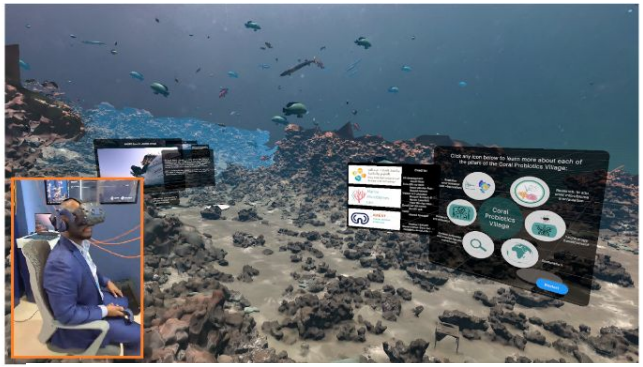


Scientific Visualization 101

Virtual Reality for Data Visualization

KAUST Visualization Core Lab
Ronell Sicat

KAUST
VISUALIZATION
CORE LAB

How can AR/VR help me

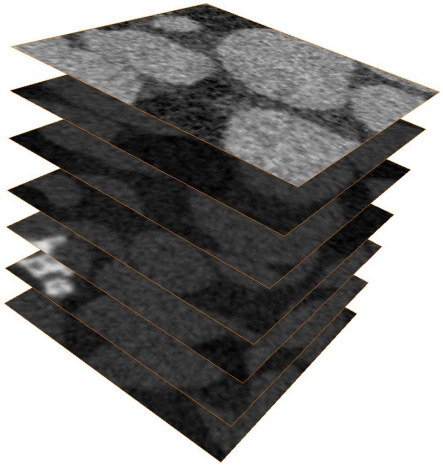
visualize

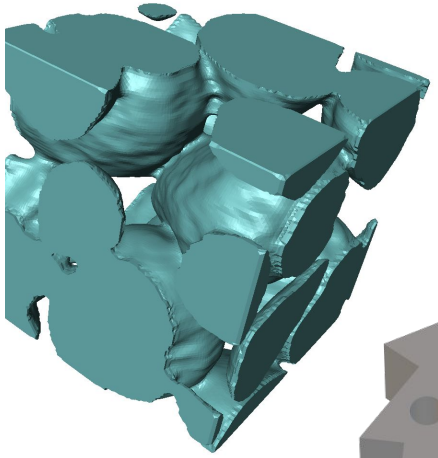
understand

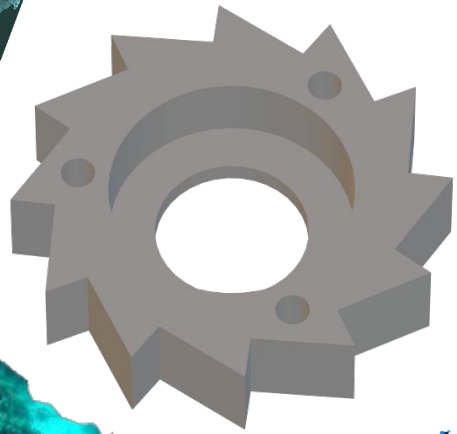
explain

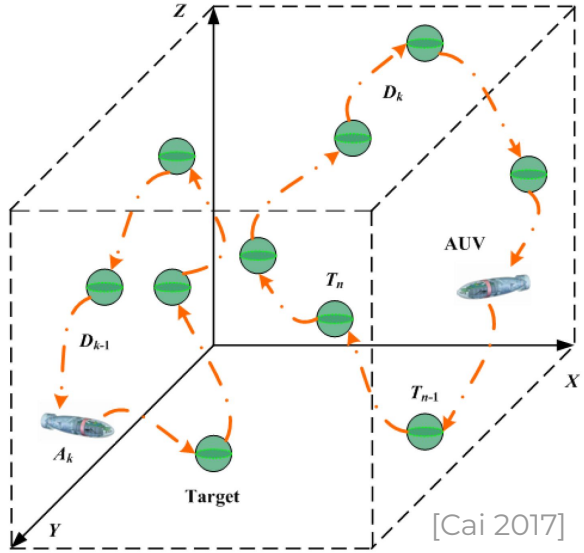
manipulate

my data better?

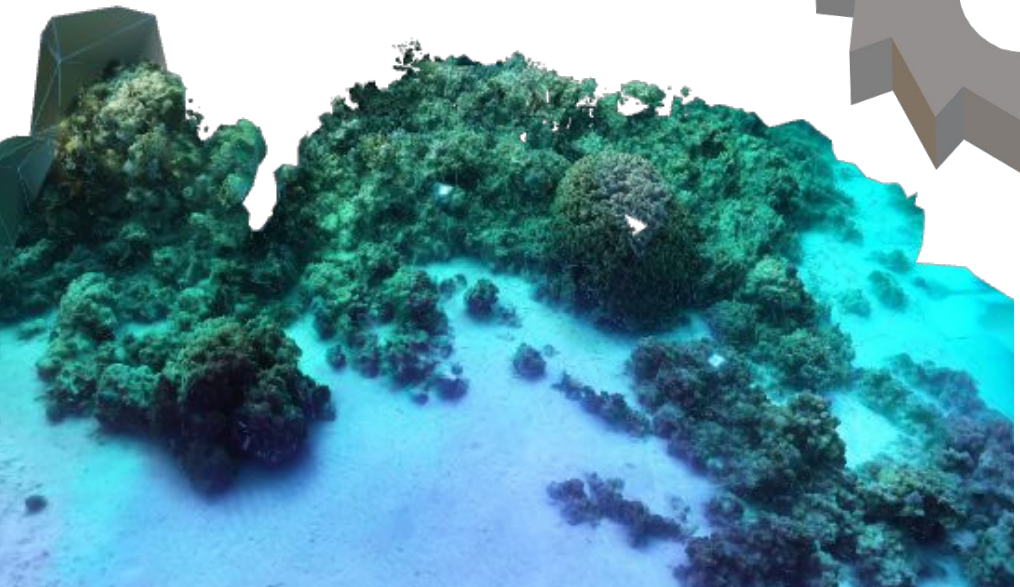


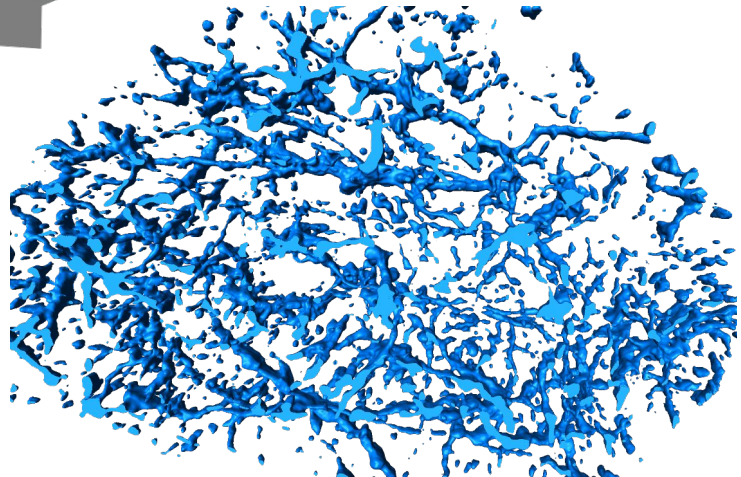




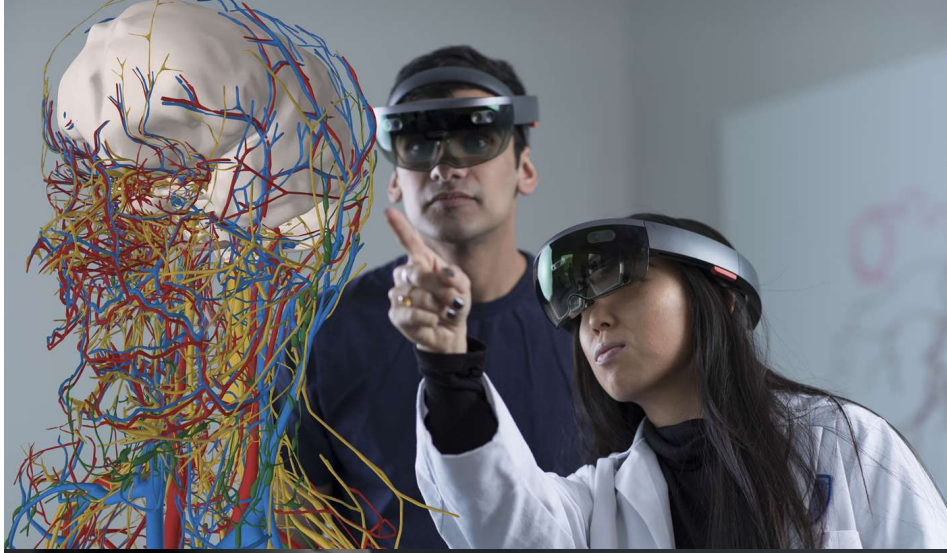


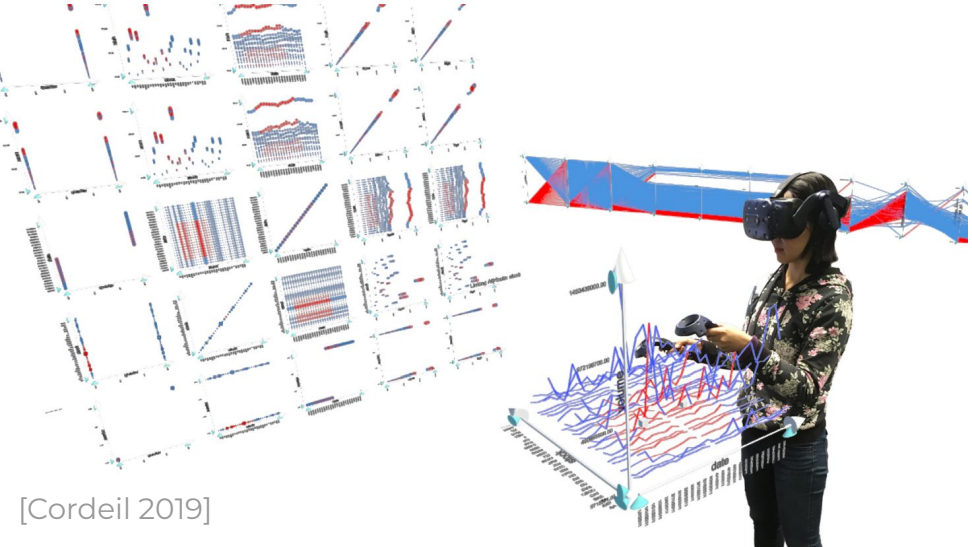
[Cai 2017]






0.03
0.02
0.01
0.01
Names Popularity Index
Names Year
LookVR

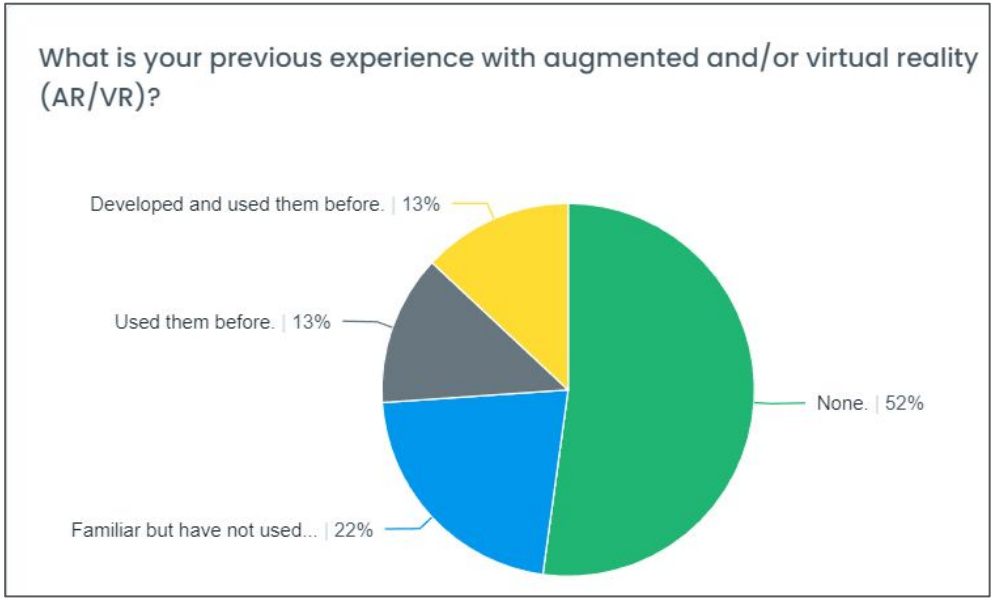



[Cordeil 2019]


C3 Vertebra
Microsoft
Image: Microsoft

Schedule

- AR/VR Introduction
- AR/VR Resources @ KVL
- **15 min. Break**
- Demos/Discussions



KVL Introduction

KAUST CORE LABS

12 CORE LABS

270 HEADCOUNT

45 FIELDS OF EXPERTISE

MANAGEMENT AND CENTRAL OPERATIONS
29 Staff

ANALYTICAL CHEMISTRY
21 Staff

IMAGING AND CHARACTERIZATION
26 Staff

PLANT GROWTH
10 Staff

ANIMAL RESOURCES
1 Staff

LAB EQUIPMENT MAINTENANCE
27 Staff

RADIATION LABELING
1 Staff

BIOSCIENCE
25 Staff

NANOFABRICATION
19 Staff

SUPERCOMPUTING
18 Staff

COASTAL AND MARINE RESOURCES
50 Staff

PROTOTYPING AND PRODUCT DEVELOPMENT
38 Staff

VISUALIZATION
6 Staff

KVL provides expertise in **data visualization** and **data science**

Dr. Sohaib Ghani
(LEAD STAFF SCIENTIST)

- VISUAL ANALYTICS
- INFORMATION VIS
- STATISTICAL ANALYSIS

Thomas Theussl
SCIVIS

- SCIENTIFIC VISUALIZATION
- LARGE DATA ANALYSIS
- DISTRIBUTED VISUALIZATION

Dr. James Kress
HPC SCIVIS

- VISUALIZATION SOFTWARE
- HPC INSITU VISUALIZATION
- DISTRIBUTED VISUALIZATION

Dr. Ronell Sicat
VR/AR

- SCIENTIFIC VISUALIZATION
- AR/VR DEVELOPMENT
- 3D RECONSTRUCTION

Dr. Didier Barradas
Data Scientist

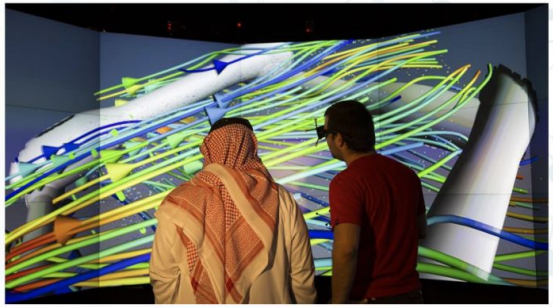
- DATA SCIENCE
- MACHINE LEARNING
- DEEP LEARNING

Dr. Abdelghafour Halimi
Data Scientist

- DATA SCIENCE
- MACHINE LEARNING
- DEEP LEARNING

KVL offers state-of-the-art **visualization facilities**

ZONE 1/2 DISPLAY WALLS: 2D/3D Analytics



CUBES VR

ZONE 5 VR

AR/VR HMDs

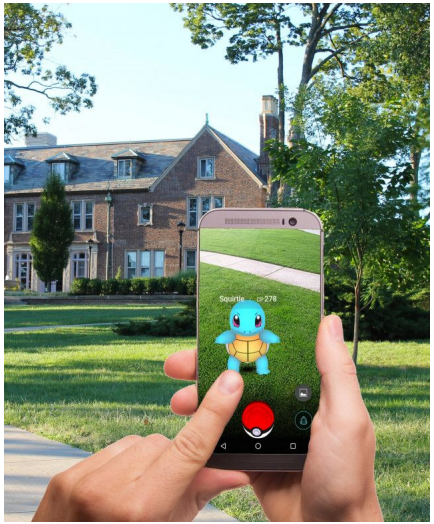
wiki.vis.kaust.edu.sa

help@vis.kaust.edu.sa

AR/VR Introduction

What is AR/VR?

Hardware and software systems to interact with and display a blend of real and virtual objects.

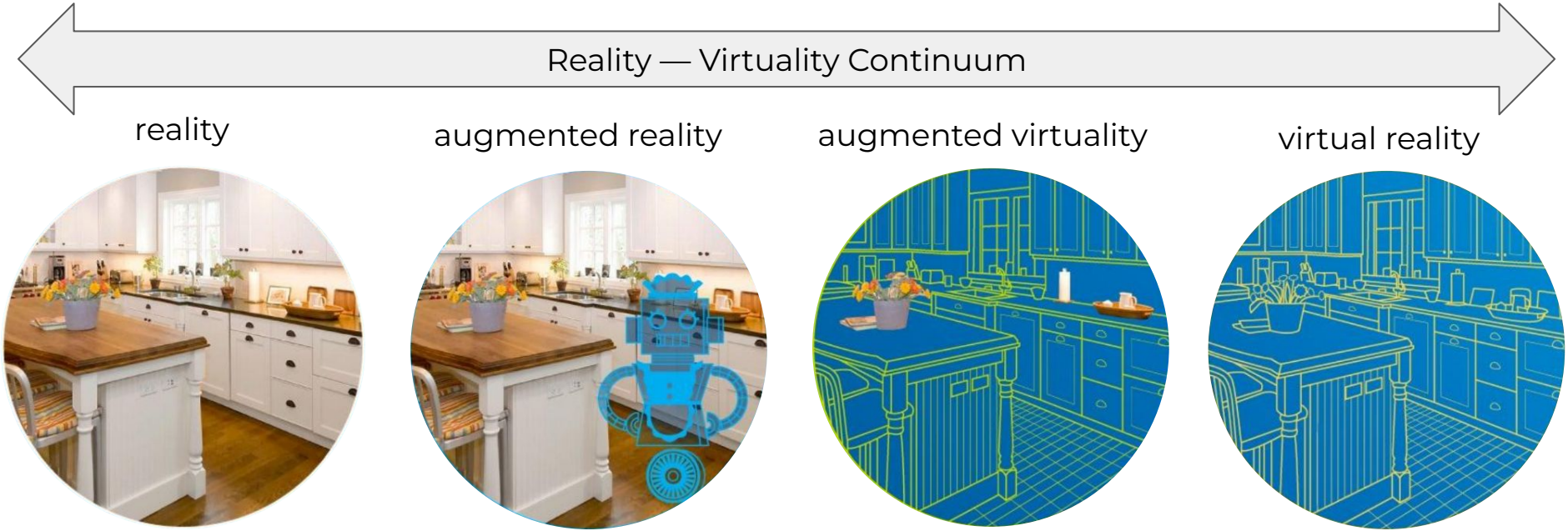


https://pxhere.com/en/photo/556168

https://mashable.com/article/facebook-messenger-ar-effects

[Riegler et al. 2019]

What is AR/VR?



http://www.kacpr.org/popup/file/20180913/Virtual%20reality%20in%20CPR%20training.pdf

Demo: VR (Unity XRI sample)

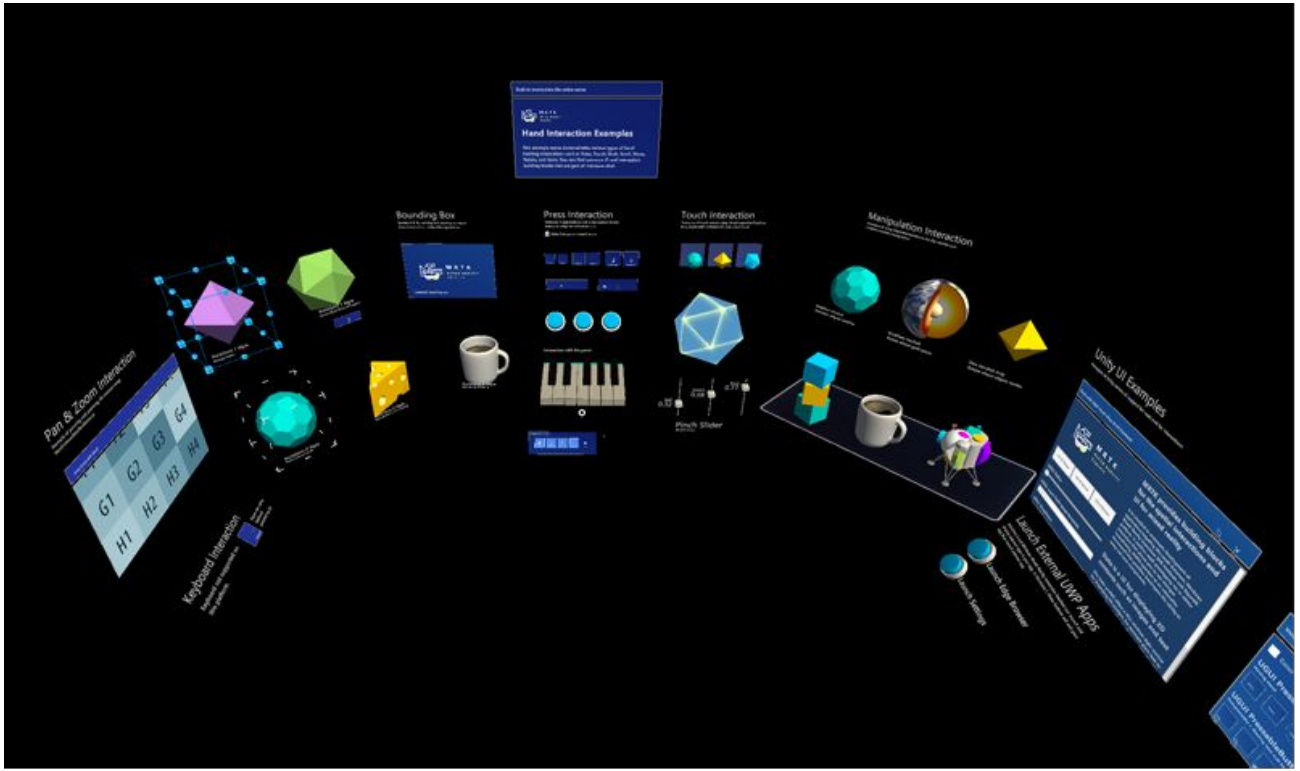
VR examples

https://www.youtube.com/watch?v=SCrkZOx5Q1M

VR examples

https://techcrunch.com/2023/01/31/meta-starts-testing-members-only-worlds-in-horizon-worlds/

Demo: AR (MRTK sample)



https://github.com/microsoft/MixedRealityToolkit-Unity

AR examples

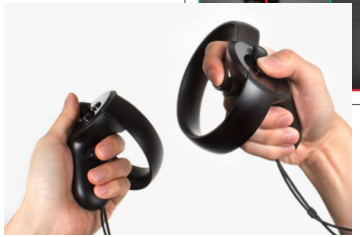
https://www.ikea.com/au/en/customer-service/mobile-apps/...
say-hej-to-ikea-place-pub1f8af050

https://www.spheregen.com/hololens-2-faq/

AR examples

https://news.microsoft.com/videos/introducing-dynamics-365-remote-assist-for-hololens-2-and-mobile-devices/

How does AR/VR work?



output

input

computer

application

virtual content

hardware + software

https://www.digitalspy.com/videogames/a790819/how-to-set-up-the-oculus-rift/
https://arstechnica.com/gaming/2016/10/why-oculus-has-my-favorite-vr-hand-tracking-controller/
Hubner et al. 2020: https://www.mdpi.com/1424-8220/20/4/1021

Hardware

Head-Mounted Displays (HMDs)

Immersive Environments (CAVEs)

Software

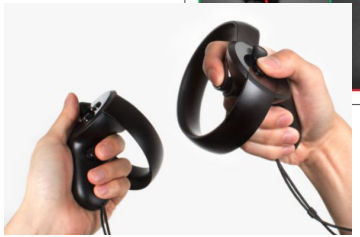
AR/VR-ready Applications

- “App” Stores (Steam, Microsoft, Meta, etc.)
- **Avizo + TechViz**
- 3DSlicer
- Paraview
- And more...

AR/VR Development Tools

- Game Engines (**Unity**, Unreal, Godot) and plug-ins (**GetReal3D**)
- Low-level programming using OpenXR, OpenGL, Vulkan, C/C++, etc.
- And more...

AR/VR application development



output

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hardware + software

https://www.digitalspy.com/videogames/a790819/how-to-set-up-the-oculus-rift/
https://arstechnica.com/gaming/2016/10/why-oculus-has-my-favorite-vr-hand-tracking-controller/
Hubner et al. 2020: https://www.mdpi.com/1424-8220/20/4/1021

Data visualization using AR/VR

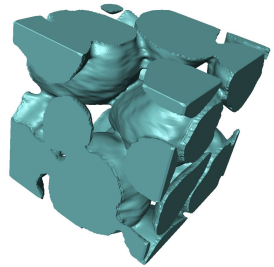
output

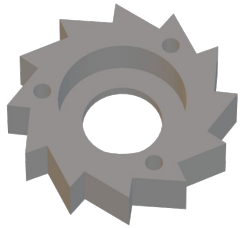
input

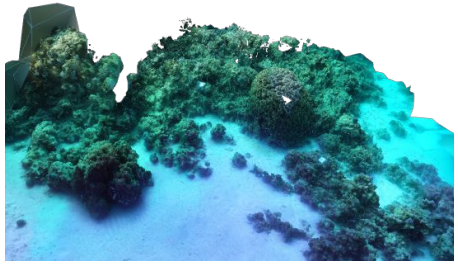
computer

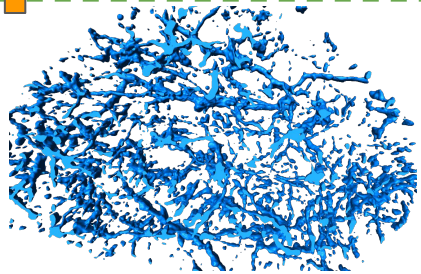
AR/VR application

virtual content





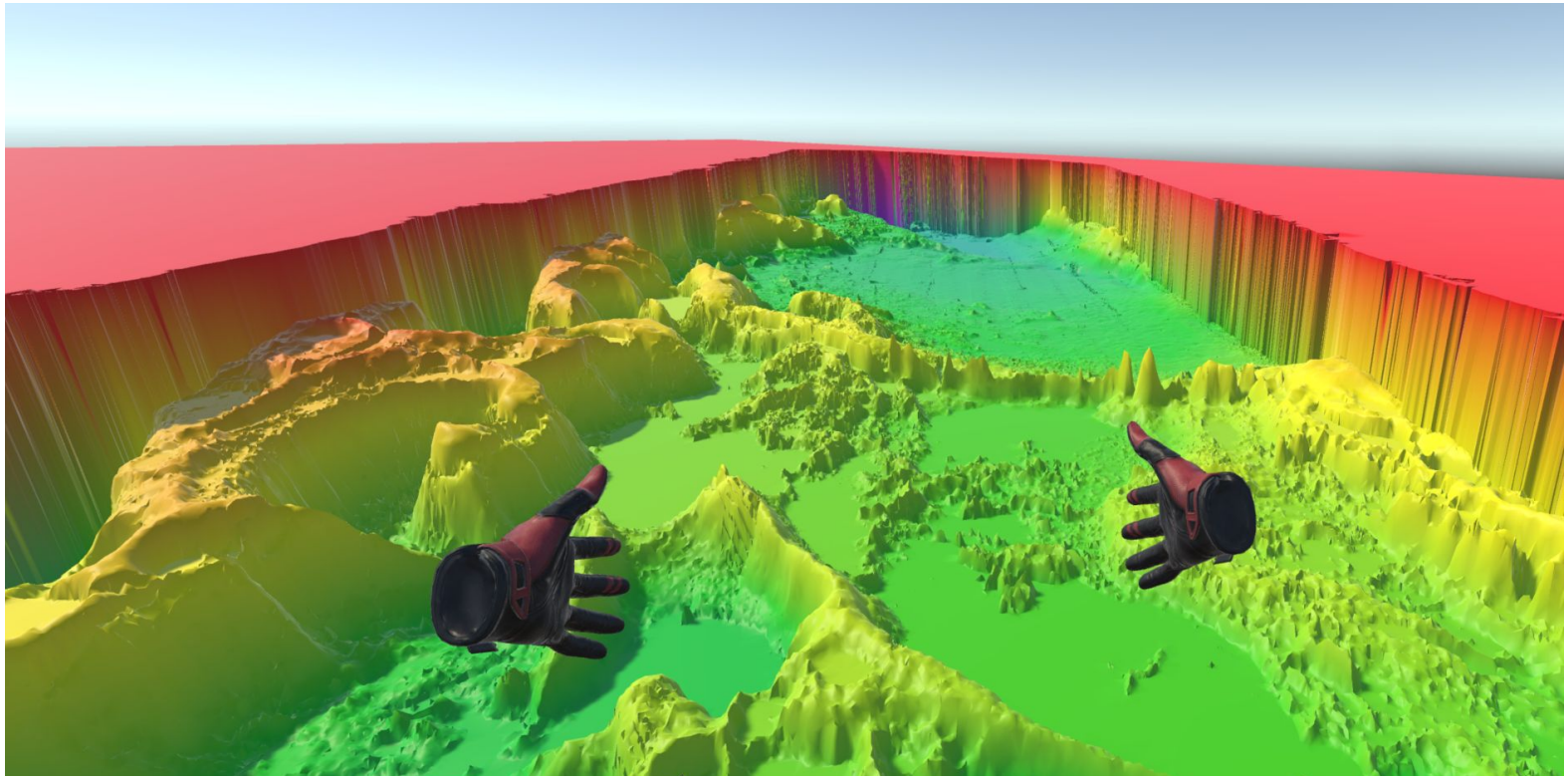




Immersive analytics

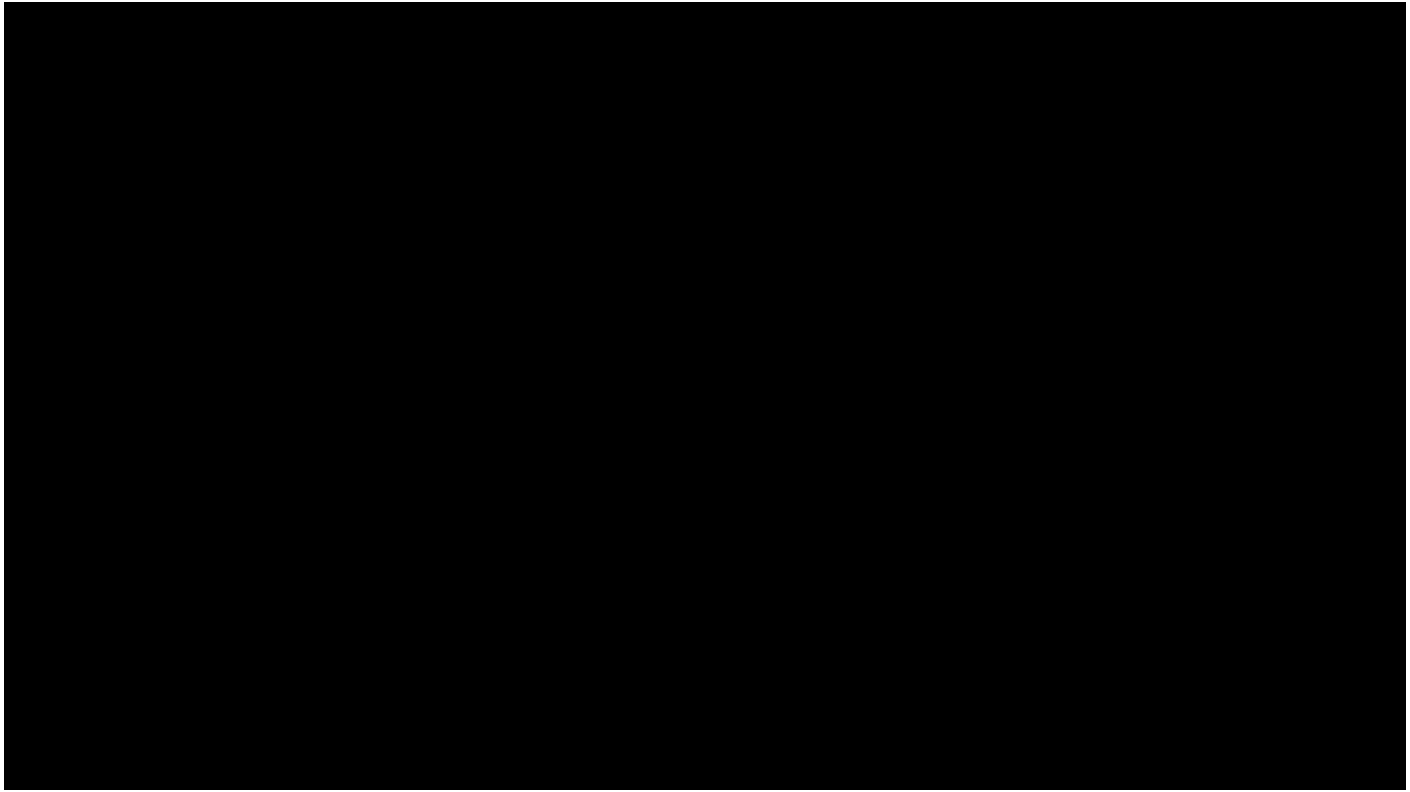
- Leverages new interaction and display technologies, e.g., AR/VR, to support data understanding and analysis.
- Can be useful for:
  - understanding **3D spatial data**
  - analyzing **situated data**
  - performing direct **natural interactions**
  - **immersive storytelling**
  - and more!
- Imagine how your data can fit any of the following scenarios!

3D Spatial Data: bathymetry data vis in VR



Data c/o CMR Core Lab

3D Spatial Data: bathymetry data vis in VR



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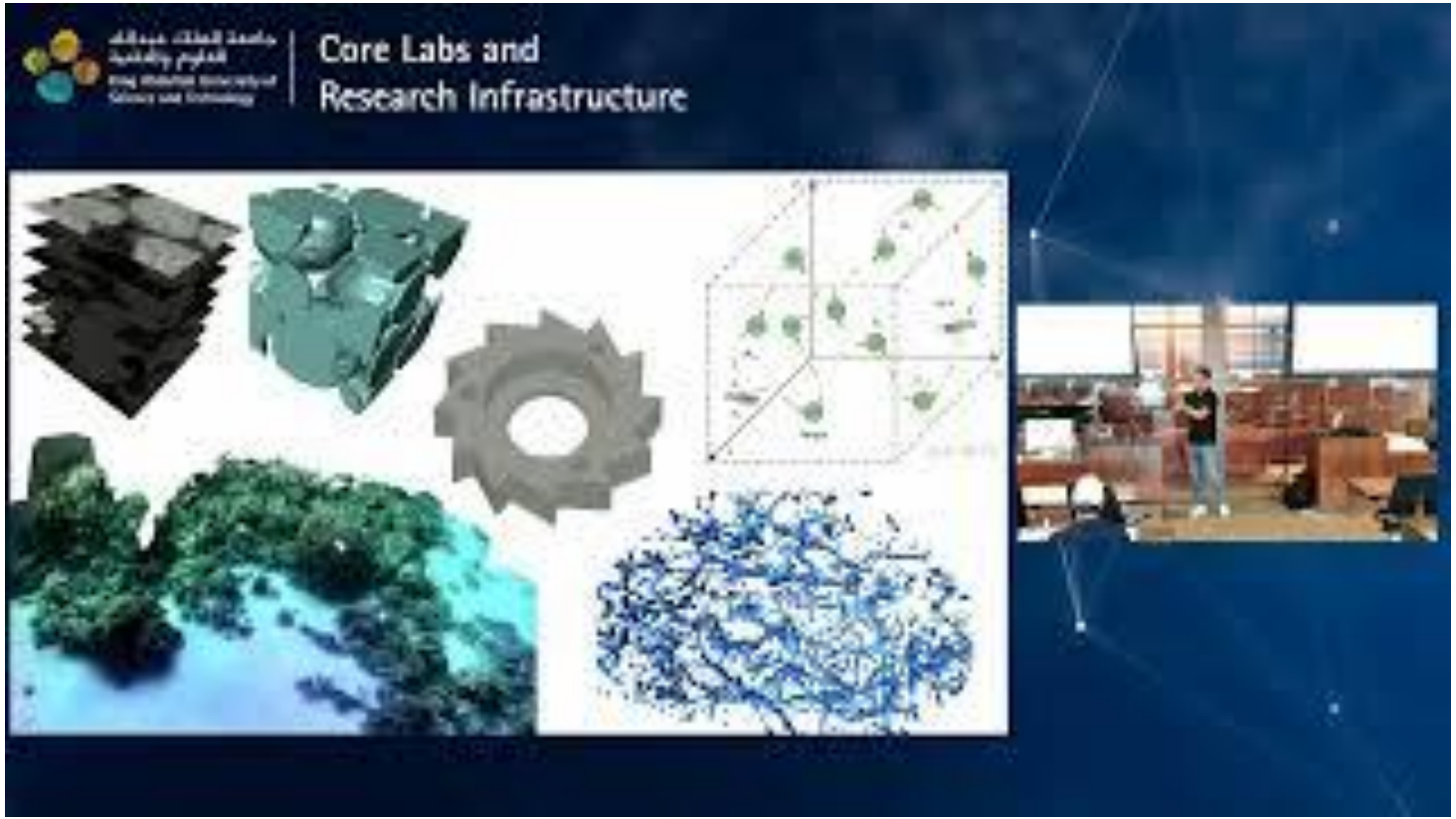
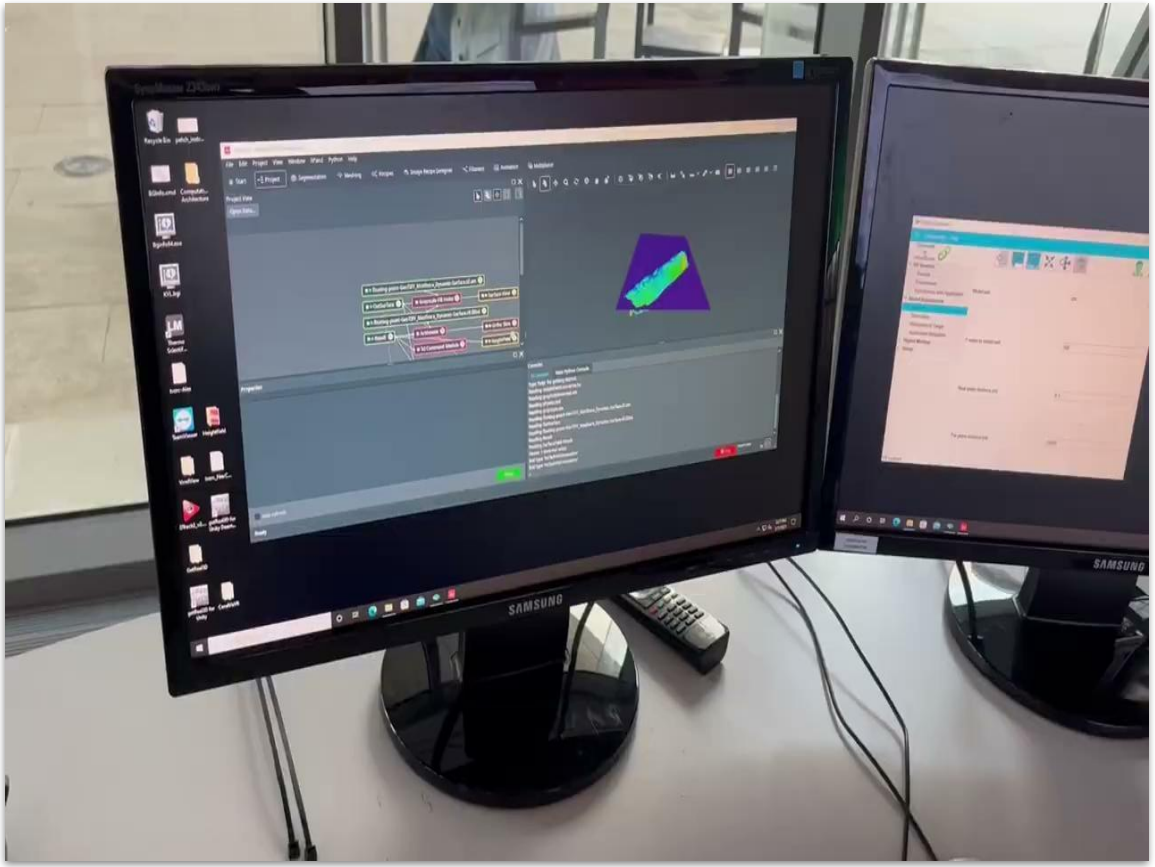


3D Spatial Data: bathymetry data vis in VR



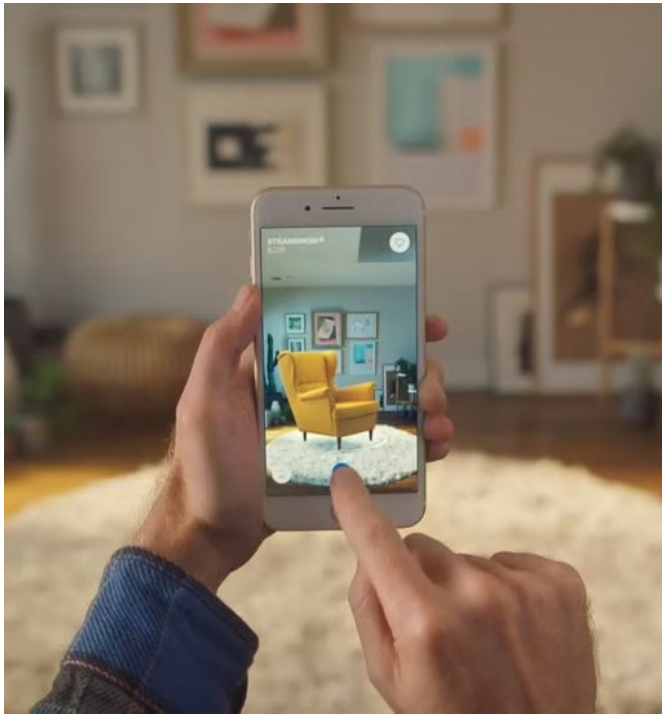
Situated Data: sensor data visualization in AR

https://er.educause.edu/blogs/2018/8/using-augmented-reality-to-promote-making-with-understanding

Situated Data: planning/prototyping in AR

https://www.youtube.com/watch?v=UudV1VdFtuQ

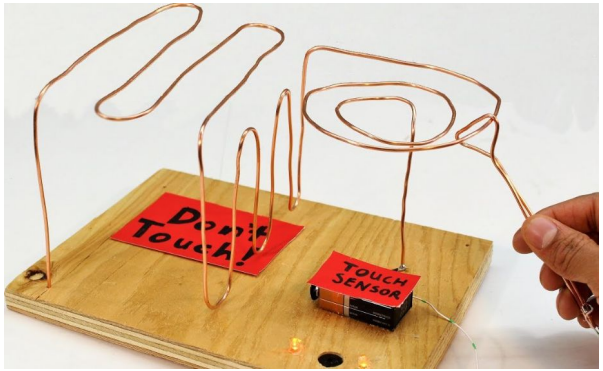
Situated Data: planning/prototyping in AR

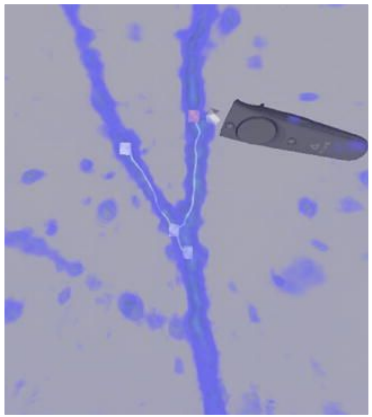


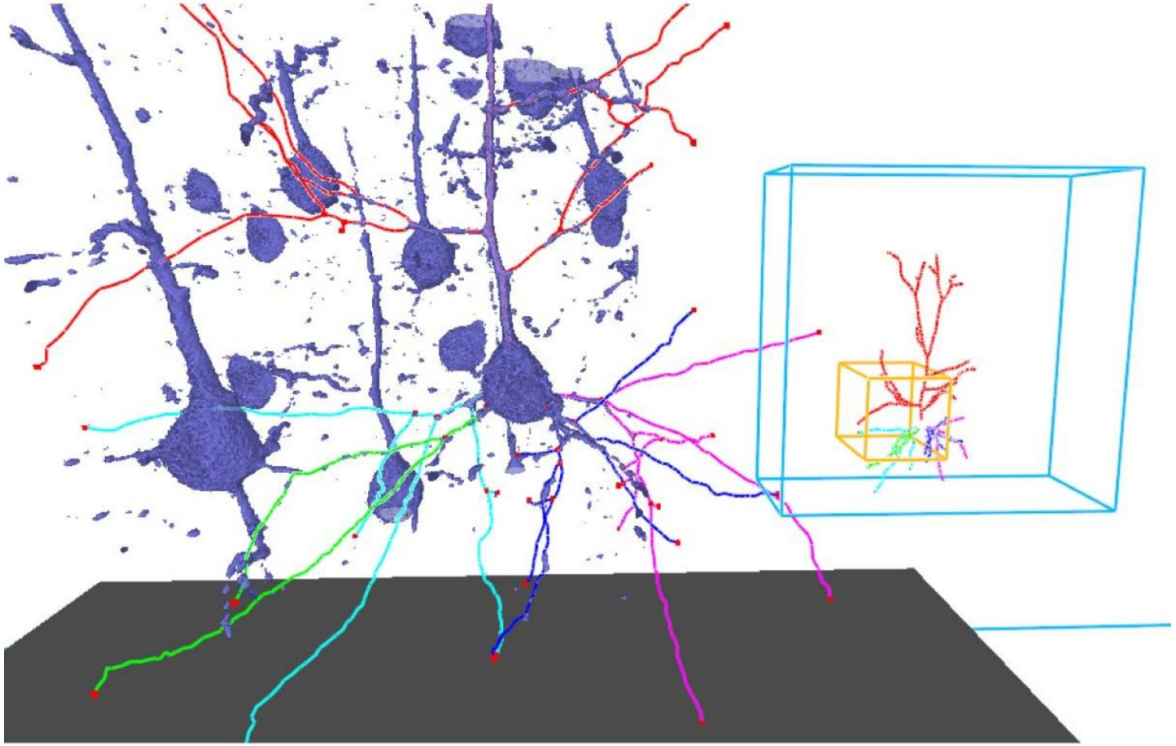
https://www.ikea.com/au/en/customer-service/mobile-apps/say-hej-to-ikea-place-pub1f8af050

https://adsknews.autodesk.com/news/microsoft-hololens-autodesk-fusion-360-mixed-reality-for-product-design-and-engineering

Natural Interactions: neuron tracing in VR

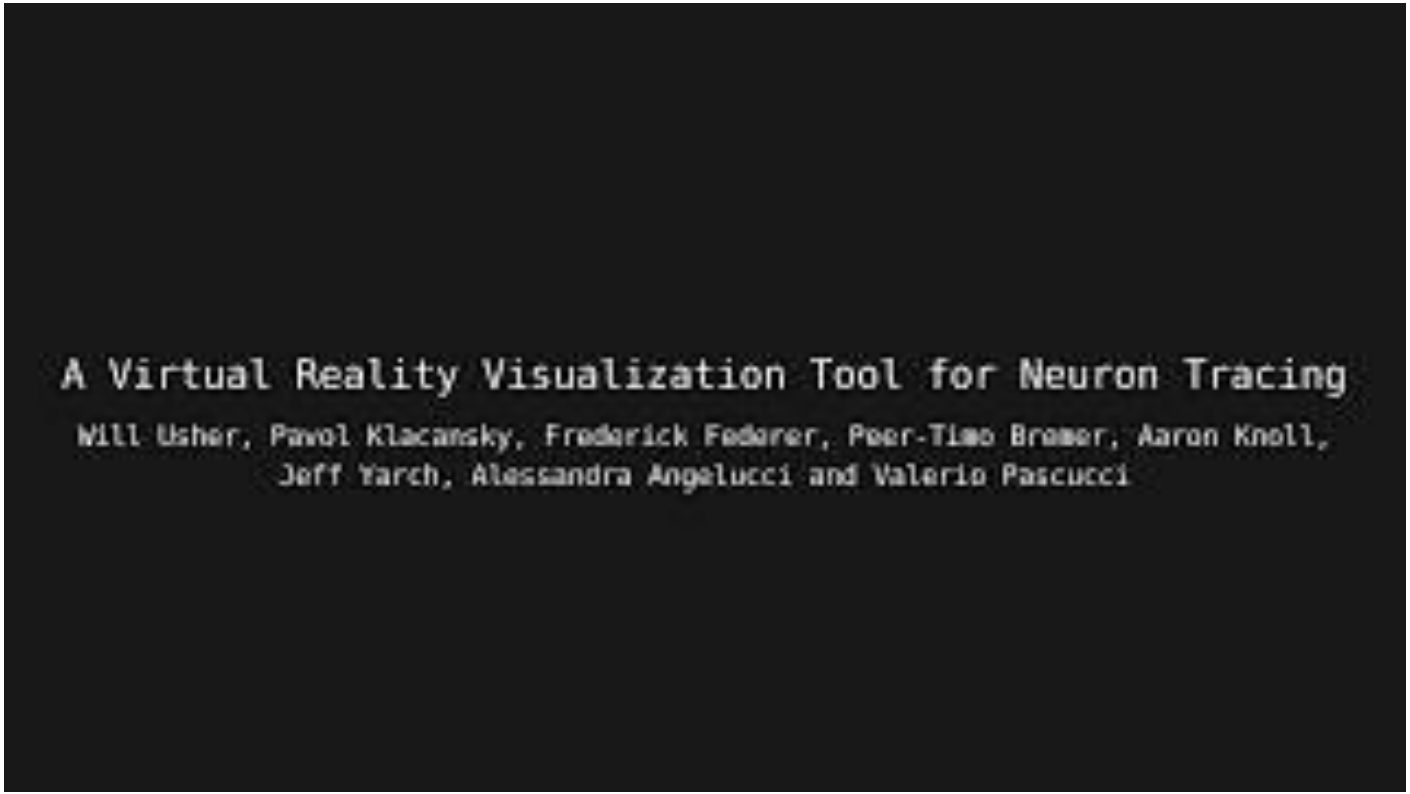




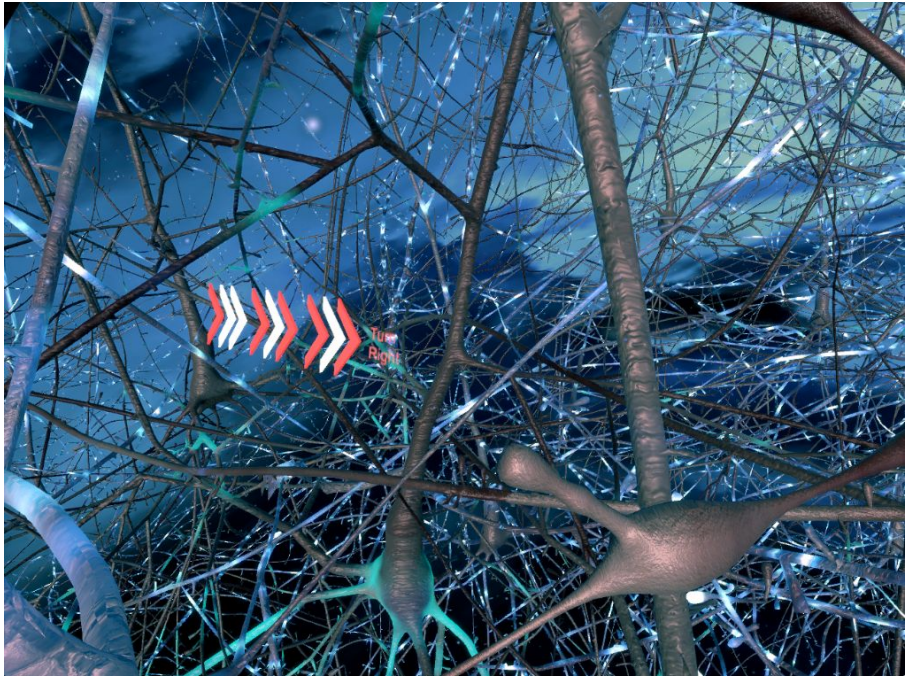


[Usher et al. 2018], https://www.youtube.com/watch?v=7KZgD053xXI

Natural Interactions: neuron tracing in VR



Immersive Storytelling: VR tour of brain cells



Immersive Storytelling: coral probiotics village

AR/VR Capabilities @ KVL

How can AR/VR **+ KVL** help me

visualize

understand

explain

manipulate

my data better?

Overview of AR/VR Capabilities @ KVL

output

input

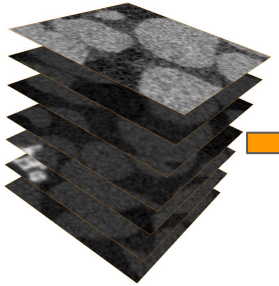
computer

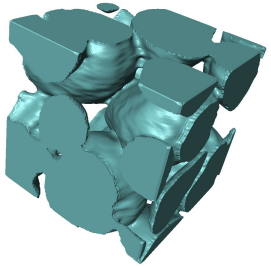
AR/VR application

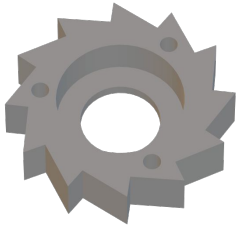
virtual content

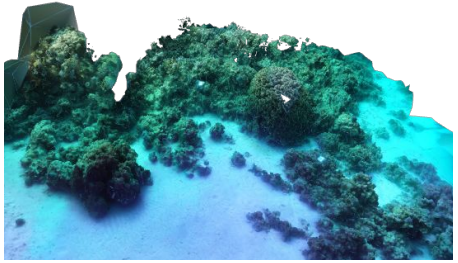
TECHVIZ

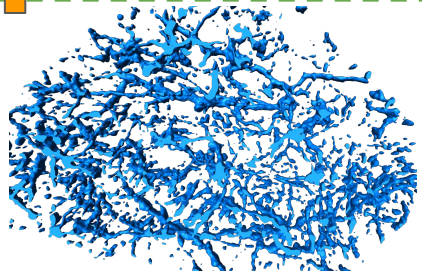
unity











Hardware + Software + Expertise

Hardware

VR Head-Mounted Displays

Device	#	Release
HTC Vive	5	2016
HTC Vive Pro	1	2018
Meta Quest 2	2	2020
HTC Vive Pro 2	2	2021
HTC Vive Focus 3	2	2021
Meta Quest Pro	2	2022

AR Head-Mounted Displays

Device	#	Release
Magic Leap 1	1	2018
HoloLens 2	2	2019

AR/VR-Ready Computers

3 AR/VR-ready desktop workstations

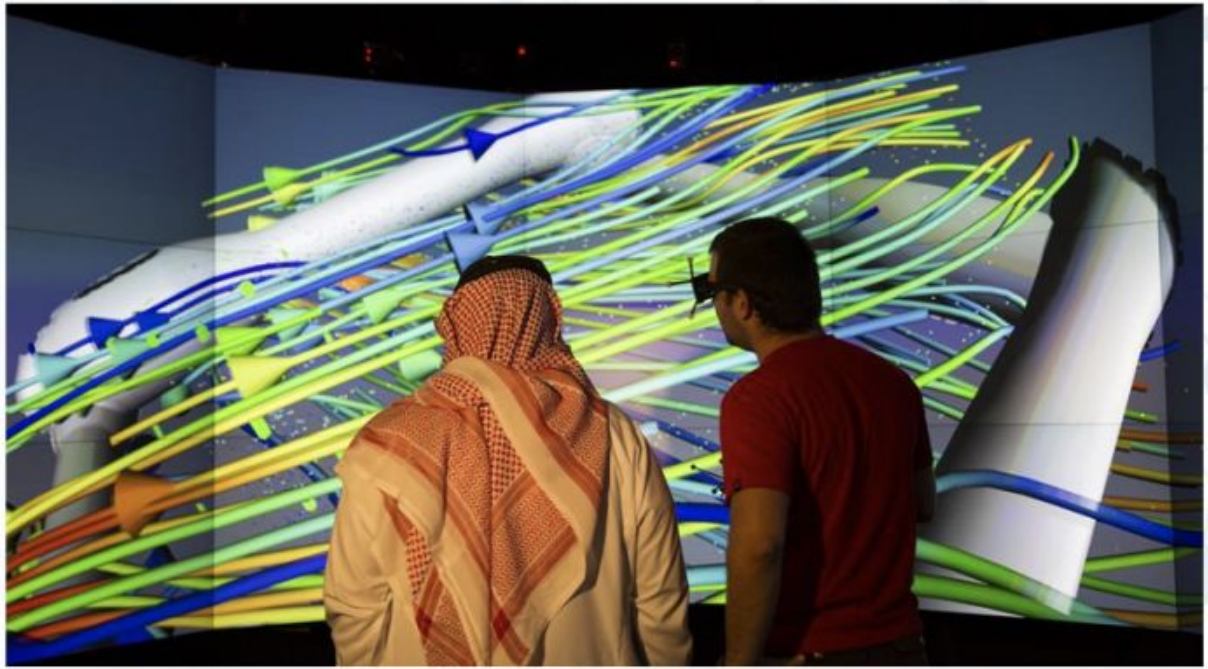
2 AR/VR-ready laptops

Immersive Environments: Zone 5

- Bldg 1 (West), Level 2
- 7 x 3 config
- 3D TVs
- 1 head node
- 3 render nodes
- tracking

Immersive Environments: CUBEs

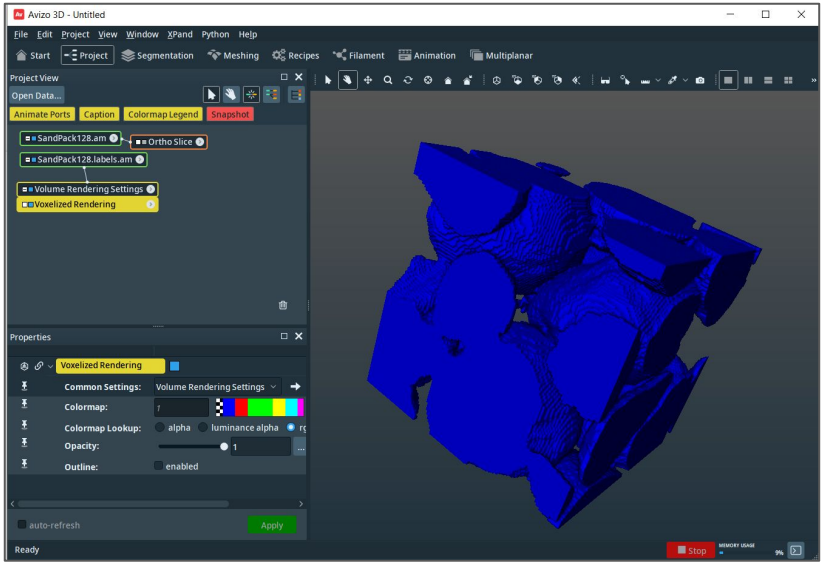
- Bldg 1 (East), Level 2
- 7 x 3 config
- 3D projectors
- 1 head node
- 7 render nodes
- tracking
- surround sound



Book via
wiki.vis.kaust.edu.sa/booking

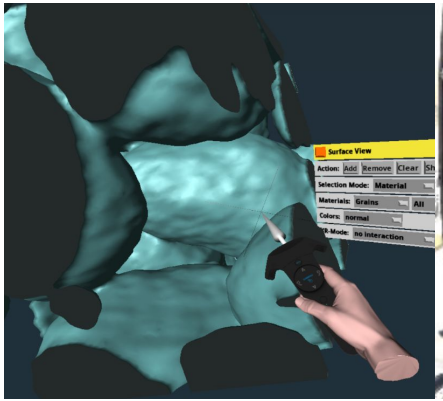
Software

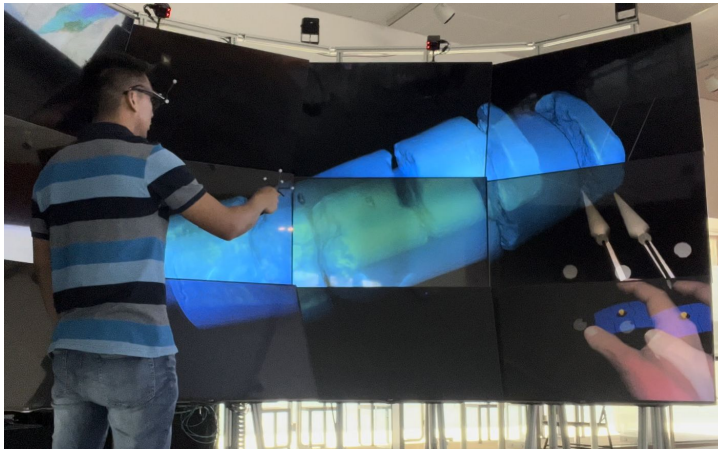
Avizo + TechViz



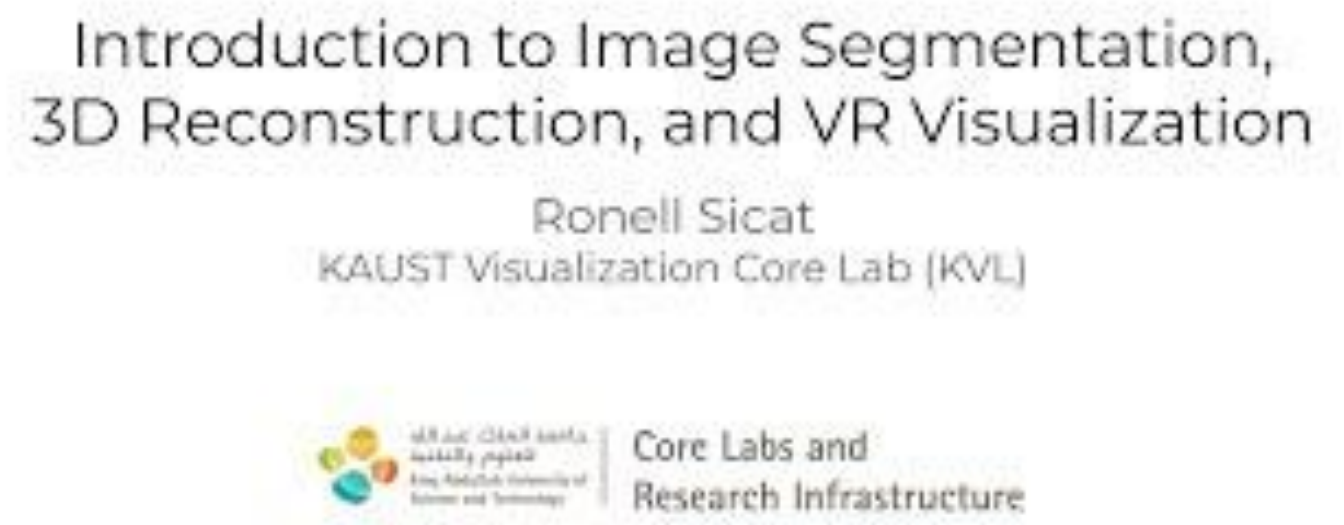
AVIZO

TECHVIZ

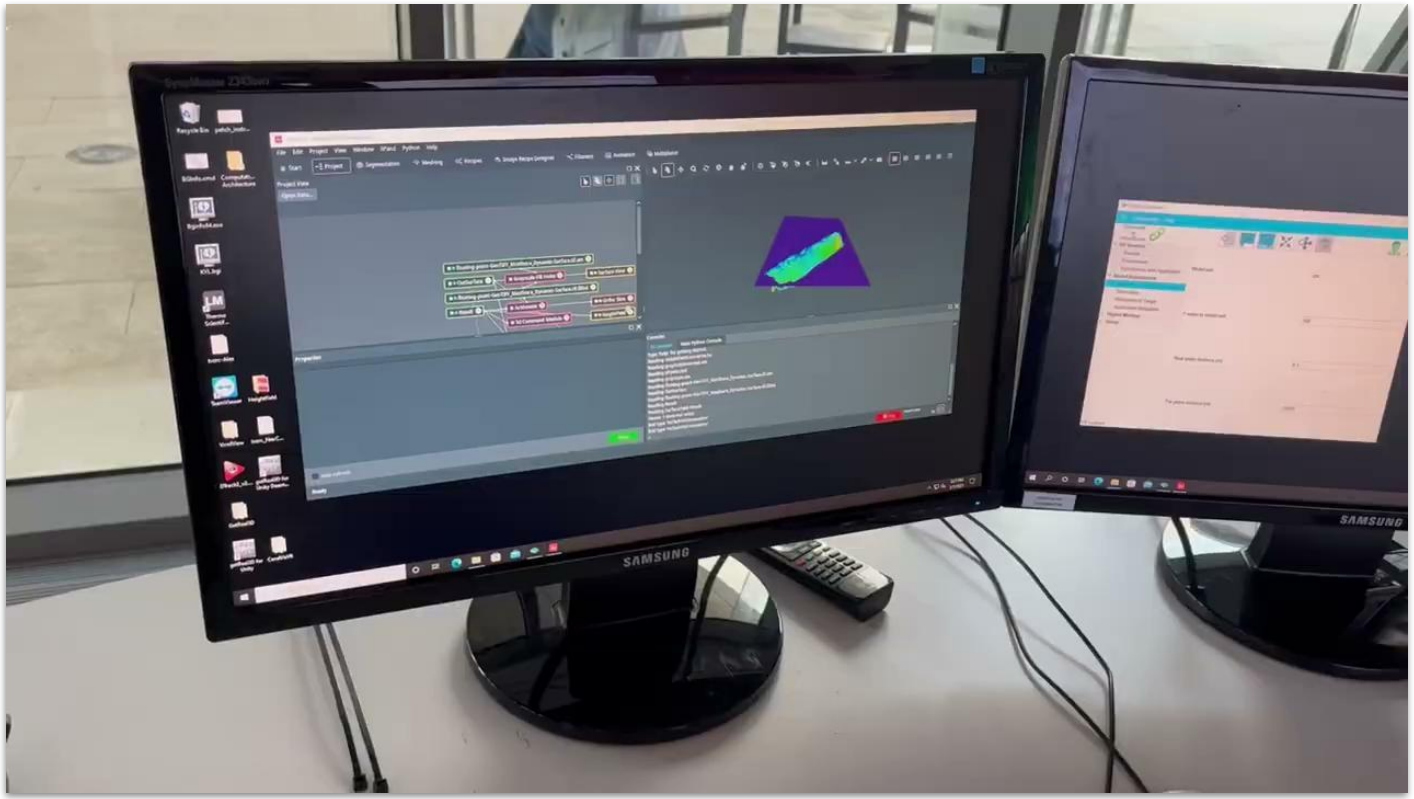




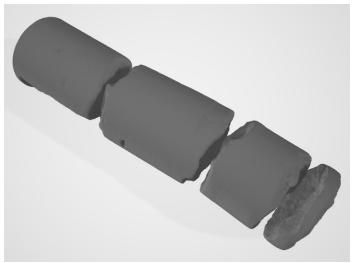
Avizo + TechViz on VR Headset

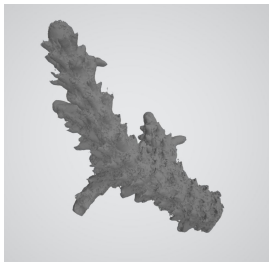


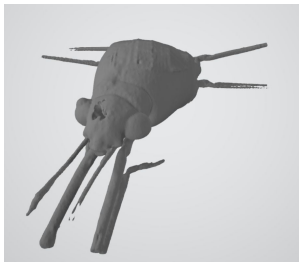
Avizo + TechViz on Zone 5



Unity AR/VR

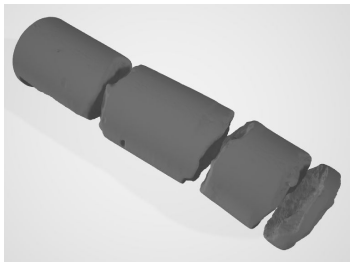


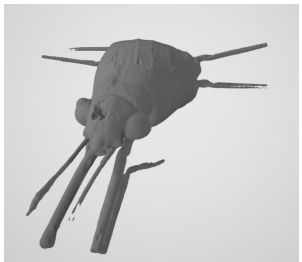




Unity AR/VR


VIRTUAL
Welcome to the Virtual ANPERC Art Exhibit!
This interactive experience was developed by the KAUST Visualization Core Lab using GT scan data created by ANPERC and their collaborators.
The guide on the right shows your controls. Click 2D buttons (like the blue one below) with the trigger button (using your index finger), and grab 3D objects with the grip button (using your middle finger). Click the "Click To Continue" button to go through each interactive station or use your right thumbstick to teleport and your left thumbstick to walk freely between areas.
Enjoy the exhibit!
Click To Continue
Trigger Button
Grip Button





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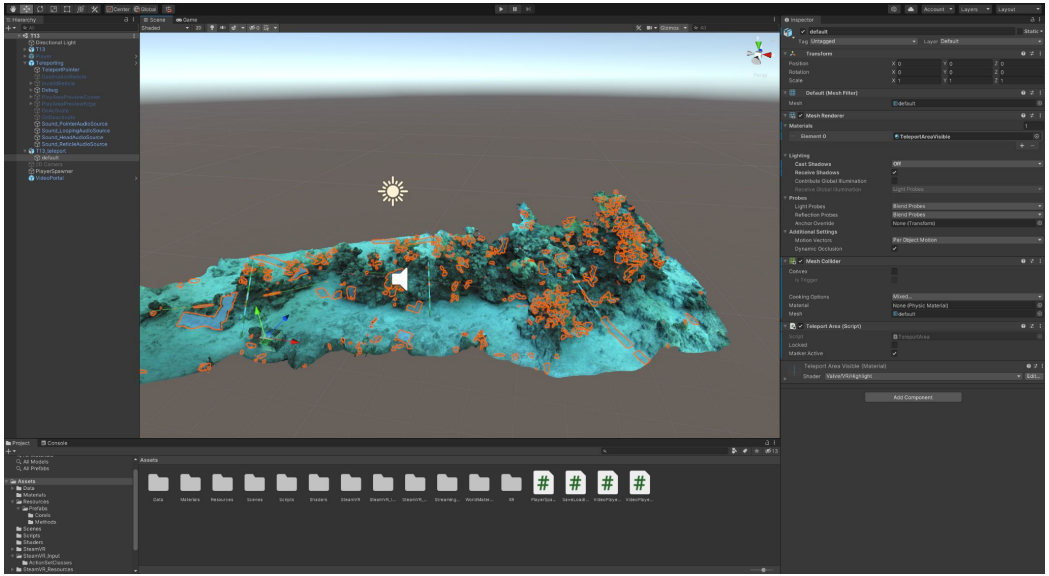
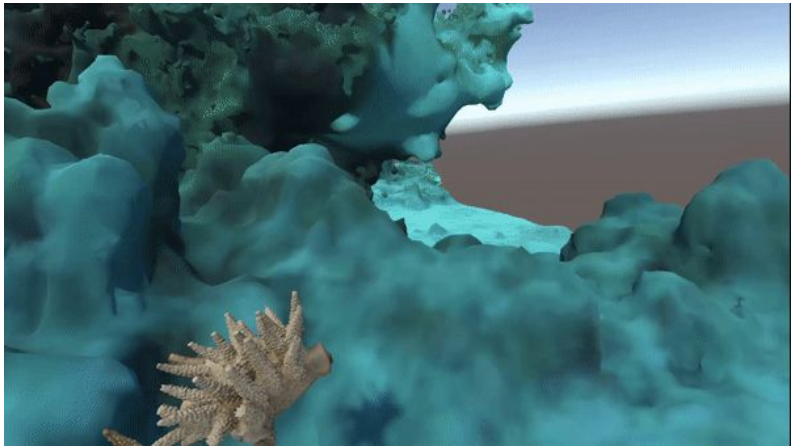
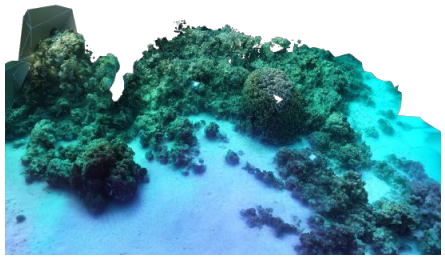
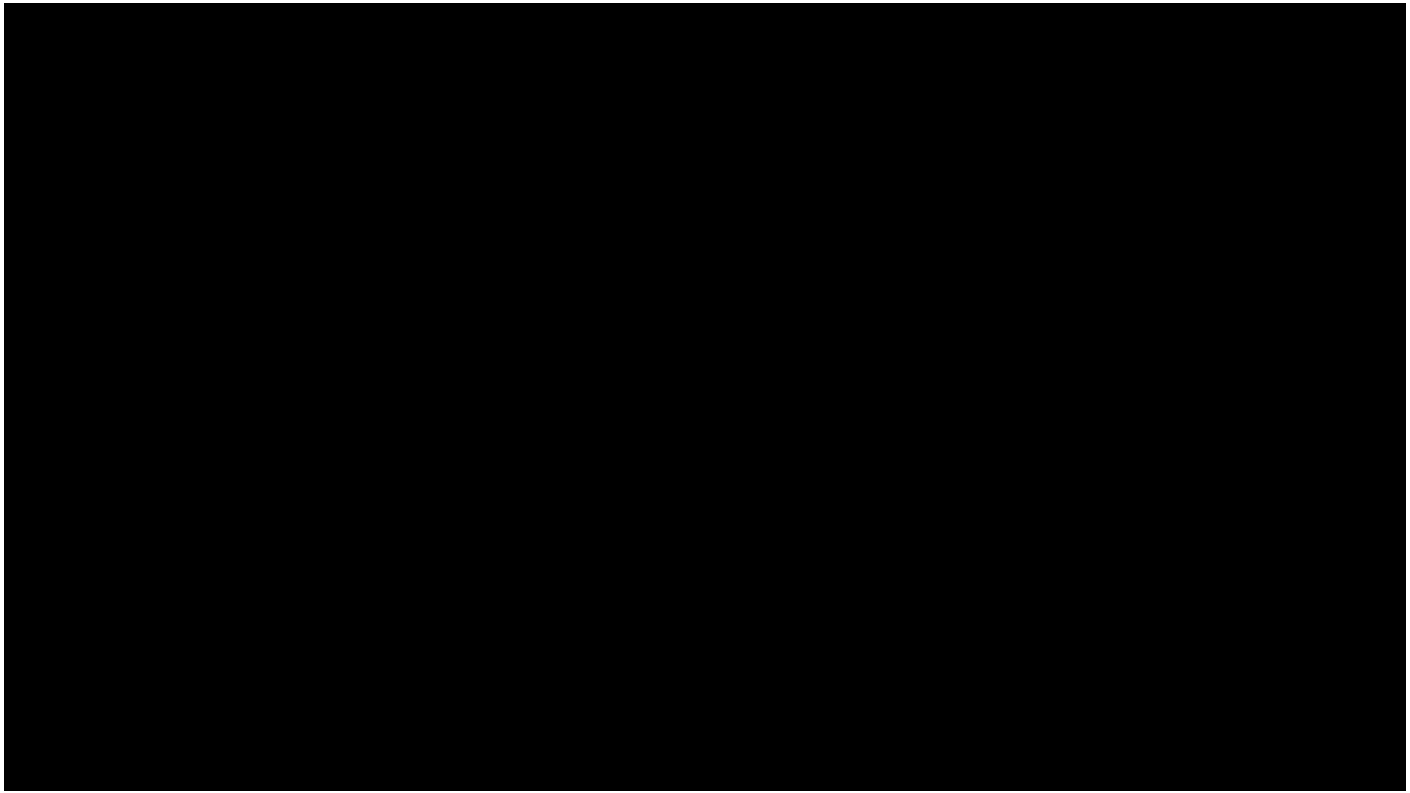






Unity AR/VR



Unity AR/VR

Unity + GetReal3D

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Expert Support and Collaboration

Ronell Sicat

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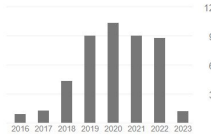

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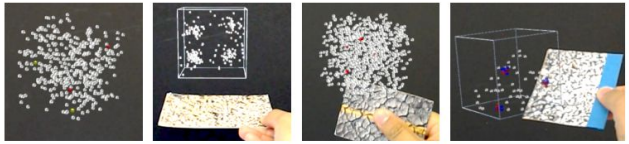
The Hologram in My Hand: How Effective is Interactive Exploration of 3D Visualizations in Immersive Tangible Augmented Reality?

Benjamin Bach, Ronell Sicat, Johanna Beyer, Maxime Cordeil, Hanspeter Pfister



(a) Distance task (b) Cluster task (c) Selection task (d) Cutting plane task

Fig. 1. Monoscopic and low-resolution approximations of hologram visualizations of 3D scatterplots using immersive tangible augmented reality with the HoloLens. Actual perception through the HoloLens provides stereoscopic images and higher resolution.

Abstract—We report on a controlled user study comparing three visualization environments for common 3D exploration. Our environments differ in how they exploit natural human perception and interaction capabilities. We compare an augmented-reality head-mounted display (Microsoft HoloLens), a handheld tablet, and a desktop setup. The novel head-mounted HoloLens display projects stereoscopic images of virtual content into a user's real world and allows for interaction in-situ at the spatial position of the 3D hologram. The tablet is able to interact with 3D content through touch, spatial positioning, and tangible markers, however, 3D content is still presented on a 2D surface. Our hypothesis is that *visualization environments that match human perceptual and interaction capabilities better to the task at hand improve understanding of 3D visualizations.* To better understand the space of display and

DXR: A Toolkit for Building Immersive Data Visualizations

Ronell Sicat, Jiabao Li, JunYoung Choi, Maxime Cordeil, Won-Ki Jeong, Benjamin Bach, and Hanspeter Pfister

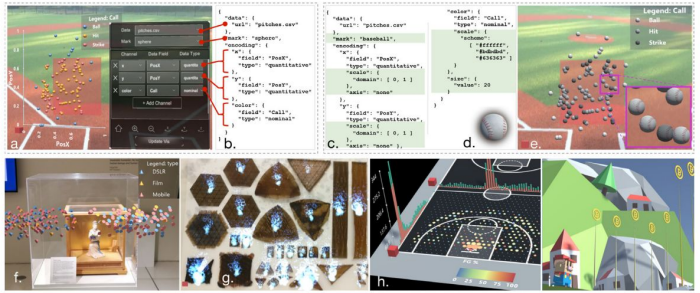


Fig. 1. DXR enables rapid prototyping of immersive data visualizations: (b,c) declarative specifications concisely represent visualizations; (a:right) DXR's graphical user interface (GUI) within the virtual world enables quick iteration over visualization parameters such as data sources, graphical marks, and visual encodings; (b) the GUI modifies the underlying design specifications; (c) specifications can be fine-tuned by the designer in a text editor; (d) the designer can add 3D models as custom graphical marks to achieve (e) novel immersive visualization designs. Example visualizations built using DXR: (f) a 3D vector field plot showing locations of photographs of an exhibit; (g) flames representing the remaining lifetime of real-world organic materials as they decay; (h) bar charts and scatter plots embedding sports data in a virtual basketball court; and (i) coins showing Bitcoin prices in a 3D game.

Others

- Low-level programming consultation
- Data mapping and conversion to 3D assets
- Commercial software testing
- AR/VR facilities consultation
- And more...

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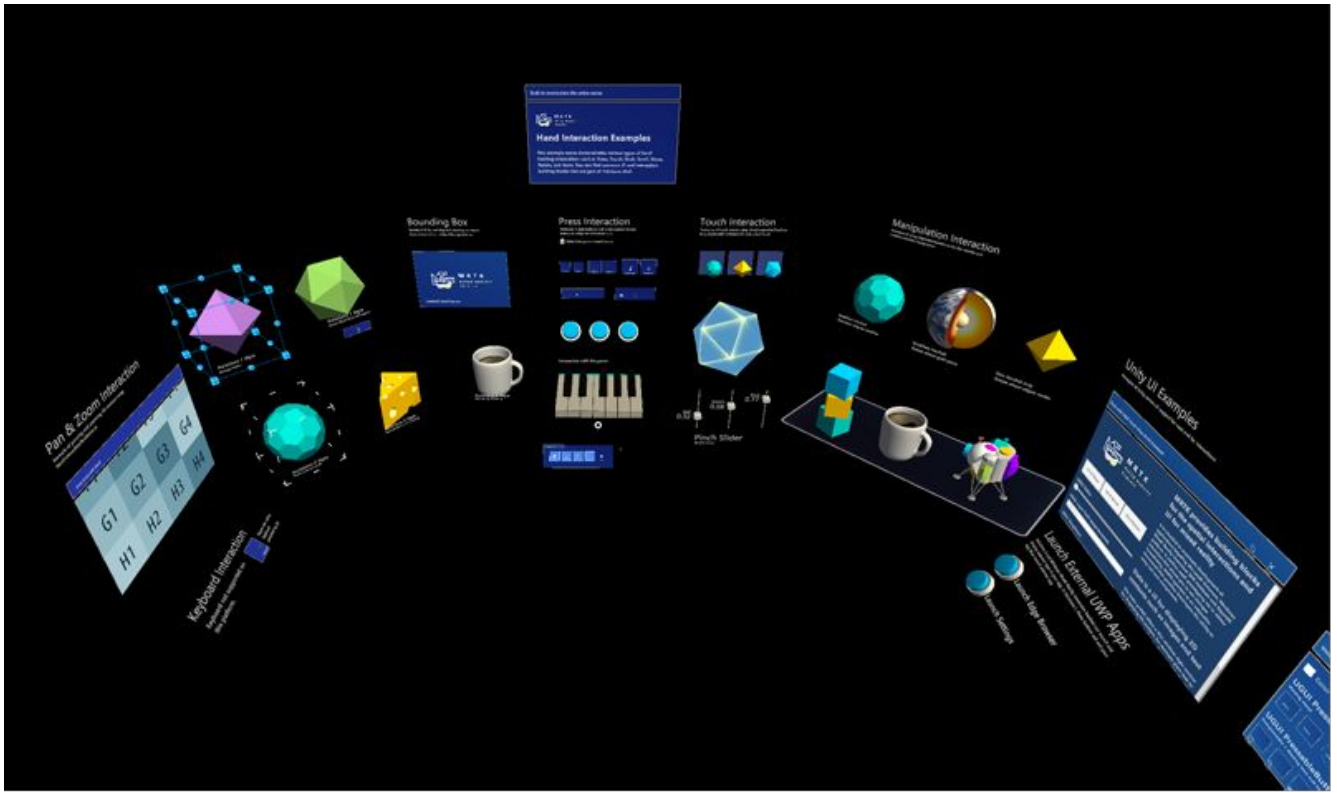
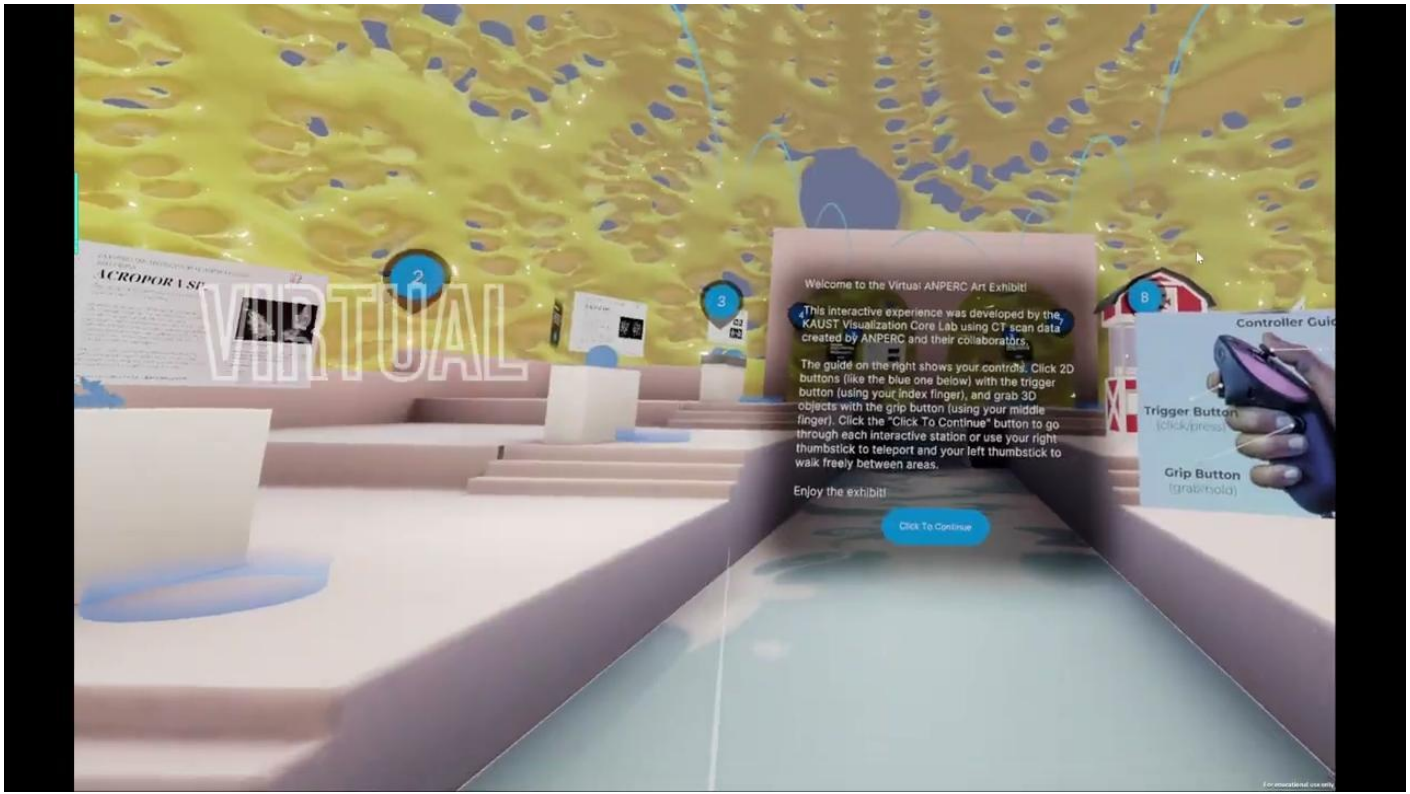
Live Demos / Discussions

VR: Coral Probiotics Village

AR: MRTK sample with 3D data



VR: ANPERC Art Exhibit



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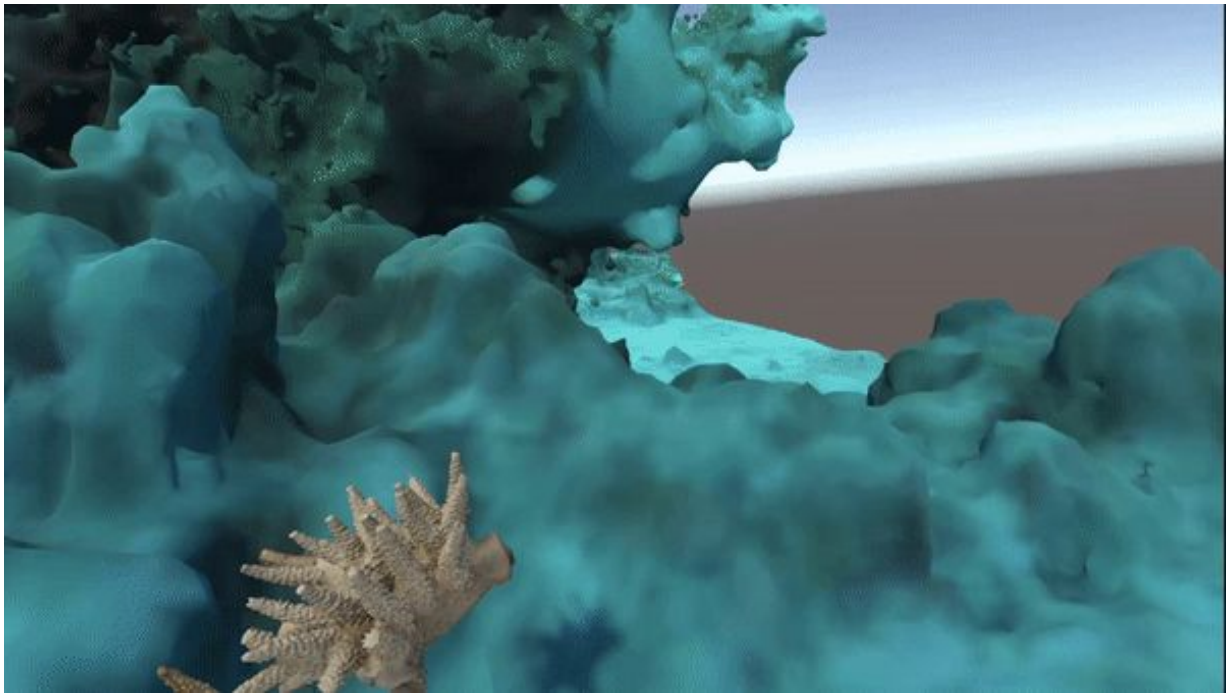
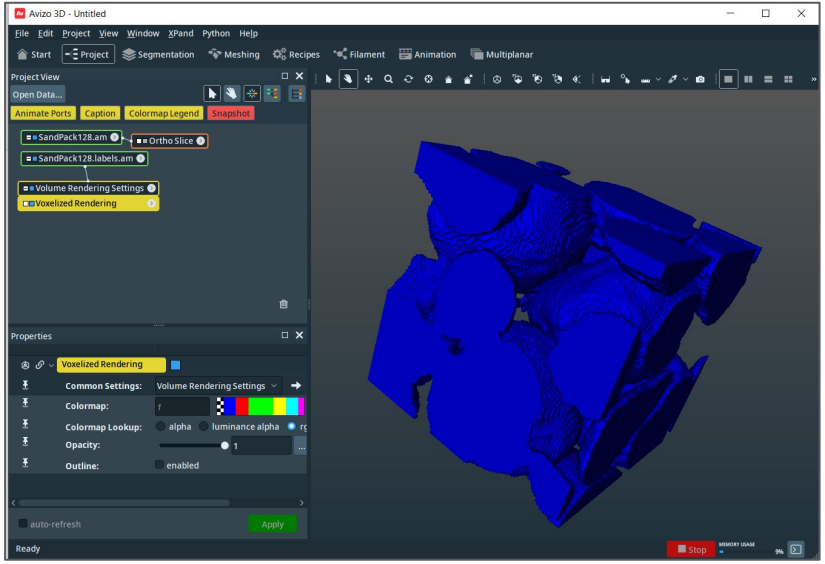
Vive: Coral planting

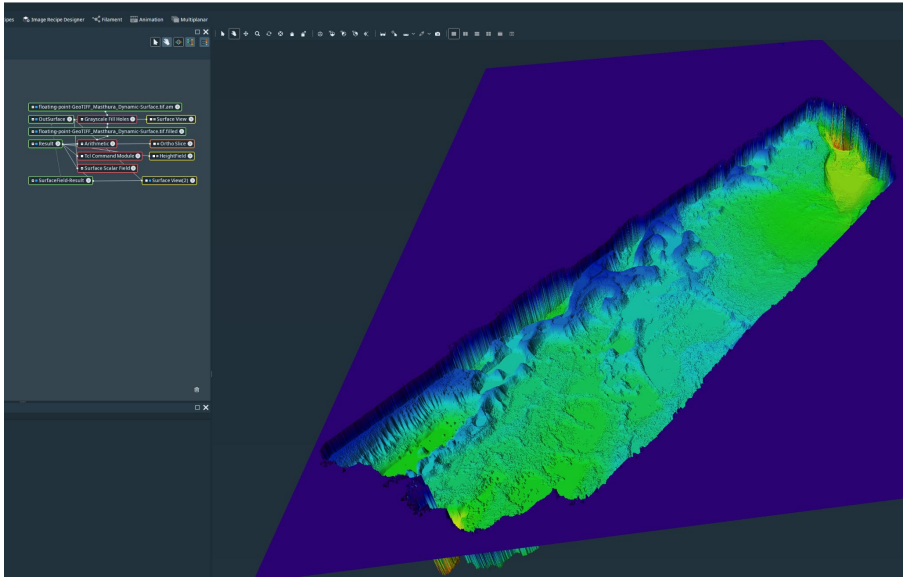


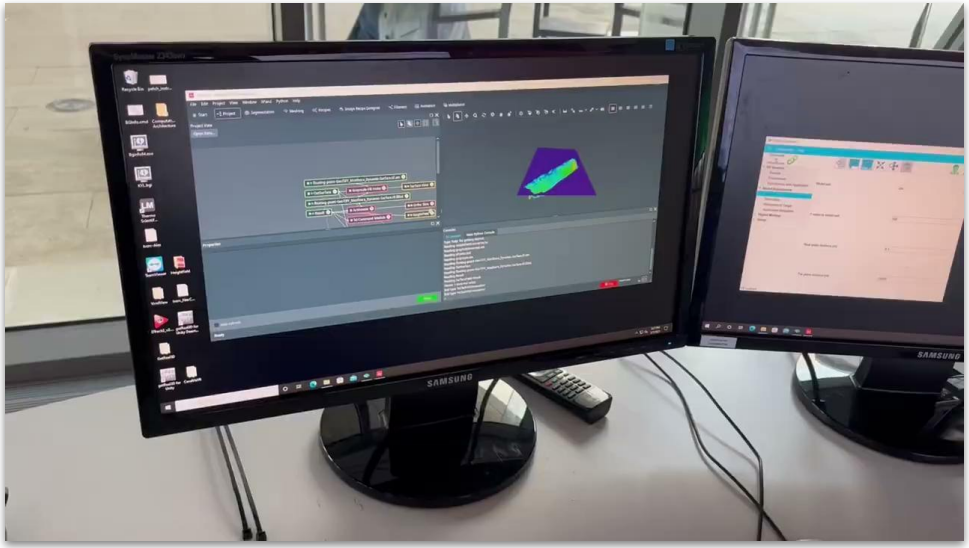
Vive: Avizo + TechViz



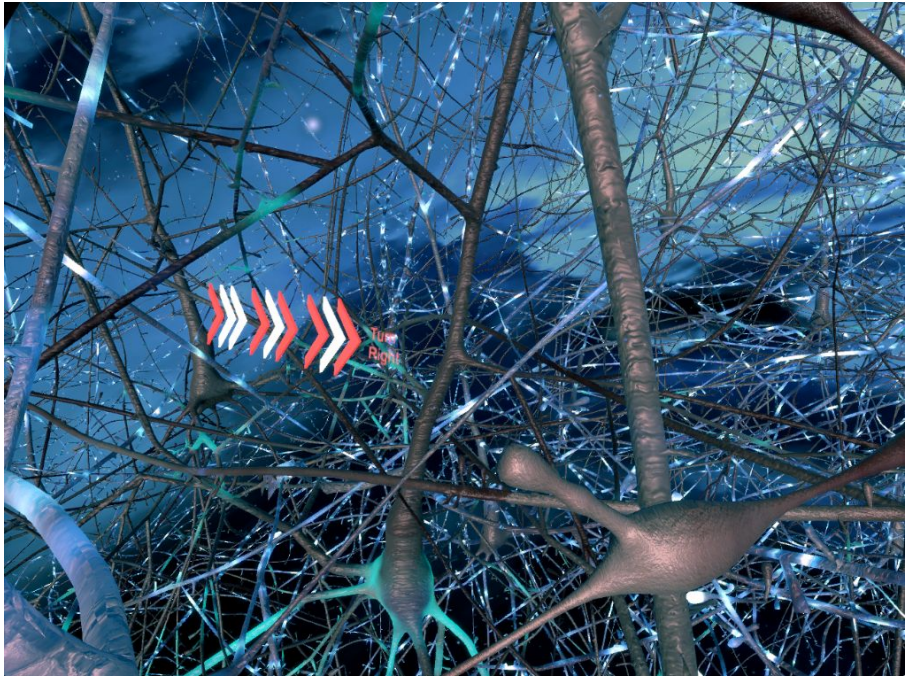
Zone 5: Coral Probiotics Village

Zone 5: Bathymetry vis

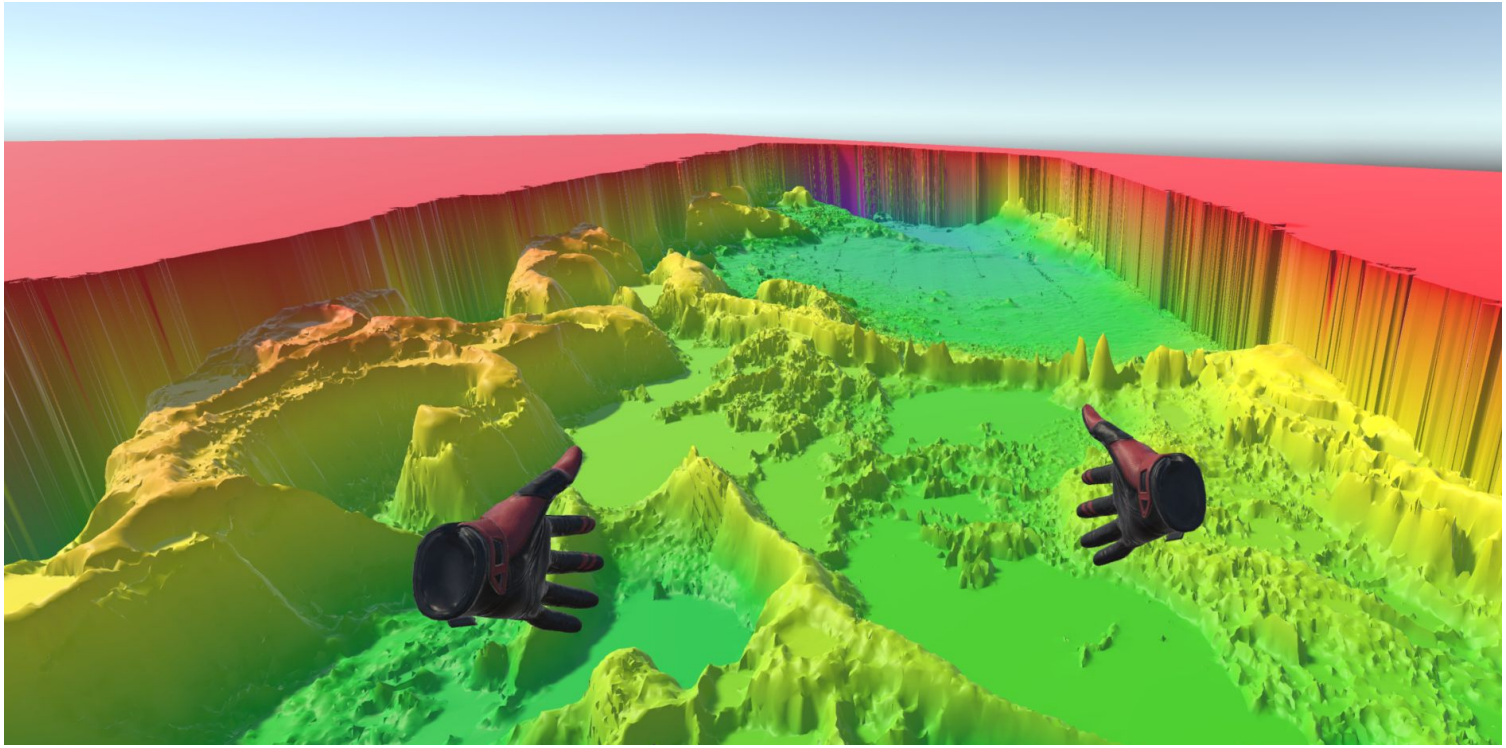




VR: Brain tour



VR: Bathymetry vis



Data c/o CMR Core Lab

Demo List:

-VR (laptop + Quest Pro) Unity XRI sample

-AR (laptop + HoloLens 2) MRTK sample with 3D data

-VR (laptop + Quest Pro) CPV

-Vive VR: Coral planting

-Vive: Avizo + TechViz (sand pack)

-Zone 5: CPV

-ZOne 5: Bathymetry

Optional:

-Vive: Brain VR

-Vive: Bathymetry

Thank you!

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