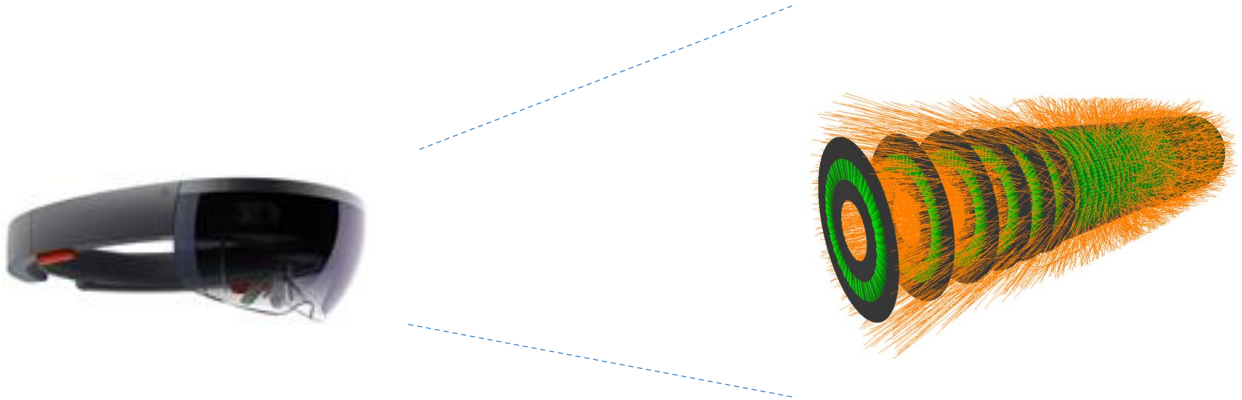

Visualization with Virtual and Augmented Reality

Tobias Isenberg and Xiyao Wang

informatics mathematics
Inria

Who are we?

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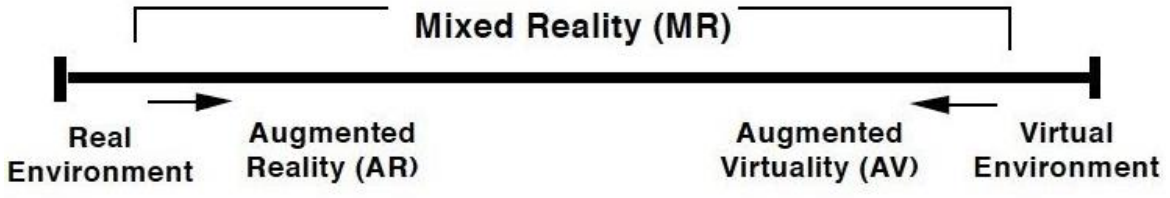
What are VR and AR?



Reality-Virtuality (RV) Continuum

[Milgram and Kishino 1994]
images: Microsoft and Oculus

Real environments with virtual data/objects

Users can interact with real world

Entirely virtual environments

Users are isolated from real world

Compared to traditional screen

less immersion

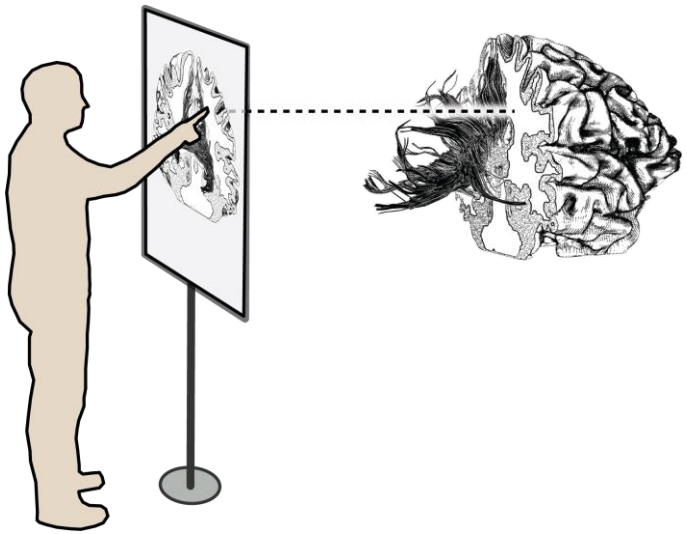
high visual immersion

images: Univ. Groningen, LG, A. Wiebel

→ good stereo perception only w/ interaction ~~→~~ stereo perception w/o interaction
→ ppl. can understand 3D data well

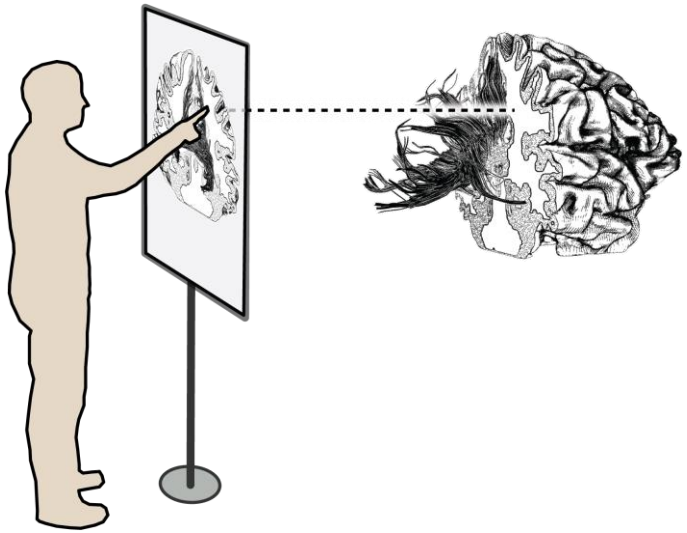
Scientific Visualization with Stereo

- Does not rely on projection



Scientific Visualization with Stereo

- Does not rely on projection
- Make use of spatial input devices
  (direct mapping)



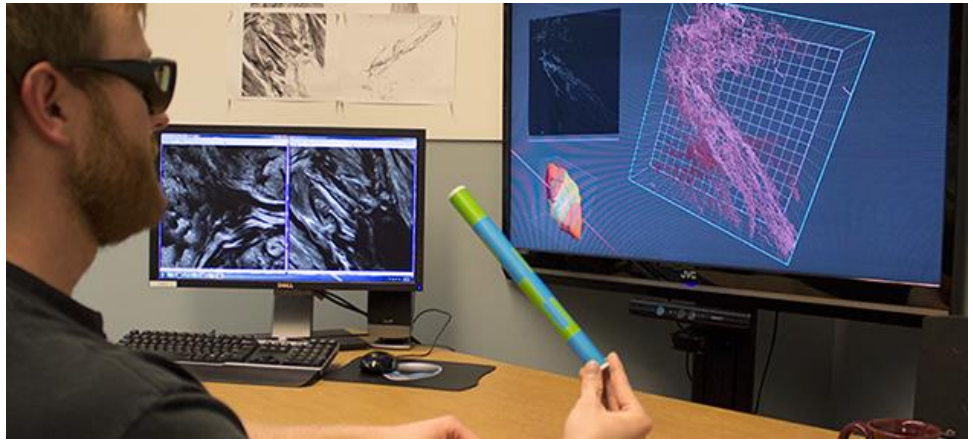


image Daniel F. Keefe

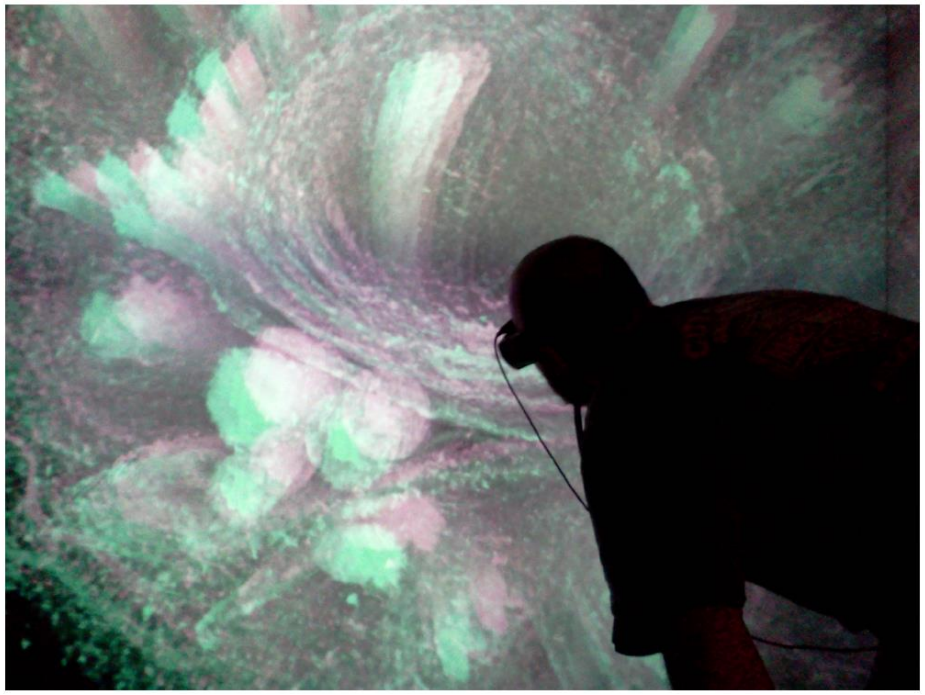
Scientific Visualization with Stereo

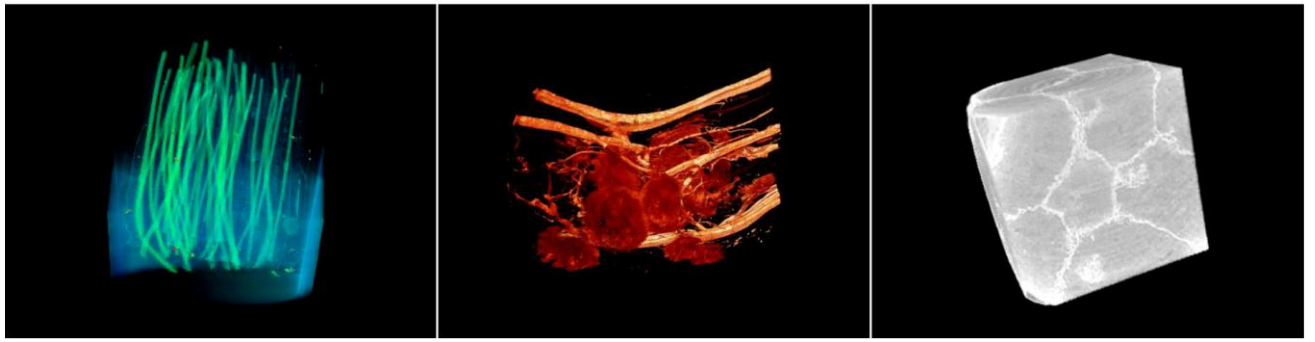
- Immersion helps data understanding

[Prabhat et al. 2008]

Scientific Visualization with Stereo

- Immersion helps data understanding

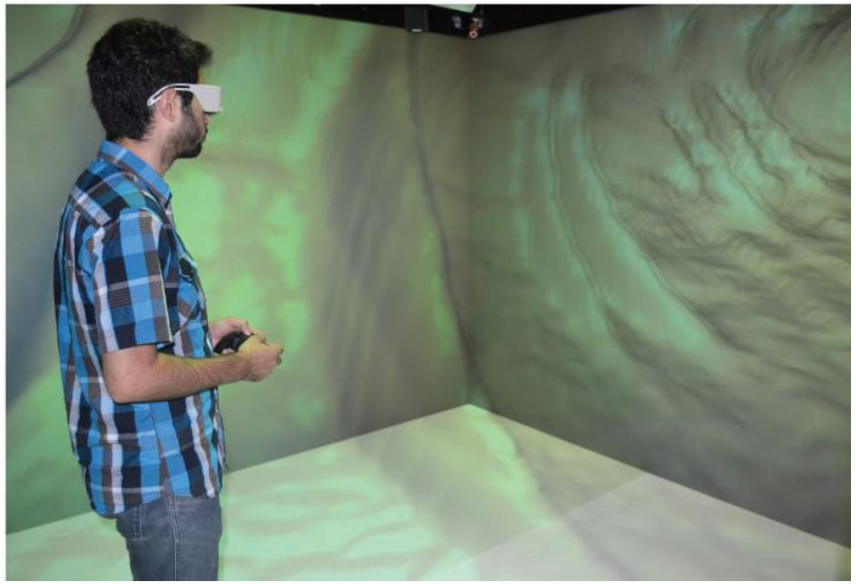




[Laha et al. 2012]

Scientific Visualization with Stereo

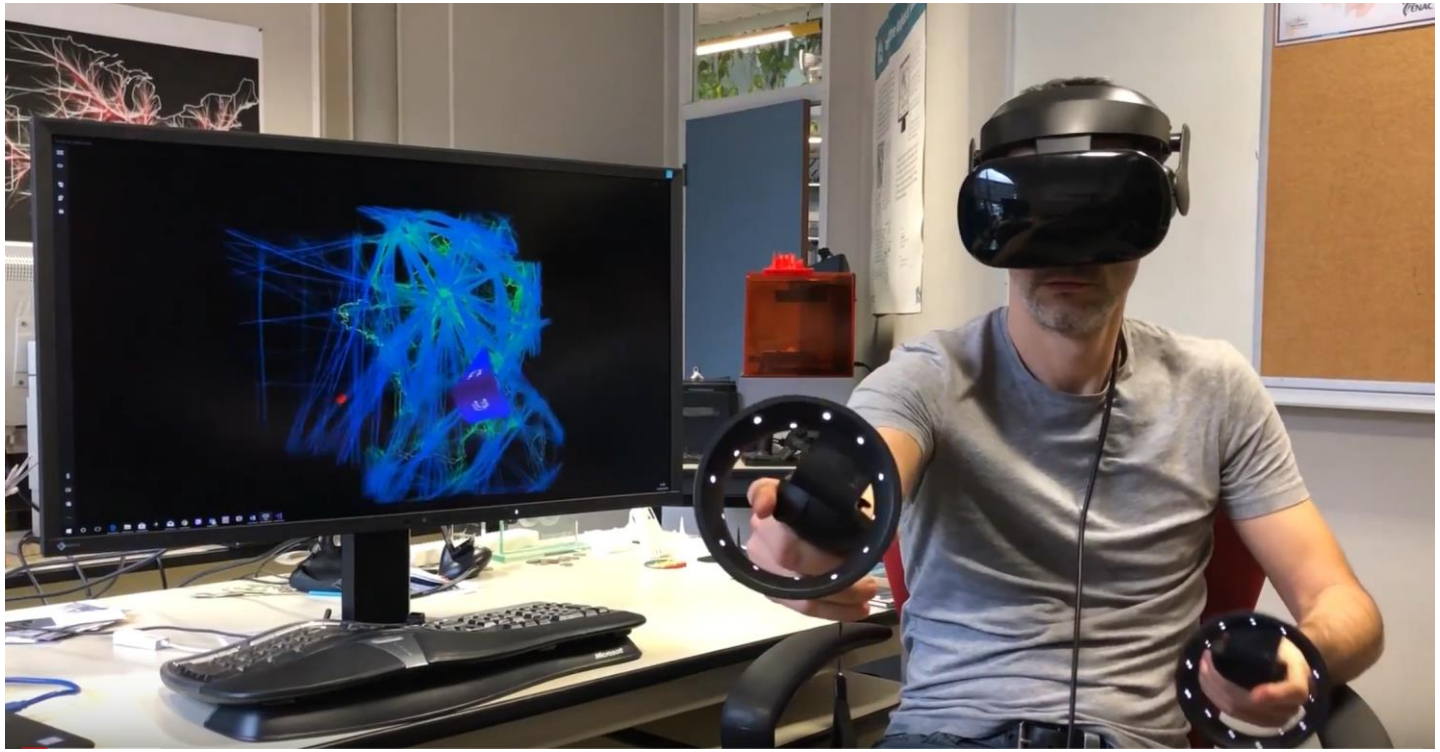
- Immersion helps data understanding



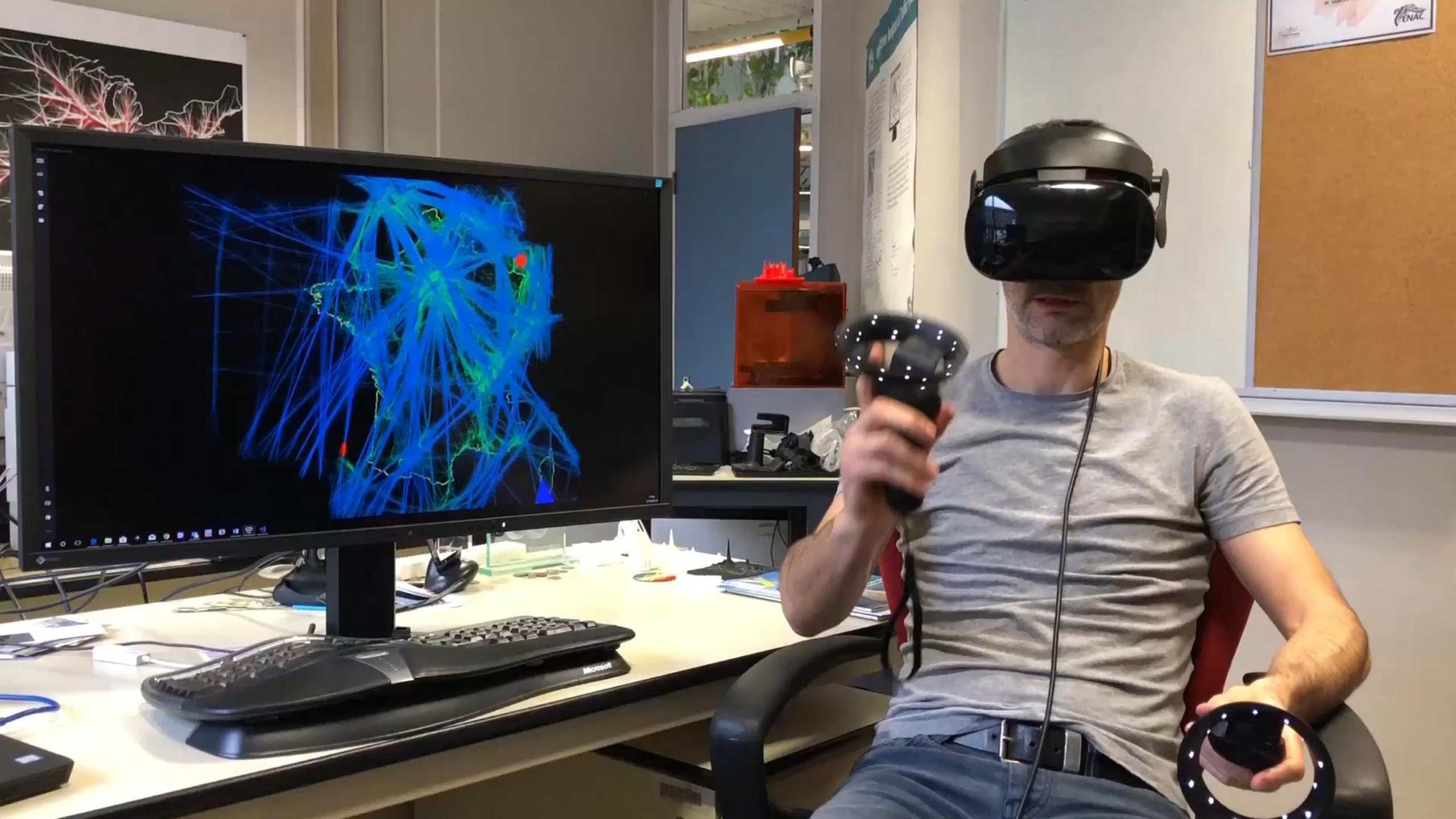
[Mirhosseini et al. 2014]

Some examples

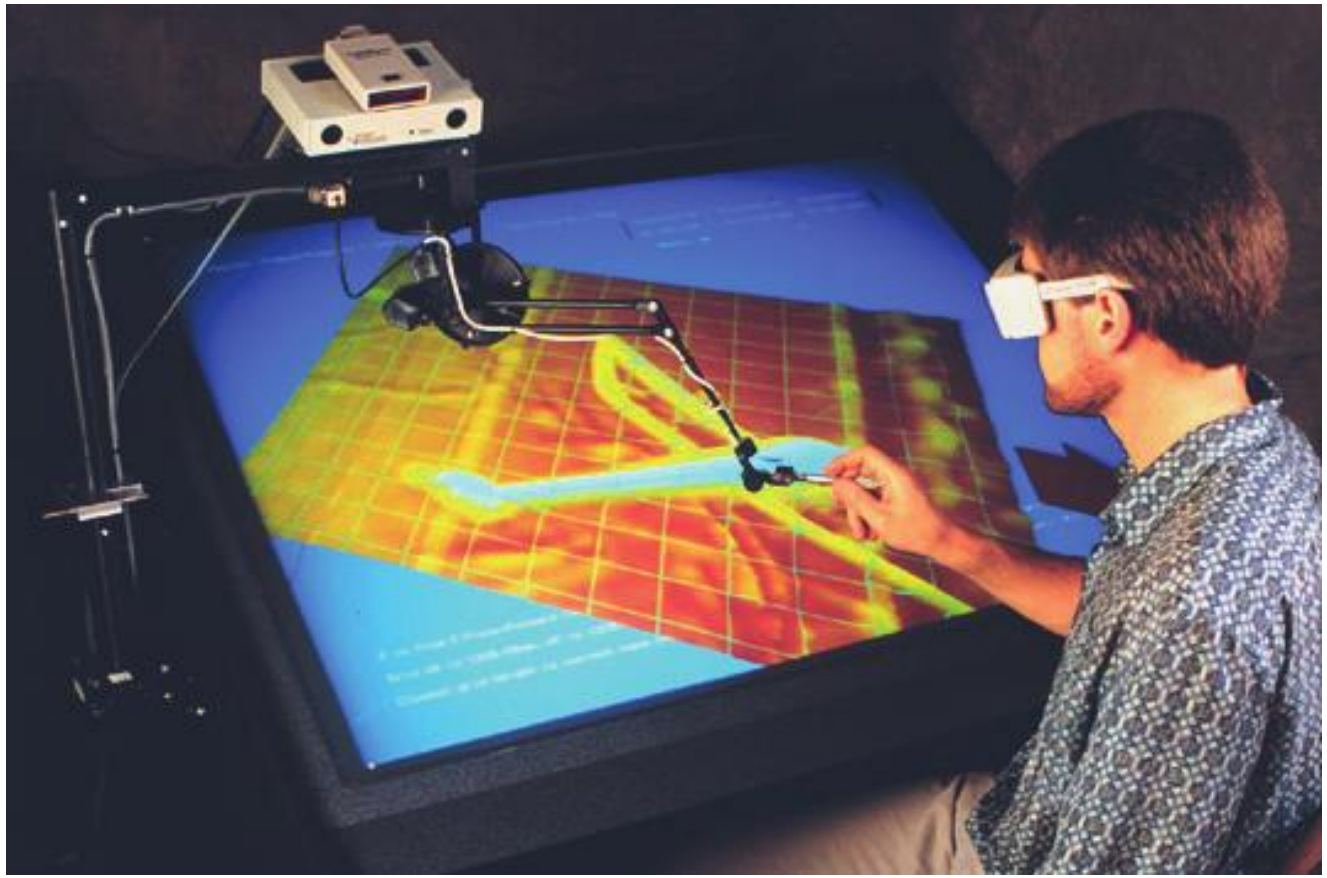
- **Fully stereoscopic view**



[Hurter et al. 2018]


Microsoft

Some examples



[Taylor, II, et al. 1993]

Some examples

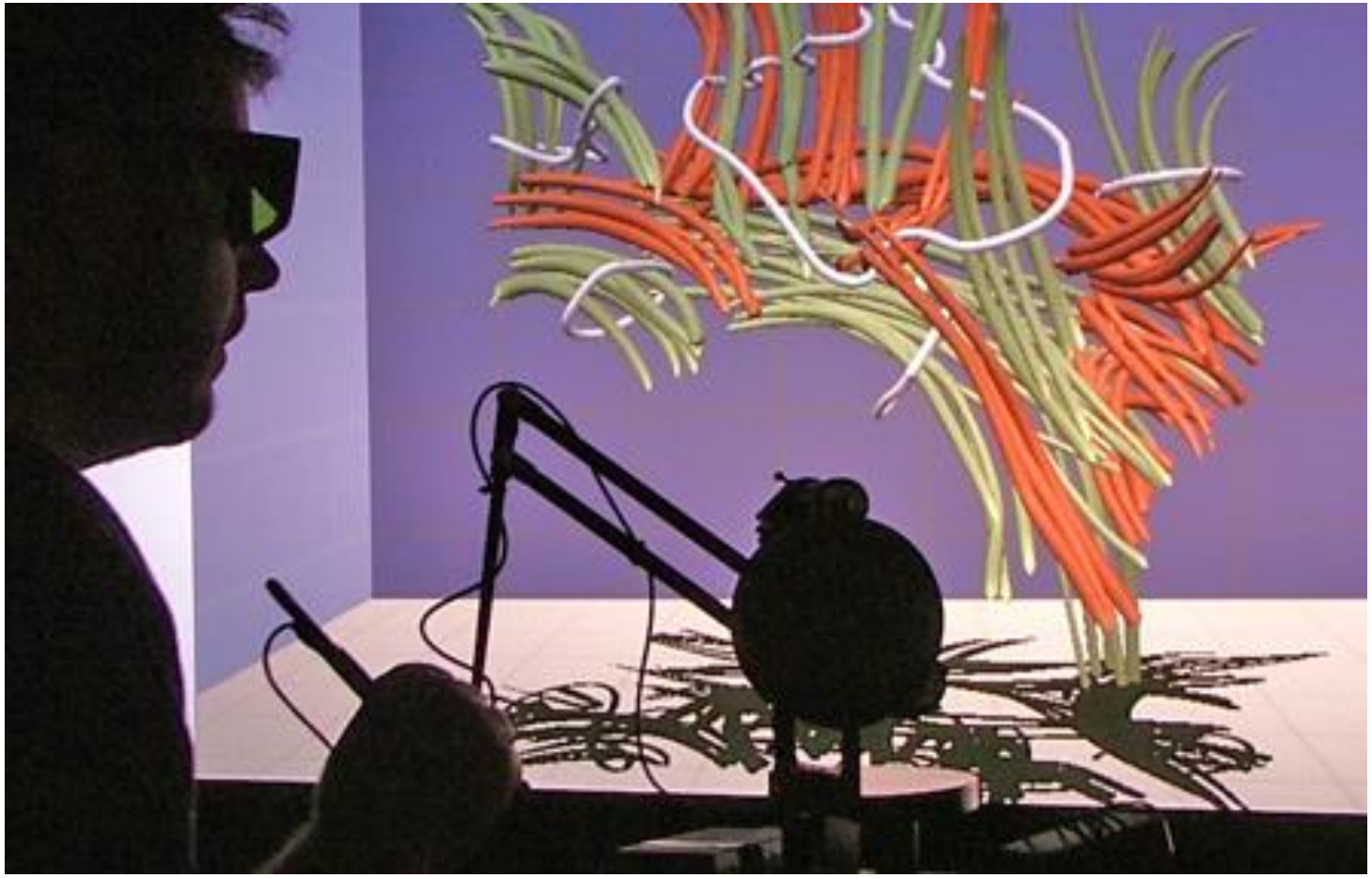
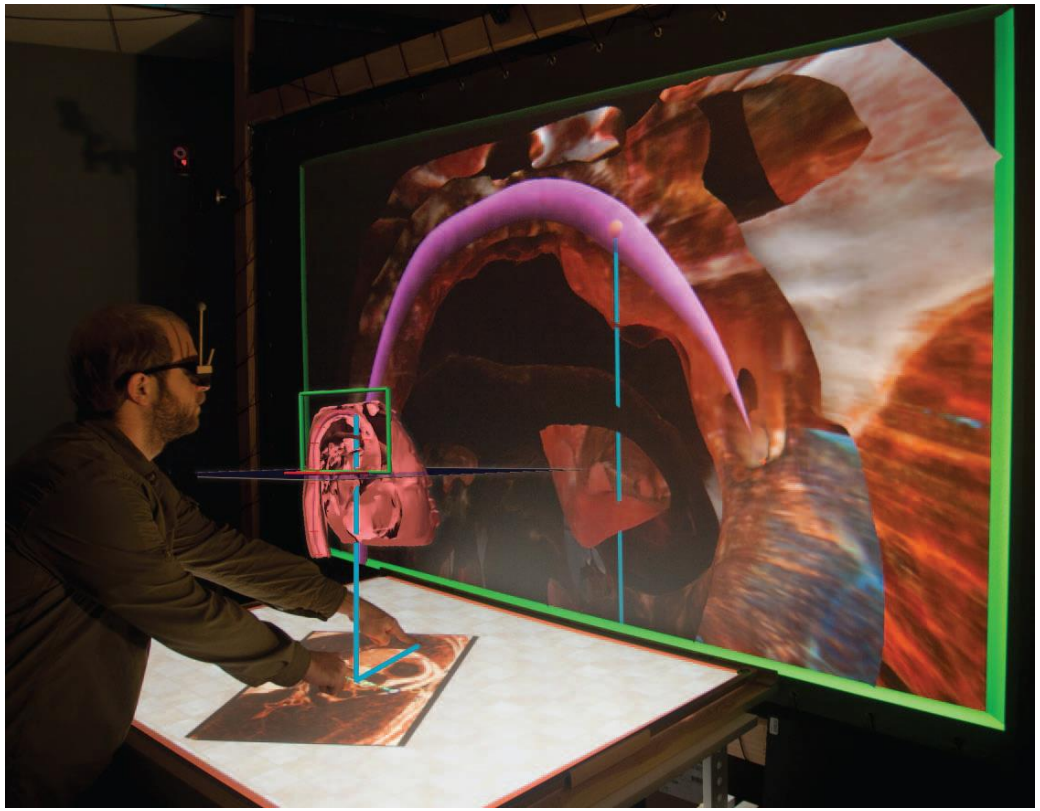


image: Daniel F. Keefe

Some examples

- **Multiple views with stereoscopic view + touch input**



[Coffey et al. 2011/2012]

Some examples

- **Multiple views with stereoscopic view + special input**

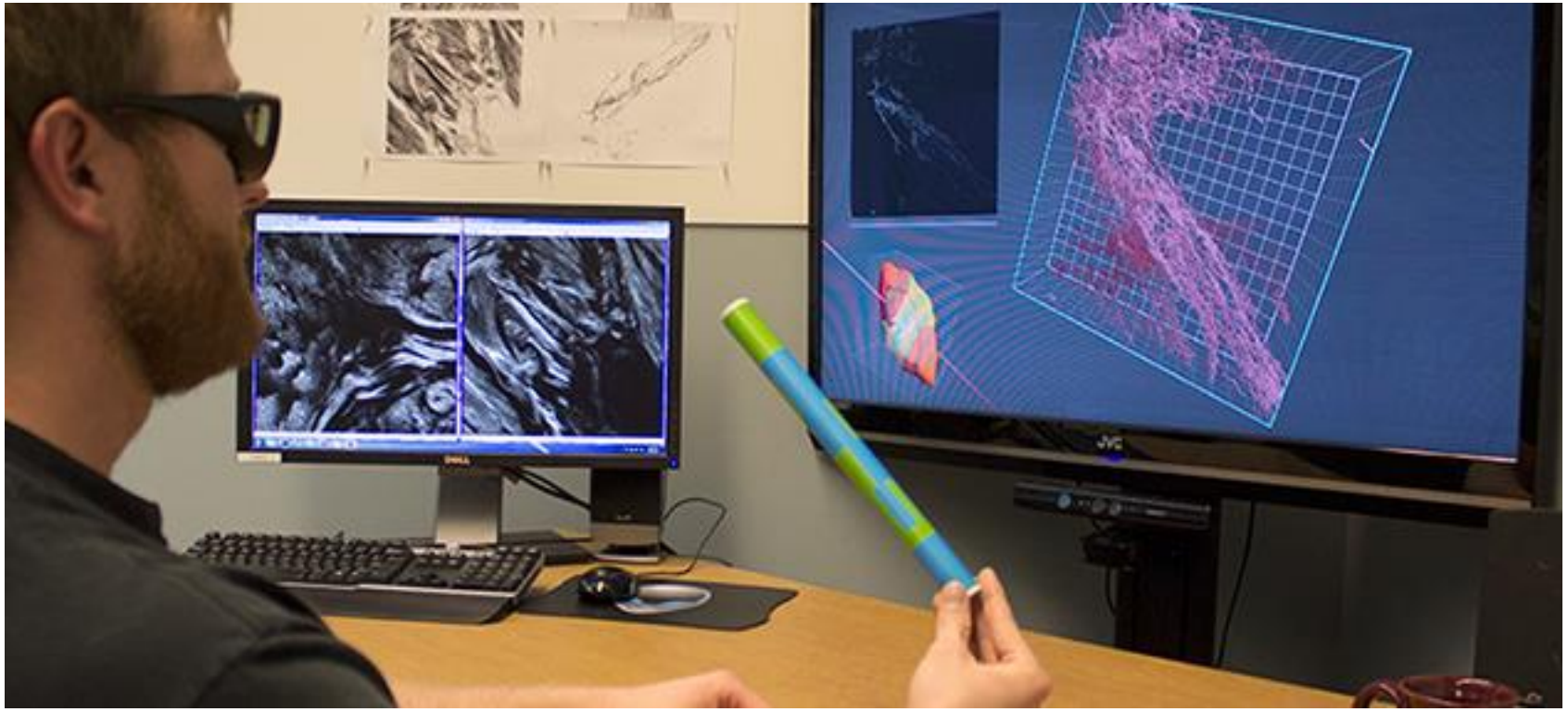
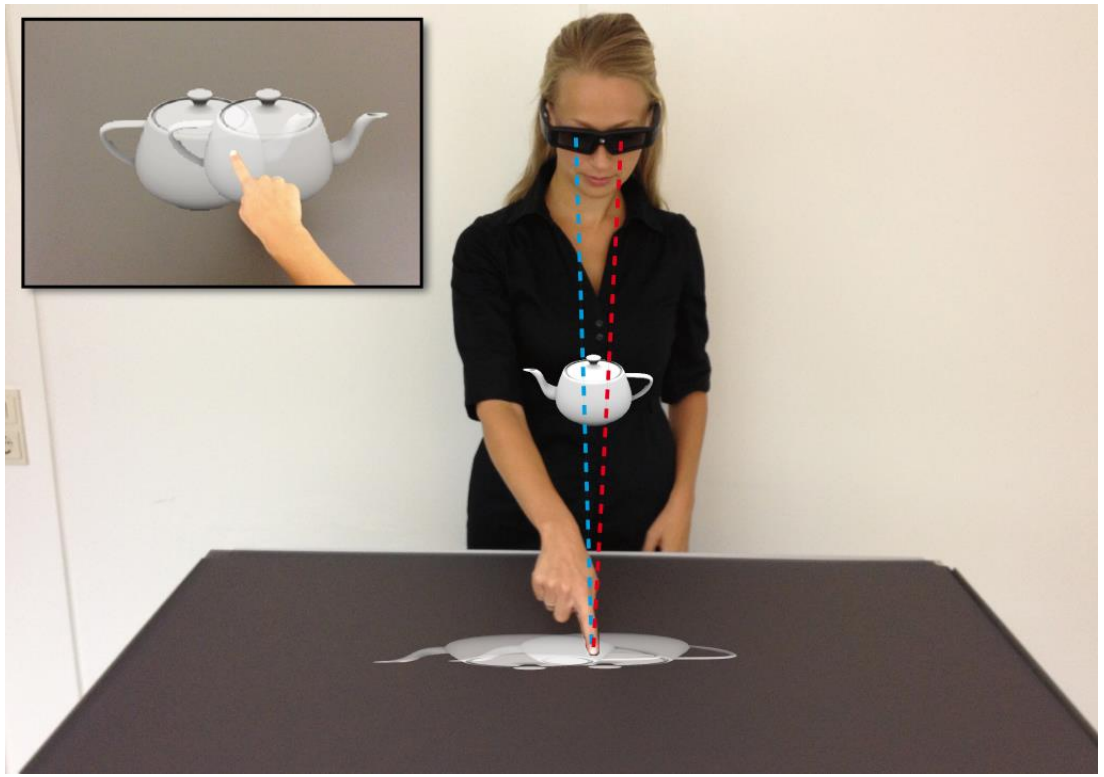
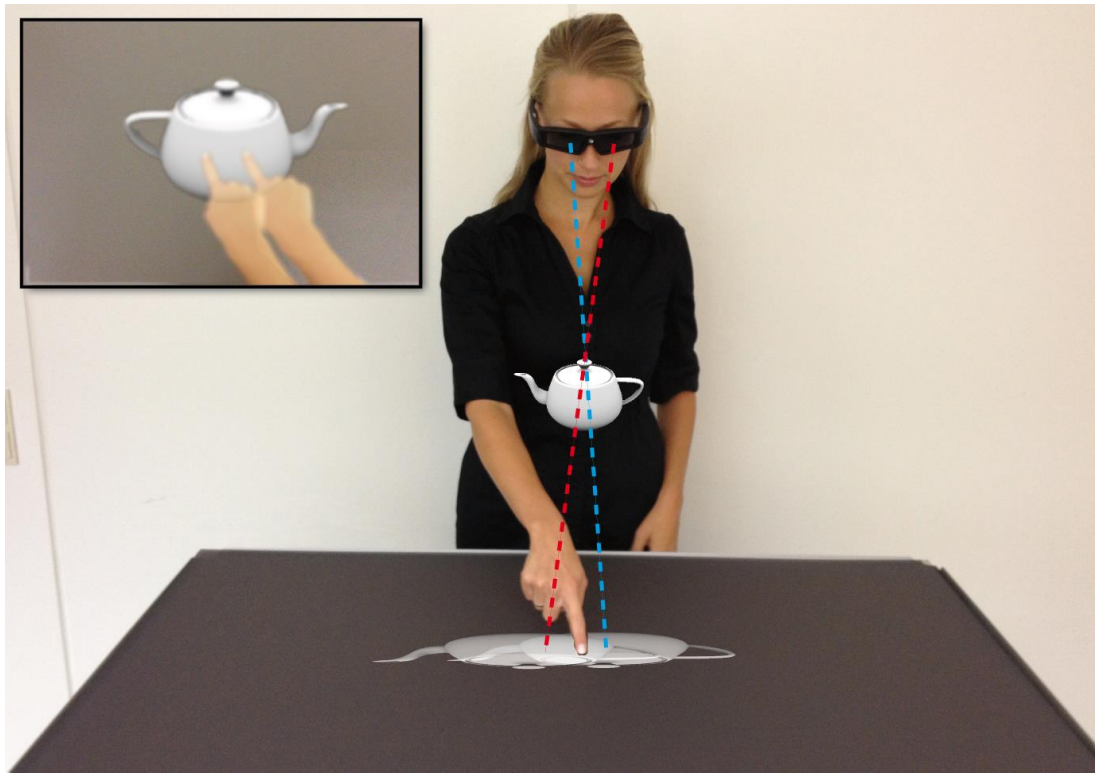


image Daniel F. Keefe

Interaction has to be tailored to the view

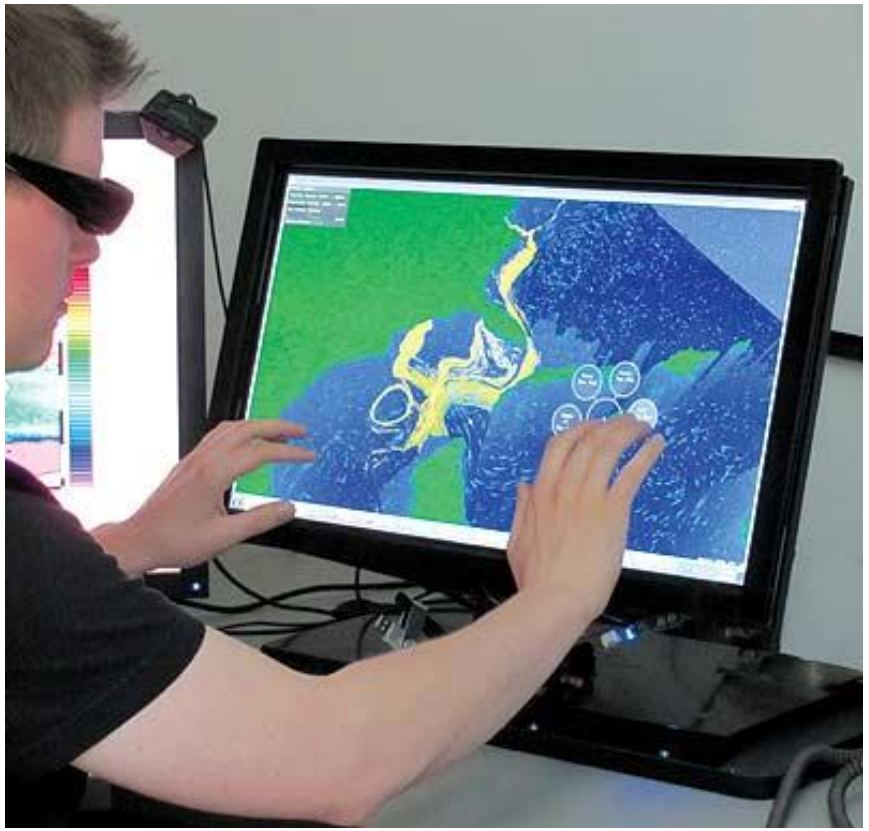




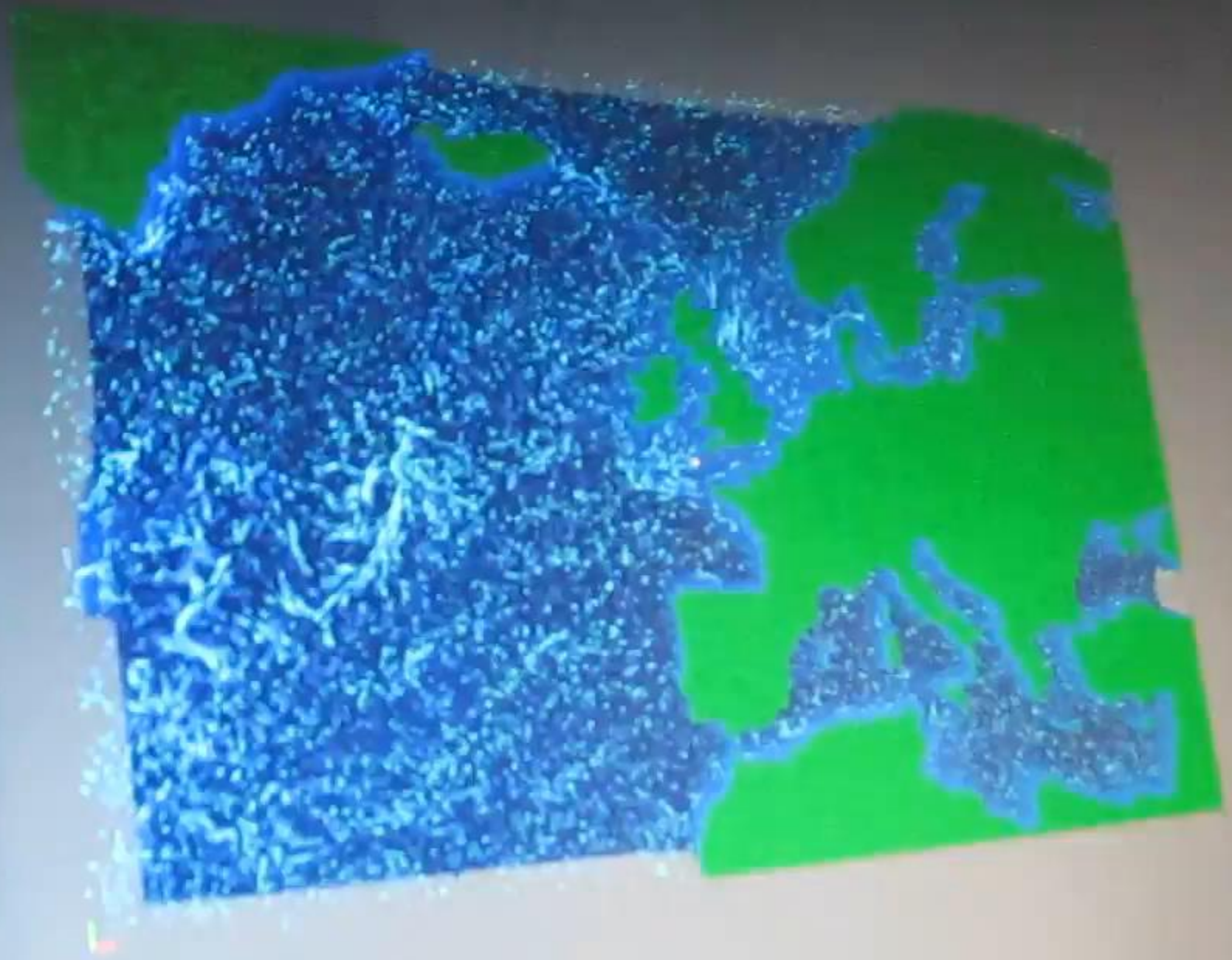
[Bruder et al. 2013]

Interaction has to be tailored to the view

- Stereo view + touch input that works

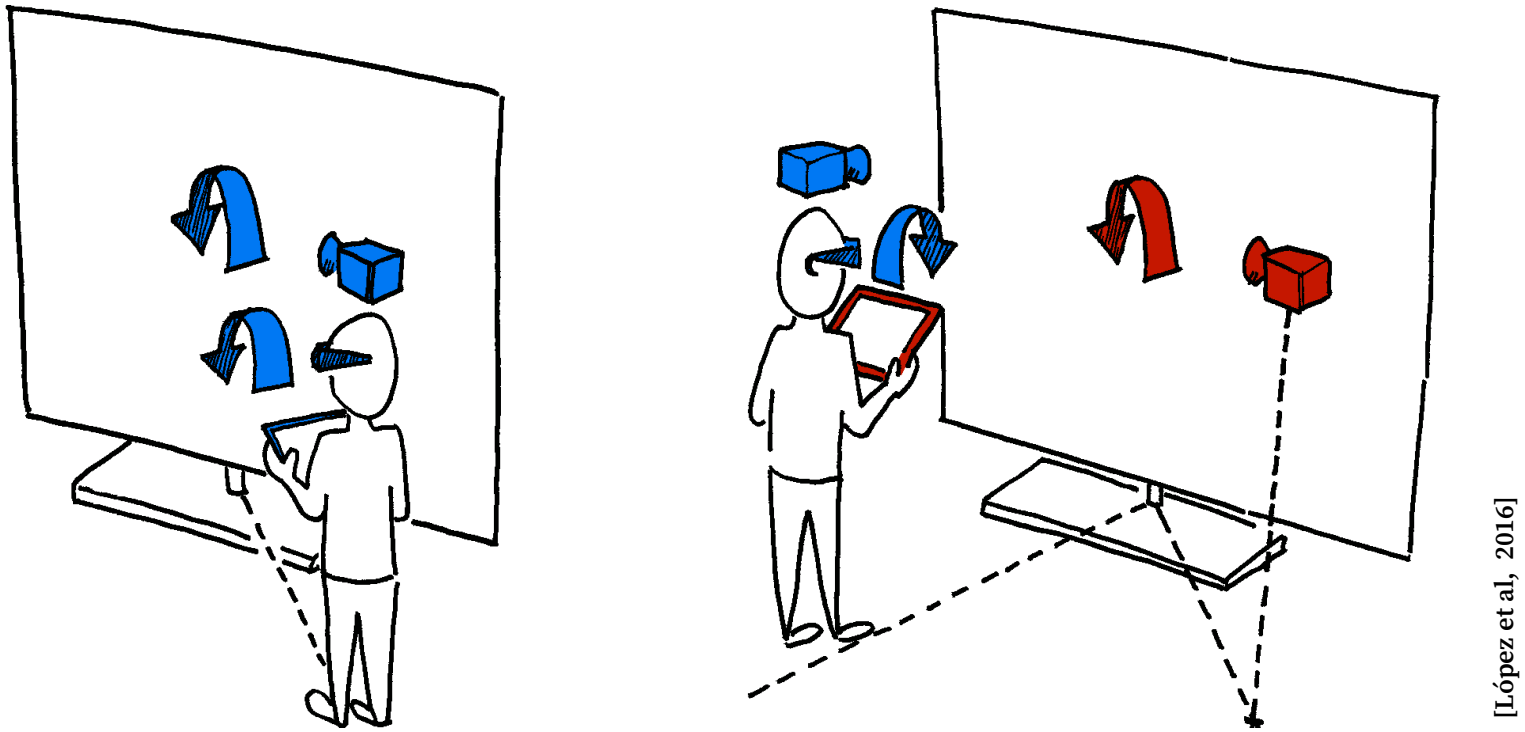


[Butkiewicz & Ware, 2011]



Tangible displays & stereoscopy

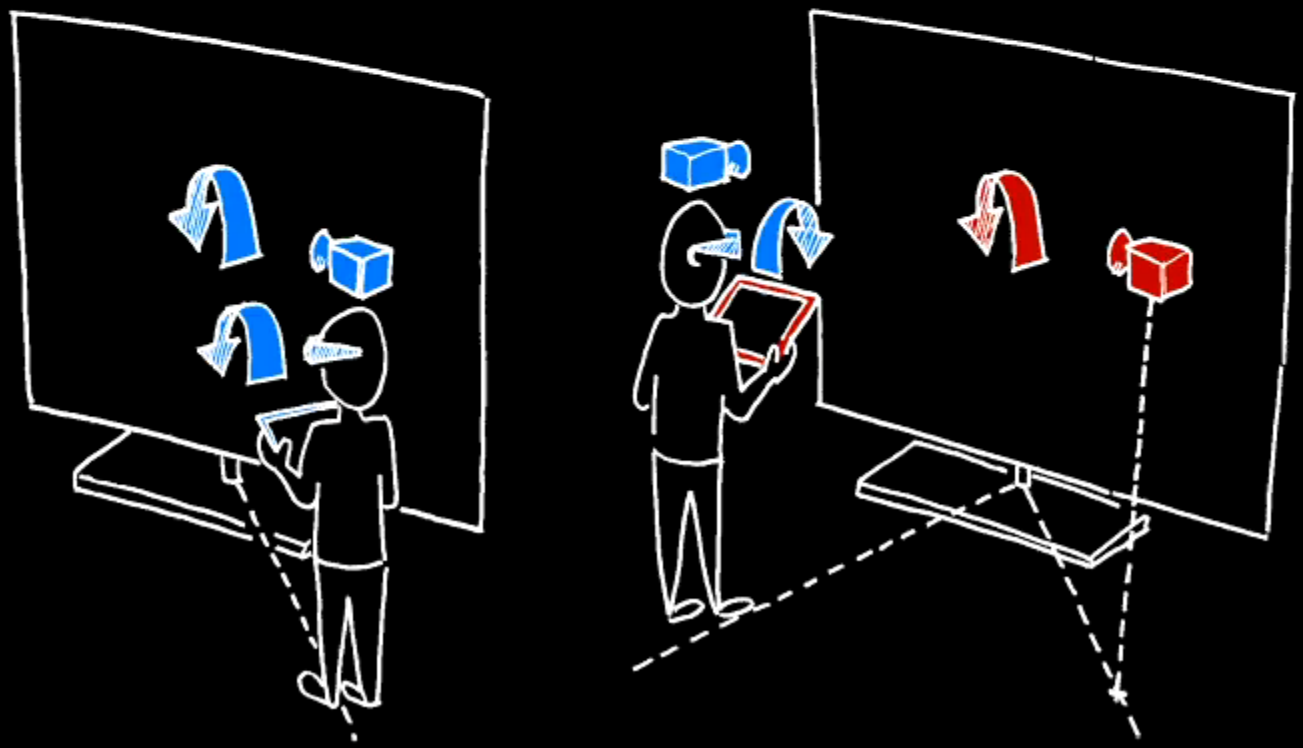
- **Mobile interaction with stereo**



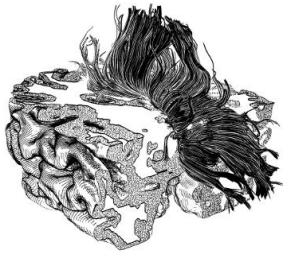
[López et al, 2016]

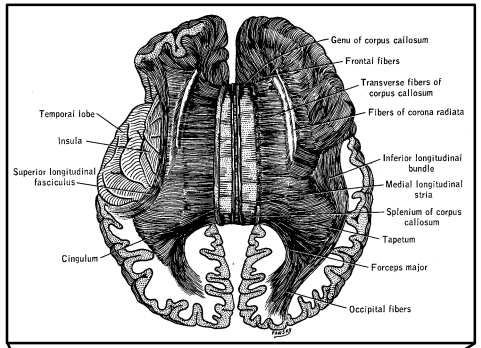
Towards an Understanding of Mobile Touch Navigation in a Stereoscopic Viewing Environment for 3D Data Exploration

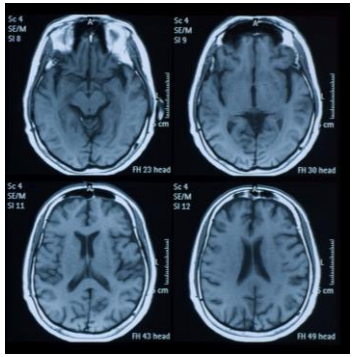
David López
Lora Oehlberg
Candemir Doger
Tobias Isenberg



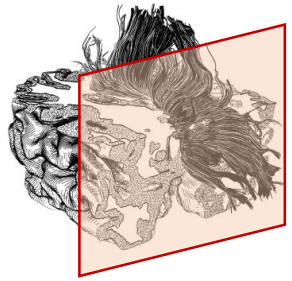
Visual representation and interaction







$$
\begin{array}{ccccc}
 & & \mathscr{V} & \xrightarrow{o} & \mathscr{O} \\
 & \overset{v}{\nearrow} & \downarrow{\scriptstyle vi} & & \downarrow{\scriptstyle om} & \overset{u_p}{\searrow} \\
\mathscr{D} & & & & & & \mathscr{U} \\
 & \underset{i}{\swarrow} & & & & \underset{u_a}{\nwarrow} \\
 & & \mathscr{I} & \xleftarrow{m} & \mathscr{M}
\end{array}
$$

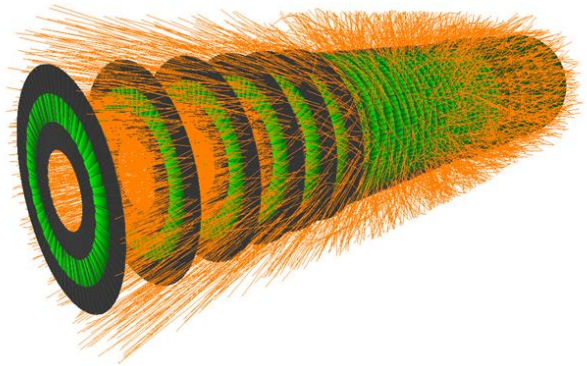


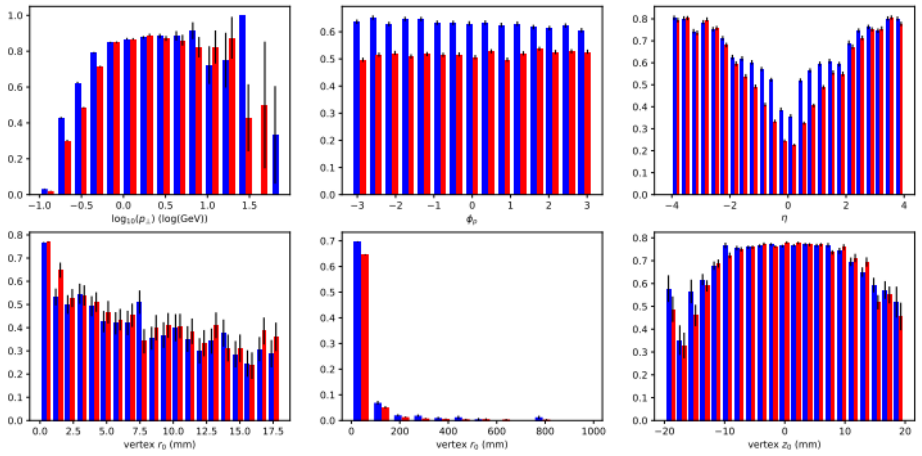
[with S. Bruckner, T. Ropinski, and A. Wiebel, hopefully to appear soon]

What do we want to do?

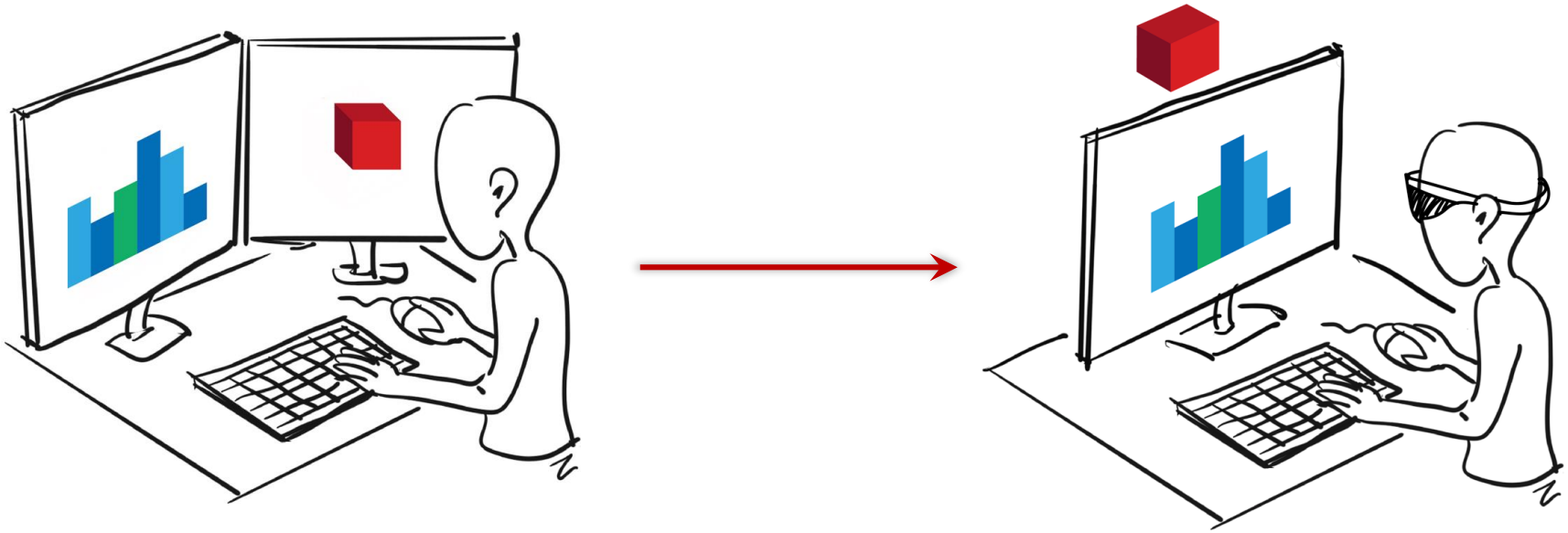
Bring the visual immersion for HEP data analysis.

Current case: understanding the results of TrackML challenge



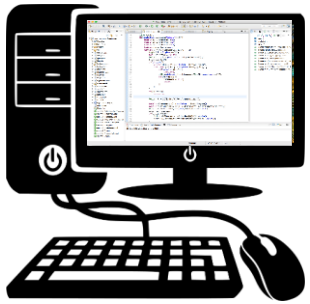


What do we envision?



Two linked views.
People can interact with each view.
Pointer goes from one to another.

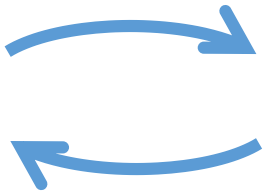
Why do we use such combination?

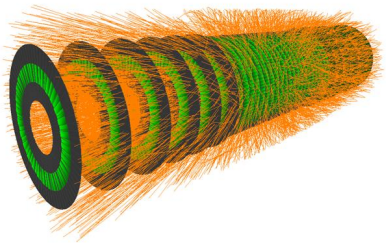


Traditional analysis tools
Familiar environments

Typing, precise input, …

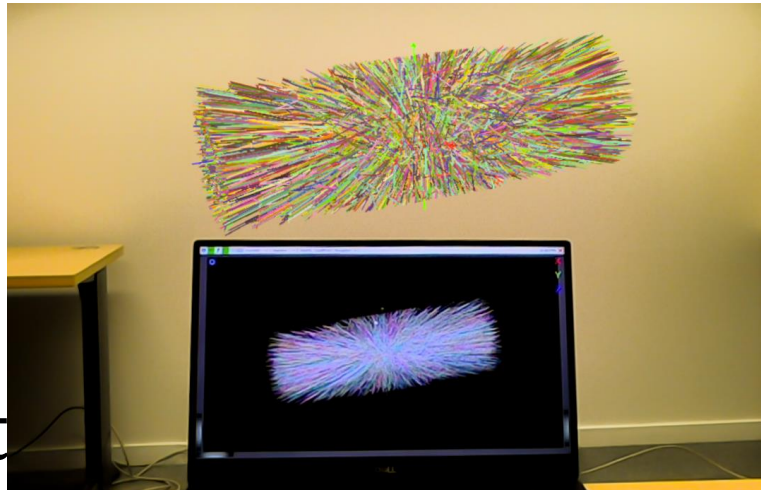
Visual immersion
Not separated from real world
Other input forms

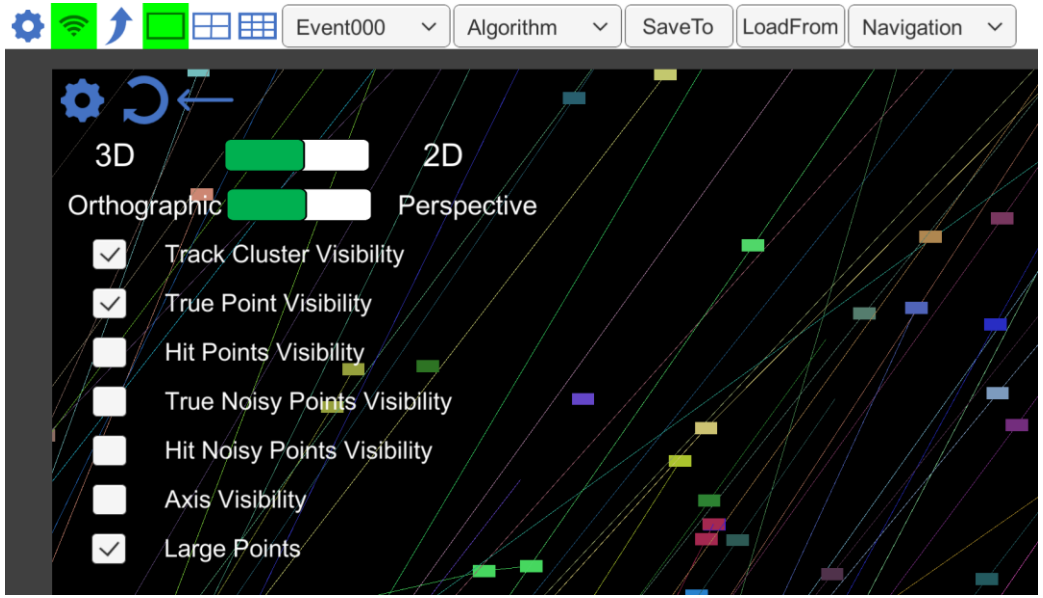


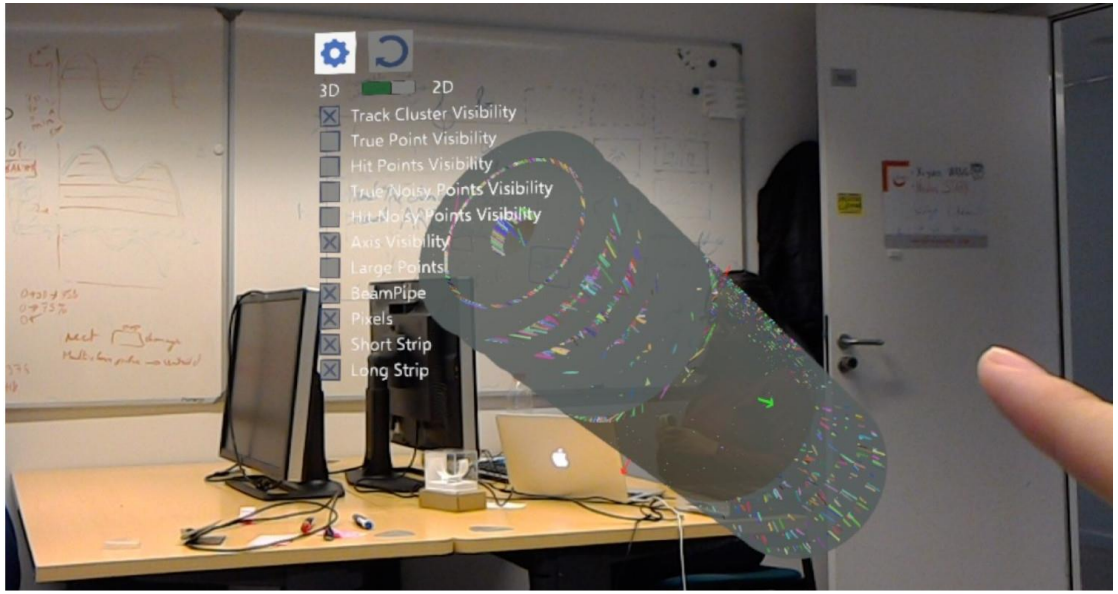


Initial design

- Interaction can be performed on both
- Linked views with the same dataset.
- Similar user interface and functionalit

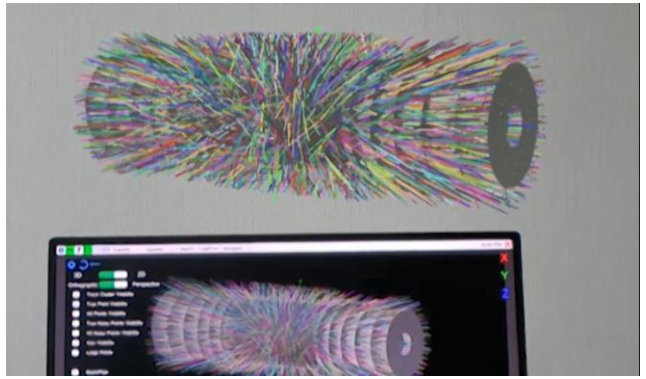


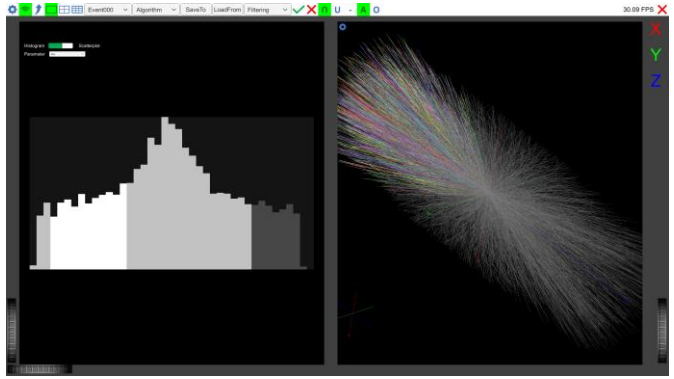


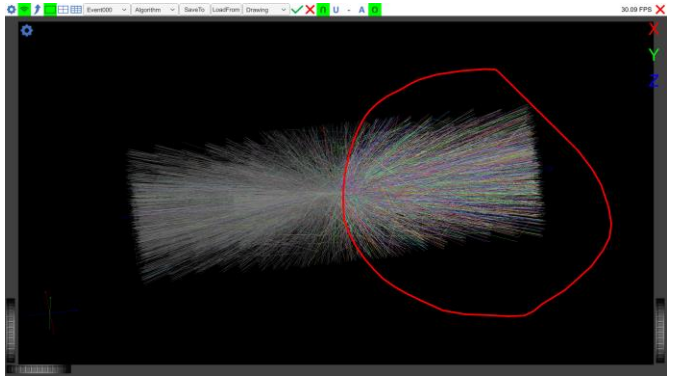


Prototype

- Navigation
- Abstraction of data and detector meshes.
- Filtering and highlighting.







Study

- **We preformed an observational study.**

Major feedback

- **Stereoscopic view offers better depth clue, benefiting the spatial understanding of the event, and for example, following the trajectories and observing their spatial arrangements.**
- **The unlimited working space of AR could be useful for complex analysis (while 2D screen has a fixed size).**
- **Being able to walk around the data has huge potentials compared to interaction on PC.**

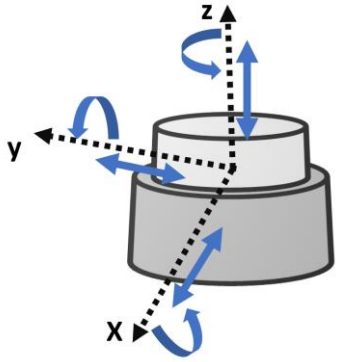
Major feedback

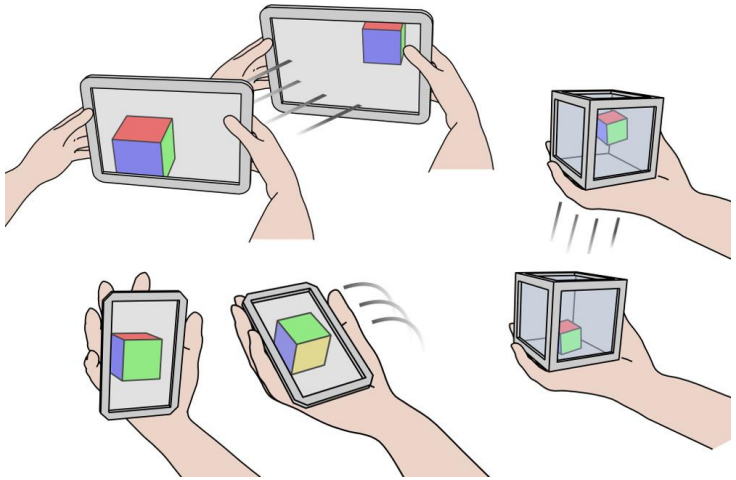
- Keeping the laptop and mouse is useful for precise interaction, and for dense information display (for its high resolution).
- Mouse is not appreciated for AR space, what kind of input device can be used to unify the interaction across spaces?
- Users lose interaction and context while walking around.

Input and interaction techniques

- 3D input device to match the stereo view in AR?

3D Mouse?



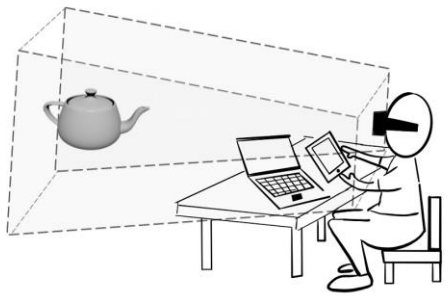
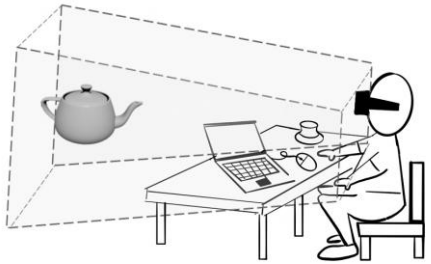
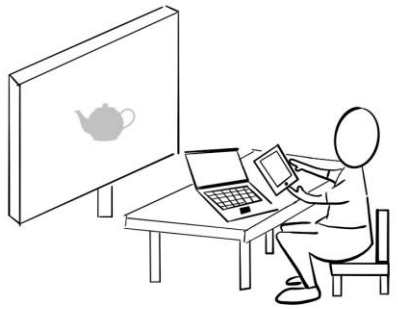
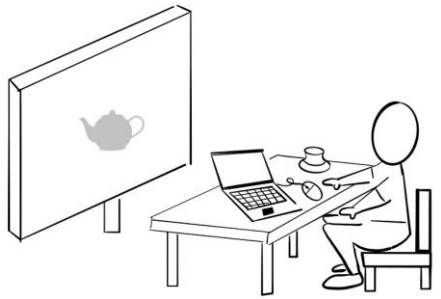


Tangible devices?

Map the interaction to a physical object's movement.

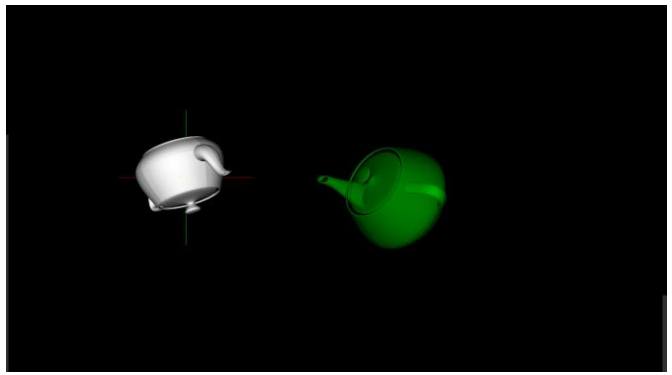
Input and interaction techniques

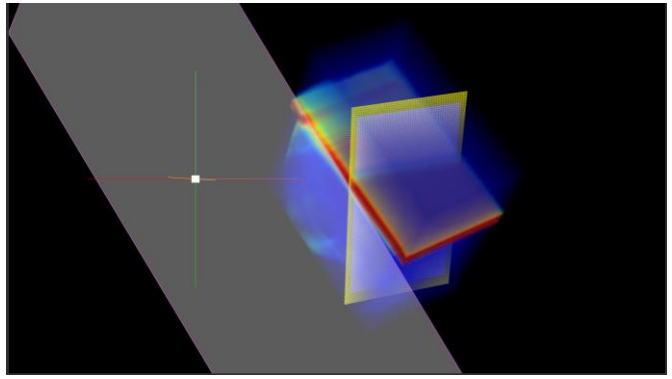
- **Study the mis-match of dimensionality between input and output devices.**
  - **Would 2D(3D) input match better the 2D(3D) output?**

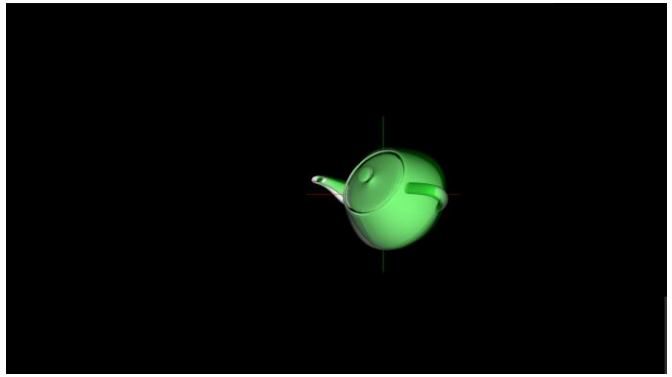





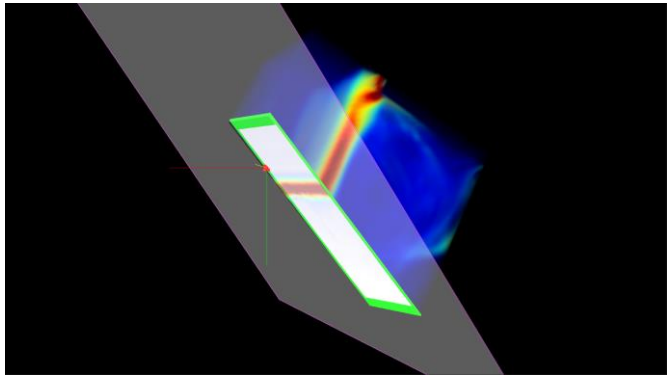
Input and interaction techniques

- 3D Docking task & 3D clipping plane task



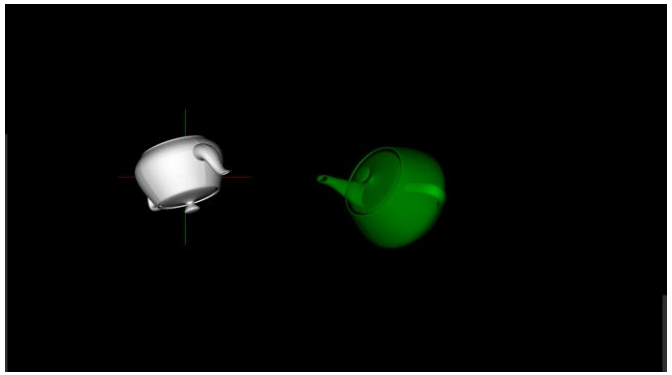


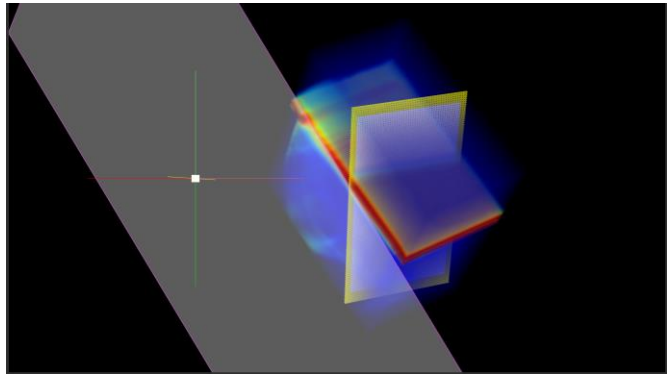




Input and interaction techniques

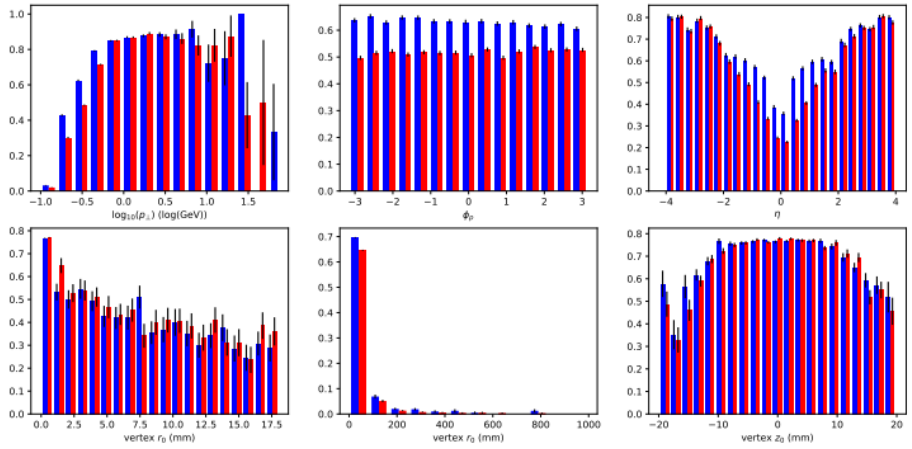
- 3D Docking task & 3D clipping plane task
  - Tangible device is more nature for rough 3D manipulation.
  - Mouse still has the most previse results for specific tasks.

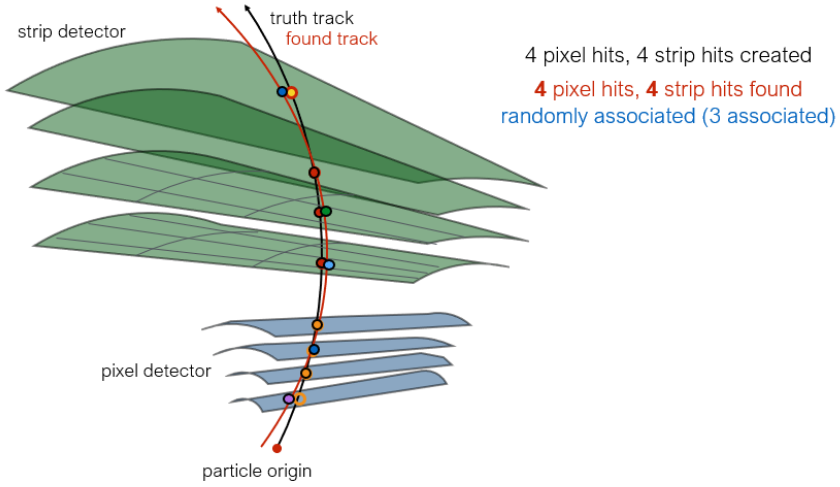




Questions

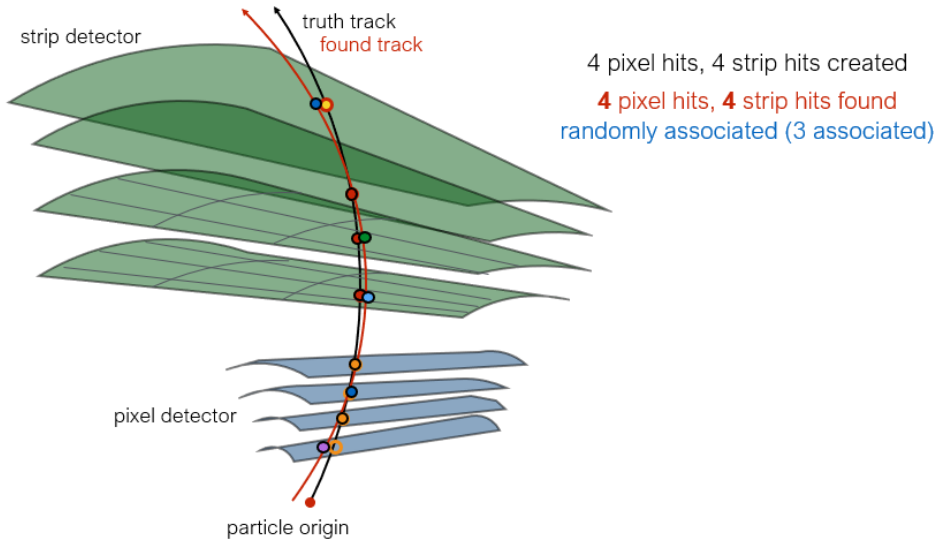
- How can we relate 2D graphs/plots and 3D representations?
  - Do we go back and forth between them?
  - Is one more important than the other, or are all equally important?





Questions

- **In addition to scoring the results, how do we work with 3D representations to compare two or more ML-based results?**



Visualization with Virtual and Augmented Reality

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