8AM

1PM in London (GMT), 10PM in Tokyo (GMT+9)

Panel: Why 3D?

Moderator: Andreas Bueckle, *Indiana University*

Presenters:

- Timothy Davison, *Independent computer graphics researcher/programmer, Austria*
- Christiane V.R. Hütter, *University of Vienna, Austria*
- Sebastian Pirch, *Austrian Academy of Sciences, Austria*
- Martin Chiettini, *University of Vienna, Austria*

CNS Cyberinfrastructure for Network Science Center

LUDDY
SCHOOL OF INFORMATICS, COMPUTING, AND ENGINEERING
Bloomington

Why 3D?

Andreas "Andi" Bueckle, Ph.D.
Research Lead

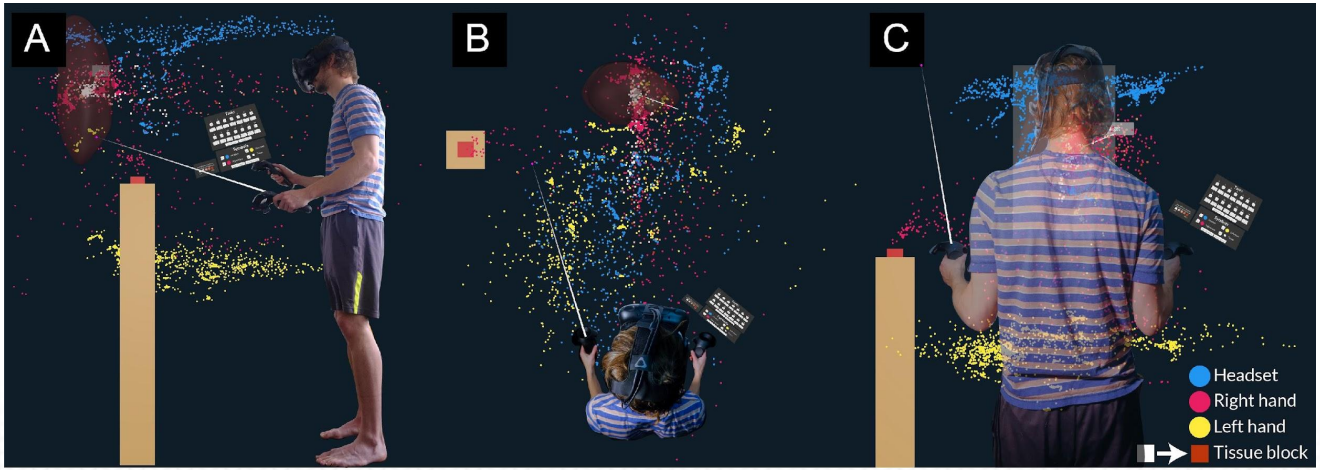
Cyberinfrastructure for Network Science Center
Department of Intelligent Systems Engineering
Luddy School of Informatics, Computing, and Engineering
Indiana University, Bloomington, IN, USA

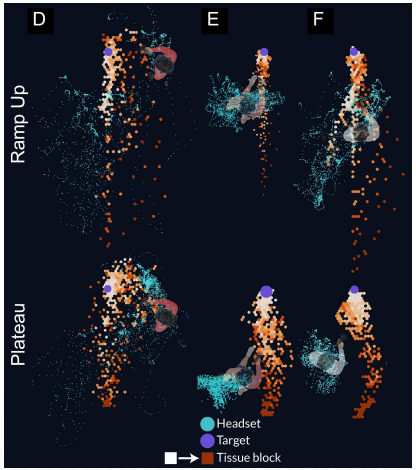
24 Hour "Multiscale Human" Event | Virtual | December 14-15, 2024

Data Visualization in VR: Vision

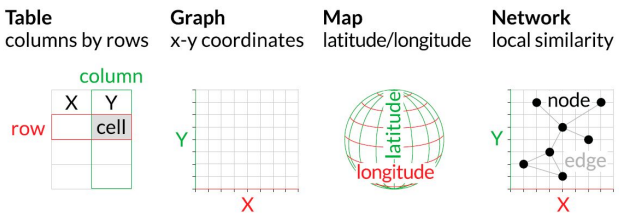
"Visual data exploration seeks to integrate humans in the data exploration process, applying their perceptual abilities […]. The basic idea is to present the data in some visual form, allowing data analysts to […] interact with it." (Keim, 2001)

- Symbiosis of computers and humans
- Visualization is for humans only
- Many formalizations for making, interpreting, and teaching data visualization





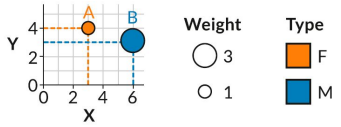
Data Visualization Literacy Framework



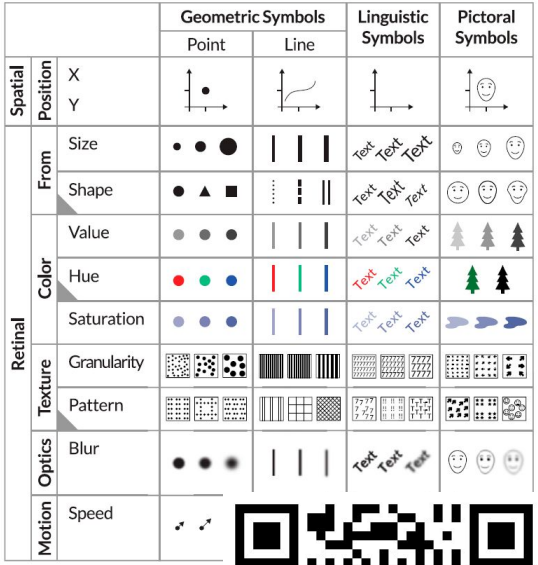
Data Scales	Logical Math Operations = ≠	< >	+ -	x ÷	Measure of Central Tendency	Examples
Nominal	✓				mode	
Ordinal	✓	✓			median	
Interval	✓	✓	✓		arithmetic mean	0–6 | 7–12 | 13–18
Ratio	✓	✓	✓	✓	geometric mean	0 1 2 3

	Outlier	Trend	Clustering
Position			
Size			
Color			

Label	X	Y	Weight	Type
A	3	4	1	F
B	6	3	3	M



Qualitative	Quantitative		
Categorical	Sequential	Diverging	Cyclic

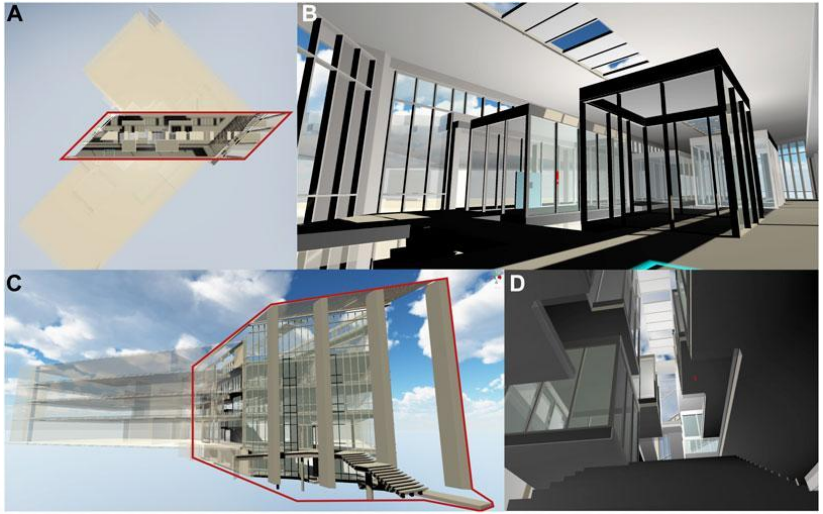


Börner, Katy, Andreas Bueckle, and Michael Ginda. "Data Visualization Literacy: Definitions, Conceptual Frameworks, Exercises, and Assessments." *Proceedings of the National Academy of Sciences* 116, no. 6 (2019): 1857–64. https://doi.org/10.1073/pnas.1807180116.

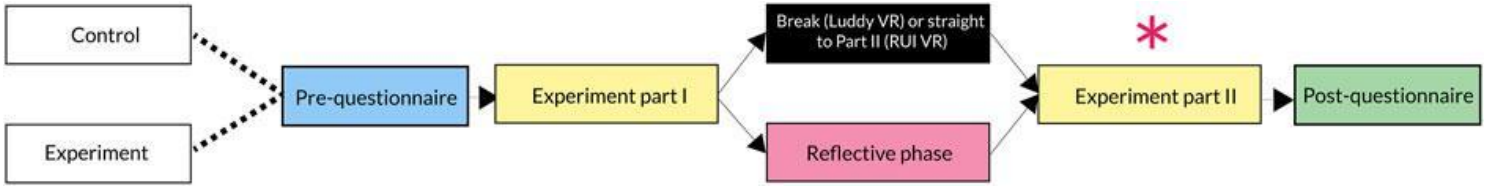
CNS Cyberinfrastructure for Network Science Center

Navigation in VR

Optimizing Performance and Satisfaction in Matching and Movement Tasks in Virtual Reality with Interventions Using the Data Visualization Literacy Framework

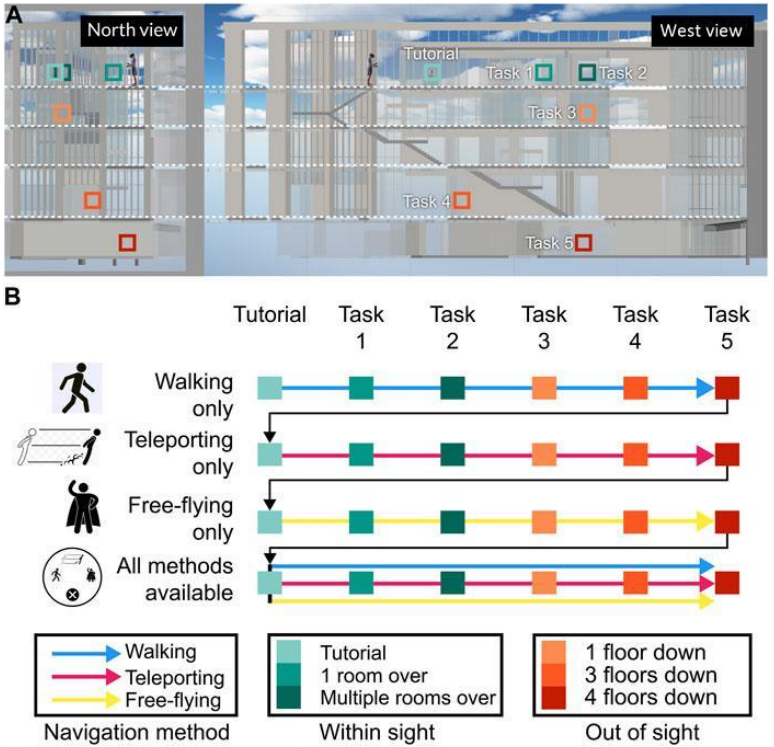


Experimental Design

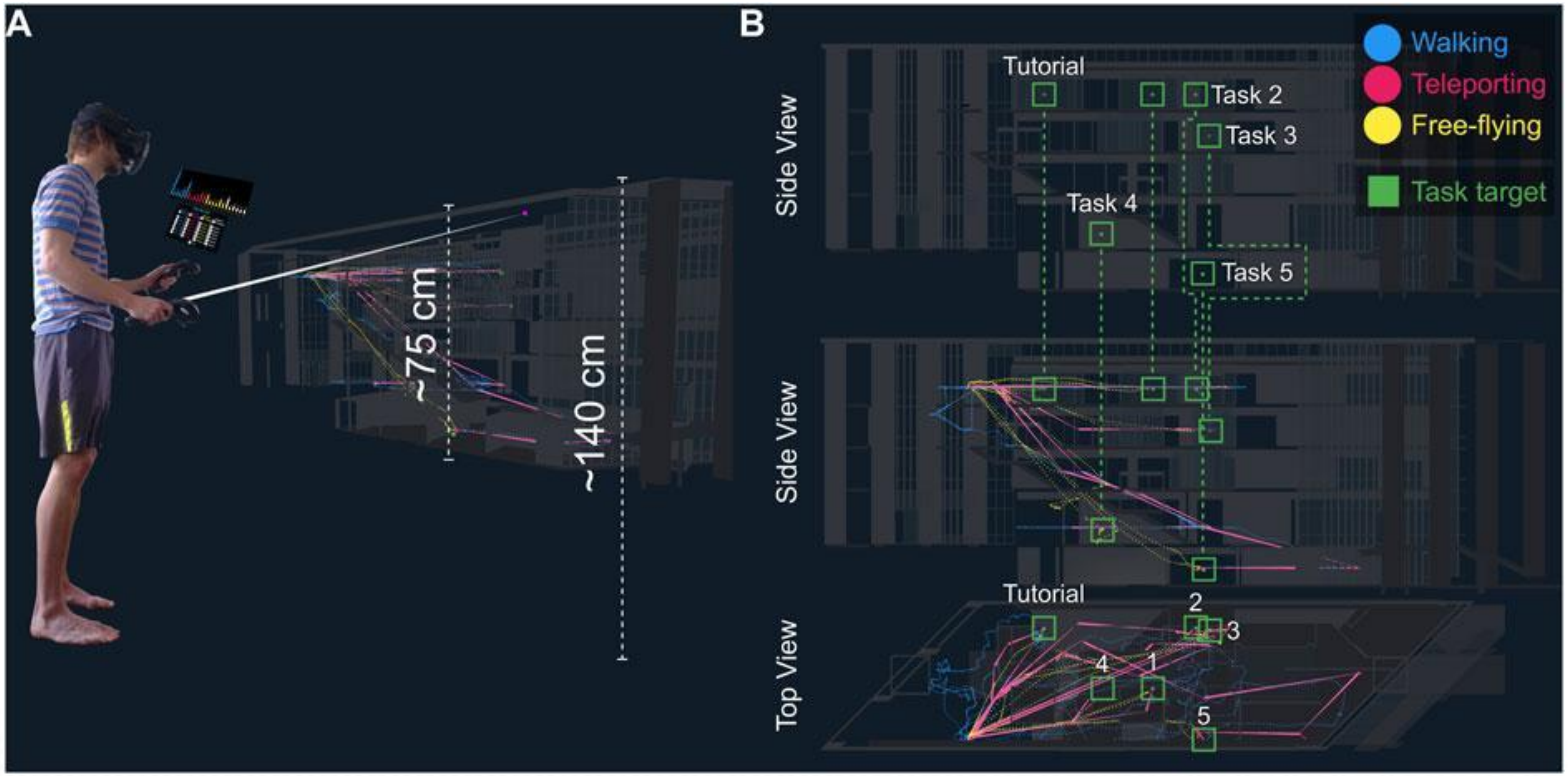


Tasks

- Go from start to Task room
- 24 tasks per round
  - 4 repeating sets
    - 1 navigation method per round
    - 4th round: all methods
  - 6 tasks each
    - Incl. 1 tutorial task
- Tasks get harder over time
- 2 rounds total (48 tasks)



Reflective Phase: Subjects view their own data



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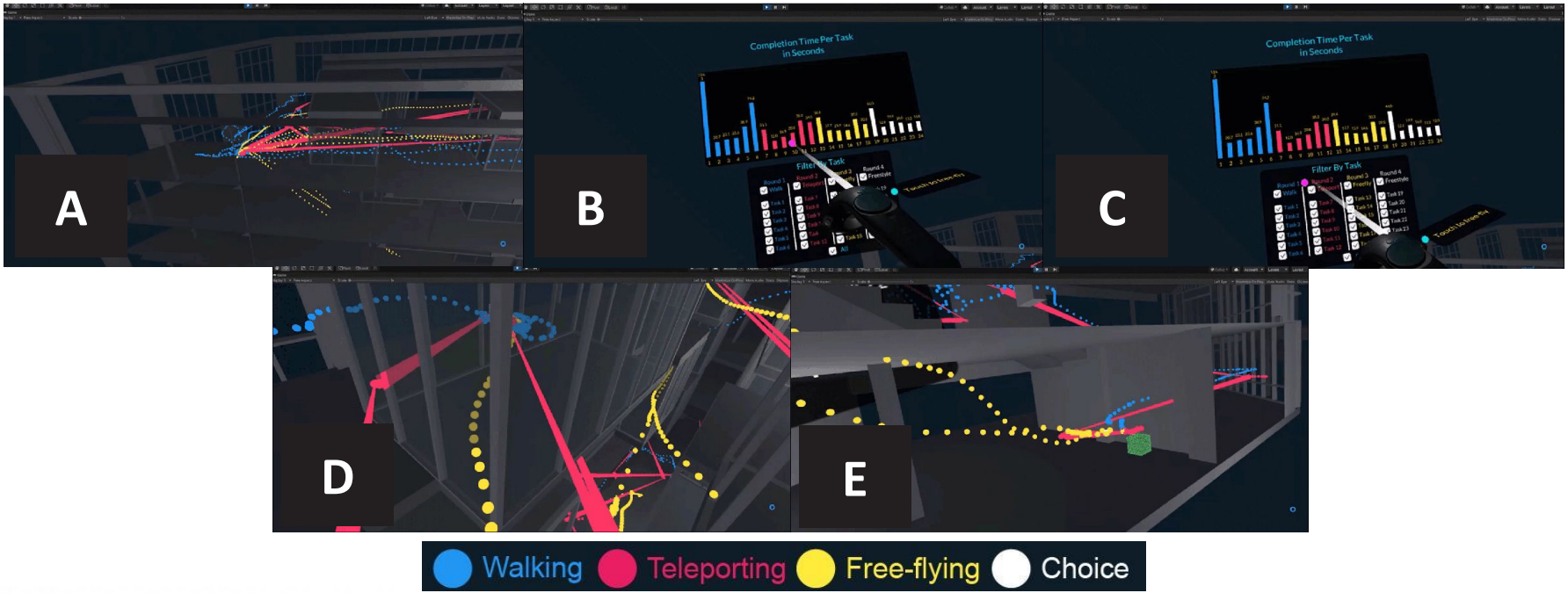


Perceptual Challenges for vis in VR

- 2D is simplicity
- VR is 3D by nature
- Occlusion
  - Depth cue -> limits what we can see in 3D
  - We experience the world in 2.05D (Munzner, 2014; Ware, 2008)
- Foreshortening
  - Shows size difference where there should be none
- 3D costs time and cognitive effort
  - No 3D as purely aesthetic choice! (Few, 2012)

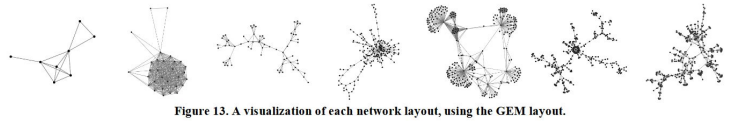
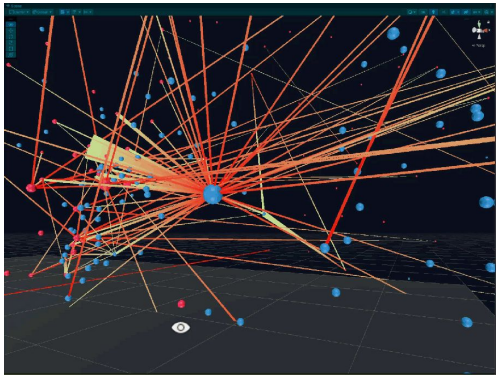
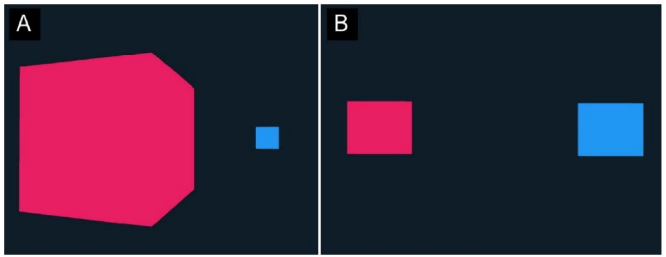


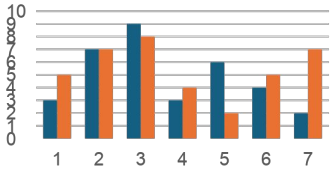
Figure 13. A visualization of each network layout, using the GEM layout.

From (Zoss, 2018)

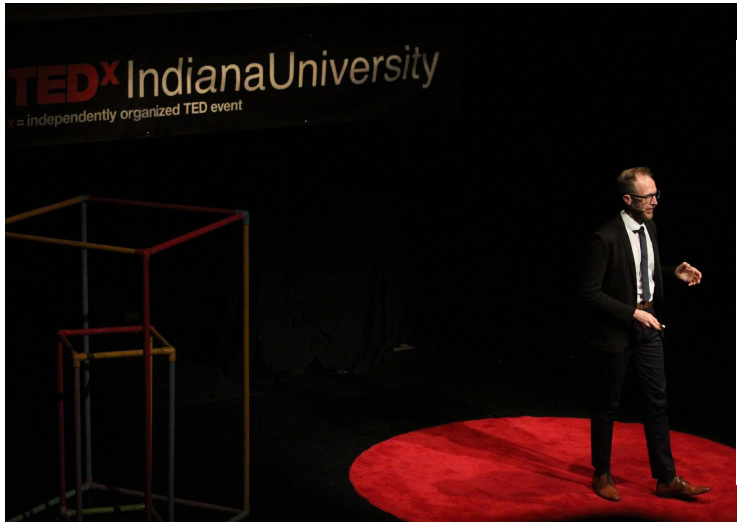




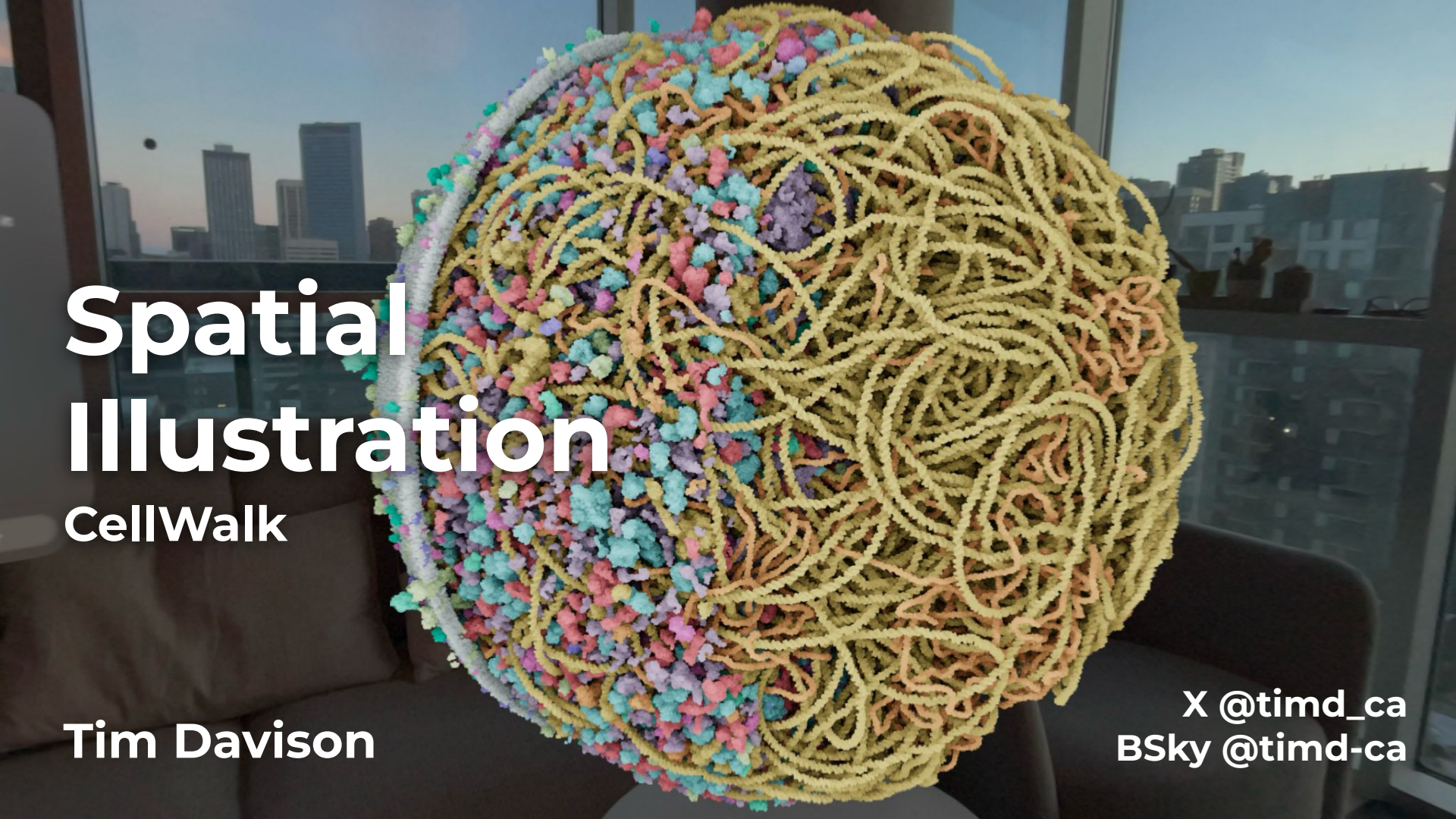
From (Bueckle, 2021)



Living and Learning in the Metaverse: TEDxIndianaUniversity



Timothy Davison, Independent Computer Graphics Researcher/Programmer



Spatial Illustration

CellWalk

Tim Davison

X @timd_ca
BSky @timd-ca

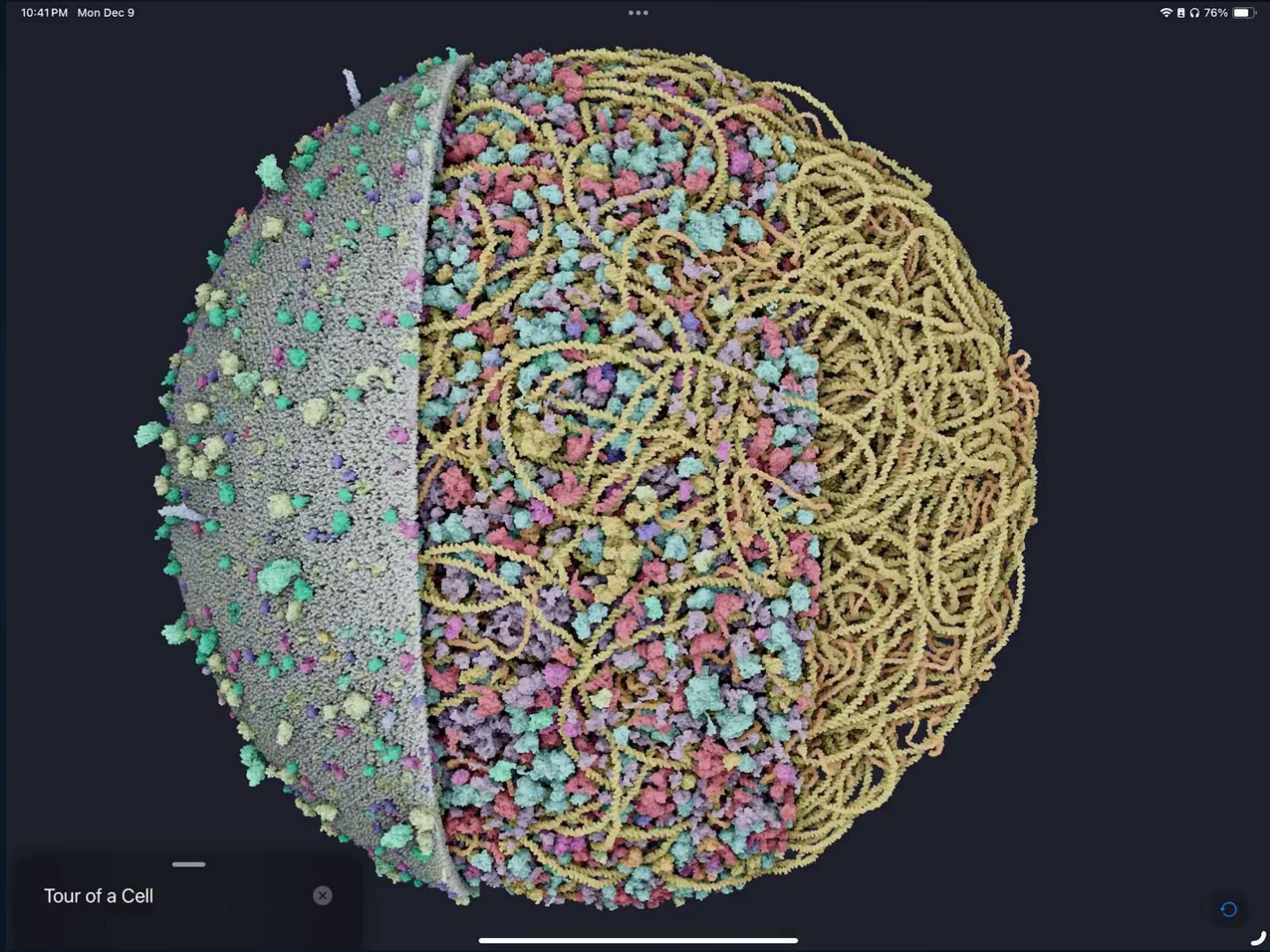
Why 3D?

Arthur Olson, Virus Wars 1982

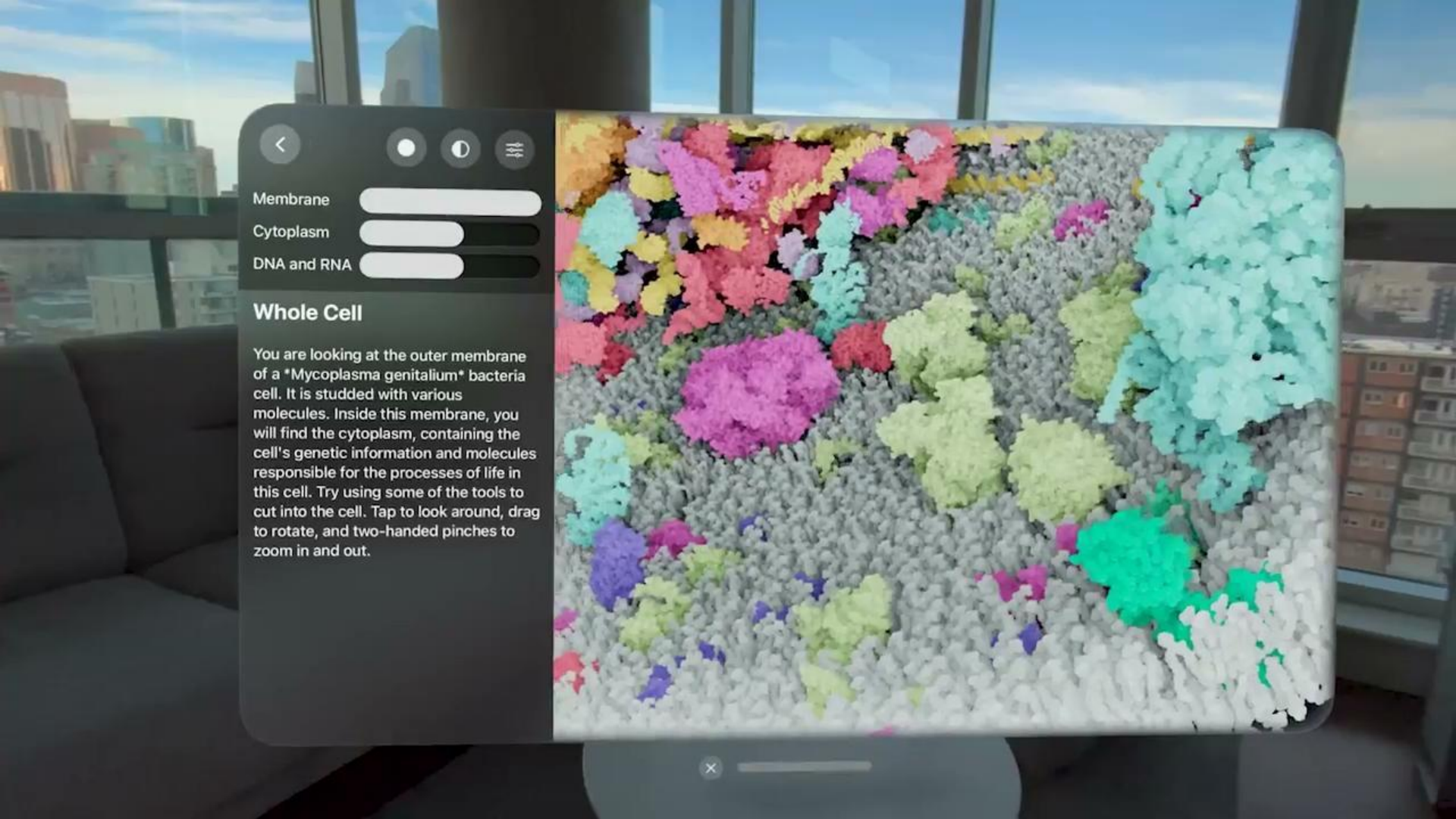
https://www.youtube.com/watch?v=D0REwUXu50I

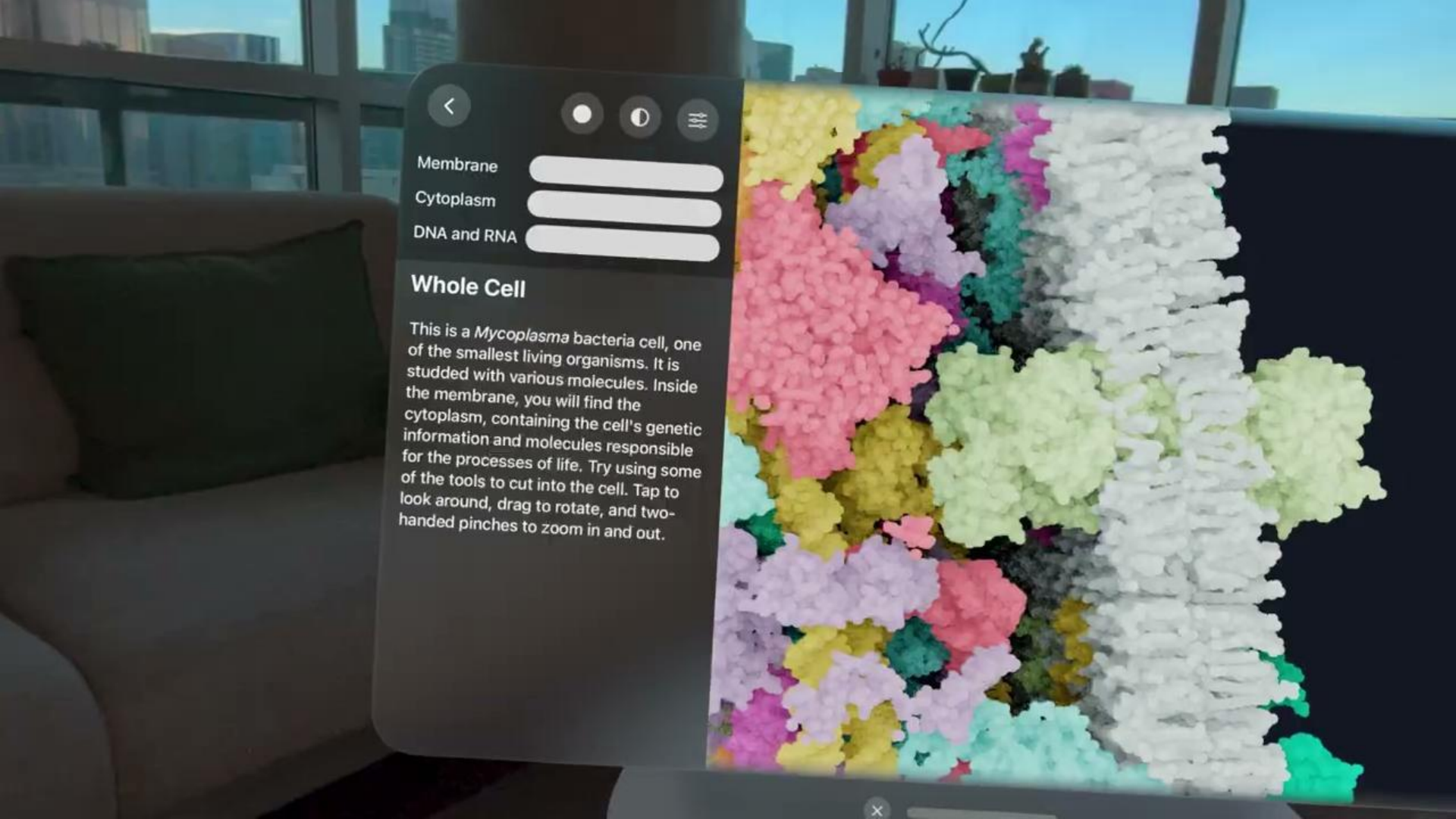

David Goodsell, Myelin 2020

CellWalk iPad

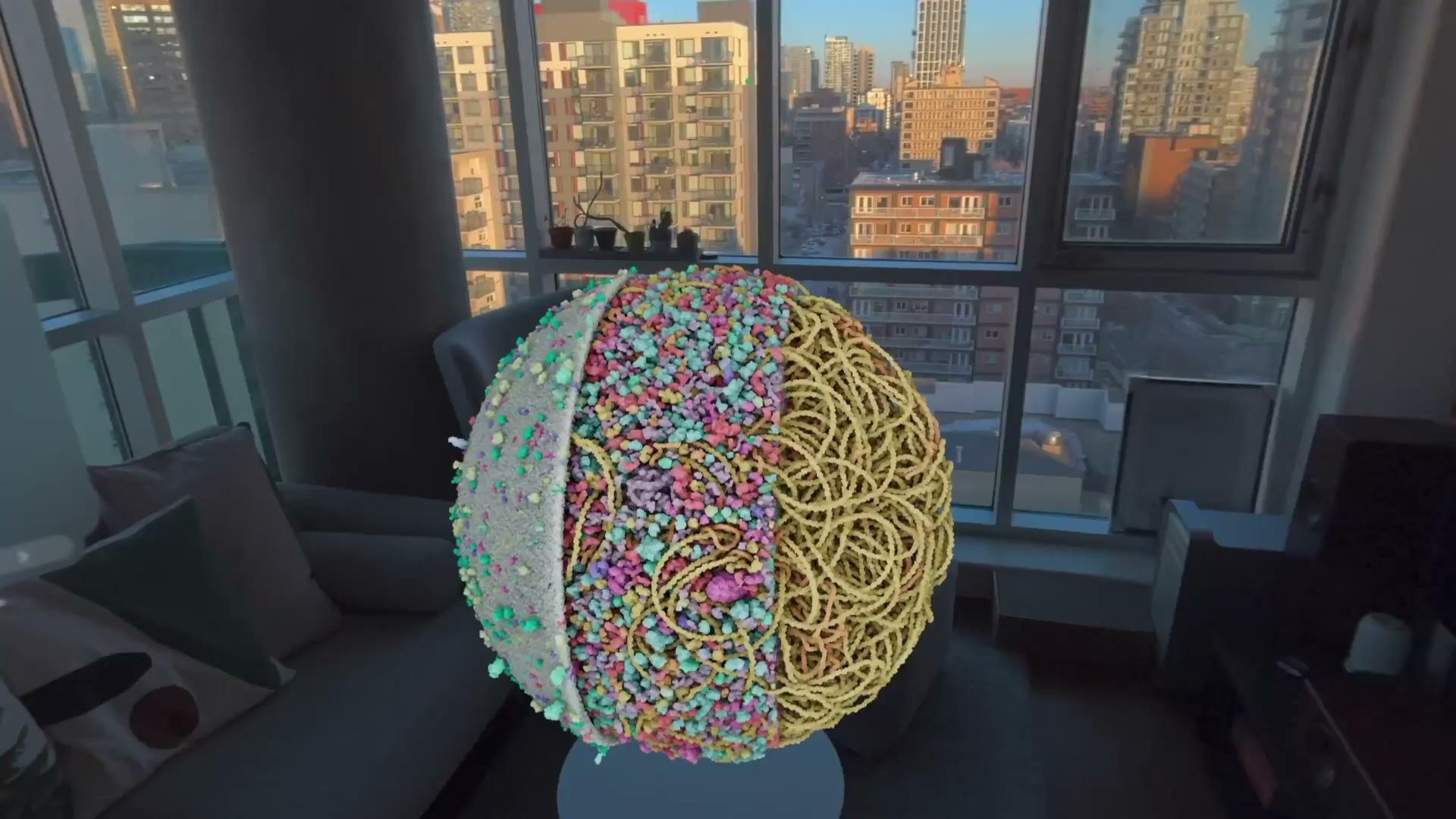


Spatial computing with portals


Membrane
Cytoplasm
DNA and RNA
Whole Cell
You are looking at the outer membrane of a *Mycoplasma genitalium* bacteria cell. It is studded with various molecules. Inside this membrane, you will find the cytoplasm, containing the cell's genetic information and molecules responsible for the processes of life in this cell. Try using some of the tools to cut into the cell. Tap to look around, drag to rotate, and two-handed pinches to zoom in and out.


Membrane
Cytoplasm
DNA and RNA
Whole Cell
This is a *Mycoplasma* bacteria cell, one of the smallest living organisms. It is studded with various molecules. Inside the membrane, you will find the cytoplasm, containing the cell's genetic information and molecules responsible for the processes of life. Try using some of the tools to cut into the cell. Tap to look around, drag to rotate, and two-handed pinches to zoom in and out.

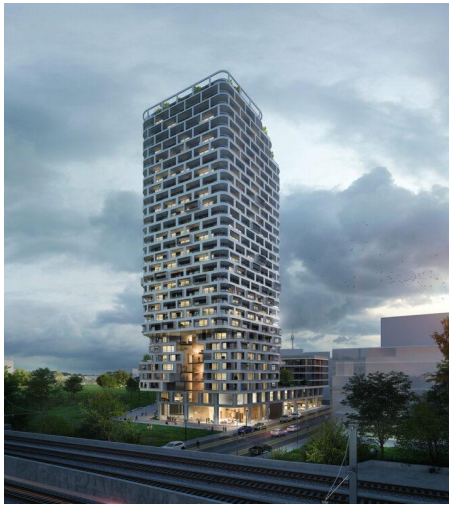
Towards spatial illustration



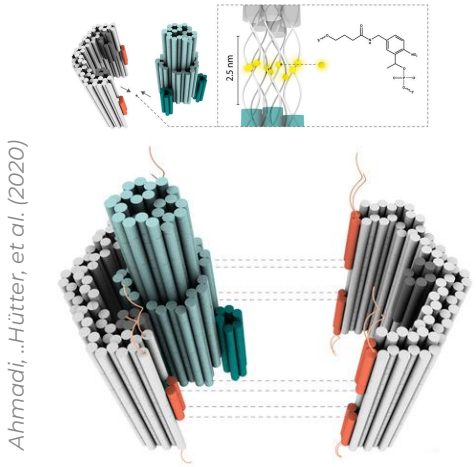

Ludovic Autin
Arthur Olson
David Goodsell
H*
and many anonymous

Christiane Hütter,
Researcher / Architect | Menche Lab
University of Vienna

Background | Architecture + Biomedical Engineering



Architecture *[M.Arch]*
[3D spatial data]



Ahmadi, ..Hütter, et al. (2020)

Biomedical Engineering *[M.Sc]*
[3D molecular data]

Computational Biology *[PhD candidate]*
[N-dimensional data]

𝕏 @ChrisHuetter
in christianehuetter
✉ christiane.huetter@univie.ac.at

Part of a highly interdisciplinary Team

..and many more such as
// Deep Learning
// Biomedicine
// Computational Science
...

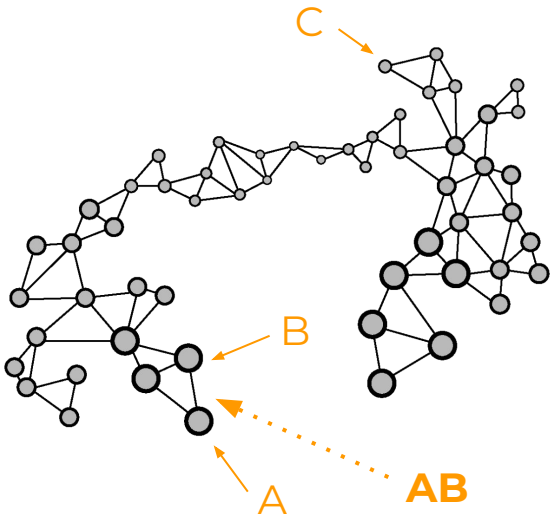
(picture outdated!)

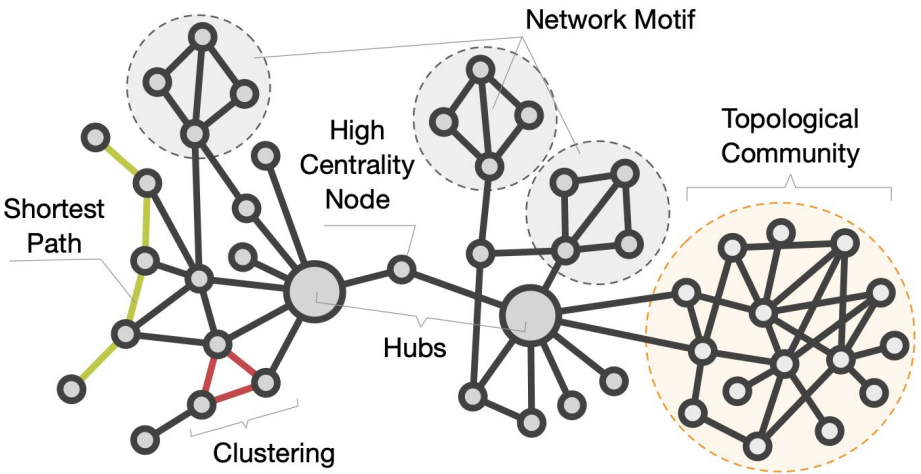
LUDWIG BOLTZMANN INSTITUTE
Network Medicine
at the University of Vienna

MENCHE LAB

𝕏 @Menchelab
menchelab.com
netmed.lbg.ac.at

Networks | an Intuitive Representation of Complex Systems

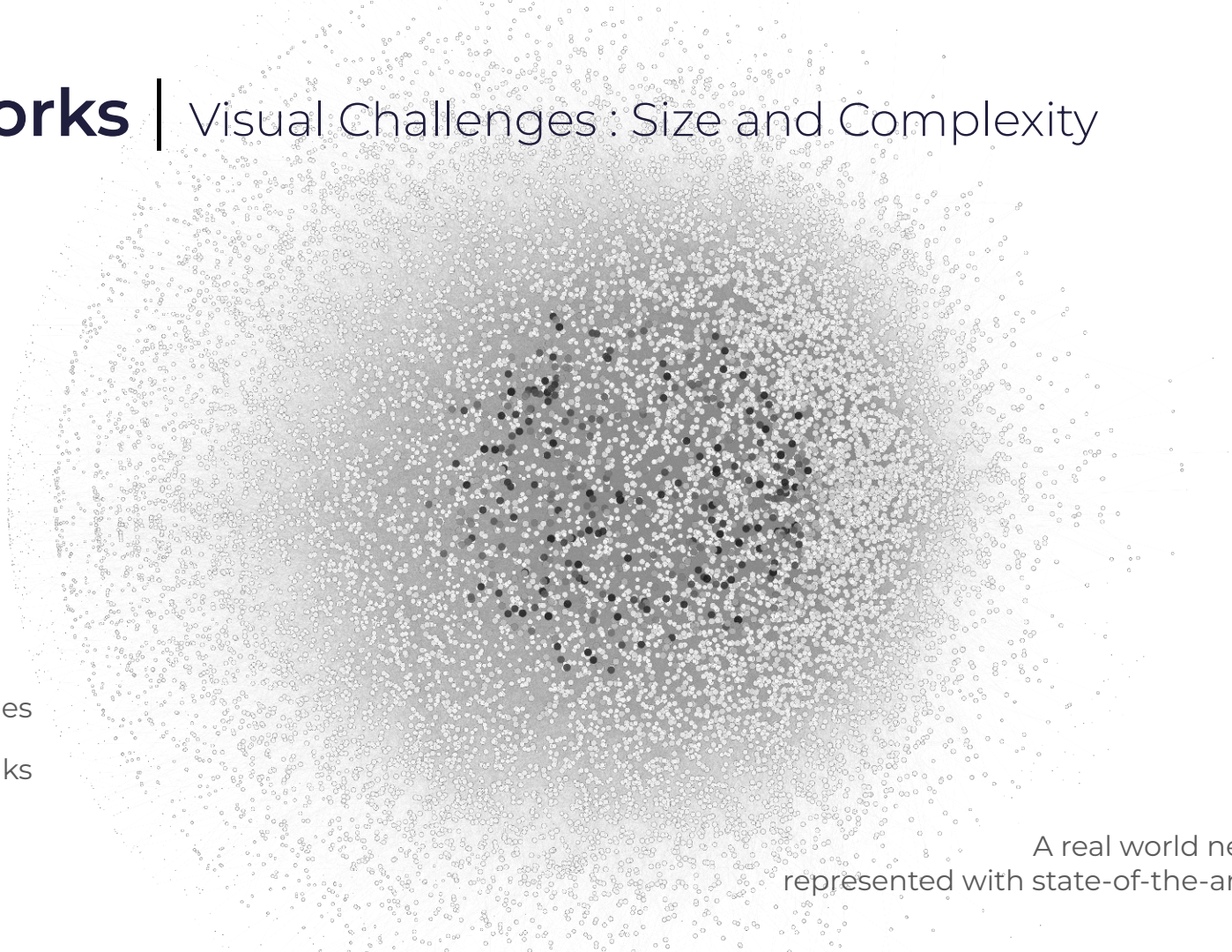




Entities = Nodes : A,B,C, ...
Connections = Links : A-B, A-...

Caldera, Buphamalai et al (2017)

Networks | Visual Challenges : Size and Complexity

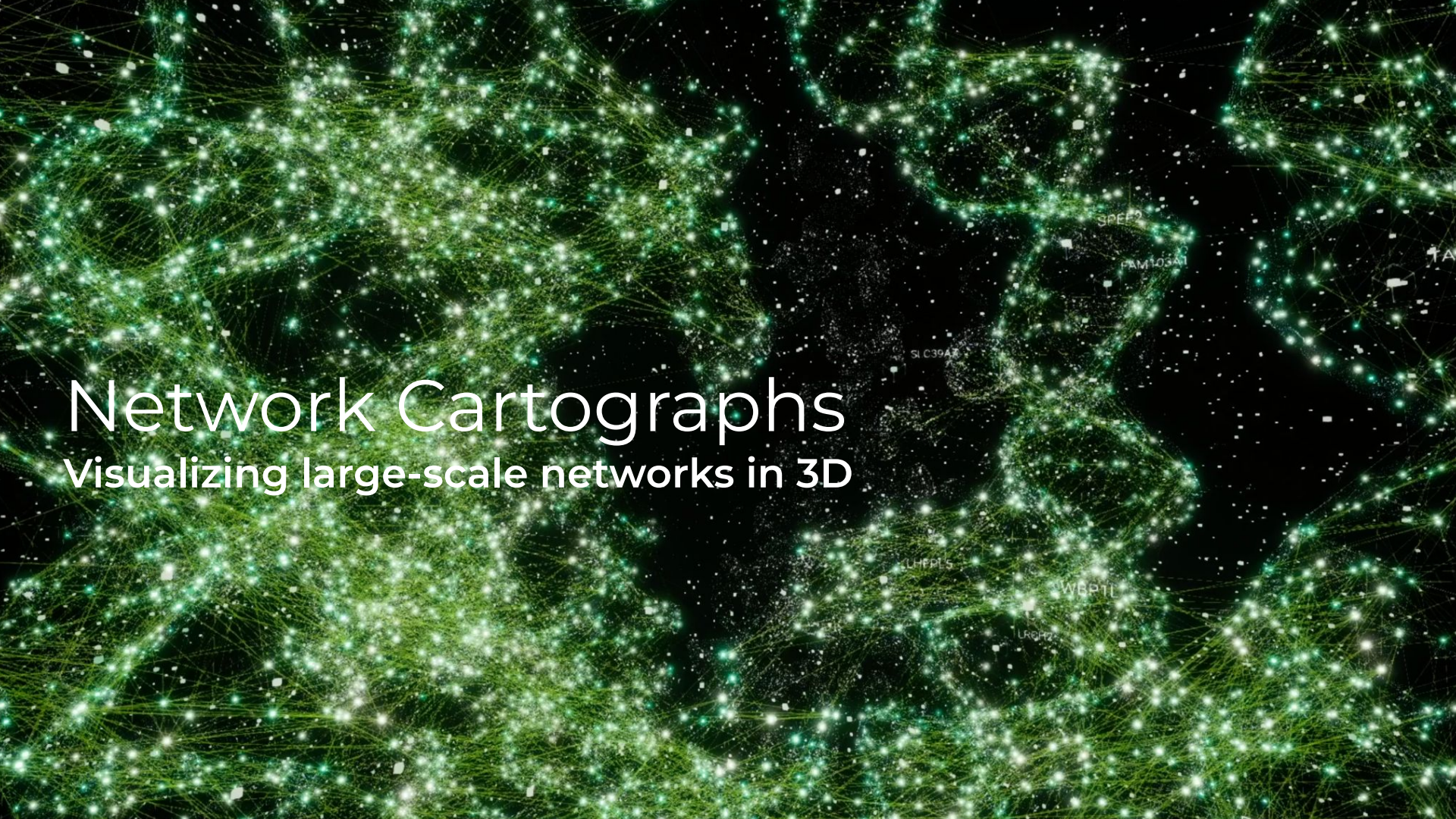


> 16k Nodes

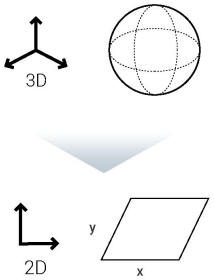
> 300k Links

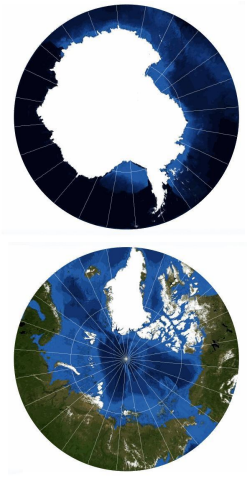
A real world network
represented with state-of-the-art tools

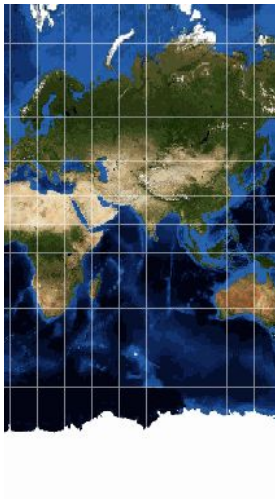
Project "Connected" by S.Pirch, M.Chiettini, C.Hütter, F.Müller, J.Menche
exhibited **@ArsElectronica (Deepspace8k)**

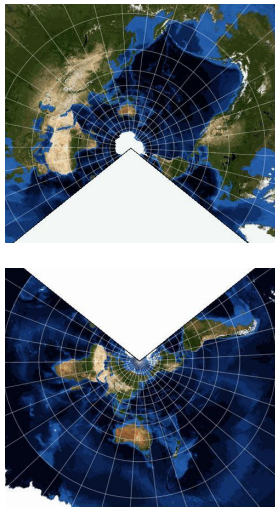

Network Cartographs
Visualizing large-scale networks in 3D

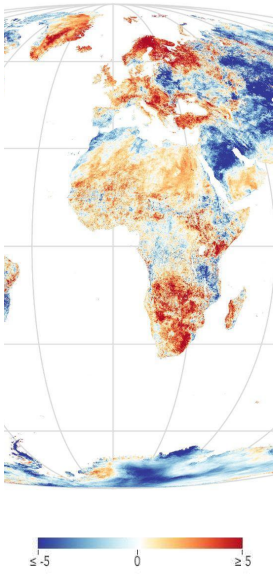
A Mapping Approach

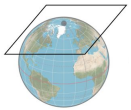


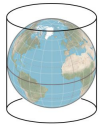


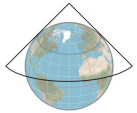












AZIMUTHAL
e.g., Ptolemy | 150 AD
Preserves directions
from center point to others

CYLINDRICAL
e.g., Mercator | 1569
Preserves true shapes, but areas
inflate with latitude (distortion)

CONICAL
e.g., Lambert | 1772
Preserves area-specific data;
not suitable for global depiction

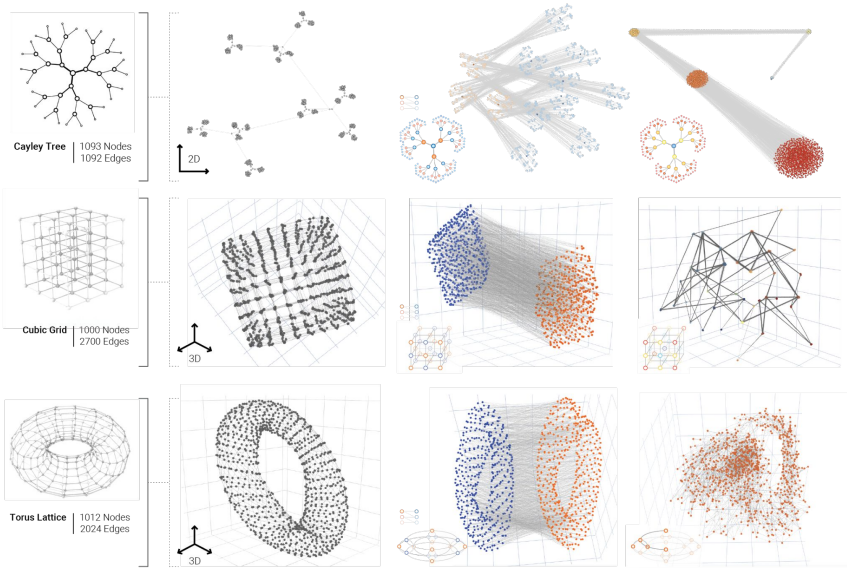
e.g., ECOLOGICAL
Captures temperature anomalies
on land surface; comparing 2018
to avg from 2000-2012 in °C

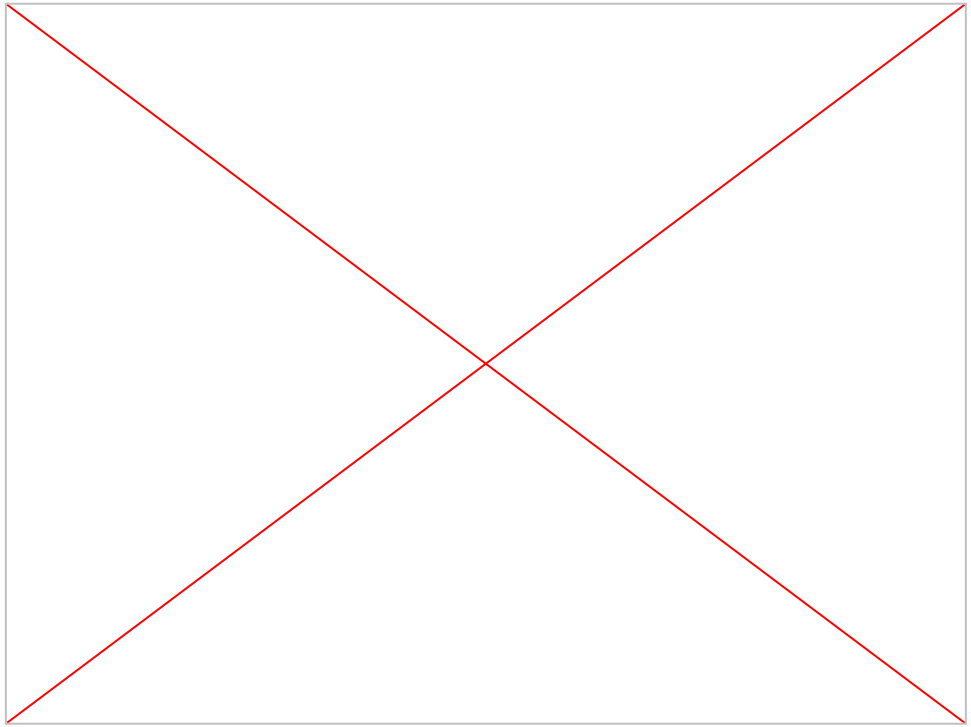
Spatial (structural) properties

functional properties

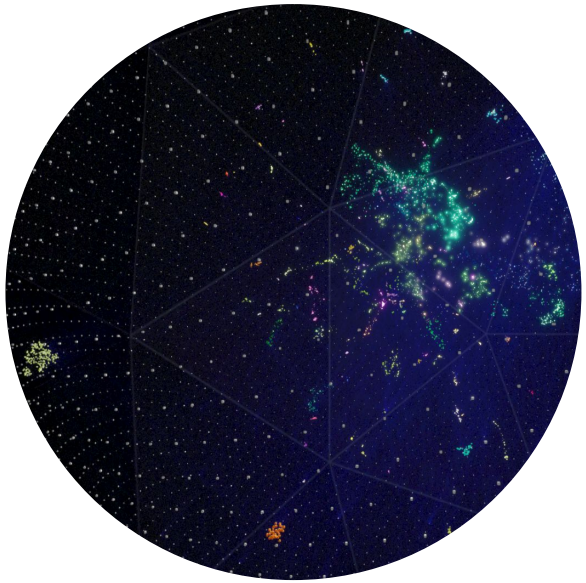
A Visualization Framework

to Highlight and Represent Features of a Network





3D Cartographs
of protein-protein Interactions



Functional 3D portrait
based on disease similarities

Topographic Layout
based on disease association quantity

Geodesic Layout
based on rare disease patient data

3D Cartographs in VR

for Interactive Exploration and Analysis

Pirch et al. The VRNetzer platform enables interactive network analysis in virtual reality. *Nat. Comm. (2021)*

Sebastian Pirch, *Austrian Academy of Sciences*

Sebastian Pirch

* 1982 Salzburg

repro technician

sebastian@lbi-netmed.com
X @sepppirch

Sebastian Pirch

* 1982 Salzburg

repro technician

3D modelling software (3Ds Max)

Sebastian Pirch

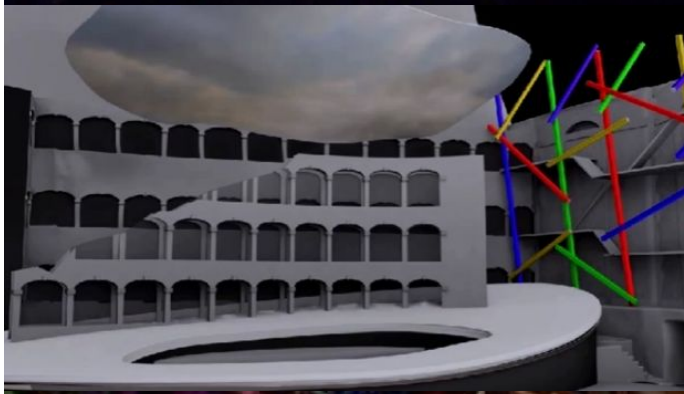
* 1982 Salzburg

repro technician

3D modelling software (3Ds Max)

Advertisement agency

Visuals and stage design



Sebastian Pirch

* 1982 Salzburg

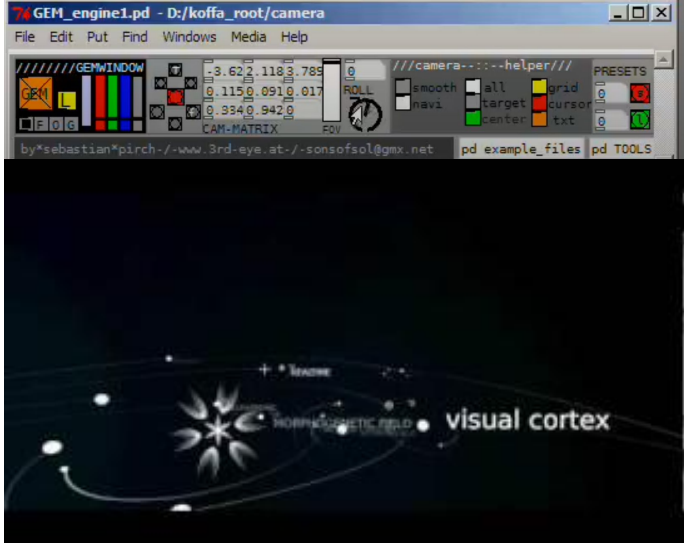
repro technician

3D modelling software (3Ds Max)

Advertisement agency

Visuals and stage design

GemEngine



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* 1982 Salzburg

repro technician

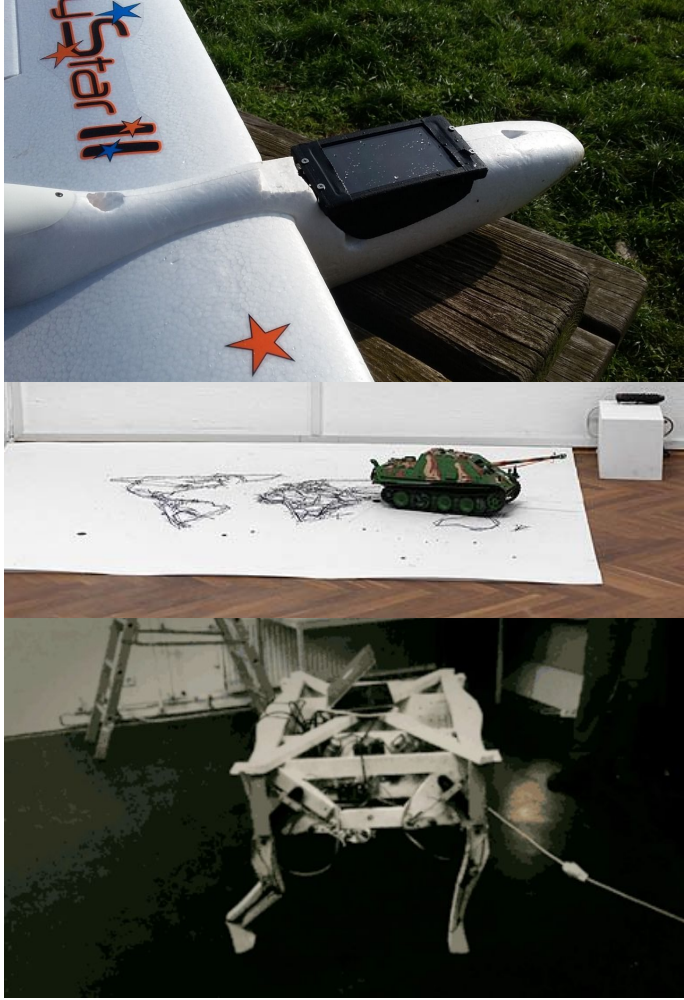
3D modelling software (3Ds Max)

Advertisement agency

Visuals and stage design

GemEngine

Art university: mechatronic projects



WHY 3D?

The world is 3D

But we life in a 2D projection on it
because of gravity

A map is a perfectly adequate simplified representation of reality

That's why people like to default to that in visualization

(Viewing devices 2D, more difficult,...why you need it anyways?)

WHY 3D?

“Only by flying can one experience the true nature of 3d space”

The Data diVR project

IMMERSIVE (VR)

COLLABORATIVE (multiplayer)

INTERACTIVE (open, extendable)

DATA VISUALIZATION and ANALYTICS

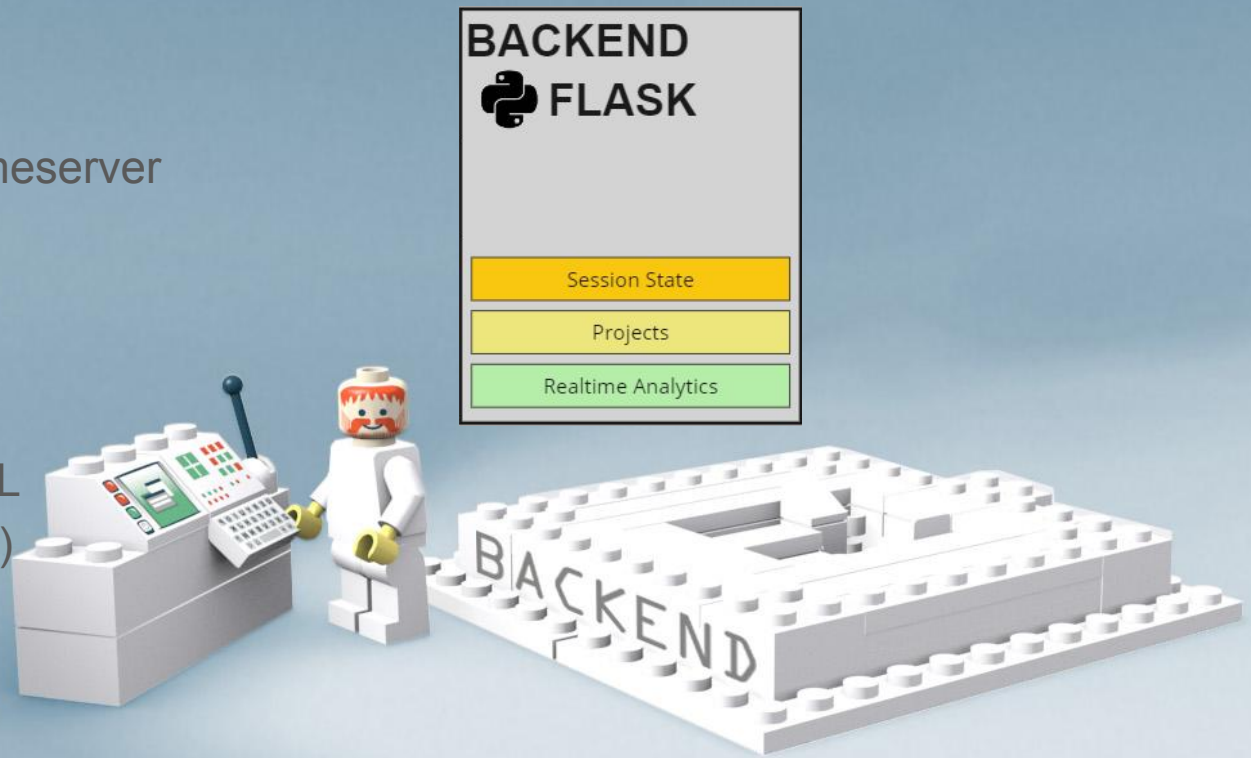
Python backend: Analytics and data storage

THE BACKEND

Python Web- & Gameserver

project data
analytics

hosts dynamic HTML
pages (FRONTEND)



Javascript and HTML frontend for UI

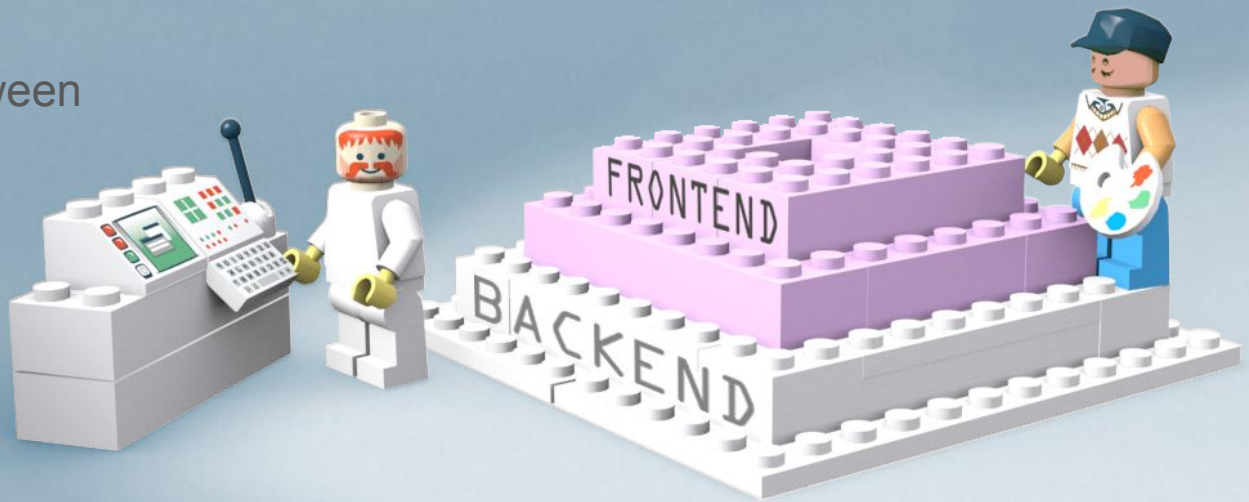
THE FRONTEND

FRONTEND
HTML JS

User Interfaces for VR using HTML and JavaScript
runs on Client in Webbrowser

communication between
BACKEND and VR
via Socket IO
and WebUI plugin

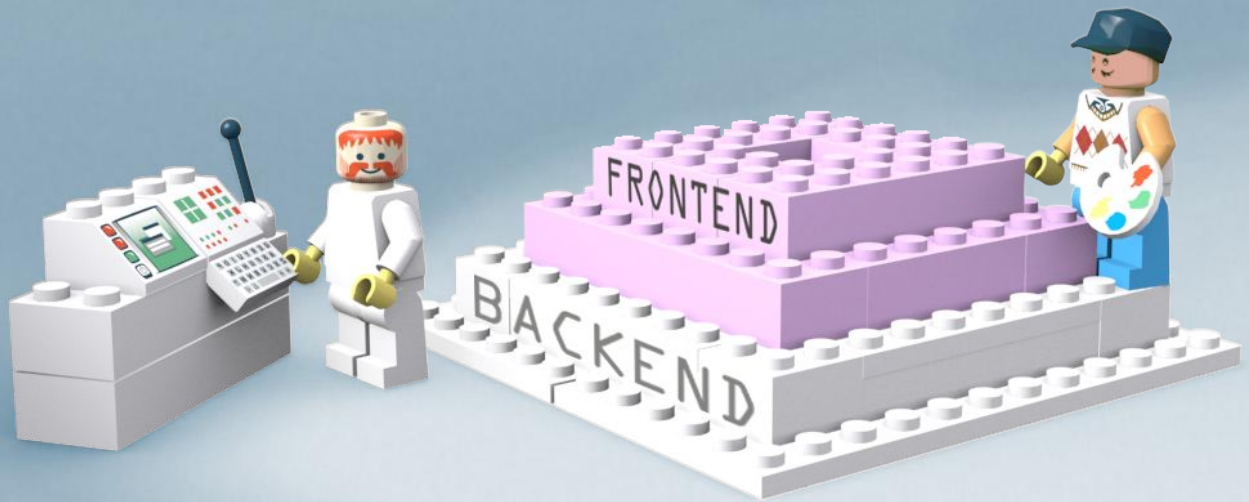
WebGL Preview



DataDiVR webapp for quick exploration and app development

BACKEND and FRONTEND together is the DataDiVR Web App

https://github.com/menchelab/DataDiVR_WebApp



The VR module is on top of the standalone backend/frontend stack

THE VR MODULE

Unreal Engine 4 + SteamVR

runs FRONTEND (ingame browser)

rendering of big networks
using voxel technique

multiplayer VR

Martin Chiettini, *University of Vienna*

About me

I like computers since 1984

Use them to make art since 1998

Finished Digital Art studies in 2016, Diploma work in virtual reality

Started at Joerg Menches group as a 3D Artist in 2018

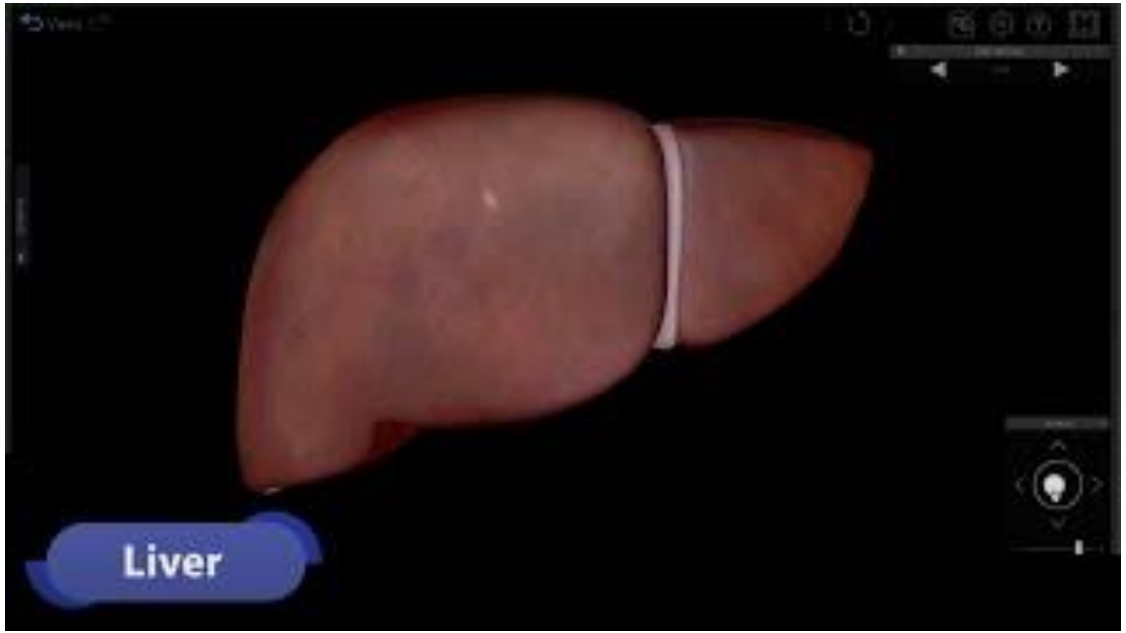
Am now responsible for IT and hardware as well as artistic projects

Creating art in VR with our project Echtzeitkunstwelt since 2020

Why 3D

3d is the obvious choice for spatial data like:

- Organs

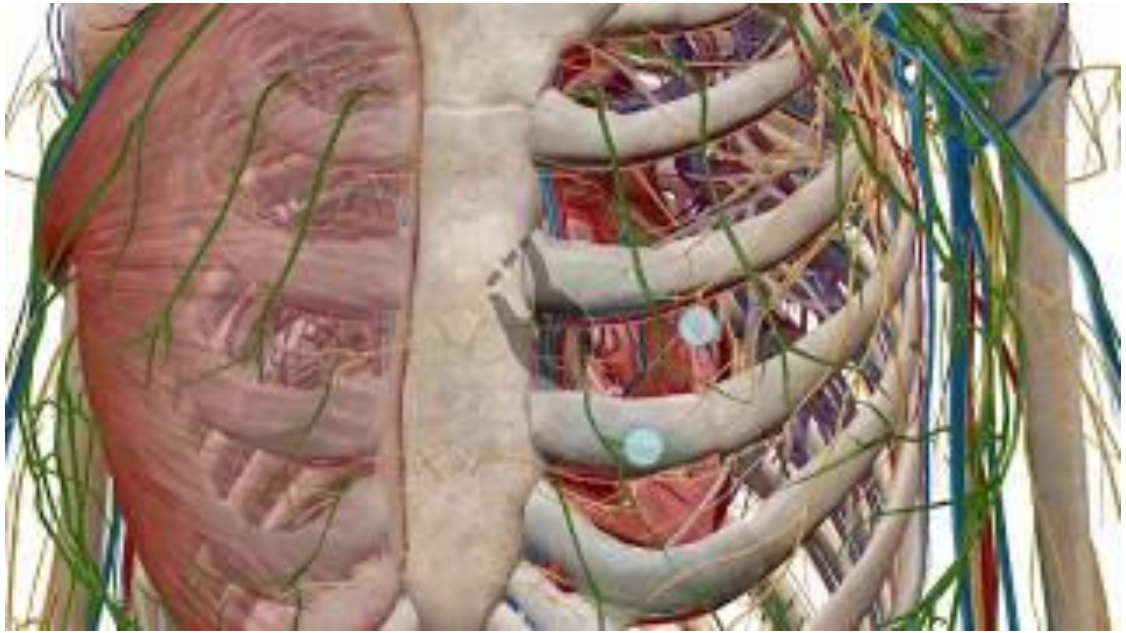


Youtube: Visible Body | 3D Virtual Tour of the Liver

Why 3D

3d is the obvious choice for spatial data like:

- Organs
- Human body models



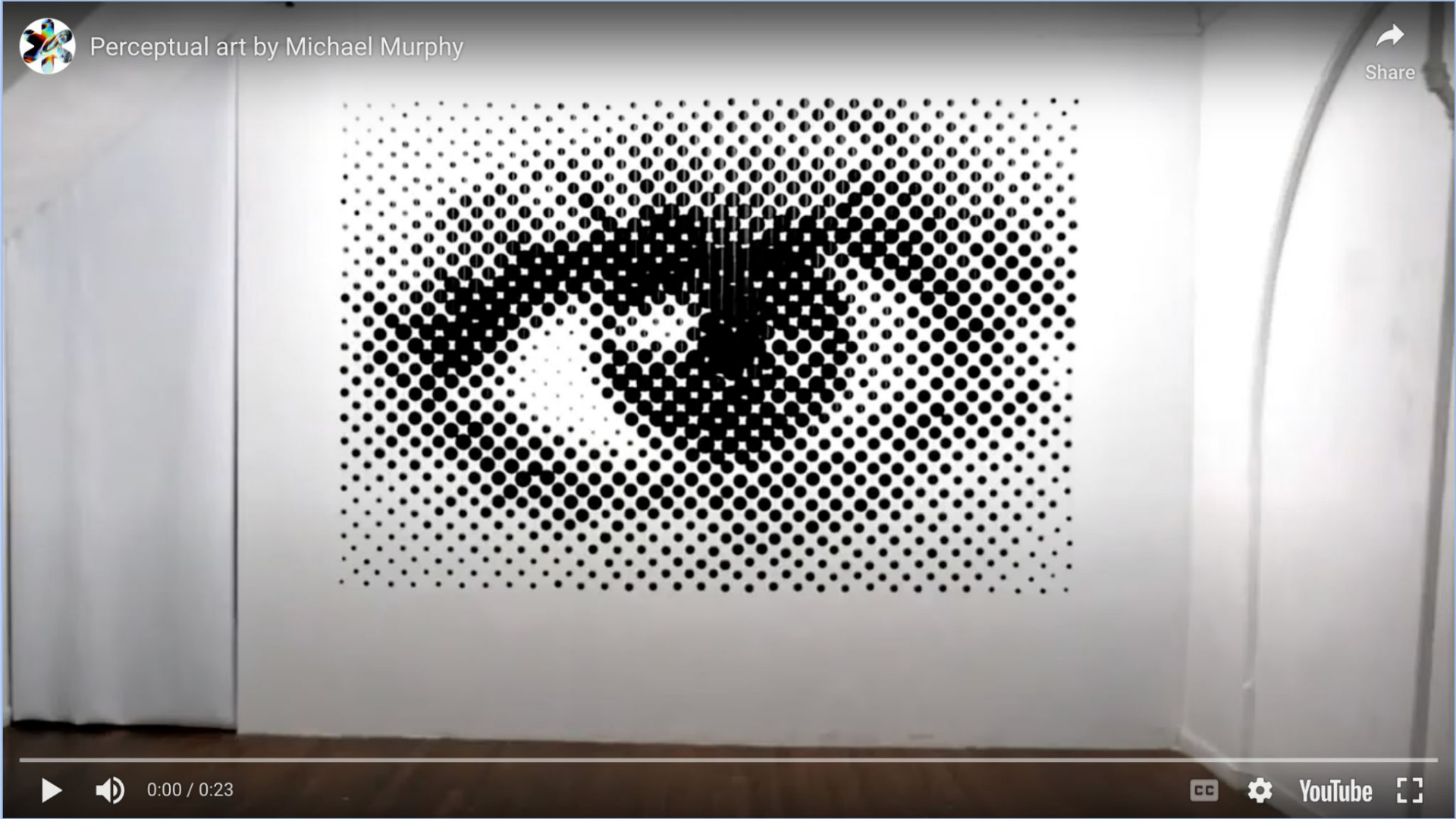
Youtube: Zooming, dissecting, and rotating the 3D model Human Anatomy Atlas

Why 3D

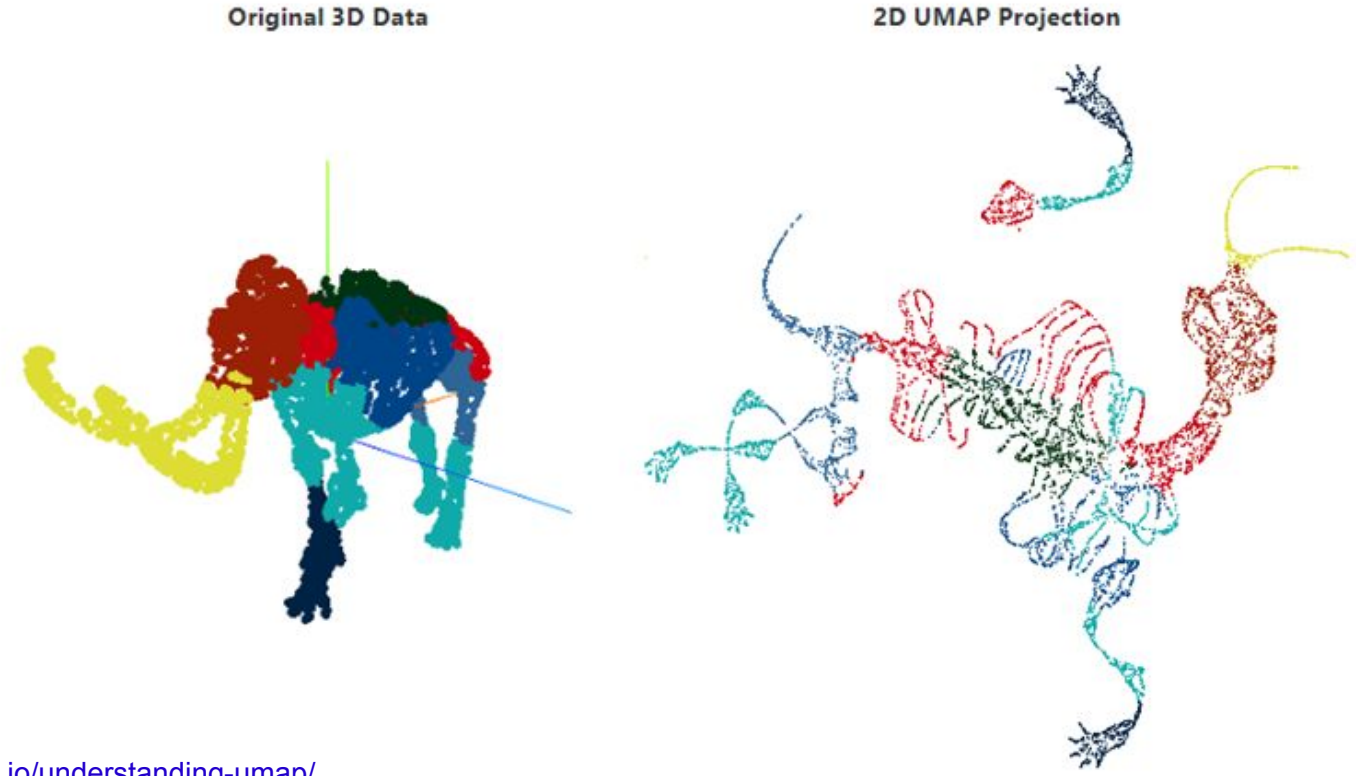
3d is the obvious choice for spatial data like:

- Organs
- Human body models
- An airport network

http://coolinfographics.squarespace.com/blog/2016/6/3/the-global-air-transportation-network.html


Perceptual art by Michael Murphy
Share
0:00 / 0:23
YouTube

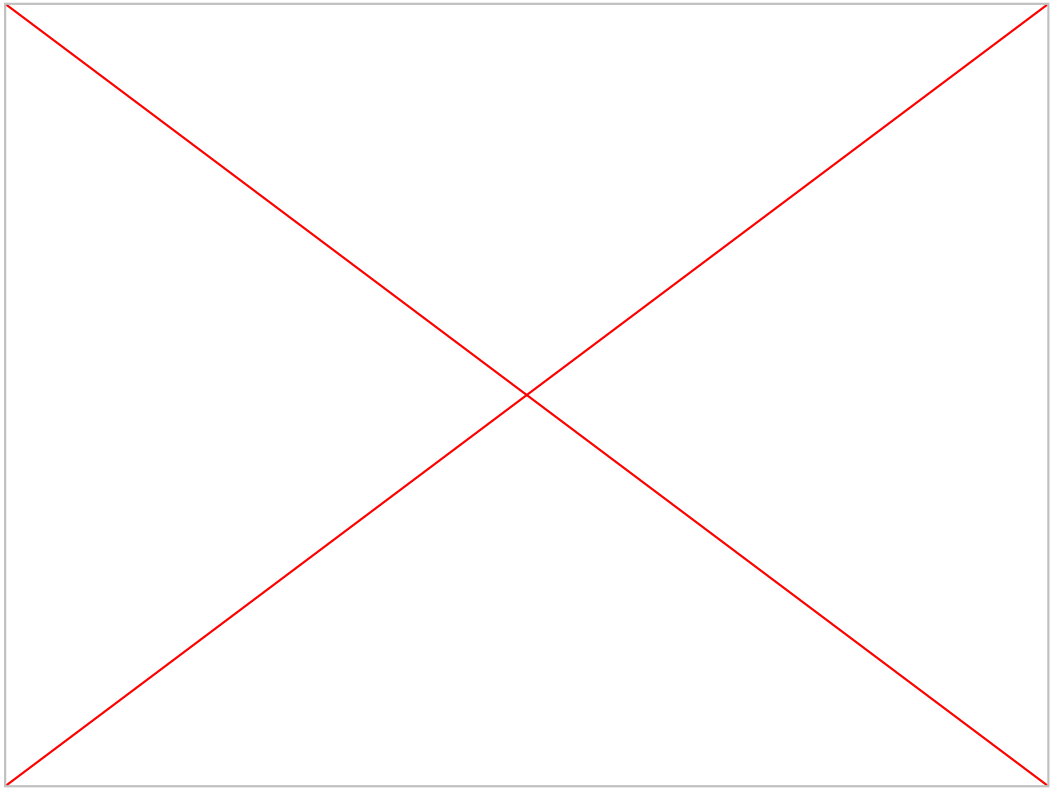
Why 3D for abstract data



https://pair-code.github.io/understanding-umap/

Why 3D for abstract data

One can see their data from more perspectives which in turn can reveal hidden structures



https://pair-code.github.io/understanding-umap/

Why Virtual Reality

- because it is immersive and gives us the possibility to experience shapes the way we are used to

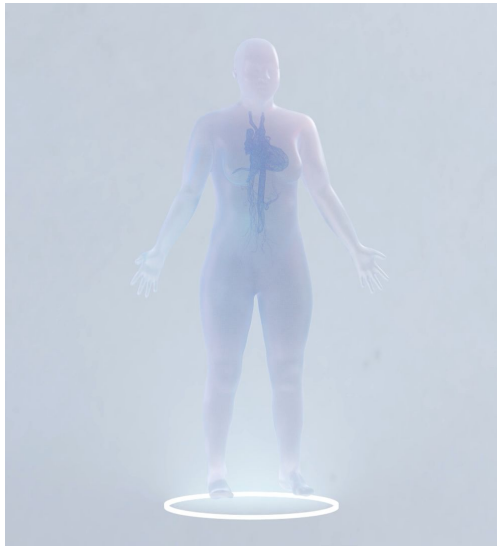
- abstract data like protein protein interaction networks could also be spatially aligned and provide us with additional insights

- you can stand inside your data, get the perspective of vastly different scales, for example stand inside cell and be as large as a protein

Q&A

https://humanatlas.io/events/2024-24h

Q&A



- How do you decide when to use 3D, when to use VR, and when to use a combination of the two?
- Many paradigms have been proposed to mix 2D and 3D in visualizations. In your experience, what are some good heuristics to determine if and how to mix the two?
- With novel mixed reality (MR) hardware like the Apple Vision Pro and the Meta Quest 3, high-resolution video passthrough is making it increasingly easy to create aesthetic MR applications for various platforms and users. What are the opportunities and challenges of using MR for your work?
- How do you deal with the challenge introduced by a third dimension, such as the unreliability of size for visual encoding?
- How can we improve enable simple but necessary tasks like note-taking in VR?

Thank you