

Using Space Around Us for Immersive Analytics

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Immersive Analytics Lab
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MONASH
University

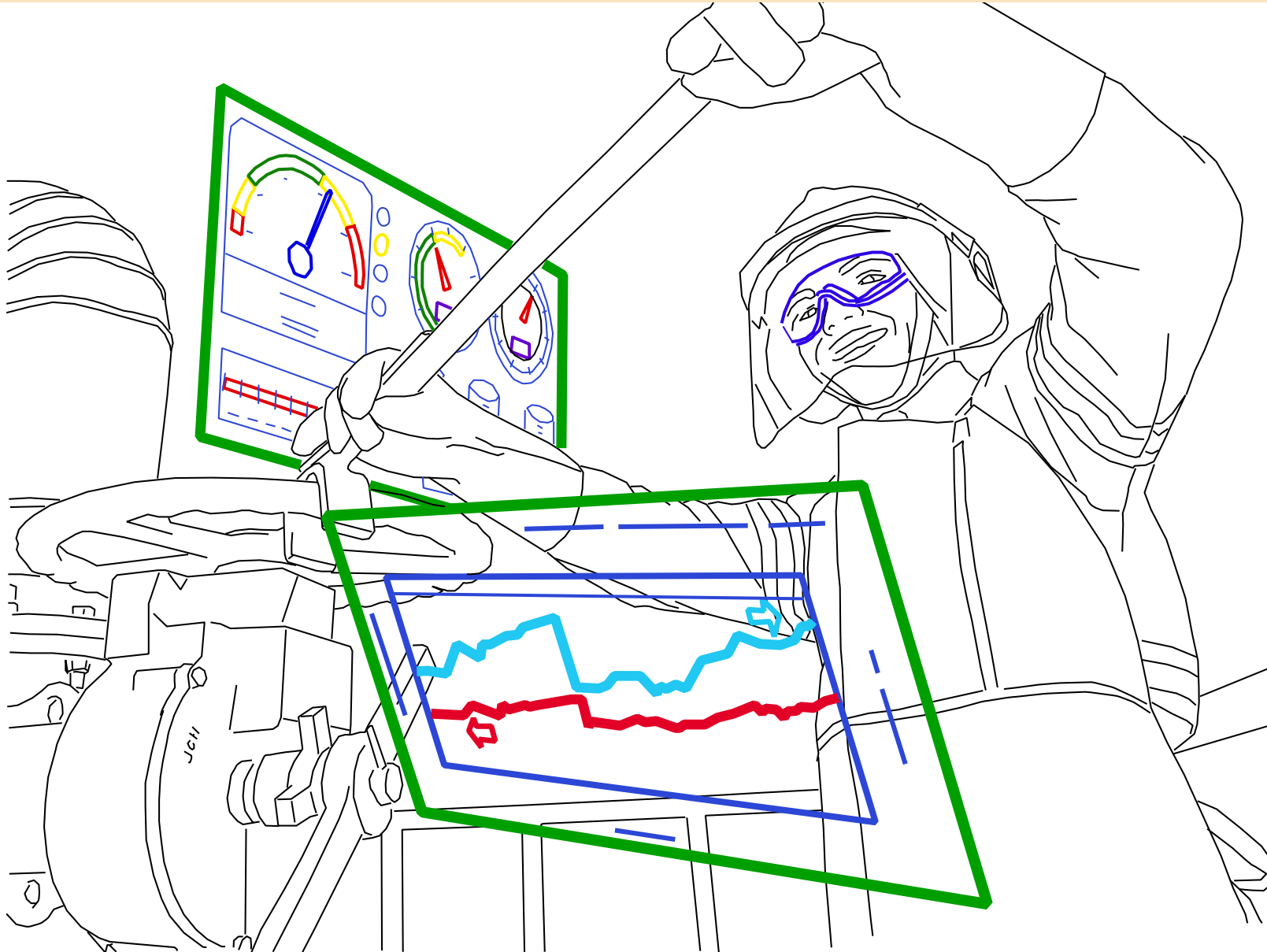
visual analytics



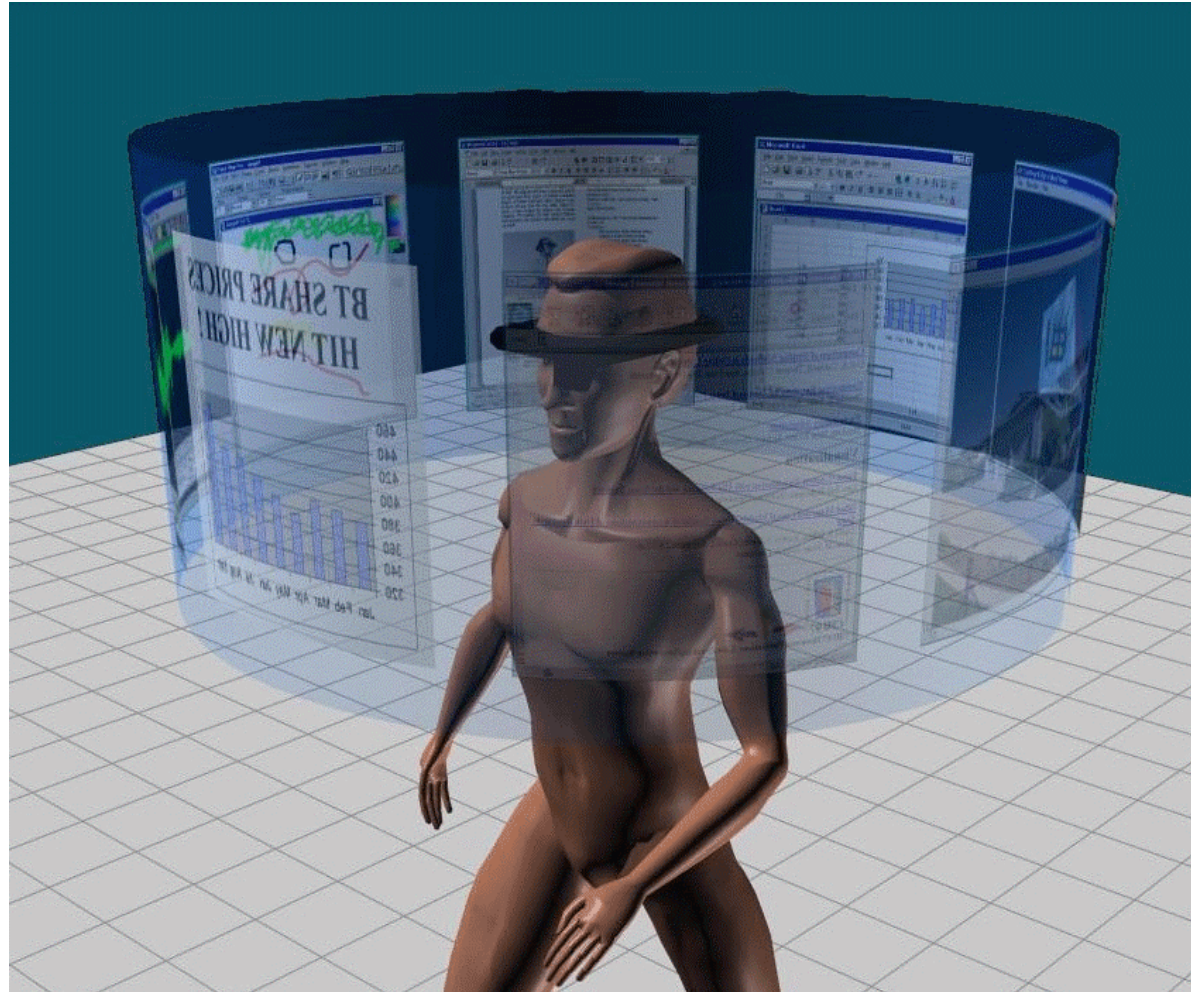
immersive analytics



spatial analytic interfaces (SAI)



spatial interface design



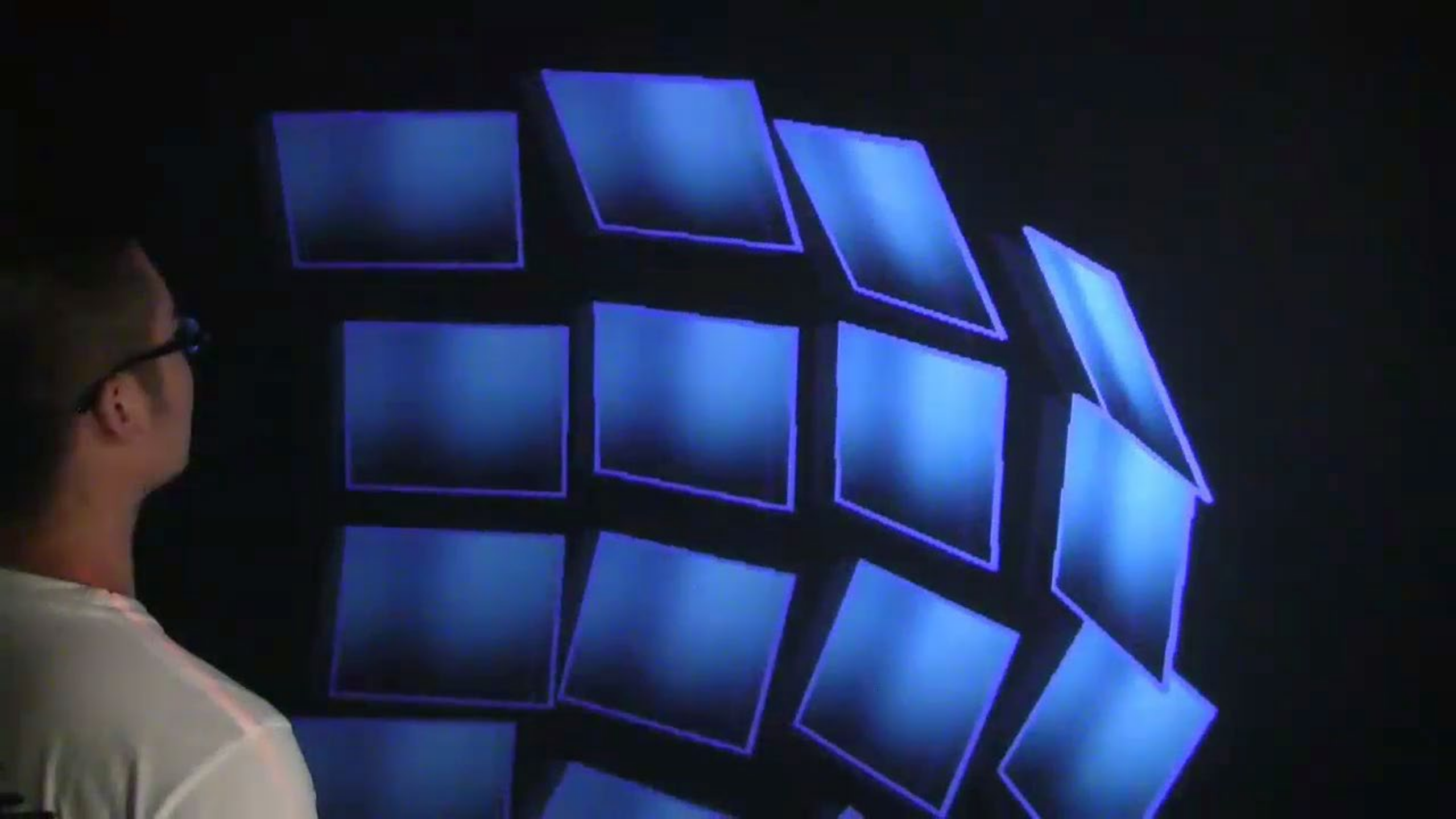
Billinghurst et al., VRAIS, 1998

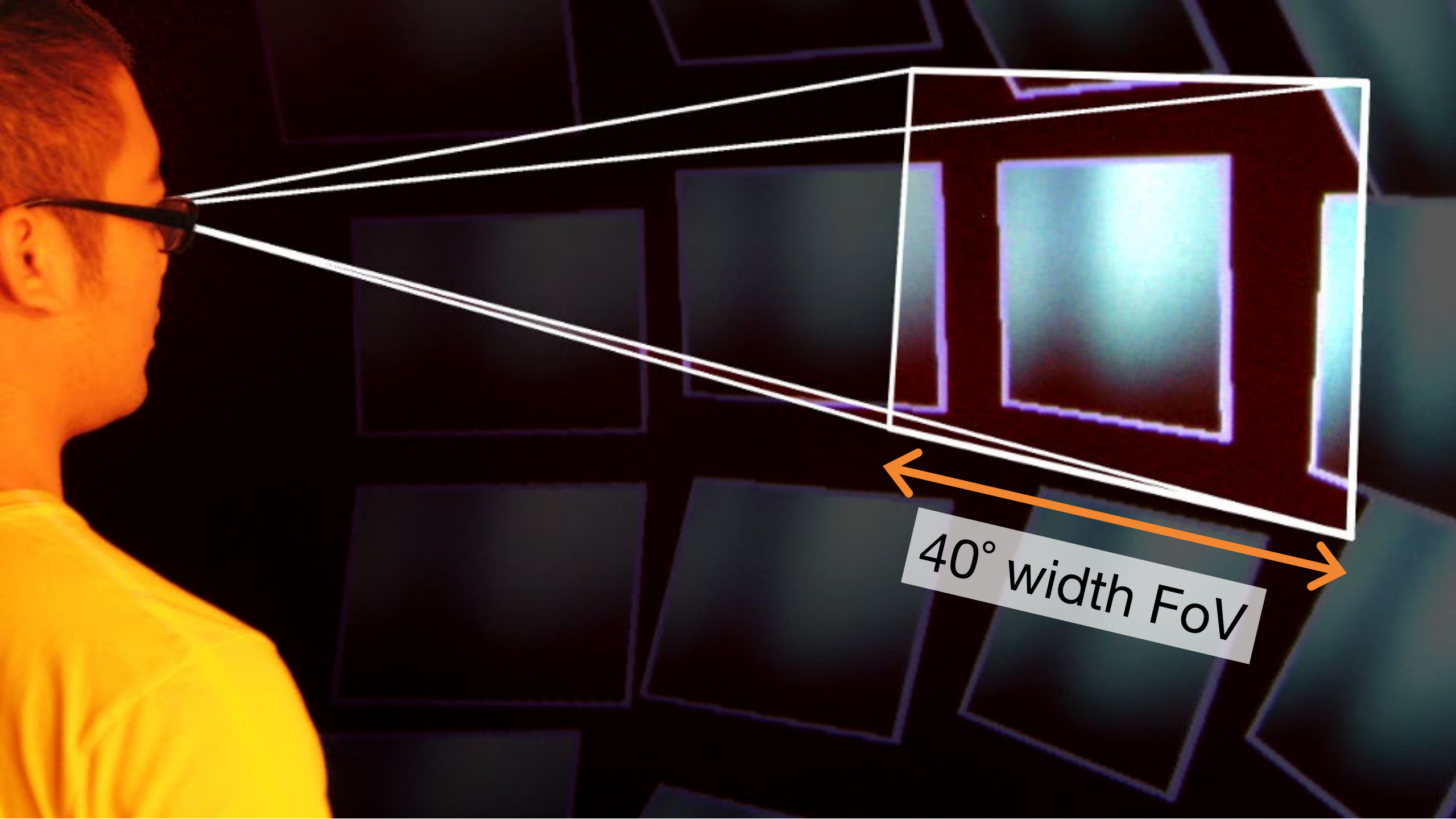
Personal Cockpit

Barrett Ens, Rory Finnegan and Pourang Irani



Barrett Ens, Rory Finnegan, and Pourang Irani. "The personal cockpit: a spatial interface for effective task switching on head-worn displays." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 3171-3180. 2014.





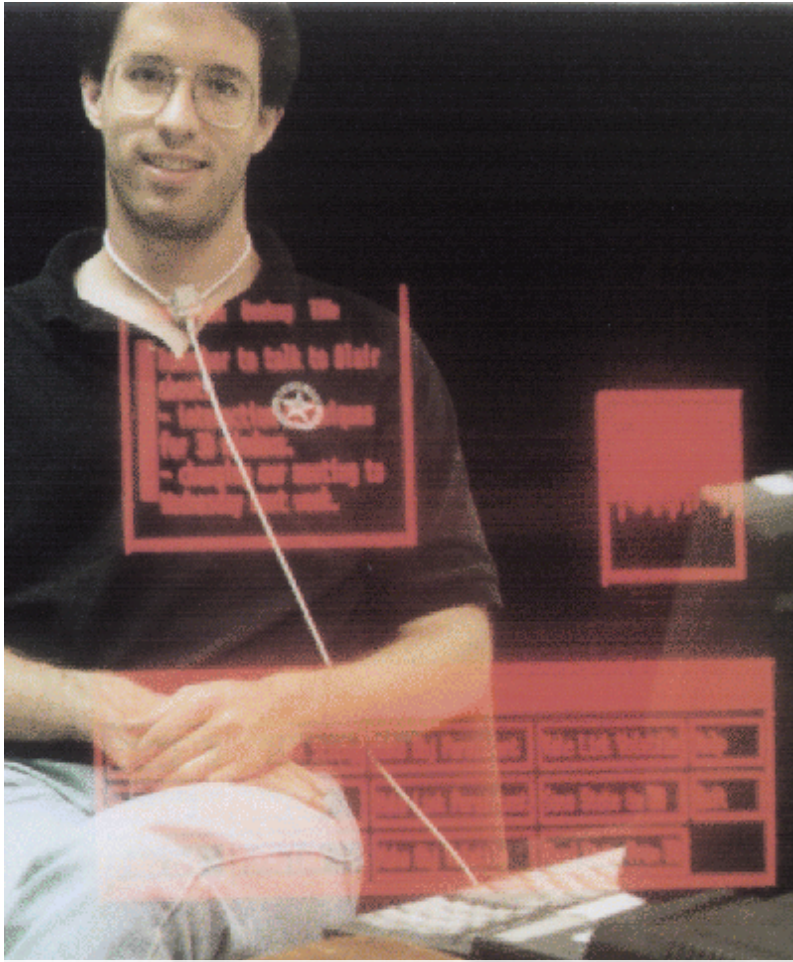
40° width FoV



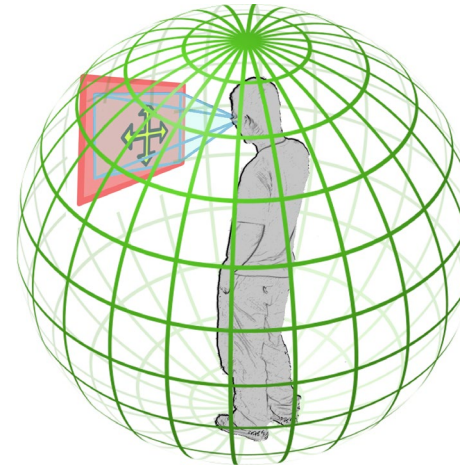
analytic task



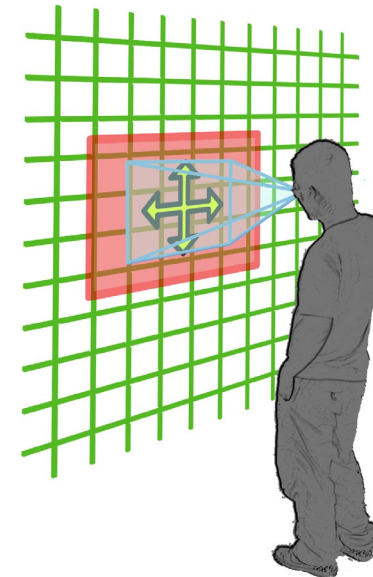
spatial reference frames



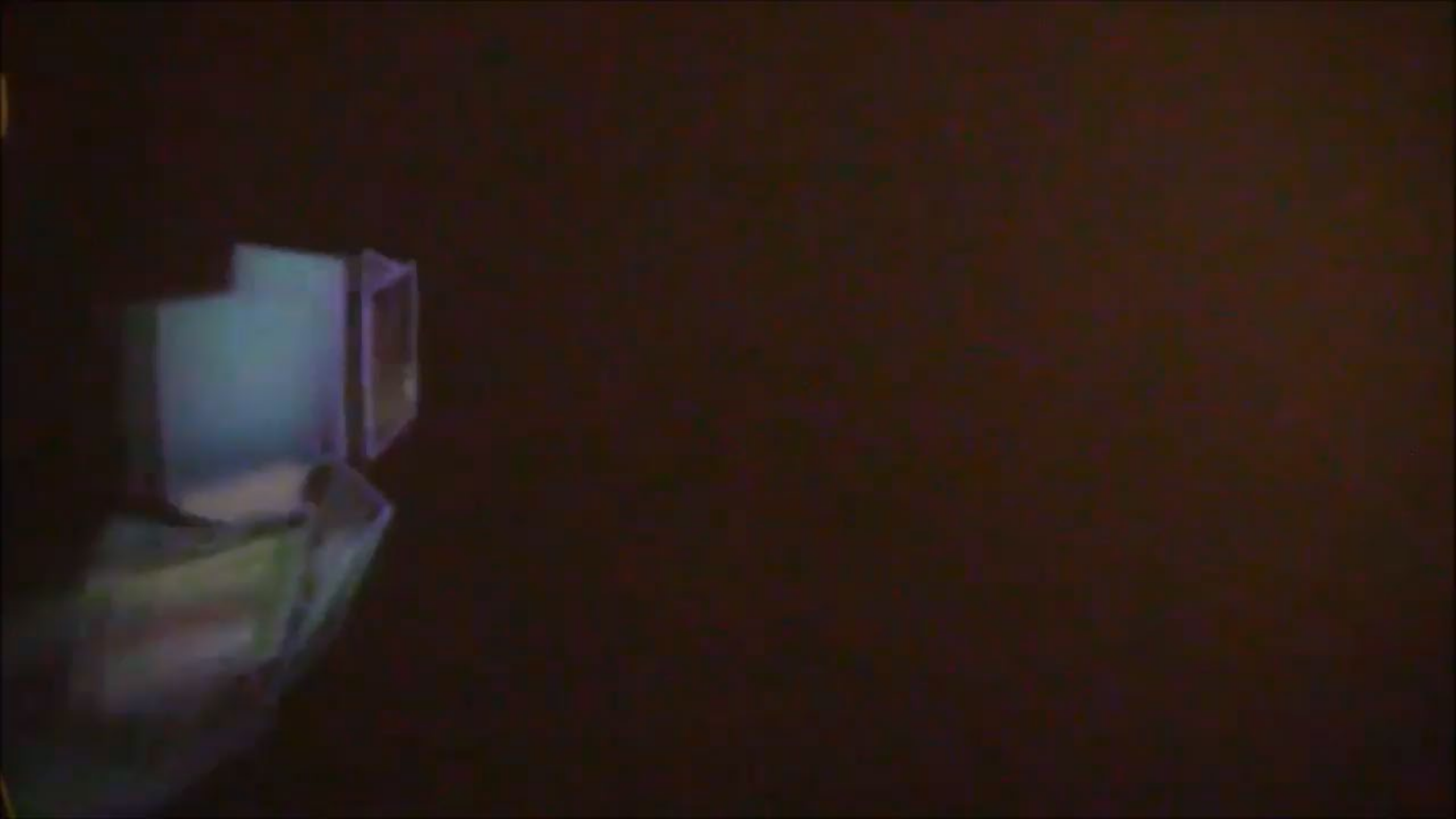
Windows on the World
Feiner et al., UIST, 1993



body-
fixed

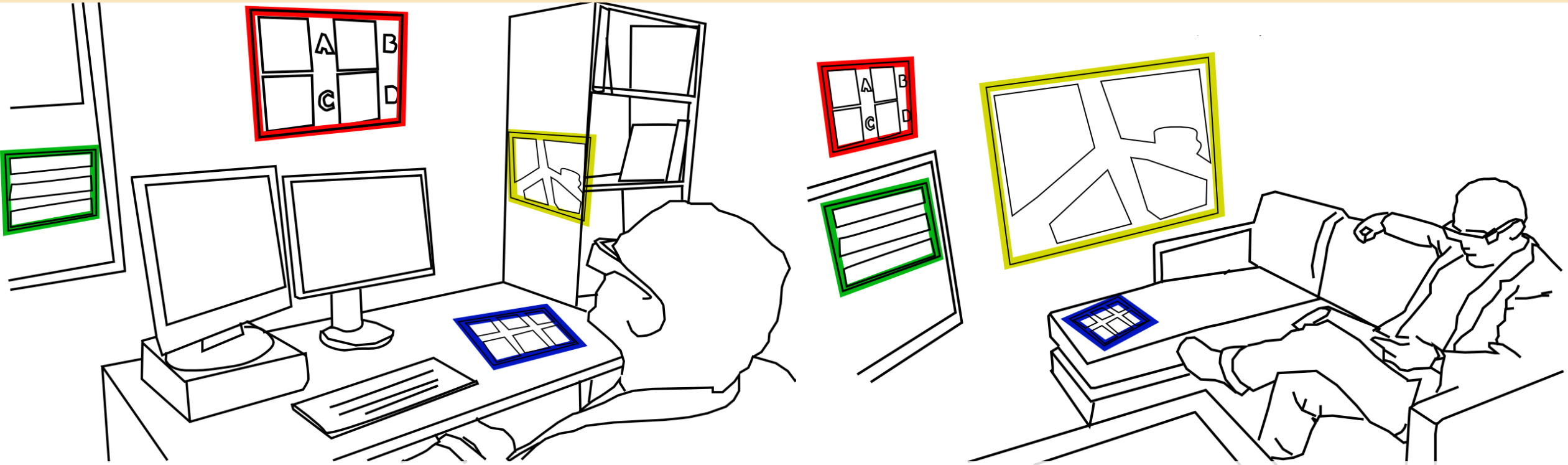


world-
fixed



Spatially Constant Layouts

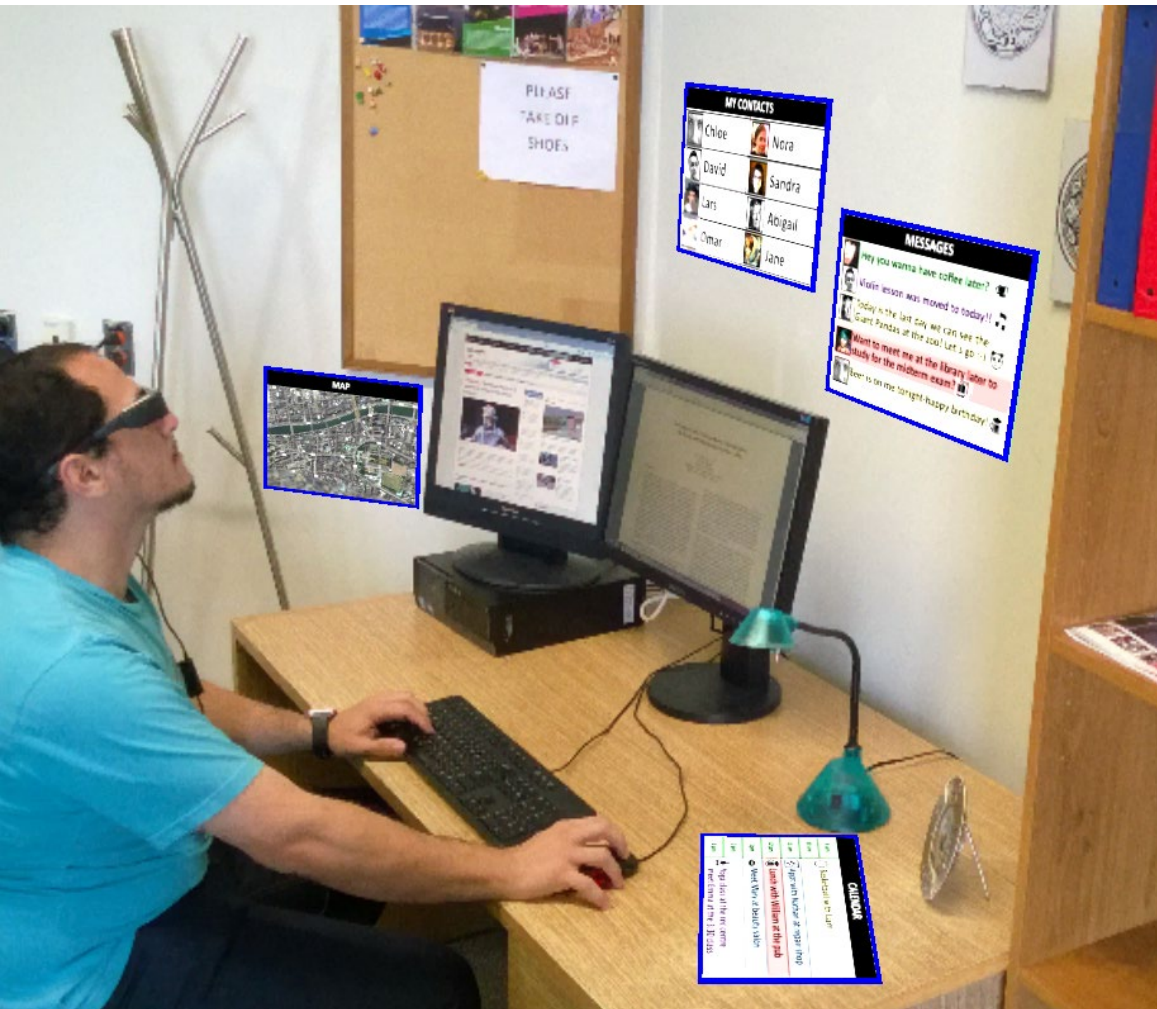
Barrett Ens, Eyal Ofek, Neil Bruce, and Pourang Irani SUI '15

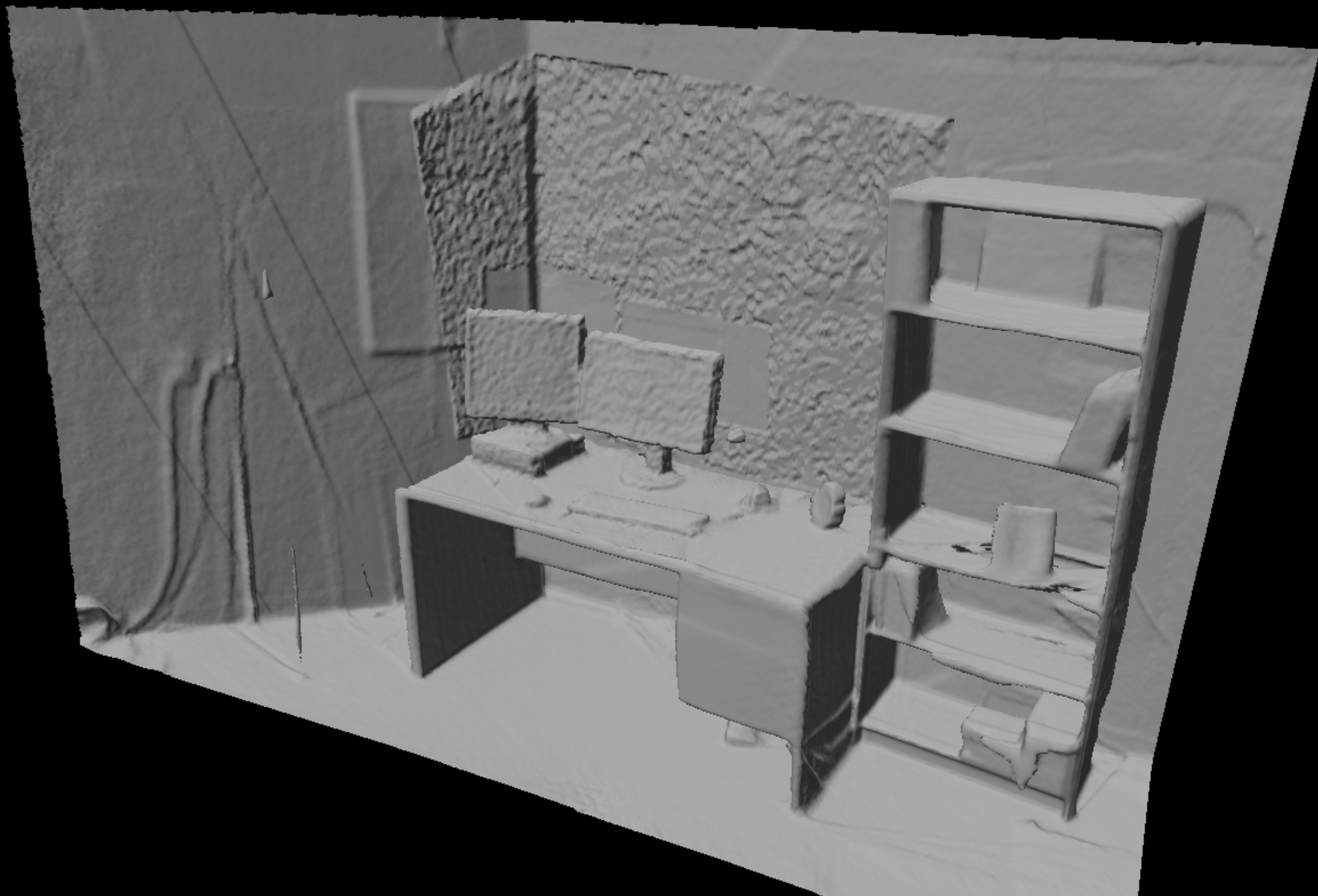


Barrett Ens, Eyal Ofek, Neil Bruce, and Pourang Irani. 2015. Spatial Constancy of Surface-Embedded Layouts across Multiple Environments. In *Proc. of the ACM Symposium on Spatial User Interaction (SUI '15)*, 65-68.

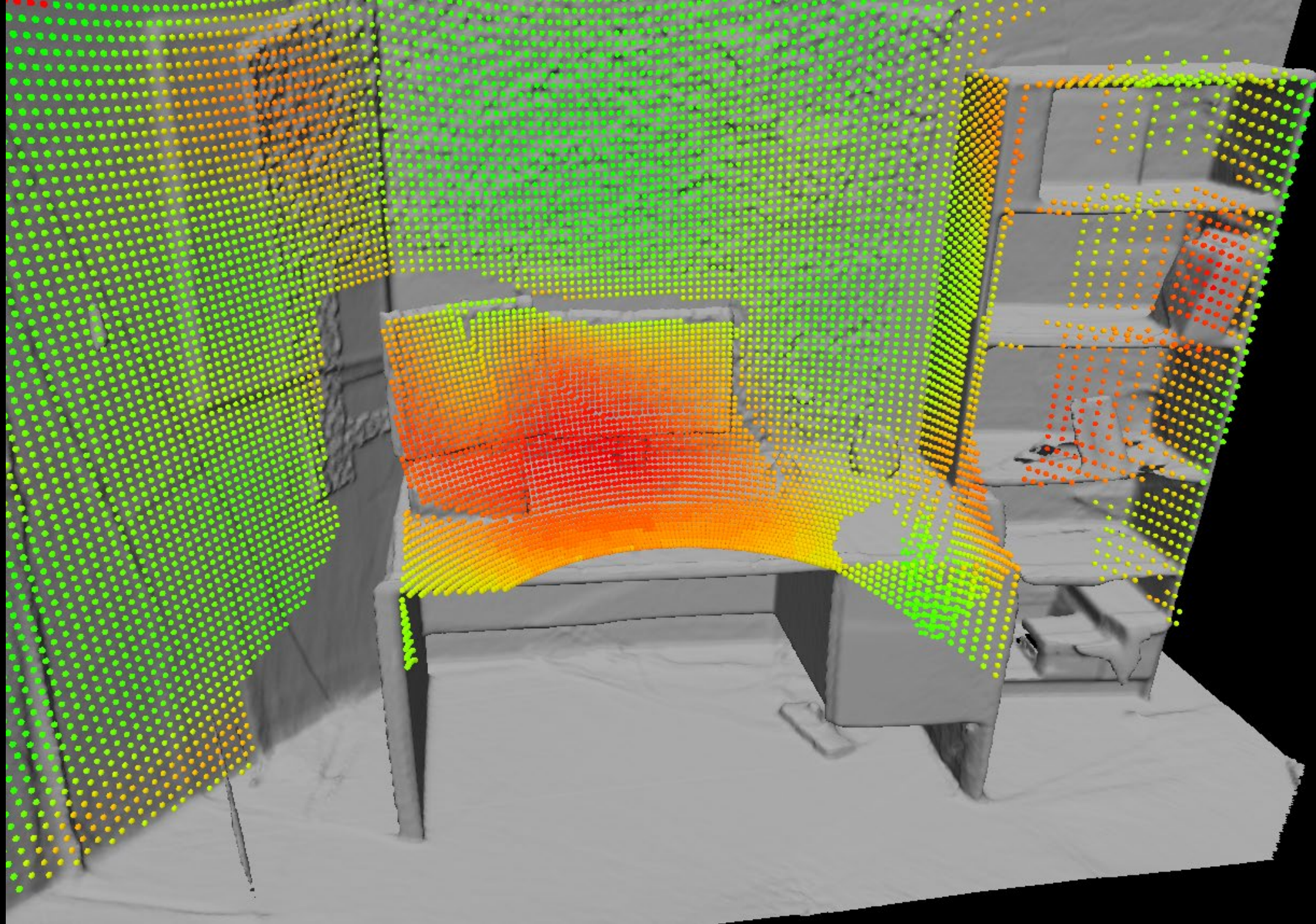
Barrett Ens, Eyal Ofek, Neil Bruce, and Pourang Irani. 2016. Shared Façades: Surface-embedded layout management for ad-hoc collaboration using head-worn displays. *Collaboration Meets Interactive Surfaces and Spaces (CMISS) – Theory and Practice*. Craig Anslow, Pedro Campos, Joaquim Jorge, (Eds). Springer.

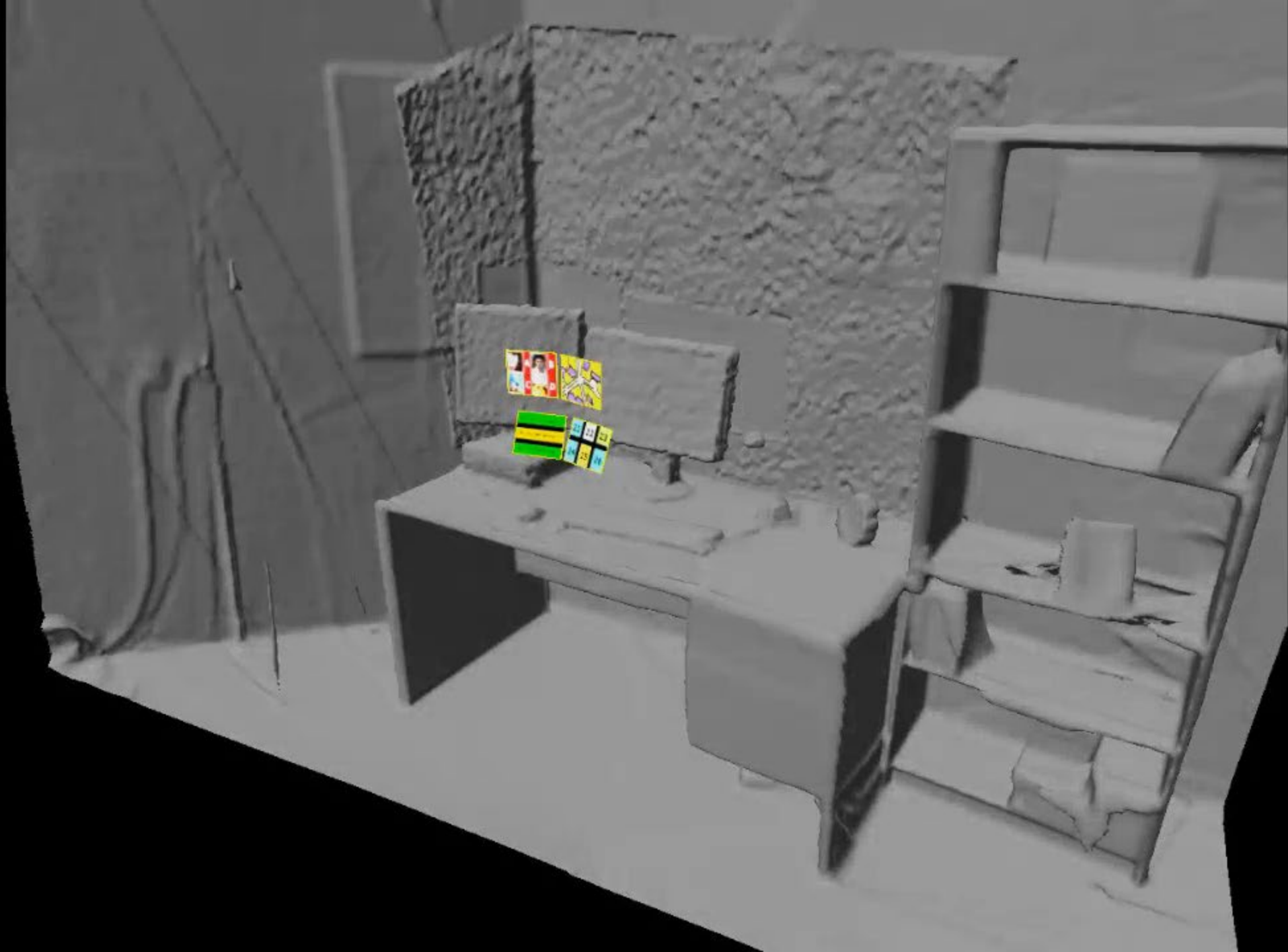
multiple environments

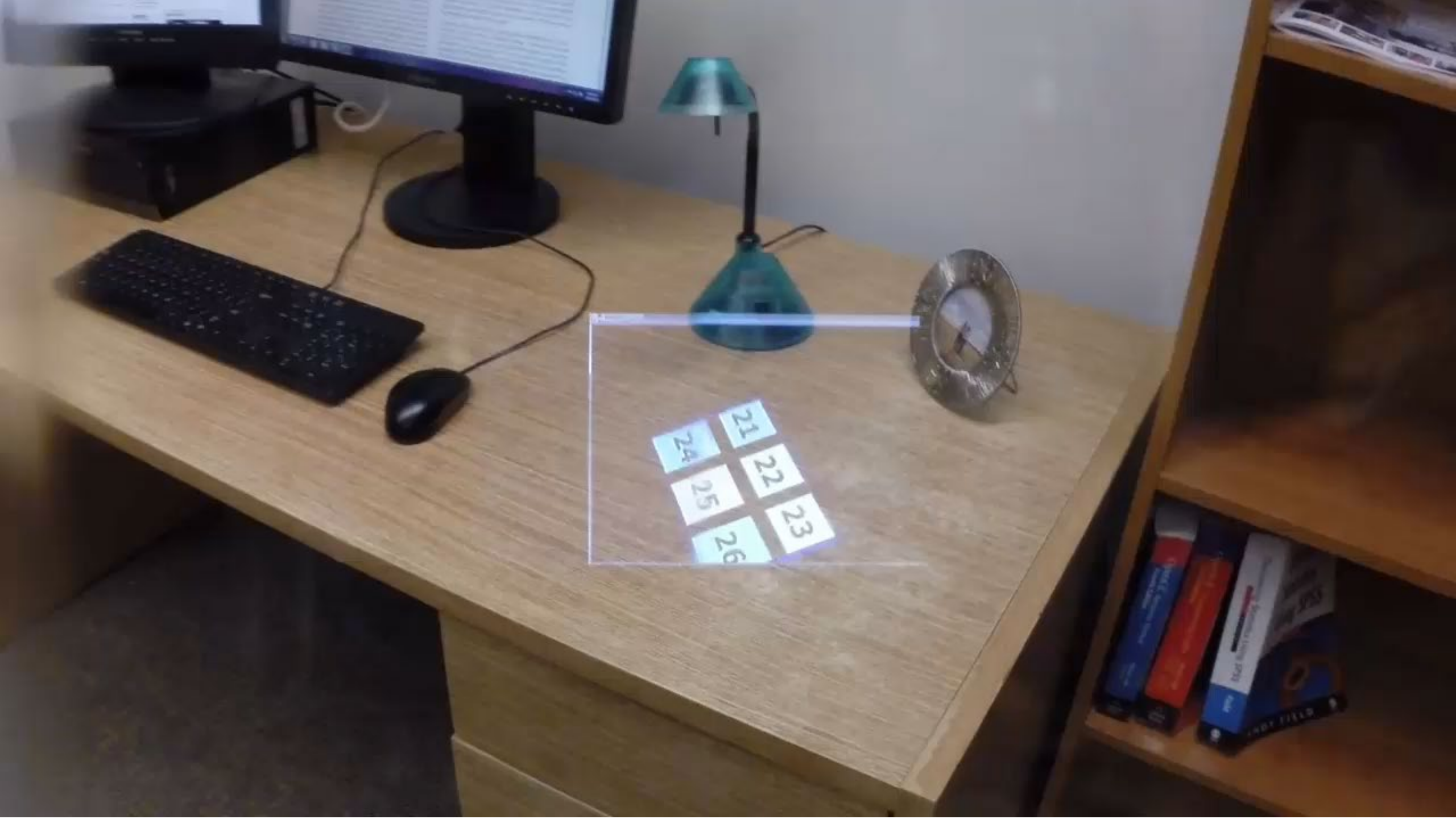








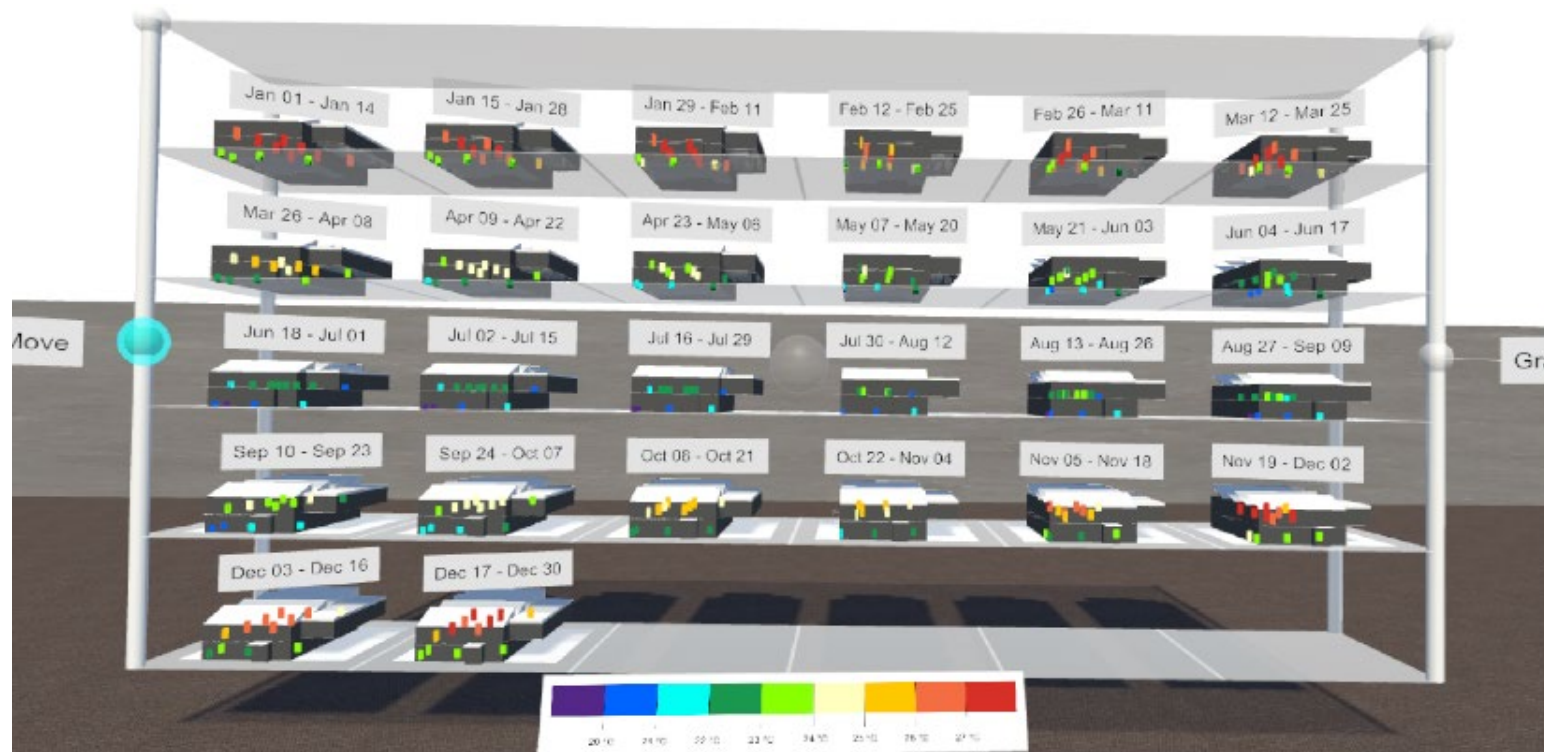




21	22
24	23
25	26

Small Multiples Visualisation

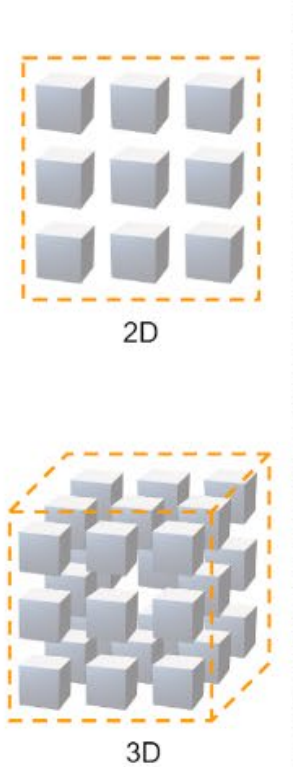
Jiazhou Liu, Arnaud Prouzeau, Barrett Ens and Tim Dwyer IEEE VR '20



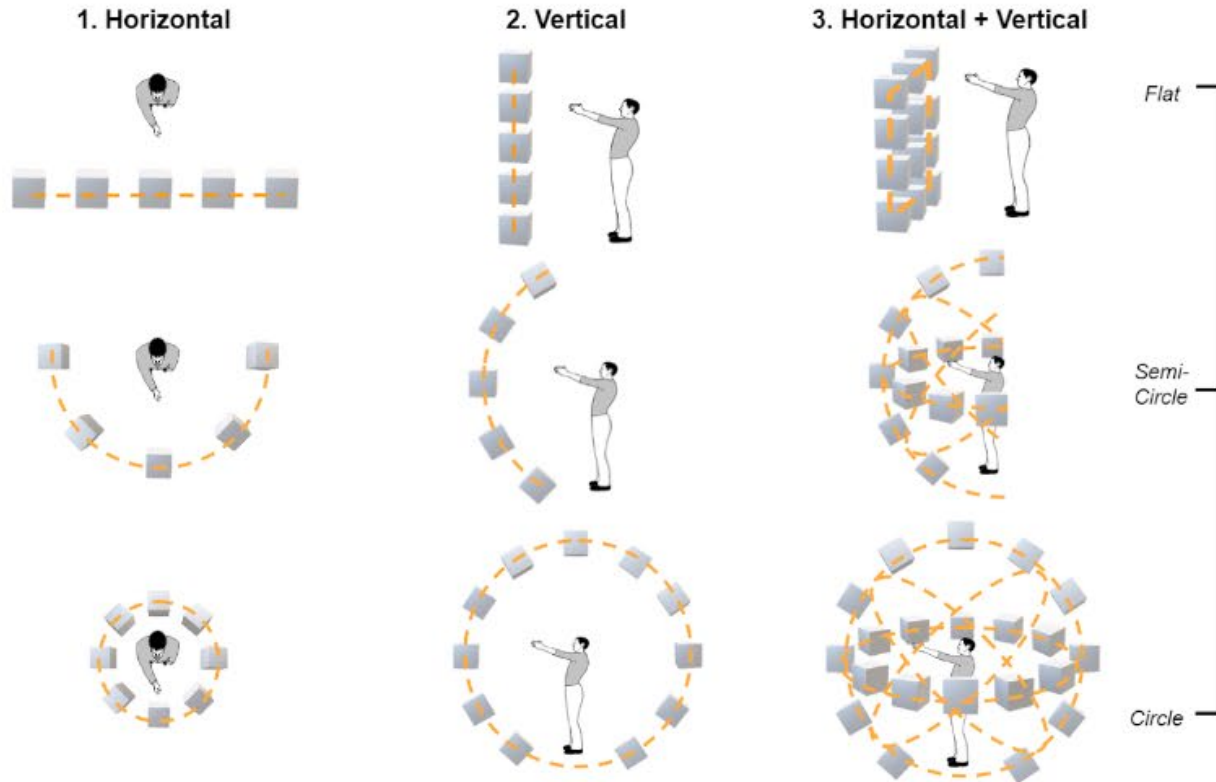
Jiazhou Liu, Arnaud Prouzeau, Barrett Ens, and Tim Dwyer. "Design and evaluation of interactive small multiples data visualisation in immersive spaces." In 2020 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), pp. 588-597. IEEE, 2020.

design space for spatial layout

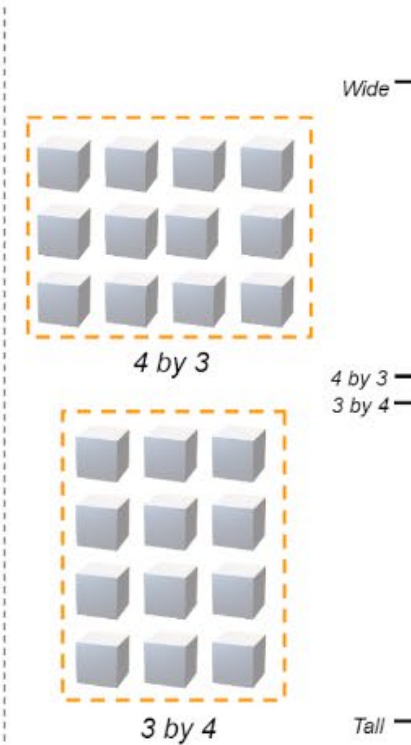
a. Dimension



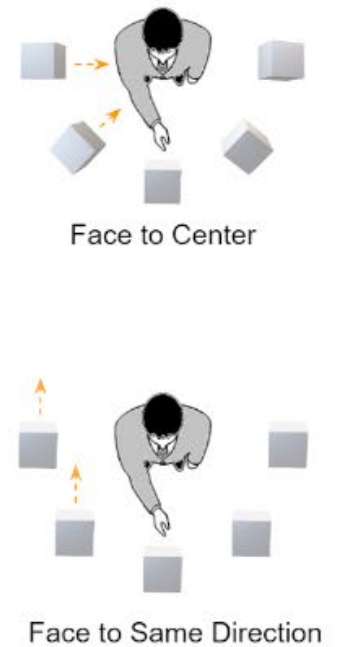
b. Curvature



c. Aspect Ratio

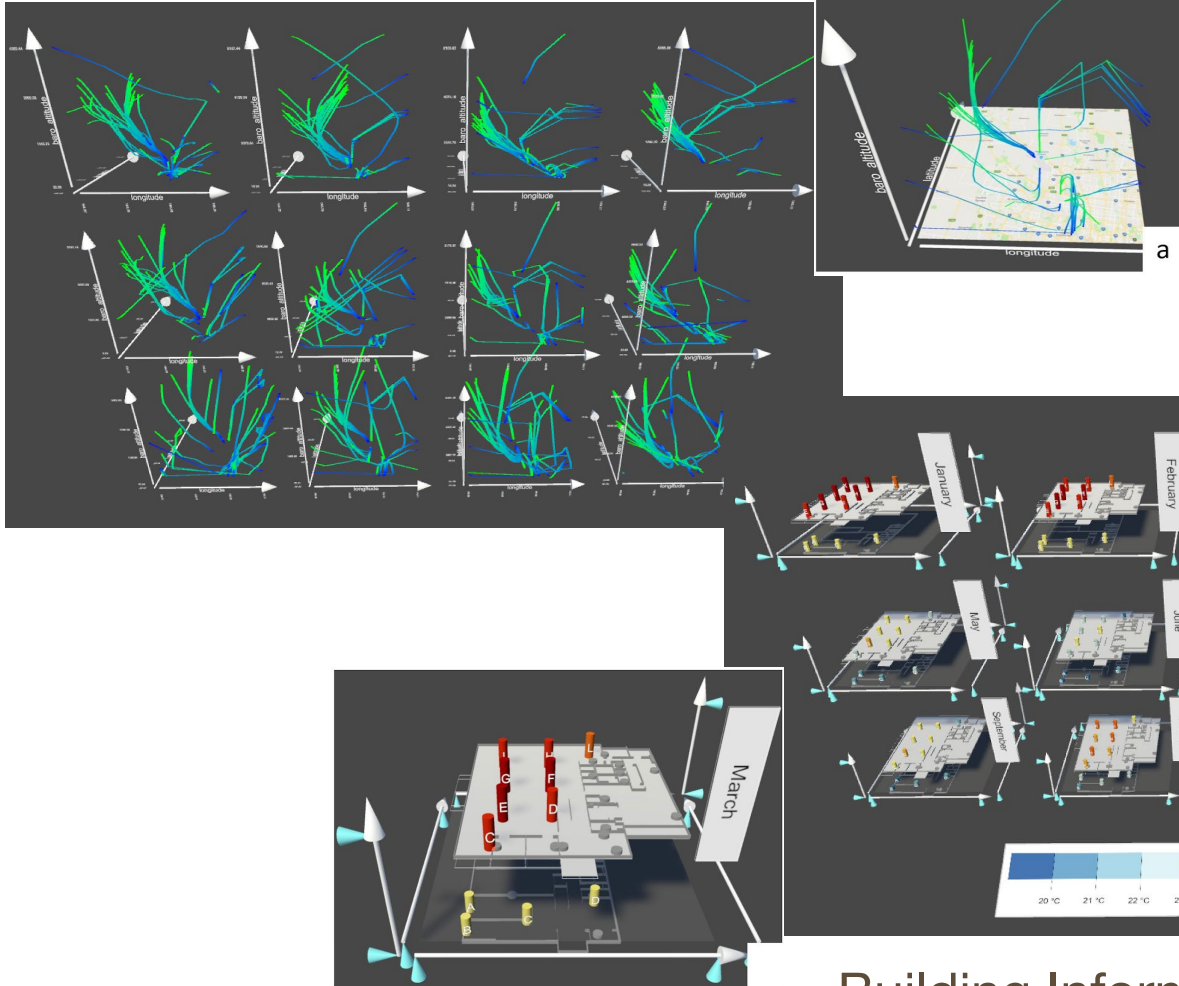


d. Orientation

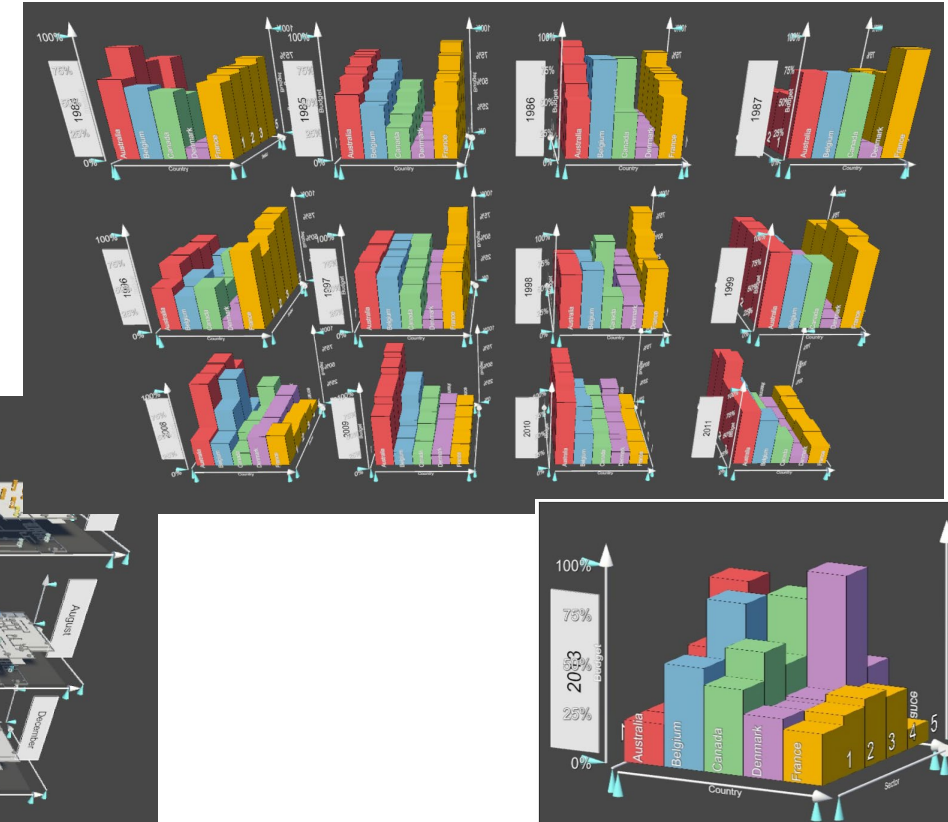


3D small multiples visualisation

Aircraft Trajectories

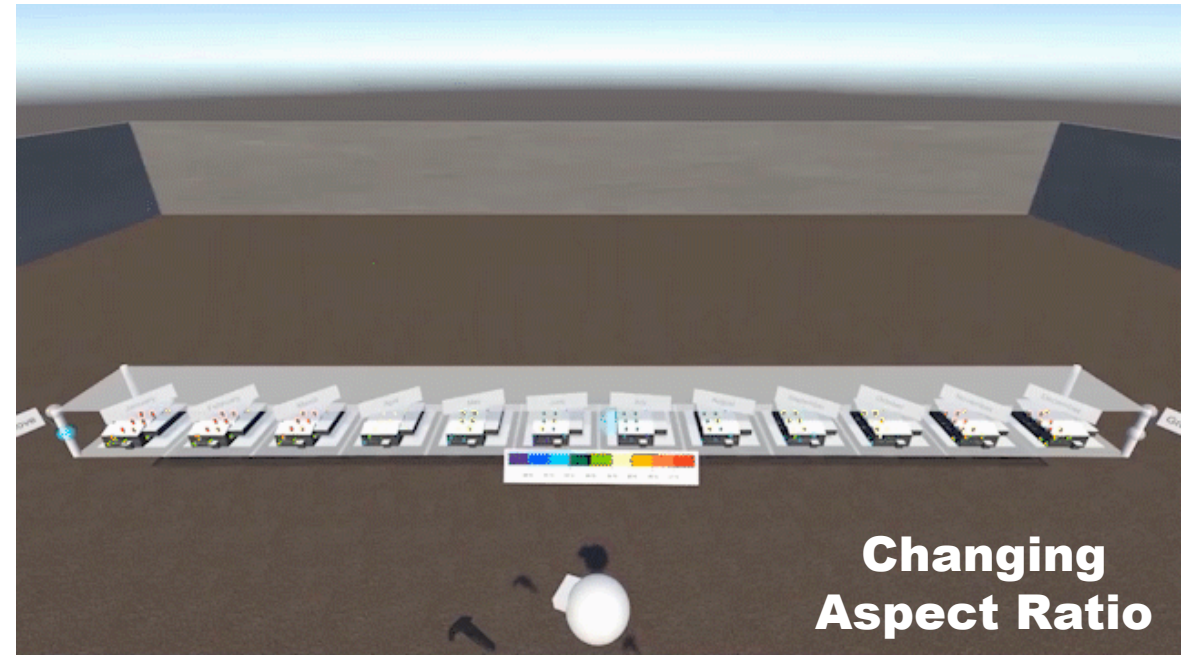
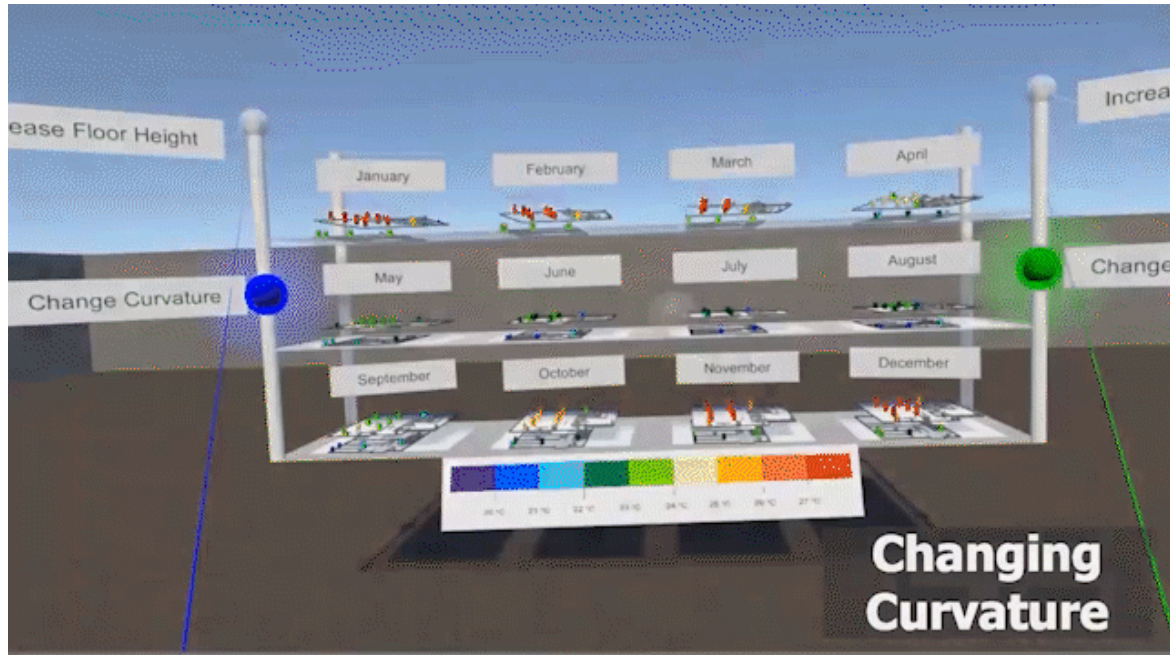


Demographic Indicators

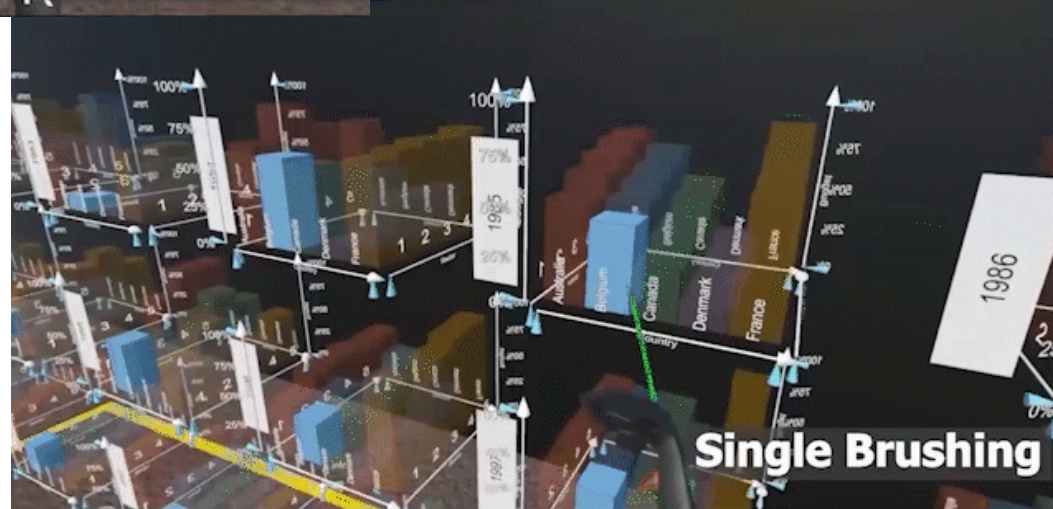
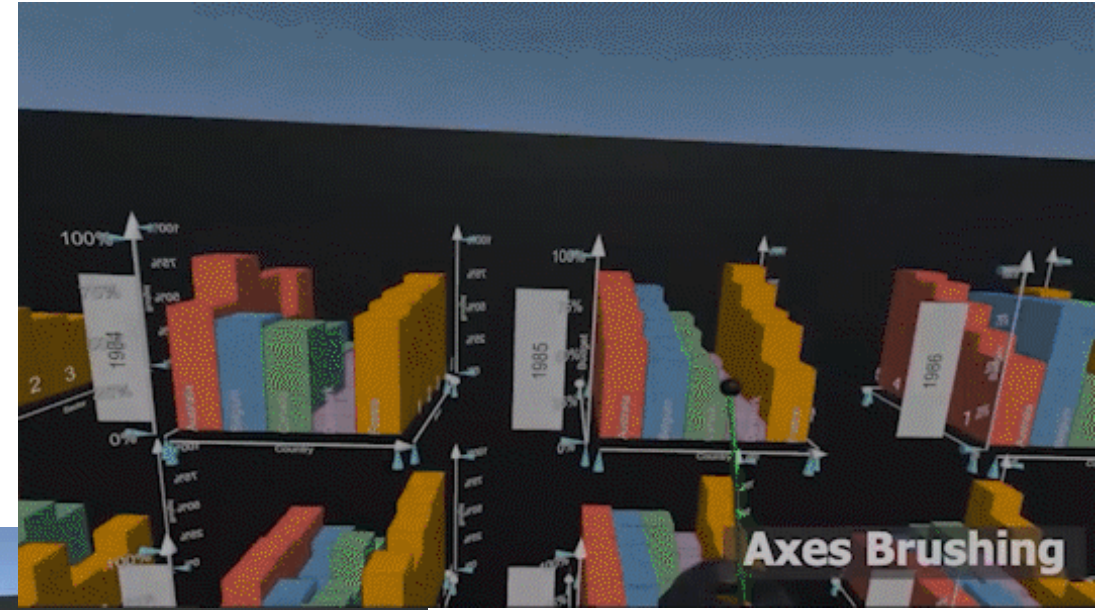
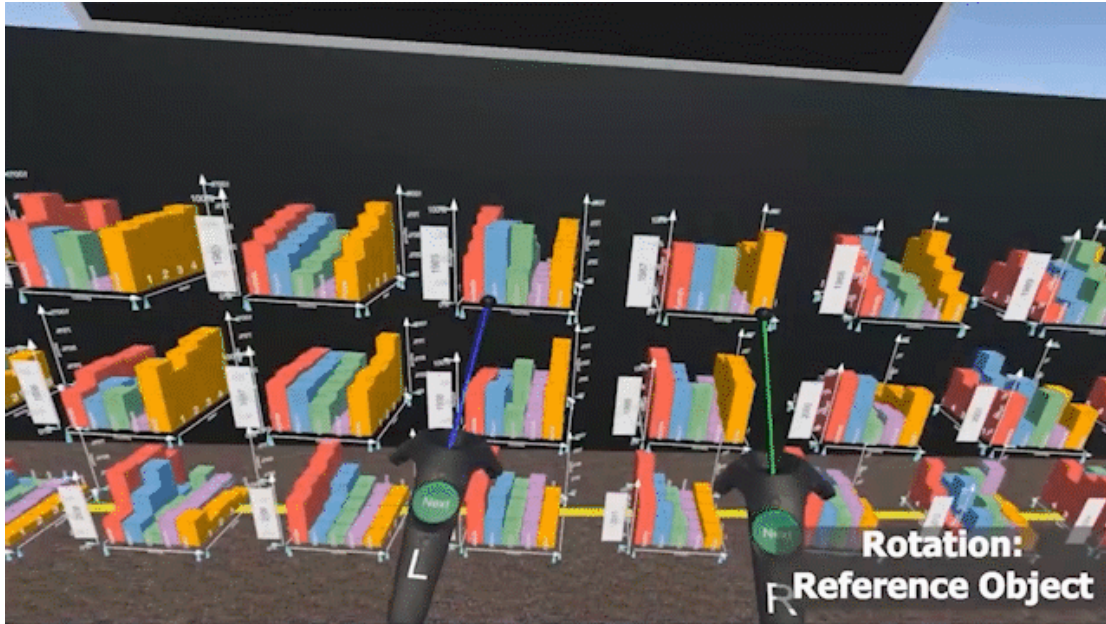


Building Information Modelling (BIM)

interaction with layouts

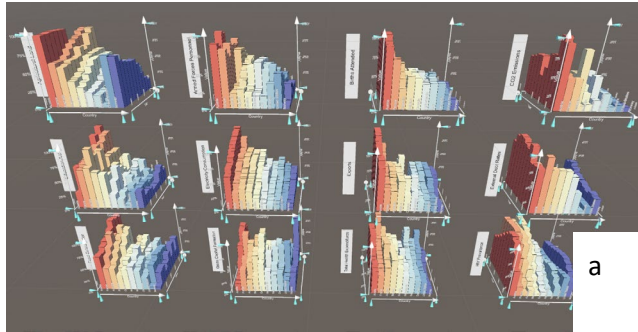


interaction with data

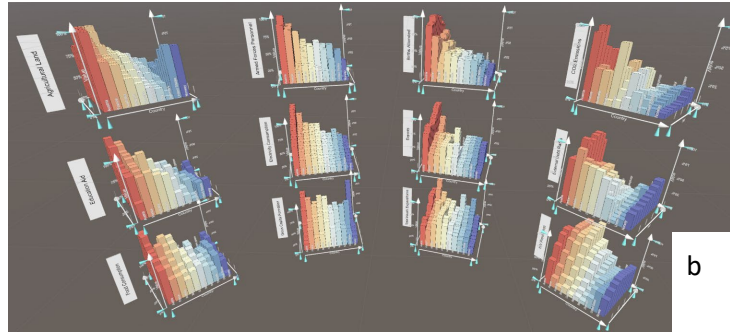


comparison task

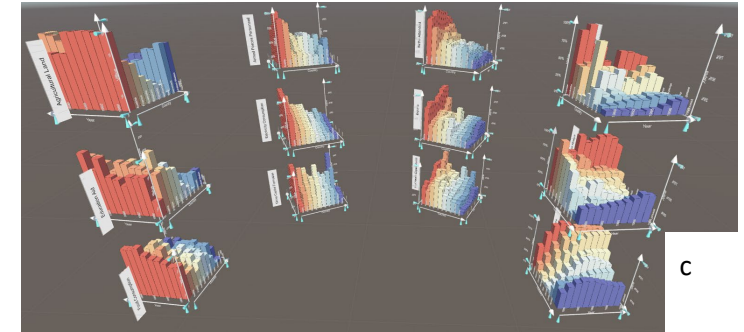
Flat



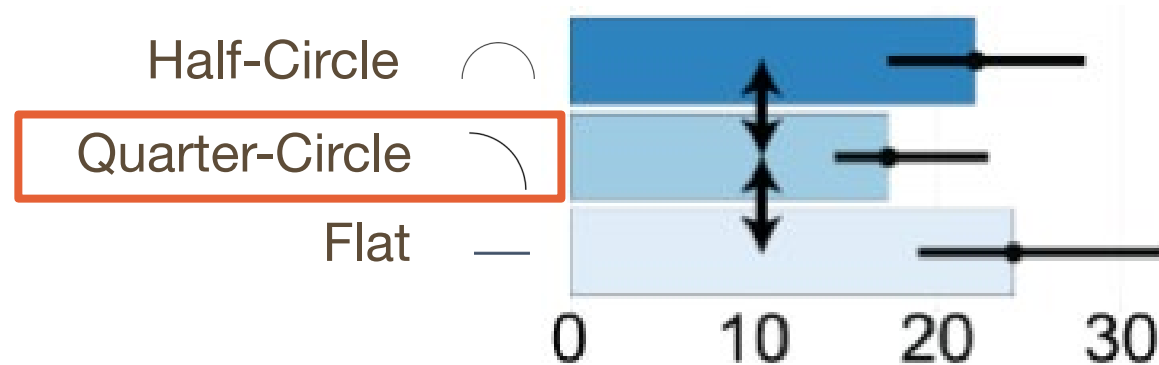
Quarter Circle



Half Circle

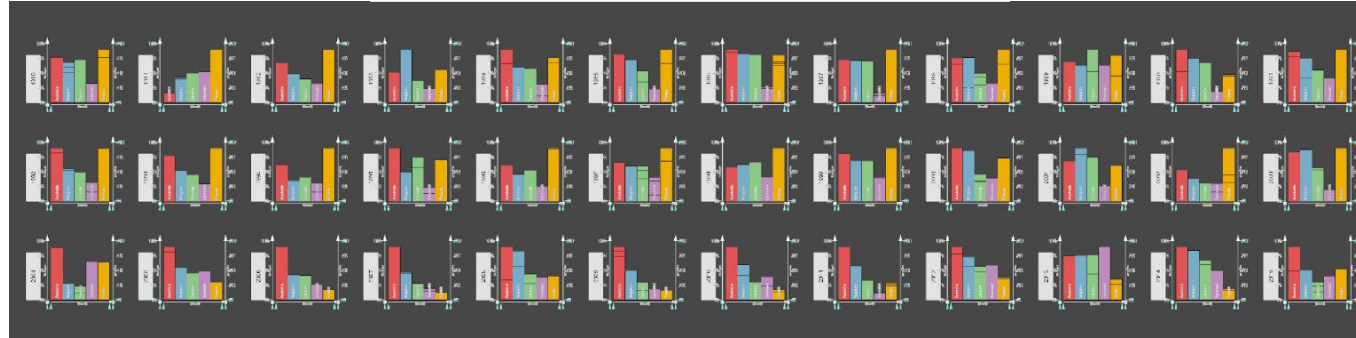


Completion Time

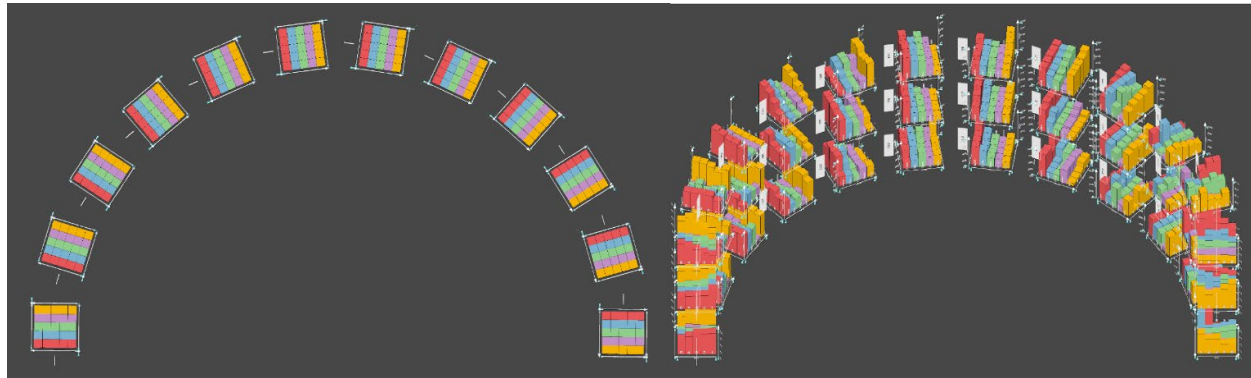


comparison task

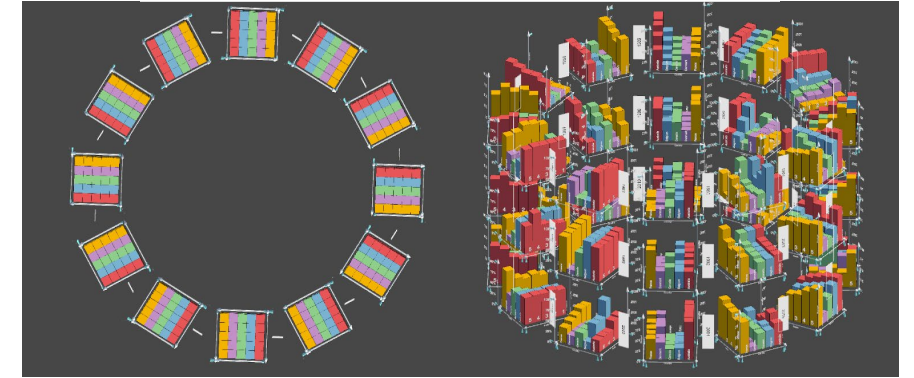
Flat



Half Circle



Full Circle



- Participants preferred Half-Circle  layout.
- Full-Circle  layout was disorienting, harder to locate visualisations.
- Flat  provides easy overview but requires more walking

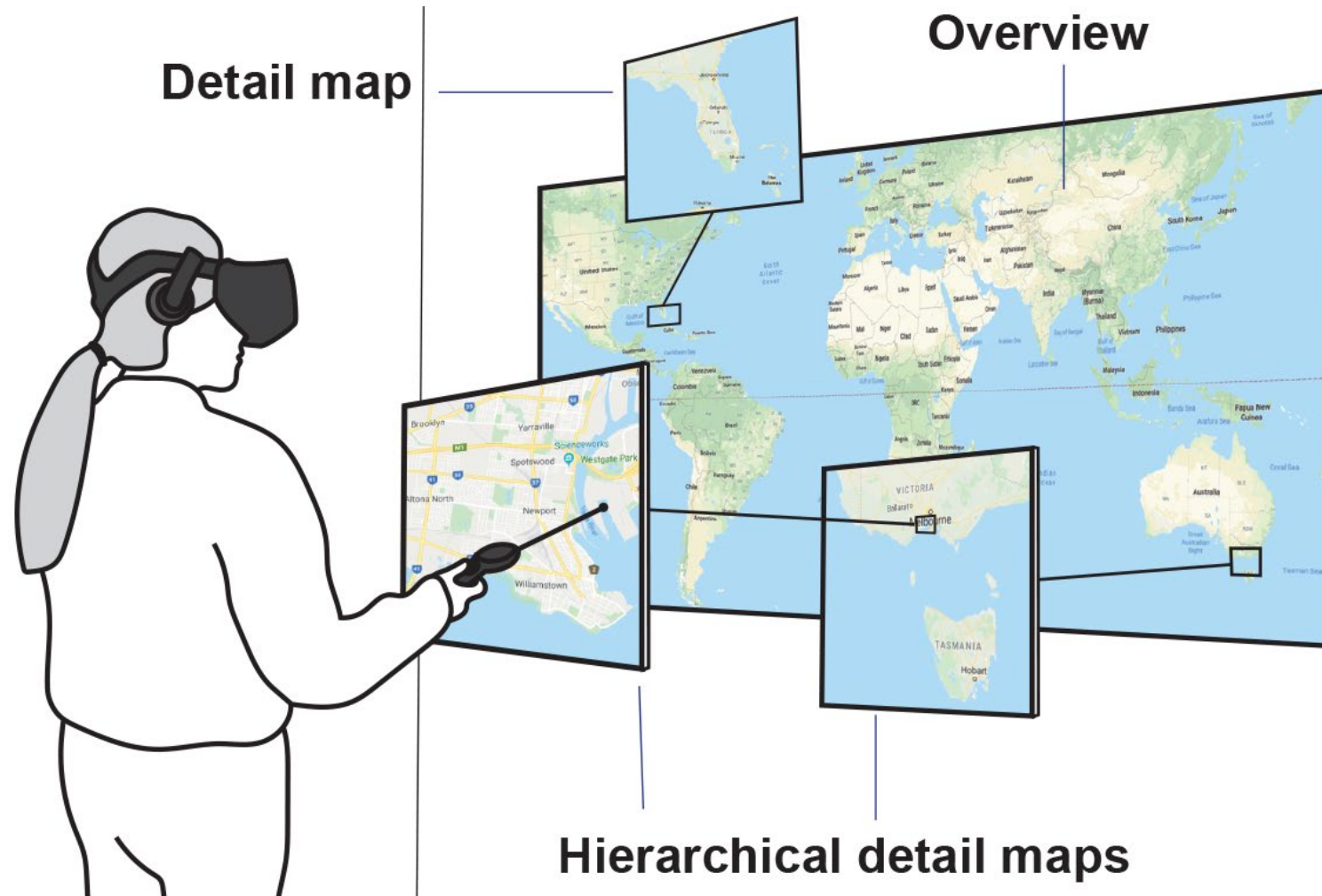
Maps Around Me

Kadek Ananta Satriadi, Barrett Ens, Maxime Cordeil, Tobias Czauderna, and Bernhard Jenny. ISS '20



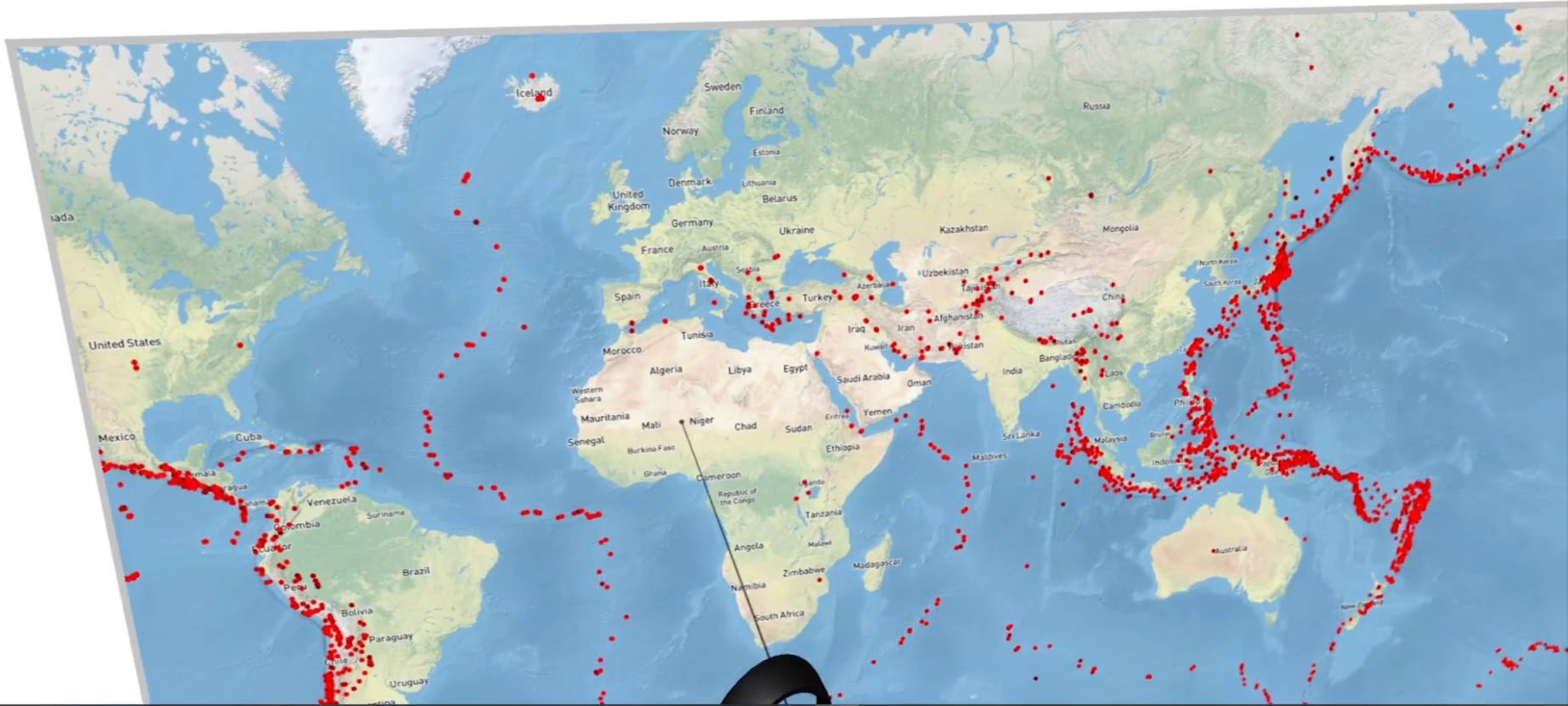
Satriadi, Kadek Ananta, Barrett Ens, Maxime Cordeil, Tobias Czauderna, and Bernhard Jenny. "Maps around me: 3D multiview layouts in immersive spaces." Proceedings of the ACM on Human-Computer Interaction 4, no. ISS (2020): 1-20.

multiview maps



Immersive Multiview Maps | Earthquake Ep

Create map slices and explore the map using multiple hierarchical map views.



observation study

observation study

16



observation study

Maps

A total of 24 maps to arrange with 3 zoom levels

16



Fixed

1



World
map

Moveable

6



Metro
maps

18



City
maps

observation study

Maps

A total of 24 maps to arrange with 3 zoom levels

16


Fixed

1



World
map

Moveable

6



Metro
maps

18



City
maps

Tasks

Tasks are performed consecutively



Naïve Layout Task

Arrange map freely



Search Task

Find and count grey circles



Comparison Task

Find all pair of maps with the same features



Route Planning Task

Find the shortest path between two locations



General Layout Task

Create optimal layouts for all tasks

 general multiview task

 adaptation of interactive geovisualisation task

observation study

Total of 80 layouts, 25 maps each

DescriptionNaïve LayoutSearchComparisonRoute PlanningGeneral LayoutAll Tasks

Search

These are layouts generated by users in the search task.

TFLI



P1



P2



P3



P4



P5



P6



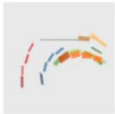
P7



P8



P9



P10



P11



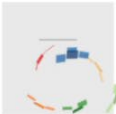
P12



P13



P14



P15



P16

Comparison

These are layouts generated by users in the visual comparison task.

TFLI



P17



P18



P19



P20



P21



P22



P23



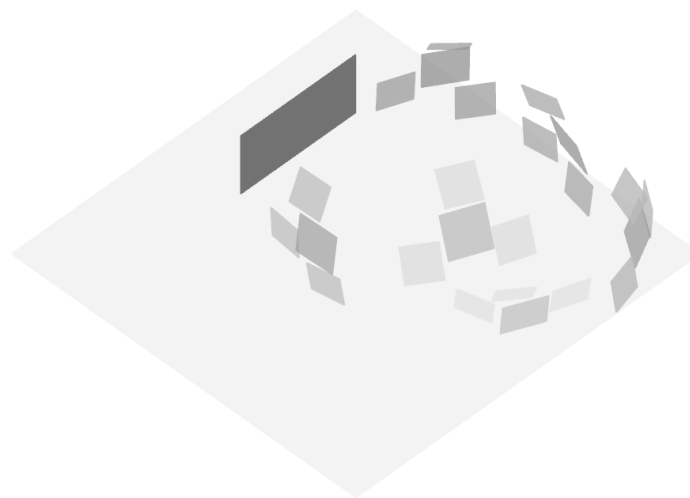
P24

Online viewer: <https://kadeksatriadi.github.io/Maps-Around-Me-Viewer>

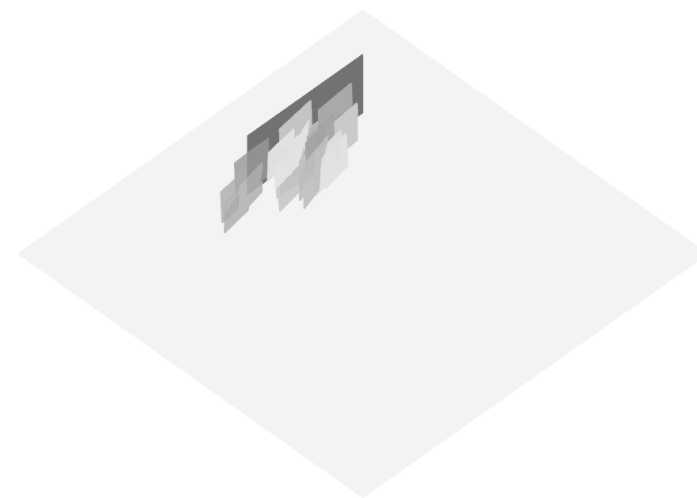
layout geometry



⌒ Spherical cap
(81.5%)

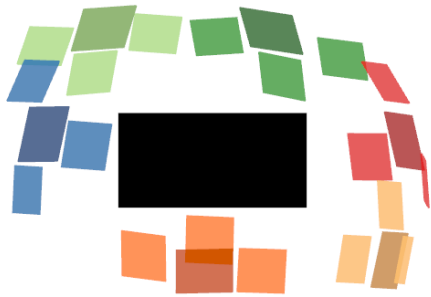


○ Spherical
(13.2%)



— Planar
(5.3%)

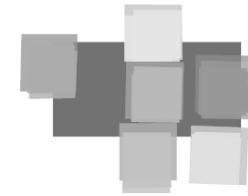
overview-detail relationship



 Central window
(62.5%)

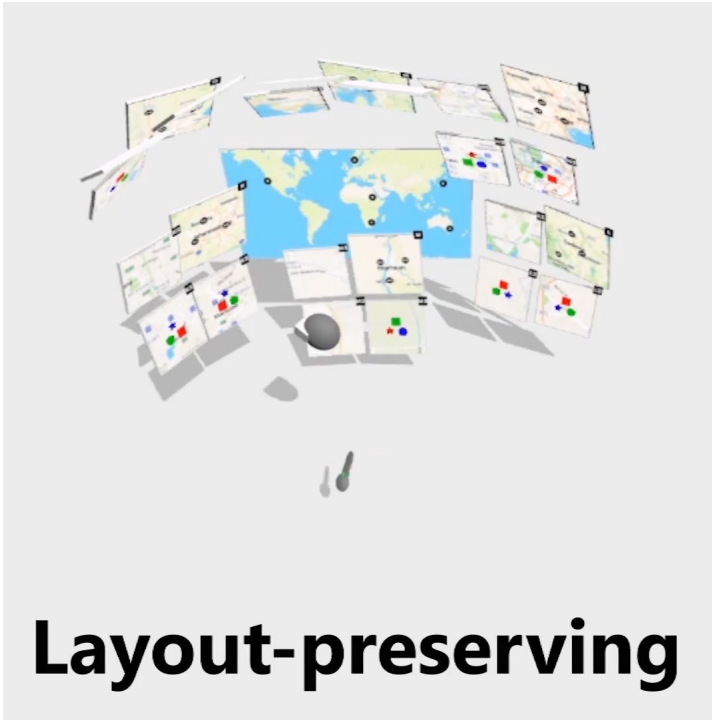


 Coordinated
(18.8%)

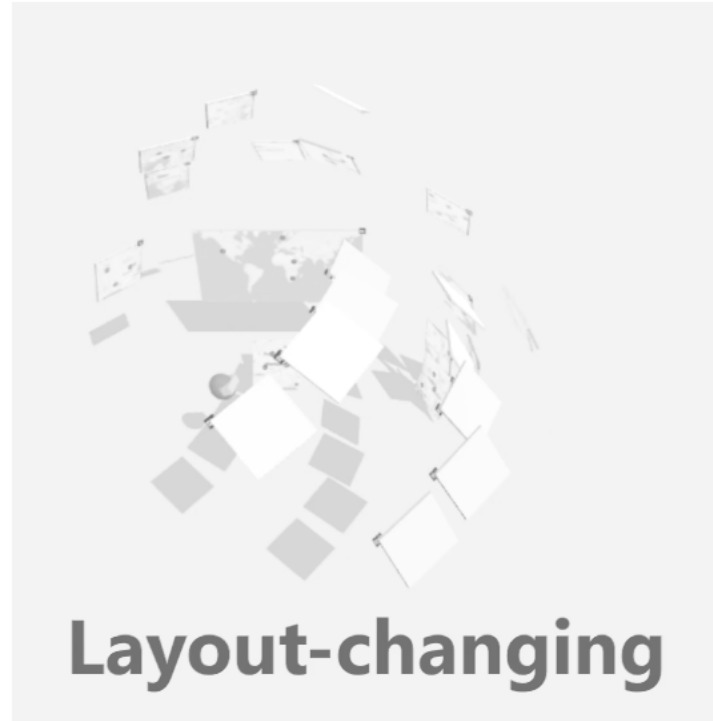


 Occluding
(6.3%)

interaction strategy



Looking around without changing map positions during the task.



Moving maps around during the task.

interaction strategy

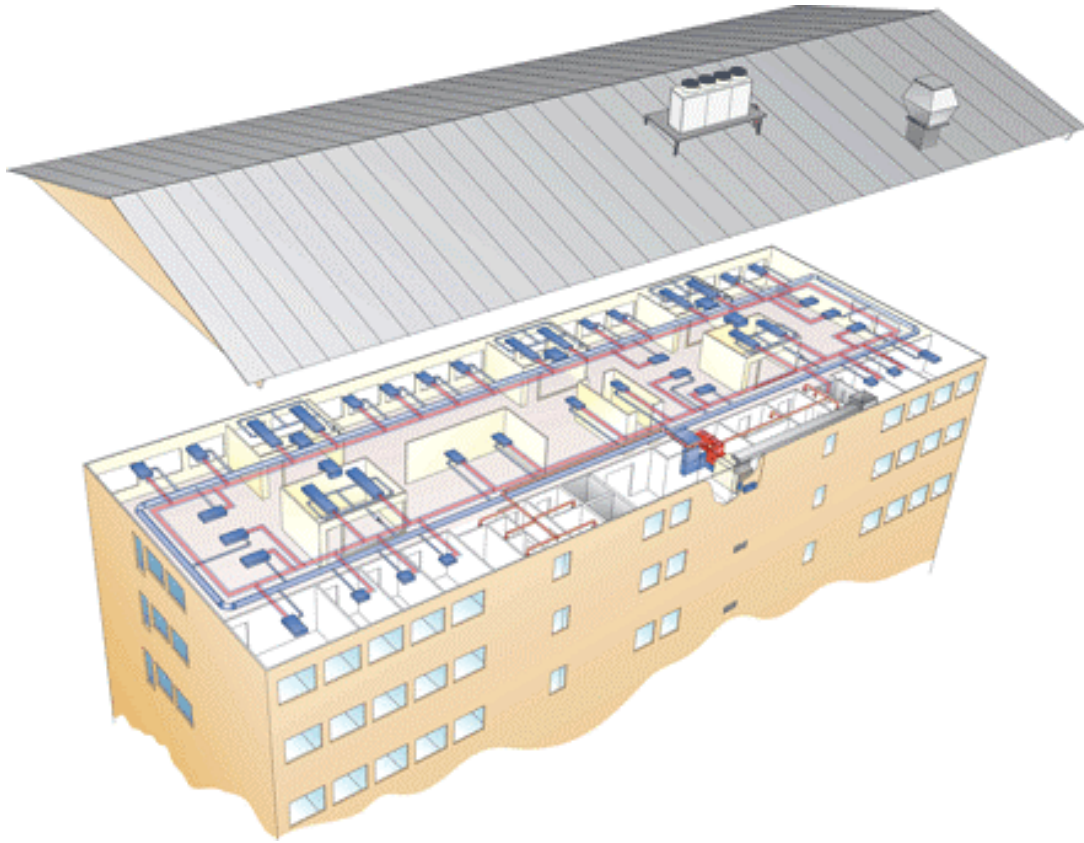


Looking around without changing map positions during the task.



Moving maps around during the task.

visualising & interacting with smart environments



ALL SENSORS



ENERGY



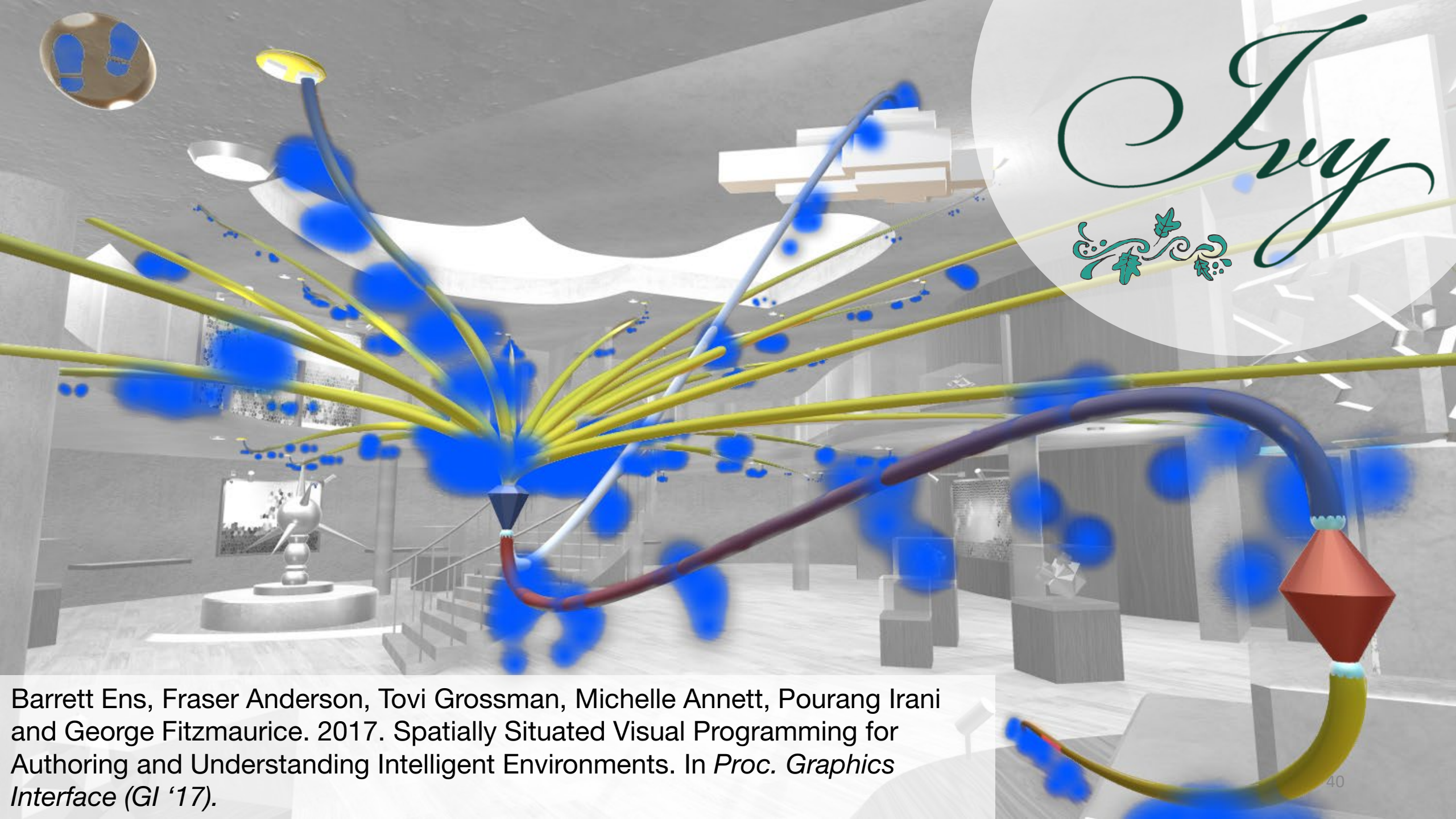
LIGHT



AIR



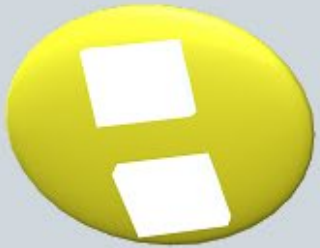
WATER



Barrett Ens, Fraser Anderson, Tovi Grossman, Michelle Annett, Pourang Irani and George Fitzmaurice. 2017. Spatially Situated Visual Programming for Authoring and Understanding Intelligent Environments. In *Proc. Graphics Interface (GI '17)*.

virtual logic constructs

nodes



port



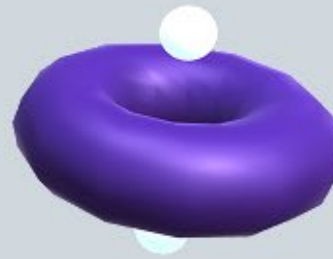
trigger



aggregator



filter

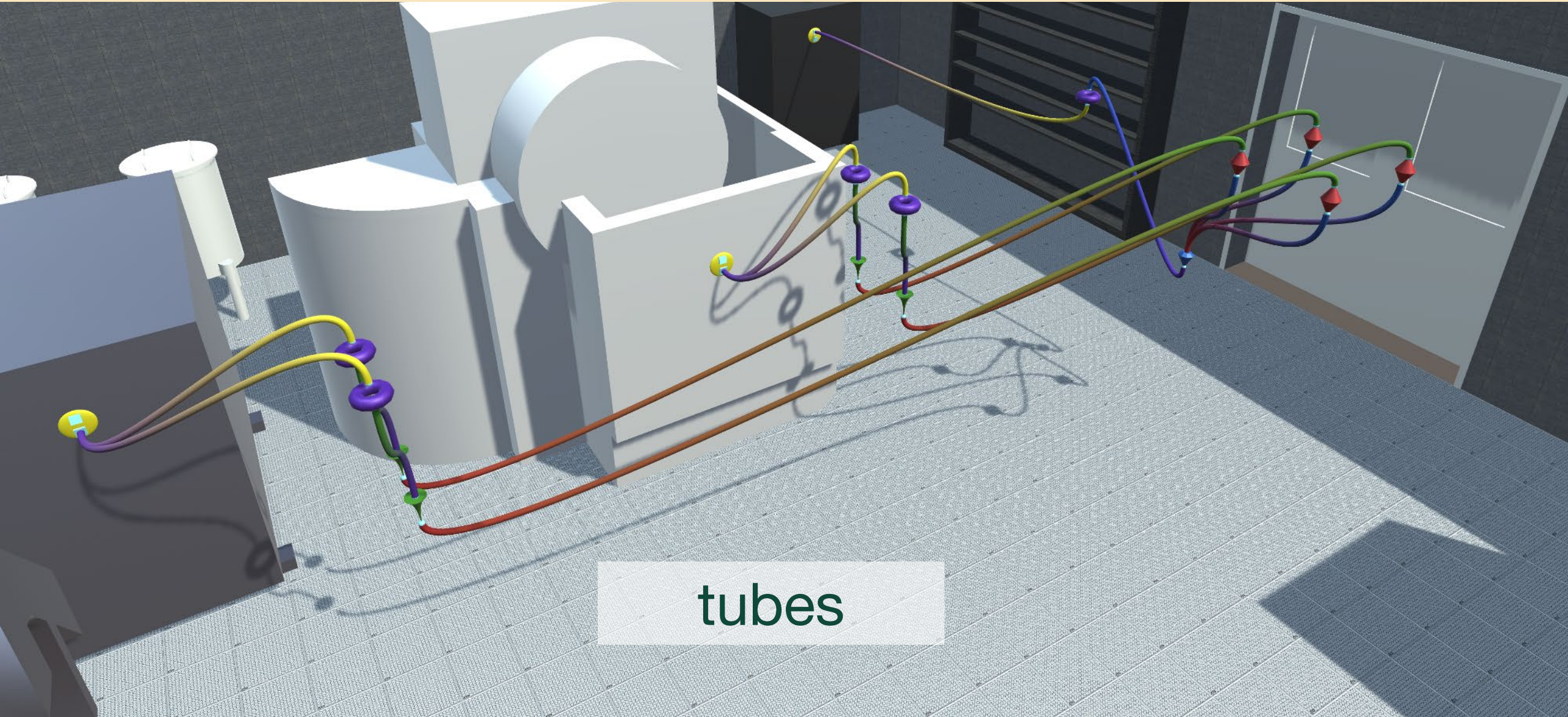


converter



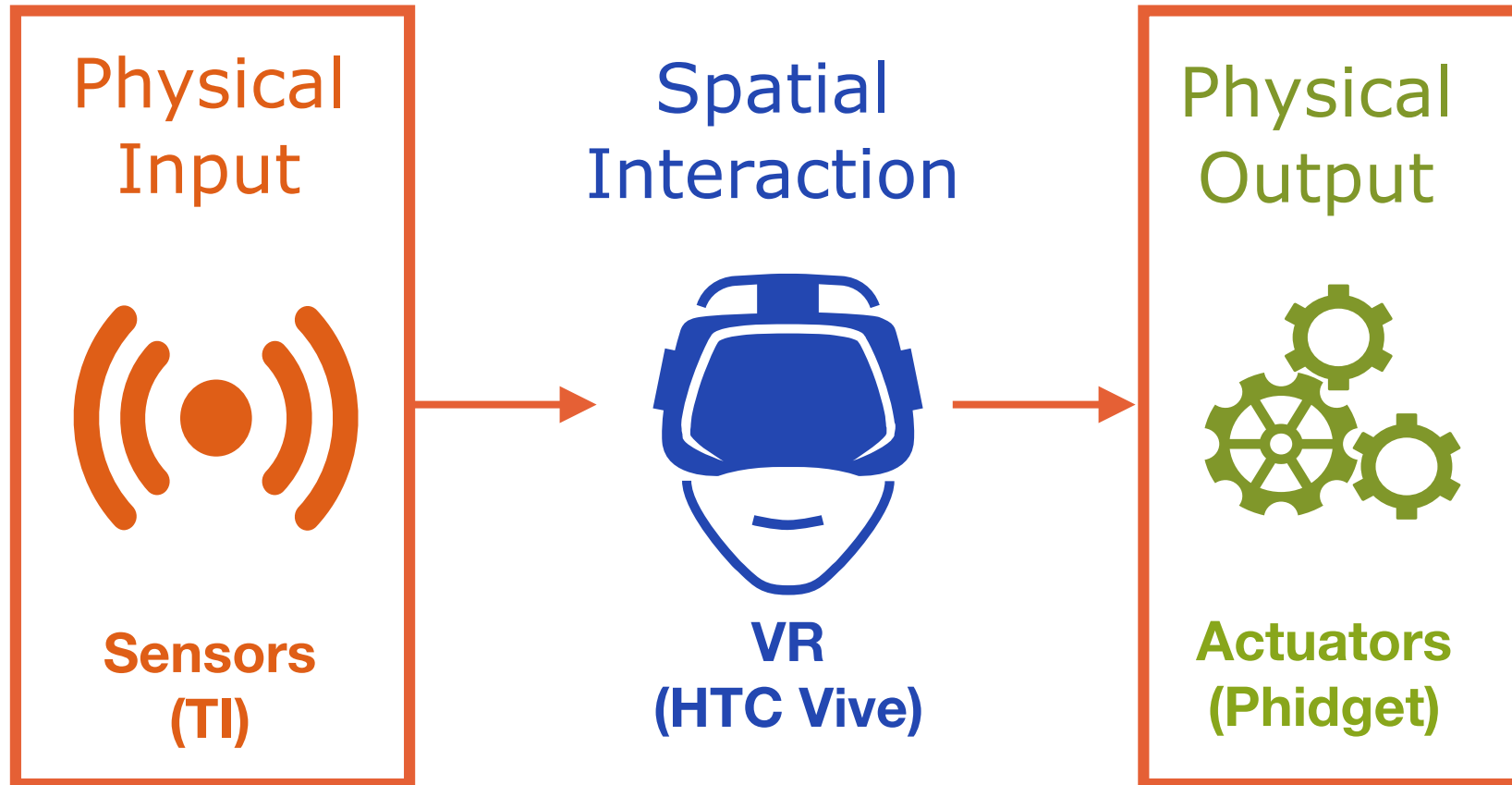
cloud

virtual logic constructs

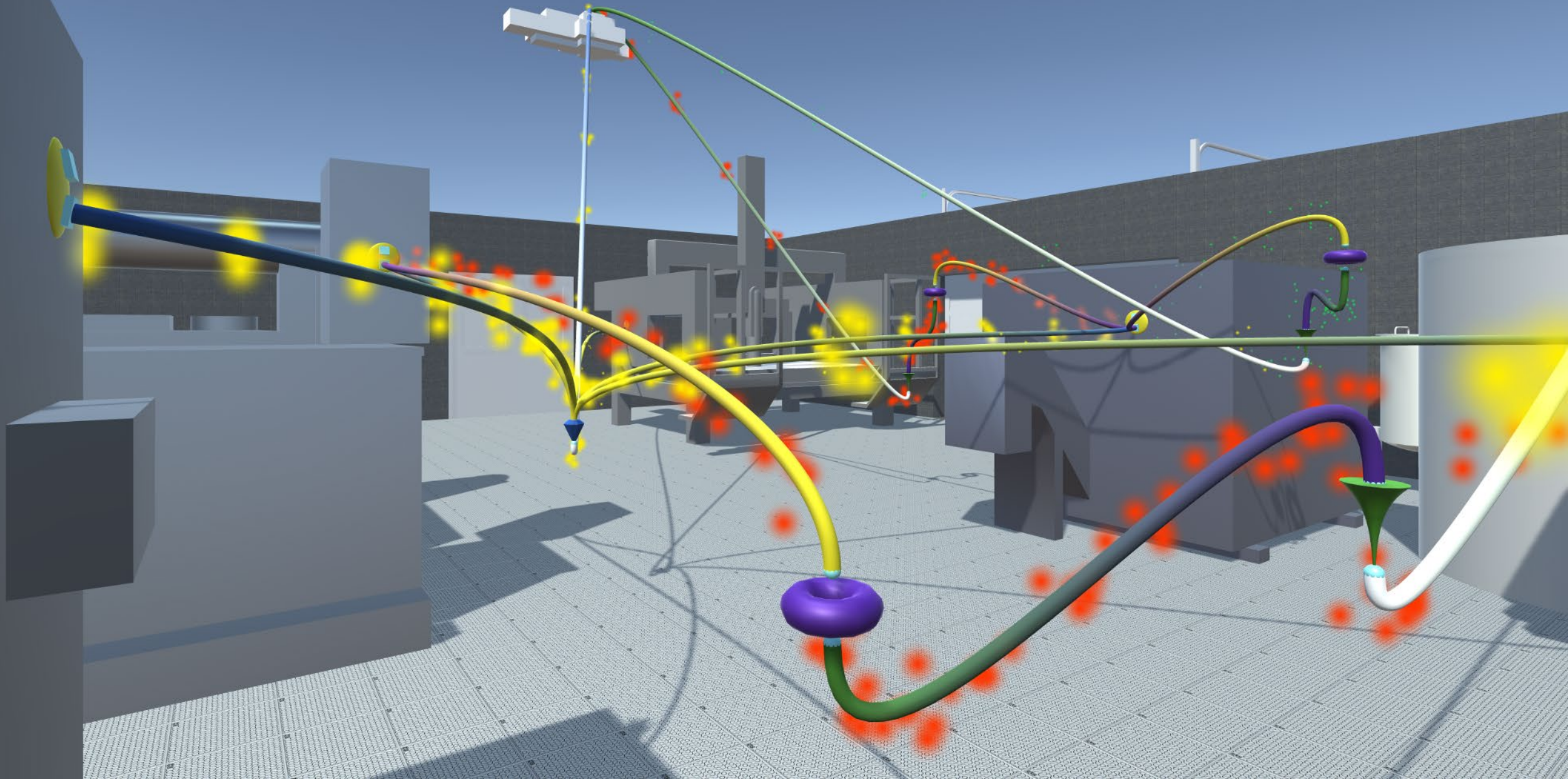


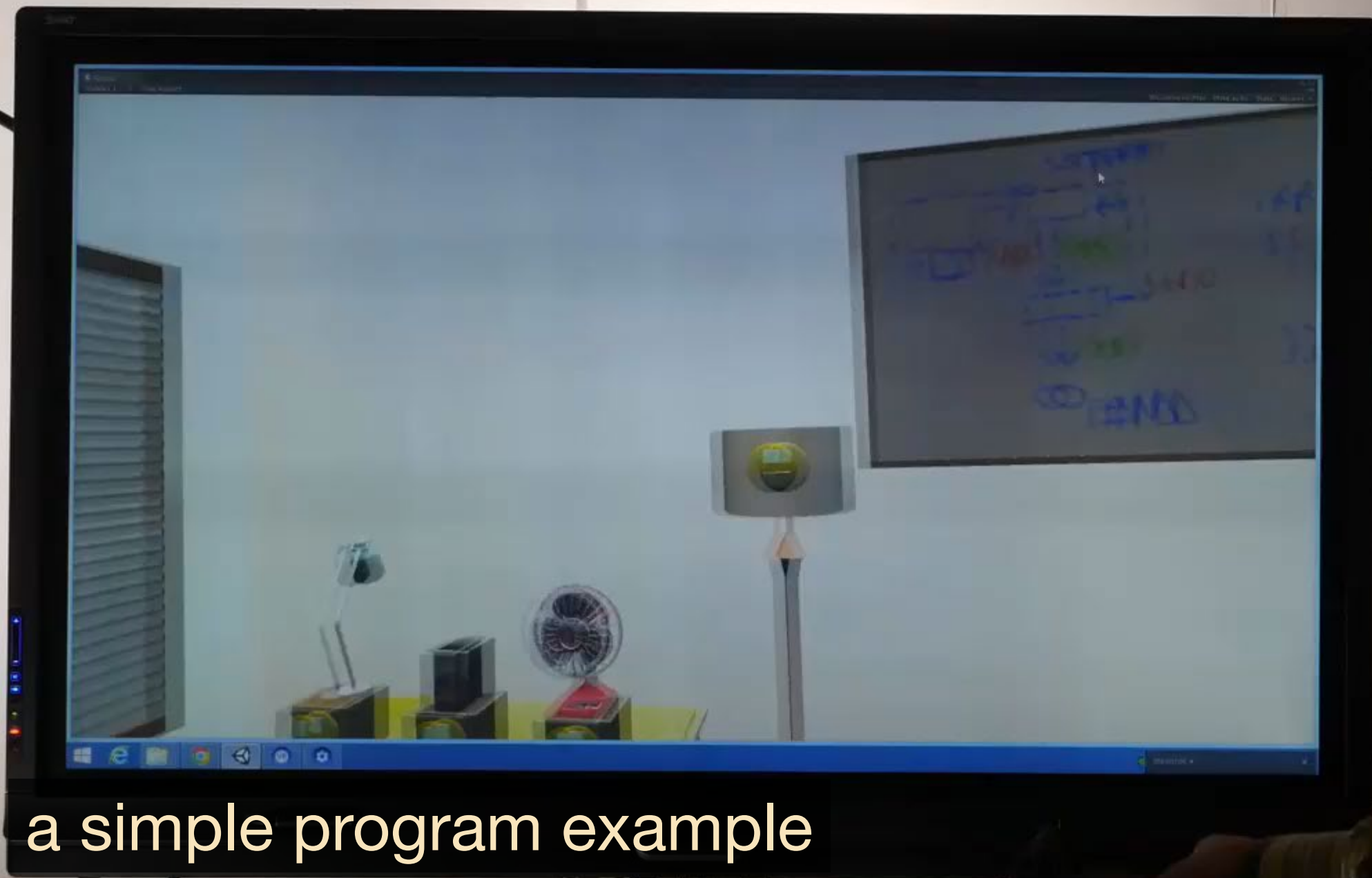
tubes

system overview

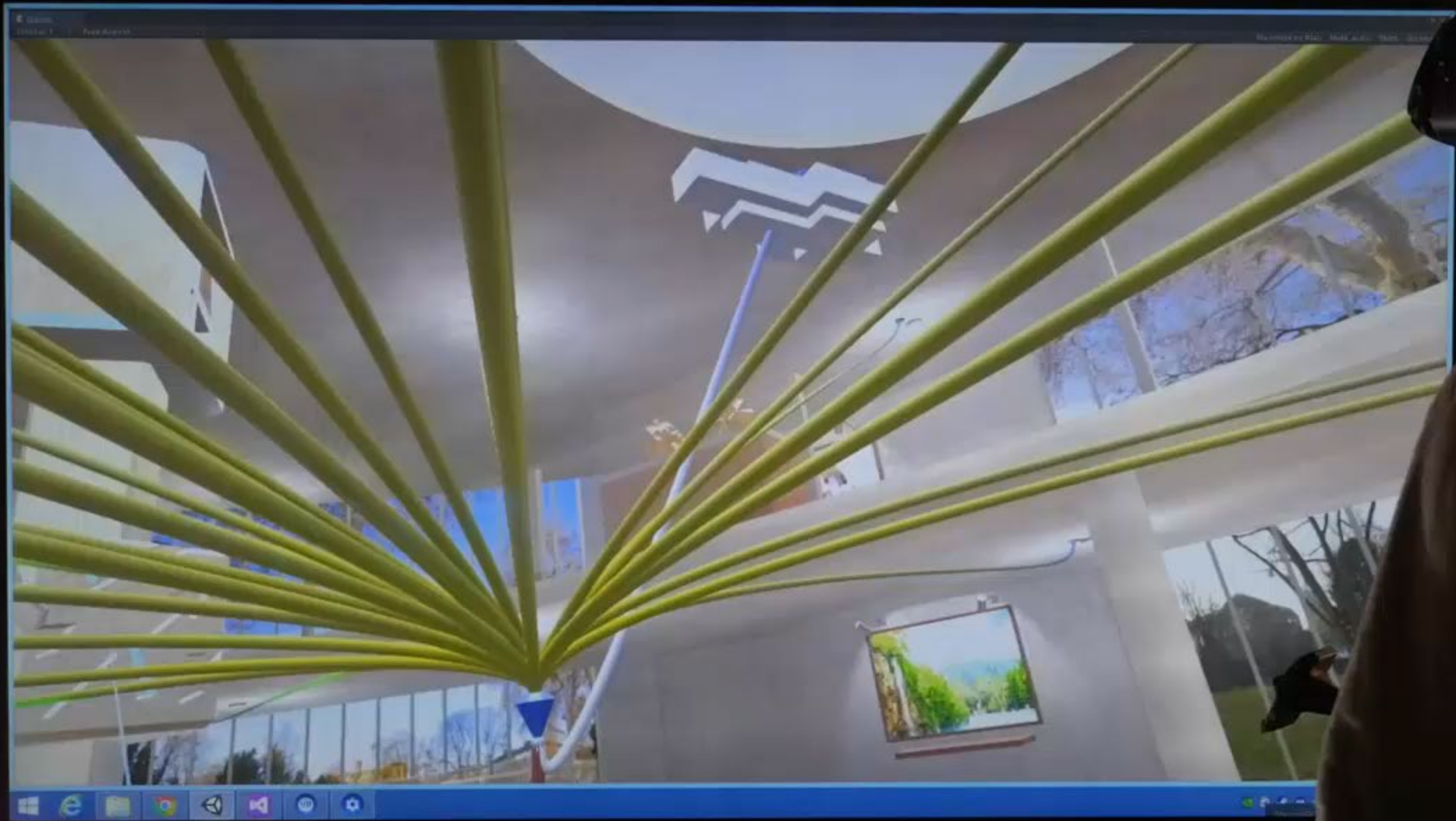


data flow

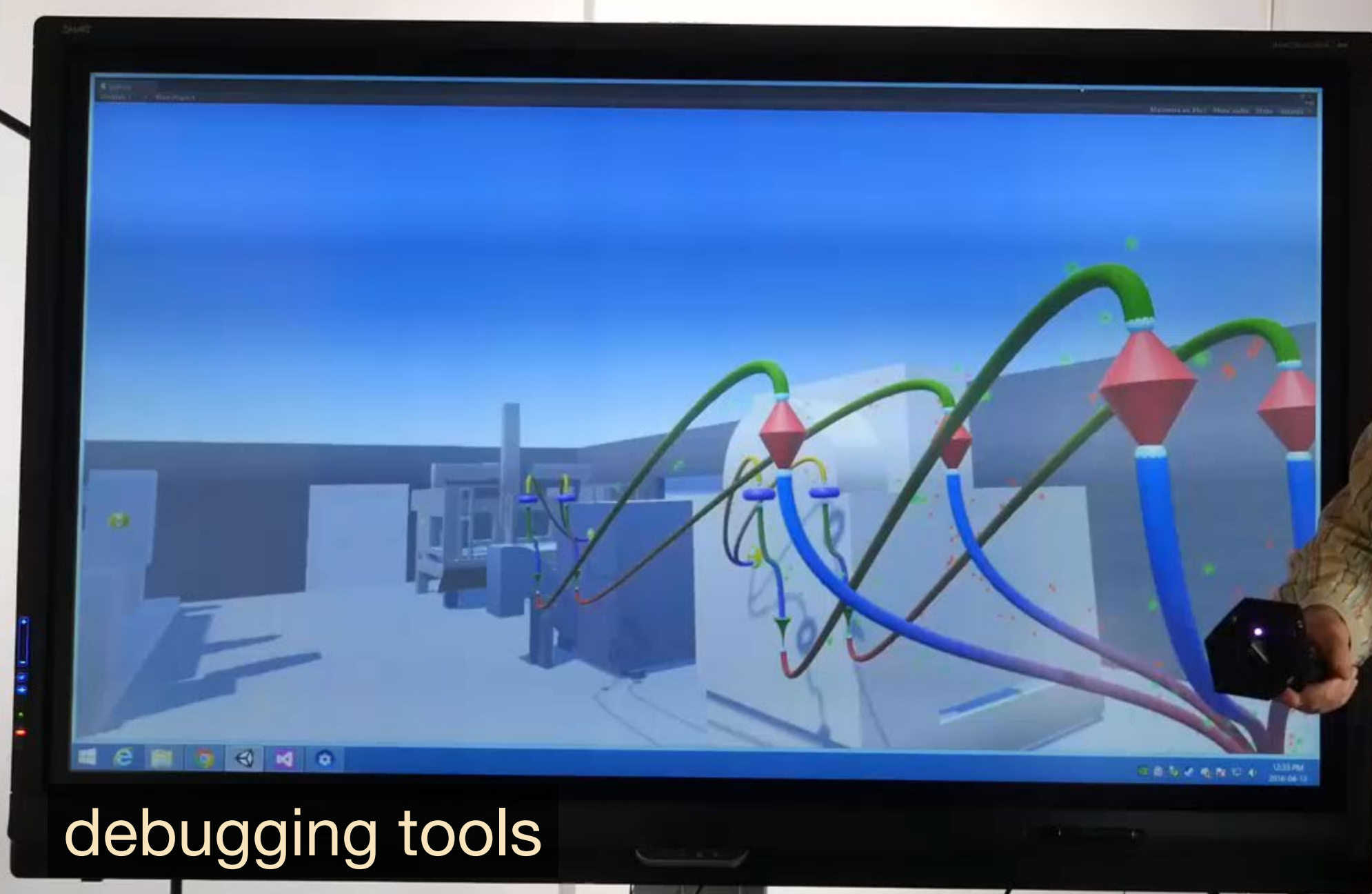




a simple program example



program inspection



debugging tools

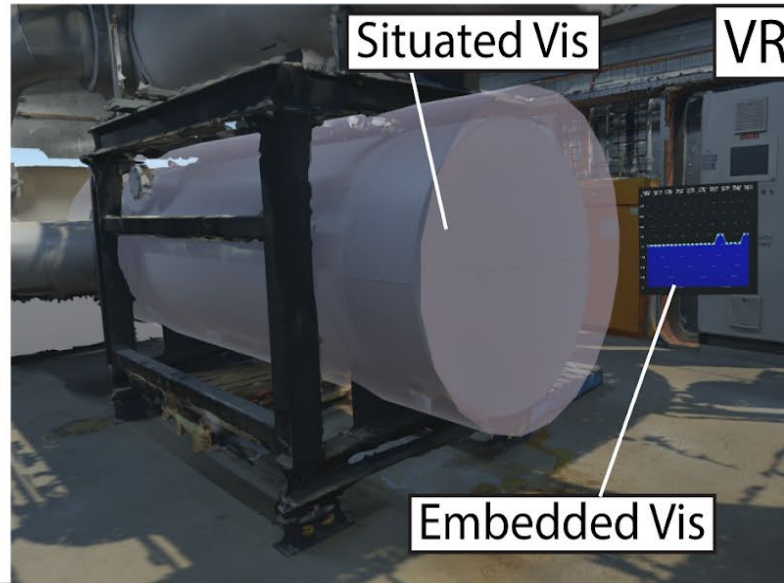
Corsican Twin

Arnaud Prozeau, Yuchen Wang, Barrett Ens, Wesley Willett and Tim Dwyer AVI '20



Prouzeau, Arnaud, Yuchen Wang, Barrett Ens, Wesley Willett, and Tim Dwyer. "Corsican twin: Authoring in situ augmented reality visualisations in virtual reality." In Proceedings of the International Conference on Advanced Visual Interfaces, pp. 1-9. 2020.

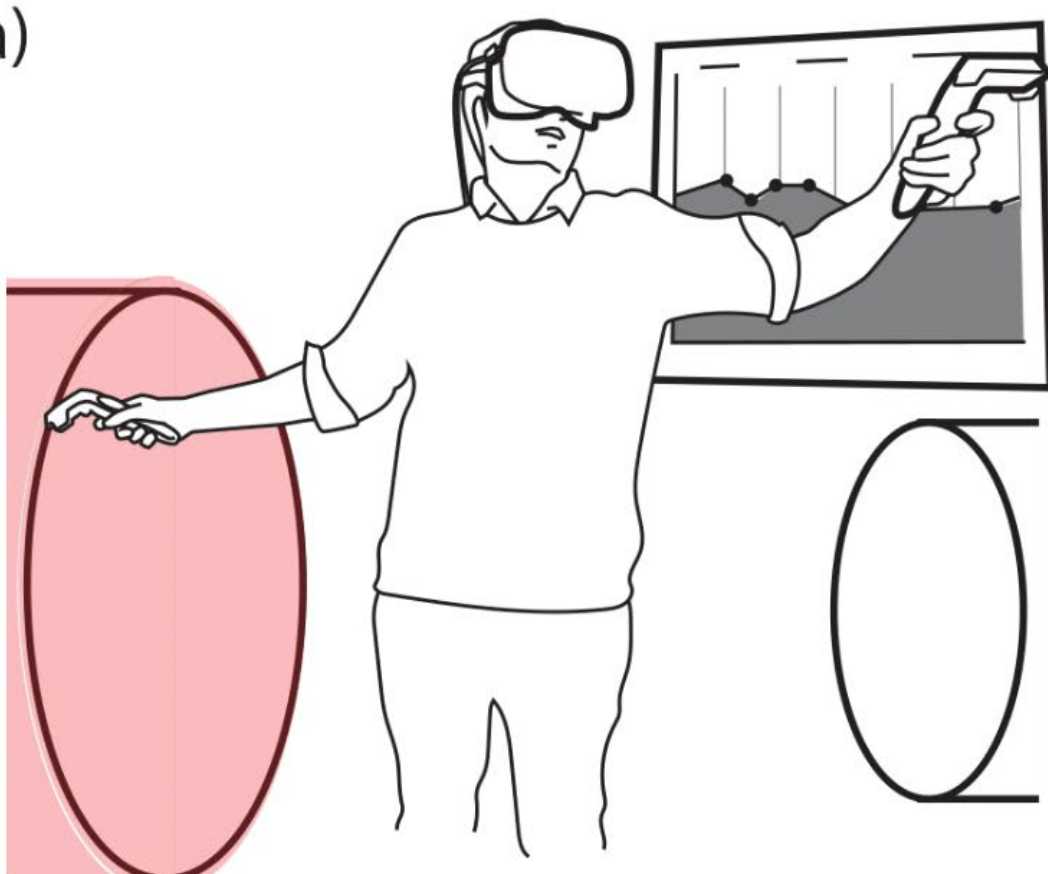
immersive authoring in a digital twin



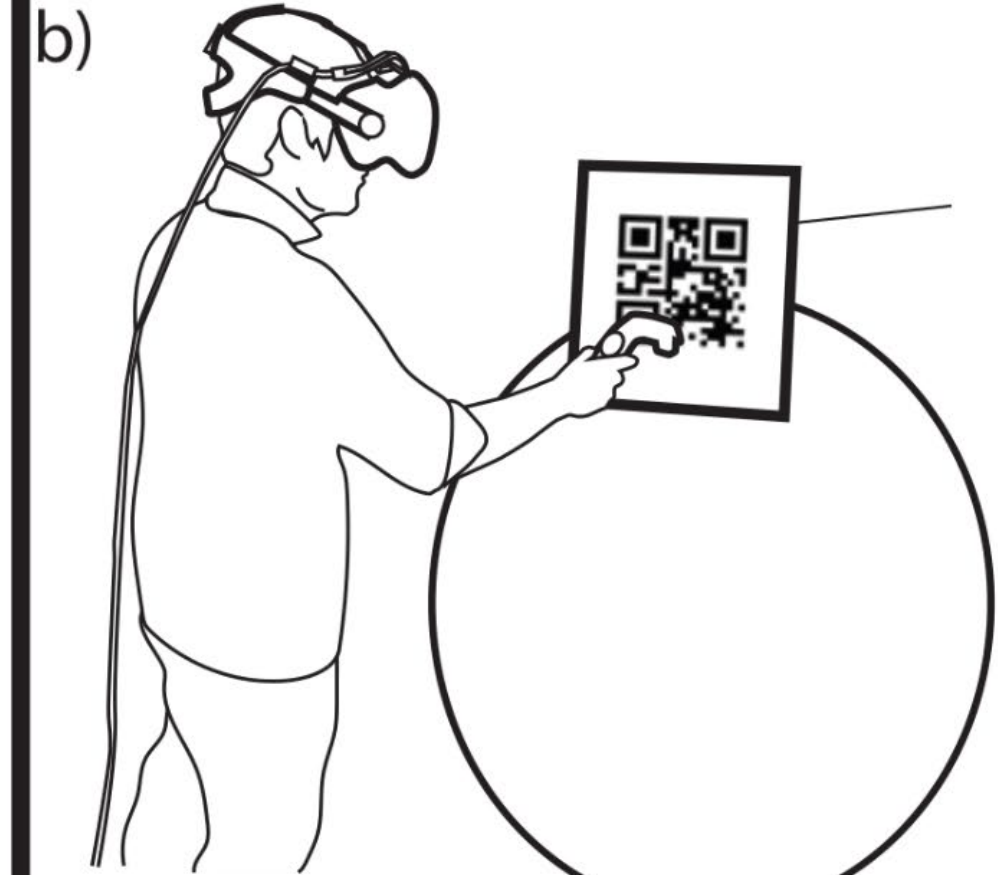
aligning the digital twin

In VR

a)



b)



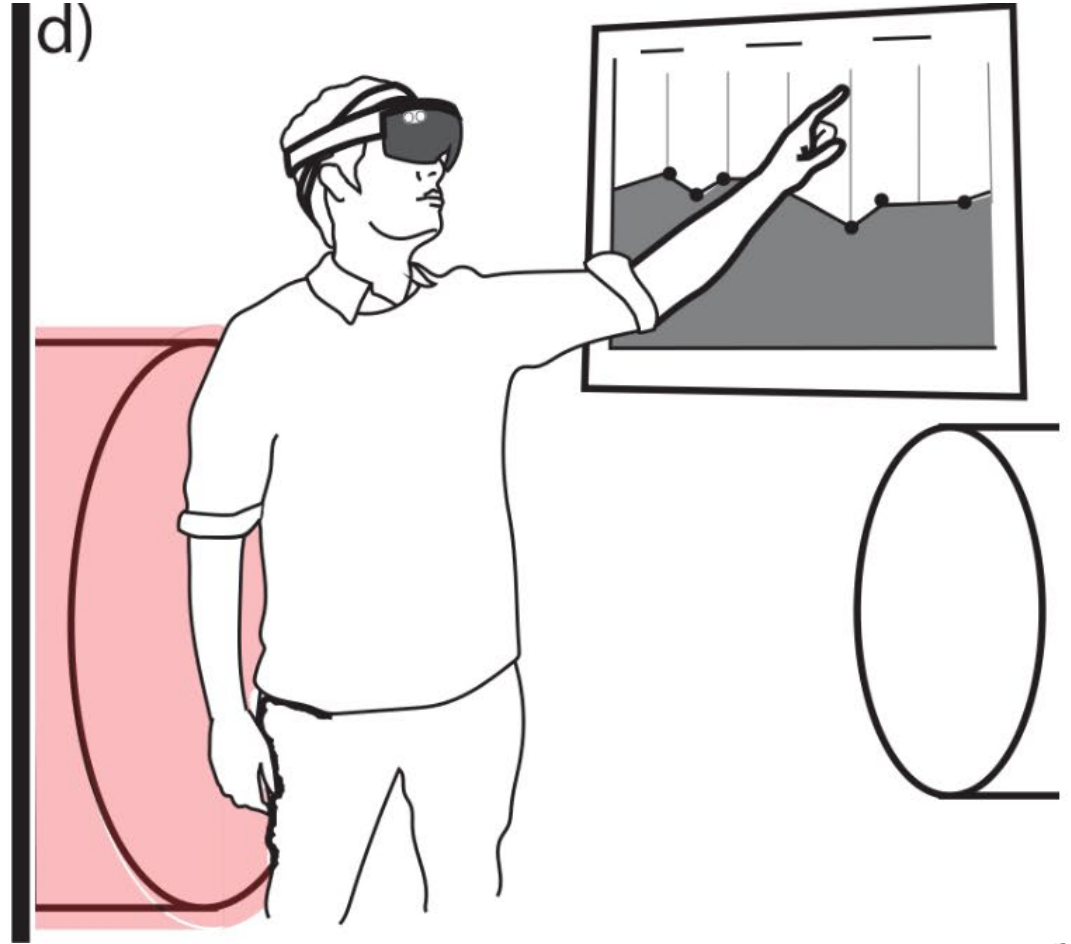
aligning the digital twin

In AR

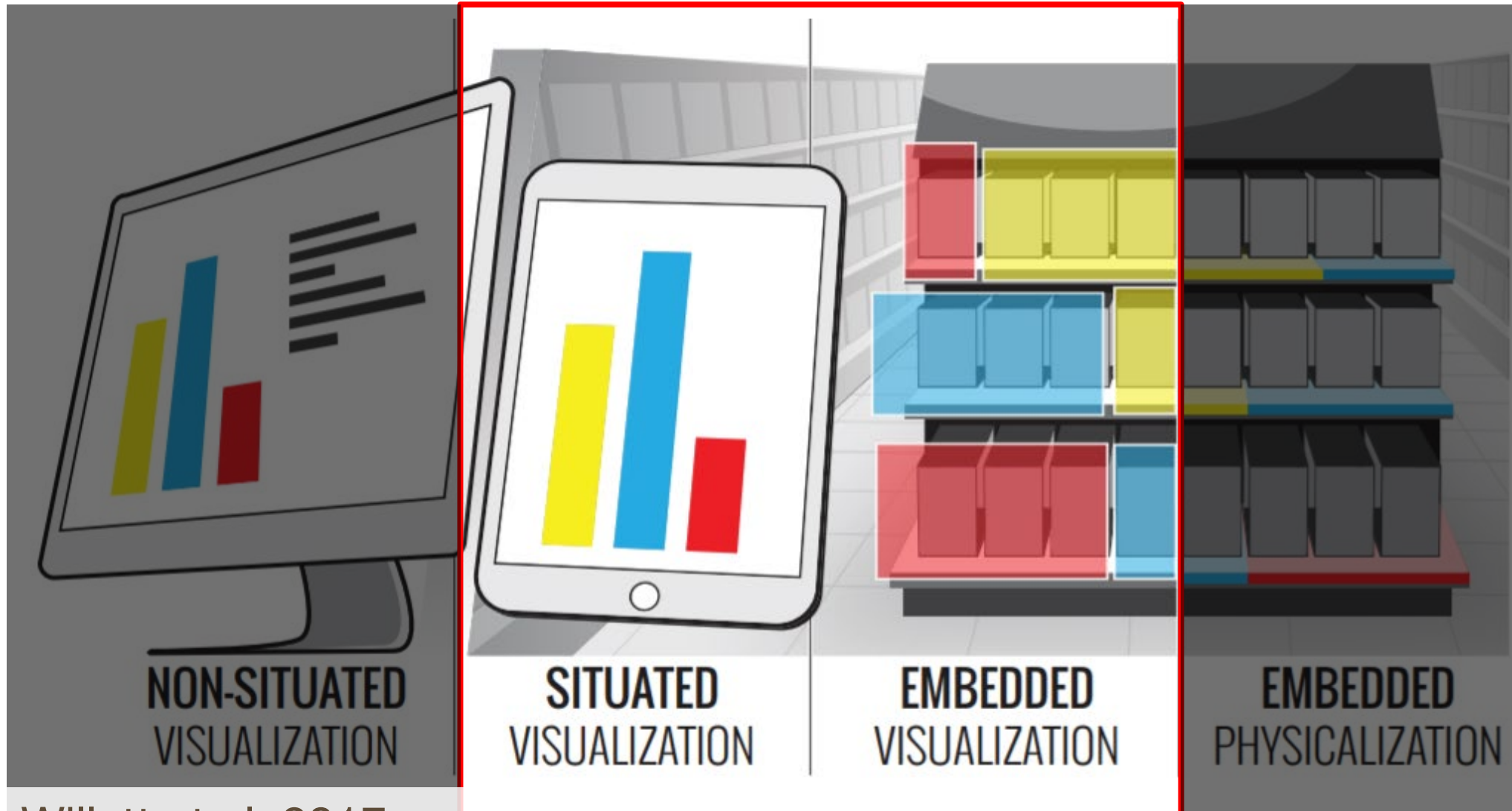
c)



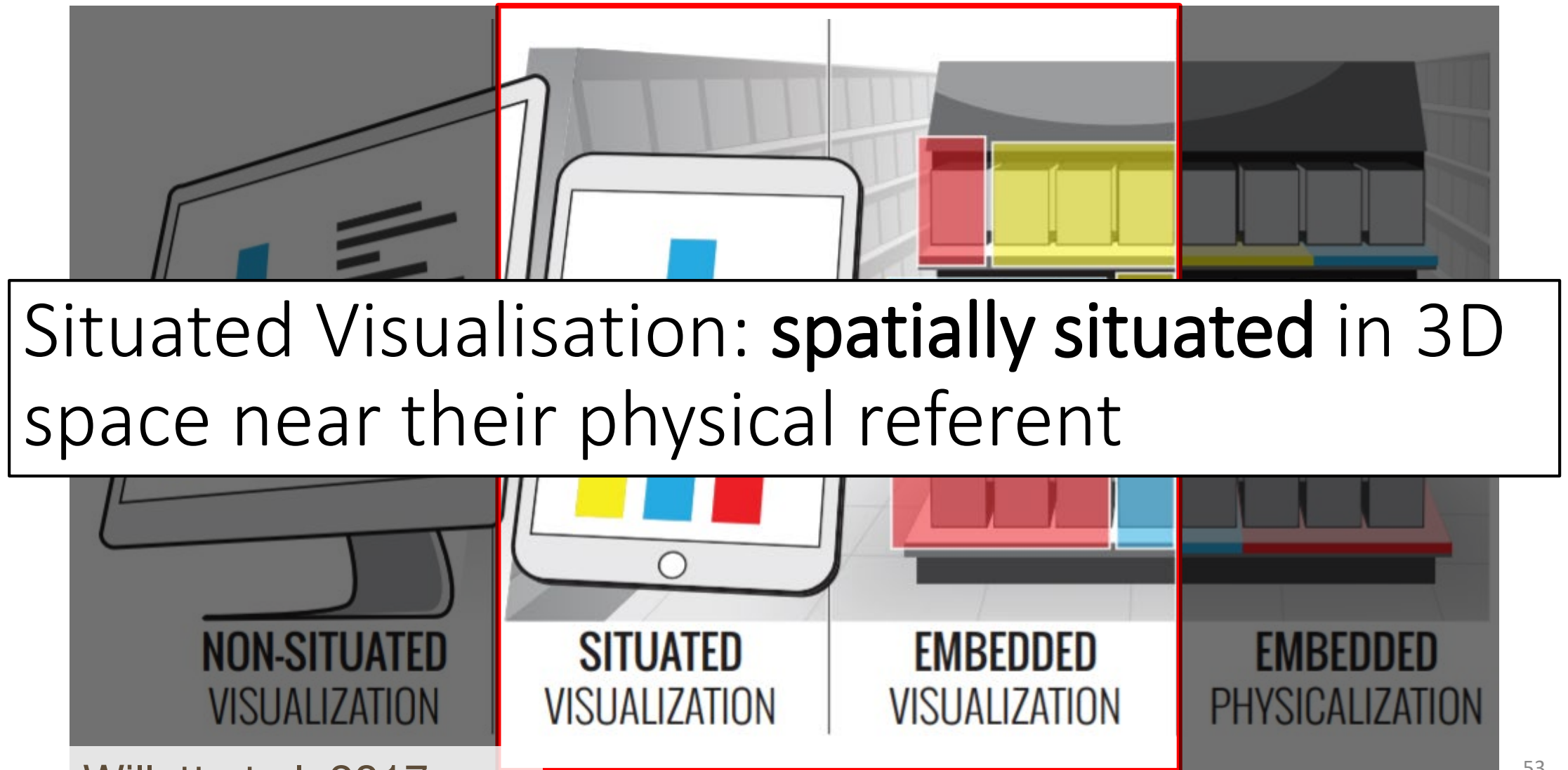
d)



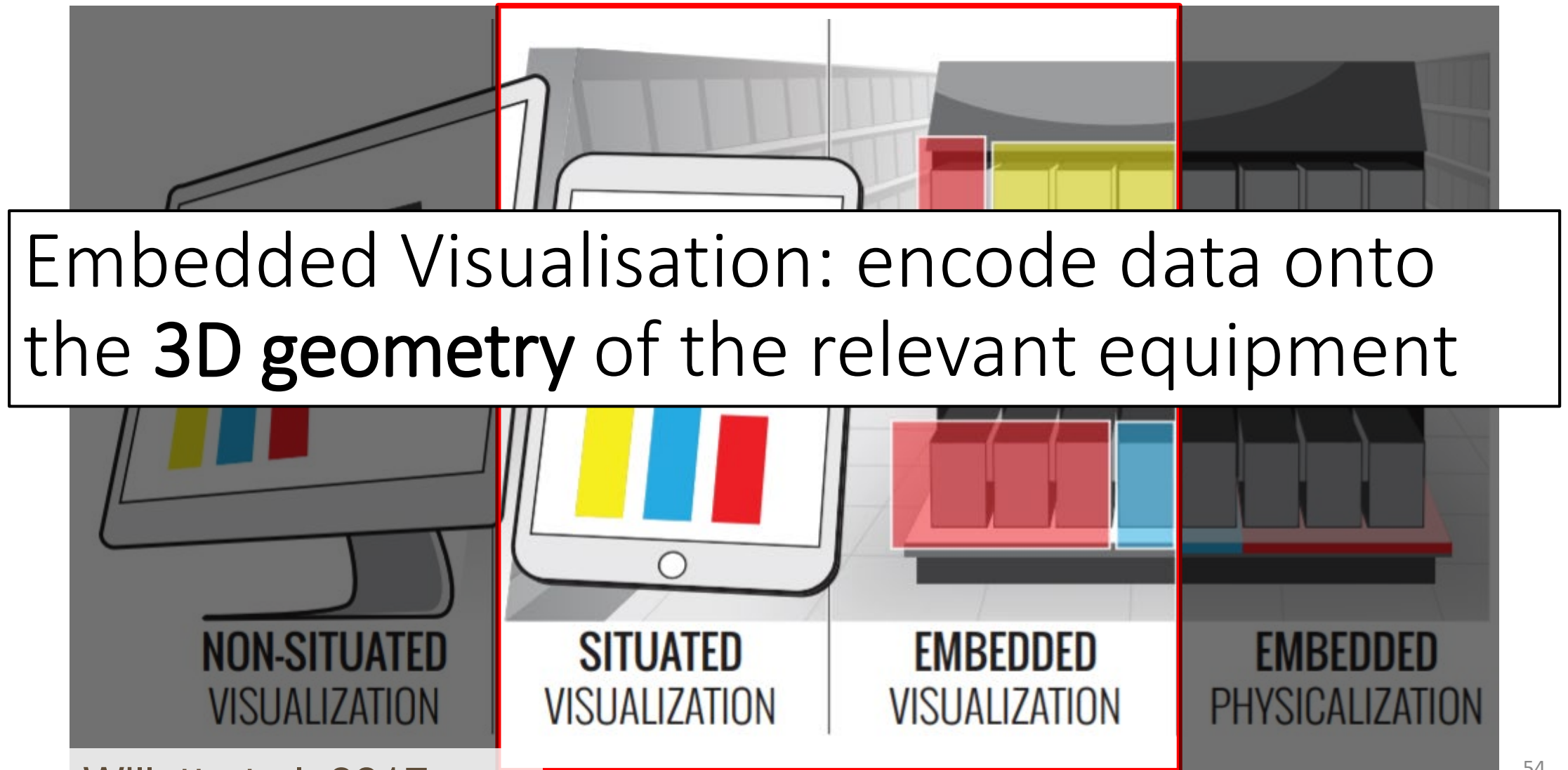
2 types of visualisations



situated visualisation



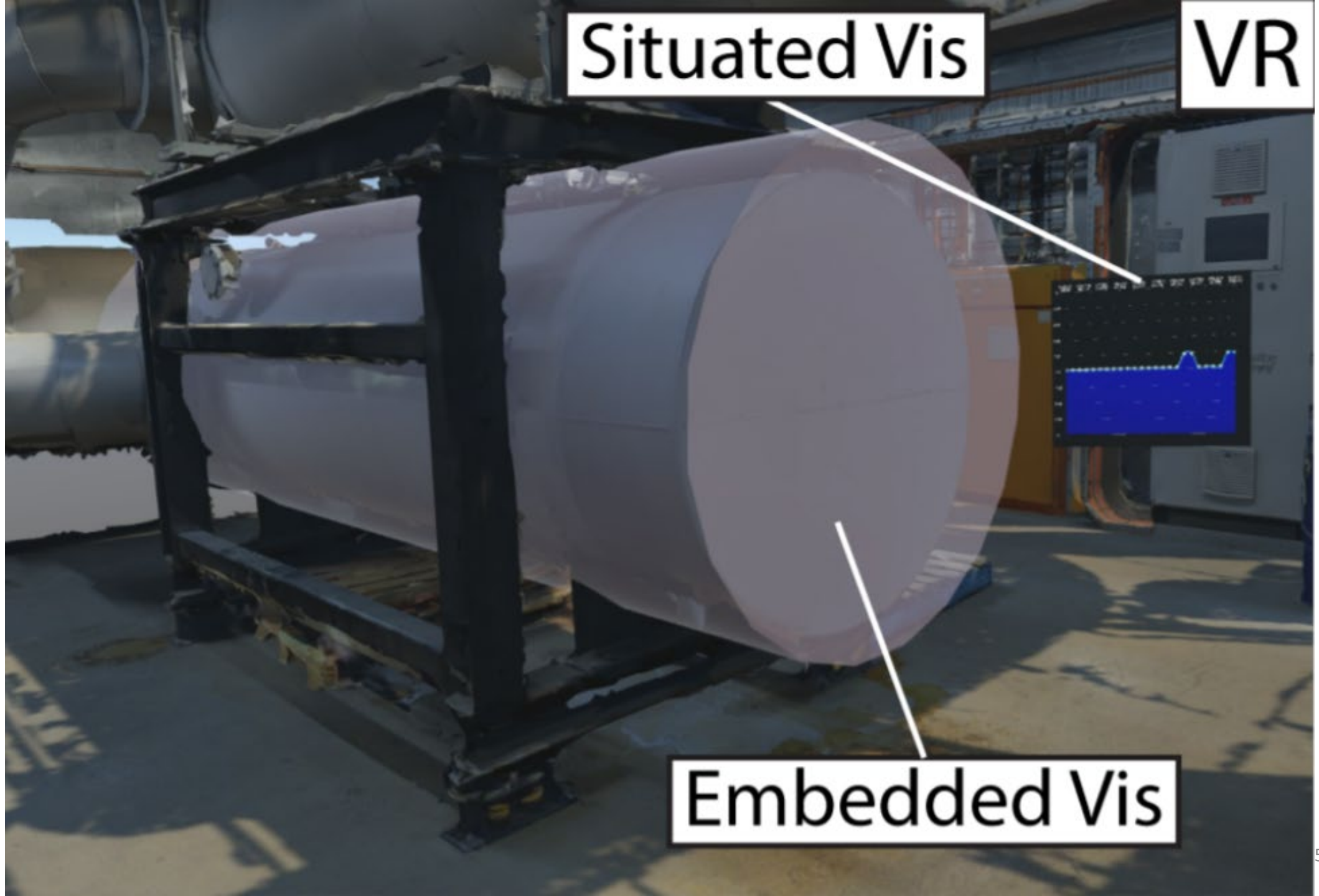
embedded visualisation



Situated Vis

VR

Embedded Vis



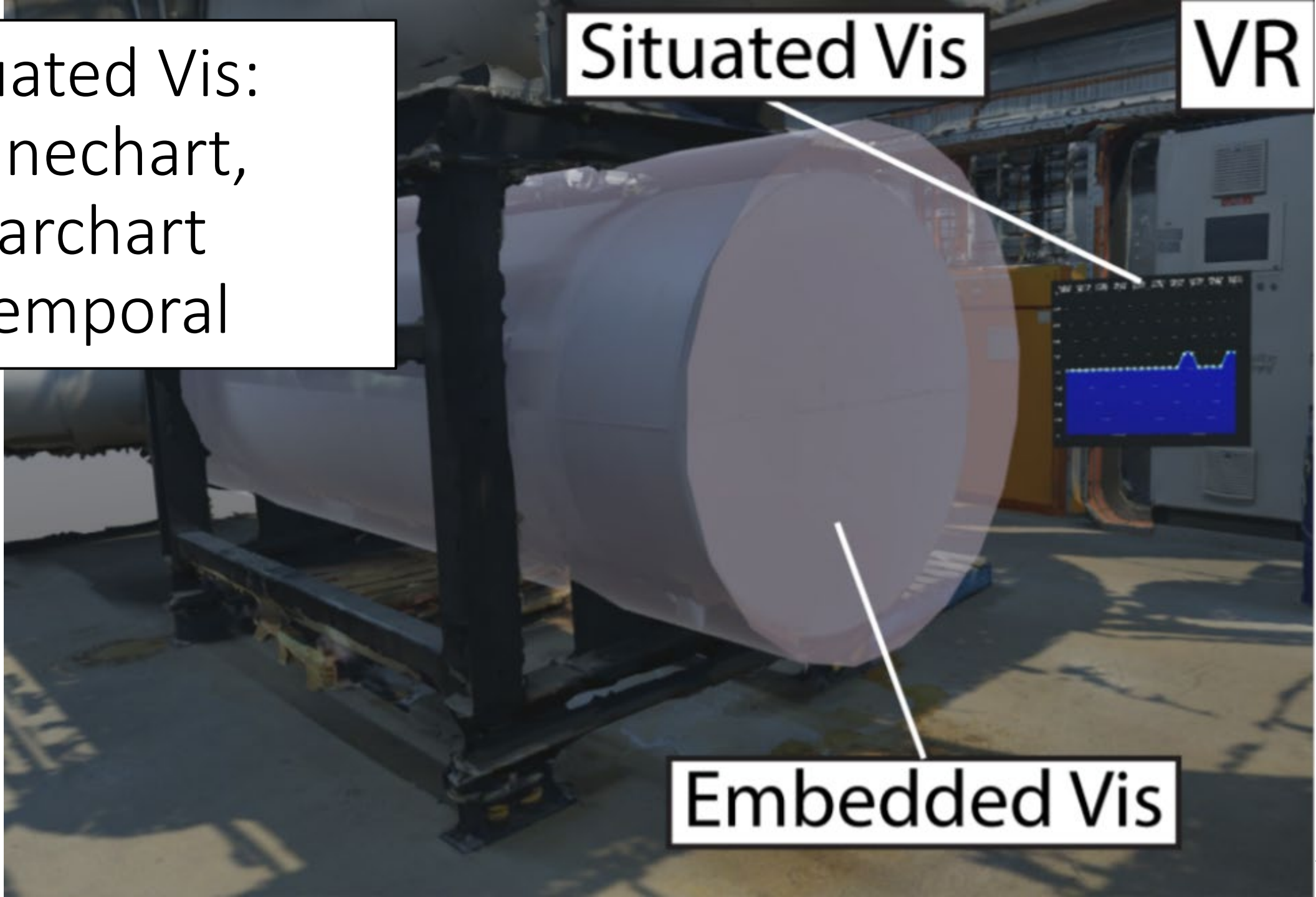
Situated Vis:

- Linechart, barchart
- Temporal

Situated Vis

VR

Embedded Vis



Situated Vis:

- Linechart, barchart
- Temporal

Embedded Vis:

- Colors, size, animation
- Instant value

Situated Vis

VR

Embedded Vis

Virtual Reality

x 5

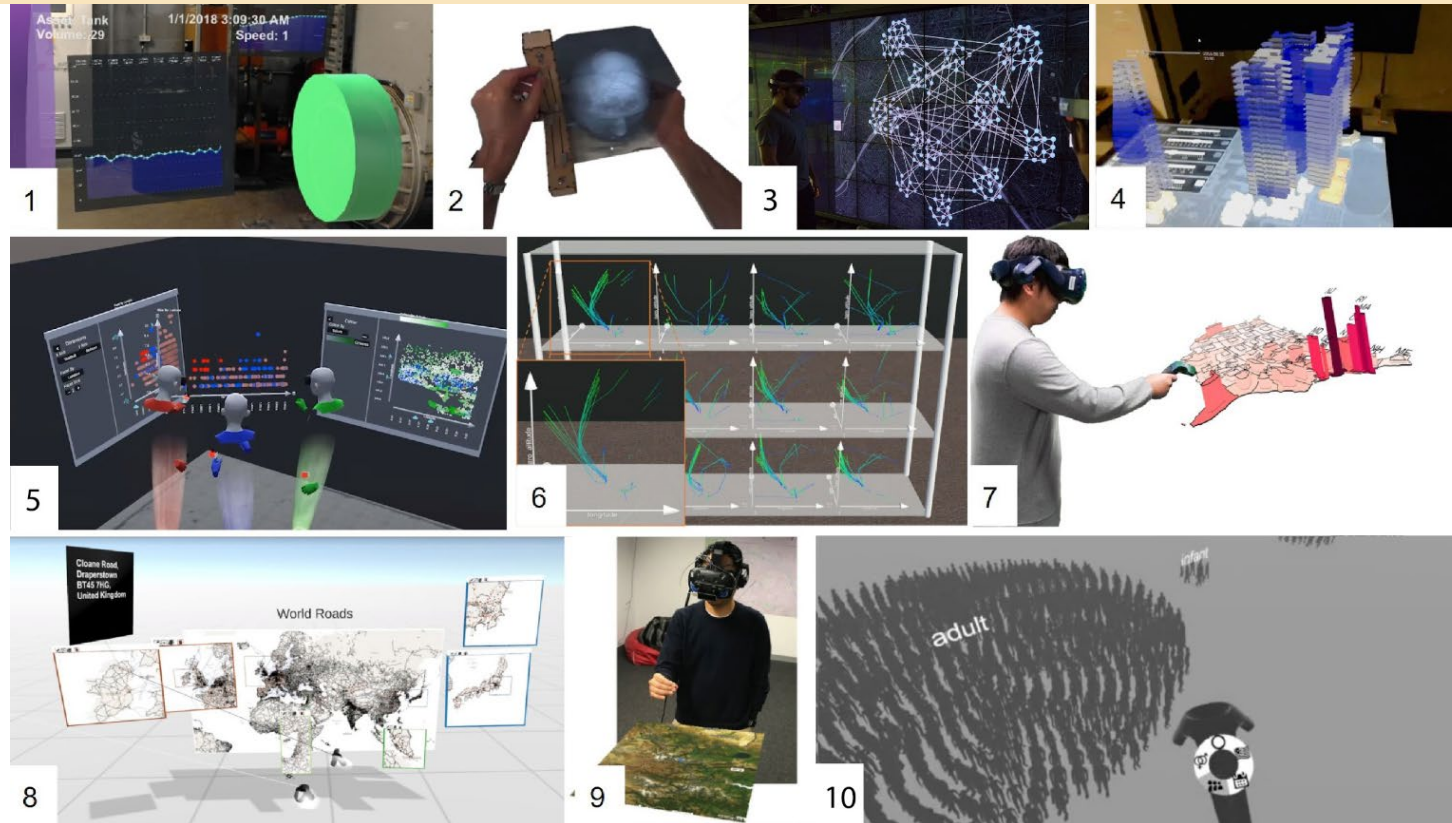
None HeatingCoil Generation Hours Lrp: 2

Min:

06 22

Grand Challenges in Immersive Analytics

Barrett Ens et al. CHI '21



Ens, Barrett, Benjamin Bach, Maxime Cordeil, Ulrich Engelke, Marcos Serrano, Wesley Willett, Arnaud Prouzeau et al. "Grand challenges in immersive analytics." In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, pp. 1-17. 2021.

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Austria

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University of Colorado Boulder

Yalong Yang

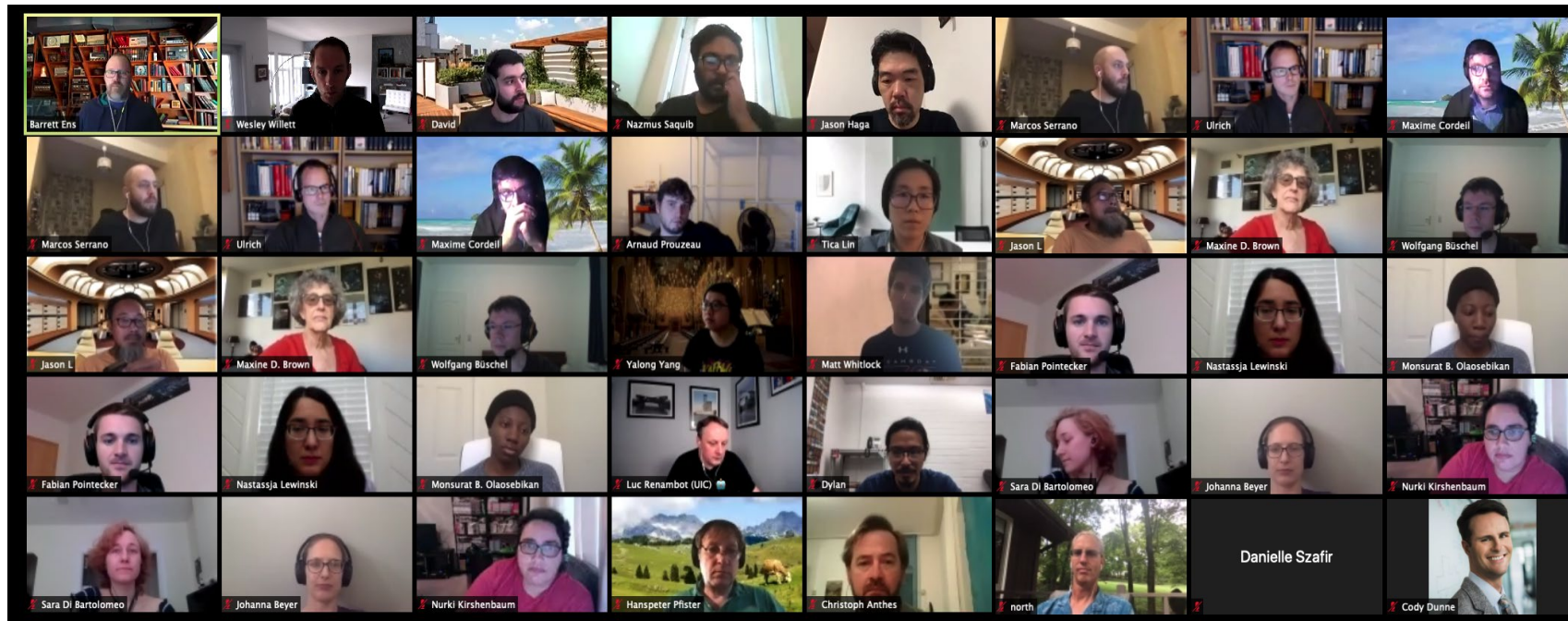
Harvard University

methods & challenges

initiated at CHI 2020 workshop

2 weeks, 4 sessions

4 topics, 17 challenges



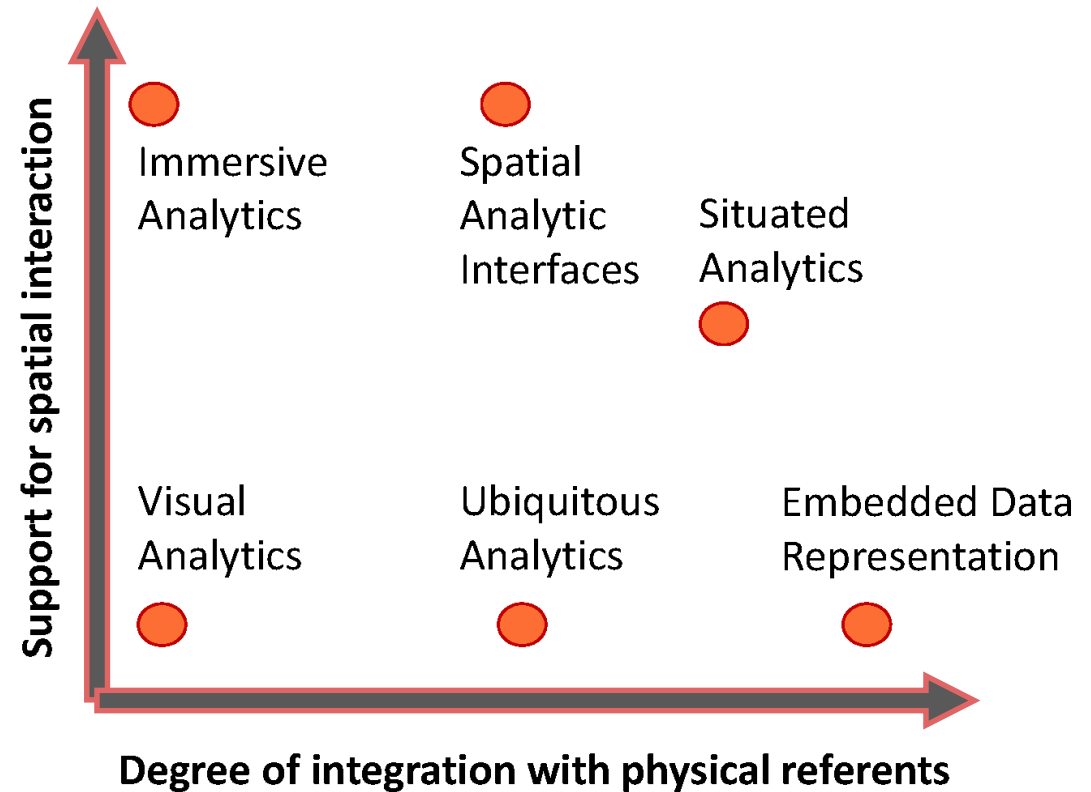
spatially situated data visualisation

Challenges

3 Designing Guidelines for Spatially Situated Visualisation

4 Understanding Human Senses and Cognition in Situated Contexts

Spatially Situated Visualisation Continuum



Using Space Around Us for Immersive Analytics

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Immersive Analytics Lab
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MONASH
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