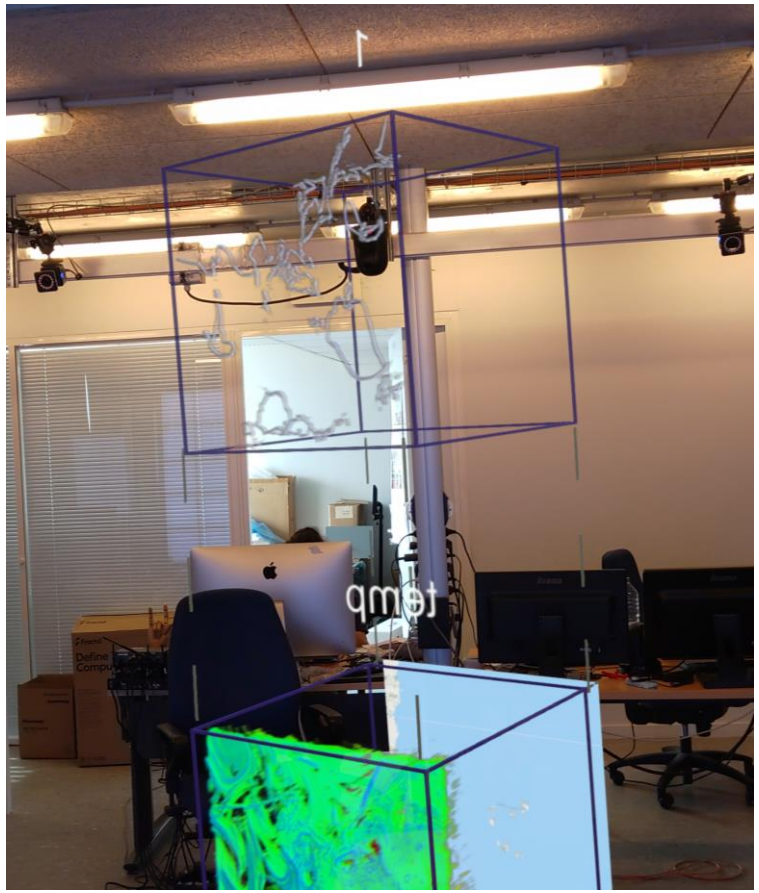

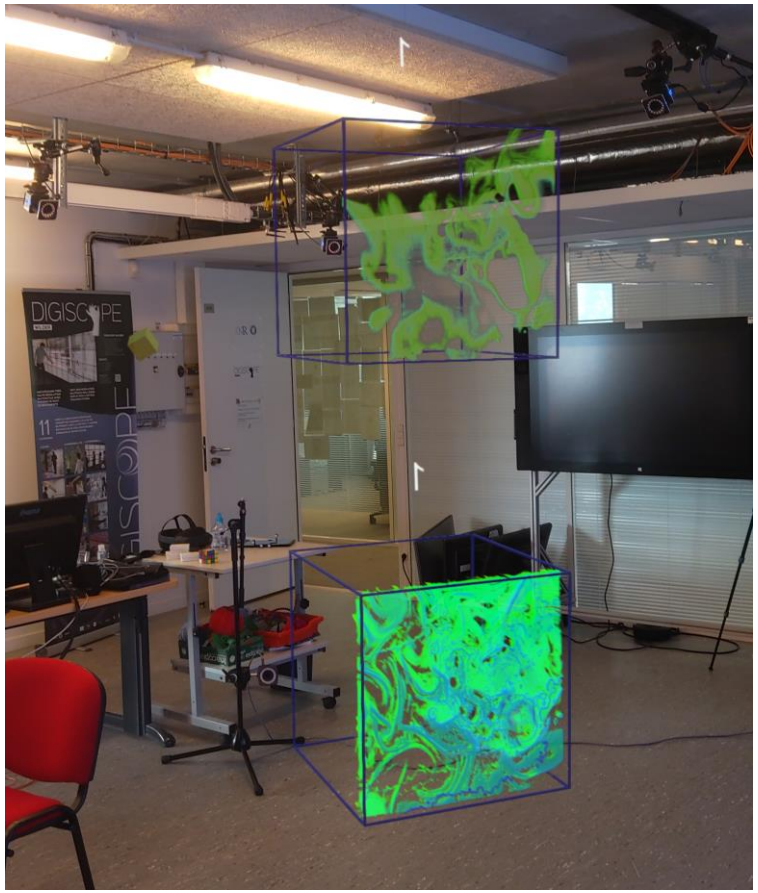

How to Study This? A Real Use-Case

Burkard Baschek, Oceanographers, HZG, Germany

- Need Datasets
- Need Real Scenarios
- Need Exploration Tools

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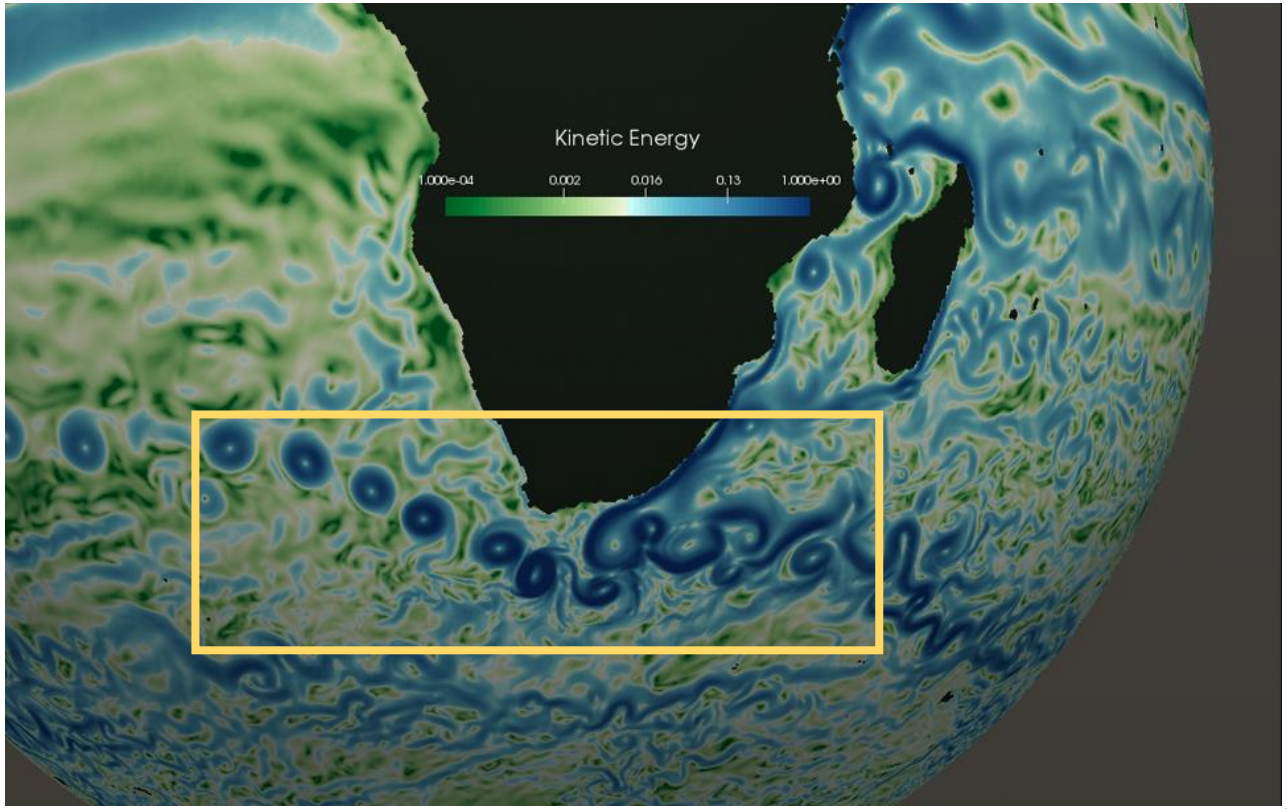


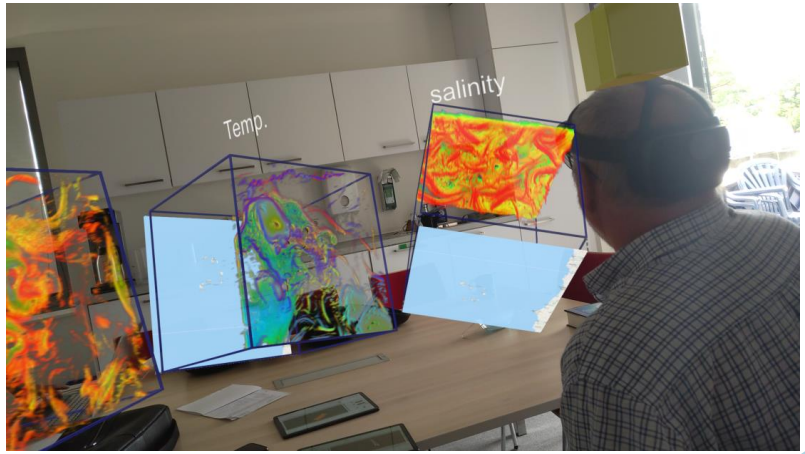
How to Study This? A Real Use-Case

Burkard Baschek, Oceanographers, HZG, Germany

- Meeting with 5—10 persons
- Issues to:
  - explain results
  - create new visualizations

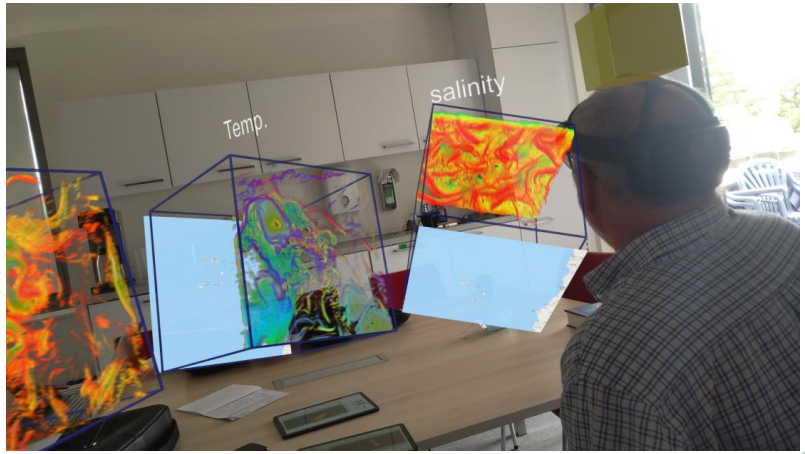
Description of the Environment – AR Headsets

- Shared Coordinate



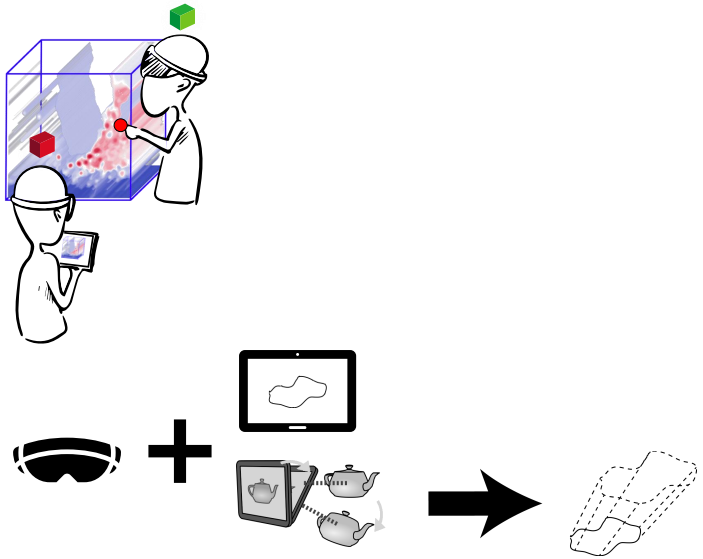
Description of the Environment – AR Headsets

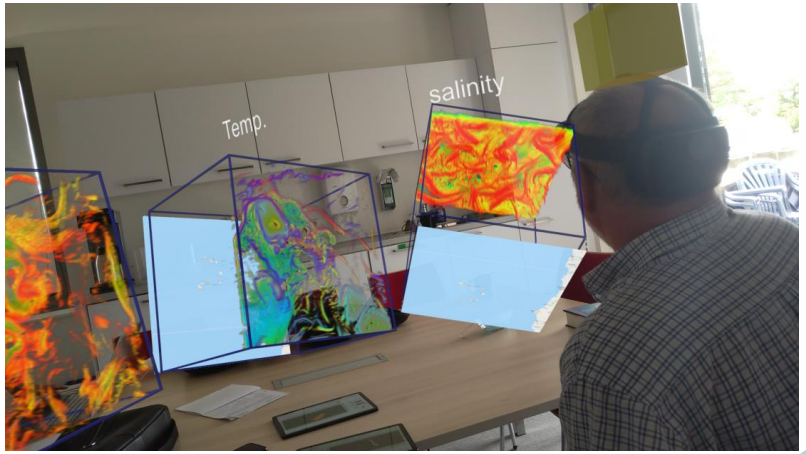
- Shared Coordinate
- Visualize multiple visualizations



Description of the Environment – AR Headsets

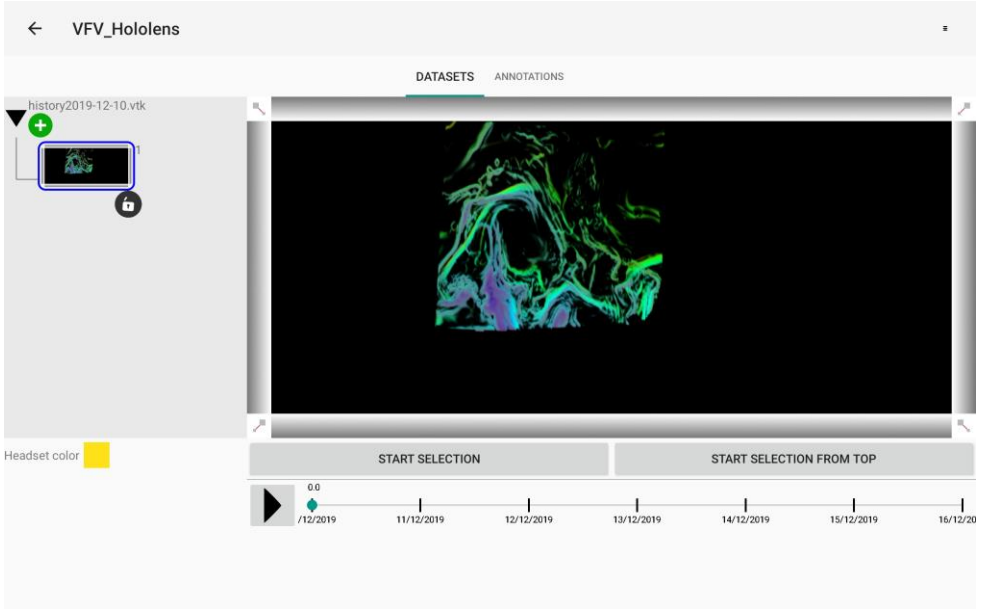
- Shared Coordinate
- Visualize multiple visualizations
- Handle spatial interactions





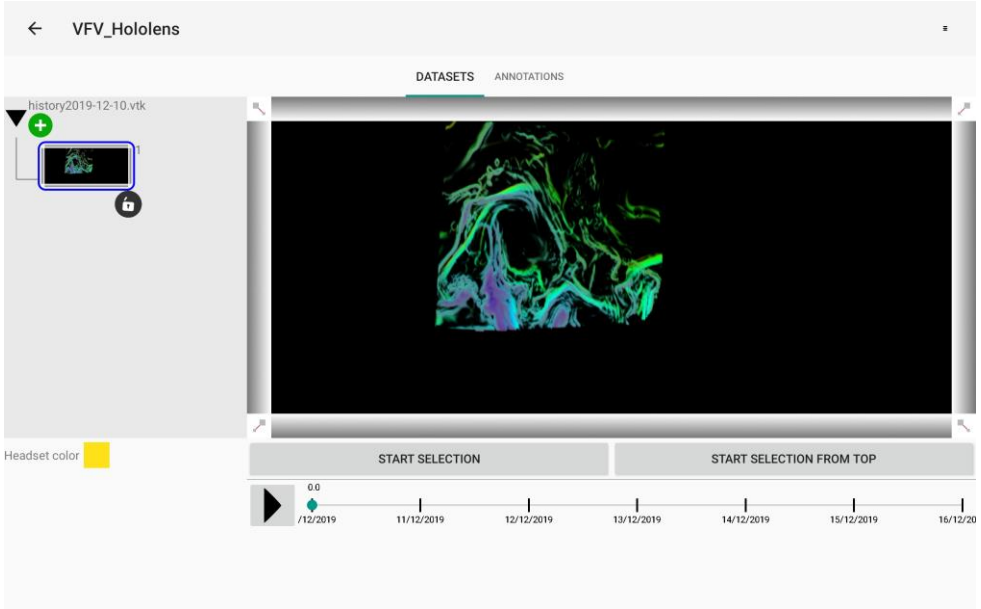
Description of the Environment – Tablets

- Handle opened visualisations



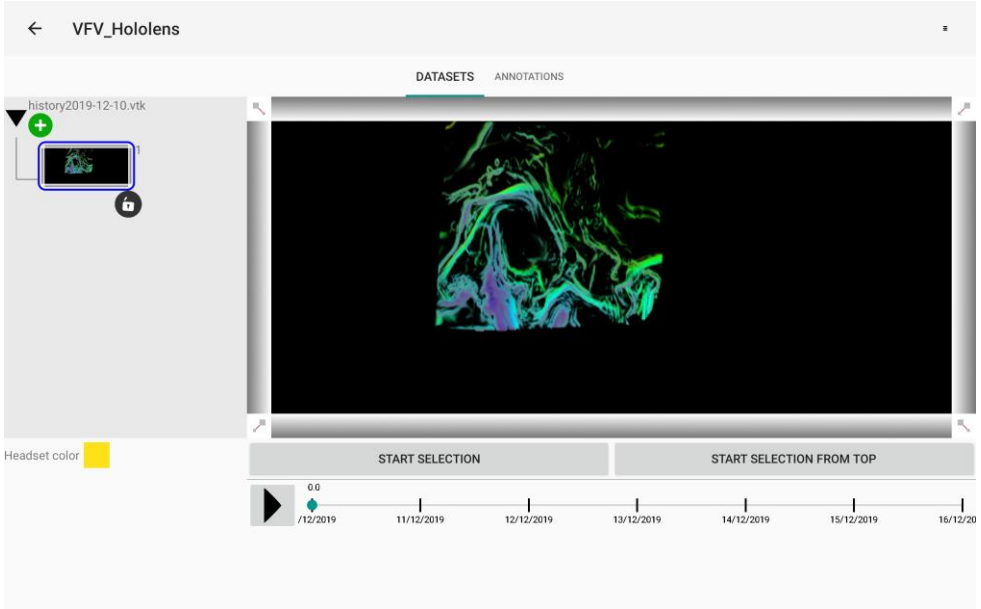
Description of the Environment – Tablets

- Handle opened visualisations
- Handle time-components



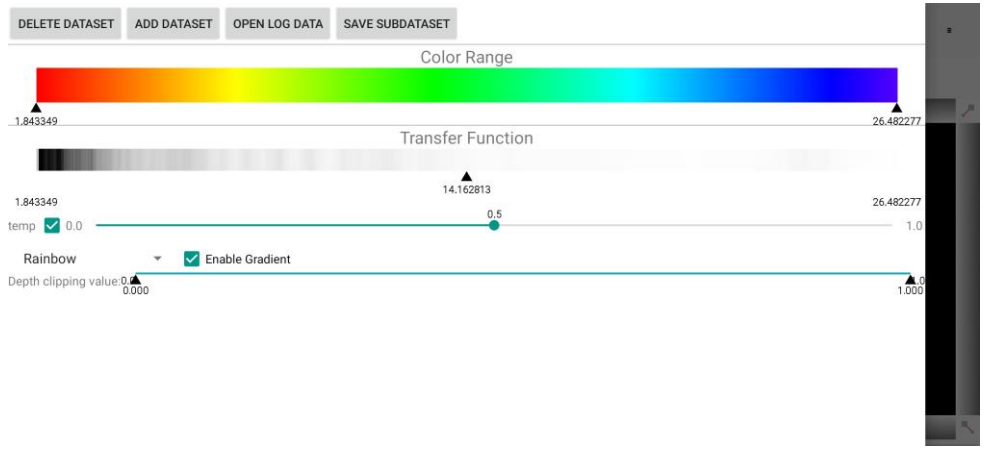
Description of the Environment – Tablets

- Handle opened visualisations
- Handle time-components
- 3D Transformations (FI3D Widgets)



Description of the Environment – Tablets

- Open Datasets / “Annotations”
- Handle visual parameters (transfer functions, clipping, etc.)

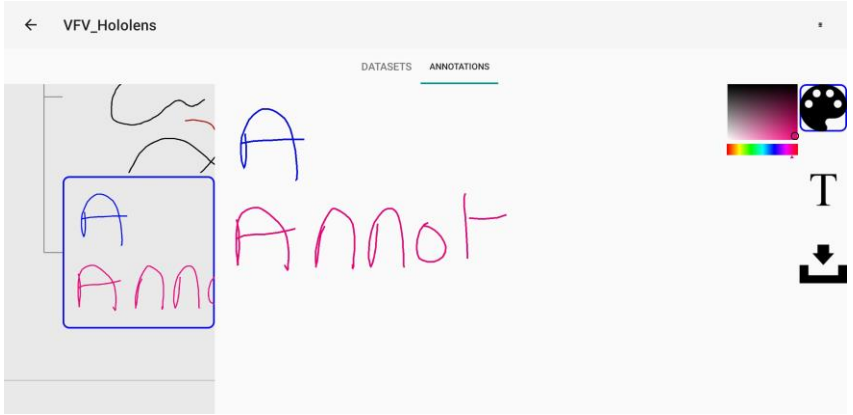


1D

$N^{th}D$ / PCP

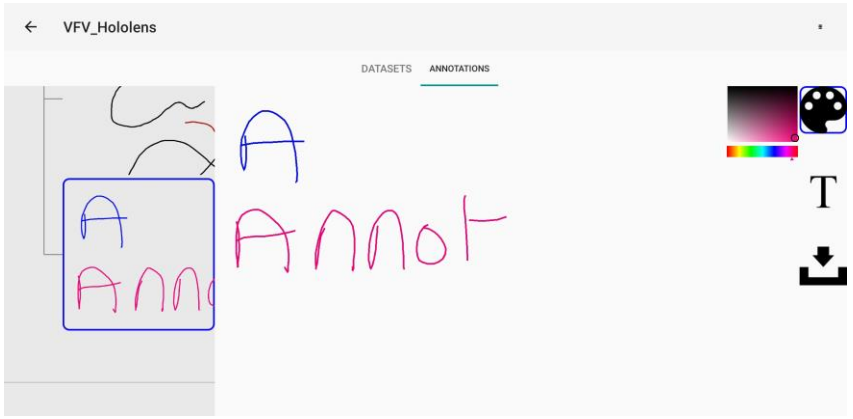
Description of the Environment – Tablets

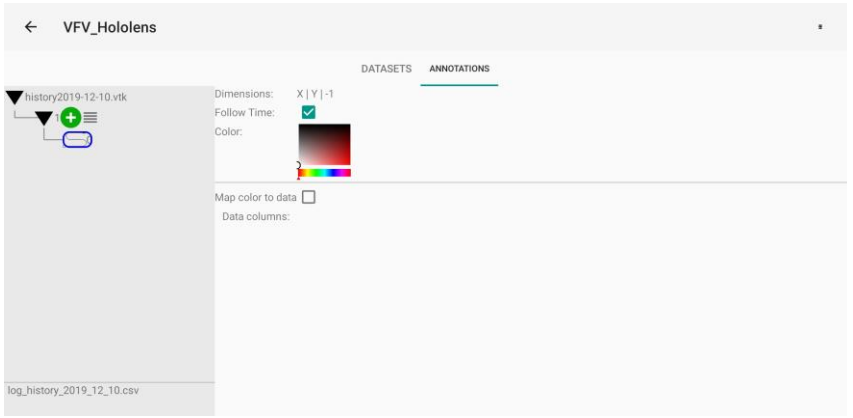
- Handle “Canvas” annotations
  - Not fully functional



Description of the Environment – Tablets

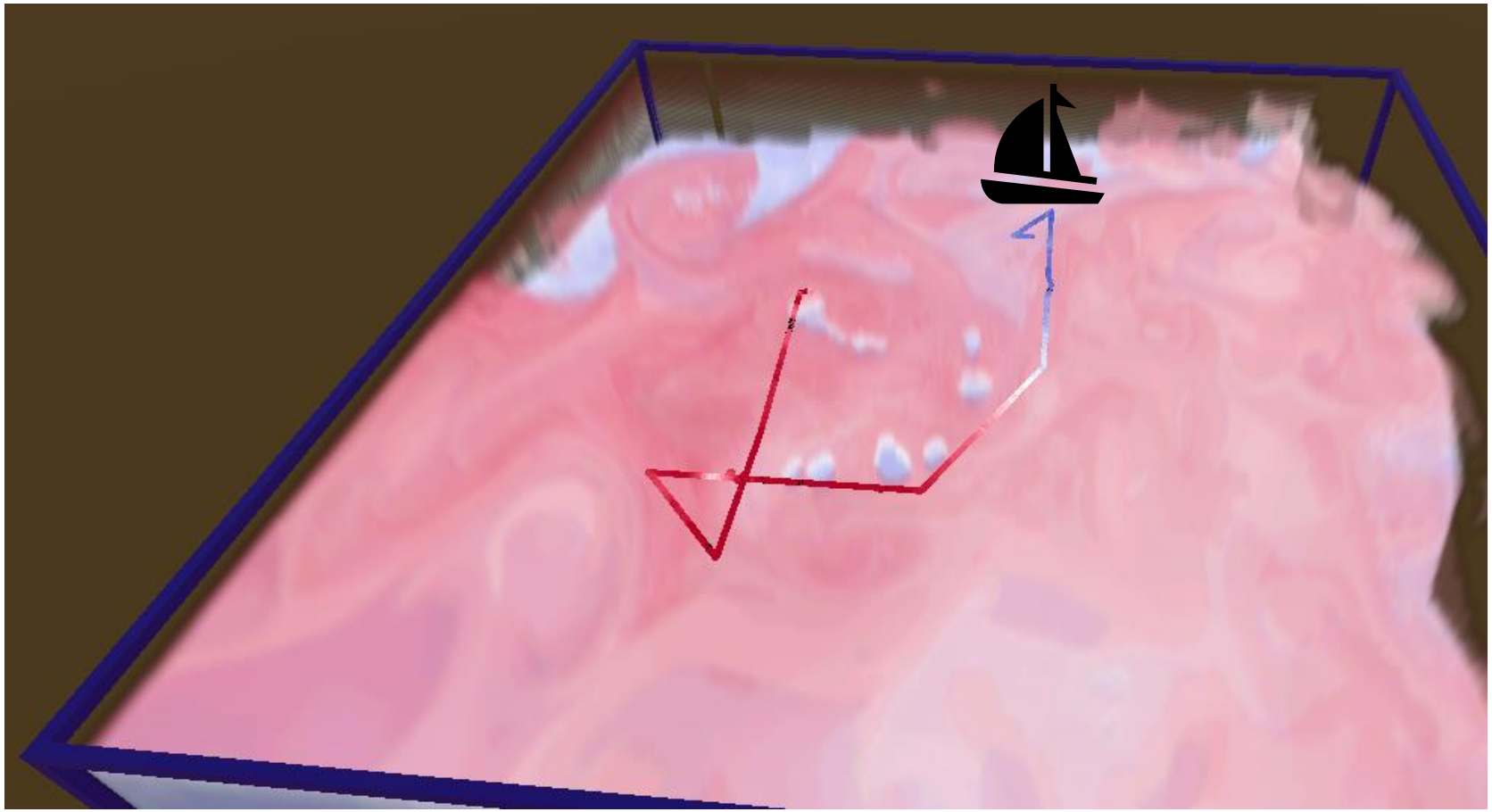
- Handle “Canvas” annotations
  - Not fully functional





- Handle 2D data

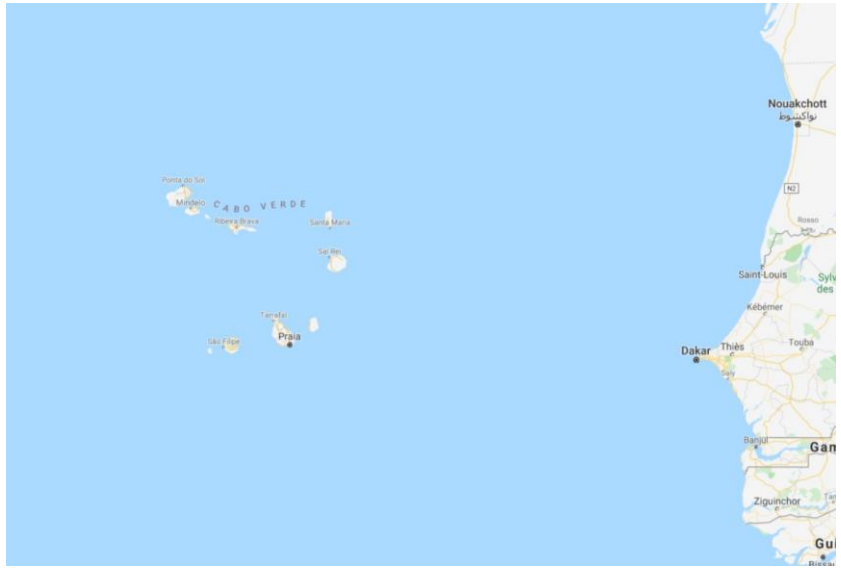
Logged Annotation – Path data



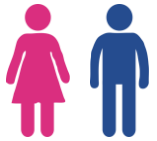
Global Software – Informal Study

2

Dataset: Cabo Verde Area
Resolution: 370 X 280 X 50 (> 5 Millions)

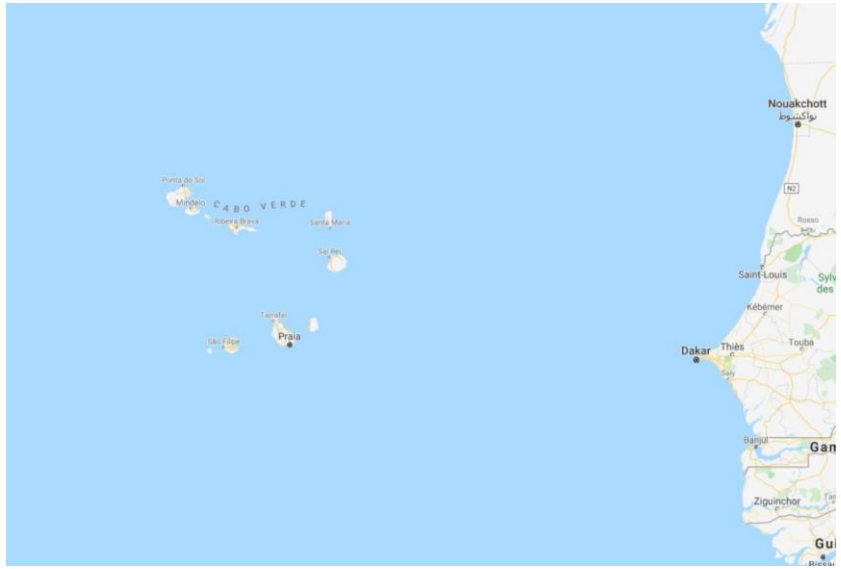


Global Software – Informal Study



2

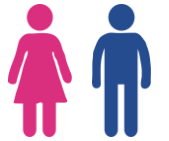
Dataset: Cabo Verde Area
Resolution: 370 X 280 X 50 (> 5 Millions)



Variables:

- Temperature
- Salinity
- Velocity:
  - Latitude
  - Longitude
  - Magnitude

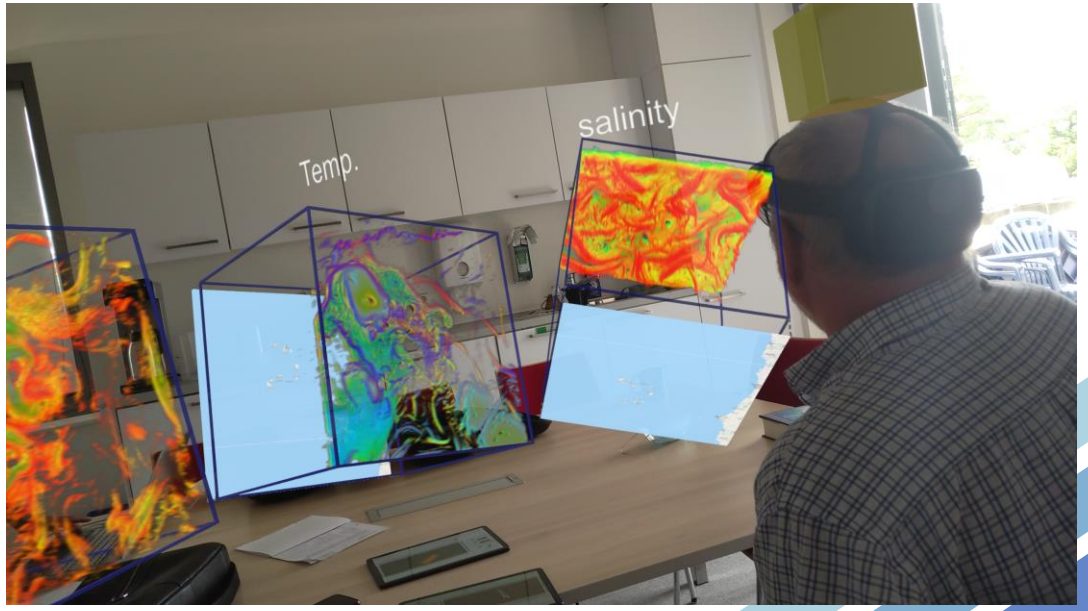
Global Software – Informal Study



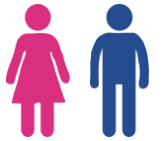
2

Main Events:

- Personal Physical Space: “This is my space, go elsewhere”



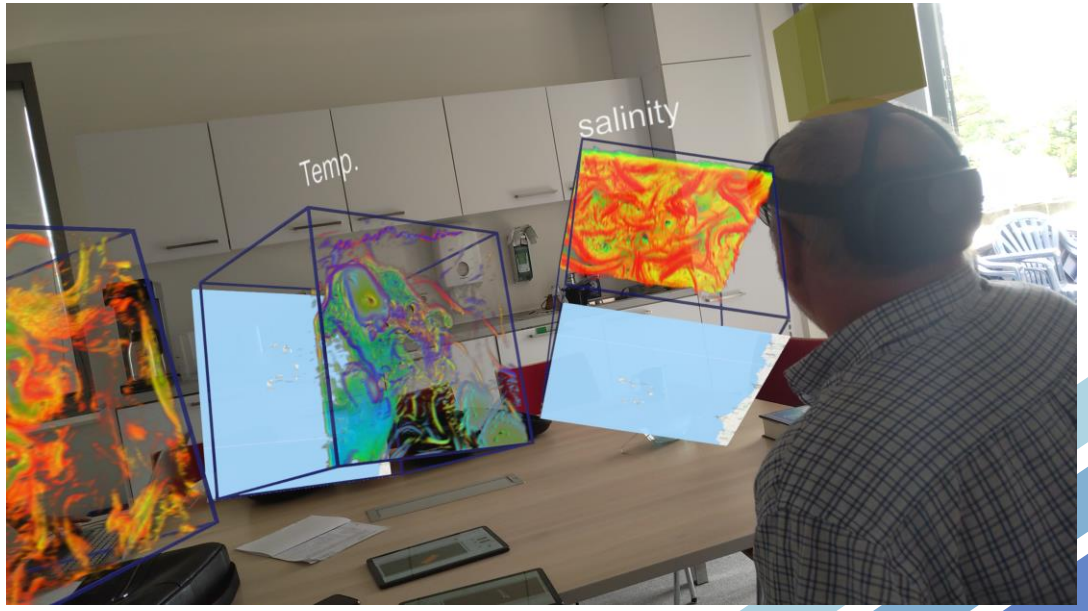
Global Software – Informal Study



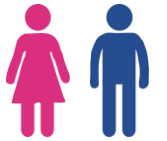
2

Main Events:

- Personal Physical Space: “This is my space, go elsewhere”
- Separation of Output and Input: Passive vs. Active Users



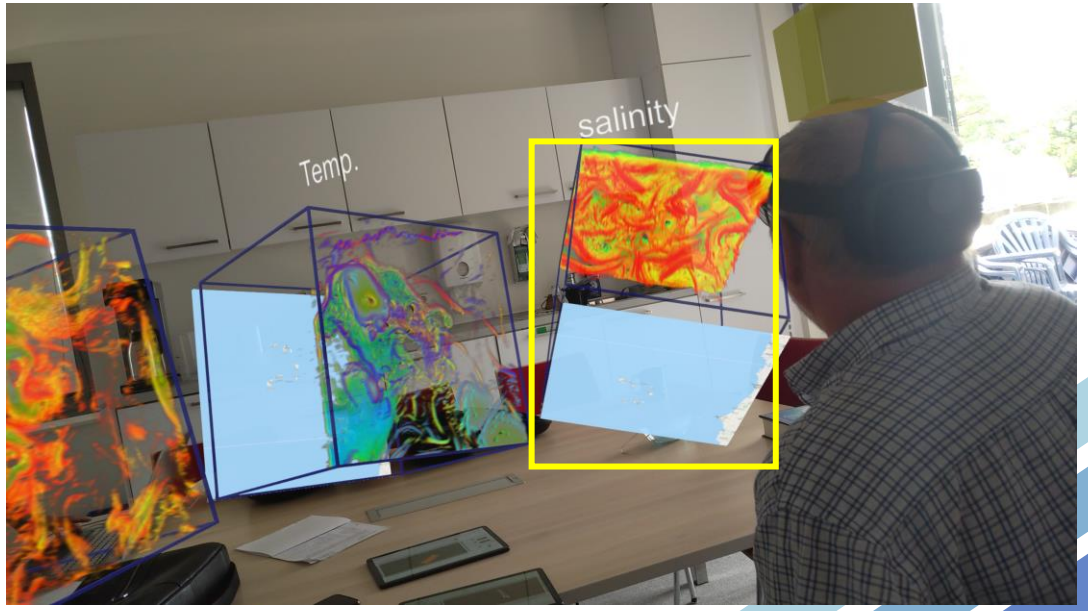
Global Software – Informal Study



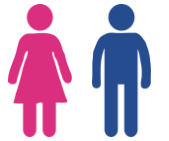
2

Main Events:

- Personal Physical Space: “This is my space, go elsewhere”
- Separation of Output and Input: Passive vs. Active Users
- First time they look at the 3D structure



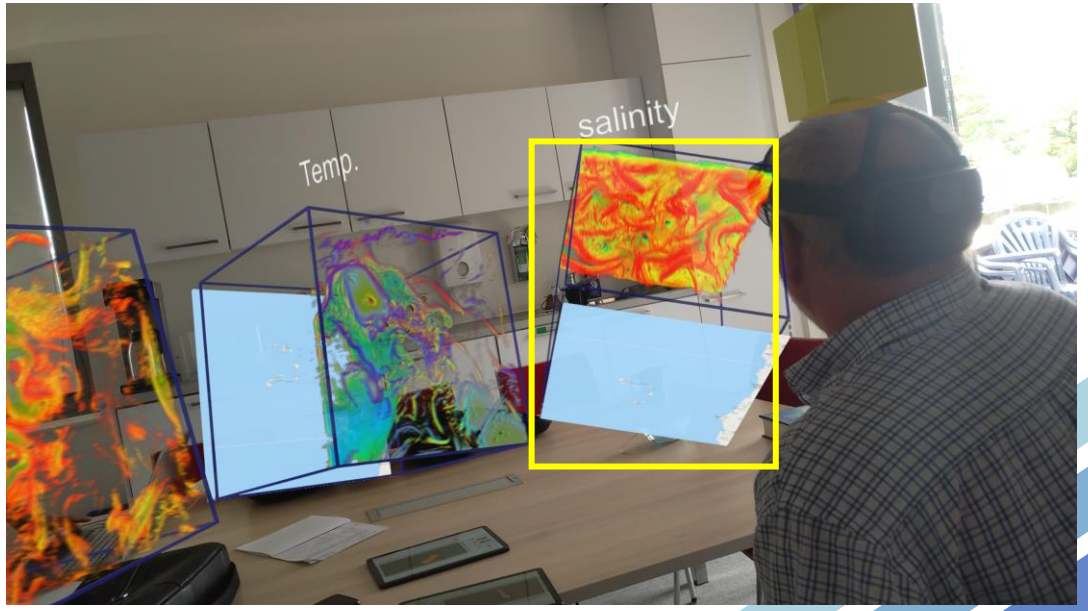
Global Software – Informal Study



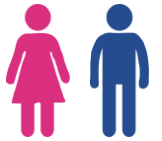
2

Main Events:

- Personal Physical Space: “This is my space, go elsewhere”
- Separation of Output and Input: Passive vs. Active Users
- First time they look at the 3D structure
- Did not look at each other



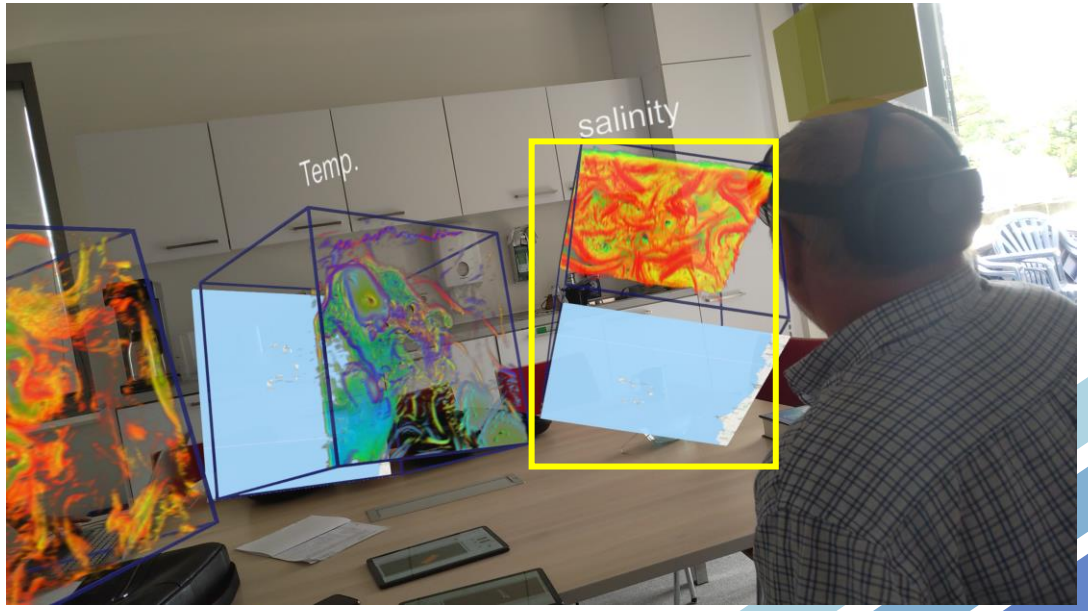
Global Software – Informal Study



2

Main Events:

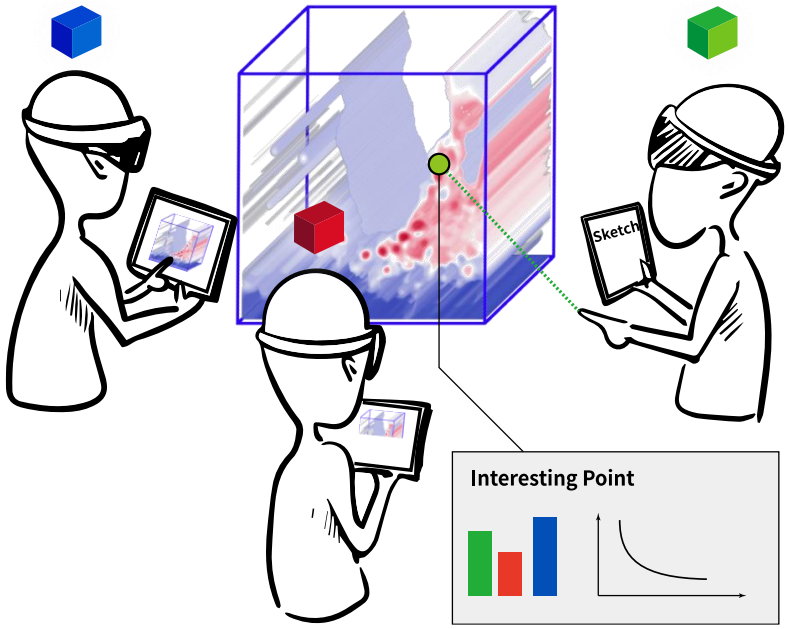
- Personal Physical Space: “This is my space, go elsewhere”
- Separation of Output and Input: Passive vs. Active Users
- First time they look at the 3D structure
- Did not look at each other
- Did not move around



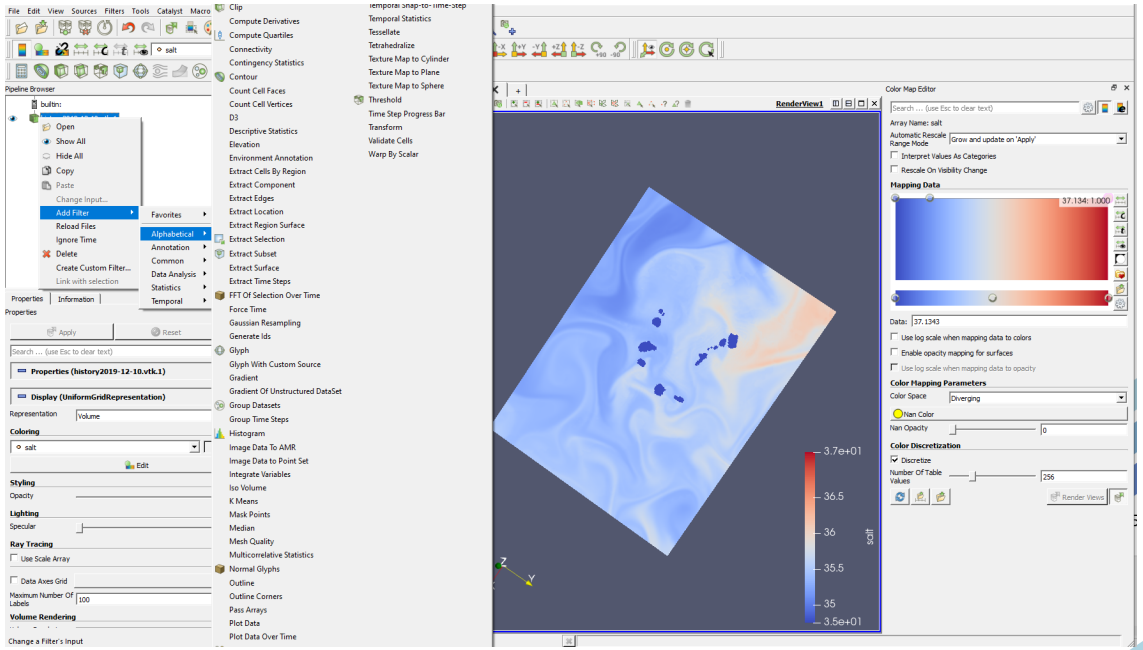
Takeaway messages

Contributions: General understandings of AR-HMDs + Tablets

New AR-Headsets + Tablets Environments



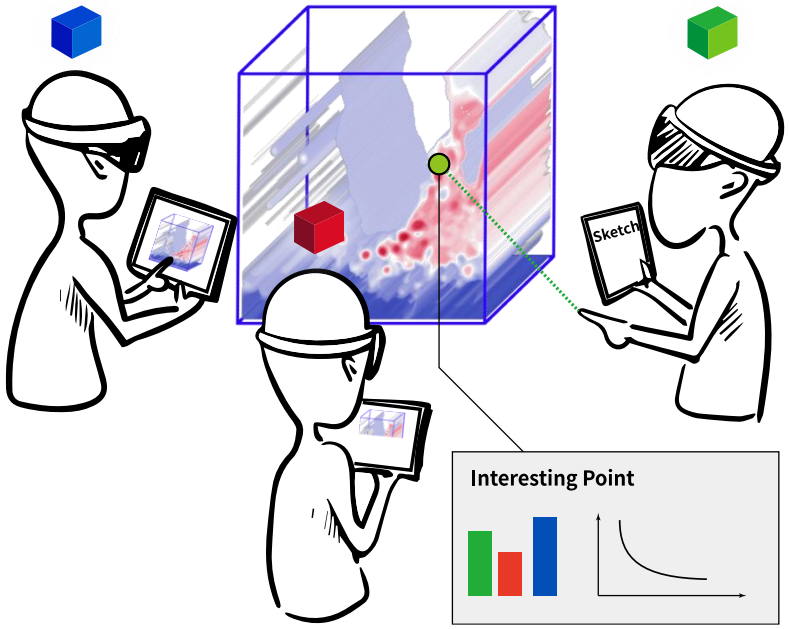
Classical Desktop Environments
ParaView



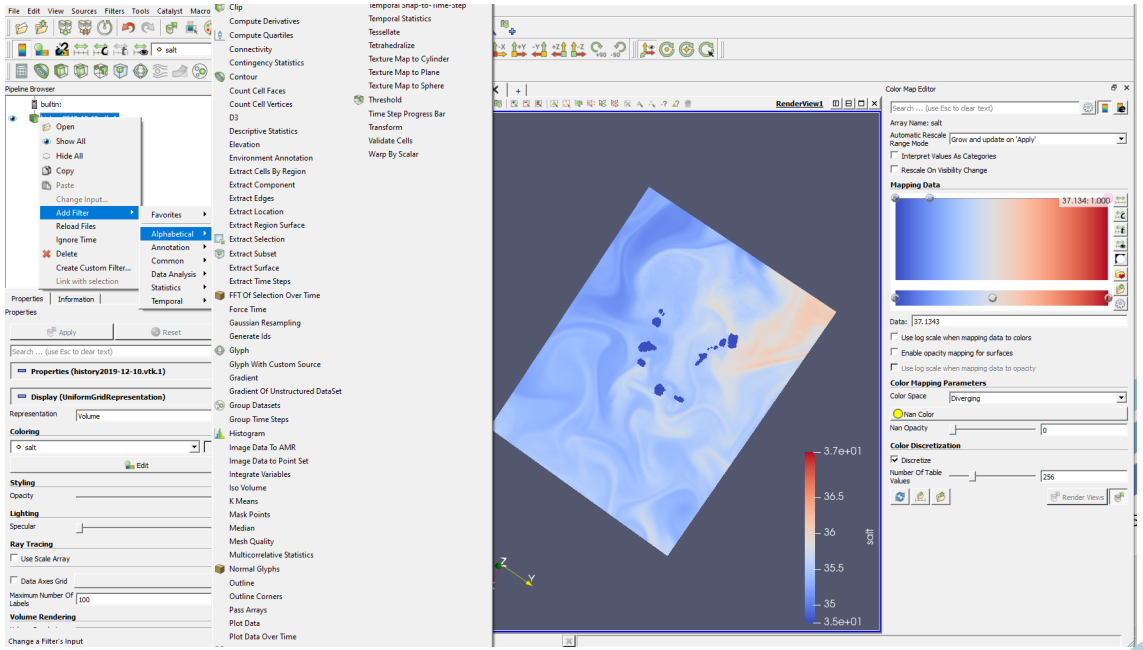
Takeaway messages

Contributions: General understandings of AR-HMDs + Tablets

New AR-Headsets + Tablets Environments



Classical Desktop Environments
ParaView

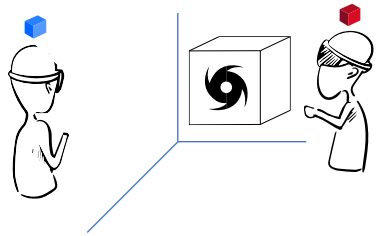


Can be both complete and standalone

Takeaway messages

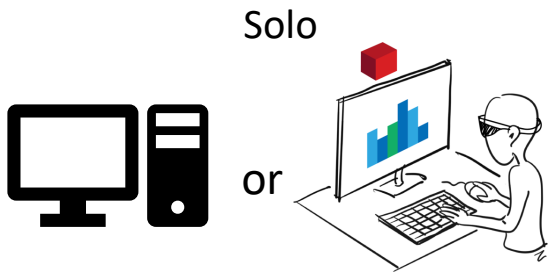
Contributions: General understandings of AR-HMDs + Tablets

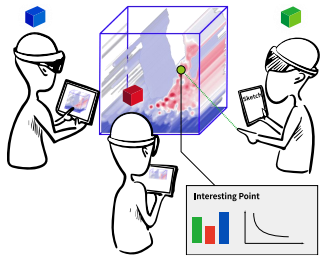
Pros	Cons

• 3D Interactions
  • Tangible
  • Hand
• 3D View
• Decouples 2D Interaction and 3D Rendering
•  Visualization
Interaction
Collaborative — Physical Space
	• 2D interface
	  • 
	• Computing power
	• Touch understood as mid-air gestures
	• Visibility conflicts

Takeaway messages

Contributions: General understandings of AR-HMDs + Tablets



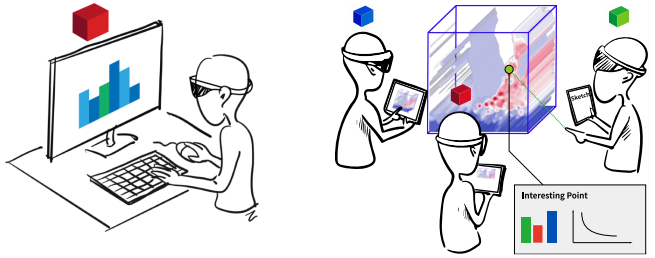


- Pre-process and explore data on computer-based environment

- Share main insights
- Discuss
- Explore alternatives

Credits

- Art: Yumin Hong (https://housenever.github.io/)



- Data: Helmholtz-Zentrum Hereon, Germany

- Code: https://github.com/MickaelSereno/SciVis_Server

Publications

Accepted Full Papers:

1. **Mickael Sereno**, L. Besançon, and T. Isenberg, "Point specification in collaborative visualization for 3d scalar fields using augmented reality," Springer Virtual Reality, 2021, to appear
2. **Mickael Sereno**, X. Wang, L. Besançon, M. J. Mcguffin, and T. Isenberg, "Collaborative work in augmented reality: A survey," TVCG, 2020, to appear
3. X. Wang, L. Besançon, D. Rousseau, **Mickael Sereno**, M. Ammi, and T. Isenberg, "Towards an understanding of augmented reality extensions for existing 3D data analysis tools," CHI, 2020
4. L. Besançon, **Mickael Sereno**, M. Ammi, L. Yu, and T. Isenberg, "Hybrid touch/tangible spatial 3D data selection," EuroVis, 2019

Publications

Full Papers In Submission:

5. **Mickael Sereno**, S. Gosset, L. Besançon, and T. Isenberg, "Hybrid touch/tangible spatial selection in augmented reality," EuroVis, 2022

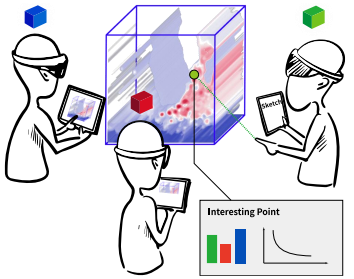
Workshop Papers:

6. X. Wang, L. Besançon, F. Guéniat, **Mickael Sereno**, M. Ammi, and T. Isenberg, "A vision of bringing immersive visualization to scientific workflows," CHI-IA, 2019

Extended Abstracts (Posters):

7. **Mickael Sereno** and T. Isenberg, "Subjective views in co-located augmented reality — initial design," VIS, 2020
8. S. Gosset, **Mickael Sereno**, L. Besançon, and T. Isenberg, "Tangible volumetric brushing in augmented reality," VIS, 2020
9. **Mickael Sereno**, L. Besançon, and T. Isenberg, "Supporting volumetric data visualization and analysis by combining augmented reality visuals with multi-touch input," EuroVis, 2019

Thank You!



RQ1 *How complementary can multi-touch tablets and AR-HMDs be to collaboratively explore 3D data?*

RQ2 *To specify points in volumetric dataset, what interaction technique(s) support(s) best users' understanding, co-presence, and performance, in a collaborative AR environment?*

RQ3 *To specify regions of interest, what are the implications of a tangible multi-touch tablet where its 3D position has meanings in the AR space compared to the original Tangible Brush which decouples the input and output spaces?*

RQ4 *As a side effect (post-hoc research question) of the interaction modalities I studied, what are the main benefits and limitations of direct interaction mappings compared to remote ones for one-user and collaborative environments?*

RQ5 *What are the subjective views advantages and disadvantages during the collaboration following the modifier and appearance dimensions for volumetric scientific datasets? Which interaction techniques and visualizations support them best with regard to the users' understanding, co-presence, and performance?*